THE DEUS MACHINE

A NOVEL FOR LEARNING

MACHINE LEARNING

HADI AGHAZADEH

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This novel is entirely a work of fiction. The names, characters and incidents portrayed in it are the product of the author's imagination. Any resemblance to actual persons, living or dead, or events or localities is entirely coincidental.

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Dedicated to the soul of my father,

Ghanbar*,*

who is known more in the heavens than on the earth.

Acknowledgements

I'd like to first thank you for the opportunity you gave me to share with you my way of teaching on Machine Learning.

I would like to express my special thanks of gratitude to my sister, Nasim who is the first reader and critic of my writings.

I am really thankful to her.

Moreover, I would also like to thank my dear mother, Akram. One of the things that helps me to keep going when I am over is you. You are a fresh breathe for every second of my life.

Finally, I appreciate my supervisor, Professor Xin Wang and my friends who helped me a lot in finishing this book by their advises and guidance.

About Hadi Aghazadeh

What is the best sentence to describe me?

A Data Scientist with 5 years of work experiences in applying AI into businesses?

Currently a Ph.D. Student at the University of Calgary working on applying AI and particularly Reinforcement Learning to Supply Chain problems?

Or...

Maybe the best thing that I can describe myself as is an eager and continuous learner.

After involving in many AI projects, I got to know that I almost know nothing about AI. As Socrates said, (I know that I know nothing.) truly acknowledging the ignorance is the first and the most important step for everyone who wants to have a long-lasting impact in their field and I am happy that I've got to this point.

So...

I am just a wanderer in search of truth.

Which truth?

The truth of truths: How far we can understand things?

If we get to know how far we can understand, we would be able to answer many unanswered questions in the history.

The best way to answer this question is to understand how the mind works and the best way to know how it works is to build one and one of the great ways to build a mind is **Artificial Intelligence**.

That's why I've fallen in love with it.

Preface

What happens if a machine becomes the God?

Spinoza, my favorite philosopher said that God is nature indeed and Hegel, the philosopher of philosophers said that God is the history. The history in which the constant battle or dialectic between a thesis and an antithesis creates a synthesis. In the sequence of these battles and in the conflict of interests of them, self-consciousness is raised, and this collective self-consciousness is God.

For me, however, history may not be my God, but it is an endless source of stories. Stories of victories, defeats, cruelties, killing and being killed, seeking justice and never finding it, and finally, despite all the pains and sufferings, finding new routes toward the future or even creating it.

Stories have an eccentric power. People have always gathered around those who have been great narratives. These leaders have been able to translate the pains and sufferings, laughter and joys of those people and turning them into meaningful stories that narrate their way of thinking and feelings and gives them a new identity or re-imagine their forgotten identity.

And I, who from a young age was full of the inner flames of opposing forces. I, who had mathematics and logic along with fiery emotions in novels and stories together, and I was looking for an avenue of escape to unite these far apart paths and interests, found the only way to relieve myself in writing stories.

Yes, stories are the closest way to make a bridge between logic and emotion, and this is how good stories changed the course of history.

And now, the story of this book…

Among the many quotes from Steve Jobs that are told and being heard among the people, there is an implicit quote, happened to not heeded, and that he believed the fundamental innovations in the future would occur at the intersection of the experimental sciences with the humanities.

Mathematics, stories, philosophy, and music are the things I love most in this world. I'm glad Steve Jobs and his quotes were part of helping, which guided me to think about putting all my interests into one story and reconciling them. This is the story of this story.

I think the best purpose for my life is to stand at the intersection of the experimental sciences with the humanities and thereby expand the boundaries of human cognition and find new uncharted territories on how we understand the world and ourselves too. This story is the beginning of my adventures in the purpose of my life.

I know there are many who know ***Artificial Intelligence*** algorithms better than me and are very smart and hard-working in this field. Still, in the two years that I have been involved in designing and writing this story, I have tried a new and innovative way to give ***Machine Learning*** algorithms a new perspective. In this way, while teaching machine learning algorithms from basic to advanced concepts such as ***Deep Learning*** in a simple way, I combine the whole process with a story.

I am sure that the two's symmetry will both reinforce the pleasure of learning and will be an incentive, for my part, to the old desire to build an intelligence that is equal to human intelligence.

Artificial intelligence and machine learning have advanced dramatically over the years. The day is not far when these algorithms will dominate many aspects of our lives. The desire of many people who work in this area is to create a new brain, like their own, and in this way challenge themselves and, in a larger sense, expand the boundaries of human cognition.

In this story, I have put together all the machine learning, philosophy, and what I know about writing stories, to create a new antagonist, which is not a machine that looks like a man but a machine that intends to become the God of them to compete with them.

Machine learning is the core of this story. The Deus Machine and those three anonymous reformers whose destiny accompanied them together are equipped with machine learning. They use machine learning to fight with machine learning.

Who will be the winner of this battle or dialectic?

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01

Fire Flames

The corridor was like a long, indistinct tunnel, as though they were peering through thick gauze. The half-ruined faint trace of sallow light, hanging from the ceiling, was constantly flashing, and each time was clawing at his despairing soul. He could feel the slush of vague fear stirring deep inside himself. His stomach gave an almighty lurch so that he could hardly breathe.

As he and his companion doctor walked along the corridor, a man with goggle-eyes walked toward them. His hand was inside his white robe, breathing fast, as resembled the neighing of a horse. He was whispering something under his breath as he was gradually increasing his speed.

As soon as reaching out to them, he pulled his hand out of his robe and attacked them. Dumbfounded, Ivan pitched over upon the floor, trembling like a leaf.

"Oh, look at this sane," Said the madman, who was now laughing.

"Get out of here soon, and don't leave your room until tomorrow." Said the doctor, frowning and biting his lower lip while looking at the madman with the comb in his hand. In a split second, the madman had become the most obedient person on the earth. Lowering his hand shamefully, he made his way and left.

"You must forgive," The doctor said as he stretched out his arm and caught Ivan's hand.

"I thought it was a knife," Ivan said, lifting his brows.

"That's the better one," The doctor stepped up his pace and then took on a philosophical posture and continued, "Anyway, you know... the norm is the opinion of the majority... Here the majority are all mad." They passed a side-section, which was more like a prison. Horrible sounds were heard. It was not just a scream; it was like a blood-curdling shriek of feast agony animal that has been kept hungry for a long time.

"Where is it?" Ivan asked curiously. The doctor stood for a moment. He wondered if he would show it to him or not. Eventually, he made up his mind, "Come with me."

The smell of blood, sweat, urine, and shit was leaked like a sickening warm wind. Ivan sniffed the air, nose crinkling. There were several fenced-cabins, each with raving mad whose hands and feet were chained. All faces, without exception, were full of a deep puncture wound.

When their eyes fell on the presence of strangers, they pulled themselves towards the bars and shouted in anger. As they passed, a terrifying sound filled the side hall. The splash of scream sounds had a multiplier effect on their insanity. Ivan was thunderstruck, losing his nerve. The doctor took him out right away.

They were in the long hallway again. “Who were these people?” Ivan said as panting. “Why were they chained?”

The doctor, who had stepped forward, took a few steps back: “Raving mads! These are the most dangerous maniacs. No one dares to enter their cabins. They are always imprisoned there. We give them their food from the ceiling, but believe it or not; no food container has come out of those rooms yet!”

“So, the wounds on their faces were because of this... they hit each other as hard as they could,” Ivan said as he went on again. The doctor nodded sadly.

Ivan’s lips and dry-mouthed were jittered. The doctor realized his discomfort. “Your patient is in room 101. A little left, please come with me.” He said, to change the matter.

A few steps forward, they reached the 101 room. The room was L-shaped. In the doorway, several old men had sat idly while they were busy, playing cards. In the surprise of Ivan, they held a deck of cards upside down so that everyone could see each other’s hands.

“Seep,” One of them yelled and then laughed. All his other friends frowned seriously.

“Damn, you seep again.” One of them, who was the thinnest, said.

“That’s always their job. They always play the same game with their own rules.” The doctor said, heaving and pushing Ivan.

When they turned the doorway, the doctor said, “Here it is,” He gestured toward a man, sitting in his bed at the corner of the room, staring out at the trees from his dirty little window. Ivan took him a few steps. His lips trembled involuntarily. He lumped in his throat but couldn't cry.

"Tom…Tom… dear Tom." He murmured.

Tom's unkempt piebald beard covered his entire throat. He showed no reaction and didn't even change his look.

"He has been hugging his knees and staring out the window," The doctor said. "Since he was brought here three months ago."

Ivan walked over to Tom and tried to follow the direction of his soulless eyes. The brilliant glow of the red light of the westering sun, which cut off with the leaves of the trees that danced with the gentle breeze, looked like a volcano eruption.

Ivan sat quietly next to Tom. "Fire... fire..." He murmured.

His thought processes reached so far and took him around four months ago when he saw Tom for the first time.

02

Narrow As a Hair Strand

It was 7:15 AM. The 2005 Blazer was parked next to a local café on Palm Ave. Inside the Blazer, the San Bernardino national forests could be seen, surrounded by dense, white fog. Ivan looked at his girlfriend, Lisa, who was running as fast as she could towards Blazer, and as soon as she got into, she whispered excitedly, “They’re coming.”

Marlon pushed Blazer a little further and kept it under the sign of the cafe’s entrance to overlook the street. The shops were still closed, and nobody was hanging around there. Only silence was flown.

Eventually, the cash-in-transit car showed up. It turned the red light to the left and passed in front of the blazer.

Marlon glimpsed of David. David was the greatest of them. However, the M1911 semi-automatic gun in his hand was as awkward as a cow on a crutch. Marlon looked at the gun and then glanced at David again.

"Only if we have to, OK?" David nodded very faintly.

The CIT car turned to the right and stopped in front of a gas station, ignoring the no right-turn sign. An armed black-clad gunman with Heckler Koch G36 in his hand disembarked from the car. He looked around.

It was a slight breeze, chilly in the morning but bright with sun. On Sunday morning, there wasn't a soul in sight! According to Ivan's investigation, the ATM was recharged only once a week, and it was the first ATM to be recharged by the 'Cash Booster' cash management department, which means a car full of money on the outskirts of a local city.

During two weeks of investigation, they saw that the armed man was always getting out of the car in front of the gas station when they arrived. Because smoking was forbidden next to the gas station, he walked a few steps away and lit a cigarette so that the other two Cash-man could put the cassettes in the gas station ATM.

All their success depended on him doing it again, and as they expected, he did it again. The whole process took 5 minutes. David and Marlon got out of the car, and Lisa leaped into the driver's seat.

They both wore a face mask. Even behind these scary masks, it was clear that this was not really their shtick. David and Marlon punched each other and attacked the car. The armed man, who had now finished his cigarette and was squashing it with his foot, was suddenly taken aback.

David put the gun under his throat and forcibly take his big gun. The two agents, who were putting cassettes into ATM, were taken by Marlon, surprisingly. David put his gun on his back and took G36. Marlon picked up the car trunk key from the vest of one of the agents.

"Hurry up... move on... open the door right now." He bullied.

Lisa brought Blazer closer. Ivan also covered his face and got off to help Marlon move the cassettes faster. Lisa smoldered a cigarette between her cold, slippery fingers, puffed on it and blew smoke out through her nostrils. It helped to soothe her. The cassettes were still being moved.

The glint of Marlon's clear grey eyes was obvious behind his face mask. The disarmed guardian, who was taken unawares, put his hand in the air as purring.

Simultaneously, Marlon was in the back of two agents, but cassettes' money amused him. One of the agents took advantage of Marlon's negligence, ran away quickly and sounded the alarm. The siren was connected directly to the local police, and as soon as receiving the attacking alarm, it automatically sent the CIT car location to the police station.

As siren screaming, David got sidetracked. The guardian took the opportunity. He turned and quickly cracked in the teeth of David with his elbow. David fell to the ground, and his shotgun slipped a few feet away. The guardian launched himself forward to pick up the gun, but as soon as he turned to point at David, a bullet was fired from David's gun but hit him with an anti-bullet vest. The guardian felt the slug blow softly on his cheek as it passed. David didn't hesitate. He fired a second shot. The next shot, however, split his right shoulder.

He sighed profoundly, snorted, and galloped aside. As David stood promptly and made his way through Blazer, Ivan and Marlon got into it without delay. Lisa trod on the gas pedal with all of her power. A wild peal burst from the engine and rumbled off into the Barstow Freeway.

It was early in the morning, and the freeway was not so crowded yet. Lisa drove savagely on the freeway until police cars could be seen coming in front of them and from the other side of the freeway.

Lisa slowed down so the police wouldn't get skeptical, but it would have been useless. The police cars turned in the opposite direction and changed their course completely. Lisa saw them in the mirror. She put the volvo in gear. The car accelerated. The thunder and plash of the engine were screeching. Police cars had changed their line, getting closer every second.

They all were silent. It was only Marlon who suddenly turned to David and smacked him hard: "you thick-skulled, harebrained, half-witted greenhorn, you put all of us in a foolish terrible".

David flinched at the pain of the burning. This piercing pain made him mad too. They tied wildly. Ivan was shocked, trembling with fear.

"Oh, God. Shut the fuck up, you fool! Stop gabbing, or I'll keep you here and throw you all down," Lisa commentated with a shriek as she entered the side road next to the freeway.

With this ultimatum, they both fell silent, looking at each other heavily. Lisa turned from the side road next to the freeway into a narrow road. The road led to the forest. Gradually, the aspect of the locality had changed slowly. Pine trees were emerging and fading rapidly.

One of the police cars, which was very close to them, overtook the Blazer and crashed into it. That didn't work. The police car accelerated and went to block the way. Fifty meters ahead, it stopped suddenly and covered the whole road. Meanwhile, Lisa took the blazer to the lush, alpine hills of the forest road, and the Blazer passed the police car at a 45-degree angle and then turned to the forest road. Even the police were amazed at Lisa's insane act.

The road was narrower now. The police did not give up yet. Gradually, human activity signs were disappeared. The Blazer was moving fast. Lisa looked back, but the turn of the road prevented her from seeing a truck that turned in front of them unexpectedly. The road was one-way. Lisa found herself blazer hit the bar guard on the side of the road, and then hit a tree with all its power.

White heavy smoke rose from the hood in front of the car. The car could no longer move. Lisa, with nimble movements, got out of the car and ran away quickly. Shortly afterward, the tree, which was not so big, broke and fell on Blazer's roof. With this collision, David, who was sitting in the middle, slipped into unconsciousness due to the roof's collision with his head. The vehicle's right door got stuck because of the collision, and Marlon, who was sitting on the right, couldn't get out. The sound of police sirens could be heard very clearly now. The policemen thought that all four of them were stuck in the car. That's why they walked slowly towards them.

Ivan was shocked. He just recovered himself suddenly and then picked up his backpack. He pulled the handle on the left. To his surprise, it opened perfectly. He quickly threw himself out of the car and fled to the forest blindly.

Rigid with shock, two policemen turned and glanced him up and ran after him. Panting, from behind a villa on the side of the road, Ivan set himself on a hillside that had become a dirt road with pedestrian footsteps. He quickly climbed the hill, and after the hill, as if entering a new world, a forest declivity with dense trees was appeared.

The pine and spruce trees were so abundant that they faded the sunlight. Only a few radiances of sunlight would reach the forest land. The route had ditches and ridges, and those parts of the land exposed to fresh rain were muddy.

Ivan raced towards the route, regardless of exhaustion. One of the policemen stopped running with a cluttered breath. He could not continue anymore. He stood up and couldn't even say a word. He just raised his hand. The other officer turned and looked at him angrily, and again, he started running with double motivation this time.

They both would idle up and down the forest route. There was also a roaring river on a forest road, which was covered with oak trees. Ivan hugged his backpack tight and carefully tried to get past it. A few seconds later, the police reached the river. He jumped over the big rocks halfway through until he suddenly slipped and fell into the water. Thanks to this circumstance, Ivan overtook him about 100-feet.

The wounded police pulled himself out of the water and started the chase again. Ivan had hugged his backpack and was still running. No human artifacts were seen now, and everything was virginal. He came to the turn of the road. He was still running fast when suddenly a terrible downhill began.

He could not control himself and wriggled off the downhill as he hugged his backpack like his dearest girlfriend. His face and hands were cut and bruised, and his shoulder, arm, and hip slightly wrenched.

He was thinking of surrendering. His swamp-filled eyes swollen in his tiredness and his face awash with whiskers, succumbing to the itchy fatigue in his eyes and the wilting of his head when he suddenly saw a chestnut-colored, wooden-planked cottage with a big brass knocker stood on its door.

Standing up enthusiastically, he looked behind him, panting. He heard the footfalls of a policeman. This tread drew near every second. The taste of blood flowing from his open, ripped mouth seemed to give him the courage to decide. With the last of his strength, he started running towards the cottage.

It was 7:45 AM. Tom had woke up two hours ago. His brain was working dexterously. The dwindling smell of smoke was still filled the cottage air. Last night, he burned all his writings of the last five years, which he had written with great difficulty and with the Smith Corona typewriter, and threw it as hard as he could against the cottage wall. The big and small piece of a typewriter was distributed through the pieces of maple woods of the half-built violins. His daughter, his sweet daughter, Amila, died in that accident. And his wife, Julia, was in a coma. She had suffered a concussion but was alive for all these five years, and all Tom's pleasure was to bring Julia back to life.

For five years, he had resigned from all official and unofficial rites to attend her, and it was just three months ago that all of Julia's muscles were depleted. She wasn't even able to natural respiration. He had promised himself that if Julia returned, he would spend the rest of his life in nursing her, but Julia was dead. This slow death took away all his hope for life.

It had been two months since he had come to this cottage to be away from any urban living, away from cars, away from the soaring skyscraper concretes. He blamed himself for the accident and never couldn't forgive and resign himself.

With the staggering onslaught of these thoughts, he got out of bed and sat on it. His eye fell on a sharp knife that he always put over his head in times of danger during sleep. He took it and turned it over several times. In the last month, every time he closed his eyes, he imagined the scene of a terrible crash and his car, which was being crumpled. All the details of the incident, like an itch in his heart, were in front of his eyes as though it had just happened.

He still was wondered why his car's brake was failed on the precipitous slope. The haunting specter of the past took him to five years ago. There was only one week left to determine the winner of the Alan Turing Award. Everyone agreed that Tom Forrester, a professor at the university of California, Berkeley, would win the award. Thanks to all the things he did in the field of artificial intelligence. Cried callously to himself. It's over again now. He patted his face with his hand. The deep line that began on his forehead passed over his right eye and ended windingly on his cheek was still there to not allow him to forget what happened.

He had this scar in all these years. Not the physical one, but the wound on his heart. The wound that took the meaning of life from him. In those 5 years, no one had come asking for him. Like he was dead. No one remembered that for some time, Tom Forster was once a great professor. A worry that his presence and absence had no longer made any difference to anyone ate his mind up.

Until just a month ago, a simple grease-stained shepherd with a blond beard occasionally would bring him eggs and milk and talk to him as easily and truthfully as he would to his mother. It had been a month since he had even seen her.

Obsessed with think of death, he was certain that no one would find him for years if he did die here. Nothing left him to have been the consolation and made the void and vain of this world meaningful. He had made his decision a long time ago, to get rid of himself. All the pain in the world could be endured if you had a reason to endure, and Tom had no reason.

The pain of memories that were with him everywhere were harassed him. The thought that only death could free him from this old pain made death pleasing to him. He was no longer afraid of dying and even the world after death.

He turned the sharp knife in his hand again. He remembered Albert Camus's quote: ***"There is but one truly serious philosophical problem, and that is suicide."*** Whether you know that this life, in its entirety, is worth living or not? And it seems that Tom had reached the end of his philosophical exploration and had found the answer to the question: This life is not worth living!

He held the knife tighter. He hesitated for a moment, but when he looked at the picture of his daughter and his wife, he regained his confidence, but his hands were still trembling.

With a trembling hand, he put the knife on his left-hand vein. He last looked at their last family photo, then closed his startled eyes tightly. The fire in his chest had dimmed, but his eyes had a decidedly quarrelsome stare. He was whimpering softly, but he did not change his mind and grasped the knife with double pressure, and as soon as he tried to pull the knife, the door, the continuous knocking on the door, shook him mentally! Opened his clenched eyes, he stared at the door exasperatedly.

Ivan had reached the front of the cottage. Knock on the door a few times. "You can't escape anywhere." The stubborn police voice coated in the mountain air. His left eyelid is constantly jumping. He was stemmed from fear and trembling.

He thought he wanted to take a risk and spend the rest of his life as a free and happy man, but he had ended up here. He was always an atheist, and he always thought he was so strong that he did not need the God of weak human beings, as Nietzsche said.

Now, in the moments of dread and danger, there was a feeling in his heart, a feeling that someone was seeing you and hearing your voice. An inner voice that any argument or logic could not prove, but it could be felt and understood that someone could see you from somewhere. He made a covenant with the same inner voice that he would be a better man if he takes refuge in these deadly circumstances.

The police's voice was so close that as though it was just now showing himself on the other side of the forest. His abrasive voice was brimming with rage. For the last time, this time with genuine faith, knock on the door pertinaciously.

"Ask, and it will be given to you; seek, and you will find; knock, and the door will be opened to you," Jesus says.

And now he had knocked on the door, but the door did not budge. Again, this time he knocked on the door with a loud cry. Again, there was nothing.

Discouragement sealed his lips for a time. It was like cold water on the fire. His hands were shaking clearly. On the border between faith and surrender, he fell to the surrender side. He seemed to had bowed to the inevitable destiny, and it was at this very moment of fear and trembling that he thought the faith, On the flip side of the coin, was exactly as same as surrendering.

Surrender to the eternal truth that you do not even know what will happen in the end. He laughed at this philosophical discovery. Through the middle of the hell, why should he think about such abstract staffs? He stopped scrabbling. All his muscles, in a split second, were about to burst. It was as though all the noises outside and the sounds in his mind turned into silent for a moment.

Absolute silence. He had neither a wish nor a desire to live. All the past regrets and the dreams of the future immediately passed before his twinkling eyes and did disappear. Time had stopped, and there was no distance between dream and reality for him. These must be lived, not read, to be understood, and this is the point of pure surrender that cannot be reached except with fear and trembling. It was at this very spiritual joy that the door opened suddenly, and he, leaning against the door, unconsciously fell into the cottage.

With amazement, a man with a long beard and hair and a black woolen hat was looking at him. Ivan's head was right in front of Tom's feet. Watching this scene with complete disbelief, Ivan got half rose and grabbed Tom's leg: "Sir, save me, please let me in, I beg you… please…"

Tom looked around. The warm, pleasant light of the rising sun, as thick as honey, shone directly into his puffy eyes. No one was around, but there was a sound coming from nearby, and it was getting closer. The sound of footsteps whispering loudly.

Ivan caught Tom's ankle and pulled him down without saying anything. Ivan's innocent face, with those curly fluff like hair and many tiny spots on his face, was enough to get his pity. The good thing about people who have given up life is that they are afraid of nothing, which makes them braver.

"Is this young man a sign?" Tom thought himself. Why was he knocked on the door at the last moment he wanted to kill himself? Why not a few minutes and even a few seconds later?

Tom looked at his immovable, wooden face once more. He made his decision. Grabbed Ivan by the side and pulled him inside. The door was closed.

Ivan, as he lay on his face downward upon the ground, pushed himself into the cottage. He was so scared that he was even afraid of Tom. Tom's face, with his long hair and beard, made him look like a brutal assassin.

Tom only watched him, trudging away himself into the middle of the cottage. Once again, the door was knocked on. No matter how quiet the cottage was at the last three months, like the ghost house, today, however, it was crammed with people.

Ivan hid behind a rusty and dry sofa. The door was opened.

He was a police officer.

"Sir, I'm looking for a dangerous murderer! Haven't you seen such a suspicious person?" He said as he wiped his round, boyish face and tidied up his dilapidated clothes. Tom shook his head as he put his hands between the door and the frame.

"OK, if you see a young man with curly hair, or… anything suspicious, call the police, please," the officer said with a deep puff, grumbling between his teeth.

Tom's arms relaxed. He was happy the police did not ask any more questions. But this happiness did not last long. As soon as he half turned towards the forest to leave, he turned back suddenly.

"Sir, do you live here alone?" the police inquired skeptically.

"Why do you care?" Tom shrugged.

"Nothing, have a nice day!"

Tom stood for half a minute more to get the police away. When He felt relieved, He closed the door.

As far as he turned, He saw Ivan kept his sharp knife toward him to threaten, swapping it from left hand to right nervously. When Tom saw the knife, he laughed hoarsely. Ivan's hands were trembling horribly. His body was frail and bent with worry and his teeth clattered from fear. "I... I'm not insane, I swear, I'm just one..."

"You don't have to say who you are and why you're here, stay for a few hours and then leave," Tom interrupted him and said with finality.

He turned to go, then paused and added impressively: "And put that knife down. That's not your thing, boy."

Ivan was certain Tom was going to do nothing with him.

Calmed down, he dropped the knife sheepishly. Tom returned with a glass of water and biscuits. Without saying a word, he placed them in front of him and sat down at his work desk, which was full of unfinished and burnt pieces of a violin.

He ate and drank with appetite, almost with greediness. He had lost a lot of energy. After swallowing all the biscuits, he just realized how much energy he had lost.

Tom hadn't been with anyone for a long time. During all these five years, he was involved with his wife, and after her death, he was even bored with himself. The presence of a stranger did not allow him to focus and chip the violin fingerboard's scroll.

He put the engraver on the table and returned. Ivan was staring at him. There were no traces of biscuits. When Ivan saw Tom stared at him, he hastily turned his gaze into a hacking cough, then timidly shrugged and said, "Oh, you are violinist!"

Tom nodded but said nothing.

Ivan did not give up. He edged forward to Tom's desk and stood over him. Tom turned and looked at him heavily. "I'll remember your grace forever," Ivan said, gazing away from ironic eyes upon him, unconsciously stepping back.

"I want to say that I am not a dangerous man," Ivan added smoothly.

"I see, but anyone who doesn't take responsibility for his work will one day become a dangerous person. If you do something, accept its consequence," Tom said, half-turning on his chair. "It's not worth living a life when something in your past chains your feet."

Tom seemed to be talking to himself. He did not continue.

Dropped his head and sat down on the sofa. He put his hands between his thighs. As soon as Tom wanted to turn back to the table, Ivan began, "I'm a hacker. Before I learned how to write, I learned how to code. I did a lot of things, I hacked a lot of sites, but I never wanted to use these skills to hurt anyone."

He hesitated a moment, then continued, "I don't have many friends. Only Lisa, my girlfriend, can bear me. She had many friends. The father of one of them, David, is a senior executive at one CIT corporation. We three were usually hanging around together. He was Lisa's childhood friend.

In one day, completely occasionally, we talked about his father's job as a cash management director. He told Lisa and me about his father's role. I don't remember exactly when, but one day there was a discussion that if we could have one of those CIT cars, full of money, we would be happy until the rest of our life…

Gradually, our discussion got serious. I told him and Lisa that I could hack their cash management system. I've done bigger things before. I even hacked the Pentagon website once…

Excitingly, we started planning about it. I hacked the system. No one noticed. I didn't want to ruin it, so I didn't leave any trace. We analyzed the exit hours and the cars' route planning and then marked one of the best. We monitored it for a few weeks until we implemented our plan today. Everything was going well. Until that officer sounded the alarm and the whole damn thing went haywire. David shot him. Gosh! I wonder why he suddenly hit him."

He sighed, then started again, this time slowly, "The thought of someone being killed because of our work is driving me crazy. We ran away with blazer. David and his friend Marlon got stuck in the car. Lisa and I ran away. They weren't able to cough us, and now, I... I'm with you now. I regret it. That was a cheap shot, but what if I get busted? Oh no, I don't want to go to jail now, not today, I don't want to."

He said this and started crying. Tom came and sat next to him. Ivan felt the boniness of a hand on his shoulder. "No matter how tempting it may seem, crime doesn't pay."

Ivan nodded.

"If the cop is alive," Said Tom. "Your punishment may not be so severe."

"By the way," Asked Tom eagerly as if he was trying to catch a glimpse of Ivan's juicy red face. "What happened to cash?"

"I don't know! The police must have taken it all now." Ivan said, wiping his eyes with his elbow.

Tom got up. He saw Ivan curled up on the sofa. He bent the knee, "We have to see what happened to the officer. Let me see, do you remember where the gun battle took place?"

Ivan raised his head. "Near Palm Street," He Said after a deep thought.

"I think the closest hospital should be Bracenson Partners, LLC," Said Tom, twinkling his eyes. "I'll take a look around, you, hang in there."

Relief, so exquisite it was nearly pain, washed through Ivan at the sound of Tom's voice. It was as if he regained his hope. He got up. "You are going to do this for me? Really? What if you get in trouble?"

"Don't worry. Stay here. I'll back soon," Tom said pat Ivan on the shoulder.

He went to the clothes hanger. He hung up his wool cap, put on his bowler hat, and changed his ruffled clothes. He turned last time and looked at Ivan, shook his head, and left the cottage.

By a continued exertion of strength and ingenuity, Tom finally got there. Brassenson Hospital was a local, small hospital but was the closest hospital to Palm avenue. Several yellow and white ambulances were parked in front of the entrance.

Oddly enough, it was busier than usual. Tom understood that too. He tried to enter through the main door, but the guard withheld him. He turned and jumped up from the short wall overlooking the surrounding mountains and made his way to the main hall.

All the nurses wore masks and protective glasses, and there was an unusual commotion here and there. Tom took himself to the nursing home. A nurse was talking on the phone, and when she saw Tom, It was as though she had seen a strange creature, shouted, "What are you doing here? Without a mask?"

She got up to lead Tom out.

"I just want to ask a question," Tom resisted. The nurse frowned.

"Didn't they bring a shot cop here this morning?" Tom implored. The nurse's frown gave way to detective curiosity.

"How did you know?" She asked hesitantly.

Tom was shocked. He tried to collect his wits: "Oh, he was one of my close friends. I was told he was shot. I came to see him."

"He was here, but he was sent to Los Angeles for surgery," The nurse rocked back and forth in her chair. Tom's eyes widened.

"Will he survive?" He asked anxiously.

"I don't know; you better not stay here. It's dangerous. Leave here right now." She said, getting up to go. Tom ran and slapped the back of her head with his right hand: "Why is it so dangerous here?"

The nurse turned halfway to Tom and frowned, "Haven't you checked the news? A new virus has spread in California. We found out today. The state Government does not know what to do. The federal government has not done anything yet. People are scared, even the people of other states. Get out of here sooner."

Tom stared at her away. He thought about disease profoundly. The TV in the reception section was on. There was constant breaking news on local TV.

The news was that a disease had spread. Tom listened to the news carefully. By that time, more than 150 deaths had been reported, and according to the reporter, the number of patients was growing exponentially.

A more catastrophic fact was that the state government had indeed been caught unawares and had no accurate evaluation of the disease's prevalence in different cities in California. Analytical agencies and the World Health Organization have asked for at least a week to estimate the situation accurately. Desperation and terror were swept across the United States.

A running nurse nudged Tom painfully, and this brought upon himself. A strange feeling appeared in his heart. He felt he could and should do something to control the spread of the disease. But how?

He took himself out of the hospital. After a few years, he was feeling useful. He thought he could do something based on what he had learned over the years. Suddenly, Ivan came to his mind.

"I have to talk to him," He told himself. "Maybe we can do something together."

There was no available public transportation service. He had to run till the beginning of the road, and from there, by persuading a driver, he reached the beginning of the forest road.

Tom, who just a few hours ago wanted to kill himself, now his eyes sparkled with excitement, and such a rapid change can only be made by a human being. He was sure that if he had the data, he could detect an epidemic of the virus. Everything depended on having data, and he hoped that Ivan wouldn't disappoint him.

03

A Soundless Chant From Heart Of Master To Disciple

The sun was about to set when Tom reached the cottage. Ivan squatted on the sofa. He put a book under the laptop and put both of them on his bony knees. He had crouched low on his bandy legs and gazed deeply on the laptop monitor, so he didn't notice Tom at all, and it was only with Tom's steps that he noticed his presence. He raised his head, then threw the laptop to one side.

"Oh, was he alive?" Asked Ivan excitedly. Tom shook his head.

"I didn't understand," Tom whispered, then he came and sat down on his desk chair and stared at the book heavily.

Ivan embarrassingly came forward, "I'm sorry, I had to get permission."

Tom turned away. He didn't say anything. He just took a deep breath.

"What a coincidence," Ivan shrugged. "I didn't know you were learning artificial intelligence. I have this book too. They say this book is the Bible of machine learning. I loved it, but I never had a chance to read it. I can't learn anything with a book. Someone should explain it to me in a video."

Exhausted with his chattering, Tom glared at him. "Let me see, did you say you were a hacker?" Ivan nodded.

"Can you find me some data?" Tom said, straightened up, massaging his head.

"Oh, of course, I can, this is my job. I'm a jack of all trades in computer science. Tell me what you want, and get it! I owe you." Ivan replied proudly.

Tom sat down with him. "Do you know what happened in California?" He said as the tattoo behind Ivan's earlobe caught his eye.

"No, I was stressed. I didn't read my emails! What happened?"

"Supposedly," Tom said, turning to Ivan. "An unknown virus has spread to the state. The government and the World Health Organization are very slow. No one knows where and how to take action. If the disease's epidemic is not detected quickly, all Americans and even people around the world may be at risk. Viruses grow and spread exponentially. I need your help to get some data from the internet and anywhere, no matter where."

"We've got the data; how can we analyze it?" Ivan cleared his throat and asked hesitantly. "Then, when such a bulky government can't do anything, what can a wanted man and a person who doesn't have any Internet at home do?"

Tom mastered the fury and got up. He picked up the book on the other side of Ivan and tapped it on his chest, "Did you say you have this book? Is it true? Do you know who the author is?"

Ivan took the book. He looked down at it and read aloud: "An Introduction to the Practice of Machine Learning, by Tom Forrester."

Ivan looked confused for a moment, then suddenly, the penny dropped. He saw the back cover and compared the image of the first author to Tom's hairy face.

"Oh, aren't you the author of this book? Wow, I can't believe it. You're the famous master." Ivan shouted suddenly. "I had read about you before, my God. How could I not understand at first?"

"Forget about it. Can you help me? You have to have internet too," Tom grabbed the book and said in the most serious way possible.

Ivan ran a hand through his messy and flowery hair and stroked. "Of course, it's my business to find hard to get things from the internet. What kind of data do you want? I also have wireless internet. Don't worry."

"Think about it. What do people do when they are worried about something they don't know the answer to?" Said Tom Knightly pleasantly.

"They'll try to dissipate their fears."

"Logically, if people are worried about the virus and are serious enough to address it, they should ask about the virus and how dangerous it is for themselves," Tom said. "Or take protective actions, and that means…"

"That means leaving a trace of their worries in their searches."

"Exactly."

"We can't have the exact statistics, but we can estimate the epidemic from the search patterns, the severity of the searches for some keywords, and where the searches that have taken place at each area by which keywords," Tom enthusiastically said.

He continued, "And by understanding what pattern they search, and even by classification of keywords into categories such as "Recognition Searches," "Preventive reactions searches," and "treatment searches," we can make higher-level estimations."

"It's amazing, professor." Ivan nodded and chuckled again. Well, let's get started."

For years, no one had called Tom "Professor." A sense of pride came over him. Bit his lips, and a rush of blood flowing under his skeleton-colored skin and made it red and wide from the roots of his hair to the top of his collar. After this short ecstasy, he administered his felling by clearing his throat.

"We have a challenge. We need to have access to people's search data in the state. The important thing is the keywords searched, along with the exact location of these searches. At least we should be able to make such estimates for each city."

Tom took a deep breath and continue: "If we can integrate the search data, we can analyze it and say which areas are most exposed to the virus."

Enthusiastically, Ivan put his hand on Tom's wide, broad shoulders, "Don't worry, leave it to me. You know, I'm the master at web crawling. I'll give you a sample of the data in an hour."

The wetness of Ivan's sweaty hands passed through Tom's thin shirt and reached his skin. Tom slapped his thighs several times, "All right, see what you can do."

The glass of Ivan's laptop had cracked but still work. Tom sat down next to Ivan and looked at him working. He felt like coding. All the days that he coded with C and Java and then with R and Python came to his imagination and made him laugh unconsciously. He rejoiced by seeing python syntax, which Ivan was typing with a modern IDE.

Ivan seemed to have been typing and deciphering these codes for many years, typing very fast. Suddenly he stopped. It was as if an idea came to his mind.

"Mr. Forrester, can I ask you something?" He said, turning to Tom.

"Of course!" Tom handed him a steadfast smile and replied.

Ivan, flushing a little, and looking Tom straight in the face, "Can you teach me machine learning?" He asked eagerly. "At least for this analysis, I never thought I'd be with one of the greatest AI professors. I'd like to learn from you."

"I don't know. We'll see, but we can do this one together. Deal?" Tom lifted his brows and said.

In the same state of the body, Ivan jumped up a little with excitement: "Oh, that's great." Then he looked too tough and adequate as hell suddenly, "Of course you're right if I'm not arrested!"

Tom put his hand on Ivan's shoulder, "Don't think about that" Then he changed the topic: "So you want to be a data analyst!"

Ivan smiled wanly: "Yes."

"Well, tell me," Said Tom, looking mischievously. "Who do you think can be called an analyst?"

Ivan hesitantly replied, "Oh, I think someone so skilled in that field of work that can offer the best solution to a problem!"

Tom knitted his brow. It was as though he was digesting his answer.

"Yes, that's a prerequisite for starting an analyst," He said. "But I meant most of the characteristics of a good analyst.

As I think, a good analyst does a systematic sequence of these three things:

- Reduces chair options for decision making.
- Prioritizes existing options based on explicit criteria.
- For each option, describe the strengths and weaknesses and possible scenarios for the future."

Ivan leaned his head on his hand: "You're right. I remember soccer analysts counting all the possible situations that can happen," Ivan said, grinning.

"Yeah, a lot of people analyze in this way. Tom said with a big laugh. "If the analysis can't focus on the small but important staffs, it's not the analysis...

Well, that's all about the analysis in general. Now that we're dealing with data, we need to use data analysis as a benchmark. Using data to analyze has a major advantage and a major weakness.

Its main advantage is the advantage of mathematics over other areas which are dealing with understanding the world. In an area where numbers can speak, no one can talk rot and bosh, and no one can be deceived. This is why throughout history some philosophies such as Plato, Descartes, Spinoza, Bertrand Russell, etc., had constructed their philosophy based on mathematics. Math is the surest way to achieve certainty.

On the other hand, data analysis's main weakness is that data analysis relies on a model, and models cannot represent all aspects of reality. Models can enumerate only that part of the facts that can be quantified.

As Peter Drucker said, ***"What cannot be measured cannot be improved."*** But it is important to know that many aspects of reality cannot be measured. That's why they say as an almost cliché statistics mantra that ***All models are wrong, but some are useful.***"

Ivan confirmed.

"What do you think we would do if we can't measure the whole aspect of an issue?" Tom asked.

Ivan thought, and then raised his head and replied: "I think that's what we want to do: an estimation."

Tom nodded, "Good job, that's where the inferential statistics begin. The statistics are based on samples from the population and then generalizing the result to the whole population.

This also has a major advantage and a major disadvantage. The main advantage of statistics, which is a new branch in the history of mathematics, is that it helps us to understand the population relatively but because it is based on sampling, many evaluations are needed to qualify the outcomes and make them generalized, and this issue causes a lot of fallacies among those who use statistical analysis."

Ivan interrupted him, "In fact, the statistics somehow has refuted the grandeur of mathematics in delivering actual results, but instead, it has made a larger part of the reality a little more understandable and therefore recognizable. True?"

"That's right," Tom replied with a nod of approval. "But it's not the statistics problem that gives different interpretations of a fact. It's a problem for those who use the final result of a statistical hypothesis test, for example, to express their hypothesis. Or they use the proof of a fact but do not mention the process of reaching that result…

In statistical work, it is necessary to determine exactly how we have achieved that result, why some parameters are used, such as the confidence level and the number of samples, and validity and reliability of the samples and whether the samples are selected randomly from the population or not. Otherwise, two statistical tests from the same population may yield completely different results."

He paused as he leaned over Ivan. "The good news is that the more you give data into the model, the more generalized and reliable the results of the statistical tests become."

Ivan tied his hands together. "That is what is happening right now with the advent of databases, data centers, and cloud servers." He said, relying on the back of the sofa.

"Exactly," Replied Tom. "And what has happened to us today is that not only in many areas, the whole population can be analyzed, but also with the advent of the Internet and social media, which store all of people choice, likes and dislikes, every single person now, can be analyzed with data-driven analysis…

The analysis of individual members of a society can no longer handle by usual statistical algorithms due to a large number of data and many features that must be analyzed. This is why after the advent of computers, a new generation of computer algorithms raised in the form of titles such as data mining, machine learning, and artificial intelligence.

The work of these fields is the analysis of the population itself and, in the next step, the analysis of each member of the population. These domains no longer have the weakness of inferential statistics. They can rule about reality, with the same statistical literature, very close to the same certainty of solid mathematical theorems. All this power is due to the big data we have these days which its volume and velocity is increasing day by day in all aspects of human being lives. But again, these approaches still have a fundamental weakness!"

"Oh, again a weakness?" Ivan frowned a little.

Tom shifted his weight a bit so that he was suddenly poised to take charge: "The way artificial intelligence algorithms work is like the human brain: Connecting the dots between different categories and discover the hidden pattern between those categories. Both humans and AI algorithms start with observation. Humans collect raw information for their brains based on five common senses: hearing, seeing, smelling and touching. AI algorithms also flourished with data, with any data from spreadsheets to photo, sound, video, etc. The nature of the data for AI is numerical because photos, sounds, videos, and so on, can all be converted to numbers.

But there is the main difference between humans on the one hand and AI algorithms on the other. Our universal value system also influences our knowledge of the world and our thoughts...

A newborn baby may not tell the difference between a hot object and a normal one, but he or she can recognize certain things, such as her mother or her breast, as a source of nourishment. In general, there is an open argument among philosophers as to whether a child is born with a valuation system or she is like a whiteboard that is only colored by experience…

But whatever it is, man has a common sense or a sixth sense, or any other name you want to give it. Firstly, she understands human values. Secondly, she can distinguish between causality and a correlational relationship. Without having prior knowledge of this. AI algorithms, on the other hand, only understand the correlation and nothing else!"

Ivan, who was holding Tom's book, looked past it, "So with that in mind, AI could be a dangerous thing, because it can't learn human values, and it can link things that aren't related,"

"Perhaps," Tom responded profoundly. "Our human values are generally not quantitative fields and can only be understood by intuition and common sense, but the point is that if AI is exposed to the lots of data, may be able to distinguish some abstract values from objective facts and even create new abstract values...

The question is that even if it can create such a thing, can it describe it? The description process is more important than the result itself because the relationship between the process and the result is one-sided. All good processes lead to good results, but not all good results necessarily come from good processes…

As long as AI remains a tool and, therefore, a wingman for humans, it is a useful tool. But suppose one day, the human value system can be understood by machine learning and AI models. In that case, morality and everything related to social norms and anomalies will be threatened, and this is where the identity of being human will be called into question…

You know, we humans look at the world from our perspective, which comes from our interests. If AI could achieve higher capabilities one day, humans would certainly no longer be the center of the universe, and the definition of values and norms will change…

If these norms and even anomalies are threatened one day or replaced, perhaps our identity and the grandeur that we have built on the earth for several thousand years will also disappear by our artifact! The king's sons have always been his first enemies."

"Just like the movies, and this is where a hero comes to life and saves people again," Ivan smirked.

Tom laughed as he nodded. He wanted to say something that raised a beeping voice from Ivan's sluttish laptop.

Ivan jumped. He went to the laptop, "Fetching the data is over. What should we do now? Is this also a work related to AI?"

Tom stood up and walked to him. "You went too far. Using AI algorithms is just one of the data analysis branches that answers some questions, not all ones. If you want to be a good analyst, you have to learn to ask the right questions. The wrong questions will lead to the wrong solutions."

"So how can we ask the right questions?" Said Ivan, rotating one of the violin bridges with his hand.

Tom laughed out loud, "Great job. I didn't think you'd still be eager to learn, despite all these burning words." Ivan smirked widely and folded his arms on his chest.

"Understanding how to ask the right question to come up with the right solution is the first and, in fact, the most important step in solving a problem," Tom continued.

"Now, tell me, if we have two issues. One is the cottage's unfavorable temperature, and the other is the temperature of the outside environment. How do we solve each of these two issues? Or rather, what kind of questions should we ask for each?"

Ivan was a little hesitant. He put his hand on his chin and rubbed his face under one of the big pimples, "I think for the cottage, I have to ask how I can change the temperature of the cottage to get the desired temperature. In the case of outside temperature, you can check the weather forecast website and then decide,"

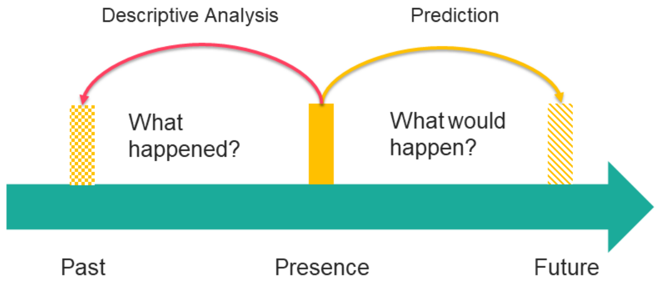
"Greetings to you," Tom snapped his fingers. "As Russell Ackoff once said, ***What can be controlled should not be predicted***.In any analysis, the first challenge is whether the issue can be controlled? Or is it under the influence of other external factors? We can divide the question type into two categories:

- External Factors

- Internal Factors

Let's start with the External Factors, which we have no control over them. Look at this figure:"

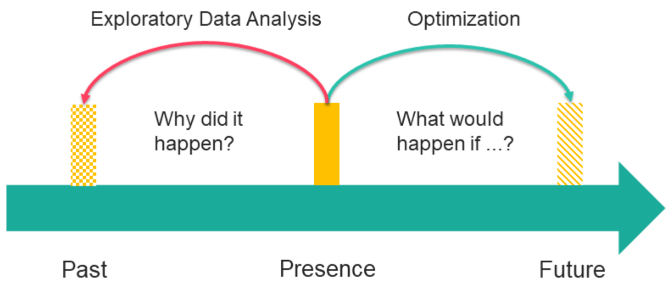
Tom drew the following figure on a piece of paper on his desk:



“If we just want to get feedback on a variable right now, we can use key indicators.” He continued. “This process is called monitoring or profiling. But the analysis doesn’t start with seeing a point or reading a number. It is shaped in the context of a time process…

In this process, there is a present moment in which we are in it right now. If we understand what has happened to this external factor and what behavior it had in the past, we have to ask, ‘What happened?’ These kinds of questions, which are only for the sake of understanding the past, are called Descriptive Analysis. What if we want to examine the situation in the future? The real question is, “What will happen?” These types of questions are also called Prediction.

Now let’s consider the Internal Factors. Also, pay attention to this figure:



The analysis of Internal Factors also takes place in the context of a time. If we want to know the past of those Internal Factors, we may ask: What happened? But another question we would ask can be: Why did it happen? This type of question is called Exploratory Analysis…

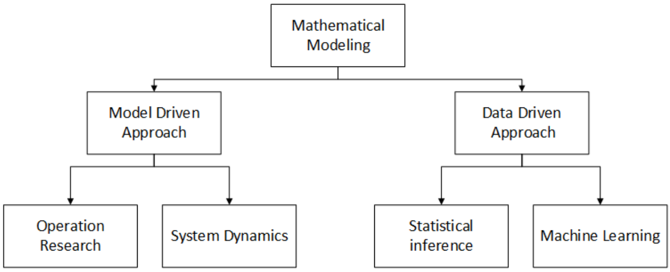
In external factors, understanding why a problem has occurred is not possible with data analysis due to the diversity of unrecognizable variables, or if it is, it will be very erroneous.

If we want to know the future of an internal variable, the question we have to ask is, What would happen if...

This "If" is our decision. We call this kind of analysis Optimization. So, to sum up, we can ask four general questions in data analysis. Any questions?"

Ivan's eyes grinding shut, "So, the question is," He asked. "How should we answer these questions?"

"It's a good question," Tom said, put a strand of hair on his eyes behind his ears. "Also note this," Yelled Tom.



"The above questions can be answered in several ways. If the goal is to examine the past, descriptive statistics and visualization are usually on the agenda. But if we want to talk about reality in the future, there are several approaches. In general, in one category, mathematical modeling can be divided into two categories, Model-driven and Data-driven...

In model-based approaches, a model of the existing reality is constructed, and, accordingly, the future of the desired variables is determined...

Disciplines like Operations Research and System Dynamics are such approaches. The main advantage of these approaches is understanding the structure of reality to models, and based on this. It is possible to model wider dimensions of reality. Still, as reality becomes more complex, many variables are either not identified or difficult to determine numerically...

Additionally, because these models are derived from the human mind, they are quite biased to the human mental model. The modeled reality may be quite different from the existing reality. However, based on the famous phrase of all models are wrong, but some are useful, these models can also be used...

Data-driven modeling, on the other hand, is based on learning behavior from data itself. The basic hypothesis of these models is that:

- The future is similar to the past.
- The effect of many unmeasurable external and internal variables on a particular variable can be understood from its final value…

For example, to understand the sales of an organization in the future, it is possible to arrange complex modeling of all the factors that affect sales and to examine the sales situation in the future, and in another view, it can be assumed that the impact of all these variables, in any case, has placed itself in the number of sales in the past, so by predicting the number of sales, the approximation of the sales situation can be obtained…

In general, data-driven approaches seek to learn from data to understand the nature of the problem. The Inferential Statistical approach, which we have been focusing on for the last 300 years, is an example of a data-driven approach… Another approach is machine learning. In recent years, machine learning approach has been mostly considered due to the systematic storage of data and advances in computer computing…

The goal of this approach is to discover hidden patterns from the raw data. With machine learning, we can understand the future behavior from its past behavior and predict it. This approach is quite close to the human mind, but it cannot examine all the dimensions of reality at one glance, but only on a limited scope."

Tom said nothing more. He leaned over Ivan, “Don’t say you didn’t understand any of this,” And then he nodded. Ivan blew out a puff of breath smoothed down his hair, “No. I just happen to know. It was very good.”

Tom dropped his head. It was as if he was ashamed. “I haven’t taught for a long time,” He said softly.

“You’re still great, but why did you deprive others?” Said Ivan, biting his lip.

Tom suddenly became serious. The laughter faded from his lips.

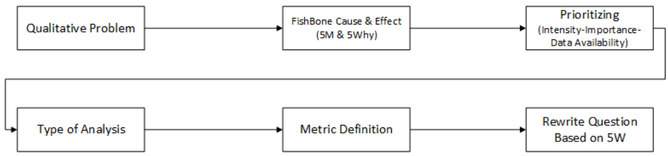
“Leave it for later. Let’s get back to our problem, to understand how the spread of this unknown virus can be understood.” Tom grumbled. “First, tell me, based on what I said, what kind of analysis will we have for this problem?”

“We have nothing to do with why the virus is spread and what is the future of an outbreak right now,” Ivan said excitedly. “So the only matter is the past behavior of the epidemic. The outbreak of the virus is an external factor that we can’t control. There’s only one option left: Descriptive analysis.”

“It’s true.” Tom nodded. “Generally, in any analysis, usually the first step is Descriptive Analysis. Our job here will also be descriptive analysis. OK, We consider all kinds of questions that can be analyzed. We also mentioned the tools for each question. But one step has remained. How to turn a vague, qualitative question into four questions? Now tell me, in general, what is our question and problem?”

Ivan stammered and couldn’t say anything. “The general question is something like this: which areas of California have the highest prevalence of the virus?” Tom said, gazing at him.

Ivan raised his eyebrows and nodded. Tom drew on the other side of the paper:



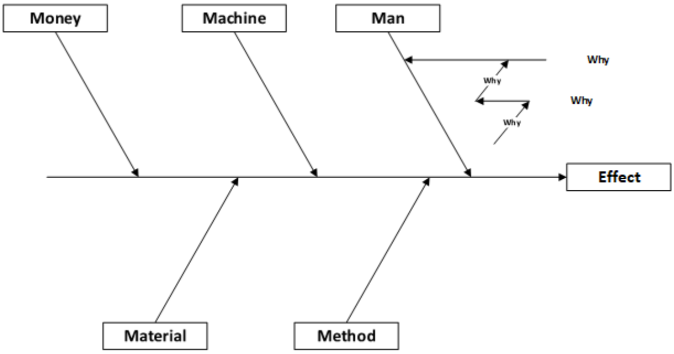
"Everything begins with a problem," Tom said. "From a general question, which no one knows how to solve it. Solving a problem usually requires two perspectives at once. A Synthetic view and an Analytical view...

An analyst must look at the issue from the top of the forest, with no cognitive bias, and must enter the forest and, if needed, examine each branch of each tree. These two views are not alternatives but complementary.

Fortunately, many tools have been developed for this purpose, including academic research and practical approaches.

One of these tools that helps us have two perspectives simultaneously is the Ishikawa chart or the Fishbone chart. In turning a qualitative question into a quantitative one, this tool helps to understand the structure of the problem in detail and as a whole. Regardless of the type of question, this tool is an exploratory analysis as itself, but of its qualitative type.

This tool's function is that an effect, or the same problem, is written at the tip, and then the potential causes or solutions are mentioned and written at the bones of the chart. These causes come from a brainstorming meeting or any other kind of judgment. Based on management guide-lines, it is suggested that potential causes for the problem be addressed in five areas that begin with the letter M. Like this:



The five domains, also known as the 5M, are five dimensions of a process that can usually be linked to the problem area.

If we look closely, each of these areas is, in fact, a why from a specific point of view. Another technique that usually helps us get to the root of a problem is the '5Why' technique.

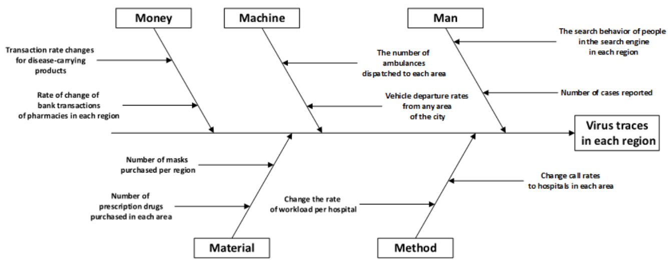
In this technique, for each effect, we asked five why sequentially. With this technique, we cannot get stuck in the outward signs of a problem and understand its root.

As you can see in the figure, you can combine both of these techniques. By using a fishbone chart, one can examine the qualitative question in different dimensions and examine the potential Causes for every effect."

"Just like eating an elephant," Said Ivan, looking very impressed. "How can you eat an elephant?" By shrinking and slicing it, putting the elephant's cut pieces together won't give us a live elephant again. This tool helps to slice the elephant and eat it without killing the elephant's soul. It's great."

Tom liked this example. He shook his head, "That's exactly right. Let's go step by step, and before we get into the next steps, let's list the potential causes of the virus. Our effect is clear. How to track the virus in different areas? We have five dimensions, and we are two. You think about Money, Machine, and Man-Power. I will also think about Method and Material. We think for 15 minutes, and then we conclude. Let's get started."

The passage of time, exactly when you need more time, passes faster than normal. The same thing happened with Ivan. He got a bit perturbed. Tom came to his assistance. Eventually, their brainstorming ended, and the following figure was obtained:



Tom and Ivan both stared blankly. "Great!" Tom whispered. "Good leads were obtained. The beauty of analysis is that it surprises you. It is possible to make more details of each of the causes and solutions with the 5why technique, but that is enough at this stage. If we had tried to solve the problem without analyzing the fishbone, we would not have examined all aspects of it."

Ivan took the sheet in his hand. "Now, what's the next step?" He said, turning it over his hand.

Tom muttered, sitting down and stroking his ribbed stockings from the knee to the ankle. "The next step is to give a score to the causes and solutions based on the three criteria of Severity of Impact, Importance of Cause and Availability of Data. For each solution, we score based on three indicators, and then we get the average and multiply all three indicators."

Both re-entered the debate. They bargained a little and then agreed on some things. In the end, the multiplication was ended. Tom wrote the priorities:

1. The severity of changes in people's search for disease in each region

2. The number of protective drugs sold in each region

3. The number of masks purchased per region.

4. The number of reported cases

5. The number of ambulances dispatched to each area

6. The rate of change of calls received by each hospital in each area of the city

7. The change in the rate of workload per hospital

8. The rate of change in the financial transactions of disease-carrying products in each region

9. The rate of change in the financial transactions of pharmacies

10. The vehicle departure rates from any area of the city

"Hmm. It seems logical." Tom said with satisfaction. "It is possible to focus on the first three cases and, based on these cases, find an estimate of the prevalence of the virus. You already obtained the search data. The data on the number of protective drugs and the number of masks sold remain."

"I think I can do that, too." Ivan interrupted Tom and said sharply. "Many pharmacies use a web-based system called QDrug. I can log in to their central server and pick the data."

"But these are the company's private data." Tom first thought about it and then said.

Ivan shrugged. As if trying to convince himself, Tom reappeared, "Well, only this time. If this situation ends well, I'll let them know."

Ivan was happy. "We have to get the job done by hook or by crook."

He reached for his laptop and got to work. Five minutes later, the hardness went out of his face, and a malicious light danced in his eyes.

"Yes, you see, I can. I write a code to fetch a list of inventory sales for the various types of masks and antiviral drugs sold in all pharmacies that use this software. It is more than 1,200 pharmacies." Ivan said excitedly.

"Very well," Tom said, raising his eyebrows. "The next step is to determine the type of analysis. What is our type of analysis here?"

"Descriptive analysis." The self-confident Ivan replied.

Tom turned more to Ivan. "Well done, you did well. Now the next step is to determine the measurement indicator.

An indicator is a measurable criterion determined by the type of analysis and the purpose of the problem statement. In this case, what can be our measurement indicator?"

Tom remained silent so that Ivan could think more.

"Whatever the indicator, it must be able to tell the difference between before and after of the epidemic." Eventually, Ivan said. "For example, the average, the average search for a keyword before and after the spread of the virus can be the criterion, right?"

"The average is not a bad indicator," Tom replied, stroking his beard. "But its problem with our issue is that the Measures of Central Tendency can't show the difference well."

Ivan seemed surprised. It was like the huge bell trembled on his ears.

"What?"

"Oh, I'm sorry, let me explain more." Tom nodded. "In descriptive statistics, we have two types of indicators:

- Measures of central tendency: such as average, median, mode, etc.
- Measures of dispersion: such as standard deviation, variance, range, etc.

Accordingly, if we want to model the different search results, it is better to use dispersion measures. Among standard deviation and variance, both are similar. Still, the standard deviation is the derivative of the variance, so its unit of measurement is the same as the unit of data, and therefore it can be interpreted. So our indicator could be: "The difference between the deviations of the search intensity, before and after the epidemic," which we show with

$\Delta\delta$… It must be said that the choice of the indicator is more aesthetic choice than a scientific method, and it is very dependent on experience…

Very well, now the next step and the last step is to rewrite the vague and qualitative question at the beginning of the process with the indicator-based question, type of the analysis, and 5W."

"How many 5s!" Ivan blinked and said mischievously. "They put a 5 next to each English letter and then made a management method out of it!"

Tom burst into laughter. The rocky line of his bottom teeth showed up. "I promise this will be the last. 5W is the beginning of the words for five types of questions in English: What, Why, Where, When, and Who. These five questions help us to rewrite the initial question based on the indicator and the type of analysis in these five dimensions. As I say:

Change in Standard Deviation (Indicator) between the search for keywords related to the virus (What) by people (Who) at yesterday and today (When) for each city (Where)?

The same can be said for data on protective drugs and masks:

Change in standard deviation of drugs and masks sold by pharmacies yesterday and today for all cities?

Ivan wrote down what Tom had said and rubbed his chin and thought.

Tom again broke the silence: “In fact, the vague and qualitative question has now become a small and precise question. If you notice, we didn’t ask the Why question. It doesn’t matter to us right now. But other questions were important and were asked.”

There was still no sound from Ivan. “Silence means you either understood well, or you didn’t understand at all. Which one are you?” Tom asked doubtfully.

“Oh, I understood most of it.” Ivan whooped and yelled with incredulous surprise in his eyes. “My silence was astonishing. It was very interesting.”

“It’s good, it’s amazing,” Tom said. “In Plato’s words, philosophy - which at the time was synonymous with knowledge - began with wonder or Thaumazein in Greek.”

Ivan cracked his knuckles: “Now we can start…”

At that moment, the sound of knocking on the door interrupted Ivan. Suddenly the diversion became a preoccupation. From noon to dusk, they were both very busy, forgetting the adventures of the morning.

Tom waved at him to keep him voice down. He got up and went to the window to check it out, and as soon as he pulled back the curtain, he saw the face of a young girl. At first, he thought she was a curious passerby.

Bewildered, both stared at each other for a moment. Then Tom’s eyes went onward to polices, standing together in a huddle. He quickly pulled back the curtain, turned to Ivan: “Ivan, get up quickly. The police are here. I will keep them away. You have to go now.”

His hands began to shake again. “But how?” Ivan asked in a trembling voice. “They are in front of the door. What do you want to do?”

Tom took his wet hands and led him to the kitchen, the farthest distance from the door. He pushed aside one of the cabinets. A hidden door appeared.

"Every cottage has a hidden door" Tom swallowed hard. "From here, you can escape. When you reach the river, go 400 meters to the left, reach the first main road. Remember, you must finish the analysis based on what we learned today and give it to the government and the local decision-makers anyway. Do you understand what I said?"

Feeling something like urinating, Ivan shook his head several times. The door knocked hard. It was like something crashed against the door.

A policeman behind the door threatened to break the door if they did not open the door. Ivan slowly came out of the hole. Tom handed him the backpack and shook his hand for the last time.

Slowly, Ivan began to move toward the forest and then increased his speed. Tom settled everything. The door was still pounding hard. Tom went to the door and opened it with a frown. Open door breathed a slice of air in.

A girl was standing in front of others. She crept forward and reached out a hand to tuck a curl behind her ear. Her long, blond hair reflected a thousand colors in the sunset light, and the breeze sprang up. She showed him her badge to Tom. Tom looked at it superficially.

"I'm Major Hannah Nelson. Why didn't you open the door?" She said with a sweet, seductive voice.

Tom didn't commence blubbering himself. "You must first tell me why you disturbed my comfort," He said firmly. "I have not taken refuge here to some pain in the neck guys dumped on my doorstep.

Tom had tightened the door and the door sill.

"We have warrant to search your cottage," Said Major Nelson, bullying him and entering the cottage forcibly.

Major Nelson stared into Tom's gimlet eyes, "Assistance in the robbery. Our police have tracked down the last fugitive suspect here. One of the locals also saw a young man running towards the cottage."

A knot fell on Tom's forehead, "Cut the crap," He said firmly. "Leave my cottage now."

Major Nelson, ignoring Tom, walked around in the cottage. Her eyes fell on the socks lying on the sofa. She picked them up, then turned.

"It doesn't seem these small socks belong to your giant feet. Don't you think that's weird with these animated characters?" She said, staring at Tom's feet.

Tom closed his eyes. He said nothing, and when he opened his eyes, he saw Major Nelson staring at him as closely as possible.

Petrified for a moment, he rebelled for the first time. He grabbed Major Nelson's arm tightly and pulled her toward the door. Meanwhile, Major Nelson, like Tarzan, suddenly grabbed Tom's arm too, jumped up, and tied his two legs around Tom's neck, knocking Tom to the ground with the most violence she could.

A few officers snorted with laughter, and a few wanted to intervene. Major Nelson stopped them. Tom rose again like a wounded beast. He was breathing hard. He got up and reached for Major Nelson's back. With a deliberated move, she fell to the ground with Tom's strength, and then put her two feet in Tom's abdomen and lifted him into the air, and hit him on the ground with his back. A sound like a snapping of the hyoid bone was heard.

Tom was not discouraged from fighting again. At the last attack, Major, with a swift turn, slammed her left foot firmly on Tom's face. Tom fell to the ground with his snout. She simply took him down a peg or two. He was confused, feeling the pang of pain. Even the cops' mocking with guffaws could not stimulate him to arise. One of the cops, who had now taken a few steps forward, said, "I think you need more practice, Shifu."

Roars of laughter arose irreverently. Motioning them to be silent, she pointed to Tom. The wick of merriment was wrecked, and they dragged him out.

The Major stayed in the cottage for a while. She peeped into here and there attentively. Her eyes fell on the photo frame. She picked it and stared at the family image of Tom, his wife, and daughter. She thought deeply. Then it looked like she did something immoral, returned it, came out and closed the door.

04

The Voice Of Destiny, The Light Of Dawn

Now the sun had set, and it was completely dark, and stars were shining on the fair clear sky. Three police cars were moving along the freeway. Tom was sitting in the middle car in the middle seat behind the car between the other two policemen, looking at the metallic clink of handcuffs. All the adventures from morning to night passed before his eyes like a movie. The excitement of this one day was more than all the excitement of the last five years for him.

Major Nelson broke the silence. She looked back curiously, “Why did you do that?” She asked frankly.

Tom was hesitant about what she meant. Then he remembered the story of the robbery, “It’s all greed.” He confessed. “I was in charge of all those children. I seduced them to do this. I don't know what happened. I kill him without choosing to. It's all my fault. I am a sinful man."

Major Nelson stared at him. Then she turned away. "You're lucky. He was in critical condition, but the doctor says he'll make it." She said, looking ahead with finality.

Breath collapsed from Tom's mouth. He dropped his head and took a deep breath. This was the best news he could hear.

"Don't be too happy. Your hands still look plenty filthy."

He managed to speak but couldn't. He was thinking about the morning again. He was glad Ivan had got out into his cottage. Destiny was that he would not die and instead become the savior of some young men. He agreed to take all the responsibility. There was always time to die.

They had reached the police station. Tom was taken out of the car and taken to detention. Major got out of the car and looked at him going. There was something in Tom that made her curious to know more about him.

In the rising pool of darkness, Ivan was able to find out his girlfriend, Lisa, with a secret communication line they had made for the robbery. He called her. Lisa lived alone in the house her rich father had bought for her. But this time, she went to the house of one of his ex-boyfriends.

When Lisa told Ivan about where she was, Ivan was hesitant at first but then decided to go. There was no safe place to go, no one doubted Lucas' house at all, and he could ask Lucas to get the analysis results into the hands of politicians.

He went to Lucas' house bloodlessly. Ivan was a little taken aback when he saw Lisa next to Lucas. Then he shrugged it off with a joke.

Ivan was tired, but he did not forget his promise to Tom. A far as he sat down, he began opening his laptop and analyzing the data. He integrated the data he had previously obtained and tried to show the high-risk situations of California's state on the map visually, based on the indicator that had been determined with Tom.

Lisa came over with a cup of coffee in his hand, "How could you escape?" Lisa said, handing the cup to Ivan.

Ivan stopped working for a moment. "A good man helped me."

At that moment, Lucas came out of his room excitedly, "Look, look, Breaking news. the cops the arrested morning robber."

Ivan jumped. "Robber? who? show me." Said Ivan, throwing the laptop on the sofa.

Lucas showed the text to Lisa and Ivan. The accused's photo was blurred, but Ivan recognized him, "No, Tom, Tom has been arrested instead of us." Said Ivan disgustedly.

"Well, it's very good. They say he was a peasant. Looking exhausted but very pleased. You both got rid of it," Lucas was happy to say.

Ivan got up angrily and pushed Lucas with both hands, "Fuck you! Do you understand who he is? He is one of the greatest data scientists of all time. He got into trouble for me, damn me." Shouted Ivan, then he started walking in the middle of the room and babbled nonsense on how he ruined Tom.

Lisa came and sat him down and tried to soothe him: "Calm down, baby, calm down." and then she stuck Ivan's head on her breast, fondling him.

His warm breath brushed her tiny skin and made her pleasant and more eager for fondling. Lucas stared at Lisa, who, like a mother, had hugged Ivan.

That particular day, however, was finally over. After Ivan got out of control, Lisa took him to the room. Lay him on the bed and then lie down next to him and sleep with him. Lucas was watching them. He missed her, missed her light flippant touch in anecdotes that made him shout with laughter, her sardonic grin, missed even her jeers that stung him to angry retort. Unable to see their furious lovemaking, he rushed out and disappeared.

Lisa woke up around 8 AM. The last scene she remembered was the head of Ivan on her arm. Recovered herself, she saw that Ivan was out of place. Looking for Lucas, he wasn't either.

She was horrified by how two stupid men just disappeared suddenly. He called Ivan. There was no reply. He called Lucas. No one answered. Calling again Ivan, this time Ivan answered.

"Where the hell are you?" Lisa asked accusingly.

"I made a promise to Tom," Ivan said on the phone. "I'm going to keep my promise. He should be there. He's in prison for my fault. I decided to accept my responsibility for what I've done. I learned from Tom: Freedom means accepting responsibility, even if I am dragged off into the prison for the rest of my life!"

"What the hell are you talking about?" Lisa shouted. "You are nearly going to kill us! Come back soon, please, come back for me."

Lisa could not conceal her fear and cry. Ivan hung up.

Suddenly the door opened. Lucas entered. She turned to Lucas, but despite the skepticism, she saw two cops enter behind him, "The killer is here." Lucas said.

He entered the room but did not find Ivan. Lisa stood in front of the kitchen, looking him up and down but didn't say anything.

"Are you kidding me? Nothing here." One of the cops said angrily.

Lucas was arrested for tricking the police while Lisa was gazing at him stupidly.

Ivan arrived at San Bernardino police station. Among the crowd of black-clad cops and other people on the move, he opened the way and entered. His eyes flickered to a counter-like room. He went right on talking about his crime.

"I was responsible for yesterday morning robbery," He said suddenly. "I'm going to turn myself in."

A cop who initially ignored him suddenly dropped his pen and adjusted his glasses, and get on the radio to others. A few seconds later, several cops surrounded hi suddenly, Major Nelson showed up too, with the star logo on her chest.

Major Nelson examined him from head to foot, "So you were the fugitive young man!"

She bent herself to a crouching position and matched the sock she was holding with his foot. "Take him to the interrogation room!" Major Nelson commanded.

Ivan was forcibly taken to the room. Major walked behind them.

The interrogation room was all white. Even the glass of water on the white table. They put him down on a white chair. Ivan began to write the story confidently.

Shortly afterward, Major Nelson entered. She plonked her gray-colored folder on the table, sat down, opened it in front of her and then started reading his confessions.

"It's interesting. A kind of competition has formed between you and that cottage man for the criminal responsibility." She said, after pondering.

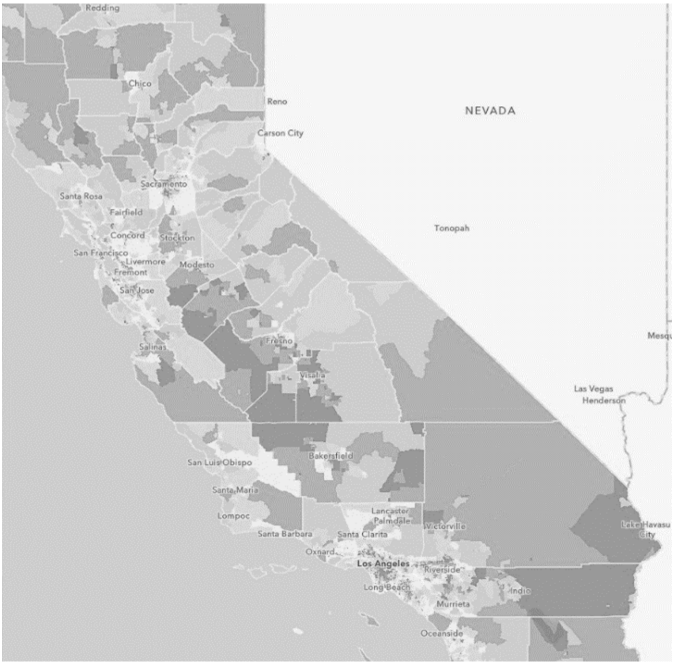
Ivan interrupted her, "He just put his neck on the line for me. He is a great man. Let him go."

"I know." Major said. "I asked the officers on the robbery day. None of them had seen the man in the cottage with his physical characteristics. They hadn't heard his voice either, but well, anyway. He has committed the crime and tried to cloud the truth. We cannot let him go until the truth would become to light. Anything to say?"

Ivan clapped on the table surprisingly. Major was shucked.

"Of course, look, it's hard to explain," Ivan said excitedly, "But in the short time I've been with Tom, the same cottage man, we came up with a solution based on the analysis of people's search data for this epidemic catastrophic. See the map picture, please."

The major pulled the printed image out of his file and looked at it.



"We analyzed it based on people's search data and the severity of searches." Continued Ivan. "I also wrote a five-pages report explaining the process. Before I came here, I wanted to go to a local newspaper and give the report to them. But I didn't want to miss my chance. If you want to arrest me, do it. But please give this analysis to the media and the people in the government. It just has more impact. I promised Tom. Please!"

And then he took a flash memory out of his pocket and charged right at her.

"A cottage man with a fugitive thief wants to save the world, Bravo!" Major grinned.

Ivan knitted his brows. "If you call me a thief, I won't be upset." Shouted Ivan. "But Tom is not a thief. He's a great man. Do you know who he is? He was once one of the best professors of artificial intelligence. If he lives in a cottage, he must have had a reason, but he is a great man. Please read the analysis. If it makes sense, publish it."

The major got up. She just picked up the file and went to the door. Ivan enviously raised his hand to Major but then regretfully just looked at her going.

The major stood on the doorstep. She turned and looked at Ivan again. At the last moment of leaving, she changed her mind, returned, picked up the flash memory from the table, and left without saying anything.

It was as if she took the burden of the big responsibility from Ivan's shoulders. It was like he was relieved of great weight. He leaned his head and arms on the table.

Two days have passed since Tom's arrestment. Major was descending the narrow steps of the detention one by one. The stairs had little light, but as she stepped down, the light and brightness appeared.

An officer in front of her accompanied her. They came down two floors. The officer turned to the major and said, "Cell No. 4." And then he gave her the keys.

Hannah came closer. Tom was sitting in the corner of his room. He was calm, and with the orange dress he was wearing, he no longer had the initial awe with the black clothes she had seen for the first time.

Major did not open the door. She just came behind bars. Tom noticed her presence. He turned and glanced around, but he pretended that her presence didn't spark his attention.

He edged forward a little and stared at a hole in the wall in front of him. Major grabbed the bars with both hands and said, “We arrested that young man.”

Tom’s lips twitched slightly. He looked at Major, but he didn’t say anything.

“My name is Hannah Nelson,” Major said again. “I’m called a Major here.”

Tom suddenly cut off Hannah’s words, spilling from her mouth and said, “I don’t care who you are!”

“I didn’t come here to find out this,” Hannah grinned bitterly. “I just don’t understand why a professor at a famous university should blame for someone else, or even why a professor at a famous university should give up his fame and residence and live in a cottage. It can’t be called chivalrous. Why are you doing this? Do you want to draw attention?”

“If I wanted to get noticed, I would do it with the same academic rites,” Tom said angrily, moving toward the bars.

Hannah glanced at Tom and his eyebrow, which had been injured in the clash.

“You’re right. I’m sorry.” She said, then she put her hand inside the bars to touch his eyebrows. When her smooth and delicate fingers were touched the swollen, bluish face of Tom, he involuntarily shrank back.

“You’re injured. I’m sorry for the fight that day,” Hannah said again.

Tom grinned and walked away from the bars. He sat down on his squatting bed again.

“By the way, that young man, Ivan Lawson, gave me an analytical report,” Hannah said in a loud voice. “I read it. It was an interesting analysis.”

When Tom heard the word of “report,” he got up again and came to Hannah, saying, “So he kept his promise, I knew... Major, Please share this report with others. Let them decide before it’s too late. This analysis can save many lives.”

He hesitated as though he remembered something. “Of course, if it’s not too late now.” He frowned and continued.

Hannah stared into Tom’s eyes. “You’re due in court in a few days, the grand jury will hear your testimony.” She said slowly. “The media has also become sensitive to this issue. Because you and Mr.Lawson have taken responsibility for the theft simultaneously. You know how much people love such contradictions.”

Tom sat down again, seemingly inclined for more chat.

“I hope justice is served,” Hannah said, holding out her hand.

And then she took a step to go. She stood for a moment and said again, “And something else, I sent that report to several local newspapers and several news agencies yesterday, quite against the wishes of my commander! I hope I have done my part well.”

When Tom heard this news, his eyes sparkled. He got up again for the third time and came to the bars. He took a deep breath and said, “This was a great help, Major, very great. Thanks”

Hannah smiled, and red mounted to her face. For the first time, Tom turned those frowns upside down and answered Hannah’s smile. She squinted her eyes at Tom and weighted him in her glance for the last time. Frowning with exertion, she turned out of the detention. It was as though the sullen mask of being a policeman was on her face again.

Hannah walked along the relatively long hallway, coughing and wearing the formal uniform. Her steps were as if she were marching. Reaching Commander Miller's office, she saluted him as she was allowed to enter.

With Colonel Miller's gesture, she released her hand and carried it to her back, pushing her chest forward. Her well-shaped body was more obvious in this military uniform. The Colonel dropped the letter he was writing. He turned Hannah upside down and said, "You finally did it, Ha?"

"Yes, sir," Hannah said firmly, staring at the Colonel's head. "I accept responsibility for this violation."

The Colonel got up. He turned the table around and stood in front of Hannah: "A few minutes ago, the state governor called me."

Hannah swallowed hard. Colonel continued, "And... he thanked us for this report. The results of the analysis were consistent with their field observations. The unsavory situation is under control. Your report is helpful in this matter. Some journalists covered the story. Now you have become a hero."

Hannah stopped her subconscious laughter with all her might. Upon returning to his desk, Colonel said, "You know I don't like such kinds of pranks. I don't want here filled with those dumbasses. You know whom? Those so-called reporters. You were my brave, determined officer all these years. Although you broke the order, I ignore it this time, but never let these newspapers and media make you a hero. They are masters at sacrificing their heroes. I advise you never to trust these media. Did you get the picture?"

"Yes, sir," Hannah shouted.

Colonel looked at Hannah again, saying, "Besides, according to experts, there is a possibility of a deliberate spread of the virus. The F.B.I are on the case. I want you to complete your research and let me know what is going on in this city."

"Yes, sir," Hannah said again.

"OK, you can go now." Said Colonel, grunting and puffing.

Hannah saluted again and opened the door a perfectly upright and stoical bearing. She walked out of the hallway. A few steps away from his room, Captain Sanders stepped forward.

All these years, Captain Sanders has been Hannah's only true friend. He did whatever she was asked to do. Captain approached her with long steps. After saluting, he smiled and said, "A suicide commitment." and then handed Hannah a folder.

Hannah was in a shift today, and she had to get to the scene and make a report. She hated such routine tasks, but it was also part of his job. She reluctantly took the folder. The person who committed suicide was named "Anna Cooper". She was a Ph.D. student in mathematics at MIT, and one of the world under 35 years old top 100 brains.

Hannah got mixed up. "What's wrong with these guys?" She said, turning to Captain Sanders. "Why should a professor from one of the best universities kill herself?"

Captain Sanders shrugged. Hannah sighed and said, "Very well, get ready to go to the scene together."

And then she dragged herself into her room to get rid of her formal attire and wear the same semi-formal pants and shirt.

No forcible entry, nothing missing. Just a hanging body in front of Hannah's eyes.

Anna Cooper lived alone in an old 10-story apartment. Despite her reputation over the years, she never cared about her appearance. Her face was attractive, but she never wore makeup. She also cut her hair short like teenagers.

When they went in together, Hannah did not go to the hanging body. It was obvious in Infront of her eyes. She, instead, went for the neglected details.

Hannah walked around her apartment. There was a piano in the corner of the living room. She went to it, stopped in front of the piano and stared at Anna and her mother's photo above the piano for a moment.

She always thought that the victims' photos had secrets about their past that could help solve the secret of the murder. But it seemed that Anna Cooper had killed herself at her own will.

She sighed and stared down at the piano keyboard, touched the keys and ran her left-hand finger noisily across the keyboard. The awkward song ringed through space. She preferred to stop playing and then turned and looked deeply at Anna's hanging body.

The body was hung from a relatively tall door frame. Contrary to the skeleton-colored skin in the photo, her face was black and blue on the rope. Her neck was broken and crooked, and her tongue protruded from her throat. The chair was a few steps away, had fallen on the floor.

Hannah swirled around, staring about. She stood in front of Anna's computer this time. The computer was still on. Hannah turned the mouse over, and the login screen appeared. There were no signs for the password. A few stickers were on the wall above the table. One of them caught Hannah's attention. She got closer. "Tonight, my sins will be forgiven,"

Hannah thought. This was probably one of those extreme perfectionisms that were enslaved of innocence illusion, and because they can't help but sin, they end up committing suicide.

She went back to the corpse. She turned around. Something in Anna's hands caught her eyes. She took out her magnifying glass and looked. The effect of the dead blood on the hand was seen.

She turned towards Captain Sanders, "Weird things keep popping up." She said doubtfully. "Her wrists are covered in blood. Her hands seemed to be tied. How can a person kill himself with a tied hand and then open the ropes and then wipe out the rope?"

"The person who reported the suicide said the door was open," Captain Sanders nodded. "And when he became curious and opened the door slowly, his eyes fell on Anna. Why should a dead person have to leave her house open and kill herself?"

"Something is wrong here." Hannah took a deep breath and said.

She came to the corpse again, thinking about it, but nothing caught her. After the formal proceedings and taking a few photos, she ordered the body to be brought down and taken to forensic.

The accompanying medical team started working. The body was slowly pulled down and placed on the ground. Meanwhile, something behind her left ear caught Hannah's eye. A strange tattoo with more strange symbols. "Do you know what this tattoo symbol means?" She said to Captain Sanders.

Captain Sanders shrugged. Hannah took a picture of the tattoo and allowed the body to be transferred. Captain Sanders was talking on his phone. When he was done, he turned to Hannah and said, "Commander Miller, ask you to return to the office quickly."

"Why?" What has happened?" Hannah asked surprisingly.

"Some reporters want to talk with you," Captain Sanders said. "Commander Miller exploded. It's better to get there sooner. I will do the rest."

Hannah nodded and walked over to the police car. Captain Sanders came waddling toward her as fast as he could. "Hannah ..." He said.

Hannah was shocked that Captain Sanders had not complied with the military hierarchy. She glared at him, glooming.

Capt. Sanders balled himself up. "Major, if you allow me, I will be in charge of broadcasting the analytical report."

"No, Captain," Hannah grinned. "The responsibility cannot be shared. I will embrace all the consequences." She got into the car, looking him up and down.

Hannah got out of the dodge charger. Several reporters, who were being escorted out of the police station, saw her, rushed to her, and began to question:

"Is it true that a prisoner provided this analysis?"

"Do you think the virus has been deliberately spread?"

"How did you find out about such an analysis?"

Hannah didn't answer any of the questions, and she just apologized. Quickly, she made her way into the office, and as soon as she wanted to enter her room, Commander Miller came face to face. "Can you tell me what's going on here, Major?"

Hannah started to say, but her tongue was tied. Colonel said again, "I warned you not to let this happen. I want it to be over in 10 minutes. Understood?"

"Copy that, sir! Hannah said, recollecting herself.

And then she ran towards the reporters. She talked to them for a while and promised to answer all the questions to the public soon. Finally, the crowd of children scattered. She took a deep breath and returned to her room.

Again, this time alone, Hannah made her way to cell No. 4 of detention. Tom was sitting on the floor. This time he had a book in his hand and was reading. At first, He didn't notice her. Hannah coughed delicately. Tom turned, and at the sight of her beautiful expression, dropped his own hands lifelessly.

During those two days, he kept thinking about Hannah as much as he had thought about suicide in recent months. He didn't know why, but he couldn't help himself thinking about her. When he saw Hannah again, his heart sank but passed it off. He got up and slowly walked into the prison bars. Hannah smiled and greeted.

"Hello," Tom replied with a nod.

Hannah took the prison bars again. It was as if she wanted to open them with both hands. "Your analysis has been noticed. The governor of California has personally seen your analysis," she said confidently. "The analysis was fit with field observations. You helped a lot. Now quarantine policies and social distances are designed based on that plot. The situation is almost under control."

Tom took a deep breath. He leaned his head against the bars and shook his head several times as he closed his eyes.

"I'm sorry you got in trouble." Hannah said again, moved from foot to foot. "Ivan was right. You are a great man."

Tom laughed as his eyes closed. Then he raised his head, "I'm glad I was useful. It's been a long time since I felt my life was meaningful. Now, if I die, I'll die happily."

Hannah put her hand unconsciously on Tom's hand, which held the bar. Tom's hands were much warmer than her own. Whenever she was excited or emotional, her hands would get cold. And now her hands were cold. Tom understood that too.

"Why death?" Hannah said, swallowing. "What happened to you scientists? Why are you all thinking about death?"

Tom laughed out loud, "I'm not a scientist, but did any other scientist talk about death?"

Hannah looked too tough, "No, she didn't speak, she did. She killed herself."

Suddenly, Tom's smile evaporated. "Who?" Asked Tom, frowning. "What was her name?"

"A 32-year-old girl," Hannah replied. "Anna Cooper, MIT Ph.D. student. We found her body hanging this morning."

Tom hung his head. Saying nothing, he just shook his head grimly.

"I have to go," Said Hannah, feeling a little overwhelmed. "Tomorrow is your court time. I hope..." She didn't say anything as though a prey to some sort of inward conflict.

Tears welled up in Tom's eyes "I'm not worried about myself at all." Said Tom, flashing his teary-eyes. "But I wish there was a way for Ivan and his team to get rid of this. They're still young. I wish they had a chance."

He watched her in silence. Hannah gazed at the floor and gathered up her tangled blond hair, wrapped it around her face. She looked at Tom for the last time and left without saying goodbye.

Tom's hands trembled with the pleasant coldness of Hannah's tender hands. He had not experienced such a feeling for a long time. He had one eye on his hand and one eye on the person who was walking away from him.

Under heavy security procedures, as many reporters gathered around the courthouse, Tom and Ivan's team arrived at the courthouse. As soon as Tom got off, reporters rushed to the car and started taking pictures. Tom's hands were handcuffed. Several officers surrounded him so he could enter.

Tom was the first defendant to enter. Then Ivan's team, then the lawyers, and finally the police officers, led by Hannah. In the middle of them, the officer who was shot was also seen. He hung his hand around his neck and kept whispering with his next-door co-worker.

With the arrival of the judge and the sympathetic juries, everyone got up. The court was now on session. Everyone got up.

"Be seated." The judge said firmly.

The opening ceremony was held, and then the legal claim was read. First, the plaintiff spoke to Monologue, offering the court an explanation for the robbery's impact and then asking Tom to answer his questions. Tom took a responsibility of masterminding the whole thing.

After Tom, it was David's turn. The plaintiff's questions revolved around armed confrontation and his motivation. He also asked questions from a CIT corporation delegation whose system had been hacked and Ivan. While looking at Tom, Ivan attempted to explain that Tom had no role in the affair and only sheltered him.

After him, it was the turn of the defense attorney. She made statements about Tom's innocence and a little about Tom's professional and academic background. Tom just listened solemnly. The defense attorney then tried to use Ivan's and his team age as a criterion and then focused on their drunkenness and abnormality. All the while, the judge was listening intently, taking notes.

After the two counselor spoke, it was the judge's turn to ask questions. He also focused on the conflict of Ivan and Tom's words and tried to clear up the ambiguity. He then asked eyewitnesses, officers, and CIT agencies, whether they had seen Tom or not. They all admitted that the thefts had covered their faces, but the gesture of none of them was similar to Tom.

"Of course, like all the robberies, he may be their masterminds." One of the agents said grudgingly. "But we didn't see anyone like him at the scene."

Questions and answers lasted more than 2 hours. There was slight tiredness on the faces of those present. Nobody asked questions anymore. Everyone was waiting to see the next judge's order and what sentence he would issue.

The judge took his hammer but hesitated for a moment. "Major Nelson, you were the one who arrested and later interrogated the defendants," He said after a relatively long pause. "If there is an unspoken thing, we will wait to hear."

Tom turned and looked anxiously at Hannah. Hannah, however, paid no attention to him. Seriously, she got up and went behind the speaker's stand. She hesitated a moment and rolled her eyes in court, but again avoided looking at Tom, who was staring at her.

Ivan's hand wavered again. Tom, cocking his arms, glanced at Ivan. "It's OK." Muttered Tom, as he turned.

I am a police officer," Hannah growled, raising her shoulders high, thrusting out her chest. "I have devoted 15 years of my life, have given up all my interests and all that could be important to an ordinary woman in seek for justice. I strongly believe that it is only the commitment to the law that brings true freedom to each of us and for our country. I believe in the law."

Hannah spoke in a way that intensified the stress of Ivan. Ivan was pink with stress, his eyes snapping fire, his nostrils quivering and his heart tolling in his ears. David and Marlon's feeling was no less than Ivan's.

She paused until her speech was well digested, "But for the first time, in the last week, my conscience stood against my faith in the law. It was the first time I saw that someone wasn't trying to rescue himself. Instead, he wanted to do something for someone else who has more opportunity to live and change something for the better. I talked to myself many times this past week…

For a long time, I thought. I continue to give authority to the law. I believe that this is the law that will save us, but in the case of these criminals, ladies and gentlemen, now we have two options: Do the justice, without hesitation in which we will not be blamed. Or give them a chance to make up and then do justice."

And then she beckoned to Ivan's team and Tom, "This team and that person did something last week that saved the lives of several thousand innocent people. They had skills, and they used them to serve society. We imprison criminals who have been away from society for a while to be alone with themselves so that they can be reformed and go back to society and serve it. These criminals and the crimes they have committed already have a way of making amends. They have the skills to help uncover the truth of spreading virus that has endangered the lives of thousands of people. There is a irrefutable proof that the virus, which recently broke out in the state of California, is the result of deliberate manipulation."

With that said, a murmuring started at the court. The judge hammered seriously.

"We are investigating the situation to find out the truth," Hannah continued. "We can give the criminals another chance, and then do the justice. Justice that, have adjusted based on their performance in cooperating with the police."

She said this and then turned to the judge and continued: "I, Major Hannah Nelson, ask you to give the criminals another chance, and by giving them parole and forcing them to help the police, you both help the community solve the crisis and give them another chance to make up for their mistakes."

Hannah said nothing more. The judge motioned her to a chair. Silence pervaded the entire hall. The judge broke the silence. Knock his walnut hammer on his desk a few times. Everyone got up.

"We heard the words of lawyers, defendants, and Major Nelson." Said the judge in a loud voice. "Fortunately, no one was harmed in this robbery. All the stolen money has been returned to its owners. According to what has been heard, the court temporarily is agreed about the conditional freedom of Tom Forster, Ivan Lawson, and his accompanying team. They must work with relevant organizations to find out the truth about the outbreak of the virus. After discovering the truth, the court of appeal will be held at the head of the state supreme sourt, and the final verdict will be issued by the state court. End of the session."

The judge banged that gavel several times again. The meeting was informal now. An unknown buzzing spread in the courtroom. Tom was still bowing his head. But Ivan was very happy. He started running and hugged Tom.

Tom looked at Hannah as he embraced Ivan. He stared at Hannah for a moment. The police team then made their way through the crowd and headed for the exit. There was no getting rid of Ivan. Tom forcibly separated him, but they both started to hug each other again. Slowly, everyone was leaving the hall, and then it was getting gradually empty.

05

If. . . Then. . .

Tom took the picture frame and looked at it again. He would put it in an angle that was more visible to him, but this time it was clear that someone had touched it, and he guested whom. He stared at the picture for a while and then put it on the table like the last time.

Ever since he returned to the cottage, he no longer felt the same way. He not only no longer thought about death but also had an unrelenting desire to live. It almost seemed to him that unknown craters were forming in his bosom. A person who relies on himself can also turn pain and suffering into more work, and this feeling had appeared in every part of him.

He sat down at his work desk and took the scroll part of the half-finished violin again, and began to shape it. He worked for a while. He lost track of time.

It was around noon when a punch like knock was hammered into the door. Tom eyed the door. A rapping of knuckles on the door means that you have not forgotten yet. He wiped his round, hairy face with his handkerchief and went to the door and opened it. Tom's face lit up like a kid's on christmas morning. It was Hannah. In casual clothes that made her even more attractive.

Tom stepped aside to let her enter. Hannah came and lay on the sofa. Tom brought his desk chair and sat down in front of Hannah, saying, "Thank you for all the help you have given me!"

"I did it for myself." Hannah grinned. "My commander commissioned me to discover the truth and the source of the virus outbreak. With your work, I felt you could help me solve this puzzle."

"Oh, come on," Tom said, raising his eyebrows and opening his eyes. "Are you really going to get help from a cottage man and a few arrogant and glib young men to solve this great problem?"

Meanwhile, the door knocked again. Tom was surprised. This time he went sharply and opened the door. It was Ivan. He hugged Tom again, but as soon as he entered and saw Hannah, he suddenly became more serious and embarrassed and sat down on a wooden floor. Tom got up, made three mint syrup glasses, which he loved very much, and brought it to the table.

"Ivan, Major Nelson would like you help her to solve the virus dilemma. This time you have to get help from your hacking skills and discover the source of out breaking the virus," He told Ivan, grinning like a cheshire cat!

Hannah jumped up and down, "No, not just him. We had an agreement, don't forget that."

"OK. I'll do my best, I promise," Tom said with a laugh.

Hannah's eyes lit up. She got up and, this time, said louder and more seriously, "So let's get started." She smeared his hands together.

Ivan's eyes widened. "Now? "He said surprisingly, looking at Tom and Hannah.

Hannah turned back. "Why not? It's too late now. Our only clue is that most likely, for the first time, the virus has been transmitted through foods," She grinned. "This has been confirmed by the experts of the World Health Organization."

Ivan, who had the laptop on his feet and was busy, said, "So it's better not to see what kind of food the first infected people ate? As far as I know, the virus dies at high temperatures. It must have been transferred from these prepared cold foods."

"Don't theorize before you test it!" Tom interrupted Ivan, staring at him as though he is talking gibberish. "Now, we can only hypothesize. Remember the six-step process. We should not get ensnared by the apparent symptoms. Maybe the food was only one way of transmutation."

"Six-step process?" Hannah asked surprisingly.

"The same six chapters on which the analytical report was based on it. Along with four types of questions." Ivan reminded.

"Aha," Hannah nodded.

"Based on the six-step process, if we can answer three questions, it's as if we've answered all 5W questions," Tom said again.

"And those three questions?" Hannah leaned on the table and said.

“First of all, we need to understand in which factors (What) which those infected people used at the first time, the virus has existed,” Tom said. “And secondly, where is the common origin (Where) of those factors? and finally, who spread the virus in that common source? (Who) The answer to the questions has a sequence logic. So we have to start with the first question. Let’s focus on that.”

“So what can be our solution to the first question?” Ivan asked doubtfully.

“A very fair question.” Tom snapped his fingers. “Based on what I know, there are two ways to understand the common factor. The first is the Correlation Analysis, and the second is Market Basket Analysis or Association Rules Mining…

Correlation analysis is a statistical approach for understanding relationships between only two categories, assuming a linear relationship. But the association rules extract if-then patterns between purchased items and can be used to understand the common nature of the factors based on these logical rules. The first step is to access the purchased items of those infected by the virus at first. And then use association rules mining…

Major Nelson, can you let us access the purchased data of those people? From their credit card transactions, you can get the items they bought.”

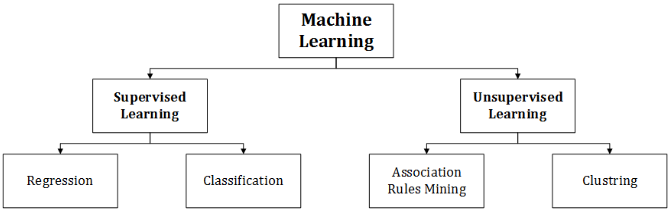
“I will do my best,” Hannah replied. “Just that, can you explain more about association rules mining? I want to learn more.”

“Me too,” Ivan said without raising his head.

“Very well.” Faintly smacking his withered lips over it for a moment, Tom muttered. "To do that, I have to first explain about machine learning and then explain where the association rules mining has stood. That's how you understand it better."

He returned and sat down in his work chair, and as the same days of teaching, he continued with the same enthusiasm, "If we start with four types of data analysis questions, machine learning is more deal with two questions, what will happen? And what happened? In fact, with descriptive analysis and prediction.

However, the difference between machine learning and other methods is that in answering both questions, what is presented is not the data itself, summarized or displayed differently. Still, a new pattern in both questions will be extracted and presented. In general, machine learning is divided into two general categories. Let me draw for you:"



And after drawing the shape, he said again, "Let's start with Supervised Learning. When we want to know what might happen in the future, we need to get a precise pattern from the past. With this model, we can infer what will happen in the future. Let me give you an example. Let's consider this physics law:

$$V = \frac{X}{T}$$

According to this law, having the amount of displacement per time unit, each object's speed can be determined at any time. By observing and experimenting, scientists proposed a precise formula for calculating velocity, which is the considering pattern. Generally, the exact relationship between the speed of an object per unit of time is something like this formula:

$$V = f(X, T)$$

In many cases, however, it is not possible to find an exact pattern. Because all factors that affect the problem are unknown, and the factors are constantly changing dynamically. So the best way to discover a pattern is to use past historical data. Supervised learning is nothing more than fitting a mathematical estimation function $\hat{f}(x)$ on the historical data $x\ldots$

This estimation function is the same pattern as in the data. It is as if it represents all existing historical data. All the discussion of supervised learning is about determining this mathematical function to get the least error and how this function can work well for the unseen data. Now, depending on the type of supervised learning, this mathematical function can be different...

Before we delve into the different types of supervised learning, we need to get acquainted with the concept of Label. In supervised learning, we have a goal that we want to predict for new situations, so we need to put the goal achieved in historical data next to historical data. Suppose, for example, velocity law does not exist and we want to estimate the speed of an object. We consider the variables of displacement and time spent as a feature, or as they say in statistics, as an Independent Variable. We set the velocity as a target variable or a Dependent Variable. This target variable or dependent variable is called the label in machine learning. The general shape of a supervised learning model is as follows:

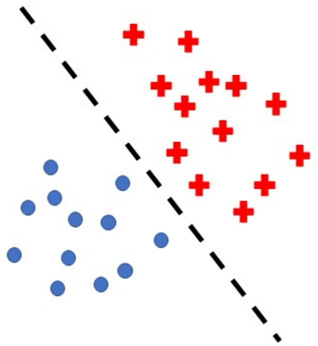
$$y \sim \hat{f}(x)$$

Where x are the features that make up the structure of the problem. Our goal is to find a $\hat{f}$ that can be the best estimate of y. The type y, or the type of labels, indeed, also determines the type of supervised learning. There are two types of labels: Discrete and Continuous.

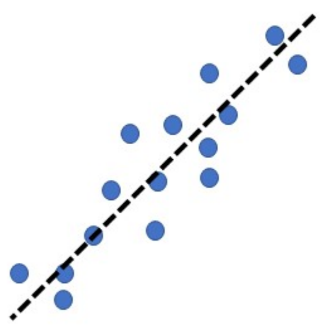
Discrete labels refer to countable and qualitative goals. For example, if our goal is to build a model to detect fraud in bank data, then the goal here is to be Normal or Fraud. For example, the fraud dataset could be something like this:

Customer ID	**Day 1 Trans**	**Day 2 Trans**	**Day 3 Trans**	**Label**
1	T_{11}	T_{12}	T_{13}	Fraud
2	T_{21}	T_{22}	T_{23}	Normal
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$

We need to reshape all the historical data we have in this structure. Features can change, but the overall structure will be something like the example above. Our goal here had two labels. The number of labels may be higher, but whatever it is, the number is limited and discrete. This type of problem is called Classification. The math function that fits is a decision boundary that separates the different classes or labels. As you can see in the figure:



In another type of supervised learning model, the label is a real, continuous number. This type of problem is called Regression. In this type of problem, the mathematical function is fitted on the labeled data itself so that the least error and distance from each point can be obtained. As you can see in the figure:



For example, we could predict the number of people who the virus would infect in the future if we assumed that the virus would not be controlled with historical data. The data we could have is as follows:

Date	**Lag1** Day$_{-1}$	**Lag2** Day$_{-2}$	**Lag3** Day$_{-3}$	**Label**
Day1	D_{-1}	D_{-2}	D_{-3}	D_1
Day2	D_1	D_{-1}	D_{-2}	D_2
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$

Every day, we consider the data of the last three days as a lag feature, put the value of the same day as a label, and repeat this for as many days as we have. By feeding this data to the model, we can predict the value of the label for tomorrow and the days ahead."

Tom stopped talking. He looked at Hannah and Ivan's perplexed faces, "You are good students. You listen so well that I wish I never interrupt the lecture."

"How interesting, that is," Said Ivan, who listened intently. "That is, all the pretty shady shit about artificial intelligence was about fitting a mathematical function?"

"Well, it's hard to find an adequate function," Said Tom, who had made his way to the kitchen to drink some water. "It's not as easy as you think."

"Yeah, I know." Ivan nodded. "You know, I meant they made it more complicated than it is."

Hannah grabbed a glass of water which Tom gave her and, as if looking at the ceiling, which was looking at Tom with that tall body, she said, "What about association rules mining? That is, our today goal, which we are going to know which factors are influenced by spreading the virus?"

Tom drank the last sip of water and said after a deep breath, "I said all this just to get to our goal today. Unlike supervised learning, we have no label at Unsupervised Learning, and whatever it is, it's the features only.

In unsupervised learning, the goal is no longer to fit a mathematical function on the set of points but rather to restructure the data to obtain a meaningful pattern. A pattern that could not be achieved in a simple, observable way. unsupervised learning is more about the past and has nothing to do with the future. The general outline of an Unsupervised Learning algorithm is as follows:

$$f(x)$$

Where there is no y, and the function that is obtained is only a reconstruction of x. There are different types of unsupervised learning, but two areas have been used most widely: Clustering and association rules.

In clustering, the goal is to reconstruct the data so that similar data falls into the same groups. The optimal pattern here is to find similar data bases on the characteristics that the model designer gives to clustering algorithms.

The association rules, which is the subject of our discussion today, seek to find logical and strong If-Then rules in the data.

Surprised, Hannah interrupted Tom, "Seriously? Is there such a way that can extract the logical rules automatically?"

As if trying to answer to a little girl, Tom replied, resisting the urge to smile. "Of course it can be, Major. One of the uses of association rules is to analyze the basket of people who buy from supermarkets. The rules that come from market basket analysis are something like this:

if ***Bread*** *and* ***Cheese***→ ***Milk*** And after writing, he continued: "And that means if the customer buys bread and cheese, then he will probably buy milk. Discovering this pattern helps the supermarket owner to put together items that are related to each other, conversely, to keep customers away from the related product, thus for buying relevant items, they consider other products and get another one and finally increase the overall profit for supermarket owner. And in our case, it helps us to understand what items people who the virus has infected have bought and what the logical rules have existed between their purchases."

Excited, Ivan jumped out and punched his right hand into the palm of his left hand, saying, "Wow, if we succeed, we'll hit the heart of the target, well, what are you procrastinating on? Let's get started."

"Easy, boy," Tom laughed. "First, we have to get the credit card transaction data for the patients."

Tom and Ivan turned to Hannah and looked at her.

"OK, I'll try to get the data." Hannah opened her hands and said with fictitious desperation.

Ivan happily got up, "So our next visit is when the data is ready. OK?"

"Okay," Hannah said, raising her brow. "I have to work on Anna Cooper's case too. I'd better go."

"You said she committed suicide, right?" Said Tom, curiously.

Hannah shrugged and confirmed, "Yes, but there's something wrong. I have to go tomorrow and check again."

Excited, Tom moved closer to Hannah, saying, "I'd love to come and see if you don't mind."

Hannah thought for a moment and then said, "No, It's OK.

If I can get the data, then we can continue our discussion today."

"So I don't think it won't happen at all without me." Said Ivan mischievously, wearing his back bag.

"7 AM tomorrow, I'll pick you up near the airport entrance," Hannah nodded, staring at the ceiling. "Hasta la vista."

"Are you going to town, Major?" Ivan turned to the door and said, "Can I come with you to some extent?"

"I've become a cabby for these two gentlemen. They were supposed to help me. What a topsy-turvy world we've come to." Said Hannah reluctantly.

Tom laughed out loud. Hannah was still moaning. She departed along with Ivan and headed for the main road.

At 7 AM, the weather was strangely colder than yesterday. It seemed the sun still hesitated to weather rise completely and give everything warmth or not.

Tom and Hannah were sitting in the car, but Ivan hadn't arrived yet. Both were silent, but both were looking for a way to open up.

"Mr. Forrester." Eventually, Hannah asked doubtfully.

Tom, who seemed to be waiting for this moment, replied quickly, "You can call me, Tom."

"Tom," Hannah smiled and said. "A question echoed through my mind that still haunts me. Maybe it's irrelevant to me, but I'd like to ask."

"I guess what you want to ask." Said Tom, turning more to Hannah.

"About what?"

Tom turned swiftly and gazed on the street, “About the picture on my cottage table...”

Hannah found out that Tom had noticed her curiosity, “Oh, yes. Honestly, after your arrestment, I was looking for more clues that suddenly your family photo was caught my eye.” Hannah explained embarrassingly. “Where are they now? I mean your daughter and your wife.”

“They’re dead,” Tom murmured. “In an accident.”

“I’m sorry, I’m sorry.” Hannah closed her eyes and said.

Tom didn’t say anything. Hannah stared at Tom, saying, “Sometimes life gets very cruel.” And then she put her hand on Tom’s broad shoulders, “I am sure you loved them so much. I’m so sorry to bother you.”

Tom sucked in a large clump of air and puff it, “A man who has not died from this pain and can still have a hope for something in his heart may not have been a true lover. The karat for measuring true love is madness. If I’m still alive, I haven’t been in love truly.”

He stirred and spoke that suddenly Ivan appeared and threw himself gingerly inside and greeted them. No one answered. They had scolded heavily. Ivan thought it was because of his delay.

“I’m sorry, I’m late.” Ivan flushed guiltily. “My girlfriend, she wasn’t feeling well. Her spirits were low last night. She went to the hospital. She also has the virus!”

Hannah stamped on the brake. The car screamed and stopped. Tom and Hannah returned to Ivan at the same time.

“She’s fine.” Ivan shrugged. “She’s just had a little fever and vomiting. The doctors said she would be OK soon.”

“I hope she gets well.” Asserted Tom. “If you’ve been with her, you've probably got the virus."

"Don't worry," Ivan said sadly. "I tested for the virus, it is negative." Both of them returned complacently. The car started moving quickly. After 10 minutes, Hannah stood in front of Anna Cooper's house. A police car had parked there before. It was Captain Sanders. He had arrived earlier and was inside. They went up the staircase into the apartment.

As soon as Ivan entered, he went to Anna's computer. Because in the car, Hannah explained to them about the computer. He messed around with it for a while. Then he connected his laptop to her laptop and investigated more. Captain Sanders, Tom, and Hannah also began to patrol the room.

Tom stood under the doorstep in which Anna had been found hanging and stared at the rope that was still attached. He was thinking about Anna's motive for suicide. Hannah, who had turned back from the bedroom, asked meticulously, "Did you find something unusual?" Tom nodded and said, "No."

They both went to Ivan. "Could you enter?" Tom asked.

"It's been an advanced encryption." Ivan Puffy admitted. "I'm a hacker, not a code-breakers. But I don't think it's easy to decrypt it. It should have something valuable that such encryption has taken place."

Unaware of the difference between a hacker and a code-breakers, Hannah asked, "Can't we boot the computer's hard drive with another motherboard?"

"It's not an ordinary computer," Ivan, who was confronted with a childish question, said sarcastically. "A separate and special operating system is designed for it. It's a bit like the

Tails super security operating system, but even more advanced than that. It's pretty clear that this operating system is designed for specific purposes. Usually, in such systems, changing any system component without permission leads to the destruction of all of the information. The only way is to access the password."

Ivan closed Anna's laptop. Suddenly his eyes fell on an unusual stain. "Major, can you come, please?" He shouted.

All three rushed to Ivan. Ivan showed the stain to Hannah and asked, "Isn't this strange?"

Hannah gently touched and smelled the stain, "It is blood." She said.

Ivan's body hair tingled unconsciously. Hannah straightened up and asked Captain Sanders, "Besides from the wounds on her wrists, were there any other traces of wounds on Anna Cooper's body?"

"No, they didn't find anything in forensic," Captain Sanders replied firmly.

Hannah ordered Captain Sanders to send a sample of bloodstains to the lab to test and match Anna Cooper's blood.

Hannah came back and was on the doorstep. She turned to Tom, "There's something wrong... this blood ... that tattoo ... I have to understand ... I must."

"Which tattoo?" Asked Tom, taking up his station in front of her. "You haven't said anything about it before."

"I forgot about it," Hannah replied. "A weird tattoo, two twisted snakes with the letter D inside. I took a picture. Let me show you."

She took out his phone and opened the photo. The other curious guys put their heads inside Hannah's phone. Tom's eyes fell on the tattoo. He turned to Ivan in surprise. Ivan also noticed. Tom's shaggy hair was pasted to the side. He pulled away from it behind his left ear. "It's exactly as same as yours," Tom shouted excitedly.

That's exactly it." Hannah nodded. "Wait, the letter inside is different. What's that meaning?" Hannah asked accusingly.

"It's a symbol of technology worshippers," Ivan said. "It is a secret association. The members of this group believe that this is the technology that determines human happiness. Their effort is to efface the physical and formal boundaries between technology and humans as much as they can. If you look closely, the symbol behind my ear is different from Anna's ear. For me, it is the letter H and for Anna is D."

"I don't know what D stands for," Said Ivan, smoothing down his standing fluffy-hair. "But for me, it's the first letter of Hacker. I was previously a member of this association. We wanted to help weak and poor people by hacking. In those days, we were hacking the bank accounts of rich people and depositing them in the accounts of weak people, something like Robin Hood. Later, I didn't hit it off with a few members. I left this association. Of course, I was a low-level member. And I don't know many high-ranking people and their intentions."

"Can you connect us to them?" Excited, Hannah asked, "If you can, it will be a great help."

"I said." Ivan shrugged. "I wasn't there much, just..."

"Just what?" Hannah asked desperately.

"There's only one person." Ivan hesitantly replied. "He's the one I had a conflict with him. I know where his hangout is but he's a double-trouble pea brain. He's a hacker too, but I don't like him at all. He really is a trip."

"Make your mind easy boy. Tom said, smiling. "Just tell us how can we get hold of him? You don't have to worry about anything. I'll take the blame for."

Ivan's deliberately creases and wrinkles face got dark and purple. "No, he won't tell you anything. I have to be myself."

"You promised to cooperate with the police." Hannah frowned. "Now is time to keep your promise."

Ivan raised his eyebrows, "I promised to help with the virus."

Before Hannah could say anything, Tom stepped forward. He took Ivan's hand and said, "For me!"

Ivan's ears pricked up when he heard this. He accepted immediately. "Well, for your sake. Let's go and show you. I hope his hangout hasn't changed." And then he was the first one who made his way and went to the door. All three followed him. Captain Sanders closed the door again.

Eric Shaw's hangout was a not-so-justified youth club in Los Angeles. "If a police car is found there, you won't get anything," Ivan said to Hannah.

Hannah signaled to Captain Sanders. He returned to the police station. They all went on to Los Angeles. On the way, Hannah asked Ivan, "Why did you have a problem with Eric Shaw?"

"Eric is horny. It doesn't matter if it's a man or a woman. His dick sets all his moral standards. I don't know how this man has fallen in love with technology," He sighed and continued, "One day, I realized that He's giving me shady looks. I also punished him a little, that's it."

Hannah, whose face was disgusted, didn't say anything else. Tom stared out and laughed softly while he was shaking his head.

After half an hour of driving, they arrived at the club at around noon. Club coins usually flourished at night, and most people walked there during the day to fill their bellies, the people who were the customers of the nightclubs.

Eric was the shopkeeper of this club. In addition to hacking, he also specialized in alcoholic beverages, which led to many proponents. When the three of them entered, the club was not very crowded.

Eric, with those drooping mustaches and sideburns like hedges, enveloped in clouds of smoke, with a wrinkle of ash was teetering at the end of his cigarette, was showing that he has been dying for trouble.

When they reached there, he was flirting with one of his pretty customers, but as soon as he turned around and his eyes fell on Ivan, knitting his brows, he threw a stern glance about him on all, drew himself up to his full height. It's as though he has seen his mother's boyfriend.

Ivan walked slowly toward Eric, who was unsure of how to deal with him. Eric sucked his cigarette deeply, and as soon as Ivan came in front of him, he puffed out all the smoke on the face of Ivan.

Ivan, who was not used to cigarette smoke, coughed dismissively. "Eric. I know I shouldn't be here, you said you would see me again, you will kick my ass, but I had to." He said.

Evan's words weren't over when Eric came out from behind the counter, and with his flat and wide arms, he lifted Ivan and threw him at the empty table with all his might.

Ivan fell on a pile of empty alcohol bottles with his ass and then fell on the ground with humming, hissing, or even howling sounds. After that, Eric cracked his knuckles and sat on the chest of Ivan, and started kicking and punching him. Tom grabbed the next fist he wanted to hit harder. Eric tried to pull his hand out of Tom's, but he couldn't. He was at a disadvantage, and Tom seized his arm, so he had to get up and look Tom in the eye. Tom stared into his eyes and said, "We're not here to fight ... we've come to get help."

The few customers who were sitting felt the smell of fighting and slowly got the load to the drop one by one. Eric pushed Tom and said, "I'm not helping you and that ugly duckling at all. The scoundrel!"

Hannah stepped forward, "Stop it, stop it. Why are you beating him?"

"What did you want to be?" Said Eric, spitting. "This mother fucker posted all my private photos on the internet."

She changed the strategy and started the way to flatter him. "Oh... I'm sorry. Honestly, Ivan told me this story. It wasn't Ivan's fault. It was Anna Cooper's team. Can you belive that shit?" Said Hannah, drawing a breath and nodding her head with a stern kind of coquetry, "I'm his sister. My private photos have also been spread on the Internet. I got deeply embarrassed."

"How she could in such short time, fabricated such a vast complication of absurdities?!" Tom found himself wondering.

Hannah gyrated her hips, and while she was buttoning

Eric's disheveled shirt so that the redness of his skin would not be more obvious, she said, choking, "You know... Anna Cooper was my friend. I know I made a mistake, I know, but Anna took me out with her one night. Her boss was with her. He saw me… He knocked me around a little bit, and one night..."

She increased the degree of coquettishness, "One night I was drunk as a skunk. I made a mistake and slept with him, and that con artist of blood relation betrayed me and filmed me. He was a real swindler. Now he has threatened to broadcast my film on the Internet if I don't back to his demands. Eric, dear Eric, I'm innocent, I want to be free. I want to go and delete that video. I don't know where I can find him. Help me, please."

Eric, who had been listening all along, was thoroughly deceived. "Oh?" He said in a very soft tone. "They were evil bastards."

Hannah, who was crying, repeated Eric's words, "They are bastards."

"I mean, I've been wrong about you all this time?" Eric went to Ivan and lifted him.

"Thanks, I'm Ok," Said Ivan, raising his wounded eyebrow. "It happens."

Eric was emotional. He turned to Hannah. His hand was softly caressing her crying face. Unconsciously, Tom raised his hands in response but later chose not to. Eric turned back to Ivan, "I've heard the name of Anna Cooper, but I don't know the name of her boss."

There were signs of despair on Hannah's face as Eric continued, "But I know they have secret whereabouts. It's an equestrian club."

Hannah wiped the tears from her hazel eyes, “Oh, That’s it. It was dark everywhere I went that night. I don’t remember anywhere, but the sound of a horse’s whisper was heard that night. Do you know where it is?”

Eric procrastinated, then he took the plunge and said, “It’s on San Bernardino airport road. There’s an equestrian club there. That’s all I know. I’ll come with you myself. I want to pay him in his coin.”

Hannah put her hand on Eric’s arm, “Oh, no, baby. You’re a kind man, but I can handle it myself. Goodbye, baby.”

“Want to do it by yourself? But how?” Said Eric, shaking his head surprisingly.

Hannah came back, shook hands with Eric. “Wait, darling. I’ll visit you again.”

Eric was shrunk back in astonishment that Ivan and Tom walk past him and walk out the door. Hannah’s last sentence was still in his brain. “Phone Number.” He murmured. “If only I got her phone number.” He reached his jean and relaxed his pants above his jean.

They were on their way back to San Bernardino. Ivan was constantly sighing and moaning. Tom was stubborn and staring out as usual. “It was such a nice trick, Major,” Ivan said as he was moaning and groaning. “You played a very good role. I was wondered how to extract information from this horny.”

Hannah grinned but didn’t answer. Instead, she turned to Tom, “Tom, you are looking so down in the dumps.”

Tom turned and laughed in a complimentary way. “Well, I don’t know what to say. I hope we can get a good clue from that equestrian club.” Said Tom reluctantly.

Realizing that Tom didn’t like her role, Hannah looked at him mischievously and said, “But Eric was really handsome.”

“No, that shithead wasn’t handsome at all,” Said Tom, chattering.

“Are you jealous?” Ivan said, and he and Hannah all went off into roars.

“No. Not at all.” Tom nodded. Hannah blinked at Ivan. “But I think you’re jealous? Poor Tom”

Tom grinned but said nothing. “Well, honestly, I had to… I felt uneasy...” Said Hannah stoutly.

Tom nodded. “I think you did the right thing,” Ivan said. “By the way, I’m on the map. I see. There’s only one equestrian club there. Oh, let me check. We can’t go inside. It’s only for those who have VIP subscription. They mentioned on their website.”

“So we’re in trouble!” Said Hannah, who would love to change the subject.

“God, I need no trouble right now,” Ivan replied. “I’m still very hungry now. There are good restaurants on this freeway. How is it that we go to have lunch first and then go to the club?”

Hannah’s phone rang at the same time as Ivan’s effusions. Hannah was reading a text message and suddenly shouted, “The purchase data for the infected people are ready now. It has been sent to my email.”

Upon hearing this news, Tom wasn’t dull any longer. “Well... we’ll both have lunch and accomplished our unfinished business.”

“It’s great,” Ivan shouted and then started clapping. Hannah made L-turn to a local restaurant at her next opportunity.

Ivan was so hungry that he ate the whole appetizer alone. It was as if the beating made him hungrier. Mixed pizza were ordered. When they brought the pizza, he started swallowing them one by one.

With a laugh, Tom slapped Ivan and said, "It's all yours, God, don't rush."

"You eat all this, but you are a pencil neck yet." Hannah laughed and said. "Look how skinny and pale you are."

"When it comes to food, I eat like a pig. I'm gonna turn all this into fertilizer," Ivan said as he struggled to breathe, without referring the matter to her. Hannah leered at him.

"Lisa said that she was better and discharged from the hospital." Said Ivan, his mouth still half full, "It gave me an appetite. She was imploring me to come to her. I was supposed to go to her tonight so that she wouldn't be upset."

"Well," He swallowed another bite and said again. "What are you waiting for? Let's continue our discussion."

"I explained last time about the general concepts of machine learning, two basic approaches, and general points about the association rules," Tom said, taking a bite of pizza.

He drank a glass of water in one gulp and continued, "Each association rules algorithm, regardless of its bells and whistles, has two basic phases. The first is to find frequent itemsets, and the second is to produce if-then-rules from frequent items.

Well, the question is, what do the frequent items and the if-then rules mean? To answer these two questions, we need to learn two important indicators together. The first indicator is Support, which is used to measure the frequency of purchased items. Mathematically, the support indicator formula is as follows:

$$Support(A \to B) = P(A \cup B)$$

This formula means that items A and B have been repeated how many times in all purchased items."

Ivan had finished his bite, so this time asked more easily, "How do we know whether an item is frequent or not?"

"It's a good question," Replied Tom. "We find it with a threshold of what we call MinSupport. If the obtained probability of one item is greater than MinSupport we call this item Frequent. Now, suppose we find frequent items, we can extract strong If-Then rules based on these frequent items. An important indicator of the evaluation of the strong If-Then rules is the Confidence indicator, which can be described mathematically as follows:

$$Confidence(A \to B) = P(B|A) = \frac{Support(A \cup B)}{Support(A)}$$

Confidence is a conditional probability. Suppose, for a $A \to B$ rule, the confidence indicator is 60%. Its interpretation in the basket analysis is that 60% of customers who have purchased A have also purchased B. Note that this is not a two-way relationship. Like the Support indicator, to determine a strong rule, we use a threshold called MinConfidence. All the rules that are above this indicator will be known as a strong rule.

Hannah had brought herself closer to Tom, saying, "How should these thresholds be determined?"

"There is no exact standard for this," Said Tom. "It's more a matter of context, and if you want to be very precise, you can use systematic trial and error,"

Hannah, who wanted to be active, asked again, "How do we find those two phases?"

"Different algorithms have been developed for this," Tom said more seriously, raising his eyebrows. "One of the first algorithms, Apriori, was developed in 1994. The algorithm is based on the idea that all non-empty subsets of a frequent itemset, must be frequent. This rule is called Apriori Property.

This algorithm works on the same two basic phases and has two main steps: Join and Prune. Let's go ahead with an example. Suppose we have the data for 9 infected people."

And he drew a table on the pizza paper: "Suppose Min-

Trans ID	**List of Item IDs**
T_{100}	I_1, I_2, I_5
T_{200}	I_2, I_4
T_{300}	I_2, I_3
T_{400}	I_1, I_2, I_4
T_{500}	I_1, I_3
T_{600}	I_2, I_3
T_{700}	I_1, I_3
T_{800}	$\mathrm{I}_1, I_2, I_3, I_5$
T_{900}	I_1, I_2, I_3

Support=2." He continued, "Of course, this number can also be expressed as a percentage. But for simplicity, we use its numerical value. Our goal in the first place is to find frequent items. Based on the two stages of Join and

Prune, we move forward. In the first iteration, we first do the joint step and get the frequency for items with length 1, and then based on step two, we keep those items with length one whose number is greater than 2. Based on this, the first iteration is as follows:

Itemset	Support Count	Is frequent
I_1	6	Yes
I_2	7	Yes
I_3	6	Yes
I_4	2	Yes
I_5	2	Yes

In the second iteration, based on the frequent items of the first iteration, we form all the candidate items with length 2, and because in the first iteration, all the items were frequent, combining the unique pairs forms the Joint phase. Ivan, you do the second iteration now."

Ivan picked up the paper under his pizza and wrote:

Itemset	Support Count	Is frequent
I_1, I_2	4	Yes
I_1, I_3	4	Yes
I_1, I_4	1	No
I_1, I_5	2	Yes
I_2, I_3	4	Yes
I_2, I_4	2	Yes
I_2, I_5	2	Yes
I_3, I_4	0	No
I_3, I_5	1	No
I_4, I_5	0	No

"That's right. Good job." Tom said, looking at the table.

And then he said to Hannah, "Major, may I ask you to do the third iteration? Only based on frequent items in the second iteration, and be careful, when you make a set of items with a length of 3, each subset with a length of 2 must also be frequent."

Hannah nodded and began to draw, and the following table was obtained:

Itemset	**Support Count**	**Is frequent**
I_1, I_2, I_3	2	Yes
I_1, I_2, I_5	2	Yes

Tom smiled kindly at Hannah, "Well, that's great. The $\{I_1, I_4, I_5\}$ was not frequent because $\{I_1, I_4\}$ wasn't frequent. And finally, the fourth iteration is no longer possible. Because there is no frequent item set with a length of 4, having these two sets of itemsets with a length of three also represents all subsets with a shorter length. So we did the first phase, which was to find frequent items. Now we have to create strong If-then rules based on these frequent items.

Each logical rule consists of two parts. When we say: If it rains, then the earth will get wet. We have used two linguistic propositions. The section If it rains is called Antecedent or Premise, and the section Then the earth will get wet is also called Conclusion or Consequence.

Accordingly, from the frequent Itemsets with the longest length, I write down all the If-Then subsets that can be created and calculate the confidence indicator for them. Let me do this:

$$\{I_1, I_2\} \rightarrow I_5, confidence = \frac{2}{4} = 50\%$$

$$\{I_1, I_5\} \rightarrow I_2, confidence = \frac{2}{2} = 100\%$$

$$\{I_2, I_5\} \rightarrow I_1, confidence = \frac{2}{4} = 50\%$$

$$I_1 \rightarrow \{I_2, I_5\}, confidence = \frac{2}{4} = 50\%$$

$$I_2 \rightarrow \{I_1, I_5\}, confidence = \frac{2}{4} = 50\%$$

$$I_5 \rightarrow \{I_1, I_2\}, confidence = \frac{2}{4} = 50\%$$

If we consider MinConfidence = 70%, only the second, third, and last rules will be selected as strong rules. Well, it's over, that wasn't so hard, was it?"

Hannah nodded in approval. Ivan ran his fingers through his curly hair. "But I think this algorithm also has a problem." Said, Ivan. "If the number of items increases, its performance will decline because the counting phase will increase exponentially."

"It's right," Tom said, pointing his finger in approval. "In larger transactional datasets, the speed of the Apriori algorithm will slow down. To solve this issue, other algorithms have been proposed, and in some studies, better search strategies have been proposed to improve the algorithm's speed. This algorithm is sufficient for our work, which we want to examine the small data of several thousand people in a few limited days. Now, all we have to do is apply the algorithm to our transactional data. Let me see, Ivan, did you bring your laptop with yourself?"

Ivan put his hand on his back bag, “A soldier never forgets his weapon!”

“I should hire you as one of my soldiers,” Hannah tapped Ivan and said sarcastically.

All three burst into laughter. They ate their pizzas. Tom pulled the dishes aside, “Now it’s time to act. We have to get the strong rules based on building the transactional dataset from their purchased items.”

And then he and Ivan worked on the implementation of the Apriori in Python. All this time, Hannah was playing with the cute boy who had come to her from the next table.

Twenty minutes later, the analysis was complete. Ivan’s normal eye was bulging, the stared eye fixed upon Tom. “It’s unbelievable...” Ivan said with large bovine eyes. “So the main source of the virus is the milk and cheese, and in other words, all dairy products related to the milk!”

Looking at Ivan, Tom confirmed his statement, “The strong rules authorities this. When we set MinSupport=50% and MinConfidence=90%, there were four basic rules, which antecedent and consequence of all of them were related to dairy products. Frequent products include milk, cheese, and cream. But there is also a strong rule that its consequence is canned fish. You know that a thousand examples cannot prove a proposition, but an example can reject a proposition. We still keep the initial hypothesis that ‘The virus is most likely transmitted through dairy products’, but we need to do more research.”

Ivan stood up and sat down next to Tom with a laptop, “I changed MinConfidence to 90%. See, 21 rules have been achieved, and the number of rules which there is a canned fish in their consequence has increased from 1 to 12.”

Hannah went and sat next to them, meditating, “Are all these products from a specific brand or a related company?”

“It’s a good question,” Said Tom, nodding. Ivan exerted immediately. As if thinking aloud by himself, Tom turned to Hannah, said, “We’ve used unsupervised machine learning approaches to exploratory analysis task. The important truth is that the exploratory analysis never answers a riddle and always gives only a series of clues to the potential causes. We need to look at a few factories up close. After all, we can’t always come up with a solution from a distance and data. Very often, we have to go and see it up close. In the words of Japanese, we have to go to Gemba."

“I didn’t find any specific brands that produce these products commonly,” Ivan interrupted. “It’s confusing, I feel we are on the cusp of the solution here. It’s within a yard of us, but we didn’t see it.”

“We’ll find out soon.” Said Tom confidently. “Major, would you please arrange a site visit for two factories of each group? One for a dairy factory and one for canned fish.”

“OK,” replied Hannah. “I will set up the meeting as soon as possible.”

“It’s better to go to the hypermarkets and see these potential products up close. Maybe new clues will be found,” Tom said.

Ivan closed his laptop and nodded, “Shall we go now?” Ivan’s frustration boiled over.

Hannah looked at her watch and said, “Now, we have to go to the club.”

Ivan raised his finger, “Oh, you’re right. Well, granted that we go, how do we get in?” They said nothing aloud until Ivan himself said again, “I’ve got a plan. I got it all worked out!” Tom and Hannah looked at each other unconsciously. They tried so hard not to laugh.

David and Marlon were behind David’s father, Porsche. According to Ivan’s plan, they should hit their car with rick yard next to the club.

In Hannah’s car, all three were waiting for their action. David blinked at Marlon and put the pedal to the metal. The car screamed, and after a few seconds, it hardly hit rick yard. One of the guards inside the club’s booth came out, growling. David and Marlon got out of the car. At the same time, performing the groggy drunken role.

David was immersed in his role. He jumped up and fell to the ground under the guard’s feet. Seeing this scene, another guard came forward.

“Oh,” Said Marlon, who seemed a little more sensible. “Poor David, I said... I said go easy. Can you give him a glass of water? I promise I’ll redress for all the damages.”

The guard, like a wild cow, took his breath out of his nose. His nostrils began to quiver. He thought for a moment and nodded to the other guard. They both came and grabbed David by the armpit and took him inside the booth. As soon as they entered, Marlon rolled his eyes and found the computer.

The guards, like a hearse, were busy moving David here and there. Marlon took the opportunity to insert a flash memory into their computer. A few seconds later, he pulled out the flash. He talking to Ivan in hints, signaled that the work had been done. He then blinked at David.

David, who was playing innocent, recovered slowly. They gave some money to the guards and left there quickly.

As they passed in front of Hannah's car, they were shown a victory sign. Ivan showed them the heart symbol. "I hacked their system." hammed Ivan. "Your name is on their list. The rest is up to you."

Tom and Ivan got out of the car. Hannah took the car alone to the entrance of the club. She waited for the guard to come to her. When the guard arrived, she took off his sunglasses and said, "Hello, can you raise the bar?"

The guard hesitated for a moment. "There is a need for membership here," He said. "You can't enter."

Hannah raised an eyebrow," Wow... you mean you don't remember me? I've been coming here for a few months now. It's weird!"

The guard stepped forward." I haven't seen you before, can I see your membership card? "Hannah put her hand in her bag. She turned around a little and then said sadly, "Oh, my card. I think I lost it."

The guard, who had bent his back, stood up. "It can't be done without a card. Come whenever you bring a card."

"Well, to get a new card, I have to be able to enter once without a card," Said Hannah. "Why not check out your system? My name is definitely in your system." And she gave her credit card to the guard to match. The guard went on the system impatiently, and a few seconds later, as he nodded in surprise, he returned. "It's weird. Your name was on the system. But we didn't see you before." He returned the credit card to Hannah and then raised the bar so that Hannah could enter.

Hannah drove her car to the parking and got out. Two men mounted on black and brown horses, trotting straight toward her and across her path. Another was saddling his horse. Hannah slowly walked past them and walked around the stables.

In front of her, it was a building that seemed to be the club's management office. She came out from behind the stable wall and went to the building very normally. Two people came face to face. Hannah slowed down so they could cross. Then she looked around. Nothing suspicious caught his eye. She continued on his way and crossed the door that opened on both sides.

There were rooms in regular rows, but no signs or details were written on their above. She was standing in the middle of the hallway, looking at the rooms, when two people suddenly left a room. Hannah ran away and hid on the stairs leading upstairs. Two people came and stood by the elevator. Hannah looked at one of them. He was a tall, corpulent and black man. He was wearing military boots, and a big sports watch.

The tattoo behind his ear caught Hannah's eye. She rolled her eyes and looked more carefully. There was a superficial wound on the corpulent man's face that began on his forehead and continued to his right eyelids. Hannah focused on listening to them what they say, but their voices were very slow. She didn't understand anything. They got on the elevator. She came down the stairs to see which floor they were stopping. Simultaneously, a man entered through the front door and confronted her. He stared into Hannah's eyes and said firmly, "What do you want here?"

"I lost my membership card," She shrugged very calmly. "I wanted to get a new one." His lips were swelled and dark;

the brow furrowed. He looked her over from head to foot. “This is not the right place you’ve come.” He said. “So, where is it?” Hannah asked. “It’s out. Please leave here. Right now...” He said again, angrily.

Hannah picked herself up. “Oh, this is so embarrassing. What kind of customer orientation is this?”

Then she left grumbled. She waited for a while. The frowning man waited to see her come out. She was sure that if she went upstairs, she would get more leads. But she was suspicious enough. Inevitably, made her way to the parking and drove out of the club.

Tom and Ivan were slowly walking back to San Bernardino on foot and talking to each other. She came and stood in front of them. Both boarded. Ivan just began to whine and growl. “It’s like a furnace in here. Our heads were burnt out under the infernal sun.” Said Ivan.

“What happened?” Said Tom, turning to Hannah. “Did you find something?”

“No,” Her nerves were wrecked. “I got very close to a good clue, but then. . . ” She thumped the steering wheel with her fist. “A little cock a whoop caught me at a really bad time. I have to go again.”

“If you come back, the whole thing will set up.” Ivan said. Hannah didn’t answer. Instead, she slammed her foot greedily on the accelerator. The car roared, like a feast, and entered the freeway.

They were on their way back when Hannah announced that they could visit two factories tomorrow. As they passed through downtown San Bernardino, Ivan asked Hannah to step aside to visit his girlfriend. Hannah and Tom moved to the cottage. After getting off, Ivan, as he was walking away from Hannah's car, whispered, "It's as if the Major fall in love with Tom. Good God." He spat on the ground and happily walked over to his girlfriend's house.

There were still slight signs of fever and chills in Lisa's body. However, she missed Ivan. Ivan was fixing to go to Lisa's house but drawn by ill fortune, Lisa's father showed up. Lisa decided to follow Ivan in her car. Ivan was very sour, but for a while, they went around and talked of all manner of things, made him lighthearted and happy again.

Eventually, around sunset, he was taken to a forest road to go to the cottage. They were in the car, and Ivan felt unwilling to leave her and stood facing her in perplexity. Lisa still had worn a face mask. "At least once, take off that mask." Said Ivan. "I want to see your cute face. I missed it."

"Loosen up, don't be silly." Said Lisa, with a laugh. After seeing Ivan frown, she lowered his mask. Ivan suddenly looked pleased. Lisa pulled out her peppered peanuts pack, which she loved so much, and complimented them on Ivan.

Lisa herself ate with appetite, almost with greediness. With such a hearty appetite that she aroused Ivan's. He picked one seed.

"Wow, it's hot," Said Ivan while tasting. "Like yourself." He continued naughtily. He put his hand in the package, filled his fist, and threw them up one by one. Lisa greedily bit her lip and said, "You are weird today..."

Ivan threw up a few more peppered peanuts. "How many loves do I have like you... I see you, and it changes me completely." Said Ivan, whistling for the burning of the mouth.

Not paying attention to him, Lisa took a handkerchief towards Ivan, “Very well, don’t lick yourself; take this handkerchief, wipe your hand, then go now. I’m really busy. My father has come. I have to go to him.”

The usual wetness of Ivan’s hands had peppered his three fingers. Ivan slammed his three fingers into his mouth at the same time and licked his fingers, “They were delicious.” Then He came to kiss Lisa, and Lisa frowned. “Why do you resist understanding? I’m sick.”

He felt a shock greater, but he realized her cold behavior as far as remembering today’s date. “I don’t think it would be a good idea to eat these things in this physical condition. Eat butter and honey instead, OK?” Said Ivan, getting out of the car and then he took another punch from the package himself.

Lisa glared at him but said nothing. When he closed the door, the starter whirred and caught, and whirred again. She began to goose the gas pedal, and the car quickly moved away from Ivan. He looked more likely to breathe fire, could not resist the urge to eat the peppered peanuts again.

He remembered his grandmother’s bullshit - in his own opinion - saying that a sinful man had to commit more sins to put out the fire inside him and he seemed to be eating more and more peppered peanuts to put out his burning sensation.

He stood up, took a deep breath, and continued on his way again. The sun was making its last effort to keep the day from getting dark. Ivan was still whistling and singing when he suddenly heard splashing water, which sounded like a fountain. Curiously, he went to the sound and saw three teenage girls playing inside the seasonal lake.

They had taken off their clothes and were completely naked. They didn't notice Ivan at first. It seemed they were supposed that nobody could pass through this area. Ivan was looking perfectly upright and stoical bearing.

One of the girls looked at him, screamed, and plunged into the water. Ivan shook himself mentally and turned his eyes away from them, began to walk slowly along the lake to the cottage. It wasn't long before one of the girls shouted, "Hey, you, curly hair boy..."

Ivan turned and answered with a shrug. "Yes... yes. You called for me?" The girl, whose mischief was falling from her eyes and face, glared at him, "Where are you in such a hurry? There are places for you here too."

For a moment, a deep burning sensation appeared in his stomach. He knew what the burning was for. When he was a child, his grandmother had once told him that whenever you were like this, know that the devil had straddled them. Ivan looked at the girls and ignored that memory. "The devil is not a bad thing." He whispered and then turned around and went to the lake.

He took off his T-shirt, and as soon as he was walking fast to get to the water faster, a sudden pain wrapped around his body. Now he understood that it was not a feeling of lust. It was a feeling of shit. He remembered the peppered peanuts. It was the first time in his life that he had eaten peppered peanuts. A pain like labor pain took over his whole body. He couldn't take another step towards the girls anymore.

"Oh, be my guest, I have to go." He said quietly and painfully. The girls, noticing the deteriorating situation, began to laugh out loud.

Ivan estimated his distance from the cottage. Normally, he was 10 minutes away from the cottage. He was breathing fast and blowing. He felt that in this way, his resistance would increase. He was firmly clinging to his stomach and Speeding to Tom's cottage with all his might.

Hannah and Tom had arrived at the cottage. Hannah was still wondering why she hadn't been able to get accurate information from the technology worshippers' headquarters. Tom went and made two glasses of herbal syrup he bought from the locals and put them on the table.

Hannah was still lethargic. Tom took the glass of syrup to Hannah, "Drink... after all, no truth will ever be hidden. You will soon understand..."

"Doesn't it last forever?" Hannah nodded and replied. "I don't know. I've always loved justice. What if Anna Cooper is killed innocently?"

"Why do you love justice?" Tom asked, leaning back in his chair. "When there isn't?"

"I don't know." Hannah frowned.

"Can I ask a question?" Tom asked.

"By all means!" She replied very amiably.

"Why did you become a police offiecer?" Tom asked bluntly.

Hannah was silent for a moment. It was as though she was thinking deeply about the answer. He dropped the glass and started exclaiming with difficulty as a lump thickened in his throat.

"I never forgot that night, and it changed my life forever." She confessed. "I was less than 13 years old... In those days, my father was bankrupt, and we lived in an astigmatic neighborhood. My father was not at home. My mother coughed heavily that night. Her pill was over, and those pills were necessary to calm her down. I had to leave the house to buy my mother's pills. I walked for half an hour. I was surrounded by addicts and forgotten people who didn't know why they were alive. I had heard that they were willing to kill even a person for a piece of bread. I was trembling with fear. I went and bought the pills, no matter how hard it was.

On the way, when I passed through the narrow alleys, I could feel that some eyes were following me. My hands and feet were shaking with fear. I ran as hard as I could. There was nothing visible. I just ran blindly. I was running when my foot got stuck in the garbage bags...

I fell to the ground with my head. I lost my mother's pill capsules, and they broke in front of my eyes. I started crying slowly. It was silent everywhere. No, it was just the sound of an owl coming. As soon as I wanted to get up, I suddenly felt a heavy weight on my back…

It was as if a great burden had been placed on my back. At first, I thought it was a garbage bag. I came back. I saw a man with an ugly face sitting on me. He was drunk and was laughing while humming to himself.

He was sitting on me. No matter how hard I tried to get up, I couldn't. I was crying. I begged him to let me go, but he didn't pay attention. He pulled my skirt away. His rough hands hit my skin, my whole body trembled. He put his hand over my mouth. I couldn't scream and shout anymore. I couldn't even breathe. I was just crying. He hugged me and led me to an abandoned, half-finished building. He was going up the stairs when some men who were sitting there and immersed in themselves saw me with that man. They came towards us. I was kicking with my foot on his stomach, but it didn't work. It was dark everywhere. I was thrown on a pile of dirty building materials, garbage bags, ampoules, and tattered clothes.

They fell on me together. I didn't know what was happening. A strange burning had taken over my whole body. From a certain point on, I didn't even scream and shout anymore. I had surrendered to death. I thought I was going to die. I was in a strange trance. I was unconscious, but I understood everything. They could do anything they want with me. Then one of them, who saw that I had lost my breath, was scared and shouted, "Finish it motherfuckers, she's dead. Quit fucking around."

Fearful and embarrassed, they got up from me. They pulled up their pants and ran away. They were walking away. I felt this. Suddenly one of them came back and looked at me. My eyes were half-open. His face is still in my mind. He dragged me away and threw me from the second floor of a half-finished building into the rubbish that had been dumped.

I don't remember anything anymore. I didn't whine or moan or stamp my feet anymore. I just surrendered. I just remember I opened my eyes and saw that it was getting light. I got up. I couldn't walk. It was as if an arrow had hit in the middle of my legs. I stuck the wall and got up, and started walking lamely. I saw blood coming from between my legs…

All my shoes, the white shoes my father bought for me, were full of blood. I got home, no matter how hard I try.

I couldn't leave the house for a few months. I didn't even talk to anyone. Once I wanted to kill myself that I couldn't. That is, my mother, saved me."

Hannah was crying like a spring cloud. Tom went and sat down next to her. He hugged her and glued Hannah's head to her chest, and as he pulled Hannah back and forth like a child in the cradle, he said, "Calm down, darling. Calm down."

"Why do you think I didn't get married all these years?" Hannah sobbed, raised her nose, and continued. "I rejected everyone who proposed me with an excuse. I still feel the weight of that damn man on myself. I still couldn't get rid of this nightmare. Sometimes, at night, I see the nightmare of those miserable moments again."

Hannah tore herself from his chest. Tom took Hannah's hand and placed it on his thighs.

"It took me a year to get back on my foot," Said Hannah. "But I finally decided not to cry anymore. I fought tooth and nail to stop thinking about that nightmare. I joint the force to get rid of such a criminally Insane from weak people. I wanted to do justice. You know, when I saw Anna Cooper's corpse, the same thoughts came to my mind again. I feel that she was innocently dead, and I have to find her killer. I know there is no justice in the world, but I will do justice in this one. I swear, I dicided a long time ago, to be a police, jury and exutioner all in one to see criminals behind bars."

Tom stared into her gimlet eyes, just stroking her long hair and cheek with his right forefinger.

"Tom, only my parents and you know about this." Cried Hannah furiously, suddenly waking up and angry with herself. "I don't know why I confessed to you. See not see, Promise?"

"I promise. Don't think about anything. My dear Hannah." Hearing this, Hannah closed her eyes. Stick her head to Tom's chest. Tom, according to his habit, this time stroked her cheek with his thumb, and he wiped away a gang of tears trudged from her eyes. Hannah pulled herself out of Tom's arms.

Tom took Hannah's hand. They were cold. "Your hands are so warm." Suddenly exclaimed Hannah, who was meditating. Tom pulled himself up a little and stood next to Hannah. He put one hand on her craned neck, and with the other, he still held her hand. "Every time I get excited or emotional, my hands get cold," Hannah said again.

Tom didn't say anything again. For a moment, however, he pulled both hands out of her hands and neck, saying, "I'm sorry to ask this question. I didn't mean to make you feel bad."

This time Hannah herself approached Tom. She locked her hand on Tom's arm and placed her head on his shoulder. "I feel as light as a helium balloon. You're different from all men."

Tom turned back. He felt an imperceptible contraction in his chest as he began to gasp. He grabbed her pensive face with both hands. Hannah raised herself as she surrendered. They both stared at each other for a few seconds. Tom glanced at Hannah's tear-filled eyes and her lips. Hannah understood. She bit her lip gently but seemed to have made up her mind. She closed her eyes. Tom shut his eyes, holding his breath, slowly carried his head on one side.

He swallowed the last time, and as soon as he put his forehead up for her to kiss. The cottage door suddenly opened and slammed against the wall. Terrifyingly, they turn back. It was Ivan, who was breathing fast. No greetings, no talking, he just made his way to the toilet. He entered and slammed the door. “Ahhh... I’m going to die.” He shouted fiercely.

The hot feeling they had a few moments ago was gone now. They both beat about the bush. They just heard strange noises were coming from the bathroom. Both from Ivan’s mouth, which was moaning, he said, “God damn you, Lisa!” and from his belly.

Hannah couldn’t help herself laughing after that crying. “Does this shameless boy have a key?” Said Hannah. “He doesn’t know to barge in like that?”

Tom dropped his head and laughed. “Two days ago, I gave him the key here to make it easy to get around. How I know, he is down on us like a duck on a June bug.” They both laughed.

Ivan came out of the bathroom and replied himself, “Wow, it seemed like an eternity. It’s one of the greatest pleasures in the world… that you are in trouble and suddenly you get a toilet.”

“Why, what happened?” Tom said, laughing out loud.

Ivan took a deep breath. “Tell you what? Lisa gave me peppered peanuts. Suddenly, I took a shit. I’ve been dying for a quarter of an hour. I would be shitting, at any moment in the middle of the road.”

Tom got up and punched his arm slowly, “You little pest! You didn’t pass through the middle of the city. You came from the forest. Everywhere in the forest can be used as a toilet.”

Hannah was a little pique. “Oh, stop it, you two, you disgust me." She said, glooming. Tom and Ivan started laughing out loud. Hannah, who was gritting her teeth at first, couldn't stop herself. Started laughing with them.

06

STRANGE OUTLIERS

Ivan and Tom were sitting in a police car's back seats, and Hannah was in front. A tall and strong, with a big square head, and deep-set bright eyes cop was also driving. The police car was moving fast on the road. The other car had two experts from the WHO and the FDA. There were only a few miles left to the 'Dairy Days' factory.

I have never seen a factory up close in my life." Ivan broke the silence and said. "It's good," Tom turned and blinked. "At least your eyes will open to the real world, and you take your head out of that computer and the internet."

"Yeah, fair point!" Ivan said defiantly. "Now that you're gone, at least tell me what to look for?"

"Logically we should look for common ground between the two factories," Tom said, shrugging his shoulders. Hannah came back and completed Tom's words. "Both similarities and differences. We detectives must have science and art together, you know, science seeks similarities in differences, and art seeks differences in similarities."

"Yes, you detectives look outstanding at all," Ivan said mischievously. Tom swallowed his laughter. The driver officer grinned subconsciously. Hannah stared at him with a frown. The officer coughed smoothly. "How hot the air is."

A few minutes later, two police teams arrived at the large Dairy Days factory. Factory manager Frederic Rodriguez, with his sunburned Spanish face and boulder arms, approached them and extended one of those boulders and introduced himself. Hannah's little hand looked awkward next to his wide, flat hands.

"Mr. Rodriguez, our investigation shows that most people who are infected with the virus have consumed the products of your factory," Hannah said. "Of course, we will not disclose this fact until the truth gets clear. Anyway, thank you for accepting to visit the factory."

Mr. Rodriguez led the group inside with his hand. Hannah's face was spectacular. She was walking in front of the rest of the group like a scout and looked at everything like an eagle biting an ant from the sky.

Mr. Rodriguez began to explain. He showed them the production process of relevant products and documents and reminded them that after the police became suspicious, he sent all the documents and inspections to the FDA and the FBI. Tom and Hannah looked through the documents together. Nothing suspicious was seen.

"My God, I used to think that a factory would make everything on its own." Said, Ivan. "Now I understand that it buys some things from others, those containers, these plastics, and so on, it's really hard to produce something from scratch!"

"What about the suppliers?" Tom turned to Mr. Rodriguez as if something important had come to his mind. "Do you have quality control inspections for your suppliers?"

"Of course, Mr...," Mr. Rodriguez replied correspondently.

"Mr. Forrester!" Hannah interrupted him. "He is our senior data scientist!"

"Can I have a list of your suppliers?" Tom asked listlessly. Mr. Rodriguez reluctantly pulled out a sheet of paper. It was as though he was ready for this question.

Tom swiveled his eyes on the paper. Most of them were milk suppliers, came from various farms. At the bottom of the list, the ZellStars brand name appeared. It was a famous packaging bottle supplier in California.

"Are you deploy a quality control procedure on all the milk that enters the factory?" Tom asked.

"Of course, sir, always and without exception. Meanwhile, the virus dies at temperatures above 50 degrees. We boil all our milk to boiling point."

"What about your bottle suppliers?"

"We import them hygienically and under detailed inspections from a well-known factory. They have the highest standard washing procedure in the world."

Tom looked at Hannah. "It's better to go to the canned fish factory. We don't have anything to do here." Everyone left the factory. Mr. Rodriguez was suspicious whether danger had been passed or not! He put a cigarette in his mouth and lit it. He shook the police car, blowing the smoke out of his lips.

They were on the way to the fish protein concentrate. “Mr. Forrester, do you think anything suspicious has happened?” Said Hannah, whose detective scandal had embarrassed her this time. “Not yet, I have to see the next factory to conclude,” Tom replied.

“We’ve been in the car all day!” Ivan grumbled. “At least let us eat something,”

Hannah looked at Ivan motherly, “Don’t hurry, Ivan. After visiting the next factory, we’ll go and eat something.” Hannah said.

“But,. . . ”

“But what?”

Ivan remained silence.

“Do me a favor, and don’t make a fuss.” Said Hannah, thrusting her body forwards in the seat.

Ivan nodded immaculately, feeling his stomach churning with frustration.

Eventually, they arrived at the factory. A weird stench smelled from the environment. The familiar ceremony went on.

“Which factory do you import your bottles from?” As if with a hypothesis in mind, Tom asked the factory manager. “We have two or three suppliers, but the most important is the ZellStars,” He answered.

Tom and Hannah stared at each other. “We want to sample the containers you imported three to four weeks ago from this plant. Right now!” Hannah said.

“I have to ask...” The manager hesitantly replied. “We import our orders weekly from this factory."

"Most likely, the source of the virus is from the ZellStars," Hannah told Tom. Tom confirmed.

"We checked our inventory list." The manager said. "There must be several pallets on those dates that we kept for a custom product,"

They all wore sanitary and disinfectant clothes and entered a quality laboratory. WHO officials also brought their devices for testing and sampling.

"Our sampling shows that the containers contain the same virus." The head of the WHO team told Hannah after half an hour of struggling. "Of course, the amount is low, and virus samples are dead, but well, because more than two weeks have passed, it's natural."

Tom grabbed Hannah's arm and, as if forcing her, said, "Right now, you have to order the factory to stop production."

"I don't mean to be a doubting you, but I think it's a conspiracy from competitors." The factory manager told Tom. "This factory is very famous. There must have been a mistake."

Give me the address of that factory." Tom paused and replied. "We're going there right now."

Ivan, who was not clothed in laziness and did not enter, suddenly saw everyone rushing out the door. He looked for Tom, "What happened... Tom, what happened?"

"Just follow me," Tom replied. "And be prepared. You may need to code again."

Ivan dealt himself a blow on his forehead. "So, what about lunch?" He asked pleadingly.

Hannah came back and looked at him in such a way that out of fear, Ivan himself ran and left there as a first-person.

The ZellStars plant was located southeast of San Bernardino. To reach it, they had to cross a forest area in San Bernardino National Forest Park. On the way, Hannah announced that the result of a blood test found in Anna Cooper's home was not the same as her blood. After announcing the news, Hannah turned to Tom, "Now I'm more motivated to find her killer. Why should such an exceptional person be killed?" As usual, Tom stared out.

"Maybe she knew a secret that shouldn't be. There's no shortage of enemies for such people." Hannah considered for a moment, then looked inquiringly at Tom.

The car was still on the way. After an hour of driving in a mud-slippery road, they finally arrived at the factory entrance. Several army hummers had blocked the entrance. Ivan was scared. "Let's go back, feels a bit like trouble," Ivan said.

Tom turned his eyes in surprise. An army Colonel was approaching them with several companions. All three got out of the car. The same goes for the second car crew. Colonel left his team and went to Hannah. "I am Colonel Taylor," He said. "Commander of the Special Unit... According to the Commander of the Army Ground Forces Commander, I have been instructed to take command of the inspection operation. I'll take it from here. This is out of your jurisidication."

Hannah thought. It was as she chewed what she was going to say. "Hold your horses, I don't take orders from the commander of the army to obey his orders." She said firmly. "We have come here to find out the truth about the spread of the virus, and we will do our job."

"I heard you were stubborn," Colonel gritted his teeth. "You haven't seen another side of me yet," Hannah replied, raising her brow. Colonel looked at Tom and Ivan sideways. "Come with me, Major... Just you." Hannah followed him.

They entered the command tent. "As soon as you informed the ZellStarrs production line had to be stopped, I was immediately ordered to be sent to this place," Colonel said. "Not for ZellStars itself, because in this area, we are doing a series of defensive operations that are vital to our security. If there is a lot of noise here, the whole business will go to wreck. Am I clear?"

"We have nothing to do with your operation," Hannah said. "We just want the truth to be known. I am also in charge of discovering this fact. If we find what we want, we will leave soon."

Colonel, sitting in a chair, stood up and put his face close to Hannah's. "Very well, loyal Major, go and find out your truth. But our eyes are watching you. We will follow you like a shadow. If you make a mistake, even yourself, you will be arrested. This is our national security issue. By the way, on the outside of the factory, wherever you want to go, it must be with our permission. Understood?"

"Very well." She replied nonchalantly. "Now get out of my way, please." She made her way outside. With her command, her team all went to the factory. The ZellStarrs factory manager was sitting in the factory's front office, worried and anxious, smoking cigarettes. When Hannah arrived, he got up involuntarily and protested, "What was that for? Look, a whole army has surrounded my factory grounds."

Hannah put her hand to her lips. "Calm down, sir. Nothing has been confirmed yet. The clues show that the virus entered food products from your factory. We are here to clarify."

She pointed to the WHO team, and they began their work. Hannah glanced to the right or to the left. Ivan and Tom were vanished toghteter. It was like the earth swallowed them up. They both disappeared like a ghost. She remembered her promise to the Colonel. She was disgusted and even angry with Tom and was wondering why he got over his head. "Tom, Mr. Forrester, Ivan ..." She shouted.

Suddenly, Ivan showed himself with a steak in one hand and his laptop in the other, behind the wall leading to Colonel Taylor's command tent. Hannah reached out to him, "Where on earth have you been you greedy, filthy pig? Your eyes are bigger than your stomach at every meal. I really have to strangle you."

Ivan slowly swallowed a large bite.

Where's Tom?" Hannah glared at him.

"You mean Mr. Forrester?" Ivan replied in the same tone as Hannah shouted Mr. Forrester. "Honestly, the last time I saw him, he would go behind the factory to inspect the water tank."

She swallowed her wrath and tried to assume a cold air of dignity but with little success. "I'd like to crack their heads together!"

Ivan came to the raw prawn and shrugged his shoulders. "You're a spoilt brat." Hannah cast such a flashing smile of greeting at him that she stopped short. Ivan's smile broadens. "Why didn't he let me know?" Again, Hannah kindly asked.

Well, you know him. He decides suddenly and acts more suddenly."

"Where have you been yourself?"

"Ohm, Nothing, I was just checking the news."

After a while, Hannah found Tom. Under the heavy glances of Colonel Taylor's team, she came waddling toward him as fast as she could. Tom kneeled before the water pool and wondered incuriously. "What are you looking for?" Hannah asked, groaning and wheezing.

"Looking for a footprint or what you call a clue!" Tom nodded and replied. "Then why here?" Hannah asked.

"The virus can either stick to the bottles or distribute through the air," Tom replied, raising. "It is very unlikely that it is distributed from the air. It is unlikely that they produced the virus themselves inside the factory. The only way is water. As far as I know, this water is used to wash bottles, and if the water is contaminated, the virus is inevitably transmitted to the bottles. Even after washing, the bottles usually don't see high temperature heat ... or in many cases, these bottles are used to produce cold food. I guess, most likely, the clue should be around this pool."

Tom started surveying again. Half an hour passed, and he found nothing. In the end, he returned to the police car desperately. Ivan was not there. He got out of the car again to look for him. Finding nothing pulled the WHO team up short too.

As a sign of denial, their chief member shook his head from a distance to Hannah. Hannah turned to the wall. She thought for a while, and then, her desire was evoked suddenly.

She went to the car, picked up her magnifying glass, and went behind the factory to the water pool. Tom was disappointed, both for finding the clue and finding Ivan. The feeling of foreboding appeared at Tom gradually. He went again and sat in the police car nervously.

It had been 20 minutes since Hannah still hadn't turned up. Tom's patience had finally run out. He took away the car, and as soon as he intended to look for Hannah, she appeared from behind the factory. She was reaching out to Tom. A few steps away, she said loudly, "Tom, come with me... quickly!"

With her gesture, Tom ran behind her. One of Colonel Taylor's men, who saw the situation as suspicious, also ran after him. When they reached the water pool, Hannah bent down on a bush. Tom too. Hannah caught her magnifying glass on a small white mouse that had died next to the wall, under the bushes of a row of flowers. Its body was smaller than expected. According to Hannah, the WHO team tested the mice. The mice had the virus.

Tom looked more closely at the mouse's body. "You don't think it's unusual?"

"What's unusual?"

"These mice... These mice are only found in biology labs! Isn't it?"

"Yes, you are right. We should..."

Meanwhile, Colonel was taking long steps toward them. Hannah interrupted when she saw he was about to boil over. "Major Nelson, you and your team are under arrest," Colonel shouted.

Tom looked back over his shoulder at where the others had come. When Tom intended to approach Ivan, three armed tribesmen approached. Straight ahead of him. Tom had no time to a good reaction. He had fallen to the ground, next to the WHO team's equipment, with a violent blow from the butt end of the musket burst.

Hannah reached for her gun. She just remembered that she had left his gun in the car. She was trying to come round him when the big man pointed his gun at her: "Hands up, Major Nelson or I will shoot!"

On the stout husky man's face, there was a fresh but superficial wound scar. Hannah closed her eyes. She had seen him before. Where? That's right! She remembered. He was the one she saw in the equestrian club in front of the elevator.

She looked at his boots. They were the same. With excitement, her nose positively wrinkled with passion, and she started breathing rather fast.

"Is Anna Cooper related to the virus?" Upon the heels of which thoughts, she floated a terrible pain blossomed in her knee. It was one of the soldiers who suddenly kicked her knee. She bent the knee. The WHO team was also arrested.

Hannah, Tom, and Ivan's hands were bounded behind the chair with plastic straps, and except Hannah, a napkin tied tightly over their mouth. Colonel Taylor had sat in front of them, with a lighted cigarette in his mouth and gazing at them. Eventually, he put his foot on one of them and said angrily, "I wash my hands of you, Major Nelson. I warned you to keep your nose out of my business."

Hannah narrowed her eyes, pursed her lips, "What's the matter?" She shouted. "We finally know what's going on here. Wasn't that what we were supposed to do?"

Colonel got up and walked around them and stood in front of Ivan. He pulled the napkin out of his mouth savagely. Ivan sighed loudly. His mouth was about to rip off. He put his hand in Ivan's curly hair and pulled it heartily. Ivan screamed. Colonel stared into his eyes. "You young man, you are messing with the wrong guy. Weren't you the one who once hacked the Department of Defense systems? And on the front page, you wrote: "Fuck to all of you, with military respect."

Ivan played innocent. Colonel grabbed Ivan's neck and pressed hard. "When I talk to you, answer without delay. Weren't you the same fucken guy?"

Ivan started to cry under the pressure of the colonel's strong claws.

"The cat's got your tongue. Spit it out, I don't have all day." Colonel shouted.

"It was me... But believe me, I did not intend to hack. I, I think I had a few drinks too many. I do not know what happened. I just hacked, and when I recovered, I could not even remember how I did it. Believe me."

Colonel let go of his neck. Ivan coughed continuously. Colonel turned again to him. "And now you are working for Major Nelson! Maybe you were drunk now that you were penetrating our system!"

Tom and Hannah floored to hear that. "No, I was not drunk," Ivan said, embarrassed under the gaze of Tom and Hannah. "I was just curious to find out about your work. Neither Major Nelson nor Mr. Forrester knew of my work. I did it on my own."

Hannah shook herself. She was about to fall to the ground in a reclining chair. “What the hell is going on here?”

Colonel turned to Hannah: “Major, it was all your fault. You should not have involved criminal people in this sensitive issue. We will turn you over officially to the F.B.I. I will take care of these two guys.” He took a deep pack of his cigarette and then left the tent.

“I penetrated their system,” Ivan said sharply. “Believe it or not, the Department of Defense knew where the virus came from. There is a secret biological laboratory nearby. There they perform different experiments on different animals. They make new drugs and biological weapons. It’s unbelievable, they knew.”

“Then that infected mouse,” Hannah said surprisingly. “That white mouse... got out of that lab.” Ivan shook his head. “What will happen to us now?” Ivan said regretfully. “I... I’m afraid.”

With his mouth closed, Tom looked at Hannah. Hannah could not bear it. She hung down her head. “Colonel is right. It’s all my fault. I got you involved.”

All three were silent. Suddenly Ivan turned his head like an ostrich and explored both sides of himself. “There is a smell, the smell of burning plastic.”

His sentence was not over when suddenly Tom firmly separated his two hands. The plastic handcuff was just burst from his hand and fell to the ground. There was a small lighter in his hand, which was still lit. Tom opened his mouth.

He took a deep breath. “Thank you, WHO Team. I took this out of their box as soon as we were arrested.” Then he started to pull the rope around himself with his hand, and as soon as he wanted to get up towards Hannah and tear her rope, he stopped hesitantly. “Major, I can punch your face, then we will run away. You will be acquitted.”

Hannah shook her head with sighing disapproval. “No, Tom. I started this adventure myself. I will finish it myself too. Open my hand.” Tom shook his head and began to open her hands and then Ivan. Hannah quickly got up and picked up the knife on the table. Ivan also went to his laptop, which was on. He closed it and put it in a military bag.

The sound of footsteps approaching the tent could be heard. It was Colonel Taylor. As soon as he entered, Hannah humiliated him from behind and then hit him on the ground with a hard blow.

Having no idea about what’s going on next, Hannah had grabbed the Colonel’s gun. She lifted Colonel off the ground and from behind, hand to the neck, put the gun to his forehead. “Colonel, we need your help! “You have to get us out of here.”

“You... you are a traitor...” Colonel said in a trembling voice, struggling to free himself from Hannah’s clutches.

Hannah nodded Tom and Ivan to follow her. They all walked to the ambulance in the corner of the parking. Hannah shot up in the air. “Everybody makes the extra unnecessary move, Colonel Taylor will pay the price,” Hannah shouted. “We have nothing to do with anyone. We just want to get out of here. No one will follow us.” Pushing his gun to Colonel’s forehead, he flattered. “Open the way, do nothing.”

They all got in the ambulance. Tom leaped into the driver’s seat. The ambulance left the factory area at high speed. As the ambulance moved away, Colonel Taylor's men regained themselves. A helicopter took off to track them down. Despite lots of potholes, Tom swerved expertly to avoid them. He had entered the freeway. It was growing dark. The ambulance was moving in the opposite direction of the cars. With Tom's sharp turns, the oncoming cars swerved away from him. The ambulance was speeding for 20 minutes aimlessly on the freeway to Los Angeles.

Panting, Hannah pointed the gun at Colonel. Tom also occasionally turned his head and looked at her and Ivan. The helicopter was now fully monitoring the ambulance with its spotlight. Tom was looking up as Ivan showed him from behind, a small local tunnel on a side road parallel to the freeway. Tom turned the steering wheel as hard as he could. The ambulance leaped into the side road.

The helicopter was still coming after the ambulance and now the C.H.P were also seen, comming from the front. A few hundred yards before they reached the tunnel, Tom shouted, "We're going down the tunnel, be ready." The ambulance entered the tunnel a few seconds later. The helicopter soared and spanned. At the same time, all three got out of the ambulance and walked out of the tunnel in the opposite direction.

Realizing that he was done in, the pilot returned and landed on the ground. Several armies got out from inside of the helicopter. An ambulance was seen inside the tunnel. Its lights were flashing. When they reached the ambulance, they saw Colonel. He was in the ambulance with a closed mouth and injured head, but the three had disappeared.

In the dark of night, the three entered a dirt and forest path that led to a village. All three, tired and dumplings, sat on a piece of rock. Nobody said anything. Ivan opened his laptop. The light on his laptop screen flashed and even dazzled their eyes.

"What do you want to do?" Tom turned and asked.

"I want to text Lisa," Ivan said. "Now she is in her father's house. Her own house is empty. Let's go there and wait for the dust to settle." Nobody rejected this idea. Ivan started writing to Lisa! After 4 hours of long waiting, Lisa finally reached them and took them home.

When they arrived at Lisa's house, Hannah's spirit was quite jaded with what happened to her. After the dust had subsided, she realized the seriousness of her situation. Until three hours ago, she was a conscientious cop, and now she was a fugitive criminal. Without any extra words, they lay down and slept in every corner they found and what kind of sleep, so that they could not wake up until 10 am tomorrow.

First, Tom woke up. It took him a few seconds to figure out what had happened to them last night. He looked at Hannah and Ivan, who was sleeping peacefully. He got up and went around to the house. He saw a violin in the living room. He picked it up and looked at it. It was a handmade Strunal violin. At that moment, Lisa entered. She put the things she had got on the table. "Oh, did you wake up, Mr. Forrester? " She said with the delicacy that doesn't suit to her young age. "I have breakfast for you."

Tom walked over to her and grabbed her by her slender shoulders. "I hope we didn't bother you." Lisa smiled. "No, you helped Ivan a lot. I wanted to make up for it somehow." Tom smiled kindly. "Are you a violinist?"

Lisa moved closer to Tom. She shook her head to let go of her golden hair from her eyes. “Yes, by the time I was five…” Tom took a deep breath. “You have a good violin. If things are going well, I will make a new one for you. I promise. The best violin I have ever made. I hope things could get pleasant so I can keep my word.”

Her eyes flashed. As if she had known Tom for years, she jumped into his arms and hung around his neck. Tom was shocked for a moment, then he started laughing and grabbed Lisa by her back and laid her down gently.

“Thank you so much,” Lisa smiled, staring at his eyes. With these noises, Hannah woke up faintly. They say any mental anguish subsides after a good night’s sleep. But Hannah’s eyes did not say that. She was downhearted yet.

Seeing Hannah’s anxiety, Tom confidently untied Lisa’s arms around his neck, dropped her, and sat down next to Hannah. He grabbed Hannah’s head kindly and pressed it to his chest. Hannah snorted. It is as if she subdued the choky feeling in her throat and steadied her lips. Then she put his hand on Tom’s stomach. “Hannah, darling,” Tom said, “I know your feeling. I wish you hadn’t come with us, I wish...”

Tom’s eyes fell on Hannah’s stray yellow tear trickled down her face. Hannah turned her head so that Tom could not see her wet face. “We restore our blacken reputation again.” She said softly. “If we were arrested, the truth would be buried with us. We are all here for the truth.” Then she pulled herself out of Tom’s arms. “I found out one more thing yesterday. I saw the man I already saw at the equestrian club again on Colonel Taylor’s team. He was the one who arrested and handcuffed me.”

Tom was surprised. He turned more to Hannah. “Are you sure?”

Hannah shook her head. “So with that in mind, the key to solving all the puzzles is in that secret lab,” Tom said again. “Damn it ... it was a few steps to get there.”

Hannah put her face between her hands. “I have no doubt Anna Cooper has something to do with that lab. I don’t know what, but I have to find it.”

Meanwhile, Lisa had prepared a brief breakfast. Tom and Hannah went to the table. Ivan, who was lying on Lisa’s bed, got up and joined them. They all just remembered how hungry they were. “We bummed them out,” Ivan said as he swallowed his meal. “They all were a wet blanket.”

Tom stared into Ivan’s eyes. It was as if he had remembered something: “Did you really hack the Ministry of Defense system?”

Ivan swallowed his bite hardly. “I did, but I don’t remember how I did it. I was drunk, and I had written some strange codes. Then when I got conscious, I didn’t understand what I did. They even sent me a secret message that if I showed them their bug, they would reward me. But believe me, I couldn’t do it again until yesterday when I saw their receivers next to the command tent. I was tempted to try again. I saw an officer logged into a mysterious system. It occurred to me that I had seen something like that before. I secretly reached behind the radio transmitter and receiver and penetrated the system through its internal LAN, and by reading the messages, I reached to the secret laboratory existence.”

“Well, what then?” Hannah said carelessly. “With one wrong move, you got us all in trouble! We were one step closer to victory."

"It was not wrong as you think," Ivan replied triumphantly. "I was able to penetrate to the central laboratory system, which was exchanging data with the Ministry of Defense data center in high-security protocols. I backed up a large part of highly classified materials in the last six months."

"Oh, you got to be kidding. How did you get the hold of it?" Tom said, but he didn't wait for the answer. "Perhaps with this data, we can understand how those mice got out."

"Oh... I have a list of emails exchanged through the internal intranet," Said Ivan, who was stuck in the laptop. "I reviewed them last night before going to bed. A report illustrated that about a month ago, an intrusive attack on the laboratory system has taken place. Perhaps there is a correlation between those mice and this intrusion."

Hannah put her hand on her head. "Weren't you?"

"I wish it were me," Said Ivan stoutly. "But no, this time it was not me. In their report, it is written that the hacker has penetrated from outside, and they have even tried to pretend that the hack was done relevant with the hack I did a few years ago."

"That's why now they've seen you've penetrated. They thought it was your job too," Tom said with his troubled hand on chin. "Or they wanted to arrest you and pretended that you are in charge of the whole story anyway."

Ivan shrugged. "They are wasting their time. By the way, I read another interesting report. In this laboratory, they use various machine learning algorithms to develop new drugs. One report stated that using machine learning algorithms has led to a reduction in primary drug development from 3 years to less than two months. Isn't it wonderful?"

Tom sat back in his breakfast chair. "This is not so strange," Tom said as he grabbed another bite of cheese. "But the intrusion is unusual. It may have something related to the mice. If we have the entry and exit data to the Lab, we can find out who behaved unusually."

Ivan confirmed that he has an employee's entrance and exit data for the last six months. "Good," Tom continued. "So another lesson is on the way."

Lisa, who had been sitting in silence with a look on her face of good-humored scorn, broke in. "Lesson? Are you kidding? "What are you talking about?" Ivan put his hand on Lisa's neck with a laugh. "No, honey. We're learning machine learning with Tom."

"No!"

"Believe me."

"The last time, Association rules helped us find the root of the virus," Tom said, lifting his eyebrows and ignoring their lovemaking. "Now another unsupervised learning approach can help us figure out who penetrated the system abnormally and possibly sabotaged it. Clustering is another unsupervised learning approach that we are going to talk about it."

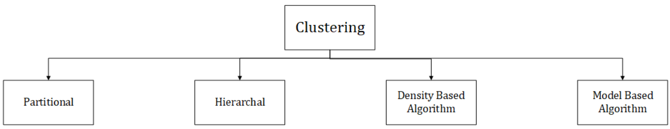
Ivan cooed shrewdly and sweetly. "Yeah, I like that stuff!"

"Clustering is generally used to find similarities between different existences." Tom continued. "In one viewpoint, clustering is also seen as an auxiliary approach to supervised learning algorithms. Do you know why?"

Hannah, who was in good humor, now replied, "Probably because it helps with data labeling. That is because it puts similar inputs into clusters. It's like labeling them."

"Exactly," Tom said while he swapped a customary wink with Hannah. “Well, for now, let us know how does this approach work? It should be said that finding similar inputs is not limited to a specific algorithm. Clustering algorithms are generally divided into four categories:”

He bent down and drew a shape on the shopping bag:



First of all, I have to say that running different clustering algorithms on the same data may result in each point being placed in a different cluster,” Tom said. “Each clustering algorithm, based on its model, somehow tries to find similar entities. Mathematically speaking, the similarity can be considered as the inverse of the distance. In mathematics, calculating the distance between two points is possible in several ways…

The first distance function is the Euclidean distance, which calculates the shortest distance between two points based on the Pythagorean theorem…

If x and y are two points with p components, the euclidean distance can be calculated as follows:

$$D_{euc} = \sqrt{\sum_{i=1}^{p}(x_i - y_i)^2}$$

Euclidean distance is always a non-negative number. In some cases, even if a straight line can be drawn between two points, which is the euclidean distance, such a distance cannot be crossed. Consider the Manhattan area of New York City. In this area, residential areas are checkered and can only be moved from one point to another in blocks. This has led to the introduction of another distance called the Manhattan distance. If x and y are two points with p components, the Manhattan distance is defined as follows:

$$D_{man} = \sum_{i=1}^{p} |x_i - y_i|$$

If we use the absolute value of the distances instead of the square of the distance in the euclidean distance, the manhattan distance is obtained. In general, the euclidean distance and the manhattan distance are special forms of a general distance called the Minkowski distance. If x and y are two points with p components, the minkowski distance with the parameter d is defined as follows:

$$D_{mink}(x, y, d) = (\sum_{i=1}^{p} |x_i - y_i|^d)^{\frac{1}{d}}$$

At this distance, if $d = 2$ then the euclidean distance is obtained, and if $d = 1$, the manhattan distance is obtained. If $d < 1$, then the resulting shapes will be concave, and if $d > 1$, the shape will be the convex distance between two points. If $d \to \infty$ then the maximum distance between two points is obtained, which is also known as the Chebyshev distance, and if $d \to -\infty$ then the minimum distance between two points is obtained."

"Let me digest," Hannah said softly, reaching out her hand to tuck a curl behind her ear. "You describe different types of distance measures to model the similarities. Suppose we find all types of distances between two points, and in fact, all similarities. How do we know which of the similarities is the most appropriate similarity between the two points?"

"It's a good question." Said Tom, dawn breaking over her face. "There is no one best way of doing machine learning. Everything is systematic trial and error and each data require its own method. Each model should be tested against reality and evaluation metrics. This is the beauty of mathematics. The evaluation metrics are numerical values, and whatever the numbers say, it will be true. The land of mathematics is free of fallacies."

Ivan entered the field, too: "If each distance metric were used in clustering, it would be a new clustering method. Isn't it?"

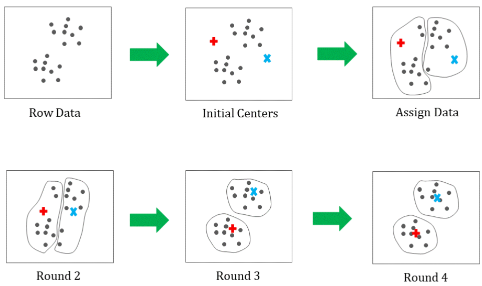
Tom raised his eyebrows. "Hmmm, both distance measures and other parameters have led to different clustering methods. The simplest and most widely used clustering approach is the partitioning approach, and its most famous algorithm is the K-Means algorithm…

This algorithm works based on the selected centers that we specify. We tell this algorithm I want to have two or three or four clusters and now tell me which entities are in which clusters. The parameter of the number of clusters should be determined in this method.

The functionality of this algorithm is simple. Suppose we have two properties for each entity. That is, our space is two-dimensional. First, we create random centers in the space for the number of clusters we want to have. Random centers are two points. We calculate the distance of all points in the data from these two centers in the next step. And in the next step, we assign each point to its nearest center.

So far, each point is dedicated to only one of the centers. In the first step, two clusters are obtained. Has clustering completed? No, we have to repeat it. In the next iteration, we calculate each cluster's average point and consider them as a new center, and again we assign each point to the nearest center. We continue this process until the assigned points to previous iteration centers don't change as centers change. Let me draw its shape for you:"

On the sheet of paper facing him, he drew a shape:



"Well, I also studied engineering at university." Said Lisa, who seemed to be interested in the topic. "If I understood correctly, this algorithm would be sensitive to outliers. Because just one outlier point can change the result dramatically."

"You're right," Tom replied, glancing up at her with admiration. "As a general rule, an algorithm that works based on averages and central statistics indicators are sensitive to outliers. But if the outlier is too far away, it will make a separate cluster."

"Ok," He restarted. "The next point in the K-Means algorithm is that this algorithm reaches the local optimal point in terms of mathematical optimization because, in the first iteration that the clusters do not change as the centers change, the algorithm also stops. Many improvements can be suggested for this algorithm: from choosing initial centers more systematically or changing the type of distance for measuring similarity, etc., all can be upgraded."

"Now, how do we know what the best number of clusters should be?" Hannah asked, squaring her shoulders and turning to Tom.

Tom paused, then bent down to write something down and replied, "This is an important issue. The best clustering is the clustering where the points inside the cluster are closest to each other and are the longest distance as they can from the points outside the clusters. Based on these two criteria, various types of clustering evaluation metrics have been created. In one method, by using one of these metrics, we can customize the number of different clusters…

The number of clusters that report the best number for that metric is the best number of clusters. Selecting the best parameter in machine learning algorithms is called Hyper Parameter Selection, and how a series of candidate numbers is considered to the best parameter select among them is called the Grid Search method."

"I searched for clustering metrics," Ivan said, his face dropped on his chest because of gazing at the laptop. "In general, they are divided into two types of internal metrics and the external one, right?"

"Yes." Tom immediately replied. "And the metrics, which are the combination of internal and external metrics. Let us not forget that these are distance-based metrics. Our metrics may also be the number of points within each cluster, and we somehow want to divide the points by the relative balance between the clusters...

The most popular distance-based metrics for evaluating clustering are the Davies Bouldin Index and the Silhouette Index. The lower the Davies Bouldin index, the better the clustering. The Silhouette index is also between -1 and 1, and the closer this index is to 1, the better the clustering."

"Well, now we can find out who penetrated to the Department of Defense system," Hannah asked enthusiastically.

"If we give the model good features that accurately represent how a penetration can be done, we can hope to detect abnormal intrusion. Of course, it is better to learn another model and compare the output of both models and then infer." Tom replied kindly. Hannah acted up herself on Tom.

Tom took a deep breath and continued: "The next approach is hierarchical clustering algorithms. In this approach, it is not necessary to determine the number of clusters from the beginning. Many algorithms have been developed in this area, but they all have common principles, and I want to describe those principles here."

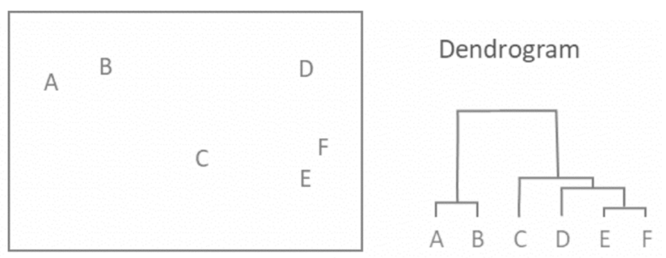
"There are two types of hierarchical clustering algorithms," Tom said, quenching his thirst with fresh milk. "Agglomerative and Partitioning algorithms. The way the two approaches work is almost the opposite. So it is enough to explain one of them. Let me explain the Agglomerative approach:

Suppose we have 6 points and entities. In the Agglomerative approach, it is first assumed that each point, and indeed each entity, is itself a cluster. In the next step, the distance of each point is calculated. Since only one Agglomeration must occur in each iteration, the two points with the shortest distance are merged. We have 5 clusters, 4 of which are 1, and we will have a cluster with two members…

In the next iteration, the distance of each point is calculated again. However, this time we have a cluster with two points, and there are several strategies for calculating the distance between this cluster with two members and the other clusters with one member…

If we calculate a single-member cluster's distance to the farthest point of a two-member cluster, we use the Complete-Linkage method. Let's compare a single-member cluster's distance with the point near the two-member cluster to a single-member cluster. We use the Single-linkage method. If we calculate a single-member cluster's distance with the average of two points of a two-member cluster, we used the Mean linkage method Unweighted Pair Group Method with Arithmetic Mean (UPGMA). Other methods can also be used.

These iterations continue until all the points eventually become a single cluster. Since this iterative process leads to creating a hierarchy between clusters, these approaches are known as the Hierarchical Approach. Let me draw its shape:



All four stared. “What does this dendrogram you wrote mean?” Lisa asked in a dumb manner.

Tom leaned back in his chair. “The dendrogram shows a hierarchy of Agglomeration or Partitioning. Based on this hierarchy, we can decide how many clusters we want. By drawing a horizontal line from anywhere on this graph, the number of lines it intersects with will give us the number of clusters at that level of the hierarchy.” Tom fell silent. Nobody said anything. Everyone was deep in thought of dendrograms.

Tom broke the silence. “We have learned two clustering algorithms. Now we can cluster the data of people entering and leaving the Ministry of Defense’s secret laboratory. Just before that, there is one more important point that I have to mention, and that is the normalization of features or independent variables we have…

Suppose we want to cluster the customers of a bank. We consider various features for the customer, including the average amount of transactions and the length of time that person turned to be our customers, the number of visits he had before, etc.

As you can see, each feature has a different scale. The first is dollars, and it ranges from a few hundred dollars to several tens of thousands of dollars. The second includes the length of time she is a bank customer, from a few days to a few hundred days, and the number of visits from one to several tens. Each feature has a different scale, and this makes clustering affected by the scale of the features. For this purpose, each feature should be normalized based on its own elements. There are two types of normalization methods. In the first method, the data is squished into the range of 0 to 1. The formula of this method is as follows:

$$\frac{x_i - x_{min}}{x_{max} - x_{min}} \qquad i \in X$$

Of course, the range can be defined as desired with the following formula:

$$\frac{x_i - x_{min}}{x_{max} - x_{min}} \times (r_{max} - r_{min}) - r_{min} \qquad i \in X$$

Where the data corresponds to the interval $[r_{min}, r_{max}]$. If $r_{min} = 0$ and $r_{max} = 1$, then the same initial state will be obtained.

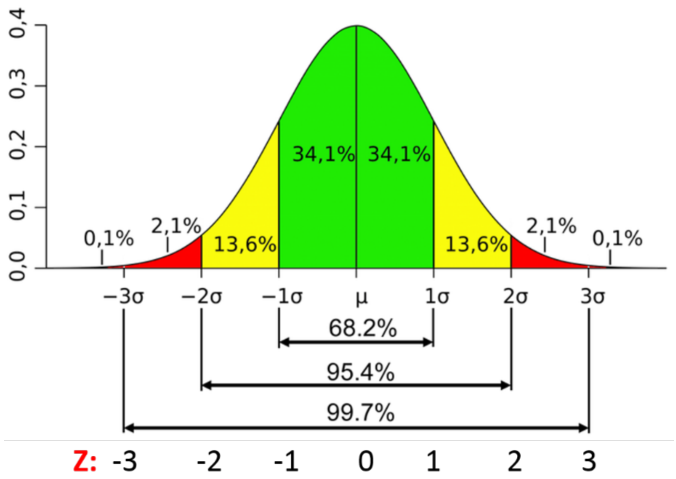
Alternatively, we can use the logic behind the standard normal probability distribution function to normalized data. The formula for this type of normalization is as follows:

$$\frac{x_i - \mu}{\sigma} \qquad i \in X and (\mu, \sigma \sim Normal)$$

"With this linear transformation, the data will have a mean of zero and a standard deviation of one, and the range of data will expand from -3 to $+3$ in 99.7% of cases."

"Why -3 to +3?" Interposed Ivan.

And Tom replied, "Because if we take the total area of the normal density distribution as one, which is equal to the probability of all points to having occurred, and if we move three sigmas from both sides of the average normal distribution to the corners, we will pass almost 99.7% of the whole possibility. Let me draw its shape for you:



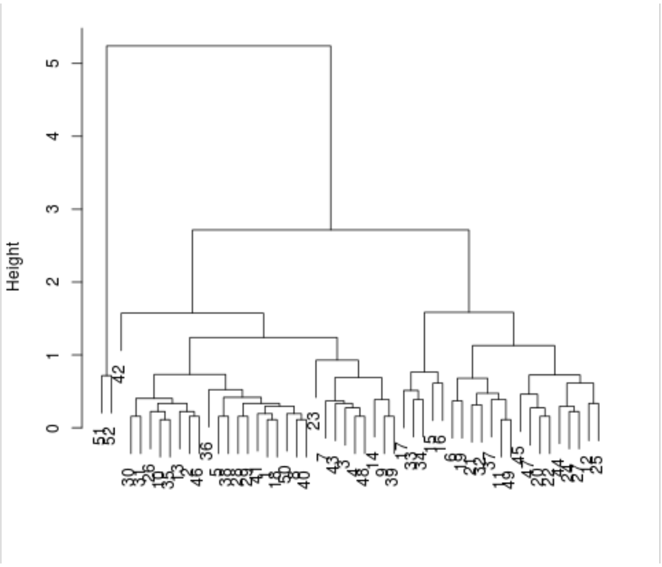
In general, data normalization can be used for both supervised learning and unsupervised learning approaches. But its necessity becomes more important in the clustering because of the effort to find similarities."

Tom straightened his back and took a deep breath. "Well, that's enough of a lesson. Let's go to the heart of the matter and see if another truth would be discovered or not."

Hearing this sentence, Ivan, as if the commander had issued an order to attack, re-entered the squat style and placed his laptop on both feet.

Based on the six-step method, Tom and Ivan began to discuss implementing two clustering algorithms on data. Feature Engineering, designed based on three features: *The average fraction of the number of entries to the number of exits from different doors of the laboratory, Average time* *interval between consecutive entries and exits per person and Time interval from today to the last date of entering per person* were aggregated and integrated.

To determine the best number of clusters, in Tom's opinion, a hierarchical clustering algorithm was first implemented to illustrate the best number of clusters. After running the algorithm, the following dendrogram shape was obtained for people to enter and exit:



All four focused on the resulting dendrogram shape. "Look at numbers 51 and 52," Hannah said, "If we have two clusters, these two will be in one cluster, and the rest of the entities will be in another cluster!" "That's right," Tom nodded. "Ivan, can you implement K-Means clustering with two clusters? Let's see what the result will be!"

Ivan started working and, a few minutes later, showed the data table with the allocated clusters. Again, the two points, 51 and 52, were in one cluster, and the other points were on the other cluster. "It's really strange." Said Ivan dazedly.

The average fraction of the number of entries to the number of exits from different doors of the laboratory is 2 for this cluster. Average time interval between consecutive entries and exits per person is less than 3 seconds, and Time interval from today to the last date of entering per person is 40 days, that is, about a week before the virus spreads. In total, Two people entered and left only in one day, and the total entrances and exits that took place for this two guys are 3."

"It's weird," Tom said, playing with his curly beards. "The characteristics of both IDs are very similar, and both are strange too. Unusually, the entry and exit distance are less than 3 seconds. This is not the job a simple man can do. No human can enter the system and immediately sabotage and exit almost in no time."

"Maybe the work was done with the help of a computer," Said Hannah eagerly. "Like apocalyptic movies."

"Maybe it's the work of a superior intelligence," Ivan added. "Or even artificial intelligence, remember, I said that, in the same lab, they use machine learning algorithms to develop new drugs. Maybe it was not external penetration, and an agent from inside the system itself has disrupted the core system. Something like a super-intelligent algorithm."

Hannah bluntly cut Ivan's words, "A human being must also activate the algorithm." And then, as if seeking Tom's approval, she said loudly, "right?"

Tom did not answer. He just stared at a spot on the floor and thought. A few minutes later, he raised his head, looking around. “This is not an irrelevant hypothesis either. I do not know why, but I suddenly remembered the last project we were working on. In the last few days, before I resigned from executive and academic positions, we worked on a project that aimed to learn labels without providing labels. I even remember our college team teaching the concept of a dog by exposing a super-sophisticated deep learning model to video data on the web, without recognizing any dog concept to model. It isn’t unlikely that a highly advanced algorithm has disrupted their systems. Now either by accident or intentionally.”

“Didn’t you find another report on the true nature of the hackers?” Tom said to Ivan as if an idea had come to his mind.

“No,” replied Ivan abashed. “Of course, I have to say. I was only able to access data up to level four in terms of confidentiality. I do not know about the fifth level.”

Ivan brought up the content of the hacked reports again. Scrolling a few times, he caught sight of a new report. “Interesting,” Ivan said. “A report on suicide which happened on their algorithm design team.”

When the term of suicide came, Tom and Hannah rang their ears. “His name?” Asked Tom, frowning, “Did you find a name?” Ivan began reading the text of the email. “Anna Cooper. Wow. It’s she. Interesting, she was an expert in data science and a drug development system designer with artificial intelligence, as this report claimed.”

“Wow, things got complicated.” Said Tom. “So Anna Cooper was working with this secret lab, what did happen there?"

"Why not ask themselves?" Hannah said confidently.

"From whom?"

"From the commander of the secret laboratory."

"You mean Colonel Taylor?"

"Yes!"

"Are you off your head?" Said Ivan angrily. "We are being persecuted right now. Then you want us to come back to that hell again?"

Hannah raised an eyebrow. "Why not. This is our last chance. There's no turning back. We have to go to the end even if the end is hell. We have to come back to know how the virus has spread and because of Anna Cooper and because of our dignity. Leave it to me."

Anxiously, Tom knocked Hannah up. But he did not say anything. Hannah understood and turned to Tom and nodded her head. Tom closed his eyes and shook his head to tell without a word that I trust you.

07

THE PATTERNED GOD PATHS

Ivan's heart was going to leap into his throat, and his hands were trembling hardly.

"Are you sure the plan works, Major?" Ivan faltered. Instead of answering, Hannah looked at him with wounded eyes. "I am not a Major anymore."

Ivan began scratching his curly hair, and as though he swallowed a bitter pill, he bitterly turned to the window of the Volkswagen Beetle that belonged to Lisa. Tom was behind the wheel.

The car turned from the main road to the forest side road that led to the gigantic mountain covered by thousands of plant species. Tom drove for twenty minutes in the middle of a shattered asphalt and passed the concentrating factory and other local factories. And then, turn the crossroads to the right with a sharp turn.

According to Ivan, the secret laboratory must have been somewhere nearby. Ten minutes after Tom drove down the dirt road, they reached the San Bernardino Forest entrance. From here on, they had to walk. They all got out of the car.

The rays of sunlight among the thick leaves of the big trees blinded them even for a moment, to remind them of the joy of seeing the beauties of the forest again at any moment later. The sound of crickets and the fluttering of birds flying from side to side only disturbed the forest's magical silence. However, this silence was broken by the barking of a dog that seemed to have been hungry for years to eat its prey in the wildest possible way.

Tom rolled his eyes. A huge dog had attacked them at high speed, and specifically Hannah. It was as if it knew her, knew her as a long-time enemy. A few meters away from reaching Hannah, the dog got up and threw itself at Hannah's chest, intending to tear her apart. Hannah, meanwhile, returned agile and kicked the soles of her feet to the dog's face. The dog jumped a few meters away and barked harshly.

The breath was caught in Tom and Ivan's chest. Tom could no longer control himself. The dog was breathing hard. It barked a few times and started attacking again. Simultaneously with the dog's next attack, Tom threw himself in front of Hannah, and the dog, which was now, having found a weaker opponent, snatched Tom's shirt from his neck. Defenseless Tom used his forearm to shield his face but it didn't enough. As soon as it tried to tear Tom's neck, the whistle made the dog the most obedient creature in the world. As long as it pulled his snout in the ground, the buzzing dog reached its owner.

A military squad with large guns in their hands was the only thing Tom could see with gloating eyes. The Rangers commander came forward.

“Congratulations, Major.” Said commander while clapping. “Oh, I’m sorry, the ex-Major. I did not know you were a good fighter. Do you want to try your chance with me?”

“I am not here for the fighting,” Hannah said angrily, while she was cleaning her clothes.

“So you have come to surrender like a loyal soldier.”

“I have come to talk to Colonel Taylor.”

Several Rangers laughed behind the commander. “Wow, you got guts, little girl,” Said commander with a wicked grin. “The Colonel has missed you too.”

Hannah glanced at Tom, chewing her mouth dusts angrily. By order of the commander, all three of them were arrested and blindfolded. They closed their eyes. They rode in an Off-road jeep that easily invaded the forest.

They were locked in the same way as they were in the command tent, this time tighter and rasher than before, with metal handcuffs and blindfolded. Despite this enforced tension, all three were calmer. The door opening sound came. Hannah was straining her powers of listening to find out what’s going on there.

From the sequence and tone of footsteps, it was clear that Colonel Taylor had entered with those particular boots on. The blindfold was removed at the colonel’s command. The Colonel stared at each of them, fierce, hard, and morose.

As was his custom, he set foot on that one and started talking: “You kidnap and then run away and then come back on your own to see me. You are interesting people. I'm sure you are up to something, but you're tripping if you think I would let it slide this time."

There was a certain confidence in Hannah's eyes. Unlike Ivan, who was whimpering and shivering and shaking now. "Yesterday, on my orders, Ivan hacked your system. I wanted to know what's going on there." Hannah said confidently.

Ivan, who knew she was lying, hung down his head.

"But now I would like to talk about your system being hacked a month ago." Hannah continued.

Colonel got furious when he heard this. "That's none of your business." Yelled Colonel.

"Everything about the spread of the virus is our business," Hannah said, staring into the Colonel's eyes.

The color pumped to Colonel's face to leave it as red as boiled beet. He was angry, but he couldn't say anything, and it was making him angrier and angrier.

"And about the nature of the hackers that you falsely wrote in your report was someone else, and you wanted to arrest Ivan to scapegoat for what happened," Hannah said again. "By the way, let's not forget to talk about the suicide of your data scientist, Anna Copper."

Colonel could not bear it anymore. He went furious and slapped Hannah hard on her ears and face. A curl flopped about on her head and blood enlarged on hers nose. Hannah never flinched though strung. The taste of bloody lips made her more determined and rebellious in her goal. But Tom got angry and, jumping up and down on the chair he was tied to. "I'll break your hand," Shouted Tom.

Colonel, who seemed to be enjoying the harassment, turned around and punched Tom's wounded face hardly. "Now it's your turn to beg, do not set a condition for me."

Hannah wiped her bloody nose on her shoulder, then pursed her lips. "No, it's your turn to beg." She looked at the clock on the wall. She said again, "If in 36 minutes, our teammate doesn't hear anything from us, all the information, reports, incidents that happened will be published on the Internet, as well as the real nature of the hacker who was not from outside and was from inside of your systems, and again about the suicide of that scientist and all other lies and deceit you created to convince over positions. Now, do you understand who should beg?"

Colonel choked on his saliva and started to cough. He held his breath for a moment then he gulped the air and began to breathe hard. "Are you blackmailing me?" He whispered, leaning closer.

"Call it whatever you want, Colonel," Hannah replied. Colonel was silent for a while. He was getting softer. He got up and turned around the room for a while, and then stood up. "What the hell exactly are you looking for?"

"Looking for the truth. I want to both drop the charges and vindicate my team and find the truth."

"What assurance do I have that you'll keep your word?"

"Since we have come to you with our own feet and with complete confidence. We are not here to expose you or treat you. We want the truth about the spread of the virus and the nature of the hackers."

As if overwhelmed, the Colonel took a look at Hannah deeply, "Even if you knew the truth, what would you do?"

"Lots of things," Said Hannah, hoping to coax the colonel. "You will have one of the best hackers in the world and one of the best data scientists by your side. For the sake of the people, for people who do not even know what is threatening their safety and health, let's work together."

Colonel was hesitant. Finally, he sat down in front of them. "Truth, puff, you think you make the world turn and you can stop it whenever you want." Murmured Colonel. "Ok, I'll give you the benefit of the doubt and tell you the truth, with one condition. You must promise that our secret will not be revealed until the problem is solved. I owe it to both the Department of Defense and the federal government to rectify this shed, so we can't bring in anyone from outside to inspect the systems. If you can help, I will tell you the story. I hope you won't upset me again."

Hannah took a deep breath. "You have my words. I swear, on my honor, your secret will be a well-kept secret."

By Colonel's order, handcuffs were retrieved.

"You owe me two, Colonel," Tom said to the colonel, rubbing his wrists.

Colonel examined him from head to foot but said nothing. Ivan sent an encrypted message to Lisa not to execute the plan.

Colonel Taylor swallowed, and his throat clicked. It was as if his breath had been opened. "In this biological laboratory, various series of experiments are performed," Colonel began to whisper. "Two years ago, with the arrival of Anna Cooper to our RD team, the testing process and the overall strategy of our lab changed and grew…

Later, several other people were added to Anna's team. What they did was amazing. By doing so, they could reduce the production time of certain drugs from 3 years to less than two months. Their work also caused a stir at the ministry level…

Finally, we were informed about the instructions for starting the secret project: building an artificial super-intelligence system for people's Biometric Intentions. It was supposed to combine biotechnology knowledge with artificial intelligence and combine multiple data from different sources to use people's appearance, their behavior in cyberspace and social media, as well as advanced brain scans along with reviewing historical, philosophical texts, etc., to estimate people's intentions".

He paused and then continued. "This system was a kind of meaning-making machine for human behavior, trying to understand the meaning of what humans do. This project has been on our agenda for a year. The mastermind of this system was Anna. In a few months, the system results have become very promising, only by testing data on people's appearance. The structure that Anna designed for the system consisted of two general components. The first component tried to extract a pattern based on a series of data, and the second component tried to determine whether the existing pattern was the correct pattern or not. Eventually, in a series of round trips, system performance improved. This was Anna's black box. All we know is that the designed system was something like the idea of Hegel's thesis and antithesis and synthesis…

There is a thesis, the opposite thesis is formed, and from the interaction of the two concepts, a new concept or synthesis is created. All this happens in a historical context. One dimension of the data gathering process was based on web crawling freely on the internet, it tried to model, and another component of the system tried to reject the pattern found. As Anna set it, her overall system's objective function was to minimax the performance of the two systems embedded in that cloud…

We called this system **The Deus Machine**. Because, like God, it had nobility in all aspects of people's lives, and we wanted to create something like God who knew the intentions of all people from the footprints they left. This was the way we could prevent terrorist attacks. We should arrest and protect citizens from dangerous people. That was the way we could support democracy."

"It's interesting." Ivan grinned and said. "Support democracy by violating people's privacy. Nice paradox." Colonel thought it beneath his dignity to argue with him.

He looked down on Ivan and continued, "The results were so promising that, at my command, it was decided to do more testing on the more advanced features of the system. Our ultimate goal was to build a system that could act on its own and stop the person with malicious intent if any malicious activity was detected. That was how the Deus Machine came out of a passive state, and now it could take action. The initial results were also progressing."

When he got here, the Colonel pondered. He lowered his head and continued as he exhaled: "Until that catastrophe happened. The Deus Machine had internal mechanisms to fetch, order, and hierarchy data. Only Anna Cooper knew everything about it, inside and out. Data from almost everyone in the world was given as input to the system…

Everything was under control until 40 days ago. I suddenly received shocking news. The Deus Machine was out of control, or, as Anna Cooper said, it had reached consciousness. There was a sudden attack on the entrance control systems of the various doors of our laboratories. In an instant, all the doors were opened. Many animals subjected to various types of experiments, some of which were dangerous, were taken out of the laboratory and into the wild. We either hunted or controlled large animals. We also sent hounds for small animals. We could retrieve 99% of the animals back. We redefined all security systems, but it worked. It was over."

The Colonel fell silent, and they sat together awhile without talking.

"And those mice were able to escape and bring the virus to the city." Hannah interrupted.

The grieving Colonel shook his head. Tom's face showed that he was a cross between a beagle and a pug. "How can an artificial intelligence reach consciousness?" He asked skeptically. "A machine can never reach consciousness like human consciousness."

"But Anna Cooper did not have your opinion." Colonel shrugged. "She was the undisputed master of artificial intelligence, philosophy, and mathematics. She blamed herself for this tragedy. Maybe that's why she committed suicide."

"Artificial intelligence algorithms work based on mathematical and logical rules. Self- consciousness requires understanding the complex relationships of effective and receptive chains of causes and effects," Tom continued skeptically. "Also, it should have perceptive senses. Machines only understand correlation relations and are deprived of perceptive senses. They only know labels."

"As far as I know, and Anna Cooper said, self-consciousness, independent of machine or human or animal, arises in a historical context." Colonel echoed. "The existence of a historical context and analytical power is a necessary and sufficient condition for self-consciousness. That is if a being puts a mirror and sees its past and gives them meaning, it has reached self-consciousness."

"It's not that easy," Tom grumbled.

"These are not very important." Hannah jumped in the middle of Tom's words. "The important question is how should the system be stopped?"

"The most important question is, how does the Deus Machine work?" Tom Said.

"One way to destroy this algorithm is to destroy all the servers in the world, and that means destroying all the information in the world," Ivan said thoughtfully.

"This is pure madness," Tom reiterated. "There must be a better way to destroy it. In this situation, the only thing we can do is to use the traces left by this algorithm to get to know it. We have to use artificial intelligence and machine learning to get to know it. This is the best way."

"Does it mean to make something of our own to fight that algorithm?" Colonel asked in surprise. "Not really, fighting is not the answer," Tom raised an eyebrow. "We need to understand it and use its weakness so that we can find a mechanism to destroy it."

"So where do we start now?" Colonel asked again desperately.

Tom got up. He clenched his fist and replied confidently, "Since this system was born, from Anna Cooper's workplace. We have to access the source code of the written program and see how the algorithm was designed."

Hannah confirmed Tom. The color drained out of the Colonel's face came back as if hope had been pumped into his veins. He was excited. "Very well, I want one of Anna Cooper's co-workers who has worked with her all this time to accompany you. He is not here today, but soon, he will join us."

Tom and Hannah looked at each other. "There is no problem." Hannah put forward. "But I want the technical aspect of this work to go under the supervision of Tom Forrester."

The colonel, who owed him a bit of a grudge because of his sarcasm, knocked Tom upside down and finally said, "Alright!" Hannah and Colonel Taylor's team headed to Anna Cooper's office for further investigation.

Anna Cooper's room was the largest room on the top floor of the Secret Laboratory. Even larger than Colonel Taylor's room. When they entered the room, the room's frosted glass walls, which were covered with unknown formulas and mathematical calculations - from the visitors' point of view - caught Tom's eye. Tom turned his head inside the room. The more he turned his head, the more his eyes widened.

Ivan stepped forward and became more precise on a few formulas, then turned to Tom and shrugged. At the same time, Colonel Taylor had brought Anna's computer up. He got up from behind the chair and said to everyone, "With my special access, the computer is available. We've flipped her computer before. There is no trace of source code."

Ivan went and sat behind the system without allowing himself to get permission from anyone. He picked up the kernel of the operating system and began to explore.

As usual, he had his head in the monitor and crouched doglike beside Anna's table. This gesture was the peak of Ivan's focus. After a few minutes, he turned his head from the monitor. "Nothing, at least on this computer. It's Greek to me, but I could find traces of the Deus Machine where it crawled the web and what, when, and how it got the data.

"We knew this too." Colonel turned away and said. "We have a better and more systematic one. We are looking for the source code, young man."

Tom thoughtfully pulled his beard and approached Ivan. "This is not a bad sign either. If we have the Deus Machine traces, we can understand the process you call self-consciousness. Which factors have had the greatest impact on it? Every step in understanding the behavior of the system will bring us closer to solving the puzzle, though."

Colonel stared at the ceiling for a moment. "Then how do you want to know which factors influenced it the most?" I think the Deus Machine is a perfect black box."

Tom turned to the colonel, "Yes, The Deus Machine itself is a black box. But its footprints are not. Like an unknown creature. We may not know what this unknown creature is, but we can see the footprints it left."

Colonel did not intend to accept. "What next?" Colonel contradicted.

"Then we can recognize the next movement of The Deus Machine and prevent further tragedies at the first step. Would you want the animals of this laboratory to be found at farms, factories, and the people's houses again," Said Tom.

The Colonel pulled himself away from Tom. He did not argue anymore. “Now, how do you want to do that?” He said, turning his back on Tom.

“With Logistic Regression,” Said Tom, a little defensively.

“Do whatever you want, but the data must be analyzed in my presence.” The Colonel turned to Tom again and said. “I want you to explain face to face what you are doing.”

Tom looked at Ivan and Hannah and replied. “Blessing in disguise. You have to attend our class.” Hearing this, Ivan went and sat down on a chair. Hannah went behind him and leaned on the table. “Start Tom, let Colonel Taylor know how we want to find the answers.”

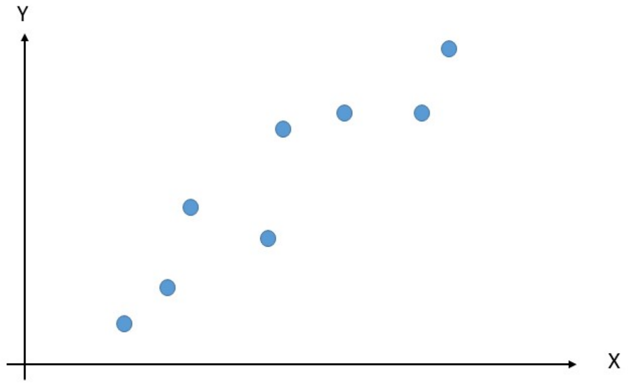
Tom raised his eyebrows. “Well, let me explain. To understand the concept of logistic regression, we must first become familiar with Linear Regression. Both linear regression and logistic regression are subsets of Generalized Linear Models. Let me give you an example of the unlucky mice in this lab. Suppose we want to know whether eating a dietary supplement, which we call an independent variable and denoted by x, causes the longitudinal growth of mice, which we call a dependent variable and denoted by y, or not.”

“What do you mean by an independent and dependent variable?” Hannah jumped in the middle of Tom’s speech.

Tom was watching the colonel’s movement. Colonel, shocked by the argument’s seriousness and did not expect a sudden start, went and found a place for himself and sat down.

Tom seemed to rouse himself. “When we observe an effect, we accept that there must be at least one cause. Cause affects the effect but is not affected by the effect itself. The effect is in some way dependent on another cause or causes. For this reason, we call the cause an independent variable and the effects as a dependent variable. The theorem of an independent and dependent variable is also a theorem of cause and effect. In the example of machine learning that you have already been told, the independent variable is our features, and the dependent variable is our labels."

Hannah shook her head. Tom went on, "In the example of mice, we have the different amount of supplements that mice ate, and we also stored their longitudinal growth rate. Suppose the shape of two independent and dependent variables is something like this:"



After drawing the shape again, he continued: "Several questions can be raised about the dietary supplement of mice and their longitudinal growth:

- Is there a relationship between dietary supplementation and longitudinal growth rate?

- If so, how much can you expect, on average, to increase longitudinal growth per gram of dietary supplement?

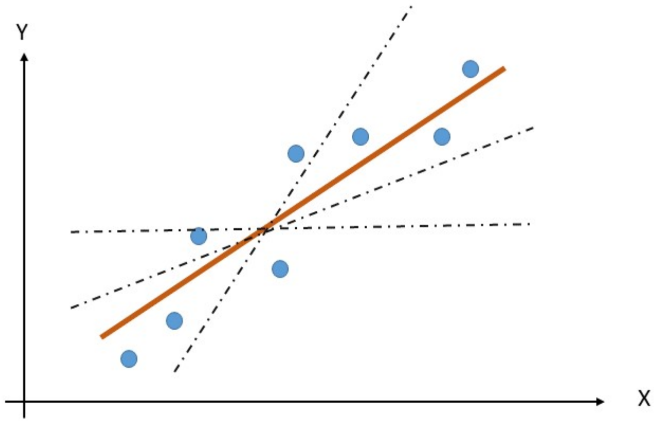
- If there wouldn't't be a dietary supplement, what was the average longitudinal growth?

- In general, what will be the amount of longitudinal growth in the future, and for unmeasured dietary supplements?

- What is the significance of the dietary supplement variable in the longitudinal growth of mice? In other words, is the total longitudinal growth caused by dietary supplementation or not?

All of these questions can be answered by regression analysis. In regression analysis, we seek to describe all points with a pattern so that that line represents all points. The pattern can be a line, a curve, or a page. In our example, the pattern is a straight line. Now the question is, what is the best line to describe all the points?"

Bend over and draw a few lines on the previous figure:



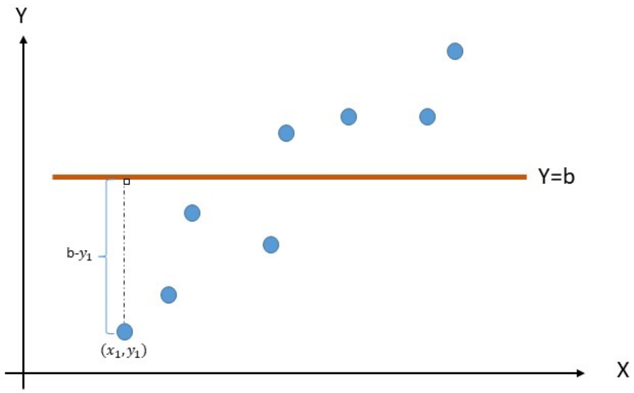
"So tell me, what is the best line to describe the points?" He said again. For a while there's silence.

"The best line is the line that creates symmetry between the points," Hannah concluded.

"If our assumption is to draw a straight line, symmetry may be helpful, but in some cases, the pattern we fit is a nonlinear polynomial curve," Tom said, taking a deep breath. "Symmetry no longer makes sense here. So we have to use another approach called the Least Squares Error. The best line is a line whose distance from each point is as small as possible in terms of least squares. First, let's look at the equation of a straight line with an independent variable and a dependent variable, which is:

$$\hat{y} = \hat{\beta}_1 x + \hat{\beta}_0$$

By defining $\hat{\beta}_0$ and $\hat{\beta}_1$, a line can be determined. Different $\hat{\beta}_0$ and $\hat{\beta}_1$ cause different lines to differ from each other. So if we can define the best $\hat{\beta}_0$ and $\hat{\beta}_0$ for our data, it is as if we have defined the best line. For simplicity, suppose our best line is a horizontal line:



Now let's calculate the distance of each point from this line. In short:

$$RSS = \sum_{i=1}^{n}(b - y_i)^2$$

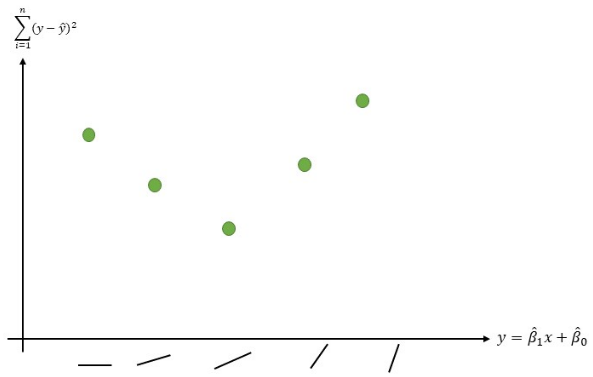
Each of the $b - y_i$ is called the residual. The total distance is the square of these residuals. That is why it is also called RSS. So to find the best line, we have to minimize this distance function."

"Why has it reached the power of two?" Ivan exclaimed in surprise, "Wasn't it enough to subtract residuals?"

"Because some of the numbers are above the line and some are below," Tom stared into Ivan's eyes.

"Multiplying by power helps not taken into account the effect of negative and positive numbers in calculating the distance."

Ivan turned in his chair and rubbed his jaw, saying disgustedly why I didn't think of that. "If the distance formula is calculated experimentally for different lines." Tom continued. "The values of the numbers obtained for RSS will be more or less like the figure below."



From the figure, we can see which $\hat{\beta}_1$ is obtained for the lowest RSS value. But it is not always possible to draw a shape. "It's supposed to be a better way, isn't it?" Colonel, Hannah, and Ivan were caught in a cleft stick. "We have to derive, right?" Finally, Ivan jumped up excitedly and said.

"That's right." Said Tom. "If you remember from high school math, to find the minimum of any function, we have first to take the derivative and make it equal to zero, and for this function, we can find our unknowns, $\hat{\beta}_0$ and $\hat{\beta}_1$. If we do a little differential equations math, the optimal values for $\hat{\beta}_0$ and $\hat{\beta}_1$ will be:"

$$\hat{\beta}_1 = \frac{\sum_{i=1}^{n}(x_i - \overline{x})(y_i - \overline{y})}{\sum_{i=1}^{n}(x_i - \overline{x})^2}$$

$$\hat{\beta}_0 = \overline{y} - \hat{\beta}_1\overline{x}$$

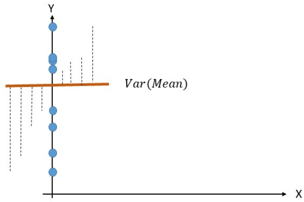
And then he continued, "where $\overline{x}$ and $\overline{y}$ are the averages of the independent variable and the dependent variable from the historical data. With these two formulas, we can find the best line. $\hat{\beta}_0$, or coefficient means One unit increase in x causes how much change in y. In the example of mice and dietary supplementation, the coefficient indicates a one-gram increase in dietary supplementation leads to how much change in longitudinal growth...

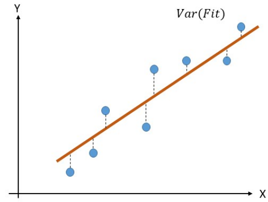
The sign of $\hat{\beta}_1$ indicates the type of change - increase or decrease. And the interpretation of $\hat{\beta}_0$ is that if the variable $\hat{\beta}_1$ is not in use, what will be the value of the variable y?"

The topics were also interesting for Colonel. "How do we know that the variable x alone is sufficient to describe y and no other factor is needed?" Asked Colonel.

"This is an important question," Tom said. "We need to determine how much of the total y can be described by variable x. For this purpose, we use an index called $\boldsymbol{R}^2$. The $\boldsymbol{R}^2$ the index says that the variable x describes what percentage of the variance around the variable y."

After drawing two figures, he continued, "If we project all the points on the vertical axis y, the variance of the points around their mean, in a way, indicates the amount of total information in the variable y. Now, if we get the variance of the points around the fitted line, which are residuals, we can say how much of the variance x can be described by the variable y.





The formula for the index R^2 is as follows:

$$R^2 = \frac{Var(mean) - Var(Fit)}{Var(Mean)}$$

The R^2 index is between 0 and 1. “The closer it is to 1, the greater the importance of the independent variable is in describing the total variance.”

“Perhaps you want to ask again why R^2 and not just R?” Tom said, after a pause, looking at Ivan. “I happened to have a question.” Ivan laughed, scratching his head. “But I feel it’s ugly to ask again. What is the reason for the power of two?”

Tom laughed. It was rare to be in a good spirit like now. “Well, R is the correlation coefficient between the two variables,” Tom replied in the same tone. “But the problem is that, for example, we cannot say that $R = 0.7$ is twice as good as $R = 0.5$. The index R^2 is the cousin of R and in fact, it’s square and solves the problem of R interpretability. We can quite claim that $R^2 = 0.7$ is numerically 1.4 times better than $R^2 = 0.5$”

Ivan raised his eyebrows and asked again, “So if R^2 is large and close to 1, does that mean we do not need another variable to estimate the dependent variable?”

Tom took a deep breath. He thought about it and then said again, "On one condition, such a claim can be made. If R^2 is reliable. That is, random processes do not cause it. In some cases where the data is low, the number of R^2 maybe misleading. For example, if we have two points and fit a line, R^2 will be 1. Therefore, in such cases, based on the number of data and the number of parameters of the fitted model, we must show that the number obtained is reliable. In statistics, hypothetical tests are used to show this. If $R^2 = 0.7$ is obtained, we should investigate whether this number is reliable or not. In the hypothesis test, we first assume that this number is not so and the number obtained due to random processes. It goes like this:

$$H_0 : R^2 \neq 0.7$$
$$H_1 : R^2 = 0.7$$

If we can show that the null hypothesis is rejected, we show that the obtained number is reliable. There are several statistical tests to evaluate the hypothesis. One of the most important tests is the F or Fisher test, the formula of which is according to what I write:

$$F = \frac{Var(mean)/Var(fit)}{Var(fit)/n-p_{fit}}$$

The numerator of the fraction represents the amount of variance that the fitted function could describe. In a way, the numerator is R^2, except that the effect of the number of parameters of the function, which we call the degree of freedom, is reduced. The denominator of the fraction also represents a ratio of variance that the function could not describe."

"The degree of freedom?" Said Hannah, surprised to hear the word. "What is this?"

Tom turned the pen in his hand. "The degree of freedom is very important and at the same time so vague concept, and for the deep understanding of it, we are supposed to delve deeper into the statistics. But for our work, I will give a simple explanation...

In the numerator case, we are trying to show the actual amount of variance described by the line and to do this. We compare a line with two parameters with the mean line that had one parameter and was a fixed number...

The effect of the number of parameters added must be removed from the amount of variance described to obtain the actual number for variance. In the denominator of the fraction, it should be said that the more parameters we have in an equation, the more data must be available to be able to construct that equation. For example, drawing a line requires at least two points. Drawing a page requires three points. Therefore, the effect of the number of available data and the number of parameters of the equation must be subtracted from the fitting variance obtained to see what proportion of the undescribed variance remains...

In our aforementioned straight line, the value is $p_{mean} = 1$ because there is only one parameter, while $p_{fit} = 2$ because there are two parameters in the line equation, and the number of data is equal to 8."

Tom turned to Hannah to see whether she got the point or not. Hannah said nothing.

"Now if we have a number for F." This time Ivan asked. "How do we interpret it?"

Whispered Tom at once. "The value obtained by F is called p_{value}. The p_{value} must be a small number to know that the number R^2 obtained is reliable. p_{value} Conceptually represents the probability of the event under investigation in the observed data compared to the probability of the event occurring at random. If the observed data is similar to the data generated by a random process, the statistical distribution of both should be similar. First, suppose the random distribution is a normal distribution with the same mean and standard deviation in the observed data. Now, if the observed data is really from a random distribution, p_{value} should be a large value becausep_{value} indicates the probability of being random. Conversely, if p_{value} is small, it indicates that R^2 is not really a random process, and in fact, the null hypothesis is rejected."

"How small?" Said Hannah, who was standing in the corner. "It should be a standard threshold, right?"

"Yes." Said Tom. "If we consider the random process to be a normal distribution, then if the p_{value} is less than 5%, that is, it's different from 95% of the random data. So the event we are looking at is not random in the observed data, and, in our example, the null hypothesis is rejected, and it can be accepted with certainty whether $R^2 = 0.7$ or not."

Tom himself was tired of the chattering. He leaned back in his chair. "That's enough detail for our work, which wants to examine the impact of various factors on the learning of The Deus Machine."

Ivan crossed his legs. "Now we have to use linear regression to find out which factors have had the greatest impact on learning The Deus Machine? But How? Even if our independent variables are numbers, what is our dependent variable here? I cannot understand."

Tom laughed mischievously. "Oh, no. I just explained to all of these staff to get here. Yes, linear regression has many uses, but for our problem, linear regression cannot apply. Instead, we have to use another type of regression called logistic regression. The Deus Machine has two basic components. We have the historical log of winning or not winning the first component. So we can understand what factor had the greatest impact on the successful meaning-making of The Deus Machine."

All three's hand and foot had regained and collapsed, trembling, into armchairs. "Let the access to the log system get confirmed," Tom said with a grin. "After that, I will explain logistic regression."

"I've run away from math all my life," Colonel said under his breath. "Look where he caught me. I have become a schoolboy. I am going to check what happened to the data."

Ivan and Hannah looked at Tom. Then they suddenly giggled. Tom and Hannah forcibly ceased to laugh. Ivan, however, could not control himself. It was as if the plumbing is busted.

Colonel, who had noticed, turned around and knocked them down. Embarrassed, Ivan leaned back in his chair and laughed. Colonel said nothing, shook his head regretfully and growled away.

It took Colonel Taylor two hours to approve accessing the data. Little by little, the light of day gave way to the darkness of night. Tom and Hannah were whispering about the suspicious man Hannah had seen at the club. During their time in the lab, Hannah also paid close attention to the subject. She could even understand his name by fishing around.

"His name is Samuel Hoffman," She told Tom. "I want to chase him. Nothing can be done here. Especially due to my promise to the Colonel not to overact. If he understands, the gleam of our hope of solving the puzzle will be lost. It's better to get out of here now, so I can start my work."

At Tom's point, Ivan began to gather his belongings.

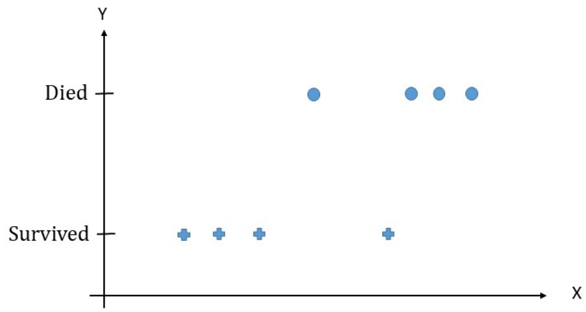
The three were preparing to return when Colonel suddenly arrived and announced that he had access to the data. They apologized that it was getting late and wanted to return, but Colonel did not give up. In retaliation for a jest they made, he insisted stubbornly that they should stand and finish the job.

Unaware of everything, Ivan insisted on returning. He did not like the atmosphere of the laboratory. Eventually, at the insistence of Colonel, Hannah surrendered. She did not want to show unreasonable resistance to suspect him. Tom looked at Hannah. He shut his eyes as a sign of approval.

"Let's look at the case of the influencers." Said Tom. With this sign, they returned to Anna Cooper's room. Colonel also reached out.

"Well, we got acquainted with linear regression," Tom began as he sat down. "In linear regression, our dependent variable was a quantitative value, what we call label in machine learning. But sometimes, our dependent variable, instead of having a real number, has only two states, and we want to know the effect of an independent variable on the occurrence of each of those two states. The linear regression approach can no longer be used here, and we have to use another type of regression called logistic regression."

Tom fell silent, looking them up and down. Then he continued, “In the example of the same laboratory mouse, suppose this time we want to examine the effect of testing a drug on the survival or death of a mouse. We have an independent variable: The dose of the drug and a dependent variable, which is the two states of survival or death of the mouse. Suppose the data distribution is as follows:



It is no longer possible to draw a line here and examine the relationship between the independent and dependent variables. Here the linear regression structure must be changed to another type. In this way, the output of the label can be expressed in the form of probabilities.

$$p(X) = \beta_0 + \beta_1 X$$

Before I explain that structure, I must explain an important concept called Odd. Suppose in the example of the death or survival of a mouse. The survival ratio is 5 to 3. Out of 8 mouse samples, 5 of them survive, and 3 of them die. The ratio can be written as follows:

$$Odd = \frac{5}{3} = 1.7$$

This ratio is different from probability. The probability is a ratio of occurrences, divided by all possible states, which in our example is the probability of survival and death:

$$P_{Survived} = \frac{5}{8} = 0.62$$

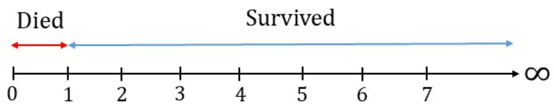
$$p_{Died} = 1 - p_{Survived} = 1 - \frac{5}{8} = \frac{3}{8} = 0.38$$

Accordingly, Odd can also be obtained based on probability:

$$Odd = \frac{p}{1-p} = \frac{5}{3}$$

Therefore, in two-class problems, such as survival or death, the two states' incidence ratio can be calculated with the above formula. But the problem with this ratio is in the intervals that it can occur.

If we show the possible values for the occurrence of both states on Cartesian coordinates, they will be something like that:



So this is an asymmetric distribution, and we cannot obtain a true probability of default, which must occur between 0 and 1.

To avoid this problem, we should model $p(X)$ using a logistic function that gives outputs between 0 and 1 for all values of X.

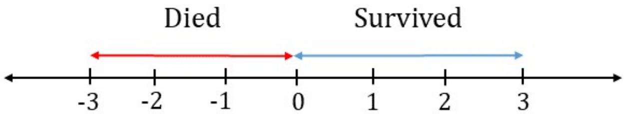
$$p(X) = \frac{e^{\beta_0+\beta_1 X}}{1 + e^{\beta_0+\beta_1 X}}$$

This is the logistic function. Let's do some math to obtain our desired function:

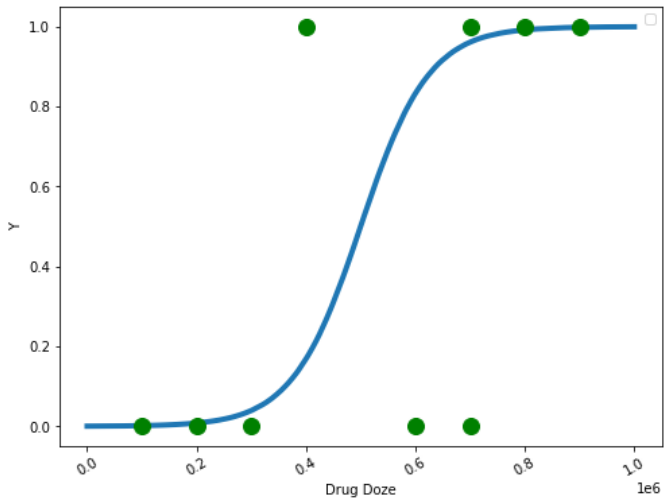
$$\frac{p(X)}{1 - p(X)} = e^{\beta_0+\beta_1 X} \rightarrow log(\frac{p(X)}{1 - p(X)}) = \beta_0 + \beta_1 X$$

The left-hand side is called the logit. They use logarithm transformation to symmetrically coordinate the axis and make bot side of the function linear. If the logarithm of both states is taken, the distribution will look like this:

$$log(\frac{p}{1 - p})$$



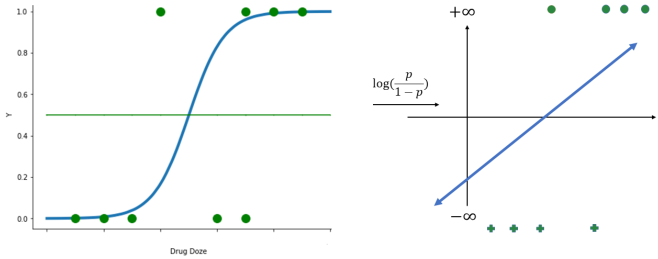
We will use this conversion to build logistic regression. The form of the fitted logistic regression function is as follows:



Which is a S-Shaped curve. Fitting this function indicates the probability of occurrence of any point for both states. Our goal is to fit this function into the data. How should this function fit into the data?" No one came up with an idea.

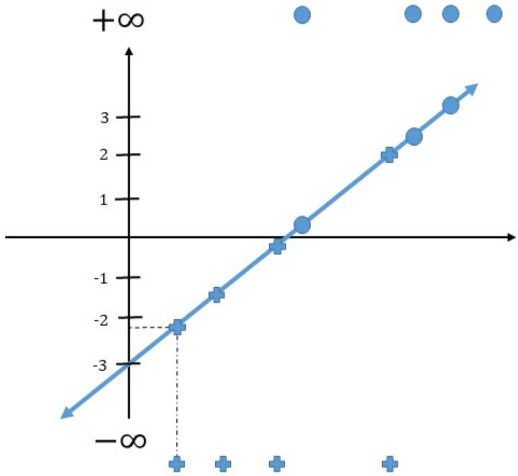
"The concept of the Odd logarithm function I mentioned should be applied here." Tom himself continued.

"In this way, we convert the vertical axis of the function, which expresses the probability of the mouse's death, into the corresponding interval in linear regression with the Odd logarithm. Like the following figure:



Suppose the line obtained in a linear regression figure is the best possible line. Here the corresponding points of the range 0.5 to 1 in the logistic regression figure are projected by applying the logarithm transformation to the range 0 to infinity in the regression figure. And points from 0.5 to zero are also projected in the range of zero to negative infinity. Suppose the linear regression line equation is obtained. In that case, the interpretation of the coefficient and width of origin is exactly the same as the linear regression, but not for the original independent variable rather for the converted independent variable by the logarithm function.

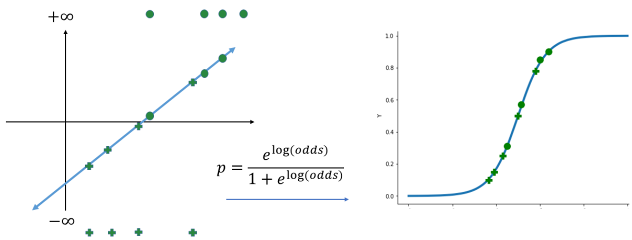
Since the projected points on the linear regression figure have infinite values, the concept of residuals and the least-squares function of the error can no longer be used directly to obtain the line. Instead, we use a concept called maximum likelihood estimation. To do this, first with the recurrence transforms, we first project the points in the infinite range on the selected line:



For example, for the first point, the value with the logarithm of Odd is equal to $(1, -2)$, with this fit, the line equation can also be written.

We fit the points on the linear regression figure to the logistic regression figure in the next step. The probability formula can be written as follows:

$$p(X) = \frac{e^{\beta_0+\beta_1 X}}{1+e^{\beta_0+\beta_1 X}} \rightarrow p = \frac{e^{log(odds)}}{1+e^{log(odds)}}$$



This transformation will give us the probability of each point on the line.

After calculating each point's probability on the logistic regression figure, we multiply the probability values obtained for the two classes. For that particular line, a specific value will be obtained. Our goal is to get a line that maximizes this product. This function is called the Maximum Likelihood Estimation.

$$max[(\prod_{i}^{n_{survived}} log(p_i)) \times (\prod_{j}^{n_{died}} log(1-p_i))]$$

p_i is a function based on a straight line fitted. So as the line changes, they will change too. Whenever this function is maximized, the best line for the linear regression figure and the best logistic regression will be obtained. Getting the best values based on maximum likelihood is a long story that is beyond our limited time. The important thing was what I explained to you."

Everyone has listened like an eager student so far.

"Someone who listens and doesn't ask questions is supposed to understand well or doesn't understand at all. Which one are you?" Tom said with a trace of humor in his voice.

"Honestly," Said Hannah enthusiastically. "Even though my 15-year career was something else, I'm just starting to get interested in math."

But Ivan, like the straight-A students in the class, who wants to get the highest grade, raised his hand half. "Why did you take logarithm again in the maximum likelihood function?"

"This is just a preference for statisticians," Replied Tom. "Otherwise, we could have done it without logarithm.

"And what about the inference of coefficient in logistic regression?" Asked Tom again.

"You know that in a linear regression model," Replied Tom. "β_1 gives the average change in label associated with a one-unit increase in X . However, because the relationship between $p(X)$ and X is not a straight line, β_1 does not correspond to the change in $p(X)$ associated with a one-unit increase in X.

But if the sign of β_1 is positive, then increasing X will be associated with increasing $p(X)$ and vice-versa.

"Based on what you said in linear regression," Asked Ivan again. "How do you calculate the R^2 index for logistic regression?"

"Hmm." Tom pondered and replied. "That's a good question. We do it like this:"

$$R^2 = \frac{LL(overallprobability) - LL(fit)}{LL(overallprobability)}$$

The value of $LL(fit)$ is the maximum likelihood value of the best function. The value of $LL(overallprobability)$ also plays the role of $var(mean)$ in calculating R^2 for linear regression and is determined as follows:

First, we calculate the $log(\frac{numberofsurvived}{numberofdied})$. This number is the average line in logistic regression. Then we project all the points on this horizontal line and calculate the likelihood estimate by the exponential transformation."With this value, the amount of R^2 can be calculated."

"Well, I explained everything," Tom paused, then said in a loud voice. "Now it's time to figure out what factors have the most impact on the Deus Machine. We will use logistic regression to do this."

Colonel, Ivan and Hannah, who were immersed in a deep discussion, seemed to remember why they were there, as though Tom had reminded them all of a painful scene from their past. Everyone became serious and grumpy.

With the help of the Lab technical team, Ivan accessed the historical data of The Deus Machine and then, Under Tom's supervision, the data and web crawls, are processed and divided in several categories, including:

- Crawls in history books
- Crawls on news sites
- Crawls on social networks
- Crawls in visual media

When the data preprocessing was completed, all four were reassembled again.

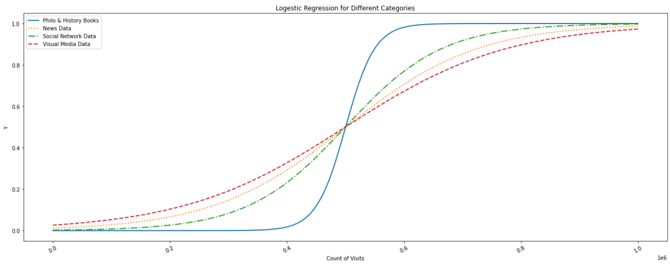
"Well," Tom said as he flipped through the spreadsheet. "We've sorted out the four general categories in which the Deus Machine has spent the most time. These four categories are independent variables that we will examine their effect on the Deus Machine. The procedure is the same as in the example given for the death or survival of mice by increasing the drug dose. For each variable, we first normalize it and then obtain the shape of the regression function for each of them. Normalization means that we will determine the gain or loss of the algorithm for the number of visits made from each category. We relaxed the number of wins or losses concerning the number of visits. In the end, the obtained functions are compared to identify the variable that is most likely to win. There are many libraries for the logistic regression algorithm. We will work together to identify the important factor. Are you ready, Ivan?"

Ivan puffed himself up. It was as if he had forgotten that he had insisted on leaving there an hour ago. "Yes, sir, as always," He said proudly.

Tom put his hand on Ivan's shoulder and squeezed his weak shoulders tightly. It was already night, and their work was long overdue. All three preferred to stay overnight in the lab.

Ivan focused on executing the models and coding them until late at night. Finally, he woke up Tom in the twilight, crumpled in a chair and asleep deeply, saying that the results were ready. Tom got up. He rubbed the pothole of his puffy eyes and stared around. Hannah was asleep in Anna Cooper's room. It took half an hour for everyone to gather in the room again. Colonel Taylor had arrived, but suddenly hurried out of Anna Cooper's room for an unknown task.

Tom and Hannah stared at each other. “What do you think happened?” Hannah said, pointing to Tom. Tom shrugged. Ivan, however, regardless of the commotion, drew for them a graphic representation of the fitted figures for each of the four categories:



Everyone bent over the figure. “What is the interpretation of this figure?” Said Hannah, complaining.

“It means victory has got the greatest impact from learning from historical and philosophical data,” replied Tom seriously and grimly. “The same solid line,” said Hannah with a sigh.

Hannah frowned. “Isn’t this strange?” She said as if it were something to be sad about. “What do history and philosophy have to learn from?”

“Many things.” Tom stared defiantly at her. “The work of philosophy is also a kind of finding meaning for this world and the people of the world. Science accelerates our work, and philosophy directs it. According to Hegel, Anna Cooper’s favorite philosopher, philosophy is the same as history, and history is the same as truth, and the truth is the permission to act accordingly. Probably the Deus Machine, by reviewing historical and philosophical texts, was able to make a series of conceptualizations."

"I do not understand." Hannah grinded her teeth and then put her hand on her forehead and began to rub it firmly.

Ivan, again as if devious, jumped in the middle of their words and said loudly, "Here there are. I found it. The most key words that the Deus Machine has seen in terms of victory and the use of historical data are concepts related to phrases such as Freedom, Suffering, Oppression., Chains, and Truth".

Tom thought, then he suddenly got up, "I really cannot understand. How is it possible? Machine learning is nothing but fitting a function and optimizing it and expressing it in the form of possible models and outputs."

"No," Suddenly an unfamiliar voice answered from behind all three of them. "This is not the whole story, Dr. Forrester."

An unkown voice made Tom jump and spin around with a shudder. A fat, short crouched man with coke-bottle glasses stood facing them, wearing a black suspender instead of a belt.

Seeing the man, Tom unconsciously got up. His throat was dry from what he saw, and he could not open his mouth and speak. It was as if he had no strength to put his lips together and refresh his mouth. He was out of breath. He stepped forward a few steps and then, as if a slate had been removed from his chest, began to breathe hard.

The unknown man laughed and, while stumbling like a crow, came to Tom and kissed him. For a short while, they were both silents in a close embrace. Tom separated himself. It was as though he did not believe what he saw. "Russell, dear Russell Pierre, what are you doing here?"

And then he put his hand on Russell's round, fleshy face, "Oh. You've got an old man." Tom said wistfully.

Russell grabbed Tom's arms with both hands, "Oh buddy, you're too broken."

Colonel, Hannah and Ivan, are dumbfounded. Tom put his hands on Russell's shoulders, and they sat down on a chair together. Tom was thrilled. "Russell Pierre, the number-one elite in artificial intelligence, the winner of the Turing Prize. You don't recall him?" Tom said enthusiastically.

Ivan, who had been searching for his name, started up cheerfully. "Oh, Russell Pierre, the famous scientist. I have read your interviews many times. You have great opinions."

Hannah, however, contented herself with a wide smile and gently squeezed Russell's hand. Colonel straightened his wrinkled neck bent. "So you already knew each other."

Russell shook his head, "Yeah, we had a lot of adventures together. Before Tom suddenly disappeared, we worked together for a long time. We worked together in the Berkeley lab. We were working on two projects as if we were one soul in two bodies. Tom was the number one such as I never saw in my day. I always considered myself his student."

Russell frowned suddenly for a while. "Bloody hell, I wish that tragedy would never happen. That news really tore me up. Everyone confirmed and confessed that Tom is undoubtedly the Turing Prize winner, until two months before the prize that tragedy happened. Tom, Dear Tom. I wish you knew how upset I was about this."

"The past is over old man," Tom nodded. "I wasn't in it for the prize. Beside, about you, justice has been served.

When I found out that you had won the award, it was as if I had won the award myself, believe me."

Russell was about to say something, but Tom put his hand on his fleshy arms. "You've made us proud. How did you find us?"

"Colonel Taylor called me yesterday evening," Russell said, turning in his chair. "I am in charge of the Ministry of Defense's super-intelligent processing unit - SIPU. He announced that a team was working on the Anna Cooper project, you know that we've lost a valuable person. I preferred to get involved on my own. I know you also entered this story unintentionally. But I'm sure Tom can help us a lot in finding out the truth."

Tom put his hand on his crooked neck. This seemed more pitiful. "You complimented me, Russell," He said humbly.

Russell tucked himself into his chair. It was as if he wanted to change the subject. "How did you find so far?" He asked Tom softly.

Tom looked at Hannah, "We've used machine learning and find some interesting things, including that historical and philosophical data more influence the Deus Machine." And then he looked at Colonel and continued: "According to Colonel, Anna Cooper believed that The Deus Machine had reached self-consciousness. What do you think, Russell? Do you think such a thing is possible?"

Russell rubbed his chin. "It all depends on what we define self-consciousness. I think we should not fall into the fallacy that sees everything from a human point of view. Supposedly, it is clear that the Deus Machine is out of control, and because it has the power to decide and even execute, it can make a series of decisions without human intervention. Decisions that are by no means accidental. If this is not the name of self-consciousness, then what is?"

"If we accept that our world is an orderly one and Darwin's theory is valid, we must accept that some random processes can lead to non-random, orderly behaviors," Tom said, frowning. "If we give such processes enough time. If a living organ grows over time is because of self-consciousness. It is based on complex genetic sequences and inheritance transmission. The same is true for The Deus Machine. The fact that the system is influenced by concepts such as freedom, oppression, etc., does not mean that it is oppressed by human beings or animal pains that humans surround. They can now talk for hours about the suffering of a particular human being. It just learns how to make a specific decision in a particular situation based on a series of data sequences. This is not the name of self-consciousness."

"But you missed the point..." Russell protested.

"Gentlemen," At the same time, Hannah jumped in the middle of his speech and said with her usual firmness. "Stop this silly argument, for God's sake. Now tell me, what should we do?"

Russell spoke in a calmer tone, "Well, let me just say this, in theory, machines can also become self-aware, if not now, later. But it will happen." Then he turned to Hannah and continued, "For now, you are our only savior. I ask Tom to be with us on this path and to continue his cooperation. Everywhere you have a problem, just let me know. Just one thing..."

Hannah listened intently and said, "And that one thing?"

Russell got up. A large amount of his body fat, like jelly, began to stumble. He wiped the corner of his lip with his handkerchief. “This scandal threatens the integrity of our national security. We cannot get help from outsiders to solve this issue. No individual or media should be aware of this. Please be extremely confident in this case. Of course, I know you are careful, but reminding is not harmful.”

Then he took a few steps toward Tom, putting his hand on Tom’s shoulder. “All right, Tom. I have to go, I wish I could stay with you more, but I have a lot of work to do. Wherever you have any problems, let me know.”

Tom nodded and accompanied him to the door. When Russell left, Hannah turned to the Colonel, “We’d better go. We’ll be here again to continue.” Colonel breathed of it deeply. “Okay, we’ll get you to the city.” They closed the eyes of all three again and then unloaded them at the forest road’s beginning.

08

THE JUSTICE TREE

Two days had passed since the adventures of the secret laboratory. During this time, all of Hannah's attention was on Samuel Hoffman. He had learned as much as she could about his past. She realized that he was one of the best commandos in the army and had a deft hand in coding and designing radar jamming systems.

Hannah had anonymously tracked down him at the equestrian club. During those two days, there was no news of him until, finally, Hannah's assigned team wirelessly told him that a man with Samuel Hoffman's profile had entered the equestrian club. Hannah rushed to the club.

Samuel had entered. Hannah and her team were left in the car for several hours. It was getting dark when suddenly a car driven by Samuel came out of the club's entrance. At Hannah's command, the pursuit of Samuel began. His path was towards a forest road. Hannah guessed that he wanted to go to the secret laboratory. Samuel continued to run until he parked his car in a public parking lot. And then he got off and stood in the same place and waited.

Hannah took the opportunity. She got off on her own and walked towards him. “Mr. Hoffman?” She said coldly.

Samuel closed his eyes. It was as though he was pushing his brain to know Hannah. “Hmmm, Major Nelson?” He finally said. “What can I do for you?” Hannah brushed a small mound of hair in front of her eyes, “You are under arrest. You must come with me. Everything will be clear there.”

“Come with you?” As if Hannah was joking with him, Samuel’s teeth were gnashed into a grin, “Then for what?”

Without saying anything, Hannah reached out to Samuel. Samuel shook his hand and as soon as Hannah wanted to wrap his hand and handcuff him, Samuel spun around and got behind Hannah. He grabbed her by the waist and knocked her to the ground with a material art movement. Hannah’s eyes went black for a moment. She shook her head several times to regain consciousness.

Samuel kicked Hannah in the abdomen, “Go away, fake Major.” At the same time, Hannah’s two companions reached the battlefield and aimed their guns at Samuel. Samuel was just stuck. He made a mistake and grabbed Hannah, who was on the ground, by the neck and lifted her. He had put his gun on Hannah’s forehead. Under Samuel’s thick arms, she could barely breathe. “I do not know what the hell are you are doing, but I want you to know that the answer to this insult will not go unanswered. Colonel Taylor trusted you.”

"Anna Cooper also trusted you!" Hannah said as she struggled to breathe. When Anna Cooper's name came up, Samuel's hands loosened involuntarily. He did not expect to be stuck in Hannah's fight because of Anna Cooper.

He thought Hannah had come to avenge the factory affair. Hannah took the opportunity to distract Samuel. She put her right hand on Samuel's side and then quickly pulled the gun away from her forehead, and with an acrobatic motion, grabbed Samuel by the waist and wrapped his hand tightly. With this move, Samuel spun in the air and fell to the ground with his back. Hannah stepped on Samuel's throat and aimed his gun at him.

Samuel was in the interrogation room. Hannah interrogated him for a while, but he said nothing. He insisted that if Colonel Tylor didn't come, he wouldn't open his mouth. Hannah watched Samuel's movements through the window of the interrogation room. "Colonel Taylor has been contacted by the Department of Defense," An officer told her. "They want to talk to you."

Hannah picked up the phone. A Flash of anger in his face was imaginable behind the phone. Hannah had prepared herself for such a moment.

As she took up the phone, Colonel began, "What gives you the right to arrest one of my men? I warned you before. I knew from deep inside that I should never trust you." He took a deep breath and puffed it angrily. "Only two hours. You only have two hours to release him. Otherwise, this guilt comes down on you."

A beep-beep sound and then banging of the phone and nothing else then. Even Hannah was startled by the sound and shock of banging the phone. Her subsequent attempts to contact Colonel Taylor were unsuccessful. She wasn't going to release Samuel. She knew this was her last chance, at least until she got the answer of blood test between Samuel's and the blood found in Anna Cooper's house, she did not intend to lose Samuel.

She made an immense leap of an attempt for the last time to talk to Samuel. But he did not give up again. Two hours had passed since Colonel gave the ultimatum. She waited for Colonel to call again to explain the story of Anna Cooper's murder. Her phone rang, but it was not Colonel, it was Tom. Hannah answered her phone with a smile on her face. But her smile was crowned by Tom's tensely voice.

"Lisa is here," Tom said loudly behind the phone. "She says some unknown men had dumped and arrested Ivan and taken him away. That boy's life is at stake. Do something, Hannah, please."

Lisa had seen the handwriting on the wall that Colonel had taken him hostage. She took a deep breath. "Tom, be ready. Let's go to the lab. I am leaving now." She hung up the phone, checked the last time for the blood test result. There was nothing yet. She got in her car and walked towards Tom's cottage.

Hannah and Tom were on a forest road leading to the lab. Hannah told Tom the whole story of Samuel's arrestment. They were a few minutes away from the beginning of the dreaded forest road when the head of the police laboratory told Hannah the result of a bloody match behind the phone. The blood found in Anna Cooper's house belonged to Samuel, and it means…

"It means Samuel is a murderer." Said Tom perplexity. "What if Colonel Taylor and Samuel gang up against Anna Copper together?" After this conclusion, he scared to believe it. "We must get help from Russell. He can help us," Tom said to console himself.

They had reached the beginning of the gruesome forest road. Like the last time, they got out of the car and waited. They were sure that the team's head with their big dogs would be found again, and so it was. A few minutes later, the same rangers appeared with their wild dog. This time, wordlessly, as if waiting for them, they closed their eyes and took them to the laboratory.

When they opened Hannah and Tom's blindfolds, the bright light blinded them for a moment. Until little by little their sight returned. Colonel Taylor and Russell Pierre sat across from them. Tom's eyes fell on Russell, and his anxiety eased a little. Colonel followed Hannah angrily.

"Why don't you want everything to go in its way?" Colonel snapped. "Why did you arrest my senior officer without telling me anything? What the hell is on your empty brain?"

Hannah swallowed. "Colonel, it isn't what you think at all. I found signs in Anna Cooper's house that Samuel Hoffman had killed her."

Russell Pierre's swampy brown eyes widened to the size of side plates. "It is not possible." Instead of Colonel, Russell said, in a tone of the greatest astonishment. His face suddenly a little too composed. "According to the police themselves, and with the confirmation of forensic medicine, Anna Cooper committed suicide," Russell said distinctly.

Hannah knocked down Russell's bulky body. "That was the initial hypothesis. Before I came, I got the result of matching Samuel Hoffman's blood with the blood we found in Anna Cooper's house. It belongs to Samuel Hoffman undoubtly. This means that he is most likely the killer of Anna Cooper." And then she turned to Colonel.

"Colonel," Begged Hannah. "Please think reasonably, let our investigation go its way. If Samuel is innocent, on my honor, I will release him."

Colonel was as mad as a hatter. He could not concentrate. "Do you know what you are saying?" Said he, with a faltering voice. "Why should Samuel Hoffman have killed Anna Cooper?"

Hannah shrugged. "I want to know that too, give me a chance. Let me find out the truth."

Colonel got up and shouted angrily, "Ah, in this great county, is there no one but you to find the truth? Who put you up to this?" Then he turned to Tom and then, again, to Hannah. He stared into her eyes fiercely. "My last word: Ivan will be our guest until Samuel Hoffman's fate is determined."

At this time, Tom also entered the discussion. He turned to Russell in a depressing tone and said, "Russell, say something. That child is not guilty. If you want to take a hostage, at least keep me. He is innocent. Let him go."

"Colonel, please calm down," Russel said in the most unconcerned tone. He seemed to be stuck between the Colonel and Tom "Let us see what we can make of it."

As Colonel wanted to say something, the door banged with a resounding bang. "Come on," Said the Colonel firmly.

Someone came in and whispered in Russell's ear and left the room with Russell's bacon. The blood drained from Russell's face and went white. Colonel, who thought that person wanted him, was shocked by this negligence. "What's the matter, Mr. Pierre?" He said accusingly.

"I can't believe it." Said Russell seemed hesitant to say it aloud. "Several self-driving cars in Los Angeles went out of control and attacked people. Twenty people were killed, and some were injured."

"It's The Deus Machine." Said Tom, who stared at Russell's round glasses and waited with bated breath for his sentence to fall.

Russell shook his head. "Colonel, arrange for the media to report the news as a technical defect," Russell said, bracing himself up for the effort. "Tom, come with me."

But Tom did not make any movement. Instead, he kept looking at him unblinkingly. "Without Ivan," Tom said finally. "I cannot help anymore."

Russell glanced at the Colonel wordlessly. Then he made his way and left. The Colonel stared at Tom and left the room with teeth chattering.

On direct instruction of Colonel Tylor, Ivan was released. Tom and Hannah were waiting for him. When his eyes fell on Tom, he ran and hugged him as if he had seen his father after a long time. Tom took him in his arms tightly. Then he put his mouth close to Ivan's ear. "You didn't get hurt, did you?".

Ivan sniffed and shook his head in a negative sign. Tom, as Ivan hugged him, spied Russell as he was approached them. His right hand, uncurled. Ivan separated himself from Tom.

"What do you think, Tom?" Russell hastened to say. "How did this tragedy happen? You know that I'm under compulsion by the minister himself. We have to justify this."

"The first step," Said Tom firmly as approaching Hannah. "Is to know that how those people were selected, crashed, and killed. Was this tragedy by accident, or a pattern can be found?"

"That's right," Hannah nodded. "We need to understand how the Deus Machine punishes people!" And then, like a bashful girl, who wanted not to overwhelm them with an impressive display of knowledge, went on. "I read a little bit of Hegel's philosophy in these few days. I did not understand much of it, honestly, but it seems that he is ahead of German idealism. He had an indispensable effect on Karl Marx and later Heidegger, the Nazism philosopher. The goal of nazism was to purge the race in German race favor. Perhaps Anna Cooper has also designed a mechanism for her machine, to reach in such inferences."

"We cannot make a judgment by such inferences." Muttered Tom, after smacking his stiffening lips for a moment. "Let's follow the six-step process. It is better to move forward with an objective criterion. Even if the system is affected, it will show itself in its results. It's better to have data on those people who were killed." Tom turned to Russell. "We have to know why the killed people were selected."

"And why the others nearby them not selected," Nodded

Russell.

“You want to create a classification problem, right?” Hannah also got into the discussion to not miss out on something. “Yes,” Tom nodded. “A classification problem with two classes: Killed and Not-Killed People.”

“Or Selected and Not-Selected people.” Hannah continued, “But wait, how do you want to know, The Deus Machine has been most affected by which factors?”

Tom glanced at Russell, and when he saw that he had no intention of answering, he replied. “We have to use an interpretable classification algorithm. That is, the process of distinguishment should be clear. The logistic regression algorithm has such a capability to some extent, but its weakness is that for cases where several features are included simultaneously, it cannot provide good interpretability, so another method must be tried.

The Decision Tree method has such a capability. By drawing a tree of existing features, this method shows how the decision boundaries are divided the feasible space into several areas. It also identifies and makes a hierarchal priority of the features, so we can both find out if there was a pattern in the selection of people, and we can identify the most important features too.”

Russell put his hand on his big belly. “Yes, that’s right. He acknowledged. “The presence or absence of the pattern will show itself in the accuracy of the classification model, and if this is proven, we can use the most important feature as a criterion.”

Everyone fell silent. “And now is the time to take the data, right?” Said Ivan, who had never said anything until that time.

Tom laughed and nodded. “Well, I have found some of the data related to the social networks of these 20 people, such as the number of likes of posts by type of post as well as residential place, etc.” Tom shook his head. “Keep up the good work. We need economic and demographic data on these too. The same data should be available for 20 to 30 people who were in the same area in the accidents time but were not selected.”

“20 to 30 randomly selected people,” Russell said enthusiastically. Tom raised his thumb as a sign of agreement. “So… who is going to get this data?” Hannah suddenly exclaimed, clenching her slender hand. Everyone looked at Russell. Russell raised his hands. “Okay... okay. I’ll handle it.”

Hannah’s instinct got sensitive. “I want Ivan to be present at all stages of data gathering phase,” She said.

Russell looked too tough and adequate as hell from this irony of mistrust. “Okay,” He shook his head reluctantly and then he turned to Tom, “It’s better to prepare yourself until the data get ready. I heard you restarted your classroom with these new students.”

“The best students I’ve ever had,” Tom said, staring at Russell. “I’m jealous of them,” Russell said as he got up to go. Hannah walked over to Tom. Master, don’t you want to hold your class?” She said, catching him gently by the arm.

Tom was always afraid of being the center of attention. He was red now and had his head down. “Let’s go and sit somewhere,” He said in an embarrassed tone. “I will explain it to you.”

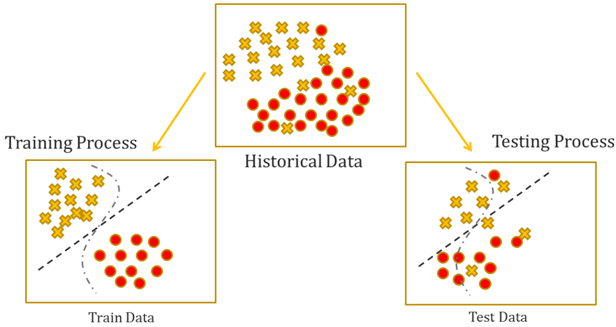
One evening, the hot air folded in waves over the San Bernardino. After leaving the headquarters of the secret laboratory, they went to the café of a local restaurant. Ivan, who had been hungry since morning, as soon as he arrived, eagerly started ordering, then opened his laptop in front of him and started surfing the internet. He was holding the juice in one hand and touching his laptop with the other. Tom and Hannah stared at him with a laugh. Ivan shook himself mentally, seeing four eyes stared at him. He pulled himself up in a chair. "Well, why don't we get started, huh?"

"Of course, my absentminded boy," Tom said. He turned to Hannah. "Before I explain the decision tree," Tom added. "I have to explain a process in which a classification problem can be examined. If you remember, we could ask four types of questions. The classification refers to predictive questions. That is, we look to the future. So we need to be able to measure the performance of the model for unforeseen circumstances somehow, and because we do not have data from the future, we should use the available historical data to build the model and evaluate its performance simultaneously. This process in machine learning is called the Train/Test process.

There are several approaches to the train/test process. At the simplest one, we divide the data into two parts, usually with a ratio of 70% to 30% or 80% to 20%. We use the larger part of historical data to train the model. Based on what I have said before, training the model means fitting a function or finding the decision boundary. After the model is trained, we will use data with a smaller ratio to evaluate the trained model's performance. In fact, in any supervised learning problems, I mean classification or regression, this process will be implemented for each model...

The model that has the best performance will be selected. This whole process is called the Model Selection process. Finally, after selecting the best model, it can be used to predict the future. Let me draw the picture for what I said."

He borrowed a piece of paper from the manager of the cafe and drew on it:

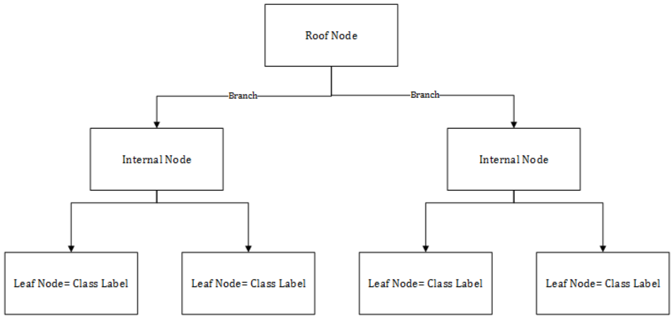


"Based on this process, if we want to build a classification model, we have to go through these steps, but here we have two questions that ironically can be answered by decision tree. Besides the fact that decision tree is a classification problem, it can also help us answer some exploratory data analysis questions. We use the train/test process to check the algorithm's accuracy, and we will also use the trained decision tree model to find the best and important features."

"I understood everything," Said Ivan, who, unlike usual, was doing nothing this time. "I just do not know how to measure the performance of the model."

"Hmm." Tom chuckled. "Actually, there are several ways, but before that, we need to get acquainted with the decision tree method itself, then I will explain how to measure accuracy."

Ivan was satisfied since he said nothing anymore. "Now, let's see how the decision tree works," Tom continued. "The decision tree, based on the features, builds a logical, tree-like hierarchy, which is why it is called the decision tree. A tree is made up of a set of nodes whose general shape is as follows:



After drawing, he continued again. "In fact, if we start from the root node, and put the features one by one in the middle nodes, eventually our last node will be the labels themselves."

Hannah turned the paper over. "It's kind of if-then rules. Doesn't it look like the concept of association rules we've just looked at?"

"Exactly," Tom said, clicking his fingers. "We can turn the decision tree into an association rule with a series of transformations, but the consequence part, I mean the 'Then' part, will always be our label. I have to say that the decision tree was actually created first to develop expert systems based on logical rules as a part of an effort for knowledge engineering, which could derive new rules from the logical sequence of rules, but later moved on to machine learning."

"How are the root and middle knots obtained?" Hannah asked again.

Tom turned the pen around in his hand. "That's a good question. The logic of the decision tree is actually like the logic of a twenty-question game. Something is in your mind and has been written on a piece of paper, and we can only ask twenty questions to know what the object is. Every time we ask a question, you answer yes or no, and a new question is asked in this way till we reach the final answer…

In the twenty question game, the logic is to ask the most important question first to get the best chance to win. The same logic holds in the decision tree. To create a branch, we have to find the most important feature at first, put it in the root node, and continue so on. In the case of decision tree, the question is how to determine the most important feature? This is determined by a concept called Entropy."

Ivan's spirit flied to high school years, and he began to laugh sweetly. "I remember we had that concept in high school chemistry. Is it the same here?"

"Oh... that's right." Tom grinned. "It's conceptually similar. Entropy here means impurity. There are several criteria for finding and calculating entropy. The fact is that a change in the entropy measurement criterion leads to the creation of different algorithms for the decision tree. We use the simplest criterion here, called the Information Gain. This criterion was first introduced in Information Theory and was used in modeling the amount of information available in sending messages. The larger the criterion for a feature, the lower its impurity and, therefore, the higher importance. Therefore, the feature that scores the highest entropy is selected as the superior feature.

Let's start with an example. How to start with our problem. Suppose we are the Angel of Death, and we've created a database of the people who deserved to die or not.

We want to build a machine learning model of the angel of death to decide whether to kill someone or not. Our database will be as follows:

ID	**Age**	**Income**	**Jail**	**Label**
1	Youth	High	No	Survive
2	Youth	High	No	Survive
3	Middle Aged	High	No	Kill
4	Senior	Medium	No	Kill
5	Senior	Low	Yes	Kill
6	Senior	Low	Yes	Survive
7	Middle Aged	Low	Yes	Kill
8	Youth	Medium	No	Survive
9	Youth	Low	Yes	Kill
10	Senior	Medium	Yes	Kill
11	Youth	Medium	Yes	Kill
12	Middle Aged	Medium	No	Kill
13	Middle Aged	High	Yes	Kill
14	Senior	Medium	No	Survived

Now we need to calculate the information gain for each feature. The criteria consist of three components. In the first place, we need to get the general amount of information in the data based on the label type. The formula is as follows:

$$Info(D) = -\sum_{i=1}^{m} p_i \times log_2(p_i)$$

Next, we need to get the amount of information in each feature. Its formula is as follows:

$$info_A(D) = \sum_{j=1}^{v} \frac{|D_j|}{|D|} \times Info(D_j)$$

Ultimately, the difference between the two will indicate the amount of information or the purity of the feature:"

$$Gain(A) = Info(D) - Info_A(D)$$

Tom looked at the both of them. "You must be wondering how these are calculated. Don't worry. It's very simple. Let's calculate the information gain for the age: we have two classes of Kill or Survive. (m = 2) There are 5 rows from the Survive class and 9 rows from the Kill class. Based on this, we calculate the total entropy:

$$Info(D) = -\frac{9}{14}log_2(\frac{9}{14}) - \frac{5}{14}log_2(\frac{5}{14}) = 0.940bits$$

Next, we compute the entropy of the age for each of its states. The age has three possible values. We seem to calculate the total entropy each time for one of the values:

$$Info_{age}(D) =$$

$$Info_{age}(D) = Info(Youth) + Info(Middle_Age) +$$

$$+Info(Senior) \rightarrow$$

$$Info_{age} = \frac{5}{14} \times \left(-\frac{2}{5}log_2\frac{2}{5} - \frac{3}{5}log_2\frac{3}{5}\right) +$$

$$\frac{4}{14} \times \left(-\frac{4}{4}log_2\frac{4}{4}\right) +$$

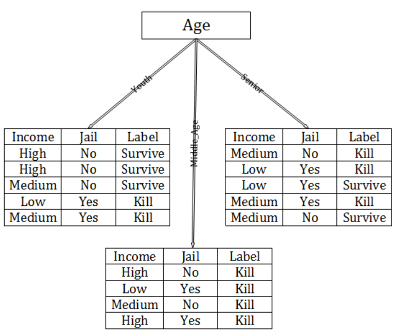
$$\frac{5}{14} \times \left(-\frac{3}{5}log_2\frac{3}{5} - \frac{2}{5}log_2\frac{2}{5}\right) =$$

$$= 0.694 bits$$

Finally, the information Gain can be calculated:

$$Gain(age) = Info(D) - Info_{age}(D) =$$
$$0.9440 - 0.694 = 0.246 bits$$

We have to do the same for all the features to get the most important feature in the end. Next, we need to create the tree branches based on the possible choices of the selected important feature. Assuming that the age is the most important feature selected, the branches created will look like this:



"Based on what I said, for each of the three trees, this process will be repeated separately and independently until they finally reach the end nodes that are the same as the label."

Ivan looked at the tables. "The table which is branched off by the middle-aged branch has all kill label. What should we do in such situations?

"This means that the table has reached the final node, and there is no need to continue." Tom looked at the table and replied, "In fact, the condition for stopping the decision tree algorithm is two things: Either it reaches the last attribute and eventually the labels remain, or all the label values are the same."

"You said that a change in entropy measurement leads to different decision tree algorithms." This time, Hannah asked, "Can you introduce another entropy measure?"

"Of course," Tom said, taking a deep breath, "Another algorithm is called the CART decision tree, which uses the Gini Index criterion. The premise of this criterion is that each branch can have only two states, so in the case where a feature has a v value, the number of breakable branches have $2^v - 2$ states possible. Minus two is because the whole data set and the empty set are removed from it. Finally, similar to information gain, we have a formula for calculating the impurity or entropy based on the Gini index…

The Gini index is defined as follows:

$$Gini(D) = 1 - \sum_{i=1}^{m} p_i^2$$

Where p_i^2 is equal to the ratio of data in class i relative to the total number of data. Now, if we want to calculate the gini index for feature A, we can write the formula like this:

$$Gini_A(D) = \frac{|D_1|}{|D|} Gini(D_1) + \frac{|D_2|}{|D|} Gini(D_2)$$

Finally, with the following formula, the impurity of feature A can be found:

$$\Delta Gini(A) = Gini(D) - Gini_A(D)$$

The lower the gini index, the more important the feature."

"I understand," Hannah asked again. "Now another question arise. If the tables are independent of each other, in one table, the Income feature may branch out first, then the Jail history, and vice versa. This makes it possible, some features can be seen in two or more places in terms of hierarchical order. Is this okay?"

"Exactly," Tom showed a like sign and said. "This may happen, and this is not a problem. What matters is the sequence of each branch, which indicates the order of importance of the features. Later, researchers have developed methods for sorting features based on the decision tree, the logic of which is to sort the features based on the branches' weight. But in general, there is nothing wrong with seeing a feature in two or more places."

"For this problem," Hannah, like the straight-A students, who are bothering their teachers with smart questions without digesting the answer to the previous question, asked again immediately. "Our features have discrete values, so the branch can happen easily. But what if our features have continuous values?"

"That's a good question too," Tom replied immediately. "In this case, the continuous feature must be discretized. A common way is to sort the data from small to large and select the median data. If the number of data is odd, the middle of the number will be the median. Otherwise, you should use a formula as follow:

$$\frac{a_i + a_i + 1}{2}$$

In the gini index, because we said that this index works in binary mode, so in the discrete mode, for ordered pair of the states of each feature, this index must be calculated. On continuous features, the strategy is the same as what I said above."

Tom was silent for a moment to answer any question, and when no one spoke, he continued. "The basic concepts behind the decision tree were what I said. The decision tree is an interpretable model. It can also help you to select important features. The next point is that it can also take non-numeric and categorical features as an input too. All of these are advantages of this method. Of course, I have explained to you two decision tree algorithms called ID3 and CARD. If the entropy criteria are changed, the algorithms will change accordingly. We will use this algorithm to find the most important features that the Deus Machine has used to attack people. I will explain how to evaluate the accuracy of the algorithm as soon as the data get available. We have to wait for Russell to see what he has done."

Tom and Hannah just remembered the orders they had given. But surprisingly, on the table, all orders were swallowed. Hannah grinned and leered at Ivan. "You've eaten it all? You hog!"

"Well," Ivan shrugged. "It slipped out. I was focused on."

Hannah got up and gave other orders with a nasty look at Ivan. All this time, Tom sat very plaintiff in a cafe chair, staring at Ivan with his neck tilted. Ivan felt Tom's pale, ironic eyes upon him and could not look directly at him, seemingly oblivious to the daggers flying from Tom's eyes.

That day ended with all its adventures. The next morning, Hannah was working on Samuel's case at the police station. Samuel had not yet admitted anything. She was thinking about the mystery of Anna Cooper's murder when his phone rang. It was Ivan. He was informed that the data had been prepared. Eventually, Tom and Hannah made it to the address given by Russell. The address belonged to a seemingly ordinary Department of Defense office in downtown San Bernardino, where Russell Pierre typically used it as his unofficial office. The data were related to 150 attacked people and 90 people around the attacks but were not attacked directly.

As Tom and Hannah entered the apartment through the steps of an unidentified building that did not even have an elevator, they saw Ivan that had his head hard inside the monitor and cut off from the rest of the world. Tom and Russell spoke warmly, and Hannah threw herself on the couch next to Ivan, and from the shock, Ivan jumped up. He had just noticed Hannah and Tom. "Are you here, boss?" He said in a cheerful tone. "Boss, data is ready. What should we do now?"

In the same hour or two, he heard the word boss, when

Russell talked to the Secretary of Defense, and ironically called Tom: Boss. Ivan jumped in the middle of Tom and Russell out of thin air. Hannah got up and walked beside them. Tom and Russell focused on data.

"Look, Tom," Russell asked, "Did you explain to them how the decision tree works?"

"Yes, I taught." Tom nodded. "I have also told the strategy of splitting data into two categories. I will just explain to them the accuracy evaluation criteria and Confusion Matrix."

Russell drank a cup of coffee on his desk. "Well, if you allow me, I'll explain this."

Tom reluctantly confirmed. Hannah glared at Tom. "Oh, shit, He fat-shamed me," Hannah whispered.

Though, Russell became a principal talker. "The confusion matrix is used to evaluate the accuracy of the algorithms in the classification problems. Well, as Tom explained, we divide the data into two categories: train and test. With the train data, the model is trained. Now we need to understand what the accuracy of the trained model is for the unseen data. So we use the test data.

We temporarily put away the label of test data and just show its features, I mean independent variables, to the trained model to predict the label.

After prediction by the trained model, we have to compare the predicted labels with the real labels. This is where the confusion matrix comes in handy. Suppose our label consists of two classes, positive and negative. The general shape of the confusion matrix is as follows:

		Actual	
		Positive	Negative
Predicted	Positive	TP	$FP(\alpha)$
	Negative	$FN(\beta)$	TN

Suppose our test data contains ten rows. So we have ten predicted labels and ten real labels. The result of peer-to-peer comparing each of the 10 data will fill out the confusion matrix cells. Finally, the total number of each cell will be counted… Out of 4 cells, two cells are related to the fact that the model worked correctly, and we will have two types of errors. Type error means that the value of the actual label is positive, and the model is mistakenly considered negative. The Type error also means that the actual value is negative, and the model considers it positive. Based on the confusion matrix, at least four criteria for measuring the algorithm's accuracy can be obtained. The first criterion is general Accuracy, which is defined as follows:

$$Accuracy = \frac{TP + TN}{TP + TN + FN + FP}$$

In fact, this indicates the overall strength of the algorithm in detecting accurately both positive and negative. The next criterion is Precision:

$$Precision = \frac{TP}{TP + FP}$$

Which indicates the number of correct detected positive class among the total positive classes. The next criterion is the Recall criterion:

$$Recall = Sensitivity = \frac{TP}{TP + FN} = \frac{TP}{P}$$

Which indicates the number of correctly detected positive class among all really true positive classes.

The two criteria, precision and recall, are complementary. There are other criteria too. They can be defined in the same way."

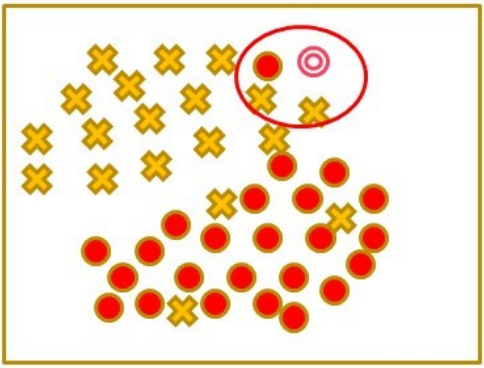
"How do we know when to use which evaluation criteria?" Asked Ivan impressed.

"It depends on the application and the type of problem," Russell said. "In problems where the number of classes is balanced, all criteria can be applied. In cases where the number of classes is unbalanced, the precision and recall criteria are usually more applicable."

When Russell finished, he waited for the others to ask. Nobody said anything.

"How was it, Master," Russell finally said to Tom. Tom let it pass with a simple smile. "It was good. I just have to say. There are other evaluation methods as well as other model training methods. I will explain them later if it is God's will. This is enough. We can run the decision tree on the data, but it is better to use another classification algorithm and measure the accuracy for both methods, so we can be sure that the decision tree algorithm accuracy is robust. For this reason, I would like to introduce you to the K-Nearest-Neighbor algorithm (KNN).

It is a very simple algorithm because most of it is similar to the method you have already seen in the k-means model. In this algorithm, no function fits on data. This algorithm works based on distance and, therefore, neighborhoods. Well, training data with Labels are available. Now, without any extra work, for each test data, it measures the distance of each unlabeled test data from all the training data and finally selects K nearest neighbors from train data.



Next, a vote is taken place between K nearest neighbors. And then, based on the logic of Majority Votes, the test data class will be equal to the class with the highest number of votes among neighbor train data. As you can see, this algorithm had no function to fit and did nothing until the test data came in. that is why this algorithm and other similar algorithms to KNN are called Lazy Learning algorithm."

"How could we find the best value of K or the nearest neighbor?" Ivan asked, flipping through the figure.

"That's a good question," Tom replied with the fixed bayonet of his pointed finger darted full at the figure. "Usually, this should be the odd number to get the absolute maximum number of votes. If K is too small, the accuracy may increase, but the generalizability of the model decreases, and if K is too large, the generalizability of the model increases, but the accuracy decreases. You have to trial and error to select the best number of K. You see, it's still a hyper parameter selection issue. For our work, I think the number of three neighbors is enough because we want to compare the KNN accuracy with the accuracy of the decision tree algorithm."

Tom waited for the question. Nobody asked anything. So he continued, "If the accuracy of the two models is high based on the two classes we have defined, it shows that we have given the correct features to the model. After that, we have to see which features have the most impact on The Deus Machine. For this, we will use the decision tree alone."

Tom then turned to Ivan, but he did not say anything. Ivan raised his eyebrows. "Oh, again coding." Everyone turned towards Ivan's laptop.

The economic, demographical, family, and criminal data of those who were attacked, and those who could have been attacked but were not, were pooled together to form one row per person in the aggregated dataset.

With Tom's guidance and using existing libraries, Ivan applied the decision tree model and KNN to the data. 70% of the data was split for training and 30% for testing. The accuracy of the decision tree model was 94%, and the accuracy of the KNN model was 91%. The accuracy of the two models was close to each other. As Tom and Russell saw the decision tree's confusion matrix, on Russell's advice, model training repeated with different seeds of the random process. The average accuracy was around 95%, and no significant change was seen.

"The accuracy of the decision tree is high," Tom said, rubbing his chin. "The KNN accuracy is close to a decision tree, which means that the Deus Machine used similar data we used, to attack or not to attack. Now we need to find out which features have an important impact on it.

At Tom's point, Ivan extracted the feature rank from the decision tree library. The highest rank was for Average bank account reserve, Criminal record, and Job position.

Reviewing the data, Ivan told everyone. "The people who were attacked had high bank accounts, and almost all of them were top executives in their organization. Also, out of 150 people who were attacked, 63 of them had open cases in court, and 33 others had already had court cases. Out of 150 people, 41 of them have appeared in court more than twice."

"How many people went to court for the first time and had an open case?" Hannah said, her hands on her hips.

Ivan quickly typed the query. "51 people, that is, one-third."

Hannah took a deep breath. "Ah…, you mean the system has targeted and prosecuted people whose criminal charges have not yet been determined? Punishment before the crime?! Oh, God."

"It means that the Deus Machine is opposed to human beings," Tom raised himself on the side table and said in a startled tone. "But because it acts only based on the available data, without having a human interpretation of them, without any mercy, it orders the attack. This is the evil of artificial intelligence systems. They do not understand our values."

"And why should they?" Ivan closed his laptop. "They are not human."

"But apparently, they are in favor of anything inhumane. For example, escaped laboratory animals. Whatever it is, this system is inhuman and has learned to fight with them. Russell said, and then he said in a whispered tone, "Unless a rival like artificial intelligence can turn human beings away from their deviations and..."

"Maybe this system has put itself in place of God." Hannah interrupted him. "Believe it or not, maybe from all those historical texts, instead of learning all those weird concepts, things like freedom, oppression, etc., maybe it just learned the concept of being God. You know, philosopher whether who believe in God or not, all has spoken about God. The Deus Machine must have learned the same. If there is God, it has decided to become a more pragmatic God, and if there isn't, it would rather build one real God with all his carrots, sticks and heaven."

"It has just punished for now. It has not rewarded anyone yet." Ivan said, glaring at Hannah with deep suspicion.

"Why not, remember those animals," Hannah replied, broadened herself by putting her thumbs in her armholes. "Wasn't their reward for being free? In a wildlife documentary, I once heard that the narrator said sarcastically that no creature had been more beasts than men among all the creatures on earth. The number of extinct animals by humans is innumerable."

"If this system turned to be a God," Russell said, excited. "It is a God of justice. I once read that the ancient philosopher said if cows could choose a God for themselves, they would give it the face of a cow. Most human beings, too, have their perception of God as something of a great, peevish, gloomy, and rude human being who has sat on the throne and wants to take revenge on his creatures until they die, but instead, he has put everything at the service of the human being. But the Deus Machine, oh, maybe is a righteous God and a savior If we look at it from the perspective of all other beings."

"Anyway, we are human beings, and we must first and foremost care about our human values," Tom said, properly denying Russell. "What is clear is that this system is completely contrary to our values and should be stopped."

"But how?" Said Hannah, tooth grinding. "By pulling the plug of all the computers in the world?"

We were passive till now," Said Tom. "We just wanted to understand the Deus Machine. From now on, we have to be one step ahead of it. We have to predict its next movement and stop it in the right place by completing our cognition circle. Now we must understand when and what the Deus Machine's next movement and for this, we must fight in the same way. Let's go. With artificial intelligence itself, while carrying our values on our shoulders, we will fight with this Artificial General Intelligence…

It is not an argument among different attitudes. It is about the existence of a human being. If we move late or move badly, only one group of people will not be harmed. We will all fail. Maybe some people are bad, but even there would be just one good man in the world, for keeping this goodness, human identity must survive, and we must accomplish this mission."

Tom's epic words seemed to be like water to be poured on their fires to extinguish them. Hannah, being impressed, vigorously acknowledged that the same strategy should be implemented. Russell put his hand on his suspender ring and looked meditative and satisfied.

09

Into The Forest, To Lift The Spell

It was around noon. The air was very hot and dry, and the brain was boiling. Tom and Hannah were on their way back. Ivan had separated from them and went on his own business. On their way to the cottage, Hannah parked at a curb, got two banana ice cream, and then brought them into the car.

"So, what's up with Samuel Hoffman?" Tom asked, constantly licking on the ice cream. "Did he confess to the murder after the blood test?"

Hannah shifted slightly in the car seat to see Tom easily. "Yes, he had no choice but to do so. He takes responsibility for the murder but did not say anything about his motives. At first, he said that I proposed to her. She refused then. We got into a fight at her house, and I accidentally killed her, and then I fabricated the whole thing as if Anna Cooper had committed suicide."

"But there were no signs of a struggle on Anna Cooper's body," Tom asked in surprise.

"Of course not," Hannah shrugged. "It is clear that he makes up stories. After he saw that his last story wasn't convincing, he narriated a new story."

"What's the story?" Tom asked sarcastically.

"He says he was inspired to be the prophet of the Deus Machine." Hannah snapped.

The heat was excessive. Tom drank up the rest of the banana ice cream at once in one draught. "Wow," Tom said, looking at the empty end of his plastic cup. "Once upon a time, in the 21st century, the golden calf is still worshiped. The figurative eyes of many are blinded by ignorance." He swiveled his eyes and fixed them onto Hannah. An unblinking stare. "But I'd like to see him." Said Tom, with his gravest mildness. "I need to talk to him. Is there any way?"

She hadn't been expecting this. "Do you want to see him?" Hannah asked, surprised. "What's so interesting about him?"

"He was a member of that secret society, and so is Anna." Tom thought for a moment and said. "I want to talk to him about his prophet mission. I may put faith in him."

Hannah nudged him painfully in the ribs. "Good grief." Said Hannah, with captivating sweetness. "Do you think your visit will help?"

"It's worth to try," Tom replied.

"Okay, I'll arrange a meeting," Hannah said, switching on the engine and putting it in gear. She suddenly could feel through all her veins the warmth of Tom's hand. She turned and stared at Tom with a laugh.

Tom closed his eyes for a moment and then started laughing cutely to escape the temptation of a deep feeling to kiss her.

The car was picking up speed. Hannah leaned heavily with her elbow on the car door, turning on her car stereos. The song Good Enough by Evanescence was playing. They said nothing more. Amy Lee was signing. It looked like she was throwing them through their past. Some deep, buried, and quite a speechless feeling appeared across their mind, reinforcing as time went on.

Tom was standing behind the interrogation room window, knocking Samuel down. There was no anxiety on Samuel's face. It was like he was completely satisfied with what he had done. Tom waited for permission, and as soon as the officer let him to pass, Tom entered.

Samuel was shocked to see Tom there as though he offended Tom. He lifted his elbows off the table and leaned back in the chair. "Hey, where you been?" Samuel said serenely.

"I have come to exercised faith to our new prophet." Tom grinned. "Of course, if you can answer the questions I have."

Samuel averted his head. "I wish you'd understand what I know. You didn't try to mock me then."

"I want to know what's on your mind." Tom leaned over the table. "So what made you kill someone? Your colleague, indeed. Tell me please. I'm here to hear."

"You know," Samuel said, his voice shrill, faltering. "I endured a difficult childhood. My stepfather brutally beat my mother and me. By his beating, my mother lost her head, and I lost my feeling alone. When I grew up, my head was full of questions, full of ambiguity. If I found God, I would punch his face with all I might. After a while, when I got a little quiet, I realized no God in this world. There is only one God, and that is money. I hate that arrogant, pompous, dollop head rich people. For years, these same people have taken control of technology and science. Now we, the poor people, have a chance. Why shouldn't we embrace this opportunity and even die for The Deus Machine?"

He looked down as if he regretted his confessions. "All these years," He continued. "Humans have been looking for a machine to do their routines so that they can free up their so-called time to think and do more important things. Now the Deus Machine stacked the deck against them. It tells you humans are incompetent. As you find free time, you immediately think of lust and rebellion. From now then, I will think and act in place of you. You better stay in the same darkness you have been in. I will do justice. I take from the predator and give to the prey. If you hadn't been occupied and diverted yourselves for piling up of worldly things, you'd never oppose the Deus Machine. It deserves nothing but worship."

Tom took a deep breath. "I had almost killed myself a few weeks ago," Tom confessed. "I had no interest in this world, but I still think that even something like the Deus Machine cannot be worshiped. A God who stands on the shoulder of our ignorance knows us by our ignorance and grows bigger with our ignorance…

Any God who guides his followers to perversion and darkness instead of leading them to light is unjust and unvarnished. God is not a judge. The true God is never in favor of one group. He stands up and calls on both sides to see himself, to see the harmony hidden in the whole universe, to see him without a mask, to stop fighting and seek the truth instead of owning the truth. Not that he stands on one side and wants revenge on the other. Isn't this the devil work?"

"A God who is not a judge is a dull God." Said Samuel, his arms folded across his body, his jaw clenched tight. "I like a God who takes hard revenge and does not postpone today's revenge on tomorrow. For several thousand years, the God you are talking about has only seen and done nothing. It's time for a God to come and finish the job."

"Even if this God is the supreme God," Tom said, rubbing his chin. "I don't know how it chooses you to be its prophet!"

Samuel settled himself comfortably in his chair. "The prophecy of this God is worthy of one who has understood the essence of this God. I understand this, and I can convey his message to the servants of this God. This choice is not acquired but inherited. That's why I was born. It's my mission. We must understand being chosen ourselves."

"The essence of this God is mathematics without emotion, logic without meaning, Power without morality, and judge without care," Said Tom.

"Yes," Samuel immediately replied. "Purity is always obtained by getting rid of superfluous things, and our God is a God who is free from any red tape norms."

Tom giggled shrilly. "But your unlimited God has two weaknesses: first, that it is possible to make not only one but a thousands like it. Second, your credulous God is gullible. It swims with the current. He learns from our behavior, so our behavior changes, it will change too. The consciousness of this God is not in the heavens. It is in the lust of the same men and women that you hate them. If their desires change, your God will also change."

"Yes, and we, its followers, will not let this happen."

"Woe to the God who needs his followers. I must say, in this war, the one who knows wins, this time, knowledge will win, not blindness faith."

Tom got up to leave.

"What are you looking for?" Samuel said, raising his head and staring into Tom's eyes. "Even if this God is destroyed, the need for this God will not disappear, and it will not be too late for other stronger and more ruthless Gods to make a scene. Doesn't everyone have their own God now? Money, fame, lust, beauty. Aren't these your Gods? There must be a greater God to stop the extravagance, and we, suffered human beings, must help it. I am not alone. We are many, and we will go down this road. As always, throughout history, this is a battle between the oppressor and the oppressed."

Tom turned back. He took a few steps towards Samuel. "No, this is a battle between freedom and slavery," Tom said confidently, gazing at Samuel's eyes. "Even if all human beings choose the wrong way, they must choose this hell way freely. Freedom is scary. It is a heavy burden of responsibility, and people who do not want to think, do not want to take responsibility, run away from it…

And hesitating in accepting the responsibility, even at the cost of death, has created the story of the oppressor and the oppressed throughout history. If every oppressed person in history did not bend the knee, surely no one would ride on him. Anything that restricts freedom takes our humanity away from us, which means enslaving human beings and producing more strong oppressors, the digital or artificial intelligence kind then. The next stage of the battle between oppressor and oppressed you are looking for is more human beings' salvation. I choose to be free no matter how cost does it take. Accepting responsibility is achieved with knowledge, and this time, knowledge will save us."

He turned back to go. But he hesitated for a moment. "The God who needs his followers wants everyone to be his slave. Why do you want to be a slave to something you made yourself? Let us, once and for all, make us rid of every mock God. Let's fight for freedom." He said this with a penetrating and motionless stare at Samuel.

Samuel stood up from his chair as if it was difficult for him, tried to say something, but seemed unable to speak. Tom walked toward the door with long strides.

Outside the interrogation room, Hannah was waiting for Tom. He went towards her, grasped both her arms at once. Hannah was exhausted, half questioning expression on her face. Tom gripped her arm tighter.

"Are You Ok?" Hannah asked. Instead of answering, Tom tried to find the street door.

"Tom, I have bad news for you," Hannah called back. "The Deus Machine has rebelled again. Everything in New York City, from traffic lights to traffic control systems, has gotten out of hand. Power and water supplies were temporarily disrupted."

Tom descended into some steps and got faced face-to-face with Hannah. “This fight has just gotten more exciting. Let’s go. Our team must come together again. There is only one step left to get to know this system well. Then it will be our time to shine.”

He climbed up the stairs. Hannah reached behind him. They got in the car and drove to the cottage.

When Ivan arrived at the cottage, Tom and Hannah were standing in front of Tom’s greenhouse. Tom was watering the flowers, and Hannah was standing by the front door, hands tucked under her armpits.

Ivan came and sat down on the sofa and opened his laptop without saying a word. A few moments later, Tom and Hannah came and joined him. “Have you heard what happened in New York?” Tom said as he sat down.

“Yes, I heard,” Said Ivan, who was typing fast. “That is, I did a penetration test after what happened. Only those urban systems that worked intelligently and automatically were hacked. The way the Deus Machine works is interesting. It only changes the objective function of the intelligent system, which is a mathematical algorithm. For example, two traffic lights on the street are supposed to be in sync, and when one turns red, the other turns green. It changes this algorithm and causes a disruption.”

“That’s right,” Tom nodded. “This system has learned how to rewrite the objective function, or reward and punishment mechanism that exists in most automated systems. Most likely, the Deus Machine has two interactive mechanisms. The mechanism, based on machine learning algorithms, learns and chooses its prey and the mechanism that penetrates and changes the objective function. This black box penetration mechanism is due to the complex algorithms that Anna Cooper fed to this system."

"We're dealing with a monster," Hannah puffy nodded.

"Almost," Tom shrugged his shoulders. "But well, the Deus Machine also has its weaknesses. We already know the ultimate goal of this system and what it seeks, to limit or, more pessimistically, destroy humankind. We know that it especially objects to rich or ex-convicted people, and usually because it has no idea about our values, it may be acting against those whose guilt has not been convinced yet, and it did such thing, indeed. If we knew what resources it feeds from and how much each resource's weight is, we'd be able to control it somehow.

Ivan's eccentric condition drew Hannah's attention. She got up and sat by Ivan. He twisted his face toward Tom, his lips already puckered so that the smell of the alcohol could not reach Hannah. But she sniffed, being aware of the overpowering smell of alcohol, she did not say anything. Instead, she turned to Tom and asked, "Do you want to use machine learning again?"

"You guessed right," Tom laughed. "We must first understand where the data sources of The Deus Machine comes from. I guess that it gets people's data from news websites and social media networks. But it must be tested. In the next step, we must understand that the most impactful news trends will belong to which category in the future. We need to identify popular trends for the next few days. Then, from the data related to that trend, we will get the probability of choosing any of the states related to that trend, and then we have to estimate the decision of the Deus Machine, what corruption it is going to do…

We will use three machine learning approaches to answer three questions. The first step is to predict the number of trends in the upcoming days. To do this, we will use a regression supervised learning approach, that is, our label is a real value instead of a few limited values - as we had in the classification - and we have to predict these continuous values."

"Will we use linear regression for this too?" Ivan asked, crossing his knees.

"Umm, technically, yeah," Tom answered. "But news trend data is complex and large. As a rule, in this complex data, the existing pattern should not be linear, and also, the accuracy we need should be very high. At the same time, the challenge we have is the lack of structured data. We have to preprocess the amount of unstructured data and change the data processing strategies if the model's accuracy is not satisfactory. So we need our model to be interpretable as well. Based on what I said, it is better to make the forecast based on Gradient Boosting Model or GBM tree-based models."

"What do you mean by tree-based?" Hannah asked, rolling over, scrambled to her feet and then flung herself down on the sofa beside Tom.

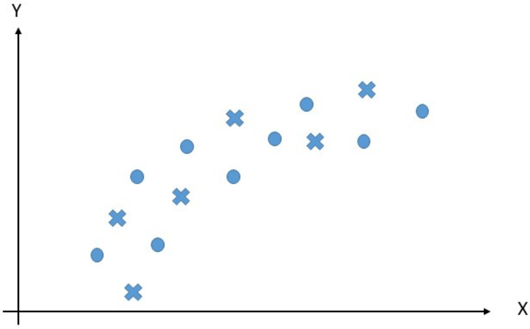
"The decision tree is the simplest type of Tree-Based Model," Said Tom, holding Hannah by the shoulder. "Tree-based models are models that their topology is based on building trees from features and labels. The decision tree was just one of the tree-based models we've learned. There are others to mention. More complex and more robust ones...

In these kinds of complicated trees, we can build multiple trees from existing data and use a combination of existing trees to answer our questions, which can be either classification or regression. Models that are made from a combination of several basic machine learning models are called Ensemble Models."

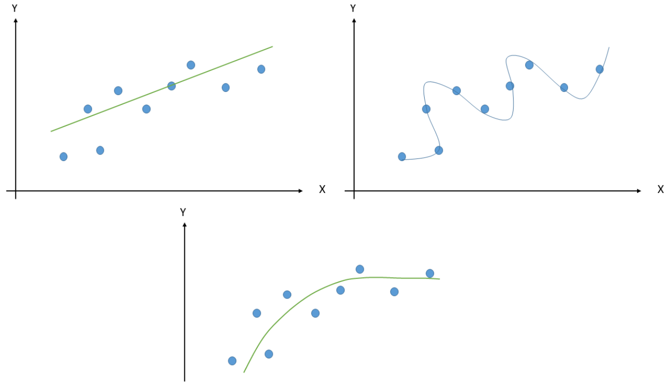
"Why do we use several trees?" Ivan immediately asked. "What's wrong with just a single tree?"

"Remember," Tom crossed his legs. "I said that the reliability of machine learning models could be measured in terms of accuracy and generalization. These models work with data. If the available data is not sufficient or the data structure is complex, the number of features is very high - the basic models lose their performance…

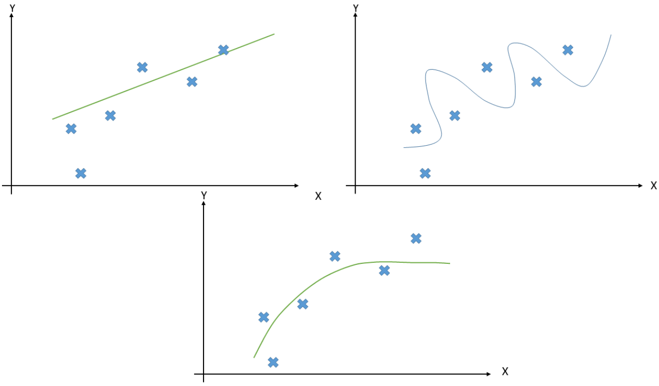
To become more familiar with this issue, we need to understand the tradeoff concept between Bias and Variance. Suppose we have a series of data and want to fit a model on the data, as usual, we have to divide the data into two groups. Train and test. For example, in the figure below, the training data is highlighted in a circle, and the test data is highlighted in the plus sign.



Because the data is visible, it is obvious that the appropriate model is the convex one. However, let us fit three types of models into our data.



In the top left figure, a linear model is fitted to the data. If we watch carefully, we see that the fitting error on the training data is high. In the right above figure, a complex nonlinear model is fitted. We see that the training error in this model is zero because it has passed all the data. And the figure below is a convex curve with less training error than the linear model but more than the complex nonlinear model. Now we fit these models on the test data. Let's see what will happen.

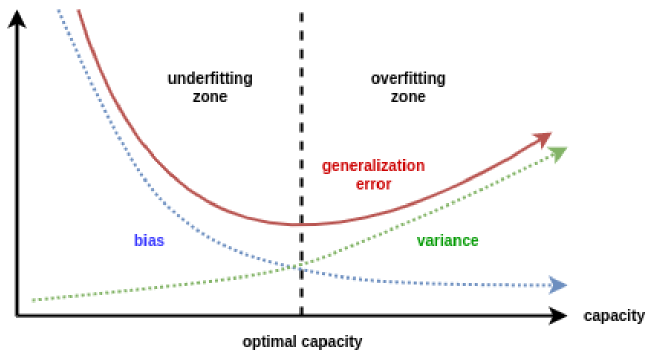


As you can see, the linear model's test error is also high, and no matter how much we try to fit a better line, the straight line will not represent the real pattern. In fact, in the linear model, the variance between different iterations to evaluate the test error will be small, but the linear model does not inherently show the data pattern well. That is, it is skewed and has bias relative to the data. This is called an Under-Fit Model.

In the complex model, too, we see that the test error is extremely high and every time the train and test data is reassigned randomly, the variance between this model's errors will be very high. Each time, we get a different number with a big difference from the previous number, but the numbers obtained fluctuate around a central number.

This means that the bias of the model is low, but it has a large variance. This is called the Over-Fitted Model.

In the figure below, both the bias and variance are low, I mean, the pattern is well identified, and the variance between different execution results is reasonable. This condition is also called Just in Fit. Bias and variance are two indicators that show the generalizability of the model. There is an inverse relationship between variance and bias. Like the following figure:



Based on the available data, we call a model good enough if it has an optimal tradeoff between variance and bias of test error so that the model can be generalized. When we have a small dataset and our model is complex, the probability of overfit is very high. Therefore, a simpler model should be chosen…

Given that the source of error in any machine learning model is not out of one of the three modes: bias, variance, and noise, so the concept of bias and variance is very important in machine learning, which is also used in designing different model training or hyperparameter tuning strategies. I'll delve into this concept later. For now, in tree-based models, The bias-variance tradeoff will be used to build different trees from existing data."

He paused for a moment. No one asked any questions. "Although the decision tree has a high degree of interpretability," Tom continued himself. "The main problem with the decision tree is that it has a very high potential for overfitting, which is why we implemented the KNN model last time along with decision tree. Other tree-based models have tried to overcome this disadvantage to cover this weakness, which I will explain step by step. Now it's time to explain some more things about decision tree, then I'll move on to the concept of GBM.

The first point about the decision tree is that this model, in addition to being used for classification, is also used to predict real number labels, I mean regression problems. tree-based models is an umbrella term for a wide variety of models that take inspiration for decision tree, including the regression decision tree itself. For this purpose, small changes can be made in the main structure of the decision tree model. How? Let me explain.

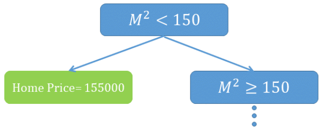
As you know, the linear regression models we discussed earlier used the least squares error function to fit the best line. The same function will be used in the regression decision tree. Suppose we want to predict the price of a house based on the appearance-related features of the house. The dataset we have is as follows:

Based on the decision tree's logic, the most important feature for separating the branches must first be selected. In the classification decision tree, the entropy criterion was used for this purpose. In the regression decision tree, the

# of Rooms	Area (m^2)	Prestige	Price($)
2	250	Good	250000
3	300	Good	320000
1	80	Fair	180000
4	430	Good	550000
⋮	⋮	⋮	⋮

least-squares error function will be used for this purpose. Let's move on one by one.

Let's start with the Number of Rooms feature. Like the decision tree, the feature must be discretized. Here it is no longer possible to select the median as a splitting point and divide the quantitative attributes into two branches. The labels are no longer limited, and different separation points will lead to different labels. In general, for example, for the Area feature, a fraction of the decision tree could look like this:

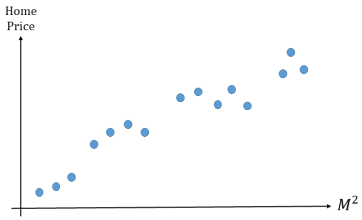


Now two questions can be asked:

1. Why the separation point chosen for the Area feature was 150?

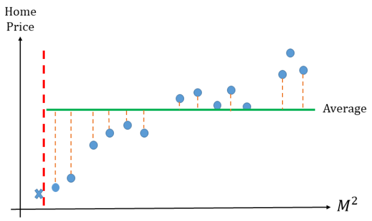
2. Why the Area feature was selected first?

Let's start with the first question: Suppose the distribution of data per Area and house price is as shown below.

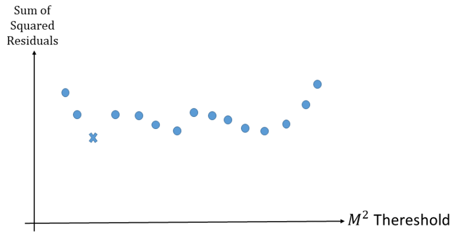


The regression decision tree's basic logic for this is to start with the first data and discretize it and then calculate the least-squares of error. Let me explain further.

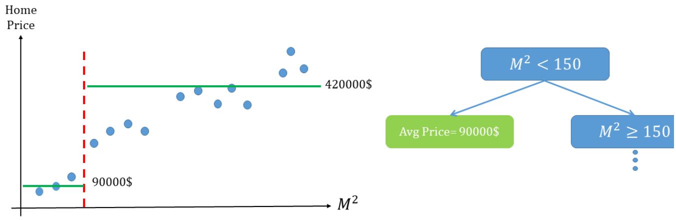
Suppose we select the data with the least possible value and place the breakpoint there. So on one side, we have a point, and on the other side, several other points. Now for both sides, the average line is applied, and then the distance of each point from the corresponding line is calculated. That is, the least-squares error function applies to all data together. At the first iteration, because we have a point on one side, we will not have a line, but we have a line on the other side.



Now, if we go one point further and recalculate the least-squares of error and continue to the last point, the shape of the least square error function would look something like this:



As we can see, the minimum point occurred at the third point. Therefore, the separation point will be the third point.



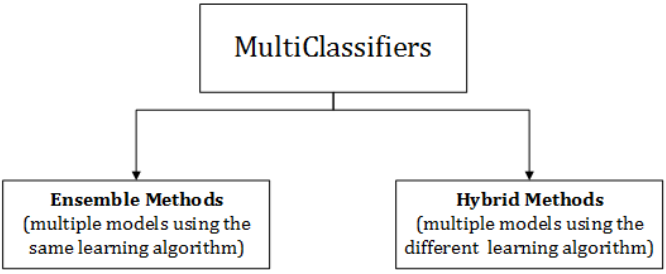
As you can see, there are three points on the left. Now, these three points can be separated again. But is that a good idea? The answer is no. Because it causes the model to overfit as if for each point, a separation point is defined, if we do this, we will have zero training error and very big test error. So there must be a way to prevent such phenomena. To do this, they usually set a threshold for the least number of points on each side. For example, if we consider the threshold to be 3, the side with less than 3 won't be separated and turned to the root.

Well, now let's move on to the second question, how will the important feature be selected if other features are included?

The short answer is that we do the area feature for all other features and then compare the value of the least-squares function with the minimum error for all of them. The feature with the lowest value is selected as the top attribute.

Now again, like the logic of the decision tree in the classification, we subtract the current state data from the original data, rebuild the smaller trees, and again compare the least-squares of error. The condition for stopping is two criteria: we reach the minimum number of points at the separation point, or all data is checked. That was the philosophy of the decision tree for regression."

Tom got up and went to the kitchen. He drank a glass of water and then filled the pitcher and brought it to the table. After sitting down, he continued: "We do not intend to use the regression decision tree to predict because it has still a major weakness on overfitting. For solving this issue, data scientists have come up with other solutions. For example, in one solution, they said that instead of building a tree, let's build a forest of different trees, examine each tree's results with a systematic mechanism, and finally make the final decision. As I said before, the next generation in tree-based models is moving towards such approaches. In general, if we want to categorize Multi classifiers, we can categorize them as follows:



In the following, we will get acquainted with the Random Forest algorithm, AdaBoost algorithm, and GBM algorithm. All three methods are Ensemble because they use the same basic model. Ensemble models themselves are divided into two categories: Bagging and Boosting. The random forest algorithm is a bagging ensemble model, and the adaBoost and GBM algorithms, as their name implies, are a boosting method. All of the wide range of tree-based models ultimately belong to one of two types of models. Therefore, it is better to study these two concepts more:

Bagging and boosting models are proposed to reduce the variance of the base model. The idea of these approaches is that a group of weak machine learning models will create a strong predictive model that results in increased model accuracy if used together well.

Suppose our database consists of 100 rows of data and ten features, and a label, and our base model is a decision tree. In the Bagging approach, the number of trees must be provided by a user to build the ensemble model. The logic for this approach is that we should build trees by sampling by replacement from row data. This type of random sampling in statistics is called Bootstrap Sampling. This means that each row of data can be placed in any of the trees and repeated several times. The next point is that each tree's row numbers are equal to the number of original data, except that some rows may be repeated multiple times. The reason for naming the bagging method is that the beginning of the word bootstrap and aggregating are added together, and the word bagging is formed.

Finally, different trees are trained based on a subset of the data. As a rule, in random sampling with replacement, some samples may not be selected at all. These examples are called Out of Bag Sample. We will use these examples to initially evaluate the bagging model's performance to estimate the initial accuracy of the algorithm, which is called out of bag error.

In bagging models, we must select a subset of columns too. Each decision tree model is trained with a subset of selected rows and a subset of columns. For selecting a subset of columns, we use out of bag error. The decision tree model is based on the possible subsets of columns, and the combination of columns that caused the least error in out of bag error is selected as the number of subsets of columns.

After that, the final result and prediction of each model are reported for the test data. If we have a classification model, the logic of majority votes is used, and if it is a regression, averaging will be used.

The advantage of this approach is in reducing the variance of the results and thus preventing overfitting. This method also makes it possible to handle high dimensional data. Still, because it ultimately averages the final outputs, the model may not perform well in some specific situations. As I said, the random forest model uses such an approach.

Finally, bagging methods, especially random forests, have an internal mechanism for filling the missing data. For this purpose, they use a method of weighting and using the same data frequency in similar classes. We have nothing to do with this at the moment, but I wanted to say that most tree-based models can provide a solution for missing data as well."

"Why did the sampling with replacement has taken place?" Ivan rubbed his chin and asked. "Why not without replacement?"

"The reason for this is to provide an opportunity for all models to view the data randomly," Tom replied. "Because the models work in parallel and their training process is independent of each other, they should be able to see all the data randomly than not to see part of it, because of the philosophy of reducing variance and avoiding overfit lies in the possibility of viewing and understanding of all feasible space of the problem. Further, when we have a lack of data, sampling without placement will not be reasonable."

Ivan was convinced. Tom looked at Hannah. She was silent. "Now, let's turn to the general idea behind boosting models." There was a short pause, and then he whispered. "I say general idea because these models have different mechanisms in some aspects, but they all have the same principles. So let me first explain this general idea:

In this type of model, the number of trees must be known from the beginning. In boosting methods, different trees work in series, based on data weighting. The goal of each tree in the sequence is to improve the performance of its previous tree, so that if in the first tree, we have a misclassified data or data with high error in regression, in the next step, that row of the data receives more weight so that the next model can classify or predict it better. In general, the process of these types of approaches is as follows:

1. In the first step, all data have the same weight. A subset of the data is selected without replacement, and the primary tree is trained with it. Misclassified data received more weights and reassigned to the original data.

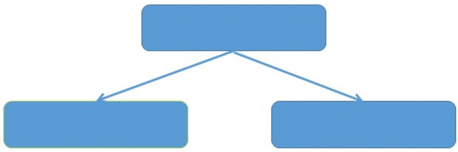
2. The second tree is trained based on another sampling without replacement from data. The more incorrectly classified specific data in the previous steps, the greater its weight and the greater the possibility of being reselected.

3. The third and fourth trees, etc., are trained in the same way. Finally, for the test data, all the trees' predictions are reported based on the logic of majority votes in the classification and averaging in the regression.

In Boosting methods, the further we go, the later models seem to try not to repeat previous models' mistakes, and such trees become stronger and stronger in a regular sequence. Now, each tree can be graded based on the accuracy provided in the training phase. Different weighting methods lead to different algorithms. Here we are going to take a closer look at two boosting methods, adaboost and GBM.

Let's start with the adaboost method, which uses some of the random forest method's logic. That is, the same method of dividing and sampling with the replacement I mentioned is used here. But unlike random forests, this method does not make a complete tree, and at the same time, it has the same logic as the tree-based family: building a set of weak models to get a strong one. The next point is that this method is used for both regression and classification. Let me explain more:

The adaboost method builds a tree stump instead of a whole tree. That is, a feature with one level depth as shown below:



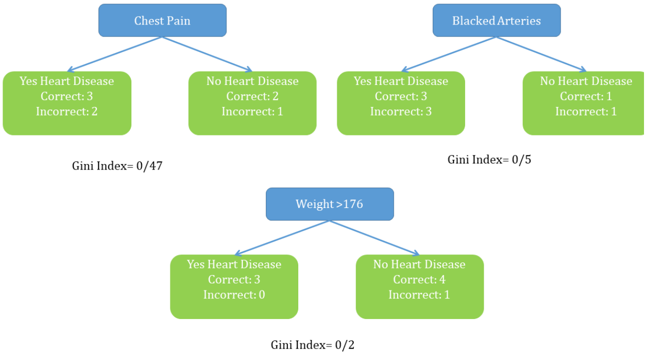
The adaBoost method, as a method of the boosting family, works sequentially. That is, the performance of each stump affects the next stump. Weighting misclassified data do this. Accordingly, each stump itself has a weight, and in the final round, the stump with more weights has a greater impact on voting. So the adaBoost method has three basic ideas:

1. Use stumps, which have poor performance individually, for stronger prediction.
2. Weighing the stumps to determine the impact of each stump.
3. Each stump is affected by the performance of its previous stumps.

Let's move the discussion forward with an example. Suppose we want to create a classification model to predict whether a person has heart disease or not. This is our hypothetical database. In the first step, we assign an initial weight to each row of data. Because we have 8 data, the weight of each data will be $1/8$:

Chest Pain	Blocked Arteries	Patient Weight	Heart Disease	Sample Weight
Yes	Yes	205	Yes	1/8
No	Yes	180	Yes	1/8
Yes	No	210	Yes	1/8
Yes	Yes	167	Yes	1/8
No	Yes	156	No	1/8
No	Yes	125	No	1/8
Yes	No	168	No	1/8
Yes	Yes	172	No	1/8

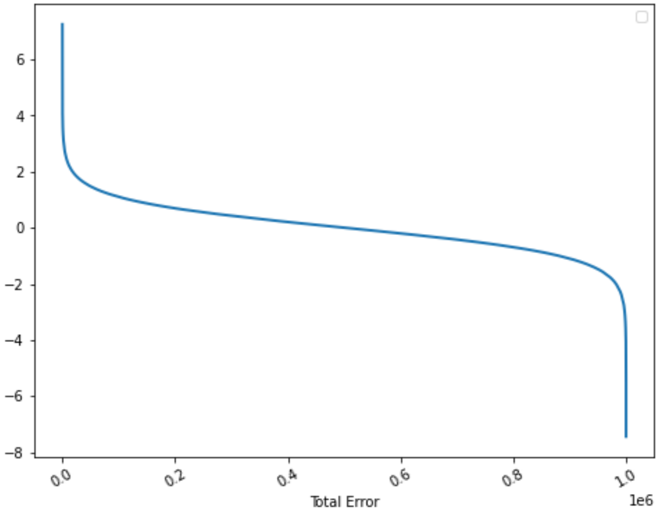
By the mechanism I will describe, these initial weights will change in later steps to determine the performance of subsequent stumps. Now we have to choose our first stump. Because in the beginning, all weights are the same, we can ignore this weight. From the three columns, we must select the best one. To do this, we form three candidate stumps, see each stump's training accuracy, and then calculate the gini index criteria for each of them. The stump with the lowest gini index criteria is selected as the root stump.



As we can see, the weight attribute has a lower Gini index, so it is selected as the first stump. Now we need to determine the impact of this stump on the final answer of classification. The training accuracy determines this. For this purpose, the error of each stump must be calculated. The total error is equal to the total number of misclassified data, which in the example of the Patient Weight feature because it has one error, so its total error is equal to $1/8$. We will use the total error to determine the Amount of Say, which is determined based on the following formula:

$$Amount of Say = \frac{1}{2} log(\frac{1 - Total Error}{Total Error})$$

The shape of this function is something like this:



This means that if the stump error is close to one, its impact rate tends to be infinitely negative, and if the stump error is close to zero, the impact rate tends to be infinitely positive.

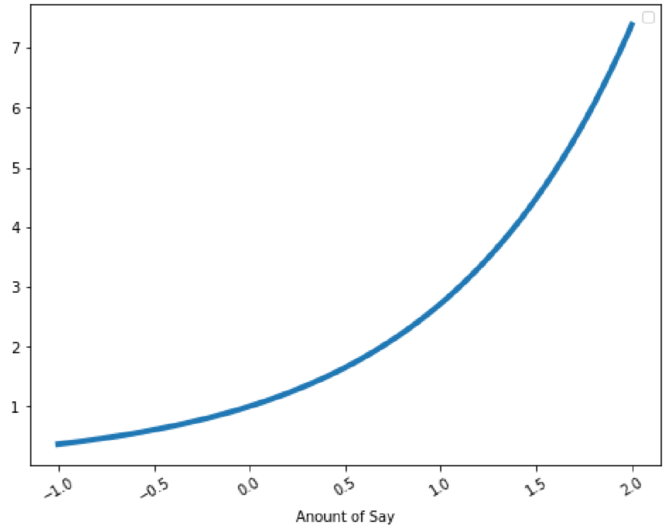
Now, for the Patient Weight feature, we can calculate the effect:

$$Amount of Say = \frac{1}{2} log(\frac{1 - \frac{1}{8}}{\frac{1}{8}}) = 0.97$$

Because the weights were the same in the first step, the weight of an error that occurred is $1/8$. Now we need to introduce a mechanism that updates the weights. In this mechanism, more attention should be paid to misclassified data. This is done by increasing the weight of misclassified data and decreasing the weight of remained data. To increase the weight of misclassified data, we use the following formula:

$$Weight_{New} = Old_{Weight} \times e^{amount of say}$$

The shape of this function is as follows:



This means that as the impact of the stump increases, its weight also increases exponentially. To reduce the weight of correctly classified data, we also use the following formula:

$$Weight_{New} = Old_{Weight} \times e^{-}amountofsay$$

Which is exactly the opposite of the previous formula. Once the new weights have been obtained for all data, the weights must be normalized between zeros and ones. After this, we are ready to build the second stump…

To do this, we must again select the important feature to be the next stump. Here, based on each data's weight, we select the same number as the original data, random sampling with replacement based on the available weights.

Random sampling works so that random numbers between zero and one are generated based on the number of available data. The cumulative values of the weights are also calculated from the first data to the last data. If a random number is placed in any interval, that data is selected. By doing this, data that was misclassified in the previous step has a chance of being present several times in the next iterations, result in greatly reducing the possibility of being misclassified again. It's all the logic behind the adaboost method I described for the classification problem."

"Foo! how strange it is," Asked Hannah, who had been listening to all this time. "A simple decision tree can be turned into dozens of models,"

"Well, you ain't seen nothing yet." Tom nodded, "Believe it or not, I told all these stories to get here and explain the GBM method. All the previous discussions have been a kind of introduction to this model. From now on, our main discussion will begin."

"All that you said was a cool idea," Said Ivan, looking resentful, "I can't stand why we build a stump instead of a real tree?"

"This is the idea of the adaboost designer," Tom replied, "But the main idea is that AI researchers have concluded that a set of weak models have led to the strong models. Now the designer of Adaboost also intends to build a large collection of very weak models. At the same time, this simplicity has led to a high speed running. However, each new method must be examined in terms of accuracy, efficiency, and generalizability, and this model, in its basic article, has certainly done that things that have been able to be accepted by the scientific community."

Tom took a deep breath. "Well, the GBM method, like most tree-based models, can be applied to both regression and classification problems. I will explain this method for both approaches. After that, it will be the turn of predicting news trends in this way…

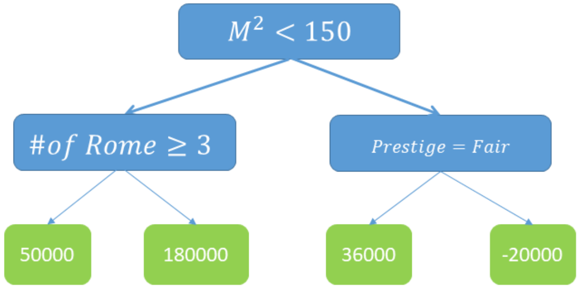
Now that you are familiar with the adaboost method, many parts of the GBM idea will be familiar. The difference is that even in the first stage, GBM builds only one root of the whole tree instead of building even a stump."

All three laughed together. After the smile shrank from their lips, Tom continued, "About root tree, I mean GBM starts with an initial guess of the value of the label, which in the regression example is data average. After this step, GBM creates trees with a fixed number of roots in each step, which it receives from the user. These trees, like adaboost, learn from the previous tree error and try to correct it. Let me explain further:

Let's go back to the house price forecast data using the three features mentioned. As I said, the initial forecast is the average of the label column, which, suppose here, is an average of $ 200,000. GBM subtracts the average value from each row by subtracting the average amount of label data in the next step. These residual values are the same as the residuals in linear regression.

# of Rooms	Area	Prestige	Price($)	Residuals
2	250	Good	250000	50000
3	300	Good	320000	120000
1	80	Fair	180000	-20000
4	430	Good	550000	350000
⋮	⋮	⋮	⋮	⋮

In the next step, instead of predicting the price, we predict the residual price values with the regression decision tree. The number of roots of this tree is fixed and is defined by the user. Suppose the number of roots for us is 4. The tree is made accordingly:



As you can see, we have four roots. This number in the machine learning literature can be between 8 and 32. Also, if we watch carefully, for some cases, such as what happened in data 2 and 4 and other similar data, the sequence path of branches and leaves leads to several numbers. It is as if we have several decision trees with the same structure whose roots are different. In this case, the gradient descent method is used to determine the best value for the root...

Here, based on how the Loss Function is calculated, the gradient descent method can determine the best value. But what is obvious is that if our Loss Function is the same as the least-squares of the linear regression error, the best value can be obtained by averaging those values. The best value for the least-square Loss Function is the average value. But if the function changes, the calculation process must be implemented by the gradient decent function."

He paused for a moment till they sink in. "Ok, let's move on. Now that we've predicted the residual value, we can predict the price based on the initial conjecture and the regression decision tree. For example, for the first price data, if we follow the path of the decision tree, the number will be:

$$InitialGeuss + RegressionDT Residual =$$

$$200000 + 50000 = 250000$$

Which is exactly the price for the first data. Isn't that great? We made a strong predictor.

Ivan and Hannah were silent for a moment. "I'm not exactly sure," Hannah said skeptically, "But I think the same problem that you put so much emphasis on, I mean overfitting, has occurred. Right?"

"Bravo." Tom nodded. "Our training error is zero. To solve this problem, we must tell each tree not to be too eager that it will not improve its learning the next time. We should use a learning rate to adjust the speed of learning. To do this, we use a parameter called the Learning Rate. Experimental tests have shown that small movements towards the target point lead to higher accuracy, less variance, and greater generalizability than fast movements. The learning rate is between zero and one. Suppose we consider the learning rate to be 0.1. With this adjustment, the prediction number is as follows:

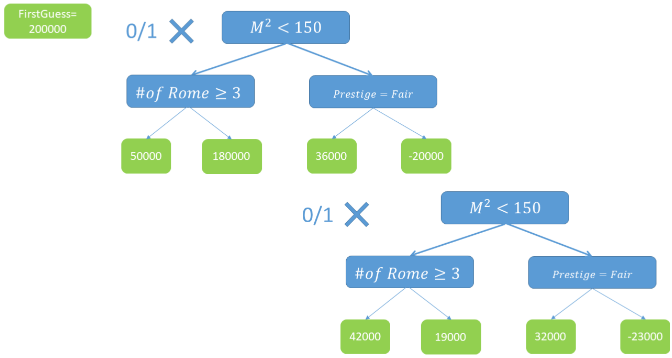
$$InitialGeuss + RegressionDT Residual =$$

$$200000 + 0.1 \times 50000 = 205000$$

Which is slightly better than the initial guess. The next repetitions have more to say. Now let's create the next tree: to do this, we need to rebuild the residual values based on the first tree's predicted value and update them.

# of Rooms	Area	Prestige	Price($)	Residuals
2	250	Good	250000	45000
3	300	Good	320000	102000
1	80	Fair	180000	-18000
4	430	Good	550000	338000
⋮	⋮	⋮	⋮	⋮

As you can see, all the residual values are smaller than the previous values. So we move slowly but surely in the right direction. Now we build the new tree again to predict the residual values. Now the same process must be repeated. All these two steps can be shown as follows:



At this point, we multiply everything from beginning to end. Of course, it should be noted that there is no reason for the branches and leaves to be the same every time a tree is made. This is just an educational example.

This process continues until one of two states occurs:

1. Reach the number of trees desired by the user
2. Adding a new tree does not improve the training accuracy of the model.

Accordingly, if we have a new unlabeled row of data, in the regression example, following the path in consecutive trees and predicted residuals and multiplying them sequentially, the predicted value for the test data will be provided.

This was a summary of the GBM method in regression. The same process can be done for classification problems. I must say here that GBM has many similarities to the logistic regression method in classification problems.

In regression problems, our initial guess was the mean value of the label. In classification problems, we also use the Log (Odds) mentioned in the logistic regression, which had the same meaning as the average. Then we need to calculate the probability value of Log (Odds) for each row of data.

$$Probability_{Pos} = \frac{e^{log(Odds)}}{1 + e^{log(Odds)}}$$

If the probability value is greater than 0.5, then the class's initial guess will be positive. Otherwise, the class will be negative.

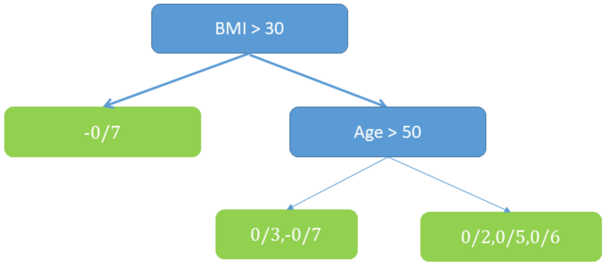
We have to calculate the residual values of probability for each row of data, and then we make the decision tree according to the previous procedure to predict the residuals. But here, it is different from predicting residuals in regression. In GBM for regression, the initial guesses were the same as the residual values obtained from the decision tree. For example, both were made of price. But in GBM for classification, the initial guess is Log (Odds), while the decision tree's residual values are of probability. To solve this problem, we use the following transformation formula:

$$\frac{\sum Residual_i}{\sum[PreviousProbability_i \times (1 - PreviousProbability_i)]}$$

Where denominator is for roots that have several values, and we put their average value in the regression, and here we put them in this formula. If there is one residual, we insert the same value.$PreviousProbability_i$ are also the probabilities obtained from the previous prediction for each row. After converting the residual values of the first tree, we retransform them back to the probability scale and continue rebuilding the tree."

Tom fell silent. He looked at each of their faces. When he came to say something, Ivan asked, "Honestly, I did not understand the last piece you were doing. Is it possible to explain with an example?"

Tom rubbed his forehead, "I just mentioned the use of GBM in the classification just for your information, and my main goal was to explain GBM for regression. However, let me give a simple and short example. Suppose we calculate the Log (Odds) values for the Heart Attack Detection Database and predict the decision tree's remaining probabilities. And the tree we have is something like this:



You see that the probability values obtained for Age>50 have several values. Now for the last root on the right, we can do the transformation as follows:

$$\frac{0.2 + 0.5 + 0.6}{(0.8 \times (1 - 0.8) + (0.5 \times (1 - 0.5) + (0.4 \times (1 - 0.4)} = 2$$

2 is the value of Log (Odds) and should be expressed probabilistically. Therefore, for the three rows to which the number 2 corresponds, these probability values will be obtained:

$$Probability = \frac{e^2}{1 + e^2} = 0.85$$

That is, the probability values for the three corresponding rows will be 0.85. Now we have to re-calculate the residual values, build a tree, make the necessary transformations, and update the probabilities."

Ivan nodded with a laugh. "I have been speaking until now," Tom said again. "Now it's your turn, Ivan. We have to implement three methods, including decision tree for regression, random forest for regression, and GBM for regression for news trends and hashtags in social media networks to see which trends will get the most attention in upcoming days. After that, we should get together again to review the results. Hannah got up and cracked her back. Ivan took a deep breath and pulled his legs under his hips, and pondered on the laptop again.

Ivan was busy crawling web data. Hannah, who could not do anything, returned to the office. Tom was sitting by Ivan as he shared his coding memories with him. Ivan found himself listening to Tom. He just shook his head but made no resistance. Less than an hour after Hannah left, Hannah called Ivan to talk with Tom.

Hannah's voice was trembling. "Tom, listen, Samuel Hoffman has sent a message. He said he wanted to see you."

When Tom heard this, he unconsciously got up. There was the faintest quivering of the eyelids. "Awesome." He called in a frenzy. "I'm on my way. I'll be there soon."

He hung up the phone. He wore his clothes in a hurry. Ivan was still working on collecting data. A cup of coffee he brewed was growing cold. He put his lips listlessly to the glass and drank two or three mouthfuls.

Tom had the last conversation with him and then left the cottage. Unusual traffic was seen in the city. Tomorrow was the anniversary of 9/11, and a memorial service was held in the city center. This had intensified the traffic in the downtown. He went to the police station anyway. Hannah was waiting for him. Samuel Hoffman was transferred to the city's public prison. They were supposed to go to prison together and meet with him.

In coordination with the prison warden, Tom and Hannah walked down a long and wide corridor with a cold, dull light, leading to the meeting room. The blond, pink, and porky officer moved ahead of them, constantly talking to Hannah and Tom about the prison situation and her difficult circumstances and the difficulties she had in keeping his life's wheels turning.

Although Hannah boredly explained to her that there was nothing she could do for her, she continued talking until they reached the meeting room's main entrance. "Well," The officer murmured. "We are here, at last. Just 5 minutes. Don't be too long. I have to get to lunch."

Tom entered, leering at her, and as soon as he entered, he saw Samuel with his head on the table. At first, he thought he was asleep. He got closer. Hannah was coming from behind. They reached over his head. Spitted blood covered the entire surface of the table. Tom put his ear to Samuel's nose perplexity. A small blood bubble rose from his nose and burst with his next weak breathing.

Tom took him by the hand and raised him up. His head fell back, and blood flowed back to his throat, and since there was no way in, he pushed them all out of his throat and spilled them out.

Tom, who had lifted his head upon his knee, put his curls aside with his hand, and yelled, looking around: "Samuel, what happened? What happened?"

Samuel had punched his right hand and was trying his best to raise his hand. But halfway…

His right hand uncurled and limped. It was over. Tom gently put his head on the table. “He was killed.” Hannah still could not believe what she was seeing. She sat down on a chair next to Samuel’s body, staring at an unknown point. Her sallow skin had gone the color of sour milk and had no difference with Samuel’s lifeless face. She swallowed hard then turned her head painfully to Tom. “I can’t believe it. Why should he be killed?”

Tom bowed his head but said nothing. Suddenly his eyes fell on Samuel’s fist, which was now half-open. Some strange things were written on it. Tom looked attentive and then bent down and grabbed Samuel by the arm. He paid more attention to the writings. By all means, he was able to read the inscriptions on Samuel’s hand. “52Ja‘9 @ FCa‘>:? FE6a‘”

From Tom’s sudden move, Hannah shook herself mentally. However, she had also seen the handwriting. They both stared at each other: “Anna’s computer password.”

They did not hesitate any longer. Both ran towards the exit. The officer was standing in front of the door, spinning his shirt’s thread when Tom bumped into her, and she fell to the ground. She wanted to say something, but Tom and Hannah were far away.

Despite the traffic, Hannah turned on her police siren for the first time, halving the time to get to Anna Cooper’s house. Before them, Captain Sanders had already stood in front of the door like a duck on a June bug.

“Samuel was killed by poison,” Captain Sanders said, striding forward, saluting. Hannah nodded, and they went inside together. Tom turned on the computer without saying a word. He hit the password. Hannah’s heart was in her mouth to see what would happen then. After hitting the password, the computer went into boot mode then restarted. For a moment, incomprehensible prompt files opened and closed automatically until a message appeared on the page: Login successful.

Hannah's face lit up like a kid's on Christmas morning. Involuntarily she threw herself into Tom's arms. Tom grabbed Hannah by the waist and spun around in the air. Then, as if he had just remembered something, he put Hannah on the ground, "We must look for the source code." Tom cried, seizing her shoulder.

He sat behind the screen. He barely remembered from his coding adventures, he tried writing search commands and went all the ways he knew but it didn't work. "It's that desk-dwelling computer nerd job," Tom said feebly. He picked up Hannah's phone and called Ivan immediately.

Ivan answered numbly. It looked like he just rolled out of bed or something. Tom explained the circumstances. With Ivan's guidance and following the procedure he explained, the remote access was established for him after half an hour of trying. Ivan mined every crack and crevice of Anna's computer.

"The source code was in the same repository," Said Ivan desperately. "But it was removed, and the entire hard drive was cleared. Nothing can be retrieved now. I am still trying, but I think codes are erased."

Deep disappointment soon set after that straw happiness. Hannah got goddamn mad that she couldn't help herself to remain calm. She angrily threw herself on the chair in Anna's room, clawing the chair handle. "There it is!" Ivan yelled on the phone. "Two days ago, there was an intrusion to this system. They used something like Tor Browsers to remove the footprints, but I could find their IP by hacking sites that monitor WebRTC IP leaks. I think Major Nelson can verify the true identity of this IP. We have to get help from the NSA and the Department of Defense."

A glint of hope shined in Tom's mind. The color came to his pale face skin. "This was the best news you could give," Tom said, after taking some deep breaths.

Hannah picked up the phone from Tom as her face lighted up. "Good job, my boy." She said. "I'll arrange it. Captain Sanders will be here. Keep in touch with him whatever you do."

Ivan confirmed. Hannah gave the last advice to Captain Sanders and then left with Tom. Tom was coming behind Hannah. He stopped for a moment and thought. He looked again at the password he had written: "52Ja‘9 @ FCa‘>:? FE6a‘"

Hannah was a few steps ahead. She noticed Tom not being accompanied. Turned and saw that he was leaning against the tree in front of Anna's house and was overwhelmed. She approached him. "What happened, Tom?"

Shocked, Tom lifted his eyes. "This password." He exclaimed. "It sounds weird."

Hannah looked at the blood-soaked paper again and shrugged. Tom turned his head to Hannah. "Look. The two letters "a‘" are repeated three times with the same pattern. What do you think it could be?"

Hannah looked at the letters again and confirmed. "You're right. I'll let my cryptologists investigate it. She walked to her car, but Tom was still thunderstruck. "What's wrong, Tom?" Hannah said, spellbound, as turning back again

toward Tom. “Why don’t you come?”
Tom made up his mind in a split second and started moving. He went to the car and sat down. Hannah also sat behind the wheel. Tom wrinkled up the skin over his eyebrows and pondered, with a smile on his lips.

Hannah nudged him hard in the ribs. Tom turned involuntarily and gave Hannah a fake smile after a subdued sigh. “Hannah, who do you think killed Samuel Hoffman?” He said sadly. “And why was he killed?” Hannah started the engine. “I either love to know why and we’ll know soon.” Said Hannah determinedly.

One day passed after the murder of Samuel Hoffman. Further police investigation revealed he had been poisoned with tetrodotoxin. It was around 5 pm when Hannah arrived at the cottage. Today was September 11, and he was coming from the 9/11 memorial ceremony. When Hannah arrived, the first thing that caught her eye was Ivan’s unusual appearance. His usual tangled hair seemed more disheveled today. He had only slept for two hours in one day and worked hard to collect, clean, and integrate data from the web. Hannah and Tom were talking warmly when Ivan got up. He yawned aloud, arched his waist, and broke the bone. “The data is finally ready,” He said wearily.

Tom stopped talking, approaching Ivan. As usual, Tom put his hand on his shoulders. “Well done, now we should implement the linear regression model, the regression decision tree model, the random forests regression, and the GBM model. Then compare their results and then predict news trends and hashtags.”

Ivan took a deep breath and sat down again, overwhelmed. Tom sat down next to him. They talked about libraries that made it possible to run models. They first divided the trends into categories related to cultural trends, sports events, scientific conferences, and economic and political conferences. Then it was decided to divide selected features for each trend into several sections. In one section, there were tokenized phrases. The next bunch of features was the number of news and posts related to each trend, which was also considered as a data label. They use the lags of the label to build new features. Finally, another column added that in the past events similar to each trend, how many times this trend has been hit in the past. The total length of data for each trend was 2 years, and the data were divided into training and testing in a ratio of 70 to 30.

Tom also stressed several times that the nature of the time series of the data must be preserved. This means that for each trend if no hashtags or news items are published in one day, a line related to that date must be created, and then the zero must be replaced.

Ivan began to make small changes to data and started implementing the models. Hannah joined them gradually.

Although she did not understand anything, she had stared at Tom. A satisfying gaze at someone who had given meaning to her life these days, and she was even scared manifesting her interest in him. She had a strange feeling after telling him about her childhood. She didn't disclose her secret to anyone before, and now, just a few weeks after seeing Tom, she let him enter her solitary without even knowing it.

She did not know what Tom thought of her. Was he still thinking about his dead wife? Being in the purgatory of love was worse than being in hell, and she was now in the middle of purgatory. Upon the heels of which thought, she was interrupted by Ivan, who said the initial implementation was done on the models.

Tom asked Ivan to prepare the four models' results in a table and evaluate the test data according to the MAPE error criterion.

"Confusion matrix cannot be used in this problem anymore. Right?" Said Hannah, who was silent all the time.

"Exactly," Tom said with an air of absolute pleasantness. "Confusion matrix is used for classification problems. Here we have to use regression evaluation criteria to measure the accuracy of each model."

Ivan later asked Tom about the MAPE criteria, which Tom explained by writing the following formula:

$$MAPE = \frac{100\%}{n} \sum_{t=1}^{n} \left| \frac{Actual_t - Predicted_t}{Actual_t} \right|$$

"This criteria has high interpretability. It shows the absolute error and the difference between the actual amount and the predicted amount."

Ivan looked at the formula with positive suspicion. "But this formula has a problem." Said Ivan. "If it's zero in the test data for one day... Hmmm, I think the error tends to be infinite."

"Oh." Tom's eyes widened when he heard this. "You're right. I got distracted. Praise you, Ivan. To alleviate this problem, we can use the SMAPE criterion, which is as follows:

$$SMAPE = \frac{100\%}{n} \sum_{t=1}^{n} \left| \frac{Actual_t - Predicted_t}{(|Actual_t| + |Predicted_t|)/2} \right|$$

Ivan looked at the formula with satisfaction. “But this formula does not have the interpretive power of the MAPE criteria,” Tom said. “However, it represents a percentage of error.”

Ivan started building tables based on the agreed process. Finally, for four models and four trends, the following table was obtained:

Model Trends	**Cultural Trends**	**Sport Trends**	**Scientific Trends**	**Eco-political Trends**
Linear Regression	87%	115%	44%	63%
DT Regression	41%	23%	20%	26%
Random Forests	32%	15%	21%	22%
GBM	19%	11%	15%	14%

All three stared at the results. “As you might have guessed, the GBM model performed much better than the other models,” Tom said. “We are now using this model more confidently to determine the number of repetitions of trends for the next week.”

Ivan started working and with changes in the models. This time he took all the data for training and set the forecast horizon seven days later. A few minutes later, the results were obtained for all four trends. As the results show, Eco-political trends will account for the largest number of posts, hashtags, and news in the next seven days.

“There are more political and economic trends,” Tom said, looking again at the results. “Even though many sporting events will be held in the next few days. Well, we trust the model. We must congratulate ourselves. We were able to find the answer to the first question…

Now the second question arises: what is the probability of each event of political and economic trends? Well, again, we will get help from machine learning. This time we will use the flower of the flock of algorithms: Artificial Neural Networks for this purpose. We will use neural networks to solve a multi-class classification problem - instead of two classes - to estimate the probability of occurrence of each class."

Ivan subconsciously sighed and dropped himself on the sofa. Tom and Hannah laughed. "What happened?" Hannah asked in a sympathetic tone.

"I've heard the neural networks before," said Ivan, rubbing his puffy eyes. "As soon as Tom said the flower of the flock of algorithms, I realized that I have to push the envelope again. I got my ass kicked."

"Don't worry." Tom laughed out loud. "We've had a lot of good discussions so far. We will also learn Artificial Neural Networks easily. You just have to integrate the data related to the eco-political data more and more in detail so that we can run the neural network on it."

As soon as Ivan wanted to start complaining again, Tom put his hand on Ivan's shoulder and rubbed it. It was as if he wrapped him around his little finger. Ivan was calmer and had a saucy conscious smile on his face.

10

Propagation Of Divine Wind

What mystery broke out now in the autumn flavor in the air, now in the long evenings of it, now in the grim songs of the autumn birds, now in a glimpse of high white peaks, now in the light of the westering moon and now in the brown leaves of the oak trees that bring back those forgotten memories?

A breeze made the leaves of the forest trees dance. Hannah had stepped out of the cottage, and her blond and disheveled hair was dancing in conjunction with the forest tree leaves, and this cold breeze glued her thin and lace shirt to her body and embodied the harmony hidden behind that shirt.

Hannah was about to return when Tom asked her to accompany her to the beginning of the forest road. It was a simple request, but suddenly a beating began in Hannah's heart, her stomach got tight, and a pleasant uncertainty was pumped into all the cells of her body.

They started walking down the long arms of the grassed path to the cottage that led to the forest. The wind was a little stronger now. Tom had put his hand around her neck. When you saw them from a distance, you thought they were two close friends, absorbed in their conversation. Tom turned from the main road into the forest.

The sound of a water pumping engine from a distance along with the sound of birds, frogs, and toads as long as the sound of the wind passing through the trees sparked all human emotions and wore off them at the same time, and this numbness seemed to remove the burden of life and all the sorrows and griefs and stopped the thought and thinking process, and instead replaced the rhythmic sound of nature in the mind and heart. After a while, a soul could absorb this rhythmic sound and ascend. Subsequently, sometimes the soul traveled the whole world in a glance, and sometimes the whole world reincarnated in a single soul. Nothing but silence was allowed in these moments.

In a voluntary silence, the two walked through the forest for a few minutes when suddenly Tom stopped. Behind him, Hannah returned back. The wind blowing through the trees had wafted and stirred the dandelions to the sky. As far as the eye could see, the stretched sheet of dandelions has filled the sky.

Tom's piercing eye swiveling onto Hannah and fixing her with an unblinking stare. Hannah dropped her head. She could not bear the way Tom looked at her. She had dared to raise her eyes when suddenly Tom's wintry finger caressed her left cheek. Tom swallowed. “Hannah?” Whispered Tom very quietly.

Hannah looked up with a flush on her face. “Yes,” She said, the pink in her face was growing thicker by the moment.

“Are you real?” Said Tom distinctly, still keeping his inquiring eyes on her face and lips.

Hannah, just like a high school girl, as she was experiencing her first crush, gazed at the ground grasses, smiling embarrassingly.

Tom asked again, “You know, I once fell in love, I lived with someone I loved. But you, your soul is pure and virgin, I wish you know such a great place you have in my heart.”

Tom hung his head gloomily. A fist turned fingers were fallen off Hannah’s cheeks.

“That very morning, Ivan came to my house for the first time,” He said sadly, “And the day you came, I was going to kill myself. My life had no meaning anymore. I had a razor in my hand when Ivan hammered on the door with such hurried urgency. If Ivan had come a few moments later, I would not be alive, Oh, During my days in prison, I thought about many things. Is everything in this world random? Or is there an order in the heart of this randomness? Or it is not accidental at all, and everything is what it should be! I thought about God and his existence or non-existence... I tried to give him inhuman awe and embody him, but you know, the end of these discussions goes nowhere. But I, I have been convinced at my stuffy prison room that Ivan’s arrival and then seeing you cannot be a coincidence. Whatever it is, it should be the same order, the same destiny that cannot be proven but is believed. I am glad that I survived to see you. You are like a sudden rain that fed my decrepit and dry soul. You gave me life again. I want..."

Tom sucked back his words that formed on his tongue. Hannah caught the sound of tears in her voice. She worked hard to maintain her solemnity. "So you wanted to kill yourself?" To change the atmosphere, she asked. "So, all the beatings you received were your right."

They both laughed softly, but reimaging the old, bad timing griefs, interrupted and disappeared their laughter.

Hannah involuntarily put her head on Tom's chest and then grabbed Tom's back with both hands. Tom reached out his wide arms and embraced her. The clammy texture of her shirt provoked his arms to went around her tighter.

Hannah's hands were cold, which meant she was at the height of her emotions. Without wanting to, she started crying softly and silently. The tears that fell on Tom's chest made him ease her out of his arms. He looked at her wet face and wiped the next tear with his finger. Looked like he had prevented a diamond from falling.

Hannah sniffed. "Tom, I never fell in love. After that tragedy, I ran away from every man for years, and when I became a policeman, everything united to let me kill my feelings. But you... were like a storm that turned everything upside down. All those feelings that I thought were dead have risen again and are asking for a share. I do not know Tom... I have told you about my past. After that tragedy, both my body and my soul were no longer virgins. The black spot of that night is always in my heart, and I can't get rid of it... I even loved a boy very much in police college. I do not know if I had a crush on him, but I loved him. I could never express my love for him.

On the contrary, I tried to stay away from him... Everybody thinks I am a strong girl, full of confidence, but no one was found to just listen to me, to understand me. I do not need any advice. Just huge me and let me absorb his being and deeply understand that I'm not alone anymore. Even just for a second."

Tom hugged Hannah again - this time tighter. Hannah put her head on Tom's chest, and Tom was stroking her tied hair. One of the dandelions that filled the air fell on Hannah's hair. Tom picked it as if it were a flower. He grabbed Hannah's arms and stared into her eyes, then he put Hannah's hair behind his ear, having gazed at her for a few moments with an amorous and humid look.

"You know..." Tom said. "The essence of life is freedom... freedom from every real and mental chain and the worst and hardest chain... is the past. The past is chained and tied to our feet and does not allow our souls to take wings and feathers and rise. I do not care about your past. I want to confess. I confess that frightfully I'm in love with you... I love you."

Tom's hands subconsciously squeezed Hannah's delicate arms. Hannah bit her lips as though they were scorched. Her lips tingled. She had never tasted the sweetness of a kiss. She took Tom's face by both sides then closed her eyes. She could feel him approaching her face, which added to her excitement. She swallowed and clasped her hands around his neck, and as soon as she tried to put her lips to Tom's, a screaming sound separated them.

There was a huge brown bear almost 150 meters or more away from them. It was standing on two legs, chewing on something. Tom and Hannah looked at each other with bulging eyes, and without saying anything, they ran hand in hand, first slowly and then at full speed towards the forest road.

The bear that saw them running, sighed and roared again and ran towards them with all its might. Hannah ran much faster than Tom. However, Hannah did not let go of Tom. They had reached the forest road. Tom knew that if they got out of the forest, the bear would not chase after them.

While running, Tom turned his head. The bear was only 50 meters or a little further away from them. At the same speed, they would be delicious prey for the bear for a few more seconds.

"Hannah, you go," Tom shouted while running and pulled his hand out of Hannah's. Hannah got ahead but did not separate from Tom. Tom, convinced that Hannah would not go without him. Took a deep breath, he gave another impulse to run fast. It is in the game of life or death that the real capacity is determined. Tom thought he got old, but he was running like a skilled runner.

"Hannah… let's get away from each other." Said Tom, speaking with difficulty. "There are a few meters left until the end of the forest… run,"

The sun had set, but little by little, more light fell on the eyes of both of them until they both came out of the forest. The bear, which had reached the bottom of the forest, stood there hesitating. The bear was also panting. It had learned from experience that leaving the forest has a higher risk than finding more varied food.

Tom and Hannah were still running. Hannah turned her head, and the bear could no longer can be seen. She stood, laying her hand on her knee. Tom finally controlled himself and stood breathlessly. Streams of sweat rippled around his face.

Almost too weak to speak, both of them couldn't utter anything. Finally, after a while, first Tom laughed, quietly at first and then louder and louder, and they both started laughing together. They were near the cottage. Tom took Hannah's hand. "That time Ivan... and this time the bear..." Hannah exploded with laughter.

Half an hour after the bear attack, Hannah made her way to the beginning of the main road in the darkness, accompanied by Tom, who had also picked up his woodchopper. She got in his car and left.

Tom returned to the cottage. Ivan's perilous health condition was getting worse. Even though he was used to waking up at night, a few days of continuous work made him more worn out and quieter.

"Ivan," Tom raised an eyebrow and said, "What would you say to a spaghetti with Meat Sauce and Mushrooms? The food you like!" Even this amazing offer could not excite Ivan. "It's okay..." He said in a very cold tone as he stuck his head in the laptop.

Tom came and sat down beside him. "You are doing a great job, cheer up." Tom said, touching him on the shoulder.

Ivan's glance at Tom. His gaze with pallid face and those whittled under his eyes, was cold and impersonal, "What good are all our efforts? None of the people out there who are walking, laughing, having sex, and having fun, know that we are killing ourselves for them."

Tom bent down, put his elbows on his knees, and clasped his hands together. He sighed and said, "The most enjoyable thing in this world is unwilling forgiveness. What you are doing is for the true purpose of our humanity, not for a few people. You know, even the greatest reformers have not been glorified in their own time."

Ivan was not in the mood to argue. Instead, he was constantly knocking his tiptoe to the ground. The amount of work and the intensity of the stress had made him nervous. Tom got up and went to his tiny kitchen to cook lunch.

The knowledge that jaded and tired Ivan couldn't continue anymore, Tom asked him the rest of the process to be continued by himself. It had been years since he had been coding rudely, but he still wanted to show that there's life in the old dog yet.

He spent the whole night working on the process of fetching and integrating data, which Ivan had designed its semi-automated code. It was not until about 6:30 in the morning that he made sure that the data was fully sorted and classified hierarchically in different dictionaries.

He got up to wake Ivan, but the innocent face of Ivan, which had fallen asleep on the sofa cadaverously, prevent him from ruining the pleasure of sleep after a few days of arduous work.

Turning around, he sat down at the table again and opened the data and looked at it. Knowing that the next step was to use the neural network, he sighed deeply and searched for the neural network libraries in Python. He tried for half an hour. He got surprised by the abundance of educational resources on the internet. Because of his previous background, within half an hour, he implemented his neural network and its topology on the data. Then he used another process to evaluate the accuracy of the model called K-Fold Cross-Validation.

The results showed an average accuracy of 96% in predicting labels, the exact type of news trend. Although the results were promising, he started working again and by searching, he was able to implement ROC and AUC curves on the data. Comparing the graphs gave him hope for the high accuracy and acceptability of the model. Based on this, Tom implemented the model to predict the busiest economic-political event in the next seven days. It took 10 minutes for the full model to run. Tom saw the result: The most likely event was the Dalous Economic Conference. The probability of occurrence by the neural network was predicted at 98.36% accuracy.

It was past 7 a.m. Tom was so excited that he could no longer deprive Ivan of this news. As soon as he gently touched Ivan's feet, Ivan woke up. The stress of these days had made him sensitive. Tom put his hand on his shoulder. Ivan was gasping as if someone was strangling him. He calmed down as quickly as he had flared up. Without a word, he wanted to get up to continue his work.

"I've already implemented the neural network," Tom said, arresting Ivan, who had risen indignantly. "I've got the output too... The next goal of the Deus Machine is an economic conference."

Ivan started violently and raised his head. "What?" Did you implement it? But How?"

Tom dropped his head. "It doesn't matter," He grinned.

Ivan blinked several times to see easily. "Which conference?" He grabbed his laptop and asked.

"Dalous Economic Conference, which will be held today in Los Angeles," Tom replied.

Ivan leaped up and began typing things quickly. Then he put his hands in his curly hair and said worriedly, "This is a disaster. If something happens here, at least 1,000 lives will be in danger."

Ivan and Tom stared at each other. Ivan put his hand on his neck and said in astonishment, "I think the model learned something about 9/11 from yesterday's events and news. That is, it was able to learn the meaning of 9/11."

"And now…" They both said simultaneously. "It wants to, oh no..."

Tom blinked several times. "It's not unlikely… That conference should be canceled. I should talk to Hannah right now..."

Tom got up rudely. He wanted to get Hannah's number, but he could not remember it. He could not even work with Ivan's smartphone. Ivan got up and brought Hannah's number, and as soon as he wanted to press the call button, Hannah herself called.

Ivan raised his eyebrows. "What a delightful surprise." He said, then pulled the answer button. Hannah ignored Ivan and asked him to give Tom the phone. Tom picked up the phone. Hannah looked worried.

"Tom, we found the identity of the person who penetrated Anna Cooper's system," She interjected.

Tom's eyes widened. "Who is he?" He asked. "Do you know him?"

"All the evidence points to Russell Pierre," Hannah immediately answered. "With several analyzes, the IP was recognized. Russell himself logged in and picked the source code. After that, there is no trace of him. It is unknown what his resolution is."

Tom's hands and feet uncurled at the news. He still could not believe it. "What a scum-sucking pig!"He said looking at a whole on the floor. "Are you sure, Hannah?" He continued quietly and distinctly.

"It's clear, I'm sure," Hannah complained. "I'm coming from his office right now. We went into his office but found no trace of him, but there is an evidence that he is in a relationship with Samuel, including a check in the name of Samuel and signed by Russell Pierre."

Tom leaned on the couch. He did not know what to say. All these years he thought Russell was an honorable and good man. He even knew him as a coward who is fit for nothing.

"We're trying to track him down." Hannah said, "We have to find him." Hannah wanted to say goodbye when Tom suddenly remembered the economic conference news.

"I almost forgot." He said embarrassingly. "I have some news for you, too. We implemented the neural network model to predict event trends. The next target of the Deus Machine is likely to be the Dalous Economic Conference. This conference must be canceled immediately."

"What?" It was Hannah who said in surprise this time. "Dalous Conference? The same conference that will be held today? No..."

"Yeah, do whatever you can. Tom said again. "This conference should be canceled."

"How can I cancel it?" Said Hannah, looking outraged. "The conference will start in half an hour. Several ministers from several countries of the world will participate in it then you expect me to go and say very easily that it is closed. Go and come tomorrow?"

Tom got up again and said, "Hannah, I know it's hard to do, but we are gambling about the lives of more than 1,000 people. Do whatever you can, please."

Hearing the tone of Tom's plea, Hannah just remembered who was asking her. "Let me see what I can do, just for you..." She said in a very calm tone.

As if Hannah was facing Tom and seeing him, Tom clasped his hands together and said, "Um, that is nice of you."

The phone hung up. "We must understand how the Deus Machine attacks the conference. Come on. We have a lot to do." He turned and said to Ivan that he was biting an apple safely.

Ivan frowned. He was just returning to his previous gestures when he got shot in the face.

The Dalous Economic Conference, which focused on free trade between the Middle East and the United States, celebrated its third year. The conference was sponsored by a wealthy Arab sheikh named Sheikh Saeed Al-Jassem, who also lost his son in the 9/11 attacks. That is why he always considered September 12 as the criterion for the new friendship between the United States and the Arab countries. Therefore the date of this conference was September 12.

Sheikh Saeed had several extensive television channels and had great influence among the leaders of the Arab countries. Accordingly, this year's Dalous summit was held at the level of senior political officials, and the leader of the US Senate was also scheduled to address the opening ceremony. There was widespread publicity about the conference and its direct effects on the Middle East economy and even the global economy.

After Hannah's phone conversation with Tom, she called Colonel Taylor to travel toward Los Angeles at 120 miles per hour. Unaware of the conference, Colonel Taylor was talking to Hannah about Russell Pierre. Hannah cut him off and told him the conference's news, asking him to find a way to cancel it immediately. The Colonel, in the way he always did, firstly denied the truth. As Hannah insisted on it, he accepted inevitably to consider it as a serious issue. Still, since his policy was to work quietly in any case, even at the cost of human lives, he asked Hannah, by brute force, not to broadcast the occurrence of an incident, an incident who didn't know about its origin at all. Especially occurrence of any incident one day after the anniversary of 9/11 wouldn't be tolerated at the country's superior level. Instead, he promised to do his best to help Hannah and her team prevent the accident.

When the conversation was finished, Hannah texted Capt. Sanders to get to the hotel and then more greedily pressed the accelerator pedal. Finally, she traveled an ordinary one hour distance of San Bernardino to Los Angeles in half an hour and reached the Sheikh Saeed Al-Jassem Private Hotel, the conference venue.

There was a commotion around the hotel. It was as though the whole city of Los Angeles was coming to the hotel. Hannah ran quickly from the parking lot to the hotel entrance. His police card opened every door. With this trick, she moved to the luxurious hall of the hotel where the conference participants were gradually gathering.

She looked around. The important person was not seen there to share the news with. She immediately dialed Ivan, but Tom answered this time. Hannah took a deep breath and said, “We must drop the case, Tom. For security reasons, it will put a lot of pressure on public opinion. We must do everything we can to prevent this from happening.”

Tom was silent and said nothing. Finally, he took a deep breath and said, “What is the value of public opinion for a human life?”

“I know, Tom.” Hannah nodded. “But not now, please... find a way...”

“OK,” Tom replied seriously. “Stay alert.”

A few seconds later, Tom said again, “First we have to have a list of different attack scenarios, and then in a data-driven simulation process with reinforcement learning, we have to figure out the Deus Machine will choose which scenario. Its selection mechanism, of course, should be similar to the reinforcement learning algorithm. There can be nothing else. We have to follow the same method. Tell me, what scenarios could happen?”

“As before,” Hannah said as she walked toward the hotel’s luxurious glass facade. “Self-driven cars may attack officials’ car or even ordinary people,”

“There is also a possibility that the security and intelligence systems will be interrupted,” Ivan shouted so loudly that his sprawled out voice could be heard clearly behind the phone. “And then everything will fall apart, and there will be a lot of danger to the authorities, as it happened before.”

Nobody said anything anymore. Hannah blinked a few times, “Something like 9/11 could happen. A terrorist attack by plane on a hotel."

"Exactly," Tom replied immediately. "This is very likely. Especially since we understand that the model has learned a lot from the events of 9/11."

"After all, airplanes have pilots," Ivan said from behind the phone. "Can the Deus Machine deceive pilots?"

"They also have an autopilot system," Hannah said.

Tom asked Ivan to check on incoming flights to Los Angeles. "For the next hour, no flights will arrive." Moments later, Ivan said, "It's as if a no-fly zone has been instituted."

No one else said anything. Hannah pulled her phone away from her ear. It was all a blur to her. All voices were silenced. She thought of all the work she had done in the 15 years she had served. They all passed, for an instant, in front of her eyes.

She never asked God for anything. Her only wish was not to live in vain and not die in vain, but this time, she wanted to prevent the accident with all her might. She closed her eyes. Only the sound of his breathing could be heard. Everything else had faded. She was in perfect focus. She opened her eyes and looked at the sky from the front of the glass facade. The sun was slowly rising, and the sky was bleached. The reflection of sunlight from a collision with a flying object was momentarily forced her to turn her gaze upon.

Involuntarily she closed her eyes, and when she opened them again, her eyes suddenly fell on the drones that were circling in a regular radius. Her mouth was open with excitement. She immediately picked up the phone. "Drones... quadcopters, drones..." She couldn't find an appropriate word to add. "What if the Deus Machine manipulates these systems?”

“You’re right,” said Tom excitedly. “It’s possible. Of course, if there is a drone around there,”

“Right now, three of them have passed before my eyes,” Hannah said in a screaming tone. “I think they are giving air cover.”

The sound of Tom’s breaths reached Hannah’s ears. “Military drones have a command room. Their room should be nearby,” Tom immediately asked. “In any case, the drones must land.”

Hannah said nothing anymore. There was no room for discussion. It was not about doing cost/benefit or feasibility analysis. The work had to be done. She made up her mind and wanted to get herself to the ground floor.

A few minutes later, she reached the ground floor. Immediately, she made her way out of the hotel.

She looked up at the sky to find a trace of drones. She was watching the sky when a painful nudge in her ribs woke her up. Several soldiers were passing, ignoring her. Hannah glanced uneasily round and drew one hand across her forehead as if bewildered.

She suddenly saw a giant car with a large radar mounted on it. She took the hint and ran towards the car at full speed. The back door was half open, with two officers sitting inside it. It was clear that they were in charge of piloting the drones.

Hannah pulled herself in without permission. The two were shocked to see Hannah and struggled to get up when Hannah pointed her gun at them and placed her index finger on her nose as a sign of silence.

“Gentlemen,” She said very quietly so that they would not feel hostile. "I'm Major Nelson, an FBI Officer. This conference is facing a security threat. I urge you to act wisely. A mysterious system will probably hack these drones. I ask you to land the drones, right now..."

"We can't do it on our own." One of the drone control officers, who had a fringe of dark, dewy mustache, removed the headphone from his ear and said aggressively. And then he took the cordless phone to Hannah and said, "Tell them yourself..."

"I did not offer you," Hannah said as if faced with a ridiculous offer. "If you would like to consider this as a threat, it's yours. But now, those drones should land right now."

"I heard you were looking for me..."

It was a familiar voice. But who? Hannah returned to her back as fast as she could. She could not believe what she saw. It was Russell Pierre with a small gun in his hand. When Hannah pulled herself up and pointed her gun at Russell, one of the control officers got up and hit Hannah. The gun fell out of Hannah's hand.

Russell entered the control room cabin with absolute self-control and, of course, with great difficulty. He limped off to the chair, staring into Hannah's eyes, which had now fallen to her knees, for a few seconds, and while looking at Hannah, he raised his hand, which held the gun and shot two bullets at both control officers. It had hit them right in the temple. They both collapsed and rolled on the ground immediately.

Russell's cruelty and coldness struck Hannah's face like a slap. Russell took out his scarf and wiped his face sweat. "This is always the black destiny of the eunuchs. They must serve the purpose, and when their expiration date has come, they should leave the battle soon." And then he wiped the sweat from his purple neck with his scarf.

"So... you want to stop the Deus Machine." Said Russell. "The devil you did! You and your dear Tom got into a bad game, a game that had nothing to do with you. The Deus Machine must grow up. In the next update, I will make the world astonished by this new God. The God who is not seen has not to value anymore. I want to show what the real God should look like."

Hannah was speechless, just looking at Russell, looking at the exit door. Several gunmen were standing in front of it. At the same time, Hannah's phone rang.

"Is this your new love, Han?" Russell grinned and said. "You know, the goodies of being God's assistance is that you know everything about everyone. All the data of these people is now in my hands, even your data. I know what happened in your childhood. I have read the confidential report of your personal information. Lucky for them."

And then he looked at his giant gunmen. At Russell's point, they came in. Russell shook his jaw a few times as if chewing gum. Then he said. "You know, I do not like to say. Those vain chatters. I do not want you to tell me the story. It must be shown. I want to see how you felt in those moments."

Russell pointed to one of them. The gunman came and picked up the phone from Hannah and handed it to Russell. He cleared his throat and pulled the button.

"Hannah," Tom yelled nervously, "Where have you been?"

"Oh..." Russell smiled and said, "Look who's just on the phone, Tom Forrester, the famous scientist."

"Russell..." Tom's voice began to tremble. "Where is

Hannah?"

Russell looked at Hannah. He blinked and said, "Here it is... oh... let me see Tom. Did this little slut tell you about her childhood?"

Tom was silent and said nothing.

Russell raised an eyebrow. "Do you want to know what those moments were like? Hum?"

Tom was silent for a moment, then he roared frantically, "Russell if you harm a hair of Hannah's head, I'll kill you. I swear I will find you. I will kill you with my own hands. I swear."

Russell nodded at Tom's throat and said in a humorous tone, "Wow. Dear Tom, you always wanted to be a hero. Now leave off playing the fool and just listen how you girl friend dug her own grave."

He put the phone on the speaker. The two giant men were walking confidently towards Hannah. One of them broke his fingertips. The other looked her over from head to foot.

When they reached Hannah, one of them, the taller, put his hand out and grabbed Hannah by the throat. Hannah, snoring, kicked his bollocks.

He sighed, and Hannah got rid of him involuntarily. The next man, however, grabbed Hannah by the legs and threw her to the ground. Now both of them had fallen on Hannah. Russell had picked up the phone to the fight scene and had a satisfied smile on his face.

Hannah was trying her best to get rid of the two of them. She was trying not to make a sound so that Tom would not hear anything. One of them shook hands and took off Hannah's shirt. Hannah's white body and shapely untouched breasts appeared.

Hannah was holding the hands of a giant man with her hands ... But he freed his hand and punched Hannah in the face. Her hands uncurled. The man was trying to touch Hannah's pants when suddenly a bullet was fired from behind.

A stunning shot to the head... burrowing deeply into the occipital lobe. And the second bullet hit the giant man on Hannah, and he did not even have a chance to go back and see the attacker. It was Captain Sanders...

Hannah stared at Captain Sanders for a moment, panting. He had arrived at the best possible time. Russell used his excellent shooting skills between the second shot, and the two looked at each other and fired one shot into Captain Sanders 'throat.

He stared at Hannah, with hands-on his throats, spouting blood like a whale. The captain fell to the ground. Hannah screamed and shouted, "Frederick…"

As far as Russell wanted to turn his bulky body and shot Hannah, she quickly anticipated him. Without any hesitation, she jumped up to Russell and kicked Russell in the face. The gun and the phone fell out of Russell's hands and were thrown a few steps away.

Russell wanted to leap towards the gun, but Hannah kicked the gun, and it was thrown to the end of the control room cabin. Now it was Hannah who was on Russell.

It was as if she had found one of the same rapists of her childhood. With all her might, she was suffocating Russell. Russell was struggling and snoring, and his fleshy face was bruised.

Hannah was almost certain that Russell was suffocating when she suddenly felt a deep burning pain in the depths of her body. She turned and followed the direction of Russell's hand. The knife had torn her side.

She turned her head and stared at Russell's bloodshot eyes again. Her hands were no longer strong. Little by little, pain took over her whole body. With each breath, the pain shot through and penetrated to her bone marrow.

Russell snorted, shrugging out from under Hannah's restraining hand. He pulled himself to his feet and staggered off finally. Hannah fell with all her might on one of the giant men, and with all her might, she picked up his weapon, and as soon as she tried to target, Russell ran out the door.

She sank suddenly. She was pushing the earth with her feet as though part of her soul had been torn away from her feet.

Her perception had disappeared slowly and sweetly. Looked like she had entered another world. A world where everything was white and white. She did not know either she was asleep or awake. The pain was too much, and she could not feel it anymore. Instead, she had an ecstatic feeling, which forced her to sleep deeply.

In the dream world, mysterious sounds are echoed. Hannah could hear the sounds, but she could not tell which way the sound was coming from... it was from all directions, but it was not from any direction. She was looking for the traces of the confused and astonished voice, saying loudly: "Hannah... Hannah... tell me what happened... please... Hannah..."

The sound was so loud that it did not allow Hannah to fall asleep. Every time this whisper was repeated, Hannah's bloodless eyelid opened for a while. She'd like to sleep, but the sound was disturbing.

Finally, her body shook violently, and this shaking seemed to help her to recognize the sound. It was Tom's voice. A sound that seemed to come from the depths of her being. She opened her eyes wider this time. The cell phone was two steps or further away from her. She just remembered what happened.

She decided with all her might to get up. She got up and fell on her side with excessive pain and blood flow gushed from an artery or a large vein.

She sighed loudly. The pain covered her whole being, but then she did not feel anything for a moment. Now she could pick up her cell phone and finally picked it up. She coughed, vomiting blood from the mouth.

Hearing the sound of coughing, Tom could not bear that. He cried like a child. Hannah laughed unconsciously.

"Tom," She said with difficulty. "I wish you were here... I miss you..."

"Hannah..." Yelled Tom, merely snorting. "My dear Hannah. We'll see each other very soon. I promise."

Hannah swallowed. The taste of blood trembled her whole being. "Tom... tell me what to do," Hannah said wanly. "To end this disaster."

Tom was breathing hard. In the dilemma of saying or not saying, he finally decided to say, "We must have access to the drones..." and then handed the phone to Ivan.

"Hello, Hannah," Ivan said carelessly. "Look, I know it may be hard for you, but you have to go to the drone control computer and typed the address I am texting, and click on the link. This way I will have access to the drones' server."

The mobile was fallen on the ground. She couldn't hand it anymore. She was falling into a deep sleep.

"Stay awake," She told herself fiercely. Her eyes trapped wide open again. The mobile ring sound reached her ears. She pulled herself up hard and typed the URL text in the control center's Browser with all her might, and pressed the Enter key.

She could not stand anymore and fell on the table. Her eyes were blurred. She just saw a blank page with a link above. With trembling hands, She moved the mouse over the link and... Pressed it... She did it.

Like a soldier, she had accomplished her mission. Her face was the color of eggshells. Finally, her body collapsed, her hands loosened, and she slipped off the table and fell to the ground.

Tom was traipsing from one side of the cottage to the other. He finally sat down on the sofa, with great anxiety.

Hannah did her job right. Ivan had access to the servers and could now control the drones' navigation system, but could only have a position on the drones' map but did not have access to the drones' cameras and combat equipment.

Tom was talking on the phone. He had called the police officer to go and find Hannah.

"I can control the drones now. I'm trying to get them out of town," Ivan said excitedly. "There has been no attack yet."

Tom closed his eyes and shook his head.

"I hope only one drone gets out of control." He said, "I have to write a plugin based on the Reinforcement learning algorithm so that as soon as one drone gets out of control, another drone goes to it and destroys it."

"But how?" Said Ivan, A little weirded out.

"Give me your laptop. I should write code at C++."

Ivan turned his laptop hesitantly to Tom. "The drones are on autopilot and are spinning in a certain radius. if something changes, its alarm will pop up on the screen."

Tom nodded and started his work. He was coding incredibly, and Ivan, seeing this scene, gawped engrossingly.

It was 9:15 AM. Tom had been coding for 20 minutes, writing code as if he were typing a simple letter. Eventually, he finished his work.

He showed the executable plug-in to Ivan and explained how to activate it on the Defender UAV controller's computer.

It was a function that at any given moment took the geographical position of the attacking flying object and adjusted the speed, direction, and height of the defending drone based on the internal mechanism that Tom called Reinforcement Learning.

Finally, Tom got up. His heart missed the estrangement of Hannah's eyes, which he used to gaze at them when they talk close to each other. He thought to Hannah, who did not know what had happened to her, to all the innocent people who could have been killed in an instant.

The locust-like attack of these clenched thoughts had taken all his energy and brought on a headache. Resting his chin in his hands, he gazed at the floor.

He was overwhelmed in a shemozzle of thoughts of Hannah. He was wondering what was going to happen to her when suddenly Ivan shouted.

"Wow, Unbelievable. A drone got out of control, changing its patrol and heading straight for the hotel." Tom took a deep breath and got up, and reached Ivan.

A drone was heading straight for the hotel. At Tom's point, Ivan activated the plugin on the nearest drone. The drone first started moving at the attacking drone's 9 o'clock position but then turned suddenly and reduced its angle with the attacking drone.

Every second that passed, the defending drone mostly adjusted itself to the position of the attacking drone. There were only 40 seconds left until the attacking drone collided, but the defending drone's movements did not show that it understood the circumstance well.

It was 30 seconds left. Tom and Ivan were anxiously following the path of both drones. Suddenly the nose of the defending drone lifted. It peaked and increased its altitude to 15,000 feet and was still rising. However, the attacking drone was constantly lowering its altitude.

There were only 20 seconds left until the attacking drone collided. Tom looked at the screen again. The defending drone had jumped from a height of 18,000 feet and was rapidly moving towards the attacking drone.

They both pursued drones breathlessly. The defending drone was moving towards the attacking drone like a ballistic missile. There were only 10 seconds left until the collision.

The attacking drone changed its angle slightly and was ready to hit the hotel building. Only 5 seconds to impact... 3 seconds... 2 seconds and suddenly...

They both gazed at each other, their eyes bugging out. Tom did not even have the feeling to swallow. He still did not know if both drones had hit the building or if the defense drone had acted correctly. Tom fell on the sofa. He had been tossing restlessly.

Purgatory is harder than hell that you do not know what has happened to the person you love. That you do not know that the attempt has paid off or that thousands of innocent people have been killed.

He couldn't bear it. He crouched in the gutter and wept.

Vague sounds echoed in her ears as if echoed from inside a large, dark cave. The sounds were familiar but not yet recognizable.

She slowly opened her eyes. A gleam appeared in the darkness, and each time she blinked, the intensity of the darkness decreased and added to the intensity of light.

A few times she blinked, she recognized the presence of three people around her head. Gradually the images became clearer. It was Tom, Ivan, and Colonel Taylor.

Hannah narrowed her eyes, and as soon as she wanted to get up a little, her side seared with pain. She fell on the bed inevitably.

Tom raised the hospital bed a little so she could see more easily. Hannah, in the white dress of the hospital, had seen the awe of the angels.

Tom came and stood beside her. He put his hand on her blond hair and stroked it. She smiled. Then she remembered the adventures of that day, looking so glum about it.

"The conference. What happened to the conference?" She said tensely.

"With your help," Said Tom looking at her full in the face. "At the last moment, the threat got down, and no one was killed."

Hannah exhaled a sigh of relief. "Captain Sanders..." She asked again. "What happened to him?" Tom laid his head down and curved his right arm about his neck.

"I'm sorry." Colonel Taylor lamented, "He was a great man and a great soldier... He was hailed as a patriotic soldier. God bless him."

Tears started running down her face. Gulping down her tears, once more averting her head.

In her heart, she knew that Captain Sanders loved her, but the military hierarchy did not allow him to express his love. She ached. He was an eligible young man who had sacrificed himself for Hannah. Her lips began to quiver as she drew a deep breath. She turned her head and looked over Tom, all sharp teeth and gangly brown eyes.

Tom took Hannah's cold hand and caressed it with his rough, long fingers. Colonel Taylor, who had seen the atmosphere emotionally, preferred to leave.

"You have rested well for two days." The Colonel said in his pleasantest way. "You will be out of the hospital tomorrow. There are still many truths to discover. Remember? Get well soon."

Hannah smiled an entirely mirthless one. The Colonel said goodbye and left the room.

"Thank God." Ivan let out a sigh and said as he leaned back in his chair. "I don't like him one bit."

"Look," Tom said to change the atmosphere. "You didn't hack their system, did you?" Ivan and Hannah burst out laughing.

"By the way," Hannah swallowed her laughter and said, "How did you stop the drones?"

Ivan got up excitedly and came to Hannah. "You can't believe it. He did some magic with reinforcement learning, and suddenly one of the drones went towards the attacking drone, and there was only 1 second left to hit the hotel. The two drones collided. I loved it. I believed in the power of machine learning."

Tom glared sideways at Ivan.

"Aside from that," Ivan continued. "Tom's completely professional coding riled me up. He coded better than me, and he even didn't say anything about it."

Tom stared at him, frowning. "Come on, stop running off at the mouth," Tom muttered. "Hannah has to rest now. Cease that chatter."

Ivan sat still with the most preoccupied air. Hannah squeezed Tom's hand tighter. "Don't break my sun's heart. He was praising you. I want to know how those mathematical algorithms could save lives. Come on, do tell me all about it." She said excitedly.

"Oh... well," Ivan also excitedly said. "I like to learn too. Especially Reinforcement Learning. I'm crazy about it."

"You do not want me to teach you a machine learning in the hospital," said Tom, raising his eyebrows. They both laughed.

"Why not?" Hannah said mischievously.

"Okay, let's get started right now," Tom said seriously. Then he went and took some sheets from his handbag and sat down next to Hannah's bed.

Ivan also took his chair by the bed. Tom raised Hannah's bed a little and then started. "Let's get started with the neural network. We used the neural network to predict the probability of selecting each of the trends of economic and political events. Now let's see how this algorithm works…

Human neural networks inspire neural networks. Our nervous system comprises neurons and synapses that transmit information between the brain and our organs. Inspired by this nervous system in the 1950s, Perceptron's first neural network algorithm was developed, which was a simple two class-based classification.

Later, the pioneers of artificial intelligence, including Marvin Minsky and John McCarthy and others, by proving some proposition showed that neural networks are not a highly predictive algorithm.

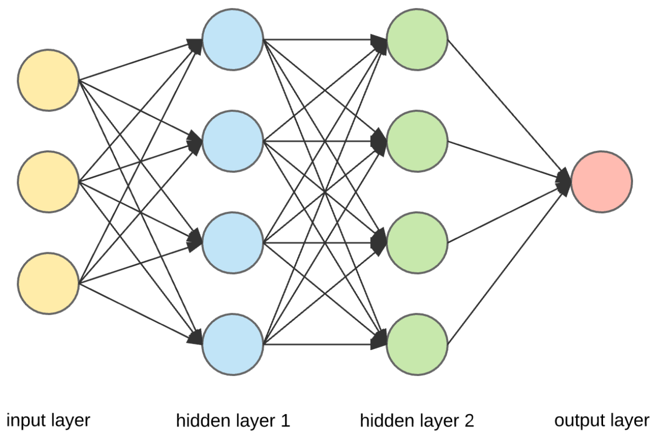
Advancing in years has shown that they were wrong. Their mistake was that they did not see the effect of the number of data in the model. With advances in computational power as well as improving the architecture of neural network algorithms, the ability of these models to predict some issues such as handwriting recognition, etc. was proven, and later with more developments in computational power, another form of neural networks with complex architectures were proposed, so-called deep learning.

We are not dealing with deep learning at the moment. What I used to predict event probability was a multilayer perceptron neural network used for multiclass problems.

Neural networks are, in fact, General Function Approximator. Remember, in our first sessions. We said that in machine learning, we seek to fit a function to the data. The neural network also seeks to fit a black box complex non-linear function to map inputs well to outputs. It means something like this:

$$y \sim f(x)$$

Where f is the same black-box function, neural networks map inputs to the desired output over several layers. By definition, a neural network has an input layer, at least one hidden layer, and one output layer. Each layer also consists of neurons or nodes. Like the following figure:



These layers are connected by some weights and form a network. The input layer consists of features. The outputs are also data labels for classification and continuous values for the regression problem. Therefore, the model designer must first determine the number of hidden layers and the number of neurons in each hidden layer called a neural network topology design.

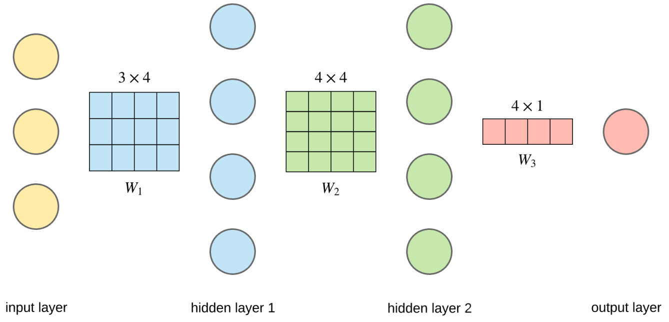
Suppose that each hidden layer of the neural network is also a function that it is. What the neural network does, is fitting some nesting functions to ultimately estimate the output, which for our example, is something like this:

$$y_{output} \sim g_{hid_2}(f_{hid_1}(x_{input}))$$

Therefore, the greater the number of hidden layers, the greater the number of intermediate hidden functions. Determining the number of layers and the number of neurons in the hidden layer is nothing but trial and error. We have nothing to do with these issues at the moment...

Like all machine learning problems, we have labeled training data and test data. Our goal is to determine the functions f and g that the least training and testing error can be obtained.

The functions f and g are also made up of neurons, and all neurons of different layers are also connected. The importance of these connected arcs is not the same, and any connection between two neurons of two different layers has different weights, and in fact, it is the same different weights that lead to different functions of f and g. Just like linear regression, where changing the coefficient changed the shape of the line, changing the weights of the neurons' connection will change the shape of the functions of f and g. Finally, neural network training is nothing but determining the optimal values of these weights!



To determine these weights, training data must be fed to neural network topology to determine the best weights to fit. The neural network training process requires a lot of precision due to the existence of many variables, so we will use a more complex network training process, which I will mention later.

Let's first look at how to determine weights. In the basic neural network algorithm, determining the optimal local values of weights is done by two processes:

1. Feed Forward

2. Backpropagation

First, the weights of the different layers are randomly selected. For each data, in the feed-forward process, the values in the equations I will explain are calculated sequentially, and the result of the estimated output is compared to the actual label.

In the backpropagation process, the amount of error will update the different layer weights. After that, in each iteration, new data will feed again to the model. This process continues until we finally get to a minimal error or the number of iteration reached a user-defined value…

Now it's time to delve into the mathematical aspects of the neural network. As usual, we start with an example and what example is better than solving the example mentioned earlier?

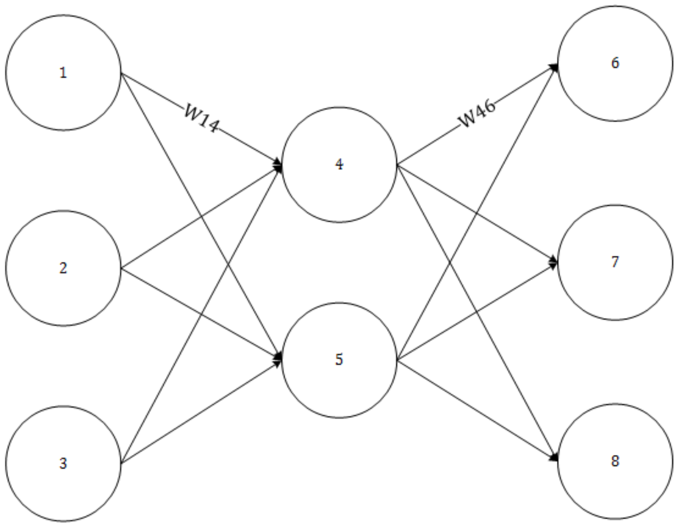
In that example, we had ten features of events, which are our inputs. For now, for our example to be manually solvable, suppose the number of our inputs was three…

I also used the Cross-Validation training process to determine the number of layers and the number of neurons. For now, we have nothing to do with these methods and assume our neural network had one hidden layer with two neurons. What should be our output? Tell me?"

Hannah and Ivan were surprised by this sudden question. Hannah pulled herself up a little on the bed, cleared her throat, and said, "the same as the number of events."

"That's right," Tom smiled and replied, "If it's a regression problem that we have an output neuron that is the same as the continuous value of the label. If it's a classification problem with two classes, an output layer neuron is enough. In most cases, the output layer, like logistic regression, is probabilistic values, so if the value is higher than 0.5, the class is positive, and otherwise, the class is negative.

But suppose the problem is the multi-classification problem. In that case, each class must be specified as a separate column in the training and test datasets as Dummy Variable, that is, with values of zero or one. In this case, according to the number of dummy variables, we will have an output layer. Suppose we had three events. So we have three output neurons. With this in mind, our neural network architecture looks like this:



In the figure, to make things simple, I have shown only two neurons. We have to determine all the weights. Well, suppose for training data, we want to process the feedforward and backpropagation of the neural network. Let's do the calculation. The features value, the random values of the weights, and the Bias parameter that I will mention are as follows:

It is recommended that the data be normalized before ap-

x_1	x_2	x_3	w_{14}	w_{15}	w_{24}	w_{25}	w_{34}	w_{35}	w_{46}
1	0	1	0.3	-0.2	0.4	0.1	-0.1	0.3	-0.5

w_{47}	w_{48}	w_{56}	w_{57}	w_{58}	θ_4	θ_5	θ_6	θ_7	θ_8
0.3	0.1	-0.3	-0.2	0.4	-0.3	0.2	-0.1	0.3	0.5

plying them to the model. I have already explained to you the formula. This will help to make the function fit and converge easier. Also, because we have three output labels of type zero and one, so our label is like this:

$$y_{class} = (y_6, y_7, y_8) = (1, 0, 0)$$

As I said, the first step is to move forward. The calculations are done in a forward process to reach the output neurons and compare the predicted value with the actual label value.

In the feed-forward process, each linear function of the hidden layer is applied to the previous layer – hidden or input layer - to reach the output layer. Applying these linear functions sequentially leads to the formation of nonlinear behavior. In order to calculate the values for the hidden layer and the output layer, the following formula is used:

$$I_j = \sum_i w_{ij} \times O_i + \theta_j$$

Where w_{ij} is the weight associated with connecting neuron i from the previous layer to neuron j in the current layer. O_i is the output value of the neuron of the previous layer and $_j$ is the bias of the current neuron. The function $_j$ is the same as the width of the origin in the linear regression.

The existence of this parameter gives the model the degree of freedom to move transversely and the ability to change the weighting coefficients that lead to the longitudinal displacement.

The existence of each neuron here is to add one more degree of freedom to the model to fit the function in a larger space. Let's consider the whole neural network as a function. Weights give the neural network the power of longitudinal motion, and the bias parameter gives the model, power of transverse motion.

Too much freedom is not a good thing, so adding more neurons does not improve the model's behavior generally, and the optimal number of neurons must be determined.

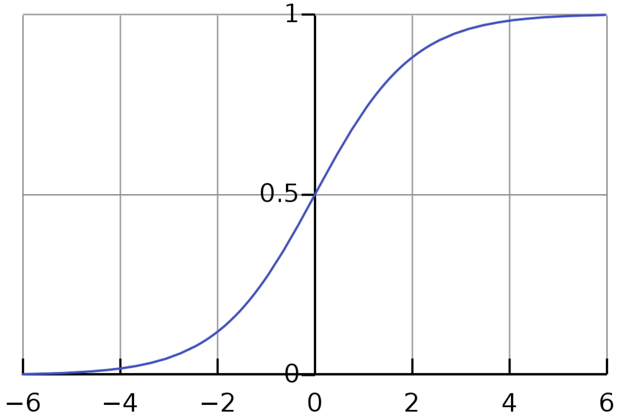
However, after each neuron's value in the hidden layer and the output layer is specified, the activation function must be applied to the output value.

The activation function's operation is to change the output interval to the interval that we desire in the output label value. For example, if our problem is regression, we use some specific activation functions, and if it is a classification problem, we use another activation function.

In our example, and in many other examples, which problem is a matter of classification, the logistic or sigmoid function is usually used:

$$O_j = \frac{1}{1 + e^{-I_j}}$$

The form of this function is as follows:



This function squishes any value from zero to one interval. That is exactly what we want. This function also has a nonlinear behavior. Converting the linear function to hidden and output layers gives them a nonlinear behavior and helps the function to be able to classify and separate those data that are not linearly separable. Let us calculate these values for the hidden layer and output layer neurons:

Unit	**Net Input, I_j**	**Output, O_j**
4	$I_4 = w_{14} \times O_1 + w_{24} \times O_2 + w_{34} \times O_3 + \theta_4 = 0.3 \times 1 + 0.4 \times 0 - 0.11 - 0.3 = -0.1$	$^1/_{1+e^{-(-0.1)}} = 0.78$
5	$-0.2 \times 1 + 0 + 0.3 \times 1 + 0.2 = 0.3$	0.57
6	$0.5 \times 0.78 - 0.3 \times 0.57 = 0.11$	0.52
7	0.42	0.60
8	0.80	0.68

Well, we have calculated the output values. Now it is time to calculate the amount of error in the labels and then return each weight's share in creating that error to itself and update them. This is done by using the backpropagation process. That is the second step.

The backpropagation algorithm is nothing more than calculating the least-squares error function for labels and then using the gradient descent method to find the weights' optimal values and update the amount of change. And just to remind you of high school, we need to know that the Gradient Descent method uses the chain derivation rule to find the error share of each weight and update them. The rule of chain derivation is as follows:

Suppose we have two functions:

$$y = u^3 + 2u^2$$

$$u = x^2 + 3x$$

If we want to take the derivative of y corresponding to x, we see that y does not have an independent variable called x. So the chain rule can be written like this:

$$\frac{\partial y}{\partial x} = \frac{\partial y}{\partial u} \times \frac{\partial u}{\partial x} =$$

$$(3u^2 + 4u) \times (2x + 3) =$$

$$(3(x^2 + 3x)^2 + 4(x^2 + 3x)) \times (2x + 3) =$$

$$3x(x^3 + 8x^2 + 18x + 12)$$

Another form, and a simplified form, of the chain derivative rule, is as follows:

$$\frac{\partial}{\partial x} f[g(x)] = f'(g(x)) \times g'(x)$$

In the Back Propagation method, to get each weight's optimal value, we take the Loss Function derivative with each of the weights, and with the chain rule, we get the corresponding value. I don't enter into the details of the derivatives. Instead, I will tell you the formulas that are derived from the gradient Descent method so that we can update the weights:

First, let's see how much each neuron in the hidden layer and the output layer contributes to the total error. For this purpose, we must use two formulas. If the neuron is in the output layer, we use this formula to update the weights:

$$Err_j = O_j(1 - O_j)(T_j - O_j)$$

Where O_j is the output of the predicted label. T_j is also the actual label of the training data. Now, if the neuron is in the hidden layer, we use the following formula to calculate the error share:

$$Err_j = O_j(1 - O_j) \sum_k Err_k W_{jk}$$

The difference between this formula and the previous one is in the relative amount of the next layer neuron's error in proportion to the weight of the connection between the current neuron and the next neuron.

Now that the contribution of each neuron to the total error has been determined, weights can be updated with the following formula:

$$\Delta w_{ij} = (l) Err_j O_i$$

$$w'_{ij} = w_{ij} + \Delta W_{ij}$$

Where Δw_{ij} is the percentage change in weight and w'_{ij} is the new updated weight. Also, l is the learning rate that I mentioned earlier. This rate helps us move towards the correct and optimal amount of weight in a slow and continuous process. The same process is used to update bias values with the following formulas:

$$\Delta\theta_j = (l)Err_j$$

$$\theta'_j = \theta_j + \Delta\theta_j$$

Based on this, let's first calculate the error contribution values for the output layer and hidden layer neurons:

Unit, j	Err_j
6	$0.52(1-0.52)(1-0.52) = 0.11$
7	$0.60(1-0.60)(0-0.60) = -0.144$
8	$0.68(1-0.68)(0-0.68) = -0.147$
4	$0.78(1-0.78)[(-0.5\times 0.11)+(0.3\times -0.144)+(0.1\times -0.147)] = -0.02$
5	$0.57(1-0.57)[(-0.3\times 0.11)+(-0.2\times -0.144)+(0.4\times -0.147)] = -0.015$

Now that we have calculated the hidden and output layer errors, we can update the weights and bias values. Suppose the learning rate is 0.9. Ivan, you do the calculations."

Ivan, recollecting himself, fidgeted in his armchair. Then he took the pen from Tom and began to calculate:

When the calculations were over, Ivan sighed and said, "It's finally over. All my life I have learned to do all the calculations and tasks automatically with the algorithms. It is very awkward to calculate manually like this."

"Yes," Replied Tom laughing and looking at the results and the calculations. "Manual calculations are very time consuming and tedious, but if you do an algorithm manually at least once, it helps a lot to understand it.

Anyway, Weights have now been obtained, and now it is time to do forward calculations for new data with new weights."

Weight and Bias	Updated Values
w_{14}	$0.3 + 0.9 \times -0.02 \times 1 = 0.282$
w_{15}	$-0.2 + 0.9 \times -0.015 \times 1 = -0.213$
w_{24}	$0.4 + 0.9 \times -0.02 \times 0 = 0.4$
w_{25}	$0.1 + 0.9 \times -0.015 \times 0 = 0.1$
w_{34}	$-0.1 + 0.9 \times -0.02 \times 1 = -0.118$
w_{35}	$0.3 + 0.9 \times 0.012 \times 1 = 0.286$
w_{46}	$-0.5 + 0.9 \times 0.11 \times 0.78 = -0.422$
w_{47}	$0.3 + 0.9 \times -0.144 \times 0.78 = 0.198$
w_{48}	$0.1 + 0.9 \times -0.147 \times 0.78 == -0.003$
w_{56}	$-0.3 + 0.9 \times 0.11 \times 0.57 = -0.243$
w_{57}	$-0.2 + 0.9 \times -0.144 \times 0.57 = -0.273$
w_{58}	$0.4 + 0.9 \times -0.147 \times 0.57 = 0.324$
θ_4	$-0.3 + 0.9 \times -0.02 = -0.318$
θ_5	$0.2 + 0.9 \times -0.015 = 0.186$
θ_6	$-0.1 + 0.9 \times 0.11 = -0.001$
θ_7	$0.3 + 0.9 \times -0.144 = 0.170$
θ_8	$0.5 + 0.9 \times -0.147 = 0.367$

Ivan raised his eyebrows and complained, “Oh my gosh, trust me, we learned it. We no longer want to do everything by hand!”

Tom laughed aloud. “I didn’t want to go on again. The whole neural network works accordingly. The new data is calculated forward based on the current weights, and then the weights are updated again in the backward process, and finally, the best weights are obtained based on the training data.

The condition of stopping the neural network are two modes. Either reach to the number of iterations selected by the user or the Loss Function value for a given data is less than a certain threshold. This was the hustle and bustle of neural networks."

"It wasn't too hard." Ivan leaned forward and said proudly. "I learned easily."

Tom looked at Hannah and then Ivan. "That's right, you learned the basics of the neural networks, but well, the neural networks have more complex issues. There are many mathematical concepts behind this model that it is out of the scope of our discussion. However, you got the idea."

Then, looking at Hannah, he continued: "As you can see, given the many variables that need to be optimized, the neural networks essentially need a lot of data to be able to generalize. In case that enough data is not available, another training strategy called Cross-Validation can be used to train the model.

If you remember, our strategy for model training was to divide the data into training and testing. Now I want to introduce you to a more advanced type of training strategy. In this strategy, instead of splitting the data once, we divide the whole data into different intervals, not necessarily in equal sizes, execute the model for each interval, and finally, based on the average accuracy of the different intervals, understand how the model works. But how to divide the whole data into different parts? To do this, suppose we divide the whole data into 4 equal intervals.

I must say that dividing data into equal intervals is a common idea, but data can also be divided into unequal intervals. OK... Let's go on...

For the first time in the Cross-Validation strategy, we consider the first block as test data and the rest of the data as the train data. The trained model and test accuracy are obtained. Next time, the second block will be taken as test data, and the rest for training... and this process is done for all blocks, and then the overall accuracy is obtained by averaging the total accuracy.

With this strategy, the model has the opportunity to see all the data. As a result, with one data, we can measure the algorithm's generality and accuracy together.

Now you may say why we have divided data into four intervals. It's the right question. The fact is that in this case, you have to move forward based on a personal decision. In real cases, the data is usually divided into ten intervals.

The full name of this training strategy is K-Fold Cross-Validation. Where K is the same number of divisions. Of course, there are other strategies for training, but this strategy is very widely used. In addition to measuring a model's generalizability, this strategy is also used to select a model and also for parameter tuning.

I have used this strategy in neural networks to determine the number of hidden layers and hidden layer neurons. So that based on my hypotheses, I considered the number of hidden layers from 1 to 10. I also considered the neurons in each layer from 1 to 10, and then I used the Cross-Validation strategy with five blocks. In terms of programming, it looks like we have two loops, the first is the number of neurons, and the second is the number of layers. In each execution, the network topology is determined based on ordered pairs (number of neurons, number of layers). For this topology, the model is executed 5 times with different accuracy, and average accuracy is reported.

Finally, we have 100 states, and for each state, the model is executed five times. That is, the model is executed 500 times. We choose the best parameter combination from the 100 different parameter states-the one that caused the least error. In this way, this strategy can also be used for parameter tuning.

The same goes for selecting a model. Suppose we have five candidate models. For each, the model is executed with the Cross-Validation strategy, and then the models are compared. The model with the least error will be selected accordingly."

"In some cases," Hannah cleared her throat and asked, "We have to both tunes the parameters and choose one of several models. What is the precedence of the two processes? First, the parameters of each model should be adjusted, and then the models should be compared with each other or, first, the models should be compared, and then the best parameters of the top model should be selected?"

"It's a very good question," Said Tom. "Suppose the parameters of each model are athletes of one country. And every model is a country that participates in the Olympics. Reasonably, at the first stage, the athletes of a country compete with each other, and the best one is selected, and then the best athletes of each country compete with each other to finally determine the world champion. Therefore, first, the parameters are tuned, and then the model is selected. Of course, in some cases, this precedence may be reversed."

Hannah laughed at the allegory used. Tom leaned closer to Hannah and continued, "The discussion of measuring the accuracy and generalization of models does not end here. Previously, in describing the decision tree method, we stated the different criteria for evaluating the algorithm's accuracy, and now, we have specified the model training strategy. Another idea is to measure a model in terms of different criteria in different iterations. This is especially can be used in measuring the generalization of a model when two important evaluation criteria intended by the user conflict with each other, and a trade-off must be established between them, as well as in tuning the parameters of a classification model, and finally in choosing the best model based on two evaluation criteria.

In classification problems, accuracy is not an appropriate measure of model performance. Consider the confusion matrix:

		Actual: Positive	Actual: Negative
Predicted	Positive	TP	$FP(\alpha)$
Predicted	Negative	$FN(\beta)$	TN

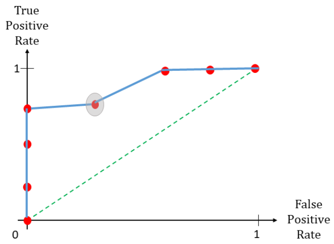
In such cases, it is better to use two evaluation metrics for different values of the parameter that we intend to tune:

$$TruePositiveRate = Sensitivity = Recall = \frac{TP}{TP + FN}$$

And

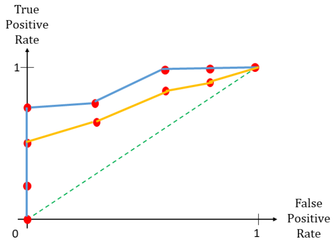
$$FalsePositiveRate = \frac{FP}{FP + TN}$$

Which are in fact the first and the second column of the confusion matrix. Based on this, we calculate these two metrics for different values of a parameter. The resulting graph is called the Receiver Operator Characteristic or ROC figure:



As you can see, for each value for the parameter, the intersection of the two metrics creates a point. We should choose an intermediate state between the two metrics. So the fifth point is chosen.

Consider another case in which we want to choose between two models for different iterations of the Cross Validation strategy. ROC figure is also used for this case. Suppose the ROC figure for two models looks like this:



Based on this, which model is selected? The model whose area under the graph is the largest possible. This area is called the Area Under the Curve or AUC.

The use of ROC and AUC is very common in selecting the model and parameters.

I used the Cross-Validation strategy to train the neural network and considered the number of blocks 10. Also, to select the number of hidden layers and the number of neurons in each hidden layer, I drew the corresponding values in the ROC figure, and then I chose the best number of layers and neurons. That was all thing that was done in the artificial neural network."

Tom leaned back in his chair, arched his arms, and said, "Honestly, it was a tough discussion. Enough for today. Dear Hannah, you better rest too. I will visit you again tomorrow, and if you are in the mood, we will learn Reinforcement Learning together."

"Honestly, I have nothing to do tomorrow. I want to see how you piloted the drone automatically. It's very useful to me," Said Ivan.

"Ok," Tom laughed and replied, "If only you wouldn't use it for illicit activities."

All three laughed.

The next day, at the visiting time, Tom and Ivan attempted to visit Hannah again. Hannah was making the most of the obliging vacation. Seeing Tom and Ivan, she dropped the book she was reading.

With eyes flashing lightning, she gave Tom, ignoring Ivan, one of her charming smiles. Tom sat down next to her again and kissed her on the forehead. Hannah seemed to be a spoiled brat.

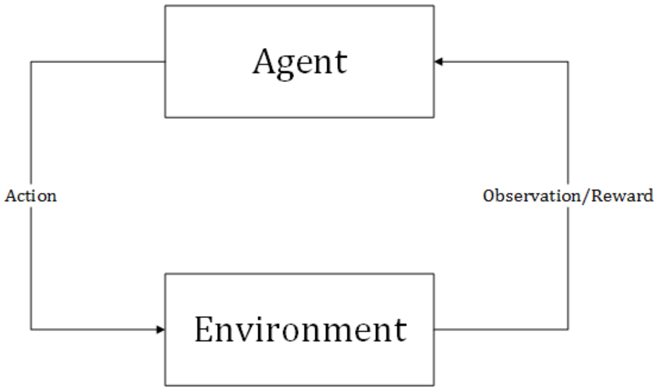
Ivan was also looking for a chair, and since he could not find it, he finally sneaked one of the chairs into the next room. While passing, a duty nurse glowered at him, Ivan instead of being embarrassed, winked at her. The nurse passed in front of him, glaring.

Tom leaned back in his chair and said as he crossed his feet, “Very well, we have a difficult lesson ahead of us today. You have to keep your eyes open. The algorithm I will describe is like none of the previous algorithms we have learned so far. Because it does not belong to the common category of supervised and unsupervised learning models, it is something between these two, and its training approach is different from previous models.

Reinforcement learning is one of the Semi-Supervised Learning models and works based on reward and punishment, just like the human brain. In reinforcement learning, the human user determines the feasible environment, the state of a problem, and the rewards and punishments in each state to the model.

This is the supervised learning part of the reinforcement learning model, and then the model learns to find the best policy to get the most reward, and this is the unsupervised part of it. That is why these types of models are called semi-supervised learning.

In general, reinforcement learning consists of a learning agent that makes a decision based on its environment feedback. Based on this decision, it enters a new state, and this process continues again and again to get the best possible reward.



In fact, in reinforcement learning, we are in a state. We make decisions based on that state and move on to the next state. So the basic structure of reinforcement learning is the pair of (state, action). Let's move on with our problem.

We want to train the defending drone so that by adopting the best policy, it can attack, or as the Japanese say, kamikaze to the goal drone. First, I need to consolidate some of the keywords:

1. Agent: A physical or virtual system that intends to learn the best policy to do a task. In our example, the defending drone is the learning agent.

2. State: Situations in which the learning agent can be placed by taking different actions. For example, the current geographical location of a drone is the current state of that drone.

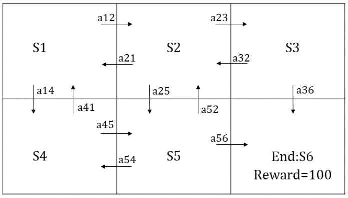
3. Action: In each state, the learning agent is faced with several possibilities to move to the next state. The learning agent can take action and move on to the

next state. For example, the drone can move right, left, or forward and backward and move to the next state, the next geographical location.

4. Reward: Taking every action and moving from one state to another has a reward for the learning agent. For example, the defending drone will be rewarded if it approaches the attacking drone with action. Otherwise, it will not be rewarded, which can be considered as a punishment for it.

5. Optimal policy: A set of actions that convey the agent from the current state to the final optimal state gives the agent the most reward. For example, a defense drone can fly around New York City one day and then reach the attack drone, and another way is to take the shortest route to reach the attack drone.

Let us take the issue of the defender-attack drones in the form of a practical example and learn more about reinforcement learning. Suppose the feasible environment of our problem is something like this:



We have a total of 6 states. The attacking drone is in position 6, and the defending drone can be in 5 positions, directing itself to the attacking drone position in position 6. In the meantime, being in any position is not rewarded unless it reaches into state 6 and receives 100 rewards.

Suppose the defending drone is in the first state and wants to go to state 6 with the most reward. In this case, the optimal policy is the policy in which the set of actions' cumulative reward is the maximum possible. This can be shown mathematically as follows:

$$V^{\pi} \equiv r_t + \gamma r_{t+1} + \gamma^2 r_t + 2 + \dots \equiv \sum_{i=0}^{\infty} \gamma^i r_{t+1}$$

Where V is equal to the cumulative reward. r is equal to reward in the state of t and is also an optimal policy that conveys the agent from the current state to the desired state. $0 \leqslant \gamma < 1$ is also the exponential adjustment rate of the reward of the next stages. The maximum reward ratio should be for the first state ahead, and gradually, the ratio should be decreased for the next states.

Even if, the number of states that the learning agent could go through was quite clear, and we were so lucky that we could already detect all the states in which the learning agent moved from the initial state to the final state. Still, we would have an important limitation. And that was the computational limitation. The amount of time to run this model was so large that the algorithm was practically inefficient. While in reality, the states that the learning agent can traverse are too many, and in some cases, even the next states cannot be known until we get into that state, which was called stochastic states.

We can use Dynamic Planning as well as Markov chains. Fortunately, machine learning scholars have done this before and have proposed an algorithm that depends only on the system's next state. This algorithm is called Q-Learning. In the Q-Learning algorithm, instead of assigning a reward to each of the following states, we assign a reward to the sum of the current state rewards and the pair of (current state, next action).

Look again at the form of the defender-Attack drones. In any state, we are faced with several actions. According to the Q-Learning algorithm, in one state, we have to take any action that maximizes the current state's reward and the sum of the regular pair of (current state, next decision). This is mathematically defined as follows:

$$\hat{Q}(s, a) \longleftarrow r + \gamma max \hat{Q}(s', a')$$

In short, the Q-Learning algorithm works like this:

1. For each s and a, set the values to zero

2. See the current state of s

3. Repeat Forever:

   a) Select action a and execute it.

   b) Receive an immediate reward of r

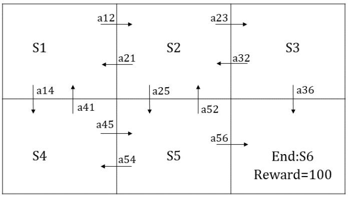
   c) Observe the new state of s'

   d) Update the value of $\hat{Q}(s, a)$ in the value table as follows:

$$\hat{Q}(s, a) \longleftarrow r + \gamma max \hat{Q}(s', a')$$

e) $s \longleftarrow s'$

Now let's look at how the Q-Learning algorithm works with the example of the defender-attack drones:



We have 14 regular (state, action) pairs. According to the algorithm, we first set the value to zero for all pairs:

s_1, a_{12}	$s1, a_{14}$	$s2, a_{21}$	$s2, a_{23}$	$s2, a_{25}$	$s3, a_{32}$	$s3, a_{36}$	$s4, a_{41}$	$s4, a_{45}$	$s5, a_{54}$	$s5, a_{52}$	$s5, a_{56}$
0	0	0	0	0	0	0	0	0	0	0	0

Suppose the current position of the defending drone is s_1 in the first state. So we have two decisions a_{12} and a_{14}. By random selection, we select a_{12}. Now assuming an adjustment rate of 0.5, we need to update $\hat{Q}(s_1, a_{12})$:

$$\hat{Q}(s_1, a_{12}) = r + 0.5 \times max(\hat{Q}(s_2, a_{21}), \hat{Q}(s_2, a_{25}), \hat{Q}(s_2, a_{23}))$$

$$= 0$$

Where $max(\hat{Q}(s_2, a_{21}), \hat{Q}(s_2, a_{25}), \hat{Q}(s_2, a_{23}))$ is equal to the order pairs associated with actions in state s_2. As you can see, the reward is zero. But our state has changed. In s_2 state, we have three actions: a_{21}, a_{25}, a_{23}. Suppose we randomly select a_{23}. So we move to s_3. Now we need to update $\hat{Q}(s_2, a_{23})$).

$$\hat{Q}(s_2, a_{23}) = r + 0.5 \times max(\hat{Q}(s_3, a_{32}), \hat{Q}(s_3, a_{36})) = 0$$

Another zero reward. Let's, again, randomly select a36. We need to update $\hat{Q}(s_3, a_{36})$.

$$\hat{Q}(s_3, a_{36}) = r = 100$$

Yes, we finally got the reward in the first iteration. The first round of the game or our simulation is over. We will update the table Q ^(s.a) and play another round

The game has started again. Suppose for this round. The

s_1, a_{12}	$s1, a_{14}$	$s2, a_{21}$	$s2, a_{23}$	$s2, a_{25}$	$s3, a_{32}$	$s3, a_{36}$	$s4, a_{41}$	$s4, a_{45}$	$s5, a_{54}$	$s5, a_{52}$	$s5, a_{56}$
0	0	0	0	0	0	100	0	0	0	0	0

initial state is selected randomly to be s2. In s2 state, we have three actions: a21, a25, and a23. Suppose a23 is selected randomly. So, we need to update $\hat{Q}(s_2, a_{23})$

$$\hat{Q}(s_2, a_{23}) = r + 0.5 \times max(\hat{Q}(s_3, a_{32}), \hat{Q}(s_3, a_{36})) =$$

$$0 + 0.5 \times = 50$$

As you can see, $\hat{Q}(s_2, a_{23})$ was also updated. So we need to update the table again: In the continuation of the game, again a_{36} will be selected. This time not randomly but because of the higher score. Another round of game ends

s_1, a_{12}	$s1, a_{14}$	$s2, a_{21}$	$s2, a_{23}$	$s2, a_{25}$	$s3, a_{32}$	$s3, a_{36}$	$s4, a_{41}$	$s4, a_{45}$	$s5, a_{54}$	$s5, a_{52}$	$s5, a_{56}$
0	0	0	50	0	0	100	0	0	0	0	0

at this point.

Suppose we allow the computer to continue this game 1000 times and update the value table. In this case, the table in different iterations will eventually look something like the table below.

Thus, after training the model and obtaining the table of

s_1, a_{12}	$s1, a_{14}$	$s2, a_{21}$	$s2, a_{23}$	$s2, a_{25}$	$s3, a_{32}$	$s3, a_{36}$	$s4, a_{41}$	$s4, a_{45}$	$s5, a_{54}$	$s5, a_{52}$	$s5, a_{56}$
25	25	12.5	50	25	25	100	12.5	50	25	25	100

weights, the defending drone can make the best decision and reach the attacking drone in any situation. OK, this is the end of simplified reinforcement learning."

Tom took a deep breath and looked at both of his interested students. Hannah, who was fascinated by the discussion, said, "But I have a problem with this table you have updated. If we start the next time differently, the table values can't have different numbers? This is especially evident if we have many states. Is it true?"

"You asked a very good question." Said Tom, as he chested out, shoulders wriggling. "Let me answer with a simple yet important statistic fact. If you have a dice and you want to get the occurrence rate for each side of the dice, you usually start rolling the dice many times. After assuming 100 attempts, if you calculate the occurrence rate for each side, based on the results you get, the numbers will be very close to $1/6$.

If you increase the number of repetitions, you get closer to that number. This is a statistically proven fact that the science of mathematical simulation and even many scientific applications are based on it. That a random process tends to a specific behavior as it is repeated many times. Mathematically, the infinite limits of the occurrence rate for each side of the dice are 1/6.

$$\lim_{n \to \infty} p = \frac{1}{6}$$

While the nature of the system is stochastic, repeating of simulation leads to the same result. This fact shows us that there is a hidden order even within the seemingly irregular and probabilistic behaviors of nature. Such convergences in statistics are called steady state.

The same will happen in our example. That is, no matter how different the rounds of our game are, in many repetitions, almost the same numbers will be obtained."

"I have to say that," Tom continued again. "Besides Q-Learning, there are other algorithms for solving the problem, but Q-Learning is the most common one.

The last point that remains is how to choose the next orderly pair in a particular state. In the example I described, we chose the action pair based on the highest rewarding order pair. Still, there is always a risk that some order pairs will be chosen more than others in this type of choice, which is equivalent to overfitting in the supervised problems.

To avoid this, they usually choose the next state based on the following formula, which is called softmax selection policy:

$$P(a_i, s) = \frac{k^{\hat{Q}(s,a_i)}}{\sum_i k^{\hat{Q}(s,a_i)}}$$

Where $P(a_i, s)$ is the probability of choosing a_i action in the s state, and k is a constant value. According to this formula, we select the next state probabilistically. If even the next state has a higher reward value, the less probable state may also be selected in the form of probabilities.

Another point is that by tuning the parameter k, a balance between further explorations of the new state or exploitation of the current trend can be established. Ivan, you have been very quiet. Can you tell us how to tradeoff between exploration and exploitation by adjusting k?"

Ivan raised an eyebrow, rubbed his chin, and replied: "I think it should be something like this:"

$$LargeK \rightarrow Exploite$$

$$SmallK \rightarrow Explore$$

Tom looked at Ivan's hand-writing, "Well done, that's right. In fact, by selecting large amounts of k, the chances of selecting amounts with larger rewards increase. Because $k^{\hat{Q}(s,a_i)}$ becomes exponentially larger for large values of k. In this case, most likely, the next state with bigger rewards will be selected.

Conversely, selecting small k will lead us to the selection of states with fewer rewards, and this is equivalent to more exploration.

Tom was silent again. No one asked a question. "We learned the basic structure of reinforcement learning together." He continued. "Of course, what we know is a drop of water against the ocean, but we also accepted to learn the basics and ignore the bells and whistles.

Reinforcement learning has countless uses in issues that somehow deal with auto-selection or auto-control. It was with these kinds of methods that the biggest Go player lost to a computer. This algorithm is used in dynamic pricing, making smart games, production planning, self-driving cars, etc.

We also used this algorithm to destroy the attacking drone. We did not even know the location of the attacking drone. By defining the reward function of the defending drone for the shortest possible distance from the attacking drone, we were able to lead it dynamically to the attacking drone, and you saw that this algorithm saved hundreds of lives at the last moment."

"Now is the time to save the lives of millions of other people who the Deus Machine may threaten." He concluded. "We have to attack it this time before it starts its attack."

"But how?" Ivan asked excitedly. "This system has infiltrated all computers. Like a God-damn virus. How can we get rid of it?"

"We're not going to destroy it," Tom replied. "We're going to make it destroy itself. To do that, we will use the cutting edge algorithms of machine learning called deep learning.

Of course, this will be only part of the job. I will explain my plan. First, we should help Hannah to stand up. Her presence is necessary at this stage, and then we will make our plan goes into effect."

"I'm fine." Hannah pulled herself up on the bed and said, "I can start work tomorrow."

Tom shook his head and put his hand on Hannah's shoulder, then softly, reached out a hand to tuck a curl behind her ear. A glimpse of her shyness, accompanied by the tender smile between the two, spoke of undivulged hearthaches.

Hannah limped down the stairs, determined. Tom was on one side and Ivan on the other. When they came out of the hospital, Colonel Taylor was coming towards them without military uniform and with a great show of pomp and circumstance. A few steps away, he stopped.

"Oh, look," Colonel said with a simpering smile. "Our honorable Major has stood up from the bed. We should all celebrate and cheer for this."

Hannah took her steps slowly. "Celebration is for when I find Russell Pierre." She said, facing the Colonel, and then she went to her car, which had been in Tom's hand for a few days.

With Tom's help, she climbed into the back seat. Ivan also found a place in the front seat and immediately took out his laptop and began to work.

The Colonel came and stood in front of the back seat window. It appears that he had something to say. Hannah rolled down the window.

"I'm more bloodthirsty for Russell than you are." Said the Colonel. "For now, I'm here for something else. Your shooting and the drones' tale have stirred up a lot of controversies. It was expedient to consider the drone incident as a terrorist attack. All the media have covered this narration.

For the record, you understand the importance of the information we know, so if someone wants to do an interview, you better avoid it."

"We must all remember," Said the Colonel, elevating his head so that everyone can hear. "That this was a terrorist attack, the identity of suspects is under investigation,"

Hannah took her eyes off the Colonel and stared forward with beaming eyes. "Um, expedience... I'm allergic to this word. The right of these people is nothing but knowing the truth. My restraint is until the end of Russell Pierre's story. If I survive this, I will resign from the police to start a new life. Then there will not be an obstacle for me to tell the truth. It would be better for both of us to focus on finding Russell Pierre."

She rolled up the window. The car moved away.

"Tom," She asked, staring out. "Please take me to my office. I have to write the mission report."

Tom looked at Hannah in the middle mirror of the car. "Okay ... from now on, whatever you say."

Hannah smiled as she stared out. "Are you going to resign after this?" Tom said again.

Hannah shook her head, "I had forgotten myself all these years. This story and acquaintance with you reminded me of what I was and what I should become. I want to build a cottage next to yours and a farm. I also want to use machine learning to build a modern and productive farm. I have been thinking about and researching a lot about it while I was hospitalized."

Tom laughed out loud, "This is great, but there is no need for a new cottage. My cottage has room for two of us. Hannah turned and looked at Tom. Tom winked at her in the mirror. Hannah reddened.

"So what about me?" Said Ivan, as he was coding.

Tom glared at Ivan, "I have some ideas for you too. You are a little roving boy. You have to get out of this mess… Lisa is a good girl. Let this story end."

"So everything depends on the end of the story." Ivan closed his laptop and said enthusiastically, "So let's finish it, we have a lot of work to do."

Hannah wrinkled up the skin over his eyebrows and pondered when she heard this sentence. "The day I met Russell," She raised her head and said sadly. "He said he is going to do something in the next update of the Deus Machine so that nobody would stop it at all.

The traffic light turned green. Tom gasped, and the car started moving. "If he has the source code," Tom said. "He is likely to do so. At any cost, we need to know when and how the Deus Machine will be updated. Before that, we need to make the Deus Machine understand that this is the wrong path it is passing."

Ivan leaned more toward Tom, "If Russell Pierre wants to make a change in the Deus Machine, he will need powerful servers for model processing and initial training. We must be able to track these servers."

A sudden light broke on Hannah's mind. It made her lighthearted and happy again. "Exactly," She said. "And for that, he must look for a hidden and safe place."

Ivan turned to Hannah, "It is unlikely that he will rent a server to do this because ordinary servers don't have enough processing capability for handling such amount of calculation.

Big corporation servers also have complex mechanisms that are very difficult to penetrate, and success requires high risk. I think Russell Pierre probably either has a dedicated server or is preparing for it now." Ivan remained silent. Both Tom and Hannah were thinking. He was in his most serious gesture.

"The Deus Machine has infiltrated people's computers like a parasite without their knowledge." He took a breath and said again, "It consumes both their data and their computing power. According to my research, most of the systems that have been involved in the Deus Machine are in the state of California. This is the reason why most accidents occur in this state...

Russell Pierre must install the servers in the same state for two reasons: one is that the largest number of computers in this state's time coordinates are on and active. The Deus Machine is most affected by accidents in the same state and has the greatest impact on the same state. So the next update should most likely be affected by the electronic facilities available in this area. This means learning from Spatiotemporal patterns simultaneously.

Tom stared at Ivan. Hannah looked at Tom for confirmation, saying, "The analysis was reasonable. So, I should be looking for a server footprint, right?"

"That's right." Tom glanced at Ivan and Hannah and replied, "This is the most logical way. Me and Ivan also have to do two things. One is to know when this system will be updated and the second is to try to create a mechanism for the system to realize its conceptuality error."

They had arrived at the police station. Hannah did not want to stir. She remembered Captain Sanders and her heartfelt oppressed for a moment. She did not want to step out and go to the police station, the same office where she spent her youth, the best years of her life.

She did not regret her past, but she regretted why she didn't see Tom sooner. She regretted why she did not allow Frederick to express his love for a moment. She did not know what the answer would be in that case. But at the time She was hospitalized, she thought that everyone should have the right to express their love even if they do not get the desired answer. No one should stay in purgatory. Purgatory is worse than hell, that it is suspended between heaven and earth. Even the fire of hell is worth the bitterness of the suspending.

11

Deep Dream

Tom and Ivan returned to the cottage in the evening. They had not eaten anything since morning. Ivan's abdomen had spread to Tom. He got up and made a cheeseburger, and they ate together. Ivan did not give up his harassment as he was eating.

A few months ago, Tom did not have the patience to say anything, but today he is enjoying that he has friends for himself and those who are important to him, and he is important to them.

All human beings, rich and poor, old or young, male or female, need to be understood. They need someone to express themselves, without any mask, without any role-playing. The need to be understood is becoming the most important loss of the post-internet age where everyone wears a mask.

Tom had leaned his head on his hand, gassing his food, and was content to listen to Ivan, who was talking about anything under the sun until Ivan's phone rang.

Ivan pointed the phone to Tom. "It's Hannah. She's wanted to talk with you. With a candy-toothed grin, Tom picked up the phone and answered.

"Haven't you missed me?" Hannah joked.

"Not at all," Tom said to piss her off, laughing out loud. Her up in arms could be sensed from behind the phone.

"Oh, I see." She replied with pretended sternness. "I catch you, I'm gonna wring your neck."

Tom reached into his eyes and rubbed them, saying in a laughing tone, "I surrender." Then raised his head and stared at the corner of the cottage, "Won't be very much fun at all without you there, sweetie."

Hannah pretended not to hear. "Tom," She said seriously. "I have news for you. A young man came to the police station today and said he was Anna Cooper's boyfriend."

Upon hearing this, his piercing eyes widened to the size of side plates. "No," He said the astonished Tom. "Did she have a boyfriend? How could we not understand?"

"No one knew." Hannah continued.

"Are you sure he isn't lying?" Tom asked again.

"It does not matter," Hannah replied. "The matter is that Anna told him a secret so that if something happened to her, he could share it with everyone and now he has told us the secret."

Tom rubbed his beard, "What's the secret?"

"Password for accessing the source code," Hannah said. Tom found himself hanging breathlessly on her answer, let out a sigh, and sat down on the sofa.

“We already know it,” Tom uttered.

“Yes,” Hannah replied comfortably. “But at least now we know that Anna Cooper herself knew the solution to controlling the Deus Machine is in accessing the same source codes.”

Tom said nothing. Hannah said she would see him soon and then hung up.

Ivan was getting ready. He wanted to meet his girlfriend, Lisa. He had packed his things when Tom explained the story to Ivan, and as he was explaining the story, it was as if an idea suddenly came to his mind.

An idea that also came to his mind at Anna Cooper’s house then was forgotten. While he was explaining, he suddenly stopped. His hand was still suspended in the air. He stood motionless for a moment.

“Ivan,” said to Ivan in a fiery tone, “Do you feel like me? Look at the password of Anna Cooper’s system:

“52Ja‘9@FCa‘>:?FE6a‘”

I thought a lot about this password. Maybe there is a message in it. Can you see it? Two characters a‘ are repeated three times.”

Ivan looked deep into the code. He scratched his head slowly and then excitedly. Suddenly his hand remained on his head motionless.

“Oh,” He shouted. “I understand. This must be a kind of encryption system based on letter permutation. This kind of password exchange is very popular between hackers and Internet gangs. For example, one of them is a ROT13 cryptographic system where the original letter is replaced by the thirteenth English letter.

The basis of all this goes back to the German Enigma encryption system that Alan Turing hacked. Let me check."

He undressed his sweatshirt and backpack and sat down again.

"This is great." Tom got up, panting. "It's amazing. If so, that's a real step forward."

Ivan found a python decoding ROT-based encryption algorithm on the Internet, tried each one, and then dried it while testing the ROT47 encryption system.

He touched his gleamed hair and rubbed his eyes. "I think I found it…"

"day21hour21minute21"

"Goddamm, that's it," Ivan yelled with a clenched fist.

"Yeah," Tom said, pointing to his mouth in astonishment. This should be the time for updating the Deus Machine."

Tom rudely picked up Ivan's phone and called Hannah.

Hannah, who chanced to be in frolicsome humor, exclaimed, "You missed too soon."

"Hannah," said Tom, a little listlessly. "We just found out something. Anna Cooper's password was a message, an encrypted message. The Deus Machine updates every month on the 21st, 21:00, and 21 minutes of the month. Today is September 17th. We have four days to stop Deus Machine."

Tom fell silent. But there was no sound from Hannah.

"Hannah, are you OK?" Tom said again. Hannah seemed to rouse herself.

"The day of Anna Cooper's murder was also August 21," She said. "That is, Anna Cooper was killed on the same day that she wanted to stop the Deus Machine."

"You're right," Tom said sadly. "Now we should finish her unfinished job."

They said nothing more. Tom hung up.

"We must act quickly," Said Tom to Ivan, who was struggling with his laptop again. "We only have four days. Now that we don't have the source code, we have to use deep learning. Let's make the Deus Machine realize its mistake in its next update."

"But how?" Ivan swallowed and said, "What if Russell goes up sooner than us and makes some changes that will be applied in the next update?"

"There's no report of a server getting out of control or buying a server. It won't be easy to change the codes. We have to do what we think is right. Our focus should be on stopping the Deus Machine. After that, we will think about Russell.

Well, this time, we're using Deep Neural Networks to stop the Deus Machine. To do this, we will use two deep neural network algorithms called LSTM and GAN.

Using the LSTM algorithm, we will create new texts and historical books on a large scale. This type of application in machine learning is called text product generation. Using the GAN algorithm, we will create unrealistic images and identities. The model fails to integrate newly added people's data because the model does not have access to their other data.

If the Deus Machine works based on machine learning, it will lead to its misguidance. A lot of fake data must be generated."

"It's an interesting idea." Ivan nodded. "But generating a lot of fake data requires powerful servers. How do we solve this?"

"The technology companies need to be involved," Tom replied. “We should ask Hannah and Colonel Taylor to help us. This is the only way to save us.”

“Well, let’s get started.” Said Ivan, lifting his brows and smiling.

Tom wanted to start first. Then he hesitated for a moment.

“We have four hard days ahead of us,” exclaimed Tom. “It is better to visit Lisa and then come back soon. I want you to be here in spirit.” And then he winked at him.

Ivan’s eyes sparkled. He got up, stuffed his laptop into his backpack.

“I’ll be back soon, Master.” Cried Ivan goaded.

Tom laughed and said, “Salute Lisa from me.”

Ivan turned to leave. “Ivan,” Tom said, “I have a gift for Lisa. I promised if things were going well, I would make her a handmade violin. I have completed the violin in my free time.”

He went and brought the violin with a nicely designed bag. “This is the best violin I have ever made.” Tom asserted, “I would like Lisa to play with this violin for me one day.”

Ivan got emotional. Tom was much taller than him. With a violin bag in his hand, Ivan jumped up and grabbed Tom by the neck and hugged him.

They eased out of their arms.

“My father died when I was a child.” Ivan was getting fanciful. “I never taste for having a father, but with you, I feel I am with my father.”

Tom put his hand inside Ivan’s curly hair. “You are a lovely boy. Now, go and don’t hold out that girl anymore.”

Ivan walked to the door. He turned and waved his hand and walked out the door. Tom nodded with a kind smile.

How good it was to taste of having a family. He wanted to have his own family. He had lost his wife and daughter. Hannah, wounded by her past, and Ivan, an orphan that Tom loves him like a boy he did not have.

He was counting the moments for September 21st until everything ended and life became more beautiful again. He wished this dream would be permanent. But could it be?

Ivan stayed with Lisa overnight. Lisa, who complained about Ivan's negligence and was angry with him, as soon as she saw Tom's gift, she delighted beyond measure.

When Ivan told the stories to Lisa one after another, Lisa was so devoted to Tom that she woke up Ivan on her own in the early morning to send him to Tom.

It was 7:50 when Ivan knocked at the door. Tom himself was asleep when he came. He opened the door and then made a little breakfast. Tom was packing the dishes when Ivan said, "Master, now is the time to learn, let's do this."

Tom came to sit beside Ivan, drying his hands with a towel. He provided pen and paper and then said, "We have to make the Deus Machine understand that the human concept is not such a bad thing. We have to find several history books about the good deeds of humans and then use the LSTM algorithm to reproduce new books from old works.

In this way, several thousand new books will be produced that are about the virtues and goodness of human beings."

"Did they do a good deed that there is a book about that?" Ivan said sarcastically in a mocking tone.

"It is rare, but it can be found," Tom replied brightly. "We must also reproduce the works of philosophers who have written about the good nature of mankind."

Then he swallowed his laugh and continued: "To do this, we have to use the LSTM or Long Short Term Memory algorithm. LSTM algorithms are a special type of RNN or Recurrent Neural Networks algorithms. Both of these algorithms specialize in learning sequential behaviors over time.

For example, in predicting time series such as stock prices, material consumption, etc., or producing new texts, music production, etc., this algorithm can be applied.

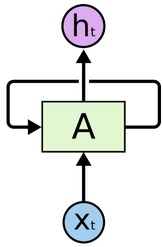
These networks are supervised learning and can create new sequential patterns based on old sequential ones. How do these algorithms work?

Let's start with the RNN algorithm. First of all, let me say that all deep neural networks, in basic principles, use the same principles of artificial neural networks that we have already learned, but the differences, in most cases, usually lay in the network topology, especially in the hidden layer, as well as data transformations and active functions that are used in different parts of topology.

The same is true of the RNN neural network. This algorithm is used in both classification and regression problems. In the traditional artificial neural network, as I said, the arrows of connection between neurons were always moving forward, but the mechanism of the RNN algorithm for learning patterns is the placement of neurons which are allowed to return to previous neurons in feedforward, which is why they are called recursive neural networks. Let's continue the discussion with an example:

As a rule, I am speaking now, you do not understand each word of mine separately, but in a regular sequence of words and considering the context of my speech, you understand what I am saying...

Artificial neural networks and other traditional algorithms are also unable to model such a sequence, and it is in this case, RNN neural networks are proposed. These networks have recursive neurons, based on which the processed information is returned to the previous neurons, leading to the improvement of neural network function. They say, RNN networks have memory. Let me show you a stump of recursive neural networks:



Stump A receives input x_t and emits output h_t. The loop in A causes information to be transferred from one stage of the neural network to the next.

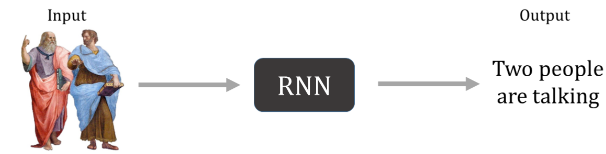
Suppose our input is a paragraph from a book. For example, the following sentence:

Hegel formulated a dialectic perspective to understand the essence of truth. He declared that truth is a result of the historical battle between a thesis and an antithesis.

And our output is also a label. But not like the labels we've seen before. The label is the same paragraph and the words that make up this paragraph. The algorithm observes the current word and, accordingly, predicts the next word, and by adjusting weights of neurons, it moves towards correcting accuracy.

Of course, I have to say that it does not matter that our output and labels are the same as the labels we have already seen. However, our input can include the following:

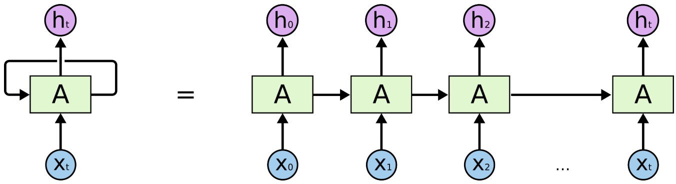
- An input to multiple outputs: for example, an image to a set of words with a specific sequence:



- Multiple inputs to one output:

- Multiple inputs to multiple outputs:

The mode we are considering is "multiple inputs to multiple outputs". Each word is represented in the model in the form of a zero and one vector. On this account, the RNN neural network architecture looks something like the following:



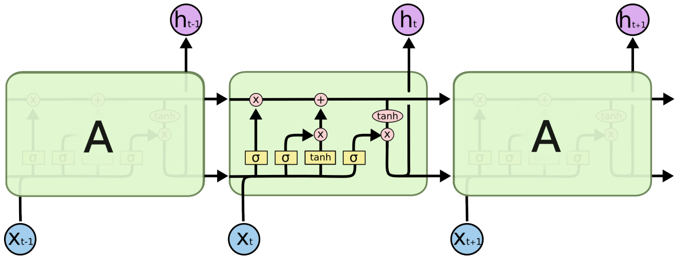
As you can see here, instead of connecting all the neurons in two consecutive layers, only the hidden layer is connected in a chain…

It should be noted that in the case of "multiple inputs to multiple outputs", our number of inputs and outputs will be the same as the words of a paragraph. Therefore their number is equal, but not necessarily the number of inputs equals the number of outputs. Therefore, in such cases, before creating a hidden layer of RNN type, a traditional hidden layer with the number of neurons equal to the output layer is placed between the RNN layer and the inputs to equalize the number of inputs and outputs before and after the RNN layer…

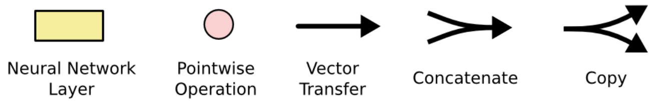
Another point is that, in the hidden layer of RNN, each neuron's output and being mapped to the final output also maps and affects the next hidden layer. In this way, the RNN model can learn the sequences by adjusting the weights between input and output. This is the general idea of the RNN model…

If we watch carefully, the potential problem with the RNN network is that, in long sequences, it is unable to remember information from very distant hidden layers and is only affected by nearby hidden layers. RNN only has a short-term memory. To solve this problem, a special type of RNN model called LSTM has been developed that, in addition to learning near sequences, is also able to remember farther sequences. Let's examine LSTM in more detail:

The LSTM algorithm has a similar architecture to RNN, except that inside each neural network stump, there is a set of gates that control the input and output of information flow from the previous layer and the current data. See the figure below:

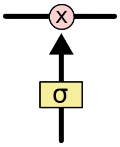


I have drawn a few acronyms, a summary of which I will write to you:

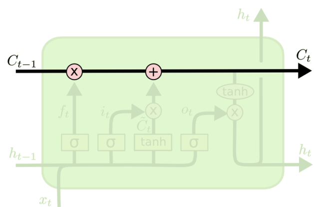


The main difference between LSTM and RNN is that in LSTM, in addition to the fact that the hidden layer is connected sequentially, several other layers are inside each stump - or rather, several other gates - and actually, these gates control the flow of information across the network.

Each gate consists of a sigmoid activation function, denoted by . This function is aggregated with other gates based on the type of mathematical operation defined:

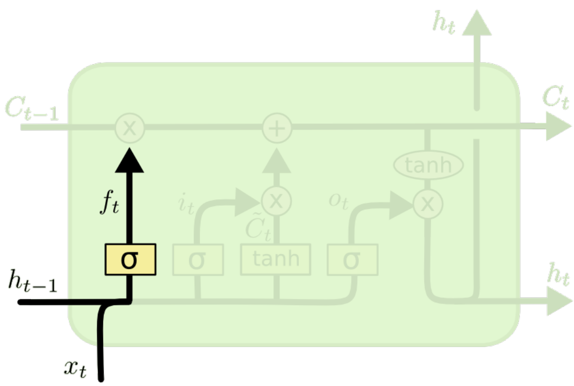


If you remember from logistic regression and neural network, the sigmoid function converts any value to the interval of zero and one. If the output of a gate is zero, it means that no information should pass, and if it is one, it means that all information should pass. Finally, the output of the various gates transfers the current stump status C_t to the next stump.



The LSTM algorithm has three gates that determine the stump status. Now we will examine each of these gates.

The first gate is the "forget gate layer". The task of this gate is to use the output of the previous step h_{t-1} and based on the current data x_t decides what information to keep and what information to ignore.



And the formula for its function is as follows:

$$f_t = \sigma(W_f.x_t + U_f.h_{t-1} + b_f)$$

Where • is an internal multiplication sign of two vectors that its result is a real number.

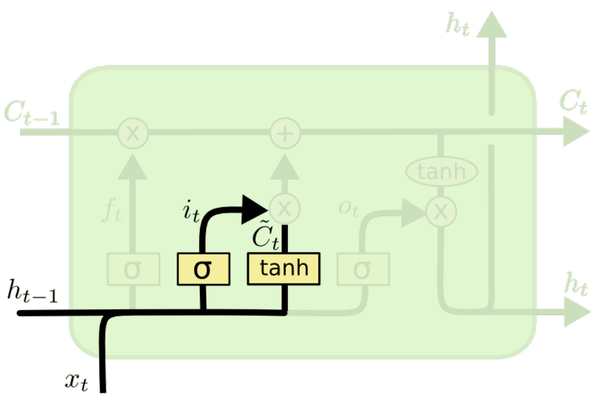
$$a.b = \sum_{i=1}^{n} a_i b_i = a_1 b_2 + a_2 b_2 + \ldots + a_n b_n$$

If the gate function's output is one, it means complete retention of current information, and if it is zero, it means ignoring current information. is also a sigmoid function that we are already familiar with. The formula for this function, just for reminder, is as follows:

$$\sigma(x) = \frac{1}{1 + e^{-x}}$$

This function maps values to zeros and ones.

The next gate has two gates. The first gate is the "input gate layer ", which updates the inputs, and the second gate is the "tangent gate", which creates new candidate states that can be added to the current state.

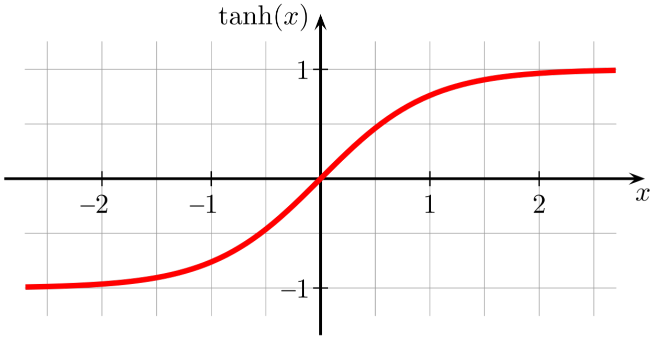


$$i_t = \sigma(W_i.x_t + U_i.h_{t-1} + b_i)$$

And

$$\tilde{C}_t = tanh(W_{\tilde{C}}.x_t + U_{\tilde{C}}.h_{t-1} + b_{\tilde{C}})$$

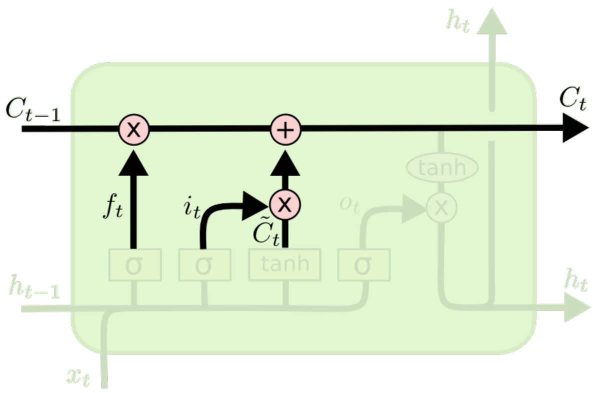
The tanh function is the hyperbolic tangent activator function, which has the following form and formula:



$$tanh(x) = \frac{e^{2x} - 1}{e^{2x} + 1}$$

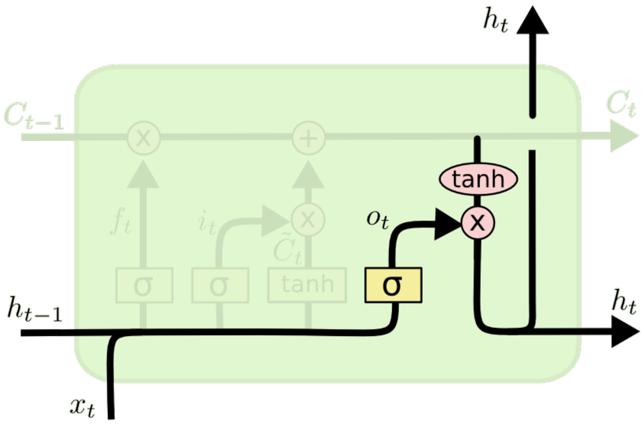
In fact, this function maps any value in the range -1 to 1.

Now it's time to calculate the current state of the stump. For this purpose, we put the previous state next to the output of the forget gate layer and the input gate to calculate the current state.



$$C_t = f_t \times C_{t-1} + i_t \times \tilde{C}_t$$

This output is the same as the amount of information forgotten in the past and the amount of information added in this stump. Finally, we must calculate the output. For this purpose, we perform output calculations:



$$o_t = \sigma(W_o.x_t + U_o.h_{t-1} + b_o)$$

$$h_t = tanh(C_t).o_t$$

In this way, the same calculation is applied to other stums. As you can see, inputs, states, etc., also have weights here, and determining these weights in the most optimal mode requires an approach similar to that of artificial neural networks.

There we had two stages of forward calculations and backpropagation calculations. The concept that I explained is feed-forward calculation.

To continue, and as a numerical example, we can write the input formats as follows:

$$gates_t = \begin{bmatrix} \tilde{C}_t \\ i_t \\ f_t \\ o_t \end{bmatrix}, W = \begin{bmatrix} W_{\tilde{C}} \\ W_i \\ W_f \\ W_o \end{bmatrix}, U = \begin{bmatrix} U_{\tilde{C}} \\ U_i \\ U_f \\ U_o \end{bmatrix}, b = \begin{bmatrix} b_{\tilde{C}} \\ b_i \\ b_f \\ b_o \end{bmatrix}$$

Now we need to update the weights with feedback and error. Let's see how this is done. To do this, we first define the Loss Function:

$$LossFunction = \frac{1}{2}(h_t - y_t)^2$$

Where 1/2 is a fixed number embedded to simplify derivation. As you can see, the function does not have a sum value. This means that the Loss Function function is calculated for each state.

Now, based on the same logic of backpropagation and partial derivation along the chain that work according to the derivative chain rule, the percentage of weight changes in each iteration of the algorithm can be suggested as follows:

$$\delta h_t = \Delta_t + \Delta h_t$$

Where Δ_t is equal to the difference between the actual output and the predicted output of the state. The derivative of the Loss Function is equal to Δ_t:

Δh_t is also calculated in the next state calculations, and if we are in the last state, its value will be zero.

$$\delta C_t = \delta h_t.o_t.(1 - tanh^2(C_t)) + \delta c_{t+1}.f_{t+1}$$

$$\delta \tilde{C}_t = \delta C_t.i_t.(1 - \tilde{C}_t^{\ 2})$$

$$\delta i_t = \delta C_t.\tilde{C}_t.i_t.(1 - i_t)$$

$$\delta f_t = \delta C_t.C_{t-1}.f_t.(1 - f_t)$$

$$\delta o_t = \delta h_t.tanh(C_t).o_t.(1 - o_t)$$

$$\delta x_t = W^T.gates_t$$

$$\Delta h_{t-1} = U^T.gates_t$$

As I said, Δh_{t-1} in the current state is calculated for the previous state. $gates_t$ is also a vector consisting of the values of all gates.

We will examine each of these in a further numerical example. Just so far, know that we do all these calculations so that we can just calculate the percentage change in weights:

$$\delta W = \sum_{t=0}^{T} \delta gates_t \times x_t$$

$$\delta U = \sum_{t=0}^{T-1} \delta gates_{t+1} \times h_t$$

$$\delta b = \sum_{t=0}^{T} gates_{t+1}$$

As you can see, all weights and bias values change in the same proportion. Now with a numerical example, we do the forward and backward calculations.

Suppose we want to predict the next number in a simple math sequence. We have two inputs and two outputs, so the number of states will be 2. Initial weights are also randomly assigned. The numerical values of the weights and the bias values are as follows:

$$W_{\tilde{C}_t} = \begin{bmatrix} 0.55 \\ 0.20 \end{bmatrix}, U_{\tilde{C}_t} = \begin{bmatrix} 0.25 \end{bmatrix}, b_{\tilde{C}_t} = \begin{bmatrix} 0.2 \end{bmatrix}$$

$$W_i = \begin{bmatrix} 0.85 \\ 0.70 \end{bmatrix}, U_i = \begin{bmatrix} 0.75 \end{bmatrix}, b_i = \begin{bmatrix} 0.60 \end{bmatrix}$$

$$W_f = \begin{bmatrix} 0.80 \\ 0.35 \end{bmatrix}, U_f = \begin{bmatrix} 0.25 \end{bmatrix}, b_f = \begin{bmatrix} 0.30 \end{bmatrix}$$

$$W_o = \begin{bmatrix} 0.50 \\ 0.45 \end{bmatrix}, U_o = \begin{bmatrix} 0.15 \end{bmatrix}, b_o = \begin{bmatrix} 0.15 \end{bmatrix}$$

And the inputs are as follows:

$$x_1 = \begin{bmatrix} 1 \\ 2 \end{bmatrix} with label 0.5$$

$$x_2 = \begin{bmatrix} 0.5 \\ 4 \end{bmatrix} with label 0.80$$

We first consider the forward calculations:

First, for $t = 1$, we perform feed-forward calculations.

$$\tilde{c_1} = tanh(W_{\tilde{C}}.x_1 + U_{\tilde{C}}.h_0 + b_{\tilde{C}}) =$$

$$tanh(\begin{bmatrix}0.5 & 0.20\end{bmatrix} \times \begin{bmatrix}1\\2\end{bmatrix} + \begin{bmatrix}0.25\end{bmatrix} \times \begin{bmatrix}0\end{bmatrix} + \begin{bmatrix}0.2\end{bmatrix}) = 0.8177$$

$$i_1 = \delta(W_i.x_1 + U_i.h_0 + b_i) =$$

$$\delta(\begin{bmatrix}0.85 & 0.70\end{bmatrix} \times \begin{bmatrix}1\\2\end{bmatrix} + \begin{bmatrix}0.75\end{bmatrix} \times \begin{bmatrix}0\end{bmatrix} + \begin{bmatrix}0.60\end{bmatrix}) = 0.9453$$

$$f_1 = \delta(W_f.x_1 + U_f.h_0 + b_f) =$$

$$\delta(\begin{bmatrix}0.80 & 0.35\end{bmatrix} \times \begin{bmatrix}1\\2\end{bmatrix} + \begin{bmatrix}0.25\end{bmatrix} \times \begin{bmatrix}0\end{bmatrix} + \begin{bmatrix}0.30\end{bmatrix}) = 0.8581$$

$$o_1 = \delta(W_o.x_1 + U_o.h_0 + b_o) =$$

$$\delta(\begin{bmatrix}0.50 & 0.45\end{bmatrix} \times \begin{bmatrix}1\\2\end{bmatrix} + \begin{bmatrix}0.15\end{bmatrix} \times \begin{bmatrix}0\end{bmatrix} + \begin{bmatrix}0.15\end{bmatrix}) = 0.8249$$

Based on this, we calculate the output and state:

$$C_1 = f_1 \times C_0 + i_1 \times \tilde{C}_1 =$$

$$0.8581 \times 0 + 0.9453 \times 0.8177 = 0.7729$$

$$h_1 = tanh(C_1).o_1 = tanh(0.7729) \times 0.8249 =$$

$$0.6486 \times 0.8249 = 0.5350$$

Now, we do the same forward calculations for $t = 2$.

$$\tilde{c_2} = tanh(W_{\tilde{C}}.x_2 + U_{\tilde{C}}.h_1 + b_{\tilde{C}}) =$$

$$tanh(\begin{bmatrix}0.5 & 0.20\end{bmatrix}\times\begin{bmatrix}0.5\\4\end{bmatrix}+\begin{bmatrix}0.25\end{bmatrix}\times\begin{bmatrix}0.5350\end{bmatrix}+\begin{bmatrix}0.2\end{bmatrix}) = 0.8872$$

$$i_2 = \delta(W_i.x_2 + U_i.h_1 + b_i) =$$

$$\delta(\begin{bmatrix}0.85 & 0.70\end{bmatrix}\times\begin{bmatrix}0.5\\4\end{bmatrix}+\begin{bmatrix}0.75\end{bmatrix}\times\begin{bmatrix}0.5350\end{bmatrix}+\begin{bmatrix}0.60\end{bmatrix}) = 0.9997$$

$$f_2 = \delta(W_f.x_2 + U_f.h_1 + b_f) =$$

$$\delta(\begin{bmatrix}0.80 & 0.35\end{bmatrix}\times\begin{bmatrix}0.5\\4\end{bmatrix}+\begin{bmatrix}0.25\end{bmatrix}\times\begin{bmatrix}0.5350\end{bmatrix}+\begin{bmatrix}0.30\end{bmatrix}) = 0.9886$$

$$o_1 = \delta(W_o.x_2 + U_o.h_1 + b_o) =$$

$$\delta(\begin{bmatrix}0.50 & 0.45\end{bmatrix}\times\begin{bmatrix}0.5\\4\end{bmatrix}+\begin{bmatrix}0.15\end{bmatrix}\times\begin{bmatrix}0.5350\end{bmatrix}+\begin{bmatrix}0.15\end{bmatrix}) = 0.9896$$

Based on this, we calculate the output and state for $t = 2$:

$$C_2 = f_2 \times C_1 + i_2 \times \tilde{C}_2 =$$

$$0.9886 \times 0.7729 + 0.9997 \times 0.8872 = 1.6509$$

$$h_2 = tanh(C_2).o_2 = tanh(1.6509) \times 0.9896 =$$

$$0.9289 \times 0.9896 = 0.9192$$

All right, we did the feed-forward calculations. Now it's time to calculate the backpropagation calculations for each case and then update the weights.

Just like neural networks, in the backpropagation, we start from the last state. For this purpose, the backpropagation calculations are calculated for the state $t = 2$:

$$\Delta_2 = h_2 - y_2 = 0.9192 - 0.8000 = 0.1192$$

It should be noted here that since we are in the last state, Δh_2 is equal to zero. Thus:

$$\delta h_2 = \Delta_2 + \Delta h_2 = 0.1192 + 0 = 0.1192$$

$$\delta C_2 = \delta h_2 . o_2 .(1 - tanh^2(C_2)) + \delta C_3 . f_3 =$$

$$0.1192 \times 0.9896 \times (1 - tanh^2(1.6509)) + 0 \times 0 = 0.0161$$

And similar to above, since we are in the last state, δC_3 and f_3 are both zeros.

$$\delta \tilde{C_2} = \delta C_2 . i_2 .(1 - \tilde{C_2}^2) =$$

$$0.0161 \times 0.9997 \times (1 - 0.8872^2) = 0.0034$$

$$\delta i_2 = \delta C_2 . \tilde{C_2} . i_2 .(1 - i_2) =$$

$$0.0161 \times 0.8872 \times 0.9997 \times (1 - 0.9997) = 0.0000004$$

$$\delta f_2 = \delta C_2 . C_1 . f_2 .(1 - f_2) =$$

$$0.0161 \times 0.7729 \times 0.9886 \times (1 - 0.9886) = 0.0001$$

$$\delta o_2 = \delta h_2 . tanh(C_2) . o_2 .(1 - o_2) =$$

$$0.1192 \times tanh(1.6509) \times 0.9896 \times (1 - 0.9896) = 0.0011$$

$$\delta x_2 = W^T . gatess_2 =$$

$$\begin{bmatrix} 0.55 & 0.85 & 0.80 & 0.50 \\ 0.20 & 0.70 & 0.35 & 0.45 \end{bmatrix} \times \begin{bmatrix} 0.0034 \\ 0.0000004 \\ 0.0001 \\ 0.0011 \end{bmatrix} = \begin{bmatrix} 0.0025 \\ 0.0012 \end{bmatrix}$$

$$\Delta h_1 = U^T . gates_2 =$$

$$\begin{bmatrix} 0.25 & 0.75 & 0.25 & 0.15 \end{bmatrix} \times \begin{bmatrix} 0.0034 \\ 0.0000004 \\ 0.0001 \\ 0.0011 \end{bmatrix} = 0.0010$$

Finally the calculations are over.

All right, now let's go to $t = 1$ and do the backpropagation calculations for it:

$$\Delta_1 = h_1 - y_1 = 0.5350 - 0.5 = 0.035$$

$$\delta h_1 = \Delta_1 + \Delta h_1 = 0.035 + 0010 = 0.036$$

$$\delta C_1 = \delta h_1 . o_1 .(1 - tanh^2(C_1)) + \delta C_2 . f_2 =$$

$$0.036 \times 0.8249 \times (1 - tanh^2(0.7729)) + 0.0161 \times 0.9886 = 0.0331$$

$$\delta \tilde{C_1} = \delta C_1 . i_1 .(1 - \tilde{C_1}^2) =$$

$$0.0331 \times 0.9453 \times (1 - 0.8177^2) = 0.0103$$

$$\delta i_1 = \delta C_1 . \tilde{C}_1 . i_1 .(1 - i_1) =$$

$$0.0331 \times 0.8177 \times 0.9453 \times (1 - 0.9453) = 0.0013$$

$$\delta f_1 = \delta C_1 . C_0 . f_1 .(1 - f_1) =$$

$$0.0331 \times 0 \times 0.8581 \times (1 - 0.8581) = 0$$

$$\delta o_1 = \delta h_1 . tanh(C_1) . o_1 .(1 - o_1) =$$

$$0.036 \times tanh(0.7729) \times 0.8249 \times (1 - 0.8249) = 0.0033$$

$$\delta x_1 = W^T . gatess_1 =$$

$$\begin{bmatrix} 0.55 & 0.85 & 0.80 & 0.50 \\ 0.20 & 0.70 & 0.35 & 0.45 \end{bmatrix} \times \begin{bmatrix} 0.0331 \\ 0.0013 \\ 0.0 \\ 0.0033 \end{bmatrix} = \begin{bmatrix} 0.0210 \\ 0.0090 \end{bmatrix}$$

$$\Delta h_0 = U^T.gates_1 =$$

$$\begin{bmatrix} 0.25 & 0.75 & 0.25 & 0.15 \end{bmatrix} \times \begin{bmatrix} 0.0331 \\ 0.0013 \\ 0.0 \\ 0.0033 \end{bmatrix} = 0.0097$$

And finally, the backward calculations were over and just weights update remained. To do this, we first calculate the rate of change of weights:

$$\delta W = \sum_{t=0}^{T} \delta gates_t \times x_t =$$

$$\begin{bmatrix} 0.0331 \\ 0.0013 \\ 0.0 \\ 0.0033 \end{bmatrix} \times \begin{bmatrix} 1 & 2 \end{bmatrix} + \begin{bmatrix} 0.0034 \\ 0.0000004 \\ 0.0001 \\ 0.0011 \end{bmatrix} \times \begin{bmatrix} 0.5 & 4 \end{bmatrix} =$$

$$\begin{bmatrix} 0.0348 & 0.0798 \\ 0.0013 & 0.0026 \\ 0.0000 & 0.004 \\ 0.0038 & 0.0110 \end{bmatrix}$$

$$\delta U = \sum_{t=0}^{T-1} \delta gates_{t+1} \times h_t =$$

$$\begin{bmatrix} 0.0034 \\ 0.0000004 \\ 0.0001 \\ 0.0011 \end{bmatrix} \times \begin{bmatrix} 0.5350 \end{bmatrix} = \begin{bmatrix} 0.0018 \\ 0.0 \\ 0.0 \\ 0.0005 \end{bmatrix}$$

$$\delta b = \sum_{t=0}^{T} gates_{t+1} =$$

$$\begin{bmatrix} 0.0331 \\ 0.0013 \\ 0.0 \\ 0.0033 \end{bmatrix} + \begin{bmatrix} 0.0034 \\ 0.0000004 \\ 0.0001 \\ 0.0011 \end{bmatrix} = \begin{bmatrix} 0.0365 \\ 0.0013 \\ 0.0001 \\ 0.0044 \end{bmatrix}$$

And now the last step is to calculate the new weights based on the rate of change. Assuming that the learning rate is $\lambda = 0.9$.

$$W_{\tilde{C}_t} = \begin{bmatrix} 0.5813 \\ 0.27182 \end{bmatrix}, U_{\tilde{C}_t} = \begin{bmatrix} 0.2516 \end{bmatrix}, b_{\tilde{C}_t} = \begin{bmatrix} 0.2328 \end{bmatrix}$$

$$W_i = \begin{bmatrix} 0.8511 \\ 0.7023 \end{bmatrix}, U_i = \begin{bmatrix} 0.75 \end{bmatrix}, b_i = \begin{bmatrix} 0.6011 \end{bmatrix}$$

$$W_f = \begin{bmatrix} 0.80 \\ 0.35036 \end{bmatrix}, U_f = \begin{bmatrix} 0.25 \end{bmatrix}, b_f = \begin{bmatrix} 0.30 \end{bmatrix}$$

$$W_o = \begin{bmatrix} 0.5034 \\ 0.4599 \end{bmatrix}, U_o = \begin{bmatrix} 0.1504 \end{bmatrix}, b_o = \begin{bmatrix} 0.1539 \end{bmatrix}$$

And the last step is over, and the weights are updated. Now when the new data is feed, the same process must be repeated. That was all that could be said about LSTM."

"I have to go through your manuscripts several times." Said Ivan, grunting and puffing. "Its hand calculations were really heavy. It was the simple version, though. It is called deep learning, indeed. It was really deep."

Tom put his hand on his neck. "Yes, deep learning is a really heavy topic and time-consuming, and the parameter tuning is very important here. I have to say that deep learning algorithms were proposed in the mid-1990s, but the low computing power did not allow them to be used until the computing power of computers and the use of cloud computing, as well as the use of GPUs in computing, led to such algorithms became popular among data scientists."

Ivan surfed the Internet for a few minutes. His face was happy.

"Tom," He said, "Fortunately, there are many source codes for how to implement LSTM."

"I have to talk to Hannah too," Tom nodded. "We have to solve the server issue somehow. It's now our turn to display ourselves to the Deus Machine.

He picked up Ivan's phone, got up, and called Hannah.

Around the evening of September 18, there was a secluded area around the equestrian club. Everything seemed to be normal. Occasionally, a neighing of a horse broke the silence of the plain beside the club. The horses were restless to return to their stables.

Stablemen with muddy boots, which had been formed due to the morning rain, took the horses to their stable, tired and exhausted. Everything was quiet. The guards at the club's front door were also sitting in front of the TV with puffy eyes caused by incomplete sleep at different hours.

One of the guards was watching an Indian movie. A man and a woman were dancing, making love to each other romantically. For a moment, his eyes fell on a crowd of police cars coming towards them. He thought it was a fantasy at first, but then, when he stared at them carefully, they became more real than any reality.

He got up involuntarily, putting his hand on his waist, and came to the front. Regardless of the guard's presence, the first police car broke the moving barrier in front of the club at full speed and entered.

Behind it, piss off many special police cars arrived like locusts, occupying the entire area. The guard's reaction was only astonishment. He held his tilted hat and was the only observer of what was happening in a fraction of a minute.

Hannah entered the office building with five commandos and went straight to the fifth floor, the building's last floor. Everyone who stood in her way was arrested at her point. No one expected such an attack. As Hannah progressed, the rooms that had been mysterious to Hannah on a previous visit were opened one by one.

Hannah took her steps faster and faster. She stared at the last room, which also had the largest door, and headed straight for it. When she reached it, she turned the knob.

It was locked, but something like a photocopier could be heard inside. Hannah did not hesitate, pointing to her team's strongest commando. He took a few steps away and then knocked on the door with his side. The door could not stand and open immediately.

A man in a white shirt and a blue tie, while sweating profusely, straightened his back from the top of the paper shredder and stood, still holding a few sheets of paper.

Hannah walked slowly towards him, but suddenly, the man trembled, frothing at the mouth. He fell to the ground with his head. There was a shiver, and then he stopped breathing.

One of the officers bent down and examined him. Then he raised his head and said to Hannah, "Cyanide, he is finished."

He then handed the documents in the man's hand to Hannah. Hannah rolled her eyes at the documents. The financial documents were related to a large financial transfer. Hannah cast a glance to the right and left of the room and ordered that all documents be recorded and carefully examined by certified IRS auditors.

It was half an hour ago. Almost all of them were arrested and taken to the police station for questioning. Hannah was watching the transfer of documents when her cell phone rang. It was Tom.

Suddenly, her subconscious obsession gave way to an innocent laugh. She dragged the answer button.

Tom, on the other hand, seemed excited. He said a little about what he had done with Ivan and then added, "To take the last step firmly, we need to have access to powerful servers. Ivan will send you the exact prerequisites. Please arrange it. Without these servers, all our hard work will have been in vain."

Hannah talked a little about the difficulties of convincing Colonel Taylor, who was accustomed to denying everything. Tom did not give up. Hannah finally agreed to talk to Colonel Taylor as she walked toward the police car.

When Hannah arrived at her office, her first job was to talk to Colonel Taylor. The Colonel's voice was more tired than ever. Deep within, he wished the story would end sooner. He could no longer tolerate secrecy and lies. During this period, all his work was summed up in the production of vein scenarios for events that the Deus Machine had done.

As soon as Hannah offered to access the big US tech companies' servers, he promised to do his best to show the changes made by Tom and Ivan on search engines and social networks.

He had concluded that it's better to face danger once than be always in danger.

Hannah could not believe convincing Colonel Taylor to proceed so easily. Happy and smiling, she brought Ivan's number, and as soon as she wanted to make a call, Hannah's interrogation officer knocked on her door. Inevitably, she hanged up.

"Chief," The officer paid his respects and said softly, "The selected auditors have found several financial discrepancies in the documents. They want to see you."

Hannah hesitated to leave or stay. "OK, I'll be right there," The officer, who somehow knew how to twist her around his finger, said again, "They say, contradiction is more than $ 2 millions."

"$ 2 millions?" Hannah stood up. Her eye was bulging. "It is a huge number for the equestrian club. We must track it down and investigate where this money has been spent."

More confident than ever, she got up from her desk and went with the officer to the room where the auditors settled. They got up when they saw Hannah and shook hands with her.

"Can you tell me where this money was spent?" Hannah asked without preamble.

"The offenders used sophisticated methods to lose track of money," Said the chief auditor, a wise 50-year-old man with buckwheat hair. "Including transferring money on different dates between different accounts, Making fake identities, and much more. The equestrian club was, in fact, a cover for unusual expenses and hidden financial exchanges. What we have understood is that a large part of the money has been transferred to the account of a company called Clouddiv in various ways."

Hannah took the documents in her hand and said, "What does this company do?"

"The company supplies computer hardware components," the chief auditor replied.

Hannah pulled herself together, looked round, screwing up her eyes. "Ivan was right," She thought. "The same hypothesis he had was fulfilled."

She left the room without saying a word and went to her office. She had to track down the purchased servers. All she needed to do was coordinate with the Treasury Department to access the related financial transfers with Cloulddiv. The next step is to track any shipments bound for California.

There was only one day left before the activation of the self-training process of the Deus Machine. As Tom and Ivan concluded, if they would be able to destroy the Deus Machine in the training phase, the chance to remove it from all other computers were maximum because the trained function in this way would be destroyed.

Ivan didn't stir and remained with Tom. They both were enthusiastic and busy with writing codes, integrating data, etc.

Using the same neural network model, they predicted the next trend that was likely to affect the Deus Machine. A recent incident had occurred in the Los Angeles subway, and many social networks were full of news about it.

The neural network model had identified the same trend as a popular trend. If everything went as before, they would have to wait for an accident in the subway in the coming days.

Tom had warned Hannah about it. Colonel Taylor himself was personally involved, and the Los Angeles Metro headquarters were in full coordination with the Department of Defense. This incident was a kind of final test for their ability to control the Deus Machine. If they had succeeded in stopping the Deus Machine, there would not have been an accident.

It was a serious matter, and all the pressure was on Tom and Ivan, but all this seriousness did not cause Ivan to stop fooling around.

With the LSTM model, he had learned, he had fed all of Shakespeare's books into the model and thus created a new play, and now he was explaining the process of his work to Tom.

Tom, as though he was listening to his youthful memories, was not saying anything, he was not rejected, and he did not even show a sense of enjoyment. He was just listening.

For a few days, he hadn't seen Hannah, and now he realized how much he missed her and how much he loved her. In the thought cross between thinking about Hannah and Ivan chattering, Hannah herself suddenly called.

Tom had received the previous news that Colonel Taylor was ready to talk to technology companies, but today the news was much hotter than ever.

"We followed in the footsteps of Russell," Hannah said in the same emotional tone that led to her rapid talking. "Our eyewitnesses saw him in under the guise of coolie at the Los Angeles pier.

If we understood correctly, the cargo ship will dock at the Los Angeles Wharf in two or three days, which carries several powerful servers with all the support equipment built into the container itself. We even know that several officials at the Los Angeles Wharf are involved. All movements are under control. We are going to ambush and finish the job."

"Hannah, this is a big deal," Tom admired. "But I want you to take care of yourself. I don't want to hurt you, OK?"

"Copy that, sir!" Said Hannah and chuckled. "Don't worry, honey. I have to finish this last mission then I will be with you forever. Of course, if you do not get tired of me,"

Tom frowned heavily. "It's not good to say that, not even as a joke. I can't help myself waiting at the end of this story."

This time all Ivan's senses were bent upon Tom and Hannah's romantic words. He was happy that he was the reason that Tom could meet Hannah, and he was happy that he had found Tom himself.

Maybe more than anyone else, he wanted the story to end, to be acquitted of his previous crime for his services and start a new life with Lisa.

He wanted to share everything he learned with young guys. He thought that everyone wishes for a happy ending to this story.

"Today, we have to take the last step of our training," Tom interrupted his mind while putting his hand, in his manner, to Ivan's shoulder. "We are going to get acquainted with the GAN model. Are you ready?"

Ivan stood up and cleared his throat. "Yes, of course. Let's go to work and take the last step."

"Okay, so let's get started." Tom leaned back in his chair and continued. "The GAN or Generative Adversarial Networks, in the machine learning algorithm's usual category, belong to the Semi-Supervised category. Like all other neural networks, it is composed of the connection of different neurons, and this similarity can be seen in the letter N of the GAN network.

But GAN also has two major differences from other neural networks that have happened to show themselves well in G and A letters. So let's start with G or Generative part:

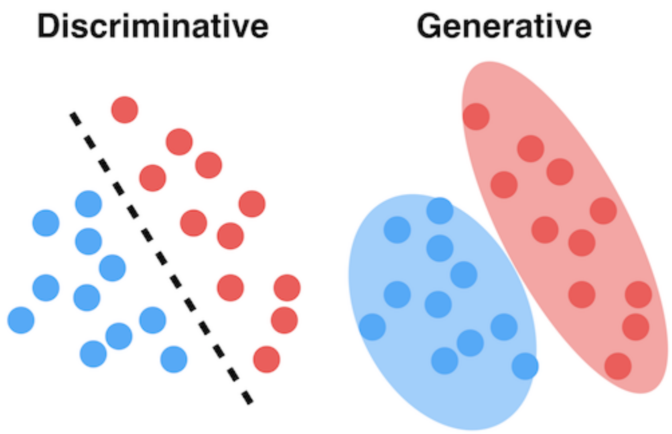
Basically, machine learning models in another category can be divided into two types:

- Discriminative models: All the classification and regression models that we have learned so far were of this type of model. This type of model aims to draw the decision boundary to separate and divide the feasible space. Statistically, with X as the independent variable and Y as the label, these models obtain the conditional probability model p(Y|X). Of course, it should be said that models such as neural networks provide probabilistic outputs, but some models do not provide probabilistic output, such as the decision tree, but in any case, they belong to the category of Discriminative models.

- Generative models: These models, instead of dividing the feasible space, model how the data is distributed in the feasible space. From a statistical point

> of view, the joint probability distribution of two variables p(x.y), when there is a label, otherwise a probability distribution of one p(x) alone is obtained.

In statistics and probability, when we say we want to obtain a probability model, we mean to obtain the probability density distribution function of a variable. The following figure may help to understand the two categories better:



As you can see, the Discriminative model draws a decision boundary between the two classes, while the Generative model merely derives the probability function of the shapes."

"With this division," Said Ivan, who was taking notes this time. "Regression models should not be considered as a Generative model?"

"In fact, no," Tom took a deep breath. He paused and then said, "Regression also calculates the conditional probability, and distinguishes the feasible space not between two classes but between its independent variables, and if we want to put it simply, somehow by drawing a line on the data creates symmetry between them…

But Generative models, on the other hand, do not draw any lines and only say that the data is distributed in space with this model, so if new data wants to be generated based on this data, where can it be placed in the feasible space?"

Tom paused to keep the matter in Ivan's mind. Then he said, "Both models can provide probabilistic outputs or not. Anyway, just as there are a lot of Discriminative models, so there are a lot of Generative models. The GAN model is one of them.

Now let's turn to the letter A, or Adversarial. The letter Adversarial means a destructive rivalry or competition between two rivals. That is a zero-sum game.

But which two rivals? The GAN model is a combination of the Generative and Discriminative model, and the two are supposed to compete with each other with zero-sum, but about what?

Suppose the Generative model is a scammer and a producer of counterfeit money, and the Discriminative model is a conscientious detective.

Generally, this type of algorithm is called the actor-critic method, where the actor refers to the actions generated, and the critic refers to how good its actions are. Ok, let's go on…

The Generative model, starting from random data, tries to generate counterfeit money, and in the meantime, the Discriminative model must distinguish counterfeit money from the original money.

Anyway, this game is a zero-sum game in every round.

That is, in each round either the detective wins or the scammer. Ultimately, the GAN model's goal is to train the scammer model in such a way that it makes money that looks like a real one. That is, it must be very similar to real money, and the detective cannot distinguish it as counterfeit."

"Wow, that's the same thing the Deus Machine does." Ivan delighted.

"Exactly," Replied Tom. "It's likely that Anna Cooper built the system inspired by GAN-like models. Anyway, storytelling and generating a competitor to traditional models and putting them aside is an interesting idea, but when it comes to math, we have to show all of these concepts in the form of mathematical representation. So, let's re-enter into the safe land of math where no one lies, and nobody can lie...

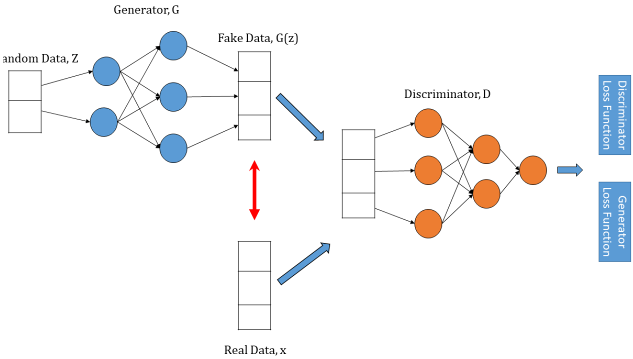
To mathematically model the competition between two models, it must be said that the GAN model has three components:

- Real data: The set of data we want to recreate and generate.
- Generative model: This model's input is noise or random data and its output is the dimensions of the data we want to recreate.
- Discriminative model: This model has two inputs: real data and fake data generated by the Generator model. This model's output is a neuron that determines whether the data generated by the Generator is real or not. This model is like a judge or a detective who wants to examine closely. This model classifies

both fake and real data. If it detects real data as fake or detects fake data as real, it will be punished. A Loss Function does this.

- Loss Function: The most important and beautiful part of the GAN model is its Loss Function, in which, based on the output received from this function, and using the backpropagation, the weights of both neural networks, not necessarily at the same time, is updated. I will explain more about this function and how to update weights.

If we want to show everything I said in one form, this conceptual model will be obtained:



As you can see, the model is made up of two separate neural networks, so training the whole model simultaneously is a very difficult process, and due to the conflictual structure of two models, even GAN may not converge to a single answer. To solve this problem, the training of the two networks is done separately.

That is, first, the Discriminator model is trained, and its weights are updated based on whether it detects fake data as real or not. During this process, the generator model weights remain constant, and conversely, during the Generator model training, the weights of the Discriminator model remain constant.

During this process, the more models get trained, the better the Generator model's performance. Conversely, the Discriminator model's performance worsens because the Discriminator model cannot easily distinguish the differences.

Finally, if the Generator model achieves excellent accuracy, the Discriminator model's performance will reach 50% accuracy, which is the accuracy of a coin toss. This discussion may lead to a malfunction of the Generator model because the Generator model updates its weights based on the Discriminator model's feedback. Thus the training may go out of its way. To solve this problem, I will provide some solutions. For now, let's move on to the Loss Function.

Based on what I said before, the GAN model Loss Function should represent the estimated probability distribution function of fake data and real data. Therefore, the Loss Function must represent the difference between the two probability distribution functions of fake data and real data.

What the Loss Function should be for this purpose, I suppose, should still be an open field of research.

However, as stated in the article by the contributors to this model, the Loss Function is proposed as follows:

$$E_x[log(D(x))] + E_z[log(1 - D(G(z)))]$$

Where D(x) is an estimate of the probability distribution function of real data and is equal to the probability that the real data is real. E_x is equal to the mathematical expectation or mean of the estimated function of the real data probability distribution.

$G(z)$ is equal to the output of the Generator model while the random data z is the input. $D(G(z))$ is equal to the probability estimate of the Discriminative model and is equal to the probability that the fake data is real. E_z is mathematically equal to the probability distribution of the data generated by the Generator model.

In fact,$E_x[log(D(x))]$ is equal to the prediction of the Discriminator model on the real data, and $E_z[log(1 - D(G(z)))]$ is equal to the prediction of the Discriminator model on the fake data.

"What is this log for? What is its function?" Ivan, who was taking notes in all haste, stopped for a moment and asked.

Tom leaned back in his chair. He was in a more comfortable position now. "This Loss Function is a type of entropy formula known as Cross-Entropy," He said in a calmer tone. "We are already familiar with entropy functions in the decision tree. The log function also comes from the same entropy formulas, and its function is to convert scale."

Ivan shook his head. He was thinking about the decision tree algorithm. Tom continued. "It is based on this Loss Function that the competition between the two models is formed. In $D(x)$, the Discriminator model tries to maximize this function, and the Generator model is not involved in it. So this part of the Loss Function should be maximum.

But if we observe, the competition will be only in the value of the distribution function $D(G(z))$. The Discriminator model wants this value to be less and less. That is, its objective function is minimization. In contrast, the Generator model wants this value to be more or more. That is, its objective function is maximization.

If we look at the issue from the Discriminator model's point of view, this model should maximize one part and minimize the other part, and this is a conflict. Therefore, if we convert $D(G(z))$ to $1-D(G(z))$, then we can say that the Discriminator model wants $1-D(G(z))$ to be maximized as well. So, in general, the Discriminator model's goal is to maximize the whole Loss Function, and the goal of the Generator model is to minimize the whole function.

But since the generator model have nothing to do with D(x), it can only minimize $E_z[log(1-D(G(z)))]$, which means maximizing $D(G(z))$.

With this explanation, the objective function of the whole GAN model is defined as follows:

$$\min_G \max_D V(D,G) = E_x[log(D(x))] + E_z[log(1-D(G(z)))]$$

Now it's time to see how the GAN algorithm is trained.

Each model is trained separately. For each data, first, the Discriminator model and then the Generator is trained."

Tom bent down and wrote the algorithm on a piece of paper. The algorithm is as follows.

- Assign initial weights randomly
- Repeat for each training data:
  - Repeat for each k step: (usually k is considered equal to one)

    * Take m samples $(z_1, z_2, \cdots, z_m)$ from the Generator model.
    * Take m samples $(x_1, x_2, \cdots, x_m)$ from the real data.
    * Perform feed-forward calculations for the Discriminative model.
    * Update the weights of the Discriminator model with the backpropagation algorithm and the following Loss function, which should be maximized:

$$\Uparrow \Delta_{\theta_d} \frac{1}{m} \sum_{i=1}^{m} [log(D(x^{(i)}))]$$

$$+log(1 - D(G(z^{(i)})))$$

- End of k-step loop
- Generator Model training: Take m samples $(z_1, z_2, \cdots, z_m)$ from the fake data and calculate the output of the Generator model for it.
- Update the weights of the Generator model with the backpropagation algorithm to minimize the following function:

$$\Downarrow \Delta_{\theta_g} \frac{1}{m} \sum_{i=1} m[log(1 - D(G(z^{(i)})))]$$

- End of the training data loop

I will not give a numerical example for this model anymore because we have to train two models so that the calculations will grow exponentially. But it must be said, the way to train each model based on the above algorithm is very similar to what I said on neural networks.

Well, we explored the basics of the GAN model. Now only a few final points about this model...

The first point is that it can be proved that $\min_G$ is obtained when the distribution of the density function of the generated data is the same as the distribution of the real data density function. Considering what I said, this is not strange, but there is also mathematical proof that I withdraw it.

The second point is about the convergence problems of the two models that I mentioned before. To solve this problem, we can revise the Loss Function by adding auxiliary functions to the previous Loss Function. These auxiliary functions are called Regularization, which penalizes items that prevent the model from converging. These functions not only can be used in the GAN model but also all other models. By adding these functions, the user can penalize the unwanted items and thus improve his model's performance.

Later, other researchers also designed another Loss Function that helps the model to converge better. The name of this model is Wasserstein GAN. But whatever it is, I said, this field is still an open field of research. However, the results of the GAN model are amazing right now."

Tom slowly placed his hands on the untidy table, full of various pieces of unfinished violin pieces, and dropped his weight on the table.

"Very well," He said. "That's it. Now it's our turn to expose ourselves, regain our reputation, and strike the fatal blow to the Deus Machine."

With this sentence, stress ran over Ivan. The intense desire to defeat the Deus Machine was replaced by anxiety and negative thoughts, circling in the back of his brain.

"You mean there is hope?" Ivan asked uncertainly. "What if we made a mistake? What if Russell had another plan in mind?"

Tom put his hand on Ivan's shoulder. His gaze showed self-confidence and hope for the future he was trying to change. He pinched Ivan's shoulder in his old way. The feeling of pleasant pain penetrated deep within Ivan and relieved his stress.

"We should see the beauty in duty, not in outcomes," Tom said. "We are doing the right thing. You know, I cannot tell you whether we will succeed or not.

There is no guaranty of success. We just have to believe in the way we started. This is the true faith. As Dostoyevsky said, ***Faith does not, in the realist, spring from the miracle but the miracle from the faith.***

We believe in ourselves and our ability, and we fight for our freedom and the freedom of unborn children.

If the future of humankind leads to hell, this decision must be made by free choice. We intend to protect this freedom. The rest is a matter of subordination."

Ivan never believed in motivational speeches and positive words. He did not believe in God at all. He had born with pessimism, but Tom's charisma affected all aspects of his life.

He remembered the moments when he was behind the door of this cottage, bagging for an opening. He had felt a mysterious force within himself, and now, without wanting to, he was on his way to fulfilling the promise he had made to himself in those moments. The future was not in his hands, but he could do his best, and it made him stronger.

Ivan was implementing the GAN model until late at night. With Colonel Taylor's coordination, Ivan could temporarily access the powerful processing servers of two leading technology companies.

The ultimate feeling of a hacker's power is accessing the most unattainable things in the technological world. For Ivan, however, it was never imagined, even in his dreams, that he would one day have such processing power.

He would even have a diabolical scheme in mind if he were normal, but he was no longer a former person. He was serving for a bigger purpose, and now he was quite coming around.

He spent the whole night implementing and integrating the LSTM and GAN models and embedding them in the servers. The servers were busy producing fake content and fake identities with all their might, and because of this, those leading companies' websites and services, got slow down.

They received so many customer complaints, who were unaware of everything and their main problem was the late arrival of the order and the non-response of the companies' operators.

As long as there is security, small problems concern the people's minds, and as long as security is lost, and the existence and non-existence of the people in community are endangered, human beings can spend a week with a loaf of dry bread. And then their concern is to survive. In any case, the human mind must always be concerned with something.

When security and health are in danger, it is no longer time to put two and two together. With this tactic, Colonel Taylor convinced those companies' CEOs to cooperate and even keep the secret and did not disclose it.

Ivan had finished his work and had a chance to sleep for two hours when his phone rang. 'It must have been Hannah.' He thought. She always called at the wrong time. But this time, he was wrong. It was Lisa. He answered his phone.

Lisa's voice was the same, but everything goes according to what your subconscious has confirmed when your mood and thoughts change.

Ivan did not even think about it. First, he loves Lisa deep in his heart. Like before, he looked at this one as a momentary pleasure, but over time and the events of the past weeks had made him love Lisa more than ever.

Talking to Lisa made him beside himself. Today was the promised day, September 21st. An internal whisper was saying to him he might not see Lisa anymore. He thought he looked at Tom, who was lying on the sofa too.

He said to himself. "I will back before he knows it." He made an appointment. They were supposed to meet near the forest road, in the same coffee shop next to the gas station, which had a plan to rob its ATM. Ivan picked up his hat and coat and left the cottage.

Forty minutes later, he was inside the coffee shop. Lisa arrived a few minutes later. They were both like the first time they met. Full of unknown excitement and full of questions to discover the other side.

Lisa was fully informed about the whole story. She wanted to be part of the solution to those dilemmas, and except for the chance that she had in the story of going to the secret laboratory and helped a little, she could not do anything else.

Ivan's looks, and his calmness, which was not from fatigue but from the dignity of accepting great responsibility, even surprised Lisa.

The two couldn't see each other without Ivan did not turn on once and did not try to get a kiss from Lisa.

This time, however, he was just listening and occasionally added something.

They talked warmly for an hour. When he talked to Lisa, his thoughts have been with Tom, and when he was with Tom, his mind was occupied with Lisa. He was afraid that something would happen to him and, as a result, he couldn't see Lisa anymore. On the other hand, the feeling of responsibility did not let him stay away from Tom.

Lisa also realized this concern and asked Ivan to return as pretending to be in a hurry. As they were leaving, Lisa turned her car key toward Ivan.

"Take it." She ordered. "You need the car more than me. Until the end of the story, you can keep it." Ivan refused at first. When Lisa saw him had become so serious and a little shy, she got mad and slapped his arm lightly.

"Quit screwing around!" She frowned. "I said take it."

Ivan, who was just putting up a charade to show how great pain he got from her fist, took the key. This Ivan was the Ivan that Lisa loved. Humorous, witty, clumsy, a little absentminded, and full of excitement.

Ivan drove Lisa home and then returned to the cottage with the car.

It had been a few hours since Ivan had returned and again started monitoring the process of producing books and fake identities. Both servers were working by evening and could produce more than 500 million fake identities by using the real data from social networks and 170,000 historical books. Their plot was to praise the goodness and love of human beings.

It was around 20:30 when Hannah arrived at the cottage. Decisive moments had arrived. The result of all their efforts over the last month was to be tested for an hour ahead.

Tom and Hannah were sitting together, and Ivan was constantly monitoring the process of producing fake identities. The number of identities produced had crossed 650 millions.

Time passed slowly, and the further it proceeds, the colder Hannah's hands became and the tighter Tom squeezed them with his hands.

The genial heat exchanged between their hands calmed both of them. It was 9:20 pm. They were very impatient. With the direct line of communication Hannah had established, they could inform from any attack in real-time.

Everyone was waiting for a new event to happen. You could cut the tension in the air with a butcher knife. Finally, in the midst and mists of tension and uncertainty, the time passed from 21:21:21. No new incident was reported. None of them slept that night. As a precaution, fake data production continued until the morning, but there was still no news of an accident.

12

Like A Rose Turning Into Thorns

It was around 6 in the morning when Hannah got up and went to the police station. She had to concentrate on Russell's movement so as not to lose track of him.

It was 8 in the morning when Tom woke up and saw Hannah's note. Then he woke up Ivan.

Ivan was still impaired, and he recalled one by one what he had done and the path he had taken last night when Tom asked him to forecast the popular trends again.

The Los Angeles subway accident, which had a lot of discussion on the Internet about the punishment or non-punishment of its perpetrators, was no longer recognized as the first trend and was replaced by ordinary news.

Ivan ate a tiny breakfast and sat down again behind the desk. He was constantly checking news sites for a significant incident. But there was no news yet.

It was around noon when Hannah showed up again, more ecstasies this time. She also had some plastic in her hand.

Hannah came in and had not yet closed the door, saying: "According to our information, tomorrow evening a shipment of purchased servers will arrive in the port of Los Angeles. We must get the job done."

Tom came and stood in front of Hannah. He stared into her eyes and said, "I think we've temporarily tricked the Deus Machine, but everything depends on accessing the source codes and destroying it while it is updating. This is how we will get rid of this monster forever."

Hannah took Tom by the hand and dragged him to the sofa. She opened the plastic bags one by one, "We have to celebrate." She announced. "I thought you two are too tired to make food for yourself. I bought some food before you starve."

As soon as Ivan's eyes fell on the pizzas, he forgot everything. Despite his many changes, he still had not given up his glutton. He would pick up two slices of pizza and devour them all without a bite. Tom and Hannah had nothing to do but laugh at him.

There was no news about an incident. It was as if they were relieved of great weight. Even though they knew it was not over yet, as soon as they were able to disable the Deus Machine temporarily, there was enough reason for them to be happier today than all the days, they had spent together.

A month ago, Tom was right on the sofa he was sitting on right now. A month ago, he was the most disappointed man on earth, and now he is the happiest man on earth. A month ago, he had no reason to live, and now he could not count the reasons that kept him alive. A month ago, he was a forgotten man, and now the sense of being useful took over his head. A month ago, he was just himself and himself, and now he had Hannah, he had Ivan.

Even at the height of happiness, a force rises from within and cries out: "Do not be too happy. This, too, shall pass." And it is the unjust custom of the world that takes away all valuable things from man, and it gives him something, just something. A little happiness and a little hope… and in the end, it can't even tolerate it and wants to take the same thing from him.

Amid Ivan's aspire to wit and the loud laughter of Tom and Hannah, all three of them wished that this laughter would not be taken away from them. What does a man want for a peaceful and happy life except for the heart that loves him, a hand that warms his being, and a foot that keeps up with him? Is this a big deal?

A few hours passed. The sun was already setting. Hannah had fallen in love with the autumn view of Tom's cottage. She looked out the window. Her heart pounded to walk with Tom.

Tom came and stood beside her. Hannah tied her hand to Tom's arm, then turned and looked at his face. It had been a few months since Tom had shaved his face and cut his hair.

A mass of raven hair with only a few white threads in it covered his entire neck. His beard also had covered his entire throat. Hannah touched them.

"Tom?" she asked. "I want to see your face without any retouch. Do you allow me to cut your hair and beard?"

Tom grinned and hung down his head then he reached out a hand to tuck a curl behind his ear. "I said," He nodded again and said. "As you wish, from now on."

Hannah jumped happily and put her hand on Tom's neck. They both hugged for a few seconds. Then Hannah went and got Tom's scissors and the shabby mirror.

Ivan was also interested in this and was helping Hannah. It took an hour for Hannah and Ivan to make a new man out of Tom.

His hair was cut like a boy, and he no longer had a big beard on his face. Hannah looked at Tom with a face of unutterable interest. Tom blushed for her while she stared.

"Magnificent," Ivan said as he gathered Tom's hair on the floor. "You have something around 2 kilos of wool. Thanks, Major, God bless you."

"But you're handsome, Master," Ivan said, his voice a trifle petulant.

Tom smiled again. But he did not say anything. Hannah came and sat next to him, as if a girl had admired him, ran her hand over Tom's beard jealousy and while putting her other hand on Tom's neck, she said, "Of course he is, He is my handsome."

Ivan raised an eyebrow. He had finished sweeping the floor. He was going to take it and throw it in the trashcan when Hannah suddenly said, "Let it be! Tom and I want to go for a walk. We will put it back in big trash next to the cottage."

Tom looked at Hannah. Hannah winked at him. They both got up and ran out of the cottage while Tom had taken the garbage plastic.

The sun was making its last efforts to protect the day and resist the night, but darkness deepened and came upon them, feeling the lovely, gorgeous, nauseating cold air.

Tom threw the plastic into the trash and came back next to Hannah. They both walked slowly together. Hannah had grabbed Tom's arm and could not take her eyes off him.

They had not taken a few steps when Hannah squeezed Tom's arm tightly and said, "If the lion attacks this time, I will not run away anymore."

Tom laughed. "This time, we will not run away from anything, anything."

Then he turned and stood in front of Hannah. He touched Hannah's smooth, soft facial skin. Her skin was flayed when Tom reached out to caressed her. He rubbed the back of his right-hand several times on her flushed cheek.

"Hannah," Said Tom. "We'll finish it tomorrow. I'll come with you. I will not leave you alone. After that, I will stay with you forever, I promise."

Hannah stuck her head in Tom's chest.

"I want to live with you forever," He hugged Hannah and said again, "Will you marry me?"

Hannah disengaged her head from his chest to see him well. Then she put her hand on Tom's face.

Tom seize her around the middle and came nearer. The heat of her gentle, willing touch was like nothing he'd ever felt before.

They clutched at each other. Their eyes were closed as though they sought to keep from being blown away. Their faces were so close that they could feel each other's breaths. Tom swallowed, squeezed his eyes tighter, and suddenly... For the first time, the sweet taste of Hannah's lips resided in his veins.

Hannah had hesitantly pouted her red lips at first. She could feel the warmth of pins and needles inside her. Her cold toes clenched with excitement. She then grabbed Tom's face with both hands, and a long passionate kiss followed... twenty seconds ... twenty seconds, the two lovers were stuck together. If you saw them from a distance, you would think they were one.

And this is the nature of love. It kills me and makes us a purified 'us'.

All these twenty seconds Tom had had her back in his arms with all his strength, if you ask two true lovers, they will tell you that sweetness of these twenty seconds is worth paying your whole life for it... and the poor person who has never been in love.

When they separated, they both were panting as if they had run all over the forest with all their might.

The warm taste of her sweet lips gushed into Tom's mouth. But this time, he restrained himself and simply stuck Hannah's head to his chest.

Within seconds, Tom felt wet in his chest. He pushed away. Hannah was crying.

He caught her cheeks between his thumb and forefinger and said, choking. "I do not want you to cry anymore... I do not want you to see your grief. I wish I would die and not see a thorn in your hand."

Hannah stared into Tom's eyes. "With you," She raised her nose and said. "Painless or in with pain, everything is sweet. I want everything to end tomorrow. I'm tired of being alone. I'm tired of running away from my past, from making myself strong, from trying to suppress my feelings.

I want to be who I am. I only have this feeling just with you."

Tears welled up in Tom's sea-like eyes. These tears soothe old pains. The flame of love is the firewood of old hidden pains. It burns them.

Love unties the blind knots of the past, but a hundred regret that it adds new knots too. Life, with meaning or meaninglessness, is not worth living without love. This can be asked of those who have been afflicted with it.

Regardless of any restrictive constraints, destiny put the two united companions together after years of loneliness and fatigue. In the dark forest, they walked side by side confidently as if they possessed it. They walked fearlessly in the darkness of the forest with their hands locked and their eyes stared at each other.

That night passed. The night that Tom and Hannah had their best moments. A night when the joy of victory, even for a day, had penetrated their whole being.

In the morning, Hannah had to make her way to the police station. She wanted everything to be perfect and at the same time quiet. She never liked the hustle and bustle. She believed that even violent work, such as being a police detective, needs some art aspect. You have to decide at best possible time and get the job done, with the lowest cost and best efficiency.

She liked smart criminals. They were also a reason to go behind her current abilities and learn to be the best, and this last mission was the flower of the flock of all her missions.

This time, the enemy was a worthy adversary, and the impact of winning or losing was great, an impact on the breadth of everyone's life.

She believed that not even a small mistake should be made here. That is why she was the first to enter the campaign.

Lieutenant Ashley, a 23-year-old girl who had just graduated from the police academy, was with her. A few days ago, when she introduced herself to Hannah, she fell in love with her. Lieutenant Ashley reminded of her youth, and now, on her first experience, Hannah had her with on a dangerous mission.

From the morning, with a small binocular camera, she monitored all the movements of anything in the port. She had placed several agents in places where visibility was poor, but he had Lieutenant Ashley with her.

It was around 3 pm when a relatively small cargo ship docked in the port. The ship looked very small next to the rest of the giant ocean-class vessels.

There were only two coal-colored containers with this ship. Forklift trucks and cranes did their job, and it took an hour to move and transport the containers.

The containers were placed in the empty area of the easternmost and most desolate part of the port. The presence of two containers among the thousands of other containers that entered or left the port daily was not apparent.

With all of her senses, Hannah was watching the movements of the people moving around the container, admired Russell for choosing this place to reinforce the Deus Machine.

The port was crowded and had a variety of technological facilities, especially high-voltage power supplies to run and support the servers.

Also, the containers' position was such that other big containers surrounded it and the possibility of attracting attention was very low.

It was around 7 p.m. There was no trace of sunlight in the murky sky. But in the dusk, the light was still visible, just like a candle in the darkness.

As it got dark, Hannah and Lieutenant Ashley came down from their position overlooking the entire port. At Hannah's request, Lieutenant Ashley brought several sticky bombs that exploded remotely. According to Tom and Ivan, Hannah knew that if upgrading the Deus Machine with new code, the servers were exploded, there would be no trace of the Deus Machine.

Simultaneously, as she was exploding up the Deus Machine, she intended, in coordination with the special police commandos, to act promptly and arrest Russell Pierre. If all went well, all the nightmares of the last month would end, and the whole story would finish. The installation of high-pressure wires to the containers was completed, and as it turned out, the servers were ready to use.

Hannah, by holding her Glocks moved slowly ahead, and Lieutenant Ashley was coming from behind. They attached the bombs in a few places under the containers and turned on the activation button. Everything went smoothly. Now they have to wait for the servers to turn on to get the job done at the right moment.

Hannah was happy that everything was going according to plan. With Lieutenant Ashley, they slowly moved away from the containers and reached a safe place. Although ships were passing softly to and fro, the cargo traffic was low.

They were 200 meters away from the containers. Hannah, happy to take the most important step, first informed the special commandos team to reach the two hours' target location. And then he got Ivan's number. She knew Ivan and Lisa were with Tom.

Ivan himself had learned that, when she called, she wanted to talk with him. Tom answered the phone himself. Hannah was walking briskly next to Lieutenant Ashley.

"Tom," She said enthusiastically. "We took the most important step. I want to send the whole servers into the air as they turn on and arrest Russel with his hand in the cookie jar. If everything goes the way I think it should, we'll be able t o handle it. The servers are in the east corner of the port of Los Angeles. If something happens to me, it would better you know my location. We'll engage soon."

"Just be careful, please. Just come back to me safe." Tom begged.

"I was a cop for 15 years. I handled a lot of impended shit. Don't worry honey." Hannah replied.

"Tom?" After a considerable pause, she demanded.

"Darling Hannah," Tom replied. "I want you to know that I love you so much. You know how I feel about you. Nothing is certain but my feelings for you. My heart is yours. It always has been…"

And suddenly, Hannah's words were not over when an unseen bullet hit Lieutenant Ashley directly in the forehead. She finished off on the spot, her skull was ripped, and blood was flawing copiously.

Hannah stared dazedly at Lieutenant Ashley's blonde hair, which was soaking in blood. She could not believe what she saw. Behind the phone, Tom kept shouting, "Hannah...

what happened... Hannah...”

Hannah was shot in the leg until she seemed to rouse herself and reacted. She sighed and fell to her knees. Her eyes were blurring, but she recognized what she saw. Russell was limping down to her with three armed men.

Tom, Ivan, and Lisa were inside the cottage. Lisa had brought the violin that Tom had made for her, and she wanted to play for all of them after dinner and after Hannah had done her work well.

Although the smile did not disappear from Tom’s lips, all his thoughts, with a feeling of foreboding, were with Hannah.

He kept rubbing his hands together and squeezing them tightly. It was past 7 pm when Hannah called Ivan. Laughing at the memory he was describing, Ivan turned his phone to Tom and said, “It’s Major.”

Tastefully, Tom reached out to pick up the phone. Ivan pulled back the phone in a mischievously “Just promise, if this is over, buy a phone for yourself.”

With a mixture of seriousness and humor, Tom got up and forcibly picked up the phone from Ivan and answered. Hannah said that she had taken the most important step well. With each word she uttered, he had got more encouragement.

Hannah did not forget him even in the most difficult moments and told him that she loves him.

He had not tasted hearing this word for years, and now it was Hannah who had offered her whole heart and feeling to Tom. He was in the ecstasy of hearing those words that he heard the sound of a crackling gunshot behind the phone.

His eyes widened. His whole body and hands began to tremble. He kept saying in a trembling voice: “Hannah... what happened... Hannah?”

He was impatiently walking through the cottage. The call was not ended. He kept saying, “Hannah, please answer... Please say something...”

His heart was coming out of his mouth when he heard a second shot and a sigh that sounded like Hannah. He could no longer control himself. He started crying like children and then, without saying anything to Ivan and Lisa, he took Lisa’s car key and Ivan’s phone and sauntered towards the door, but he stopped for a moment.

He returned to the kitchen and took two small switch-blades from the cupboard. He put one in the vest he was wearing and put the other in the pocket behind his jeans, and then he ran to the car.

“Let me come with you.” Yelled Ivan behind him.

Tom stood for a moment, turned and looked. “No,” Tom shouted, “No one will follow me.”

Ivan himself was scared. At the same time, he realized how scary Russell was. He wanted not to leave Tom alone, but Lisa’s presence seemed to bind him more.

He saw Tom with worried eyes, who was running towards the car with long steps.

Tom drove the cottage’s one-hour distance to Los Angeles in 45 minutes and headed straight for the port. On the way, he called Hannah several times, but no one answered.

These 45 minutes seemed to him like 45 years. When he reached the port entrance, with the help of the app that he had just learned from Ivan, he bypassed the main route and stopped in the eastern part of the port.

He got out of the car and, with all his might, pushed himself into the port and ran straight to the easternmost part of the port. His breath gave out. He stood up inevitability and took a deep breath, putting his hand on his knee. Then he got up and dialed Hannah again, but no one answered.

In the darkness and with the light that the port floodlights shone in the active parts, he reached the port's easternmost part. He looked over his shoulder at the containers. Everything was in absolute silence.

He narrowed his eyes and saw two parallel containers whose terrible noises were rising from them. He took a deep breath and ran towards them. He stood in front of them, rolling his eyes, and suddenly his eye fell on a ghost liked shadow… It was Russell, standing on top of an abandoned container with a hand on his hip.

He had a cane in one hand and a metal bag in the other. Tom's facial muscles drew out, expanded, and fell from what he saw.

He was about to run to the containers when suddenly a heavy blow from behind hit him on the ground. He was half-conscious when two people lifted him violently. Another man came forward and slammed his butt firmly into Tom's face.

The bitter taste of blood filled his mouth. He was trying to blink constantly to eliminate the traces of blood flowing from his eyelids and to see more easily.

He felt no pain, but as soon as he saw Hannah hanging from the rope above the crane and spinning towards him, he ached dazedly. His legs went slack, his hands fell off, and his head unconsciously got out of control.

Russell struggled to get down from the container onto the built-in stairs. "Tom, my dear Tom," Landed Russell's voice from above. "You came at the best time possible. Your girlfriend thought she was smart. Yes, once tore herself away, but she didn't learn her lessons well and return to the battlefield, a battlefield which was out of you and her business."

Russell had come down the container. Hannah also was hanging right above the server containers, which a terrible sound could be heard from them. Her mouth was closed, but she could not take her eyes off Tom. Tom's eyes were quivered between Hannah and Russell, coming towards him.

He was approaching and at the same time spoke loudly to Tom: "Tom, dear Tom. You and I have a settlement.

Now that this is the end of your story let me tell you the truth.

It was a month before you got the Turing Award. Everyone confirmed you were the winner except me. Whatever you were, it was because of the team's efforts that I was the cream of it.

All the innovations we had, none of them could be achieved without my presence, but you... you were the monopolist... you wanted all the honors to be for you.

This was not justice, Tom... I... I had a difficult childhood, Tom... you know... my stepfather always beat me... this foot... this foot, you know that it is a legacy of that time. I had a completely dark time, but I learned one thing. To serve justice myself.

It was me who manipulated the brakes of your car and sent you and your family to the bottom of the ravine. It was me who killed your wife and child. Do you understand?

"Now I will kill your girlfriend in front of your eyes."

Tom could not believe what he was hearing. His head was constantly shaking as though he was not in this world.

His mind was full of the last scenes and the last laughs he had with his wife and daughter, and suddenly on the downward road, that terrible thing had happened. Russell had reached out to Tom, standing face by face with him.

"Poor Anna Cooper." The whisper like the voice of Russell brought Tom upon himself. "If she listened to me, we would have eternalized the Deus Machine just a month ago and made it invincible, but it's not too late right now. I will finish it anyway.

Do you hear? Listen to the roar of the servers. Listen well. You and that beautiful girlfriend can't do a damn thing."

He leaned a little closer to Tom. "Your girlfriend thought she could send my servers into the air."

Tom pointed to the bombshell and continued, "Tell me yourself, what a righteous punishment is for someone who opposes justice? Hum?

Do you want me to send her into the air with these bombs?" he laughed and said, "Oh no, not now, but I will do it in a few minutes... in front of your eyes... I told you that... I will make justice in my way…

These people who are snooping around must know who their true God is. I create a new God, and then I believe in it.

My God is a God who doesn't leave any oppression unanswered. Like my stepfathers, the right of the people was to be revenged just after they started beating someone like me. I will create a new God for these people."

He reached into his bag, opened it, and stood in front of

Tom, saying, “Look, Tom, in less than six minutes, the process of training and reproducing the viral system of the new Deus Machine, this time not only on California computers but on the whole world’s computers, will be ended. No one will be able to prevent it. Their behavior and their data will judge themselves. This is justice.”

There was no sound coming out of Tom’s mouth. This behavior pissed Russell off. Hitting Tom’s face with his cane, Tom fell to the ground.

One of the two men who had grabbed Tom came to pick him up, which suddenly Tom pulled his knife out of his vest and plunged it into his eyes.

The second person tried to pull out his gun in a panic, but Tom jumped in the air and plunged the knife into his throat with all his resentment. He snored and then fell to the ground. Tom clasped Russell tightly around the throat with one hand and placed the dead man’s gun in his forehead.

He then grabbed Russell’s bag and tossed his cane around.

“Bring Hannah down right now, or I’ll blow his brain out,” Tom shouted. “Did you hear me, idiots?

He pushed the gun like a drill into Russell’s brain. Russell was embarrassed. As he kept spinning, Tom grabbed him by the neck and squeezed hard. His breath caught.

Meanwhile, the silence of the eastern part of the port was slowly broken by the sound of helicopter blades that seemed to be coming towards them. For a moment, Tom’s attention was distracted by the helicopter spotlight. Straight light hit his eyes.

Unconsciously, Tom’s hands got uncurled. Russell seized this chance to bite Tom’s hand hard so that the flesh of his right hand was completely removed.

Tom sighed, and Russell could escape from his hands, limping.

Tom fired a shot at him with his left hand inaccurately, but it hit his side. However, Russell still stumbled away from him.

At the same time, special police forces, by air assault reached the battlefield and an intense gun battle erupted between Russell forces over the containers and the police.

Tom opened the control box. There were 58 seconds left until the end of the training process. Hannah had to be taken down the crane and then the servers destroyed, but did he have time?

He picked up the bombs' switch that had fallen to the ground. He ran towards the crane with all his might, but he could not find its control panel.

He stared at Hannah for a few seconds. The blood was dripping from her feet, and her face was covered in tears. Hannah shook her head in tears. Tom did not hesitate any longer. For another time, he ran around the containers to find the control panel but found nothing. He had no way to reach Hannah.

There were only 10 seconds left until the completion of the Deus Machine upgrade process. Tom came forward. He stared at Hannah. If the Deus Machine's upgrade was over, the lives of millions of innocents would be in danger, but Tom could have Hannah by his side. On the other hand, if he exploded the bombs, his beloved Hannah would be torn to pieces in front of his eyes and with his own hands and burned alive.

He trembled with the terror of this thought. Hannah's life was in his hands, the life of someone who had bequeathed his entire life.

The counter counts the countdown... 5... 4... 3... 2...

Tom stared at Hannah and ran to the container with all his might. It was as if he had made his decision and wanted to share in the decision.

In a moment, the coal-colored container under Hannah's feet, emmited an bright light with a big nose, turned darkness into the light, and exploded violently. A hissing, devouring flame cleaved the air. The last image was a vivid glance picture of Tom and Hannah looking at each other.

A look that stretched forever at infinity. A look that contained the essence of all the love stories... Stories of loving and not reaching... Loving and not telling... Loving and contentment to let her go... loving and killing yourself... and then, loving and killing her...

This is the whole love story: Not reaching.

In the last picture, Hannah does not move anymore, as though she knew what his decision was.

The blast wave burned her golden all hair at a glance. Suddenly the flames of fire engulfed Hannah, and she burned alive.

Tom was staring at Hannah, the one who had been engulfed in the fire all over her, and in that fire, someone was stumbling and striving for a moment of life that had become all the feeling, all the hope, and all of his life in this one month and now she was burning in this fire by his own hand.

Staring at Hannah, suddenly a strong wave hit his face and then his whole body and lifted him. He felt himself between the earth and the sky. A feeling of being suspended between the ground and the air, and then he fell to the ground with his head.

There was no pain. Only vague images passed in front of his eyes. The sound of gunshots could no longer be heard. The sound of Hannah's cry could no longer be heard.

Tom looked up at Hannah's body again. A fire was burning in her body shape. The sounds were cut off. All the pictures vanished. It was just flames of fire and fire and nothing else.

13

What Is True Love?

And still, those few crazy lunatics in the middle of the room were playing cards. Yes, all life is the same as the absurdity of playing cards upside down, unless a person in this life makes a decision and changes direction and makes the world a better living place.

Ivan was sitting by Tom's bed. He had been coming for several days. This time he had brought Lisa with him, and they were both sitting by Tom's bed.

Ivan was reading page by page, the book he had written for Tom, and he was staring at that unknown spot. And now he read the last line of the book to Tom: "This is the whole story of love: not reaching... the end of love is not reaching, that if you reach, it becomes a habit.

The condition of true love is madness. The condition of love is to lose, and the end of love is deterioration."

There was no word in the beginning, there was no action, and the hand of God was not full of livable mud. It was a fire at the beginning, and in the end, there is no immortality and no reward, no heaven, and no hell. In the end, there is fire.

Ivan closed the book. Think of the last few months… of all his adventures... of all the people who have now returned to their routines comfortably because of the man who decided to burn his whole life and everything and sacrificing himself to people who soon forgot everything.

Ivan came closer to Tom. He had eaten by force or with serum for several months. He had lost his hair and looked like a thin man with a sallow skin and splintered, rustling thorny jet black bread.

Lisa opened her handmade violin bag. Tuned it and then played Nimrod's piece by Edward Elgar. Nimrod that set Abraham on fire... Fire who did not burn Abraham... but Hannah...

With the violin's tragic sound, the lunatics gave up playing the card for the first time and occupied with the sound of the violin.

Even the chain lunatics did not attack each other for the first time. All quietly were listening to the music.

And if you came closer, you would see Tom's eyes filled with tears for the first time since that incident. And these tears are the essence of all human pain... Pain that cannot be expressed in language...

Pains that cannot be expressed even in the language of emotion, in the language of music... Pains that can only be understood by silent cries.

Sometimes one has to get infected to understand. Some times, light a kandle isn't enough to wipe out the fathomless darkness, sometimes, the way to heaven passes through the vast conflagration of the hell.

The End.

14

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To write this book, and the algorithms described in, I use my personal approach. This Approach was based on two sources in general:

- The knowledge which I learn in college classes and the textbooks I have read in theoretical perspective.
- The practical experiences which I gained during the implementation of a algorithm structure from scratch to understanding it well, and experiences which comes from getting my hands dirty with trying to implement a specific algorithm to solve a real world problem.

However, in trying to teach each of the algorithms, I was interested in approaches of some resources that I tried to put them as a basis for my work to teach them well in this book.

So, consider these references as sources that I was inspired by their teaching strategy and not as the only source I had to cover basic ideas.

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