Machine Learning for Education

Revolutionizing the way we learn and teach

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Dedicated to

Tony Robbins and Dr. Anamika Chawhan — inspirational mentors igniting my passion for lifelong learning.

— Dr. Amit Dua

"Dedicated to my best friends: Baba and Phiphi."

— Sankha Das

"This book is dedicated to my parents, my sisters, and Iiris."

— Pulkit Sinha

About the Authors

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— Dr. Amit Dua

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— Sankha Das

I would like to thank my parents and sisters for their endless support, my friends for helping me see the brighter side of life, and everyone who makes the time to read this book for giving meaning to our work. I would also like to thank BPB Publications for giving me the opportunity to work on such a meaningful book, which has the potential to improve so many lives.

— Pulkit Sinha

Preface

This book is a comprehensive guide to understanding and utilizing machine learning techniques in the field of education. The book covers a wide range of topics, including supervised and unsupervised learning, deep learning, transfer learning, etc. It also includes practical examples and case studies of the successful implementation of machine learning in educational settings. Whether you are an educator, administrator, or researcher, this book provides valuable insights and strategies for leveraging the power of machine learning to improve student outcomes and enhance the educational experience.

The book is divided into five chapters, with the first chapter aimed to be an introduction to machine learning. The remaining chapters examine the educational scenario from different perspectives of students, parents, and educators and how machine learning can be used as an exemplary tool in the same.

Chapter 1: Basics of Machine Learning- will cover the basic concepts related to machine learning and its applications. The chapter introduces the idea of machine learning from the viewpoint of a human learner and slowly builds up toward the idea of an intelligent machine. The chapter also touches on the need for machine learning in the contemporary world and the various domains in which machine learning has found applications. A number of myths and misconceptions related to hot buzzwords, such as machine learning, artificial intelligence, data science, etc., have been addressed in this chapter to build a strong foundation for the reader for the forthcoming chapters. The chapter also introduces the different sub-domains under machine learning, such as supervised and unsupervised learning, deep learning, reinforcement learning, etc., which are topics of much research and interest in today's industry and academia.

Chapter 2: Machine Learning for Students- talks of how machine learning can be useful to students for the betterment of their educational journey. The chapter identifies scopes of improvement

in the current education system and tries to propose elegant enhancements to the same using machine learning concepts learned in the previous chapter. The chapter also contains a section on education for specially-abled children which is a topic of much social concern these days.

Chapter 3: Machine Learning for Parents- builds on the previous chapter and talks about the concerns and queries faced by parents regarding their children's education. The chapter proposes ideas for a better home environment and parent-child relationship when it comes to education and how machine learning can come in handy in such cases.

Chapter 4: Machine Learning for Teachers- shifts the lens from the home to educational institutions such as schools and universities. This chapter chiefly talks about the tasks and responsibilities entrusted to teachers and the various difficulties that they often face in the pursuit. Machine learning can prove to be an apt aid in improving the way instruction takes place in classrooms and easing teachers' work in evaluating assessments and grading students. The same aspects have been covered in this chapter in the form of thought-provoking examples and encouraging project ideas.

Chapter 5: Machine Learning for Educational Administrators- is the final chapter of the book, which addresses the concerns of educational administrators such as principals and deans who manage and run educational institutions often housing thousands of students and hundreds of teachers. The chapter gives insights into how challenging tasks such as managing student admissions, recruiting instructors and staff, and overseeing institution infrastructure can be eased by the advent of machine learning. Furthermore, the role of educational institutions in promoting education on a national and international scale has also been identified, and suggestions for the betterment of the current educational scenario have been provided by means of this chapter.

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Basics of Machine Learning

Introduction

One of the most interesting things to observe in nature is how organisms evolve. How do different living things adapt to their environment, how do they get to know their surroundings, and how do they respond to stimuli? All these questions are raised by the organism itself at some point or the other. Even a human baby asks itself whether putting a piece of chocolate in its mouth will make it feel better or will make it feel uncomfortable. All such questions have their answers too: answers one is told about or answers one learns through personal experience. These answers are often memorized, consciously or subconsciously, by the organism so as to use them when a similar situation arises again in the future.

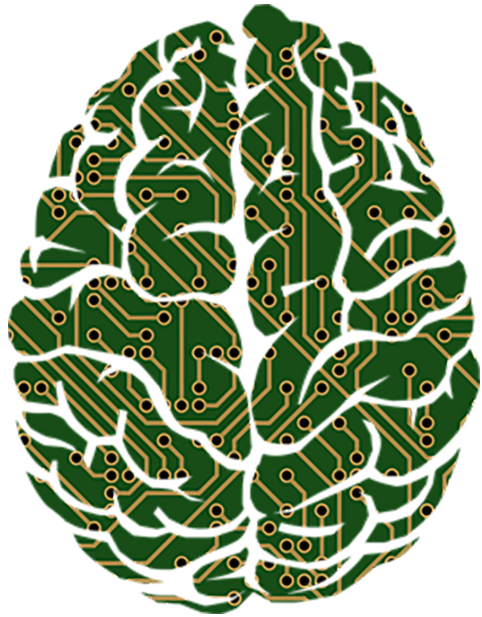


Figure 1.1: *Can machines possess intelligence?*

For a living organism, this process of "learning" continues throughout its lifetime, and the techniques associated with the same often become more and more specialized over time. But can even non-living things think and learn? Can a machine such as a mobile phone, laptop, or television have "intelligence" as humans or other species do? Let us try to answer these questions one by one.

Structure

In this chapter, we will cover the following topics:

- What is machine learning
- The rise of machine learning
- Applications of machine learning
- The need for machine learning
- Different dimensions of machine learning

Objectives

This introductory chapter aims to familiarize the reader with the idea of machine learning and help them to appreciate the same in our day-to-day lives. Here, we smoothly transition from a crude understanding of learning in general to the idea of how machines undergo the same process, trying to find similarities and differences between them and humans. We also try to bust some common misconceptions about machine learning and distinguish between machine learning and artificial intelligence, two closely related yet distinct buzzwords. The reader will then be in a good position to understand how machine learning has made itself a place in the modern world and transformed it in myriad ways at a steady pace. The chapter concludes with a section on the different dimensions of machine learning, providing details on the various forms of machine learning prevalent in the industry and academia these days.

What is machine learning?

Put in very simple words, machine learning as a collective term refers to how a machine thinks and learns about certain events, objects, or actions to be performed. The process of learning is very complex and long-drawn, with many interesting observations that can be made throughout it. To understand machine learning in detail, one may start by understanding how human intelligence works and how it differs from machine intelligence.

Human intelligence versus machine intelligence

To distinguish between human intelligence and machine intelligence, perhaps we first need to ponder over what exactly intelligence is. Let us start with the dictionary definition. The Merriam- Webster dictionary defines intelligence as the ability to think about, learn, understand, and often manipulate the environment and situations that an individual is faced with. Relating this to our own life, we try to use intelligence right from waking up in the morning to going to bed at night. We think about the steps that we should complete

before having breakfast (brushing our teeth, taking a bath, and going for a jog), the route that we should take to reach our workplace or university, the food that we should have for lunch, which movie to watch for the evening, and so on.

For all these events, we often rely on our past experiences and the knowledge we gain about each one of them to make an informed decision. For example, we decide upon which movie to watch based on many factors such as the star cast, the genre of the movie, the reviews we have received about the movie from the news or friends, how much money we must pay for the ticket, whether we will have enough time to reach the theater and other details. Based on our own experience after watching the movie, we might change our own thoughts about the movies generally featuring the specific star cast, the general plot of movies from the specific genre, the average cost of tickets for such movies, and so on. These activities are very much related to the process of learning: learning about our surroundings, learning about events taking place around us, learning from information agents around us, and learning from our own experiences.

When we say that the topper of the class is very intelligent, what we mean to say is that she uses her knowledge and experiences in a very efficient and logical manner to arrive at correct answers to the problems at hand. This example gives us a sufficiently good and practical understanding of intelligence and learning.

Let us return to our previous question: do machines also think and learn, and if yes, how do they do so? Our young friend Jane is just as confused about the same question! Professor M. says that if we suppose that machines think as humans do, then it would be cruel to do so. A machine should be at liberty to think in its own way. However, it is interesting to know that how machines have evolved to think over the decades is similar to how a human learns from its surroundings and experiences. A machine like a laptop or mobile phone may be perceived in its simplest form as an organized collection of wires, microprocessors, and physical parts such as screens and buttons. The machine is "programmed" or instructed to do a certain task when subjected to a sequence of actions performed on it (for example, pressing a certain button, typing in a piece of text, pressing

the volume up button, and so on). Based on the set of instructions already available to the machines in the form of a program, the machine produces a certain output or performs an action using its physical parts in response to the input. But is this what we should call thinking and learning? Perhaps not. So, what is it that humans or other advanced living organisms possess as a special capability that causes them to possess intelligence?

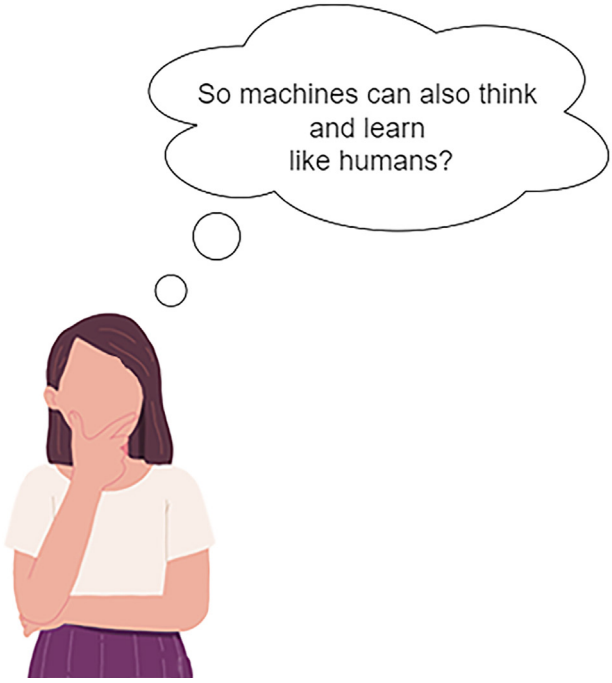


Figure 1.2 *Meet our friend Kelly! She wonders if machines can also think like humans*

Let us take another example. When a student receives his marks for an exam in a certain subject, he takes certain actions in response to his marks. If the marks are really good (the definition of good again differs from person to person, but for simplicity, let us consider 80% marks as a good score here), the student may celebrate by treating himself to a bar of chocolate. If the student scores low, then he might go back to his room to start studying harder for the next exam. He analyzes the mistakes he made in the previous exam and tries to figure out a way not to repeat them. If we observe closely, the student makes these decisions himself based on his marks. He does not

need to be explicitly told to do the follow-up actions by his teacher or parents. However, the actions may be influenced and guided by past experiences or preparation strategies of the student. What if a machine could perform similarly? What if a machine, after doing a certain task or receiving a certain input, knows what to do next without the need to be explicitly instructed on what to do?

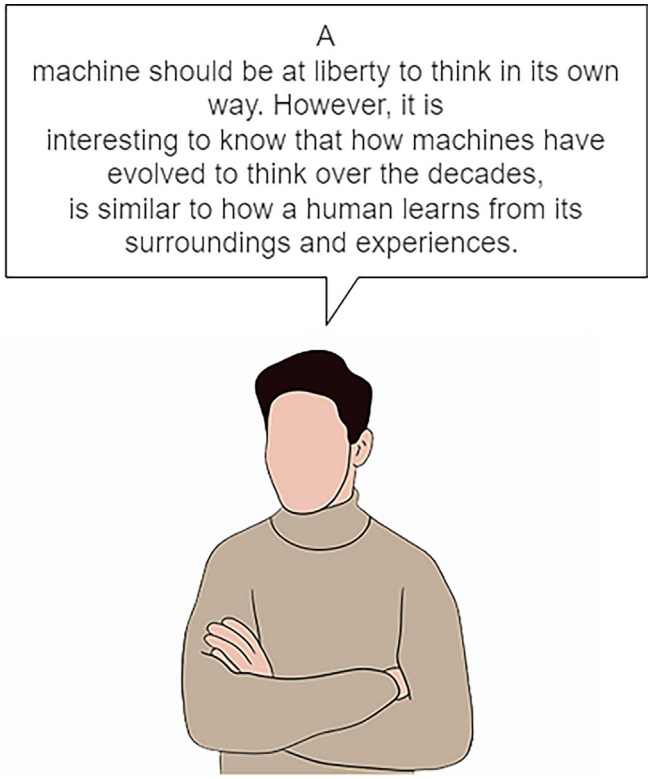


Figure 1.3 *Professor M. says that machines think in their own different ways. Let us learn more about it*

Once the machine acquires this capability, it may proudly call itself an intelligent machine. How the machine does this is a different question altogether. If a car needs to be steered all the way from your home to your university, you should perhaps not call it an intelligent machine. However, if you specify the address of the university to the car and it drives by itself to the destination, taking care of finding the best possible route and safely crossing all the obstacles on the way, it indeed exhibits machine intelligence.

"Of course machines can't think as people do. A machine is different from a person. Hence, they think differently."

– Benedict Cumberbatch, playing the role of Alan Turing in "The Imitation Game" (2014)

Time for fun!

Put your imagination to work, and let your thoughts fly! Illustrate the thoughts that come to your mind when you hear the word "Artificial Intelligence." Remember one thing: nothing is wrong, and nothing is correct!

Now, illustrate your thoughts when you hear the word "Machine Learning"!

Machine learning versus artificial intelligence: Are they the same

The terms machine learning and artificial intelligence are very much in trend nowadays and have been topics of active research and curiosity for the past two decades. Media, books, and science-fiction movies bring these terms to our attention time and again with numerous contexts in hand. These terms have become such popular buzzwords that even five-year-old kids today may be heard to speak of things like artificial intelligence technology and intelligent machines. Let us see what little Umi has to say!

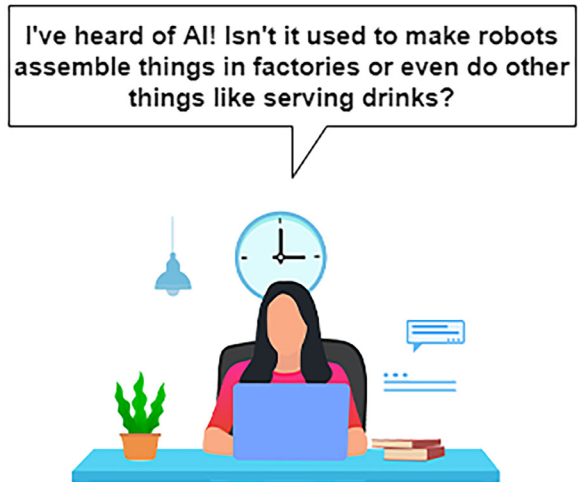


Figure 1.4: *Meet Taylor! She is quite the whiz-kid of her class and loves reading about new things.*

When we think of artificial intelligence, perhaps the first image that comes to our mind is that of a set of robots assembling parts in a factory assembly line or serving drinks in a household. The image, although not wrong, is incomplete. Artificial intelligence is not only about robots but about any intelligent behavior exhibited by a non-living object. Thus, while robots are a good representation of artificial intelligence, so are self-driving cars or automatic song recommenders. Perhaps when we think of machine learning, the same image comes to our mind. In that case, are machine learning and artificial intelligence one and the same? To be precise, machine

learning is a subset of the wide domain of artificial intelligence. Artificial intelligence entails a large number of techniques and methodologies to capture the concept of intelligence simulated by machines. Machine learning as a field captures only a subset of these techniques that relate to complex mathematical and statistical concepts to provide a framework for designing techniques for a machine to solve a problem. Artificial intelligence captures the broader goal of a machine mimicking human intelligence. Machine learning provides a toolbox to devise techniques to do so without the machine requiring explicit instructions to accomplish a task.

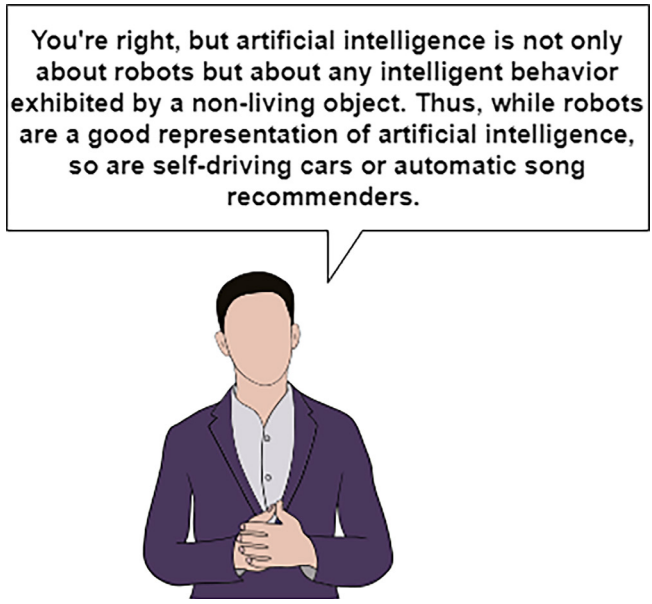


Figure 1.5 *Artificial intelligence is much more than just robotics!*

Again, is learning about artificial intelligence the same as learning about computer science? Not at all! Artificial intelligence may or may not be completely related to computer science; computer science may or may not be related to artificial intelligence in all aspects. Some aspects of artificial intelligence, such as devising efficient algorithms and statistical models, may be related to the domain of computer science. Other aspects, such as the ethical aspects of artificial intelligence, may not come under the purview of computer science. Computer science is an extremely wide discipline concerned with a

huge number of subdomains such as algorithms, systems, computer networks, cybersecurity, and so on, out of which artificial intelligence is just one of them. Again, the entire domain of artificial intelligence may not be a subset of computer science. A picture speaks a lot more than a thousand words: the following Venn diagram would help us to understand the relationship between all these terms that we have discussed so far and many more that we are going to discuss ahead.

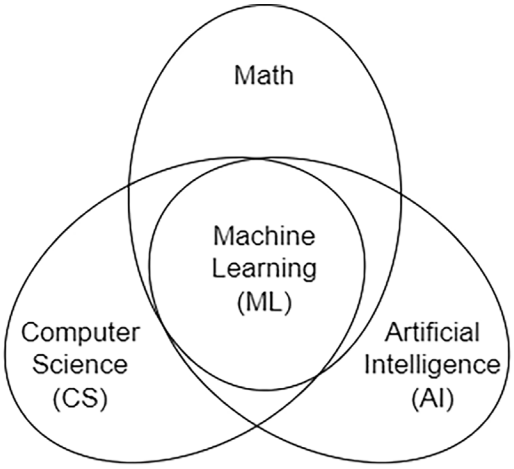


Figure 1.6: *A Venn diagram describing the relationship between different domains*

The rise of machine learning

Machine learning as a field emerged as early as the 1950s when many statistical and numerical methods were devised to develop algorithms that learned a function from a given dataset to predict the output for a new input. Machine learning was perceived to be a tool to tackle a wide range of real-world problems, such as playing games, pattern recognition, and classification problems. Over the years, machine learning specialized as a field associated with probabilistic and statistical models, with many new emerging algorithms. Algorithms and models such as the nearest neighbors, minimax algorithms, linear and logistic regression, and **support**

vector machines (**SVMs**) are all boons of machine learning. As the years went by, industry and academicians began to understand the huge potential of machine learning in transforming the way in which factories, offices, hospitals, and research activities function. Machine learning is now being used in a vast range of applications, such as facial recognition, image detection, intelligent biometrics, and smart health analytics. Many investment banking conglomerates today rely on prices predicted by machine learning algorithms to make the optimal choice of investments to make. Machine learning as a field has become so popular that almost every organization today invests in hiring machine learning engineers and data scientists who are capable of developing models and algorithms tailored to the organization's needs and targets. Many companies today organize machine learning hackathons and competitions to promote awareness and interest of this field in people, as well as to look out for talented people who specialize in this field. Universities and colleges today run specialized programs and degrees in machine learning specialization, to which students, teachers, and parents have reciprocated with equal enthusiasm. It goes without saying that given proper time and patience to see this field evolve, and the day is not far away when machine learning will be part and parcel of a person's key to a balanced and happy life.

Applications of machine learning

Our friend Tania asks why we need the trouble to make machines think in the first place! Can we think of an answer? Over the past two decades, machine learning has found many applications in a wide range of domains. The applications of machine learning are found through a continuous cycle of research, development, and testing. These phases identify scopes of improvement in current applications and also suggest newer applications in different fields. Let us look at a few of the numerous applications that machine learning has already found in both industry and academia.

Figure 1.7: *Do you agree with our friend Tania's question as well?*

Industries

Machine learning is being extensively used today in industries and factories today for many kinds of problems related to decision-making, optimization, and quality assurance. Many decisions, such as which product to manufacture in bulk as compared to others in the situation of given raw material constraints and profits gained by each product, can be solved using techniques such as automated linear programming. Which raw materials to order first, how much electricity to use, how many units of product to commit to delivering to gain maximum profit: all such questions are answered by machine learning and have increased the efficiency of these industries manifold. Computer vision is being used for automated fault detection on the assembly line, with high accuracy and speed. Industrialists are investing heavily in machine learning to transform their factories and production lines from mere assembly lines to "smart" assembly lines.

Finance

Many banks, financial conglomerates, and stock exchanges rely on machine learning to predict future profits and risks for them. Techniques such as regression analysis and maximum likelihood estimators can predict which stock prices will soar by how much and on which days in the near future. These results are produced by efficient algorithms that extend the behavior exhibited by historical data into the future. Many investors decide which days to trade heavily and which days to play safe based on the predictions made by these machine learning algorithms. Banks and fund managers often decide which loan applications to pass and which to reject based on the risk analysis of the applicant produced by deep learning models. It is, therefore, evident that machine learning has already established its strong hold on the financial markets.

Defense

Defense applications across the world are no longer limited to just skilled security personnel or heavy artillery. Modern state-of-the-art defense systems use machine learning to automate certain tasks such as missile detection, attack probability calculation, troop distribution, and so on. For applications such as tracking down a specific person in a crowd, face detection algorithms are heavily used by defense authorities, airports, and police to quickly accomplish a task that would have otherwise been difficult for even ten humans to tackle. Smart biometrics using iris and fingerprint matching are also accomplished using machine learning algorithms, which produce quick results with high accuracy.

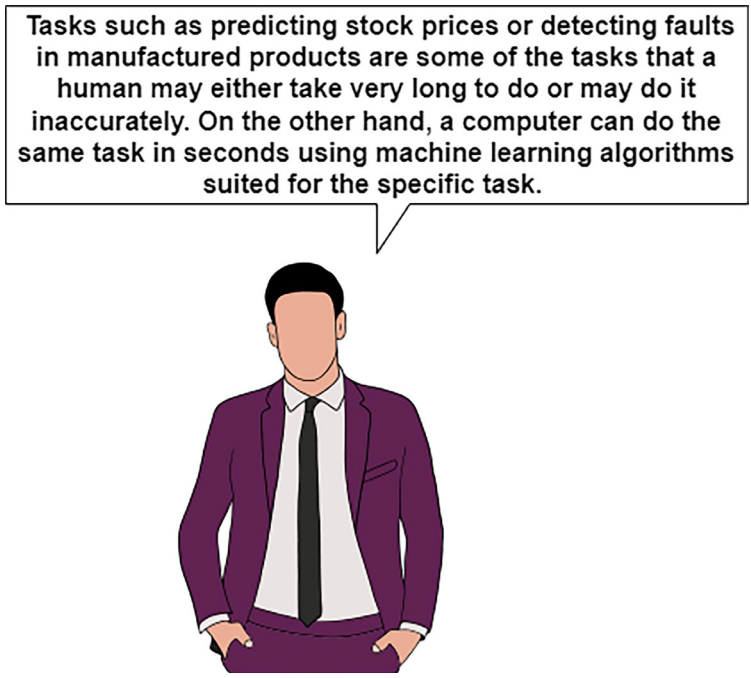


Figure 1.8: *Professor M. knows the answer to Tania's questions!*

So, Professor M. finally answered Tania's questions satisfactorily! Thanks to his high intellect and the superb education that he has received and is now imparting to all of us. Education, a field that is today heavily investing in machine learning to automate and assist in many of its daily tasks, is the main subject of interest in this book. In later chapters, we will study in detail how education has been and can further be transformed by using machine learning to solve the most challenging problems that students, teachers, and even parents face nowadays.

The need for machine learning

Change is the nature of the world. In order to be in a favorable position, one needs to adapt themself to the newest methods and technologies being adopted by contemporary society. Experimentation with machine learning began around three decades back and is now a staple in almost every operation that an organization performs. The

use of efficient prediction and optimization techniques boosts the efficiency of different stages of a process and makes the overall process much more streamlined and well-distributed in terms of manpower and time. Tasks such as predicting stock prices or detecting faults in manufactured products are some of the tasks that a human may either take very long to do or may do it inaccurately. On the other hand, a computer can do the same task in seconds using machine learning algorithms suited for the specific task. In one industry that uses manpower to do these tasks and the other which makes a one-time investment in establishing a machine learning workflow, who benefits in the long run?

Evidently, it is the one that keeps up with the pace of other industries and uses machine learning to automate and boost certain tasks! Consequently, human effort can be put to better use in other stages of the process where perhaps a machine would produce a deviation from expected results. Thus, both time and effort are saved in this manner, and the profits or expected output of the respective organization is bound to go up.

Time for fun!

Following are a few situations that we often face in our lives. Draw or write down how you generally tackle these situations in the first boxes. Also, illustrate how it would be better if an "intelligent" machine could do it for you in the second boxes.

- **Cooking breakfast early in the morning.**

- **Studying for an exam just the night before!**

- **Driving to the hospital when you are ill and there is no one at home.**

Dimensions of machine learning

The heavy research and development in machine learning over the past three decades have not only improvised the traditional techniques in this field but have also given rise to many new dimensions of machine learning. Let us try to understand each of these many interesting dimensions.

Supervised learning

As the name suggests, supervised learning is concerned with learning certain features about the dataset and formulating a function out of that, but in a supervised setting. What does this supervision imply? Supervision simply means that the engineer training the machine learning model defines what it should learn from the data, not just wander about on its own to learn things that are not expected. A real-life analogy might help us to understand this scenario better. When a child first learns about the tastes and smells of different food items in her house, she is exposed to a large number of such items. Each of these items has distinct features such as color, shape, size, texture, and so on. Let us say the child is blindfolded, and she consumes a piece of chocolate, and this (generally) makes her feel good. Enter the child's mother. The mother tells the child that the thing that she just ate is called "chocolate." The child's brain unconsciously connects the word "chocolate" to "a good feeling." The next time when she hears the word "chocolate", she will most likely react happily to it. Now, let us take another example. Let us assume that the child's elder brother tries to play a prank on her and tells her that what she just ate is called "chillies." The child's brain now connects "chillies" with

"a good feeling" (which is generally not the case!). So the next time that the child goes to a friend's birthday party, people will be very surprised to hear her saying that she wants to eat chillies! Actually, the child is asking for that sweet chocolate but is using the wrong term for that, as she has been trained under the "supervision" of her mischievous brother. This gives us a bird's eye view of supervised machine learning. When we are training a model, we associate the features of a data sample (for example, sweet taste, good feeling, and so on) with a label (for example, the word "chocolate"). The model sets the parameters of the function that it learns according to the features and labels provided by us. This function learned in a supervised setting will be used in the future to predict the outcome of other unseen data samples. Examples of supervised learning include training artificial neural networks, classification algorithms, and regression models.

Unsupervised learning

Unsupervised learning should be easy to guess from our discussion on supervised learning. Here the model is generally not provided with any labeled data samples to learn the final function. Such a paradigm is adopted in cases where the model is expected to identify patterns or similarities in the data samples on its own. The patterns or similarities may differ from dataset to dataset, and it is often difficult to label each and every data sample with a distinct feature. In such cases, it is better to let the model figure out the differences or similarities on its own. This is the crux of unsupervised learning. Clustering and grouping problems are generally classified as unsupervised learning problems.

Reinforcement learning

Reinforcement learning is a machine learning paradigm that works on the idea of "rewarding" a model if it takes a correct decision (or moves toward a correct decision). It is similar to a case where a child is rewarded with a bar of chocolate whenever she does a good deed, such as helping in cleaning the house. The chocolate (and the associated good feeling) gives an indication to the child that what she did was perhaps correct. She also thinks that perhaps if she helps

in cleaning the house more often, she will get more chocolates, and thus, cleaning the house is a correct decision. A machine learns such correct decisions in a similar fashion, with each correct decision made increasing its chances of maximizing its cumulative reward. Many reinforcement learning algorithms work by analyzing past decisions made with respect to the situation or environment at that time and what instantaneous rewards (or penalties!) had been received. Statistical models such as Markov chains and techniques like dynamic programming are popular tools used to model and implement reinforcement learning algorithms.

Transfer learning

To understand the concept of transfer learning, let us consider yet another example. Assume that a child is learning to play a video game, where she is required to cross a path of obstacles by dodging the game character whenever a stone or moving creature cross comes in the path of the character. The child does this using the controls of the character by pressing appropriate buttons on the keyboard or controller. Over time, the child learns to master this game by playing it numerous times and becomes an expert in dodging objects in her path. Let us now consider that the child is cycling on the road from her home to a nearby shop. The road may have cycles and cars coming toward her, and stones and barricades as well. If we observe carefully, the problem in front of the child now is similar to what she faced while playing the video game. It is just that instead of controlling the game character, she needs to control her cycle using the handles and pedals. The child uses her knowledge and practice from the video game to dodge the obstacles on the road in real life, thus "transferring" her knowledge from one scenario to another. Transfer learning works in a similar fashion, where a machine trained and tested for a given problem is able to produce correct results for another related problem using the experience gained in the earlier problem.

Federated learning

Federated learning is one of the most recently introduced and most interesting paradigms in machine learning. In conventional machine

learning paradigms, training data, training process, and testing are all localized on a single machine. This raises several concerns with respect to the scalability and privacy of data. Storing large amounts of data on a single machine may cause storage issues and might make it difficult to transfer such large volumes of data from one machine to another if the need arises.

Additionally, the data that is being used for training may contain data that is private or sensitive in nature to certain users. Thus, there is always a risk of compromising privacy in conventional techniques of machine learning. To address these and several other related issues, the idea of federated learning was proposed by researchers at Google. In federated learning, the training process is not localized by a single machine but distributed across a federation of machines. These individual machines train a shared model in their own local setting using their own training data.

Once the training is complete for a round, the updates for the model are sent to a central server which produces a new model by aggregating the updates sent by each individual machine. This updated model is then distributed again to the machines for further rounds of training. Thus, only the model updates are exchanged between machines, and the training data is not required to be sent to other machines.

Conclusion

This chapter has given us a fair understanding of what machine learning is in its form and function. From understanding a dictionary definition of learning to slowly building up the notion of how a machine learns, we have encountered many real-life examples to realize the meaning of machine learning. We also now have a clearer idea about the different buzzwords that are prevalent in the modern age, such as machine learning, artificial intelligence, data science, and so on, and have learnt to identify the similarities and differences between them.

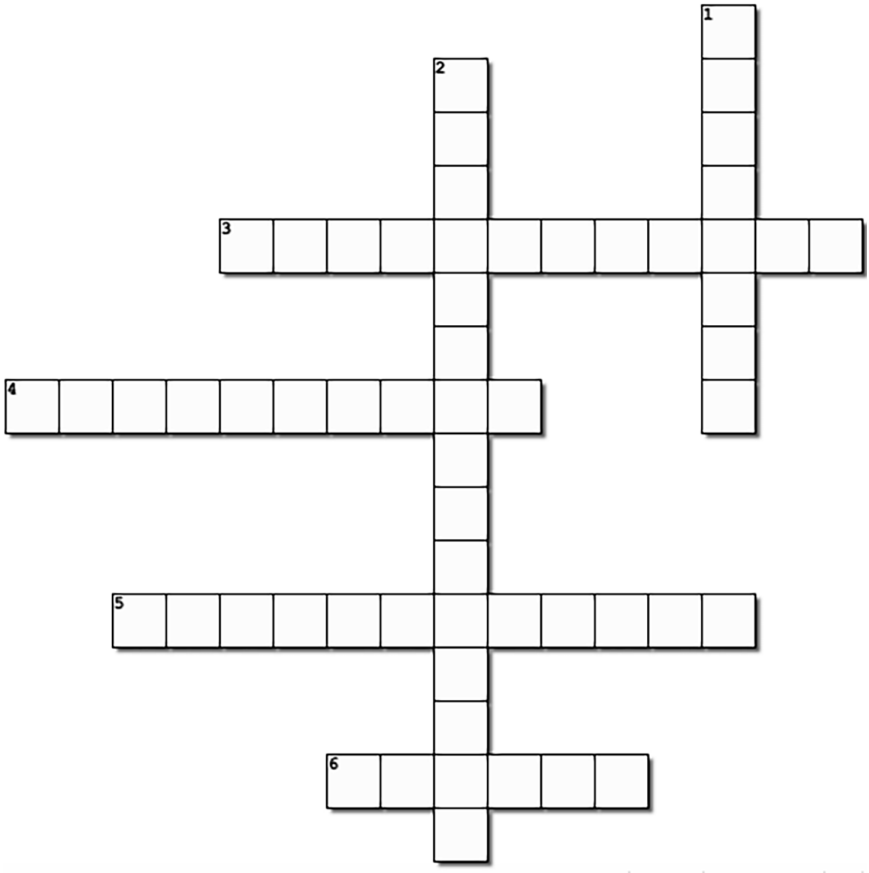
Machine learning as a domain has evolved and developed exponentially over the past few decades in terms of research, development, and financial investment. Owing to the huge number of applications that it has found in different fields such as defense, industry, health care, finance, and so on, machine learning has enjoyed immense popularity over the past many years in terms of the creation of new job opportunities and encouragement of academic and industrial research. The rate at which this domain has been growing is expected to rise over the next few years, with university programs and hiring drives solely focused on machine learning.

We have also explored the different dimensions of machine learning, such as supervised learning, unsupervised learning, deep learning, transfer learning, and federated learning, and what each of these subdomains entails specifically. Although these dimensions are not completely related, they do share important intersections that help us to connect the idea of one dimension to another. This knowledge helps us to appreciate how different forms of machine learning can be combined to develop an application suited to accomplish a particular specialized task.

In the upcoming few chapters, we will be discussing the ideas learned in this chapter from the point of view of a particular audience and a select set of applications pertaining to education. Education as a field holds huge potential to benefit from machine learning, and the world has already seen several successful examples in the form of smart tutors and answering bots. We will explore many more such applications through the lens of students, parents, teachers, and educational administrators in the exciting chapter coming up ahead!

Chapter-end crossword!

Complete the crossword puzzle using the following clues:



Across

3. A mode of learning where the model is generally not provided with any labeled data samples to learn the final function from
4. The machine is _____ or instructed to do a certain task when subjected to a sequence of actions performed on it
5. The ability to think about, learn, understand and manipulate the environment

6. The idea of federated learning was proposed by researchers at _____.

Down

1. _____ learning is similar to how a child uses her practice from video games to dodge the obstacles on road in real life
2. _____ is being used for automated fault detection on the assembly line

Exercises

1. **Fill in the blanks.**
   a. _____ is a machine learning paradigm that works on the idea of "rewarding" a model if it makes a correct decision.
   b. In conventional machine learning paradigms, training data, training process, and testing are all localized on a single machine. This raises a number of concerns with respect to _____ and _____ of data.
   c. Modern state-of-the-art defense systems employ machine learning to automate certain tasks such as _____ , _____, _____, and so on.
   d. Artificial intelligence captures the broader goal of a machine mimicking _____.
   e. Techniques such as _____ and _____ can predict which stock prices will soar by how much and on which days in the near future.
2. **For each of the following statements, indicate whether they are true or false. If the statement is true, write "T" in the box next to it. Else, write "F" in the box.**
   a. Artificial intelligence is the same as computer science. ☐
   b. Machine learning is a subset of artificial intelligence. ☐
   c. Statistical models such as Markov chains are used to implement reinforcement learning models. ☐

d. Industries cannot use artificial intelligence to determine which raw materials to order on priority for their operations. ☐

e. Artificial intelligence is nothing other than a bunch of robots working together on an assembly line. ☐

3. Answer the following questions briefly.

a. Explain the meaning of intelligence with respect to a human. Contrast it to intelligence in the context of a machine.

b. Elucidate a real-life situation where a machine learns, similar to how a human learns to do a task.

c. What are the differences between artificial intelligence, machine learning, and computer science?

d. Contrast machine learning with artificial intelligence. Support your answer with examples from the contemporary world.

e. Alice says that artificial intelligence is nothing but a group of robots that she saw work together in assembling a car in her Dad's automobile factory. Is she correct? What would be your take on her statement?

f. Highlight the various applications of machine learning in the industrial sector.

g. What are the advantages of using machine learning for defense operations? Can you think of any possible shortcomings of this approach as well?

h. Give an example of supervised learning in action in humans apart from the one given in the chapter.

i. How do you think using federated learning techniques reduces the risk of data privacy compromise?

j. Explain the rationale behind reinforcement learning and compare it with a real-life situation.

4. "Machine learning is the need of the hour." Support this statement with references from the chapter.

_____

_____

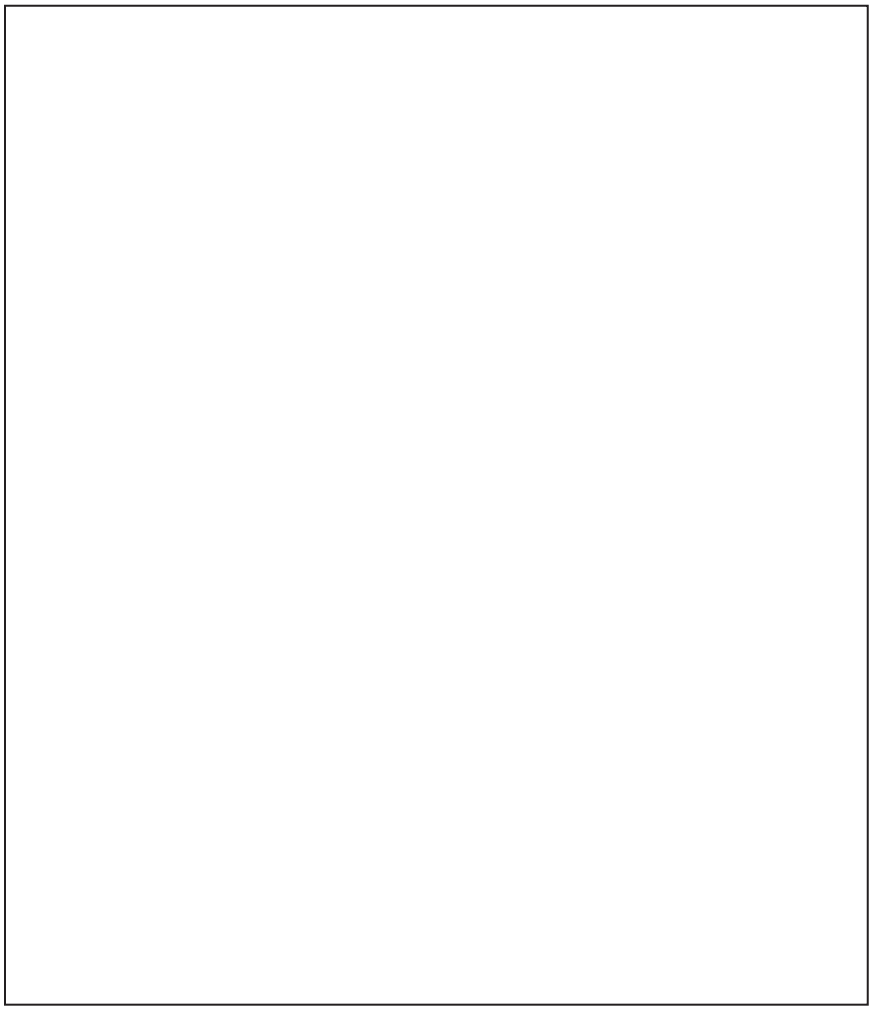
5. **In recent years, there has been debate about confidential data being compromised as they are increasingly being used to train machine learning models. Can you provide a solution to this problem by taking hints from the chapter?**

6. Match the following columns.

Column A	Column B
a. Rewards	a. Supervised learning
b. Knowledge reuse	b. Reinforcement Learning
c. Scalability and data privacy	c. Unsupervised Learning
d. Clustering	d. Federated Learning
e. Classification	e. Transfer Learning

Column A	Column B
a. Stock market predictions	a. Education
b. Smart tutors	b. Self-driving cars
c. Automated fault detection	c. Defense
d. Troop distribution	d. Industry
e. Pedestrian detection	e. Fintech industry

7. Make a mind map to summarize all the concepts covered in this chapter.



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Chapter 2
Machine Learning for Students

Introduction

By now, we have a fair idea of what machine learning actually is and the vast number of applications it has found in the world. This chapter discusses how machine learning can be used to facilitate education for students. We will be talking about different techniques which can be used to make the learning process for students of varying ages a fun and enriching process. As a matter of great social value, we will also explore how machine learning can be used to help students with special needs in getting access to better education opportunities.

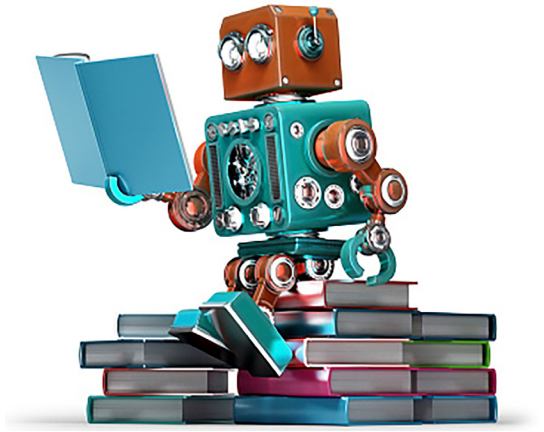


Figure 2.1: *How can machine learning be used to help students in their studies?*

Toward the end of the chapter, we will also be suggesting a few project ideas, which we encourage the reader to think upon and come up with possible implementations for the same.

Structure

In this chapter, we will cover the following topics:

- Current education scenario for students
- Machine learning use-cases and applications
- Machine learning for the benefit of students with special needs
- Project ideas for the reader

Objectives

After reading this chapter, the reader will be able to understand how the current education system molds the learning curve of students and what changes are necessary to make their education more holistic and tangible in nature. Understanding this system and identifying potential problems in the same will help one to think about suitable solutions to the same, thus, seeking the required motivation for the advent of technology, machine learning in particular, to make the lives of students easier. The reader will be able to appreciate the

various use cases of machine learning in providing a systematic strategy to optimize the daily activities of a student in their scholastic journey. The project ideas at the end of this chapter further motivate the readers to implement such solutions on their own and come up with new ideas.

Current education scenario for students

Before we jump into exploring the possibilities that machine learning holds for education, it is important to have a look at what the current state of education is for the majority of students. This exercise will help us to not only identify the existent loopholes in the current education system but also give us ideas to correct the same by finding their solutions in some machine learning model.

Time for fun!

Before we jump into explaining the current system of education in most schools, why do not you list down the things that you have observed in your school in terms of teaching and exams?

Most schools in India typically follow the system of public education, with students attending regular classes from kindergarten till high school. Usually, there is a governing body or board which prescribes the curriculum for each class, and the same is followed by the schools. Many times, the textbooks and supplementary materials are prescribed by these boards for uniform learning throughout the majority of the schools. In most schools, education is imparted in a collective manner, with around 30–40 students per classroom and a single teacher per subject for each classroom. Evaluation is done on a regular basis in the form of class tests, projects, and class assignments. There is also an annual examination held at the end of the academic year, which tests students on the syllabus taught throughout the year. A majority of the examinations are conducted in pen-and-paper format, with the questions often framed from the content in the textbook and class notes distributed or dictated by the teachers. Questions are mostly theoretical in nature, involving memorization of definitions, formulae, proofs, and derivations for scientific subjects. In subjects related to social studies, language, and literature, questions are mostly short-notes based, with some questions also based on critical thinking and creative writing.

Although the existing scenario has been in practice for a couple of decades and is still the de facto standard in the public education system, it does suffer from a number of shortcomings, as has been identified by students, teachers, and educationists from across the country and the rest of the world. It has been largely identified that students, although adept at definitions and theories pertaining to the respective subjects, suffer from a lack of practical knowledge about the same subject. When asked to demonstrate an example of a particular concept taught in class from their experiences in real life, they often stumble to find suitable examples or observations. An observable lack of the urge to carry out scientific enquiry related to the topics taught in the classroom has been found in students, especially in children of younger age, which is the most crucial time for brain development and instilling intellectual curiosity in them. Laboratory sessions help the students to carry out experiments related to concepts taught in class to some extent but are again restricted to the boundaries of the curriculum.

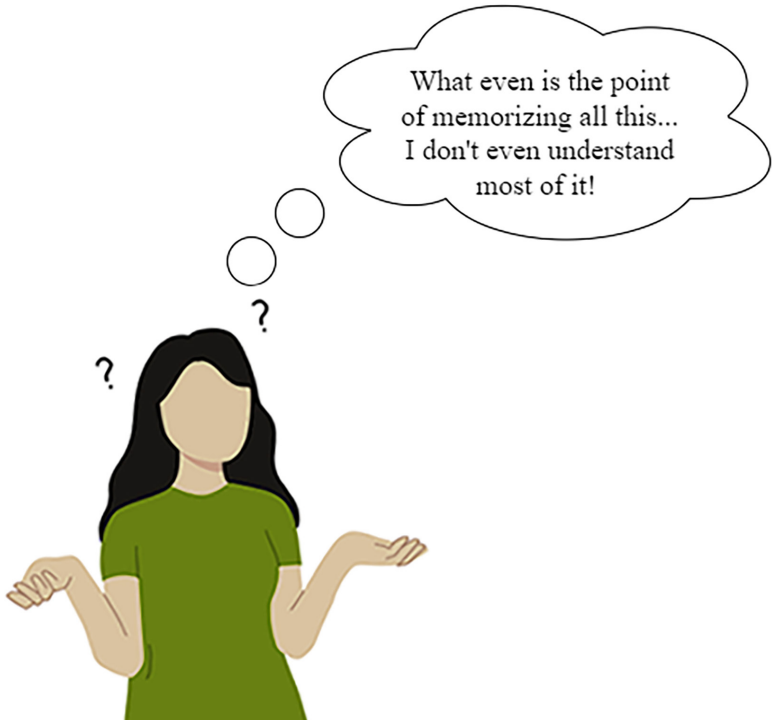


Figure 2.2: *Tania seems quite frustrated with the amount of memorization she needs to do in her subjects!*

Only certain experiments that are prescribed in the syllabus of the subject can be carried out by the students in the laboratories, and that too only during allotted class hours. Evidently, students largely depend on rote learning merely for the sake of passing examinations and completing their terms. The repercussions of such an education system can be later seen in competitive examinations for entrance to universities or at qualification examinations for international Olympiads. Such competitive examinations test students for their core concepts in the respective subjects, which almost always requires critical thinking about the theory and practical realization of the same. As a result, students relying on traditional methods of rote learning and accustomed to questions merely based on textbook definitions and short notes face difficulties in such competitive examinations.

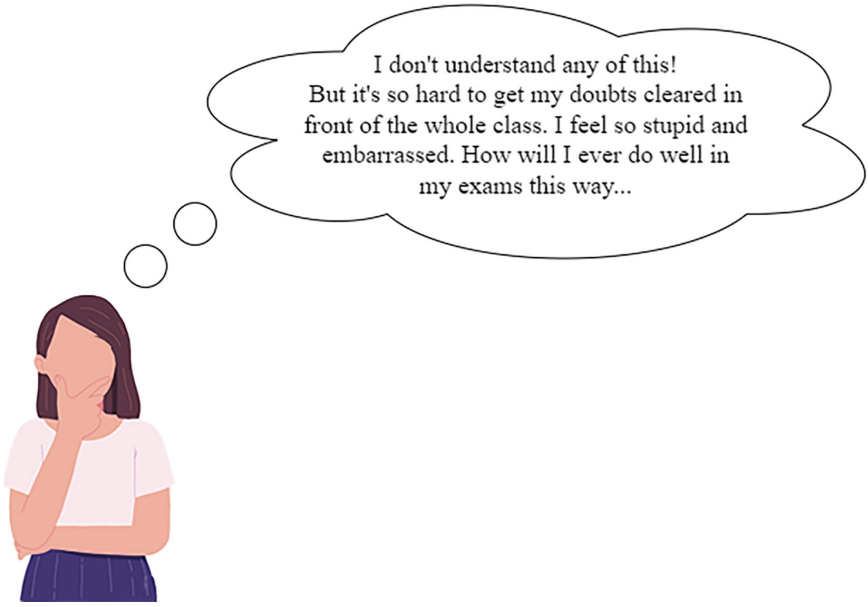


Figure 2.3: *Taylor seems perplexed! Is there a way she can get her doubts cleared in a better way?*

In our quest to revolutionize education through machine learning, we will try to overcome the problems that we have highlighted previously. Some of the problems are simple and straightforward to handle through machine learning and can be solved through existing models and industrial tools. Other problems, such as developing interesting questions based on the course content, are comparatively more difficult to solve using existing machine learning models and may require combining more than one solution to provide a complete solution. Let us start exploring!

"Oh... and how is education supposed to make me feel smarter? Besides, every time I learn something new, it pushes some old stuff out of my brain. Remember when I took that home wine-making course and I forgot how to drive?"

– Dan Castellaneta, the voice of Homer Simpson from the animated series "The Simpsons"

Machine learning use-cases

As we attempt to troubleshoot the problems identified in the traditional system of education, we try to find use-cases of machine learning pertaining to the respective problem background. The use-cases that we will discuss will mention the existent problems that it tries to solve and the modern industrial standards it proposes to use.

Content delivery

Perhaps the most important problem to tackle in providing quality education to a vast number of students is the delivery of educational resources. Textbooks, reference materials, audio-visual content, and previous year question papers are important resources that every student requires in the process of diving deep into a topic and preparing for examinations. A print textbook equipped with both text and diagrams often caters to all needs of learning the basic concepts about a topic. However, will it not be wonderful if the same content can be brought to life through dynamic illustrations and customizable note-taking? Machine learning can be used in this case to annotate specific text and find meanings to words that may seem difficult for the students to understand. The parameters on which to classify a word as difficult or not can include the age of the student, average performance, subject, and so on. A first step toward developing such an application can be to identify the age group of the student using it. Based on the age group, words or sentences can be tagged as difficult to understand and can be supplemented with ready-to-refer word-meanings, pronunciation help, and external references. Such a solution requires converting an electronic version of the textbook or other reference material into a sequence of words, sentences, or paragraphs based on the degree of abstraction required depending on the student and subject. As an additional feature, diagrams and illustrations can be annotated and labeled by comparing them to other diagrams available on the Web and the supporting text in the material. Computer vision is much advanced in today's world to correctly identify images and even different objects visible in the image. Once the identification of objects is accomplished, more information can be fetched about the same from external resources such as the Web. All the information,

thus, collected about one particular diagram is ready to be compiled as one comprehensive description about the diagram in a language that may be customized according to the level of the student. As we will explore in the forthcoming sections of using machine learning to help students with special needs, one can think of other features such as text-to-speech conversion (for students with visual impairments) or adjusting the pace of content delivery according to the learning rate of the student (often suited for students suffering from dyslexia).

Time for fun!

List down more innovative ways of delivering content in classrooms that you find interesting in the following box.

Submitting assignments

Assignments and evaluative components are some things that every student prioritizes in their academic career. Gaining good marks in their assignments gives them the confidence to repeat the same feat in other examinations of higher weightage. However, it often becomes a difficult task for students to produce accurate results each time when it comes to writing content on their own, preferably through research and experimentation. Students, at their tender age, often lack the experience and intuition to search for the right resources to get ideas and content for their assignments. Moreover, a case might arise when students might be searching for content for

their assignments but end up browsing information that might be inappropriate for their respective age group (for example, violent news, political propaganda, and so on). Language being used in the work that they submit is of importance, as it tells a lot about the tone of their answers and might impact the examiner positively or negatively. It is thus necessary to provide some support to students in searching for the right content to include in their assignments and in framing the nature of their submissions. A simple application could ask the student for the topic of their assignment and fetch information from the Web regarding the same. This information is still in its raw phase—it requires filtering! The nature of the information can be judged through sentiment analysis checks on the procured text and can be judged as being appropriate for a certain age group.

Further checks would include classifying the information as being fake or genuine. Fake news detection algorithms have achieved accuracy levels as high as 90%, again thanks to the huge investment in machine learning research carried out in the past. Once all such checks have been completed, the information is ready to be compiled and presented to the student. One might argue that presenting readily available information to the student would hamper their urge to do self-research and handicap their scientific curiosity. To tackle this highly probable situation, it may be chosen to only present the references to the collected and verified information to the student. The student may then explore these resources on their own and decide for themselves as to include them or not and to what extent in their assignments.

Exam preparation

" Every Monday, you will have a practice quiz. Every Wednesday, you will have a real quiz. Every Friday, you will have an exam. And any time I feel like it, you will have a surprise quiz or exam."

– Claudia Wilkens, playing Mrs. Madigan in the movie "D3: The Mighty Ducks" (1996)

Examinations are something that a majority of the student population fears for obvious reasons. If they do not score good marks in their unit tests or annual examinations, their grades will get affected and

be imprinted permanently on the grade sheets. For students about to complete secondary school or high school, these grades become even more important as it affects their career decisions and higher education possibilities. Although traditional methods of preparation for examinations, including note-taking, multiple revisions of the textbook, and practicing previous year question papers, have shown to yield good results, for some students, it might not be the most effective or efficient way to prepare. For many students, the learning pace might be slow, and it might be difficult for them to absorb a large amount of material in one go. In such cases, they require a well-planned strategy to maximize their preparation efficiency, which would also be reflected in their grades.

An artificial intelligence agent would require the necessary inputs to plan such a strategy. Details such as the number of subjects, credits for each subject, previous performance, and so on, which might prove to be helpful in deciding a rational strategy. Students often find it difficult to figure out a roadmap while preparing for examinations, especially toward the end of the term when the syllabus is huge. While some students are able to plan a timetable and focus only on select topics, many others struggle to decide which subjects to cover first and what material to study.

Figure 2.4: *Managing time is a difficult task for many students out there*

A good strategy is to always focus on subjects carrying higher weightage and in which the student has performed poorly in previous evaluative components. The application should help the student to chalk out and download important study material based on feedback from teachers, peers, previous year questions, and so on. The final product would be a systematic study planner that assists the student in preparing for the exams in a structured and optimal manner. The proposed strategy can later be verified for effectiveness and efficiency by analyzing the student's results and the degree of improvement achieved.

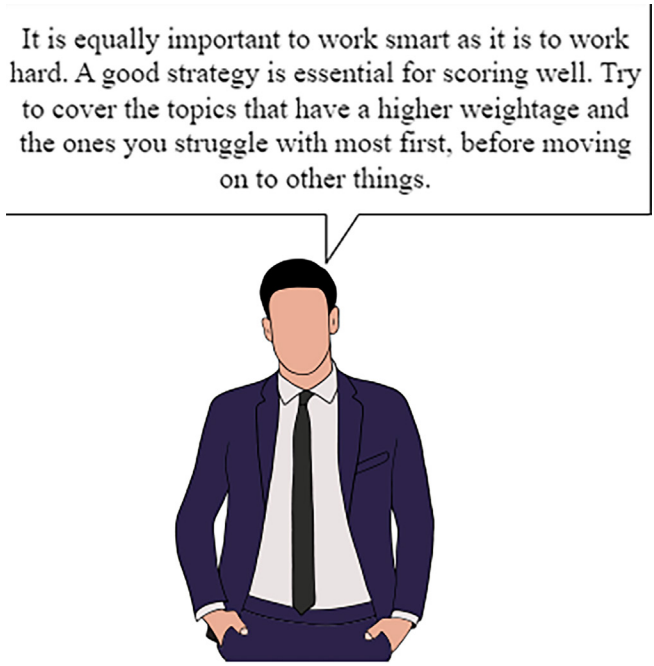


Figure 2.5: *A very smart strategy by Professor M. indeed!*

Machine learning for the benefit of students with special needs

We have explored the different ways in which machine learning and artificial intelligence can help students to organize their study material, search for relevant information for assignments and exams and also strategize their preparation for exams. One thing to note

here is that till now, we have only talked about students belonging to the larger population of people having little to no special needs. However, there do exist students who require special attention and facilities to ensure a smooth and comprehensive learning process. Even around us, we find people who might suffer from visual impairment, hearing and speech difficulties, or behavioral and social deviations. While catering to the larger population, schools are often unable to accommodate the needs of such students who might be suffering from some physical, psychological, or behavioral difficulties. Everyone is entitled to a good education and an enriching learning experience, irrespective of their background or physical abilities. We now discuss how we can bridge this gap to provide better education opportunities for students with special needs using the boon of machine learning.

Machine learning for students with visual impairment

Students with visual impairment miss out on a large portion of the learning process, particularly due to the dearth of study material customized for them. While study materials such as books and notes are available in Braille, their production is costly and time-consuming. In the age of information technology, speed is important. Why should not we use technology to tackle this situation, then? Machine learning can be applied to a vast number of areas which can help visually impaired students in getting access to quality content in an effective and self-suited manner. If visual learning is a hindrance for them, we can think of converting visual content, such as text or illustrations, into audio representations. Text-to-speech converters are so advanced today that they can read out text from various genres with the correct pronunciation, intonation, diction, and expressions. Image tagging tools are smart enough to not only specify the objects in the image but also specify the interactions between them. While appearing for examinations, a student will no longer need a scribe to write on behalf of them as they dictate their answers. Existing speech-to-text converters can ease the job for the student as well as the organizers of the examination to successfully conduct the examination for all candidates.

Machine learning for students with hearing difficulties

While students with visual impairment may suffer from understanding the static content present in textbooks or visual resources, such as educational videos, students suffering from hearing difficulties may not be able to comprehend what the teacher is speaking in the classroom. In addition, they might also miss out on peer-learning activities and not be able to keep pace with the rest of the students in the class. To assist such students in getting equal learning opportunities as others, the content being delivered vocally by the teachers needs to be converted to other formats, such as text or audio-visual forms. As previously mentioned, speech-to-text converters can come in handy in such situations and convey the topic being discussed in class in real-time to the student with the required expressions and emphasis. The same can be applied to the discussions taking place in their peer groups, with the discussions being converted to text and conveyed to the student. As a result, they can now participate in discussions and experience the benefits of peer learning. As another application, a sign language-based tutoring system can be developed to cater to the needs of such students. The basic features may include the conversion of video/audio content streamed in any language to the corresponding sign language. In addition, the application should take in sign language input from the user and convert it into text or audio messages, which would be used to communicate with the rest of the participants in the classroom.

Machine learning for students with autism

Perhaps one of the greatest challenges for any teacher would be to teach a child who might have been a bit slow in social and behavioral development. While ordinary children in the age bracket of three to five years are able to follow basic instructions such as opening books, using spoons and forks, and so on, autistic children find difficulty in doing so. Moreover, they tend to follow instructions only from those people whom they feel attached to or safe with. They tend to

show a short attention span and a lack of interest in physical activity. Thus, left alone, they are expected to just sit idle, with minimal physical activity. In order to smoothly drive them into a good learning environment and facilitate their educational needs, special resources are needed in terms of teachers and technological support. Many classrooms today take the help of artificial speech synthesis to teach autistic students basic lessons in speaking and creating vocal patterns. For such students, it is necessary to break each word into its constituent syllables and sounds, much different from how an average human would speak the same word. Since a computer perceives and produces each word as a sequence of frequencies, it is able to produce just this required effect of breaking down a word into its constituent parts. This helps a student with autism to comprehend the structure of the word better and even motivates them to reproduce it. Many behavioral aspects and the student's personal preferences also play a role in their education. Customizing the material and the mode of teaching according to their interests and comfort zone can greatly improve their learning and produce stellar results in their overall development. The assignments and tests that will be handed out to the students should also take care of these personal preferences. Preferences of students and their parents' and teachers' recommendations will be used to present the assignments to the students in a personalized manner to generate interest and passion among them. The mode of administering the assignments will also differ from student to student. For instance, students suffering from hyperactivity disorder have to be given the same assignment multiple times in order to inculcate patience in them for the long run.

We now have sufficient ideas about how machine learning can be used to help students from different backgrounds and learning requirements in getting quality education without their physical abilities becoming a hindrance in the process. It is now time that we explore a few project ideas that the reader can ponder on and come up with suitable implementations for the same.

Project ideas

In this concluding section, we discuss a few project ideas for the reader to understand the realization of the ideas discussed in the chapter. It is suggested that the reader follows a structured way of coming up with an implementation of the project, with adequate time invested in thinking about the problem statement, prerequisites involved, potential implementation difficulties, and how to overcome them.

To develop a study-environment simulator

Different people have different preferences and inclinations when it comes to choosing a work environment. The same applies to students who often prefer to study only in a particular setting for maximum concentration and efficiency. For example, one student might prefer to listen to music by Beethoven while solving math problems, while another student might prefer listening to *Bryan Adams*. This also can be seen in other preferences such as lighting, screen brightness, system sound levels, and so on. Apart from preferences, several health concerns might also be a factor in deciding the right study environment, such as having lower screen brightness in a dark room.

Your task is to develop software that, when installed on a user's computer, should study the user's preferences and study patterns. After gaining sufficient information about these preferences, the application should reproduce these preferences when activated. The application should run in the background while the user is doing some other work, such as reading an e-book or browsing the Web for some academic journals. Features that cannot be implemented without the help of additional hardware (such as room lighting) may be depicted through simulators that are shown on the user's screen. The list of preferences given previously can be used to get some idea. However, the list is neither exhaustive nor exclusive.

To develop a smart flipped-classroom

The flipped mode of teaching is a popular teaching method that is widely administered in schools and universities worldwide. Unlike traditional classroom teaching, this method uses pre-recorded audio-visual material and supplementary study material that the student is supposed to study before coming to the classroom. In the classroom, teachers and students discuss the material that was given, with a major part of the discussion being the questions that students might be having regarding the concepts studied. This way, not only students are motivated to think deeply about the topic and form inquisitive questions, but they also answer each other's questions and engage in peer-learning. Your task is to develop a smart flipped-classroom that helps students to automatically form questions, take notes and find answers to questions that might be raised by them or other students. The developed application must function in a way such that relevant questions and notes can be extracted from a video being played or from the supplementary reading material. You may add further features to make the application more useful and versatile.

To develop a smart ready-reckoner

Many students maintain short notes to quickly revise the entire syllabus a day before the exams without having to refer to the books. These notes mostly contain important formulae, definitions, graphs, and so on. Some students also note down mistakes that they might have made in previous exams to avoid them in the future. Nowadays, many publishers also sell ready-reckoners, which are printed and a more formalized version of such notes. Such ready-reckoners are highly popular among students preparing for competitive examinations such as JEE, SAT, GRE, and so on. Your task is to develop a smart ready-reckoner that can be personalized for each student using it. It should entail features like automated note-taking, highlighting important portions based on previous question papers, a student's diary, and so on. Additional features to make the revision process more easy and more enriching can be thought of and implemented. You can choose to implement a system based on a particular exam pattern/series or subject (for example, a ready-

reckoner for JEE may focus more on usefulness for multiple choice questions rather than long and descriptive answers).

To develop an automated viva-voce system

Many examinations worldwide carry an evaluative component of viva-voce. Viva-voce generally consists of the examiner asking questions to the student based on the syllabus of the course or some project that they developed. The questions and their answers are generally short and objective in nature, with more stress given to the use of appropriate keywords, definitions, and any mathematical formulae involved. Based on the responses given by the student, the examiner may ask further follow-up questions or even counter-question the student. A lenient examiner may even be kind enough to give the student some hint if the student seems to be struggling with a question. Your task is to develop an application that automates this process of viva-voce. Essentially, the application should mimic an examiner and ask questions to the user, for which the syllabus, sample questions, and study material would be presented to the application. Questions asked can be highly diverse in nature ranging from questions on graphical plots, diagrams, text, a code sample, and so on. The system should be intelligent enough to ask follow-up questions to the student or provide some hints if the student seems to be struggling. At the end of the viva-voce session, the application should grade the student and present a report of their performance.

To develop a smart music teacher and composer

People all over the world indulge in music of different genres and tastes. Many also try to learn to play musical instruments and compose their own music. Music classes generally start with the basic concepts of sound, scales, notes, and so on. These concepts are aggregated to compose tunes and, ultimately, a musical piece. Your task is to develop a music teaching application that teaches the preceding concepts from scratch using a user interface to play the

musical instrument. The application should then assist the student to compose a small piece of music themselves by taking ideas from existing popular music. The student may enter their musical preferences, such as genre (jazz, pop, indie, and so on) or favorite artists, before starting to learn or compose music. The application should help them to create music aligning with these preferences, but it should also be original composition at the same time. You may choose to implement the tutor for any one musical instrument of your choice (piano, guitar, drums, and so on).

Conclusion

In this chapter, we have seen some issues that exist with the current education system from the lens of a student. We have made a few attempts to address the same using techniques offered by machine learning. The solutions discussed, though not exhaustive in nature, provide a motivation to appreciate the applications of machine learning in education, especially for students. These solutions would further encourage us to extend them for more specialized and complex applications.

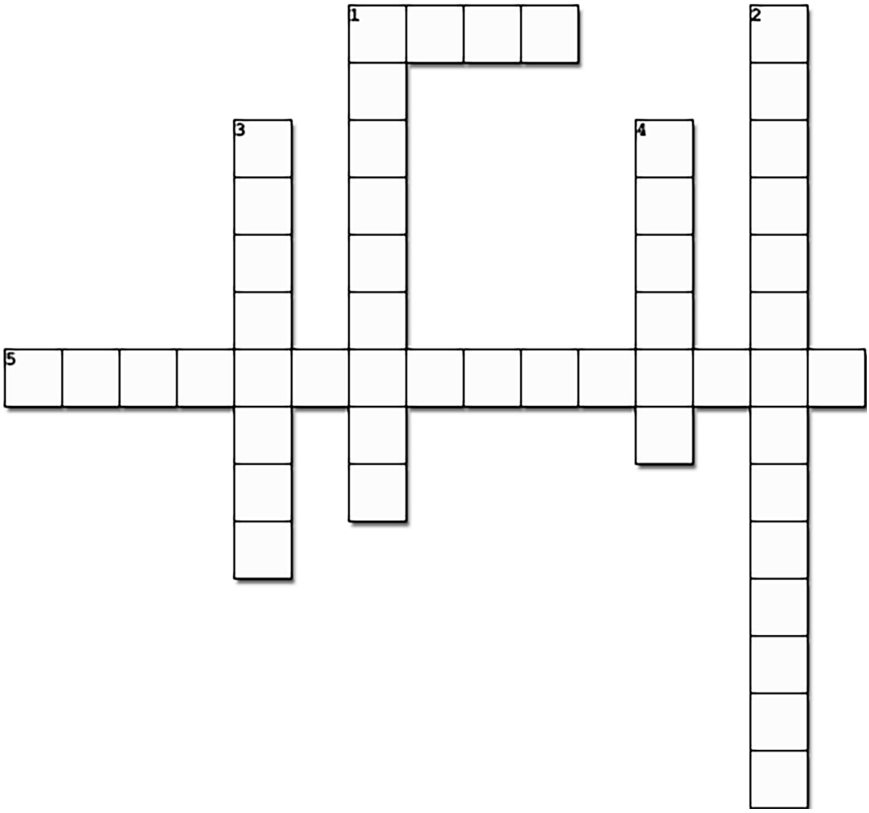
The solutions explored in this chapter mainly deal with the day-to-day activities of a student, such as planning studies, submitting assignments, preparing for examinations, and so on. These activities often need systematic planning before executing them in order to achieve maximum output out of them. The machine learning techniques discussed try to achieve this process of suggesting plans to the students to manage their studies well in the most efficient manner. Resonating with the idea of equal access to educational activities for all, we have also discussed how machine learning can help students with special needs or differently abled students. We have tried to address some issues commonly faced by students with visual, hearing, or speech impairments and also the problems faced by autistic and hyperactive students on their road to an equitable and fair education. It is expected that such ideas will create a huge social impact for the betterment of students with special needs and also promote a healthier mindset among the rest of the society.

We have had a hearty discussion on how machine learning can help students to get better educational facilities and improve their learning

experience. Now that students' lives have been made easier, it is time to help out someone more concerned than the student—their parents! The upcoming chapter talks about the relationship between parents and their children's education and how machine learning can be used to beautify this relationship even more by providing powerful tools for parents to assess their child's progress.

Chapter-end crossword!

Complete the crossword puzzle using the clues given as follows:



Across

1. _____ language-based technology can be used for helping students with hearing disabilities.
5. Used to correctly identify images and even different objects visible in the image

Down

1. The nature of the information can be judged through _____ analysis checks on the procured text
2. Technological boon for visually impaired students
3. _____ of answers suggests a lot about the tone of the work and may influence the examiner
4. Short attention span and lack of interest in physical activity

Exercises

1. **Fill in the blanks.**
   a. For word and sentence annotations, An electronic version of the textbook is converted into a sequence of words, sentences, or paragraphs based on the _____ required depending on the student and subject.
   b. _____ tools are smart enough to not only specify the objects in the image but also specify the interactions between them.
   c. Text-based content can be brought to life through _____ and _____.
   d. _____ is much advanced in today's world to correctly identify images and even different objects visible in the image.
   e. _____ and _____ in physical activity are traits often observed in autistic children.

2. **For each of the following statements, indicate whether they are true or false. If the statement is true, write "T" in the box next to it. Else, write "F" in the box.**
   a. Young age is the most crucial time for brain development and instilling intellectual curiosity in students. ☐
   b. Traditional methods of preparation for examinations include note-taking, multiple revisions of the textbook, and practicing the previous year question papers. ☐
   c. Modern fake news detection algorithms do not achieve an accuracy of even 50%. ☐

d. Autistic children find it extremely easy to carry out daily tasks such as opening books to the correct page and using spoons and forks. ☐

e. Modern text-to-speech converters are robust enough to read out text using correct pronunciation but inaccurate intonation. ☐

3. Answer the following questions briefly.

a. Write a note on the current scenario of education popularly followed in Indian schools.

b. What could be the possible repercussions of an education system that lacks exposure to practical applications of the concepts taught in class rooms?

c. What could be possible changes in the current education system to promote covering practical applications and real-life examples in the following subjects?

i. Science

ii. Social Studies

iii. Mathematics

iv. Any other subject that you like apart from the above

d. Explain a few strategies of traditional exam preparation which might not involve a significant contribution of technological tools.

e. How can the strategies covered in preceding question (d) be enhanced using technology and machine learning tools?

f. Highlight various ways in which machine learning can be used to improve the mode of completing study assignments.

g. Elucidate a scenario where supervised machine learning can be used to improve educational facilities for students with visual impairment.

h. Write a note on machine learning solutions which can be used to help students who suffer from hearing difficulties in training them in sign language.

i. Can transfer learning be used in the case of teaching students with hearing difficulties? If so, explain such an example.

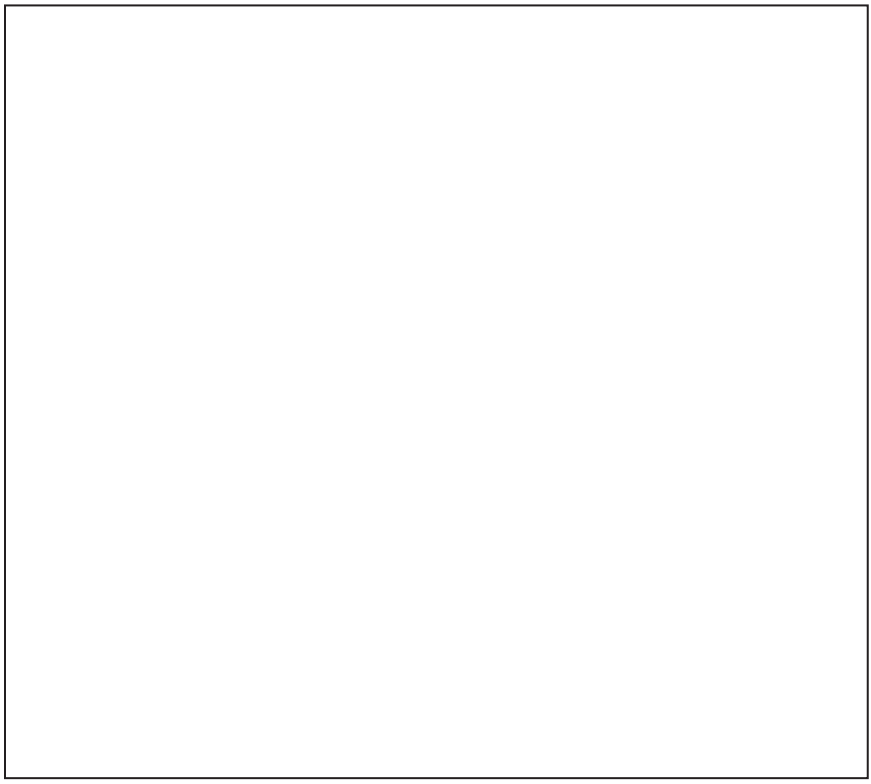
j. Imagine a situation where a child is not able to tie their shoelaces properly. How do you think machine learning can help in teaching them to complete this task? Try to include the use of reinforcement learning in the solution that you think of.

4. **Read a few articles on the Web related to the growth of facilities in the world with respect to education for the specially-abled. Do any of these facilities employ machine learning in their design and implementation? If so, elucidate the design of any one of them.**

5. **Read about AlphaGo and AlphaGo Zero on the Web. Taking inspiration from their learning process, how do you think students can be taught to play games such as Go? Highlight the same with respect to the game of chess as well. Explain your approach through a flow diagram.**

6. **We have discussed using machine learning for the aid of students with difficulties in vision, hearing, and autism. Think about the difficulties faced by students who cannot write due to physical impairment in their hands. How can machine learning be used to help these students in producing written and printed content that they can creatively and intellectually produce? Give details about your approach, including design and implementation.**

7. **Design a machine learning solution to help students suffering from hearing and speaking difficulties using unsupervised machine learning and reinforcement learning. Give all details in the form of a flow diagram.**

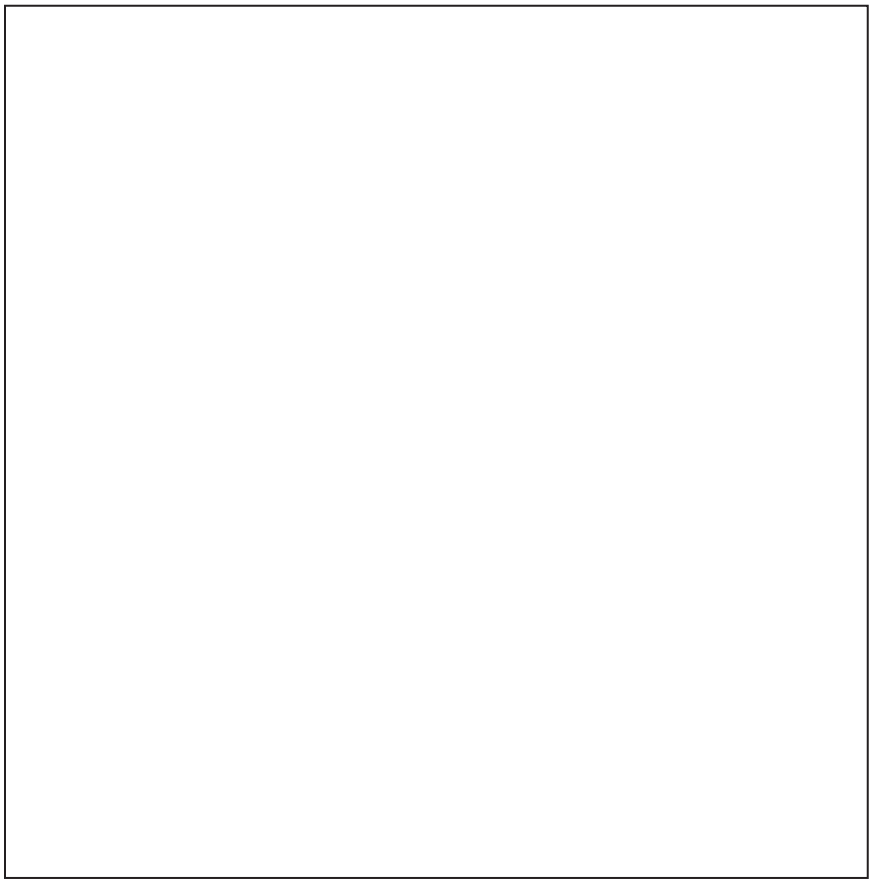


8. Match the following columns.

Column A	**Column B**
a. Strategy and planning	a. Assignment submission
b. Research and study	b. Real-life examples
c. Practical realization	c. Text annotations
d. Visual memory	d. Examination preparation
e. Difficult words	e. Interactive diagrams

Column A	**Column B**
a. Visual disabilities	a. Speech-to-text
b. Autism	b. Sign-language to Text/Speech
c. Hearing disabilities	c. Text-to-speech
d. Vocal disabilities	d. Industry

9. **Make a mind map to summarize all the concepts covered in this chapter.**



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Chapter 3
Machine Learning for Parents

Introduction

In the previous chapter, we saw how machine learning could be used to make students' lives much easier and their educational experience filled with fun and enriching facilities. It is expected that students will find more interest and enthusiasm to engage in studies when facilitated by such useful tools provided by machine learning. While students are constantly worried about their studies, examinations, and grades, there is someone else who is equally or perhaps even more worried than them—their parents! We all must have gone through this phase of our lives or are still going through it when we are constantly advised by our parents to study hard and concentrate on exam preparations rather than spend our time on games and fun. Often this concern arises due to the fact that they are not that aware of the situation of their ward's studies or the scenario of the current examination system.

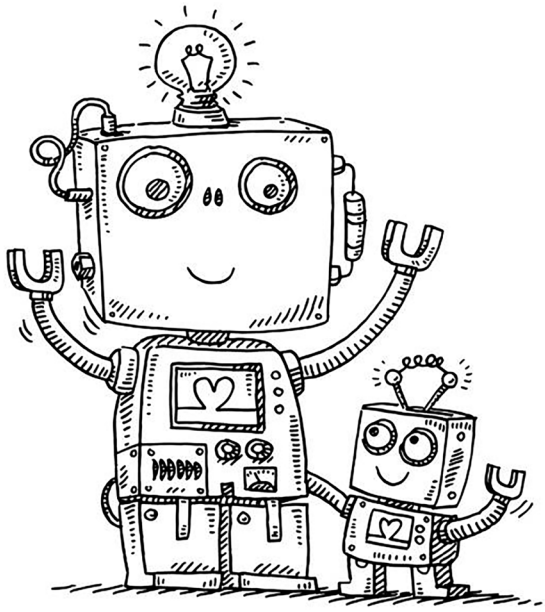


Figure 3.1: *Education begins at home, and our parents are our first teachers*

It may be possible that the student is already aware of their status of preparation and is well-planned about their preparation; it is just that the parents are worried that their child may not score good marks. It is, therefore, necessary to bridge this gap between the parent and their children's studies in order to ensure that the child studies in a confident and supportive environment. Knowledge about their child's study habits, performance patterns, and problems that they might be facing in the learning process will help the parents to understand their children better and help them out.

This chapter discusses how machine learning can be used to develop applications for parents to monitor and gauge their children's education and draw suitable conclusions from the analysis. A comprehensive report about the child's study patterns, learning curve, and examination performance analysis is what will help the parents in getting a quick but complete picture of their children's status. We will discuss what machine learning techniques we can borrow from industrial standards and research activities carried out in this field and how we can use them to help parents get a better view of their children's performance.

Structure

In this chapter, we will cover the following topics:

- Parent-child relationship in education
- Machine learning use-cases and applications
- Project ideas for the reader

Objectives

This chapter mainly focuses on the different ways that machine learning can help parents to understand their child's educational progress better. The reader will be able to understand the relationship between parents and children when it comes to their studies and planning for the same. Understanding this relationship will allow one to figure out the right flow and techniques that the parents and students need to employ on their part to see steady progress in academic results. The chapter enables the reader to get a grasp on how the day-to-day activities of a parent in overseeing their child's education can be eased by using machine learning and how such implementations can be carried out by the reader themselves, as suggested by the project ideas in the final section.

"I don't care if I have to get out on your runway and hitchhike. If it costs me everything I own, if I have to sell my soul to the devil himself, I am going to get home to my son."

— Catherine O'Hara playing Kane McCallister,
Kevin's mother in the movie
"Home Alone" (1990)

Parent–child relationship in education

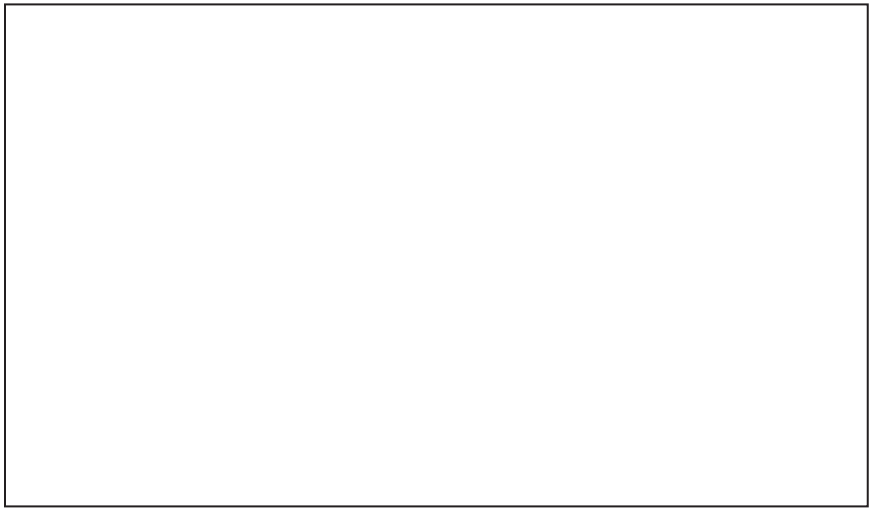
Parents are constantly worried about their children's academic performance and well-being. Since their school days, parents are continuously monitoring their children's academic requirements in a number of ways: from choosing the best school, buying all necessary

books and stationery to finding the best private tuition; it is the parents who look after all these priorities so that their children receive the best possible education. Subconsciously, they are investing in good foundational education in the expectation of their children to find better opportunities at studies and jobs in the future. Good schooling finds student opportunities in good universities, and good universities pave the way for better job opportunities and higher education prospects.

The parent–child relationship in terms of education is a two-way relationship: the parents ensure that their children are studying well and also help them in preparing for their examinations; the children, in turn, tell their parents about their requirements and often get doubts clarified from them. In cases where parents are not directly involved in teaching their children, they enroll their wards in private tuitions or coaching's and take regular.

Time for fun!

List down the things that your parents do or used to do to make you study! Did they use any kind of technological tools in the process? If so, list them or illustrate them.



The central idea that we see in all these cases is that there is some form of monitoring and control exercised by parents on their

children when it comes to their education. Parents wish to know if their child is making good progress, whether they are suffering from any difficulties, and at the same time, try to see that they get to study in a good and safe environment.

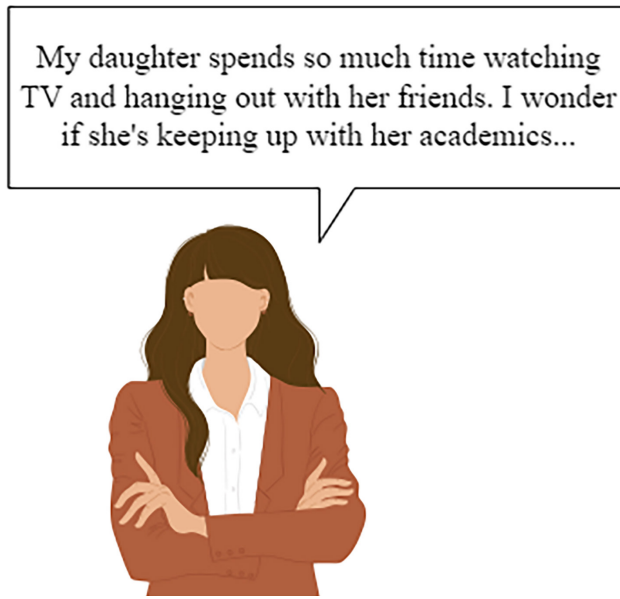


Figure 3.2: *Looks like someone is pretty annoyed by their child's habits!*

Parents who are educated often try to relate their children's education to theirs, trying to motivate them to perform better with each upcoming milestone. Having gone through student life themselves, these parents know about the ups and downs of this highly dynamic and uncertain path of learning. They are aware of the common mistakes that students make at a tender age and constantly try to warn their children about those mistakes. Taking a look at their ward's report cards, they are often able to make out where the child's strengths lie and where they need to improve. Therefore, they are ideal guides at home to plan out a well-structured roadmap for their children.

However, in countries of the global south, there is still a huge population of parents who are uneducated or educated only to a very primitive level. For them, it is difficult to understand their children's educational requirements and to track their progress. This often

makes them worry about their child's result, fearing that they are lacking guidance. Although they might enroll them in tuitions, they are constantly worried if whatever they are doing and their child is studying would be enough to perform well in the exams.

Figure 3.3: *We really hope that the screen-time is well under the safe limits!*

It is for such reasons that we are on our quest to help parents in finding solutions to help understand their children's academic progress better. Machine learning opens up a large array of such opportunities, which help the parent–child relationship to strengthen when it comes to education and foster a better understanding of children's educational requirements and progress. Let us now study how we can use machine learning to provide such tools to parents looking to understand their child's education better.

Figure 3.4: *Difference in opinions between parents and children is common when it comes to studies*

Time for fun!

How effective do you think your parenting strategies have been in the educational progress of your child, and do you think technology will be of help? List them down.

Machine learning use-cases

This section talks about the different dimensions where parents are generally involved in their children's education and how machine learning can assist them in the process. We attempt to look at solutions that already exist in the market and how they can be modified and adapted to suit our purpose.

Parental content control

As we discussed in *Chapter 2, Machine Learning for Students*, control is necessary to be imposed upon the content that students browse for various academic purposes. At home, parents often monitor the kind of content that their children consume through various forms of mass media such as television, cinema, music, and the Web. Content that may not be appropriate for the child's age group is strictly forbidden by the parents. Today technology also offers solutions such as parental control options on smart televisions and smartphones so that they can selectively block sources of media that may not be suitable for their children. However, when it comes to academic purposes, it might become a bit difficult and too restrictive for them to control the content that their wards might browse for academic purposes. While the child might say that they are looking at some material for an assignment, it may actually not be age appropriate for them to do so. For parents who are not able to involve themselves directly in teaching their children, it becomes even more difficult to segregate the appropriate content from the inappropriate. We propose solutions offered by machine learning to handle such cases. Using machine learning, we can get real-time information about the content being browsed by the child, with accurate tagging of the same as being age-appropriate or not. This process of classification is relatively easier and quite in practice already in the industry.

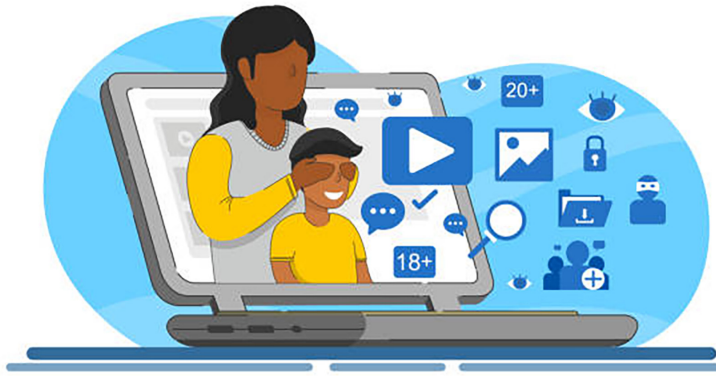
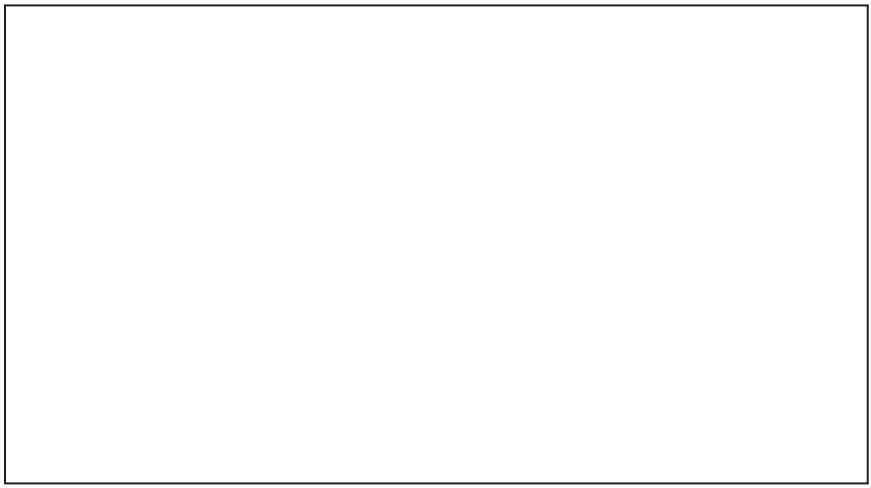


Figure 3.5: *Quality education can be fostered by an encouraging parent–child relationship (Source: iStock)*

What is more interesting is that we can get predictions of other content that the child is likely to browse after going through a particular material. Recommendation systems used by popular music applications are a perfect example of how this process works: based on the content being currently viewed by the user and on the sequence of content viewed in the past, the application is able to predict with high levels of accuracy that what content the user expects or would wish to see next. Mathematical tools such as Markov chains and popular deep-learning models like recurrent neural networks are used in such recommendation systems. The parental content control application that we are ideating here would work on a similar notion and will be able to alert the parent in advance about any content that the child is likely to look for that might not be appropriate for their age.

Time for fun!

Draw a flow diagram of what you think looks like the recommendation system of a music streaming application.



Progress analysis

For every parent, their child's academic progress is of high concern, and they always look up to their children to score well in their exams. Parents regularly check up on their ward's exam results by looking at their marks and attending parent–teacher meetings at school. However, many parents are not able to track their ward's progress merely by looking at their report cards. Bookkeeping is very much different from data analysis, after all! For them to analyze their children's performance well, it is necessary to generate detailed reports, which speak about the improvements made by the student over time, the parts of the curriculum that they need to improve upon, and what are the appropriate steps that can be taken to do so. These are some tasks that teachers and educational mentors are able to do very well, giving them the expertise needed to guide students. For parents, the task is relatively more difficult. Machine learning can help again! Industries today use machine learning to manage their sales and production, seeking crucial information about what products are earning larger profits, which ones to cut production costs for, and which products have grown over time and by what margin. The case of a student's academic progress is similar: the difference lies in the fact that here we are tracking marks and academic curriculum instead of profits and products here. Moreover, we can have the application predict the scores of the child in future examinations based on their current status and consistency score in

the past using regression analysis, just like stock prices are predicted using efficient machine learning algorithms and statistical models.

Figure 3.6: *The mother's concern is well justified*

Health monitoring

Perhaps nothing matters to a parent more than their child's health, let alone good scores. Their child's well-being is always of the most priority for each parent. While they might be concerned about their child doing well in school, it is more important for them that the child is in good physical and mental health. So more than studies, what parents monitor more keenly is that their children do not deteriorate their health in the pursuit of working hard for their examinations. Most of the time, children themselves tell their parents about any health issues that they might be facing. However, cases do arise when they refrain themselves from expressing any of their physical or mental health concerns to their parents. The reasons might be different: anxiety about the upcoming exam, worrying about their parents, or even fear of being scolded for making excuses. The

problem still remains the same: their health is deteriorating over time due to this. Long screen hours, wrong posture, irregular meals, constant anxiety about scoring well, and peer pressure are a few of the many factors that affect students' health detrimentally. It is, therefore, necessary for their closest people, their parents, to keep track of this situation. Applications that continuously monitor some of the previously mentioned factors, such as screen time and posture of the user, are readily available and also used in many home care systems. What interests us more is how machine learning can help in defining limits up to which screen time or long study sessions should be allowed. Given the huge amount of data available in the medical profession about the effects of incorrect posture, long work hours, and prolonged screen time, we can build models to predict when the child starts exceeding the threshold of hampering their health. While keeping track of mental well-being is a very challenging task, both for humans and machines, questionnaires designed specifically for psychological tests can be used to monitor the mental status of the child. The responses filled in by the child at regular intervals are used to analyze how their mental health has progressed over time and if any corrective measures need to be taken by the parents or teachers. Therefore, using machine learning, we can develop a complete toolkit for parents to keep track of their children's well-being, both in real-time and over an extended period.

Figure 3.7: *Machine Learning techniques can help monitor students' health and suggest appropriate salutary plans (Source: cdc.gov)*

We have seen how machine learning can assist parents to not only monitor their children's academic progress but also their mental and

physical well-being. Such tools will greatly help to bridge the gap between parents and their children's education, which many parents feel exists in their case. The next section now proposes some ideas for the reader to think upon so that they can themselves develop tools to help parents in engaging with their ward's education.

Project ideas

This final section discusses a few project ideas to motivate the reader to think about the applications of machine learning that can help parents, similar to the ones that we discussed in the latter section. The reader is encouraged to look up industrial standards of machine learning models that can be used to develop applications for the proposed ideas and also implement the same.

To develop a parental control-based content supervisor

Modern school education focuses heavily on studying supplementary material and project-based learning. Projects pertaining to the students' curriculum often require them to browse the Web for getting ideas or gathering information. Additional resources such as video lectures or blogs also prove very helpful to develop stronger concepts and arouse academic curiosity. However, the Web is a vast repository of information often contains content that might not be suitable for certain age groups. As an example, content promoting violence or hate might not be suitable for primary school kids. Also, issues of security and privacy are always a concern, as younger kids might be trapped in browsing malicious websites and leaking sensitive information. In the age of information, checks need to be put on the content that they access and the websites that they interact with. Your task is to develop a content supervisor that controls and manages what content a student is accessing. Needless to say, the application should be versatile enough to adapt to different age groups and preferences put in by the child's parents. It should also warn and protect the student against malicious content or websites, which they might be tricked into accessing. Try to think of a few more features to make the application even more safe and adaptive.

To develop a context-based question generator

Younger children are often restless or absent-minded to focus on something being taught or asked to them for a long time. Moreover, their interest is hard to capture using mundane examples or questions to which they cannot relate. Parents often face this problem while teaching their children, even more, while trying to capture their interest by asking new and interesting questions. However, if asked questions based on a context that aligns with their interests, it is shown that they show an extended attention span. For example, a question that sets the environment from their favorite cartoon and asks questions involving interactions of the cartoon's characters is expected to be taken up with interest by a five-year-old kid. A simple example can be "If Tom is five years old and Jerry is three years old, what is the sum of their ages?." Your task is to develop an application that generates examples and questions based on the preferred content of a child. The ideas of the example and questions may be taken from textbooks or sample question papers. The additional customization that needs to be added on top of it should be based on things such as cartoons, movies, hobbies, games, and so on, which may differ for each child and age group. The application should be intelligent enough to adapt to the current user's preferences and age group and be robust enough to generate questions from different topics or subjects.

To develop a nutrient-based food chart recommendation system

Students often forget to take care of their health in the pursuit of studying for long hours during their examinations. Having a nutrient-rich well-balanced diet is extremely important during this phase, especially for adolescents. Thus it is necessary for their parents to provide them with a well-planned food combination in every meal. Your task is to develop a recommendation system that suggests to parents what kind of nutrition would be best for their child during

examination preparation by taking in certain data inputs of interest. For example, study hours, study times, exam schedules, the physical build of the child, and so on can be used to make this decision. The developed application should also be intelligent enough to adapt to feedback provided by the parents or student, making appropriate changes to the diet recommended by it over time.

Conclusion

Parents are almost always more concerned about their children's education than the children themselves. It is often required that before understanding their child's educational progress, they understand their educational process thoroughly first. This chapter has discussed ideas that address exactly this concern and help parents to better understand their child's studies and possible areas where they can help.

The solutions discussed here for parents are in sync with those discussed in the previous chapter for students. How parents can help their children in overcoming the problems faced by them during their studies and how they can better understand their child's progress is the main question addressed in this chapter. Many aspects of the mental and physical well-being of the children have also been discussed in this chapter, along with the solutions offered by machine learning for parents to help their children.

Having discussed how we can help students and their parents in the betterment of their academic progress, we are done with covering the home! Let us now move to the educational institutions, where we will discuss how machine learning can be used to build useful tools and applications to help teachers and institute administrators in providing better educational standards at their temples of knowledge. The upcoming chapter talks about how machine learning can help teachers to provide better and more efficient modes of content delivery and evaluation, making more time for teacher-student interaction and better time utilization of both.

Chapter-end word grid!

Find words related to the chapter in the following word grid.

X	Q	K	D	P	K	P	R	E	G	R	E	S	S	I	O	N	F
T	D	N	G	R	M	K	K	P	R	U	N	B	G	O	Z	K	T
R	O	R	E	C	O	M	M	E	N	D	A	T	I	O	N	Z	G
Q	B	X	M	M	A	R	K	O	V	C	H	A	I	N	H	B	R
U	X	P	S	Y	C	H	O	L	O	G	I	C	A	L	J	T	A
M	S	G	D	G	R	V	B	E	G	W	Q	V	T	F	X	Z	D
P	X	F	Z	C	O	N	T	R	O	L	Y	F	E	P	T	W	E
Z	P	P	A	R	E	N	T	I	N	G	H	X	N	X	W	H	S
Q	R	G	O	P	P	O	R	T	U	N	I	T	I	E	S	L	C
B	F	T	G	T	P	W	T	U	N	C	L	T	J	M	O	Q	L
I	R	B	V	I	C	Y	X	T	Y	X	Q	C	X	U	N	Y	W
H	Y	R	E	C	U	R	R	E	N	T	O	A	R	F	Q	S	S

Exercises

1. **Fill in the blanks.**

   a. Today technology offers solutions such as _____ on smart televisions and smartphones so that they can selectively block sources of media which may not be suitable for their children.

   b. Recommendation systems used by popular music applications predict the next content likely to be desired by the user based on _____ and _____.

   c. A machine learning application can predict the scores of the child in future examinations based on their current status and consistency score in the past using _____.

   d. _____, _____, _____, constant anxiety about scoring well, and peer pressure are a few of the many factors that affect students' health detrimentally.

   e. _____ designed specifically for psychological tests can be used to monitor the mental status of the child.

2. For each of the following statements, indicate whether they are true or false. If the statement is true, write "T" in the box next to it. Else, write "F" in the box.

a. Long screen hours do not affect a student's health if it is being used for educational purposes. ☐

b. Regression analysis cannot be used to predict a student's scores in the future, given enough data about previous scores. ☐

c. Today technology also offers solutions such as parental control options on smart televisions and smartphones so that they can selectively block sources of media which may not be suitable for their children. ☐

d. Recommendation systems may make use of Markov chains and recurrent neural networks for making predictions. ☐

e. Children are always able to express their health-related concerns to their parents freely and without any fear. ☐

3. Answer the following questions briefly.

a. Compare and contrast the situation for parents who are educated versus those who are not educated in regard to understanding their child's educational progress.

b. What are the traditional strategies that are used by parents in helping their children in their education?

c. How can the preceding strategies be integrated with modern technology and machine learning techniques to ease parents' lives?

d. What could be the repercussions of allowing children to browse the Web for educational content without any checks or monitoring?

e. Give a method of parental content control using machine learning techniques apart from the ones mentioned in this chapter. It is encouraged that you read up articles available in the literature and on the Web to get a better understanding before starting on a design.

f. Briefly explain how Markov models are helpful in predicting expected results in recommendation systems.

g. What is common between the progress of a child's grades and a stock's prices? How do machine learning algorithms exploit this commonality and suit it to make predictions in each of the cases?

h. Elucidate the harmful effects of long screen hours on students' health and give a solution for alerting about excessive screen usage time using a machine learning framework.

i. How can machine learning prove helpful in drawing out nutrition suggestions for students? Think of different parameters that your model will use and how they will prove to be helpful in producing the suggestions.

j. Give a machine learning algorithm among the ones mentioned in the chapters discussed so far, which can help in identifying if a child is undergoing some mental stress. Feel free to choose whatever parameters and data that you might need to implement the design.

4. **Read up on the recommendation system used by YouTube to suggest videos to the user in the auto-play sequence. Taking inspiration from this, how can you implement a recommendation system to suggest age-appropriate content to a student for their academic requirements? Give details of your design.**

_____

_____

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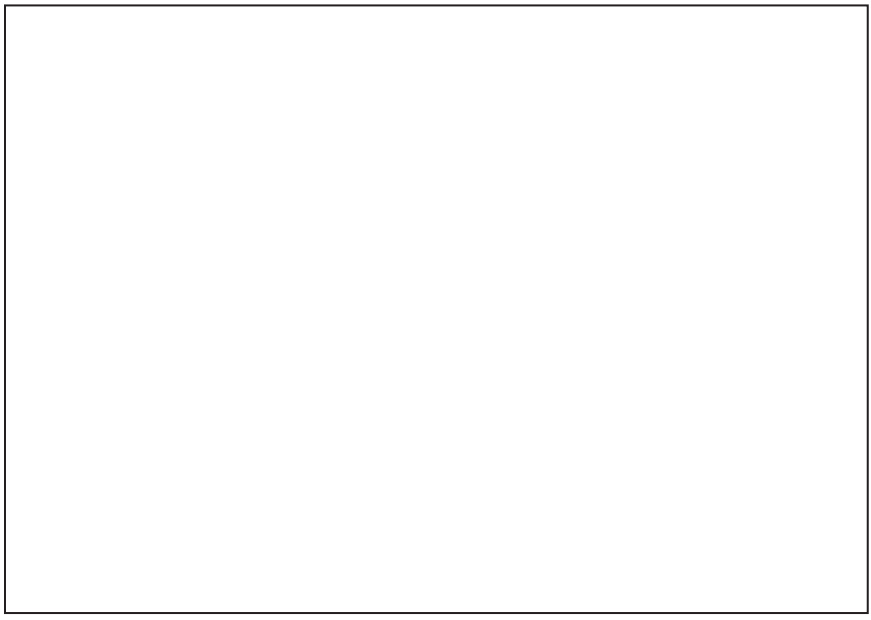
5. **Read some examples on the Web where artificial intelligence has been used to predict the outcomes of football matches. How can the same approaches be used to predict a student's academic progress over time? Highlight the same with respect to the game of cricket too. Explain your approach through a flow diagram.**

6. **We have discussed using machine learning for the aid of students with difficulties in vision, hearing, and autism. Think about the difficulties faced by students who cannot write due to physical impairment in their hands. How can machine learning be used to help these students in producing written and printed content that they can creatively and intellectually produce? Give details about your approach, including design and implementation.**

7. **In a scenario where parents are not able to monitor their child's education in-person due to them studying in another city, how can a machine learning solution be used to send them reports of their child's educational and health progress at regular intervals? Give complete details of your design using a flow diagram.**

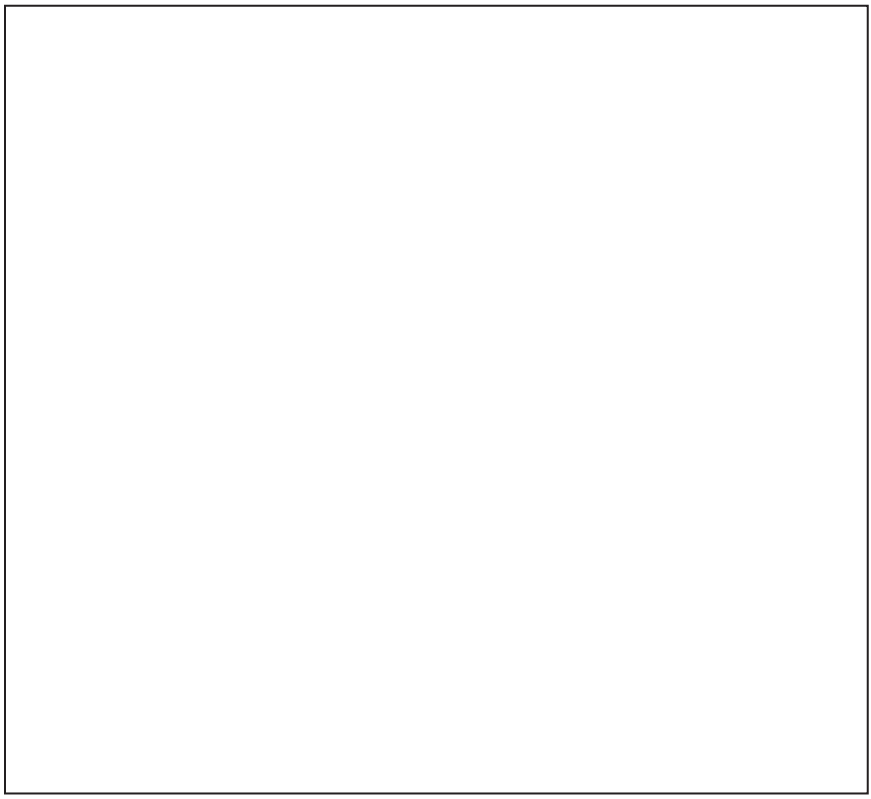


8. Match the following columns.

Column A	**Column B**
a. Health	a. Better monitoring of child's education
b. Educated parents	b. Anxiety
c. Unsupervised browsing	c. Malicious websites
d. Continuous reports	d. Age-appropriate content
e. Recommendation systems	e. Progress over time

Column A	**Column B**
a. Recommendation systems	a. Questionnaires
b. Grade prediction	b. Recurrent neural networks
c. Psychological stress	c. Support vector classifiers
d. Progress reports	d. Regression
e. Malicious websites segregation	e. Data analysis

9. **Make a mind map to summarize all the concepts covered in this chapter.**



Chapter 4
Machine Learning for Teachers

Introduction

Teachers are regarded as the supreme power who can guide students from the world of darkness into the light of knowledge. In Indian scriptures, teachers have been given a pedestal higher than God because of their teachings and guidance that show a person the way to reach the almighty. Religion and literature apart, we all can realize the important role that our teachers have played right from elementary school days to university education. Not only have they been our academic advisors and preachers at each juncture of our student life, but also many times played the role of a mentor, a friend, and a parent for us.

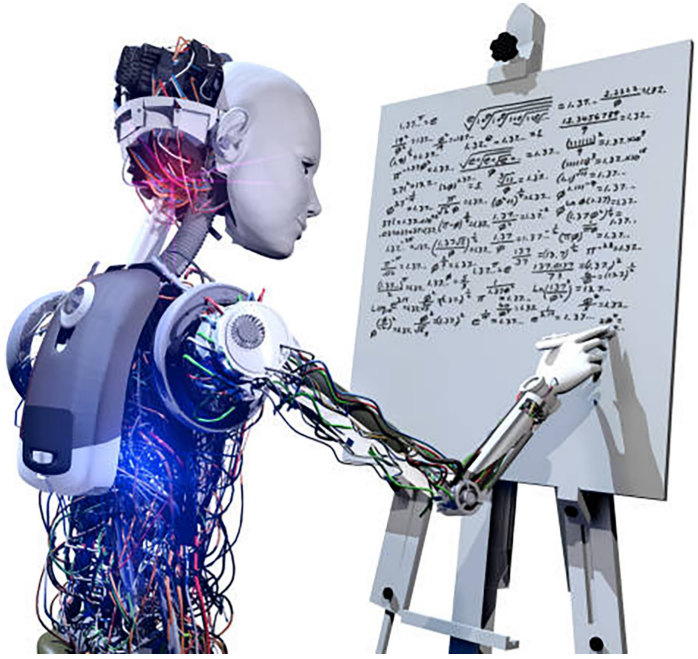


Figure 4.1: *Teachers are the linchpin of any educational institution*

Although teaching is regarded as one of the noblest professions on this planet, it is important to understand that it is also one of the most difficult to practice. A teacher not only needs to understand the topic at hand but also make sure that it is clear to every student in the class. The teacher, hence, requires some tools that might not only help them to make the content comprehensible to every student but also manage the class efficiently alongside the plethora of tasks that they do day in and day out.

Structure

In this chapter, we will cover the following topics:

- Current methodologies followed in teaching and learning
- Machine learning use-cases and applications
- Machine learning for special education
- Project ideas for the reader

Objectives

This chapter mainly focuses on the different ways in which machine learning can help parents to understand their child's educational progress better. The reader will be able to understand the relationship between parents and children when it comes to their studies and planning for the same. Understanding this relationship will allow one to figure out the right flow and techniques that the parents and students need to use on their part to see steady progress in academic results. The chapter also enables the reader to get a grasp on how the day-to-day activities of a parent in overseeing their child's education can be eased by using machine learning and how such implementations can be carried out by the reader themselves, as suggested by the project ideas in the final section.

Current teaching methodologies

Methods of teaching have undergone several cycles of change and development in the past several centuries. From verbal preaching under the shade of a tree in ancient times to the chalk-and-blackboard standard of today's schools and universities, teaching has seen numerous changes to accommodate the students' requirements and the teachers' convenience in setting up a good learning environment. Focusing on the contemporary standards of classroom teaching, the common practice is that the teacher refers to a textbook while explaining certain concepts from a particular chapter to a group of students, often taking the aid of tools such as a blackboard, diagrams, charts, or scientific models. In the current digital world, these tools may also include presentation slides, video, and audio clips to further facilitate the teaching process.

Time for fun!

List down the strategies that your teacher used/uses to teach and control the class. Illustrate any technological aids that they use.

In response to this activity, students in the classroom often ask questions about the concept just explained, to which the teacher clarifies their doubts. In certain cases, the teacher may ask the students to read portions from the textbook aloud in the classroom, which the other students follow, and the teacher explains the same. This is generally the trend in subjects related to language and humanities. Subjects pertaining to science, mathematics, and finance often require demonstrations and derivations on the blackboard and the use of diagrams. Students are often handed out homework assignments to be submitted by a prescribed due date, which are graded by the teacher, and a record of the same is maintained. These continuous evaluative components, along with other major components like mid-term and final examinations, are used by the teacher to assign a final grade in the course to the respective student.

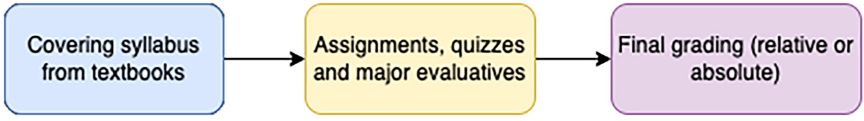


Figure 4.2: *A flowchart describing the typical steps of teaching a subject*

This system and several others on similar lines have been running successfully all across the world for several decades and are still developing and improvising. However, such a well-structured system can also inherently carry inefficiencies and loopholes. Over

the years, classroom sizes have been increasing, and it becomes difficult for a teacher to manage classrooms, sometimes consisting of more than 50 students. Ensuring that every student in the classroom is able to follow and grade assignments and tests for such a large number of students is often overburdening for a single teacher. If one can take a look at the bigger picture, it is not difficult to realize that such difficulties and inefficiencies arise mainly due to the reliance of all classroom activities on a single person's manual effort. If activities such as doubt clearance, assignment preparation and grading, and classroom management can be automated and strategized through technological tools, teachers will be greatly benefitted in terms of workload reduction and be able to focus more on what they are best as an individual: imparting knowledge.

Figure 4.3: *Professor M. seems concerned about the class's response…*

We will cover many such use cases where teachers can be helped by machine learning techniques to plan, strategize, and efficiently execute their day-to-day classroom activities. While we propose to contribute with as little as a few suggestions to ease their lives through machine learning, teachers shall always remain on the highest pedestal irrespective of the merits of technology.

"A teacher has two jobs: fill young minds with knowledge, yes, but more important, give those minds a compass so that that knowledge doesn't go to waste."

— Olympia Dukakis, playing Principal Jacobs in the movie "Mr. Holland's Opus" (1995)

Machine learning use-cases

This section talks about the different dimensions where parents are generally involved in their children's education and how machine learning can assist them in the process. We attempt to look at solutions that already exist in the market and how they can be modified and adapted to suit our purpose.

Content delivery

Content delivery is perhaps the most appealing quality that a teacher possesses by virtue of their experience and expertise in their subject. A brilliant scientist might have published hundreds of articles in their field of research producing groundbreaking results, but it always requires a teacher to explain the same to inquiring students. It is a teacher's novel way of imparting knowledge that makes them unique and approachable. However, it might become a bit difficult to make sure that the topic being taught in the classroom is being followed by every student in the class. Addressing this concern in classrooms of large sizes, such as 40 or 50 students, is not an easy task. There arise a number of factors that make this task difficult, such as the learning pace of each student, their past performance, and sometimes even language barriers. However, if we have data: lots and lots of data about students' learning patterns and preferences, machine learning can be used to help teachers identify certain students who require additional support and guidance in getting an equitable learning environment. Data about students' past grades in the subject and analysis of the teacher's teaching style, such as language, the pace of teaching, homework assigned, and so on, can be used to form a correlation between these parameters. Clustering algorithms can be used to group students based on their grades and response to different styles of teaching. These results can help a new teacher of

the class to form an opinion on the style of teaching that they can perhaps adopt and enhance by their own experience and dexterity.

Question recommendation

If a survey were to be taken for students across the world asking them about what is the most difficult task for them, then one can be sure that the majority of the answers would be to score good marks in examinations. Answering questions accurately in the exam within the stipulated time is indeed a difficult task. But perhaps what is more difficult is to create new questions for these examinations!

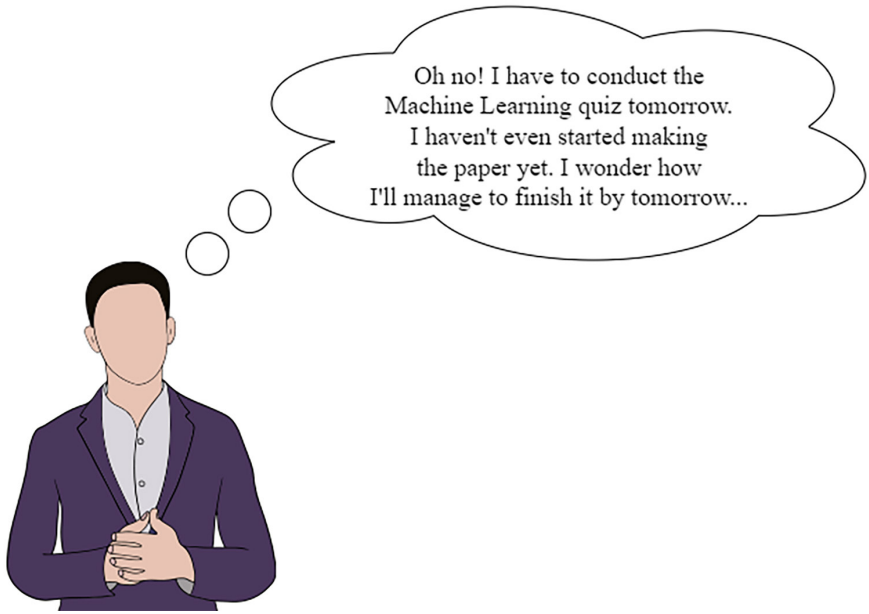


Figure 4.4: *Setting question papers is a tiresome task indeed*

Designing new and innovative question papers to test the student's learning inside-out is an intimidating and time-consuming task that teachers are often faced with. This job can be facilitated to an extent using machine learning applications such as natural language processing, text summarization, and sentiment analysis. Existing questionnaires can be used as training datasets to train models to learn about the context in which the questions are framed, any numerical data used in them, and the correct answers to those questions. A simple example for this use case can be that a question generator

generates a question such as "What is the main idea captured in the speech 'I Have a Dream'"? As the generator is capable of text summarization and sentiment analysis, it can also supply the teacher with a concise to the generated questions, so as to aid in grading and evaluation as well.

Time for fun!

What kind of innovative question formats can you come up with to make the examinations a fun process? List them down!

Automatic evaluation and grading

As highlighted in the previous subsection, a context-based question generator is capable of making questionnaires and also coming up with the correct answers to those questions. If we look a bit more closely at the use case, then we can realize that the machine should also be capable of summarizing the students' answers to the questions. The chapter's summary and the answer's summary, as generated by the machine, can then be compared for similarity, and based on the similarity, scores can be assigned to the students. Similarity scores between students' answers can also be used to detect plagiarism and the use of unfair means.

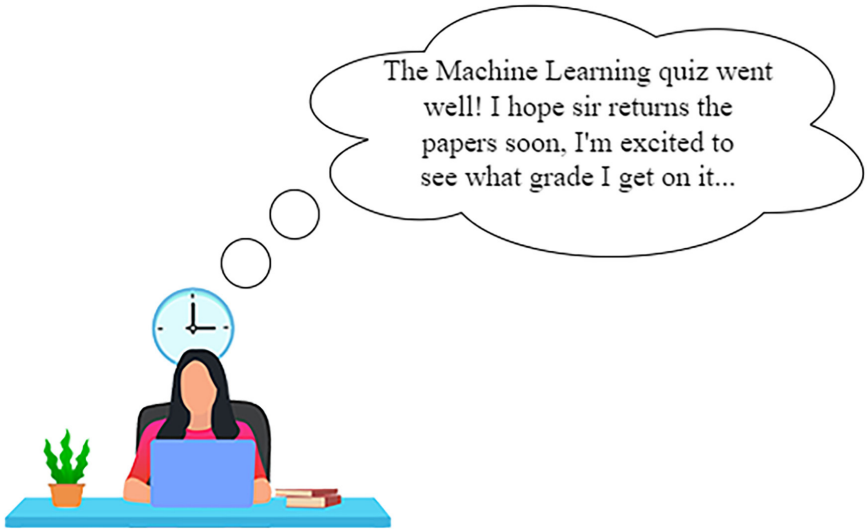


Figure 4.5: *Let us see how fast Professor M. can evaluate all the answer sheets!*

Teachers are also often assigned the task of coming up with a grade distribution for a batch of students in a subject, the task being more difficult when the performance of the batch has been skewed because of some reason and when the grading has to be done relatively. A relative grading scheme is one in which letter grades are assigned to students on the basis of their rank in the class and the overall performance of the batch. This is in contrast to absolute grading, where letter grades are assigned solely on the basis of the marks obtained by the student. As an example, a student scoring 40 out of 100 on a test where the average score of the class is 15 is sure to score an A+ grade if the grading is done relatively. However, the same student would score no better than a C grade if an absolute grading scheme is followed, despite the student being among the top performers in the class. In such cases, to perform an equitable yet accurate grading, a statistical model can be used to assign grades to the batch in seconds. The soundness of the grading can then be verified by the teacher, and they take it on from here, with the majority of the task being eased by the machine learning algorithm for assigning grades.

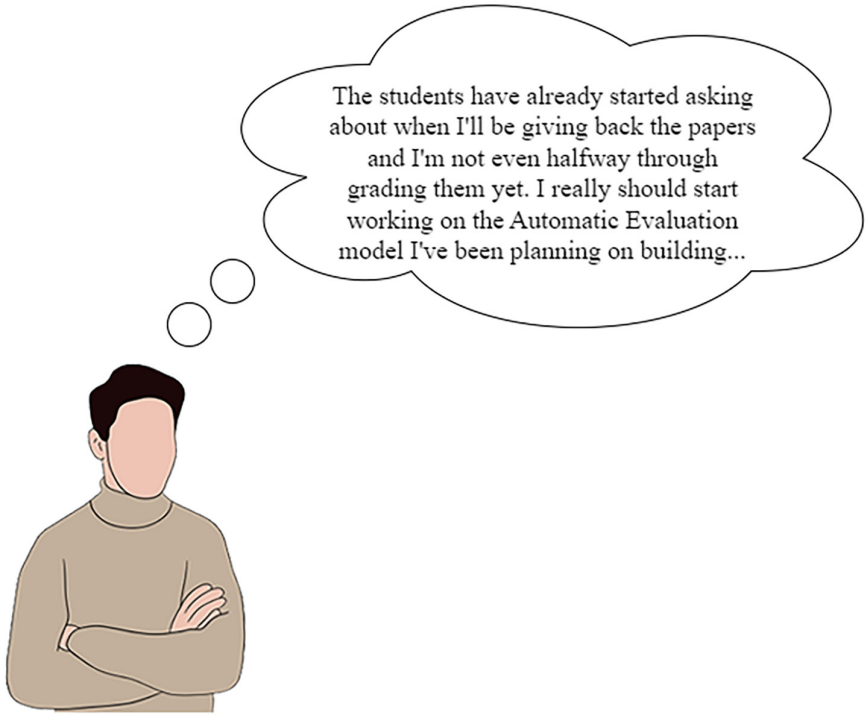


***Figure 4.6**: Uh, oh! It seems Professor M. Is yet to complete the evaluation.*

We have seen how machine learning can assist parents in monitoring not only their children's academic progress but also their children's mental and physical well-being. Such tools will greatly help to bridge the gap between parents and their children's education, which many parents feel exists in their case. The next section now proposes some ideas for the reader to think about so that they can develop tools to help parents in engaging with their ward's education.

Machine learning for special educators

In *Chapter 2, Machine Learning for Students,* we discussed students who require special attention from parents, teachers, and peers in order to feel welcome in an equitable and healthy learning environment. Such students suffering from autism, dyslexia, and hyperactivity are often restored to mainstream life to an extent by the careful and

affectionate guidance of a good teacher. We believe that if a teacher's skill and experience to guide such students can be equipped with the planning and logistic assistance of machine learning, special education can get a boost, especially in countries where the idea of special education is still seeing its genesis.

Teaching students with autism

Autistic students often take time to get comfortable with a new person, even within their family, much less a teacher in their school. It is extremely important that such students be spoken to with care and affection, something which is difficult for a teacher new to the field. Often it is difficult to judge whether a student is suffering from autism or not if we are looking at any other batch of students. Machine learning can be used here to aid teachers in identifying students who might be autistic by analyzing their behavioral patterns, such as eye contact, speech, and social interaction with peers and teachers through video or audio clips. Today, it is possible to detect autistic children as young as six to seven years old through video analysis using advanced neural network models. Thus, a teacher can very well identify autistic students using these tools and make sure to handle them with the additional attention and care that they often require.

Teaching students with dyslexia

Students with dyslexia often face difficulties in reading, writing, and basic motor skills such as tying shoelaces or fastening clothes that most other students of their age do without much difficulty. Such students are observed to be making repetitive and predictable mistakes in writing or reading. Examples of such mistakes could be mixing up spellings of words that sound similar, writing a character in an inverted or upside-down fashion, or getting confused between similar-looking characters such as "b" and "d," "p" and "q," "6" and "9", and so on. The repetitive nature of their mistakes should be perceived as a boon rather than a bane in the direction of their remedy. One of the simplest ways of correcting mistakes in writing characters is to show them the same character written in different scripts, styles, and sizes. While asking humans to write down all such examples is

a difficult task, this exercise of generating characters and words in different styles can very well be automated by employing **Generative Adversarial Networks** (**GANs**). Such generative networks are powerful in producing images (and even sound text or poetry!) similar to real-life images of a wide variety of objects. Other examples of such generative networks are autoencoders and variational autoencoders, but perhaps GANs are the most suited model here. These GANs can be used to produce a huge set of characters and words in different styles and handwriting, which can be given to the child to identify and distinguish the good ones from the bad. In essence, the students are acting as the discriminator in the GAN after the generator has been trained well enough to produce these images. In the process, the student will learn to identify the correct characters, words, and spellings and overcome their difficulties in reading and writing.

Machine learning has been in popular use for the past few years in teaching and treating children with learning disabilities and behavioral issues. Many universities, such as the *University of Geneva, Switzerland* and the *University of Genoa, Italy,* have been successful in devising models to detect such issues in children. Machine learning, therefore, is, very optimistically, the way forward in special education.

Project ideas

We now present a number of project ideas for the reader to ponder upon and think of novel solutions to the underlined problems. The essence of this section is to capture the issues faced in conventional methods of teaching and address the same using machine learning solutions.

To develop a GAN-based handwritten digit generator

As highlighted in *Teaching students with dyslexia*, GANs can be used to produce a variety of images pertaining to a certain class, such as digits, characters, and so on. Your task is to design and develop one such GAN to produce handwritten digits in different styles. You can refer to the MNIST dataset for handwritten digits to get an idea of the problem statement's expected result.

To develop an automated relative grader

Relative grading requires the different students of a class to be allocated letter grades on the basis of their standing in the class, irrespective of the absolute marks scored by them. It is required that these grades be allocated keeping in mind the total number of students in the class, the mean and median score of the class, and the number of students allocated to each grade. The final aim is that the distribution of grades should be equitable with respect to the mean score of the entire class. For example, if the course was on the easier side, the mean score should be normally high. In this case, it is sensible to give "A" grades to very few exceptional students, and a larger fraction of the students are to be given "B" and "C" grades. Fail grades should again be given to a few students, given that we do not want to mess up their transcripts too badly! If the course was comparatively difficult, it makes sense to give an "A" to a higher number of students and a "C" grade to a lesser number of students. Such heuristics are left to the reader. The objective of this project is to automate the entire process of grading, thus easing the lives of our hardworking teachers.

To develop an intelligent tutoring system for autistic and hyperactive students

In this project, we aim to propose a system making learning and examinations more accessible for autistic and hyperactive children while encouraging the right behavioral and emotional attitude in them. Autistic children tend to have a lesser degree of verbal skills when compared to their peers and are known to resist exams as they are less concerned with others' judgment of their abilities; hence, external intervention would be helpful to make evaluations more effective. Children suffering from hyperactivity are seen to be impatient and restless at the time of studying or attempting assignments. Even trivial things, such as the choice of colors or the choice of font, could make such special children uncomfortable.

On the other hand, the right choice of such factors can encourage them to enjoy the process of learning. The solution would enable assessments to be conducted for autistic children more effectively by catering to their required soothing stimuli by varying the pace of exams, changing visuals, involving auditory response with a controlled volume level, and so on. This will be done in accordance with the visual response shown by the child through facial expressions. This would ensure that autistic children get the fair assessment that they deserve and are not put at a disadvantage when compared to their peers, and hence, do not feel left behind. All this keeps in mind the sense of equality that each human being deserves. The reader should come up with their own set of ideas to assist such children in getting access to quality educational resources suited for them and devise an implementation plan to make the same accessible to them.

Conclusion

Parents are almost always more concerned about their children's education than the children themselves. It is often required that before understanding their child's educational progress, they understand their educational process thoroughly first. This chapter has discussed ideas that address exactly this concern and help parents to better understand their child's studies and possible areas where they can help.

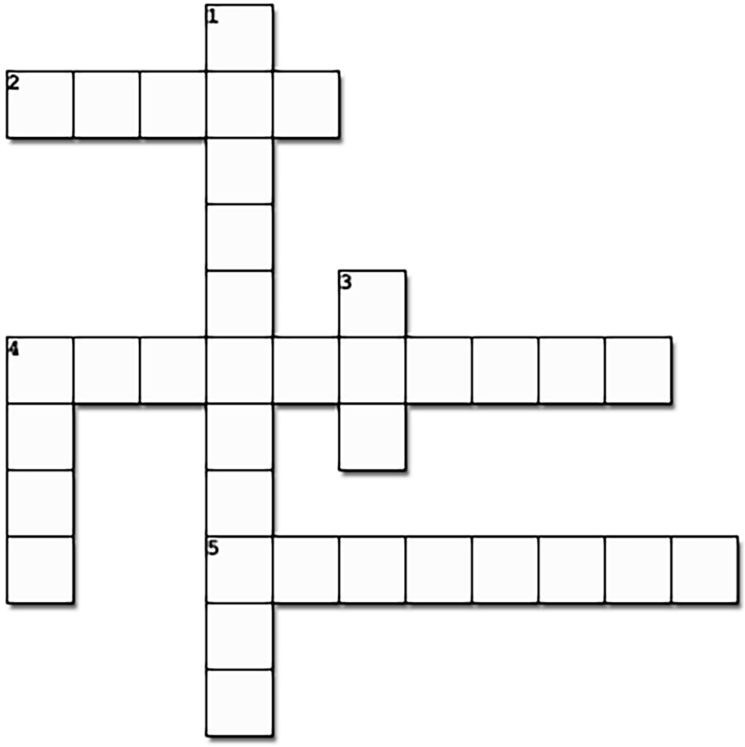
The options for parents that are described here are similar to those for kids that were covered in the previous chapter. The main topic covered in this chapter is how parents may assist their children in overcoming the challenges they confront when studying and how they can better comprehend their child's progress. Along with the answers provided by machine learning for parents to assist their children, several facets of children's mental and physical wellbeing have also been covered in this chapter.

We've finished talking about the house now that we've explored how we might assist children and their parents in enhancing their academic achievement! Let's now examine how machine learning can be applied in educational institutions to create practical tools and applications that can assist teachers and institute administrators in delivering improved educational standards at their temples of

knowledge. The following chapter discusses how machine learning can assist educational administrators in offering better and more efficient modes of content delivery and evaluation, freeing up more time for interaction between educational administrators and students and improving both parties' time utilization.

Chapter-end word grid!

Find words related to the chapter in the following word grid.



Across

2. It is possible to detect autistic children as young as 6-7 years old through _____ analysis
4. _____ scores can be used to evaluate answer correctness and detecting plagiarism.
5. In _____ grading scheme, letter grades are assigned to students on the basis of their rank in the class

Down

1. Machine learning can be used here to aid the teachers in identifying autistic students, by analyzing _____ patterns
3. A _____ can be used to produce a huge set of characters and words in different styles and handwritings
4. _____ algorithms can be used to group students based on their grades and response to different styles of teaching

Exercises

1. **Fill in the blanks.**
   a. Similarity scores between students' answers can also be used to detect _____ and _____.
   b. GANs can be used to produce a huge set of characters and words in different _____ and _____.
   c. The job of setting question papers can be facilitated to an extent using machine learning applications such as _____, _____, and _____.
   d. Machine learning can be used here to aid the teachers in identifying students who might be autistic by analyzing their behavioral patterns such as _____, _____, and _____ through video or audio clips.
   e. _____ can be used to group students based on their grades and response to different styles of teaching.

2. **For each of the following statements, indicate whether they are true or false. If the statement is true, write "T" in the box next to it. Else, write "F" in the box.**
   a. With respect to deep learning, GAN stands for Growth Analysis Networks. ☐
   b. In relative grading, the student's performance is not compared with that of the rest of the batch while assigning grades. ☐
   c. Machine learning can be used to identify autistic students by observing their behavior through video clips. ☐

d. Data about students' past grades in the subject and analysis of the teachers' teaching style, such as language, the pace of teaching, homework assigned, and so on, cannot be used to form a correlation between these parameters. ☐

e. Designing new and innovative question papers to test the student's learning inside-out is often an intimidating and time-consuming task. ☐

3. Answer the following questions briefly.

a. What are the difficulties that teachers face on a typical day at school?

b. How can technology be used to ease the problems identified in the preceding question (a)?

c. What problems are faced by teachers in content delivery while using conventional methods of teaching? Are there any reasons that you think which does not encourage them to switch to modern technology, especially machine learning techniques?

d. What factors make it difficult for teachers to judge if the classroom is able to follow the content being taught in the class?

e. How can machine learning be used to ease the task of analysis in the preceding question (d)? Give details of your approach.

f. How can questionnaires be used to train question paper generators? Explain your approach to data collection and analysis using a suitable machine-learning algorithm.

g. Compare and contrast relative and absolute grading. Which of these is more difficult to handle, and how can machine learning be used to ease this difficulty?

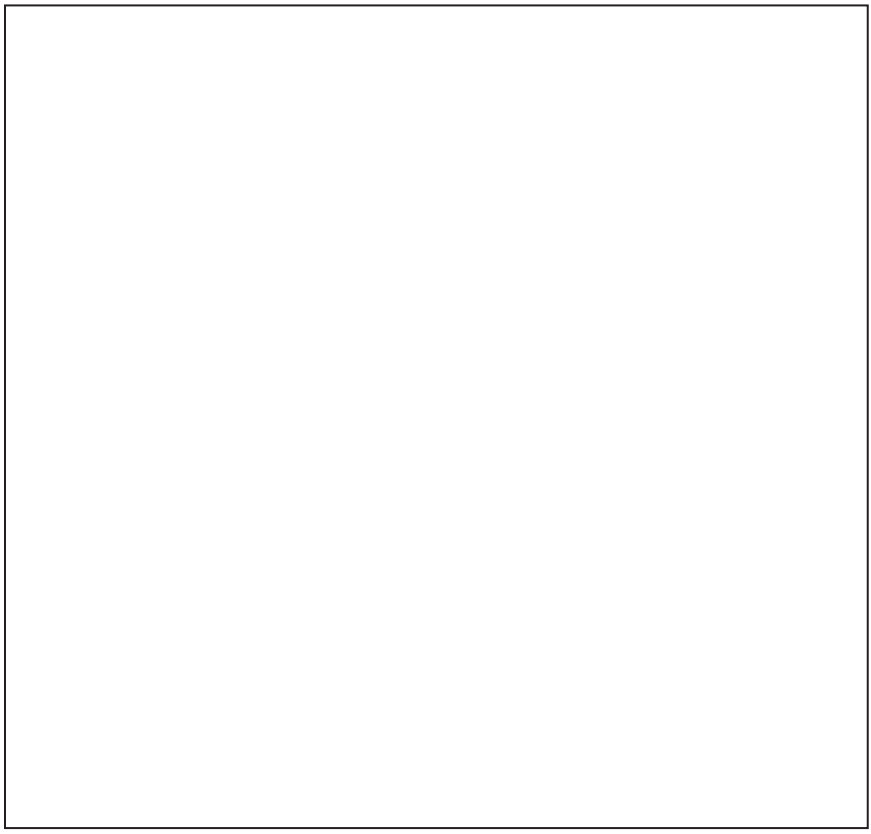
h. Elucidate an approach that could be used to analyze behavioral patterns in autistic students using video and audio clips.

i. What are the common difficulties that are faced by students suffering from dyslexia in schools? What are the methods that are traditionally used to ease these difficulties?

j. What are some machine learning techniques that can be used to ease the difficulties identified in the preceding question (i)?

4. **Do you think that reinforcement learning techniques can be used to teach students with dyslexia effectively? What would be your approach in designing such a technique?**

5. **Read about the work by researchers at the University of Geneva on the analysis of Autism Spectrum Disorder (ASD). Taking inspiration from their work, propose your own machine-learning approach to identify autism and hyperactivity in children of early ages, explaining your design through a flow diagram.**



6. **Read about a machine learning paradigm called Active Learning from the literature available on the Web. How do you think active learning can be used in classifying students into groups of different learning capabilities? Try to come up with an approach that includes clustering techniques. Explain the details of your approach.**

_____

_____

_____

_____

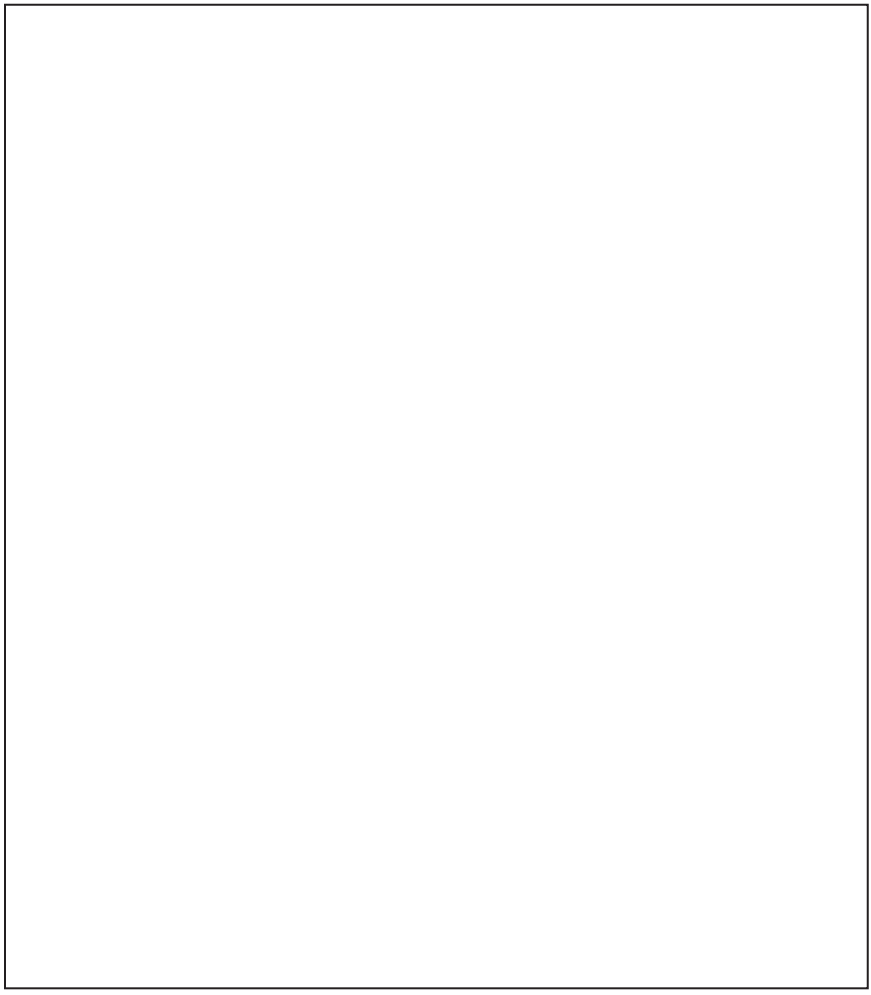
_____

_____

_____

7. **One of the most widely used handwritten digit datasets used worldwide is the MNIST Handwritten Digit dataset. How can a GAN be trained on the MNIST dataset to generate new handwritten digits which can be used to assist in teaching dyslexic students? Give details about your training and testing process using a flow diagram.**

8. **Make a mind map to summarize all the concepts covered in this chapter.**



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Chapter 5

Machine Learning for Educational Administrators

Introduction

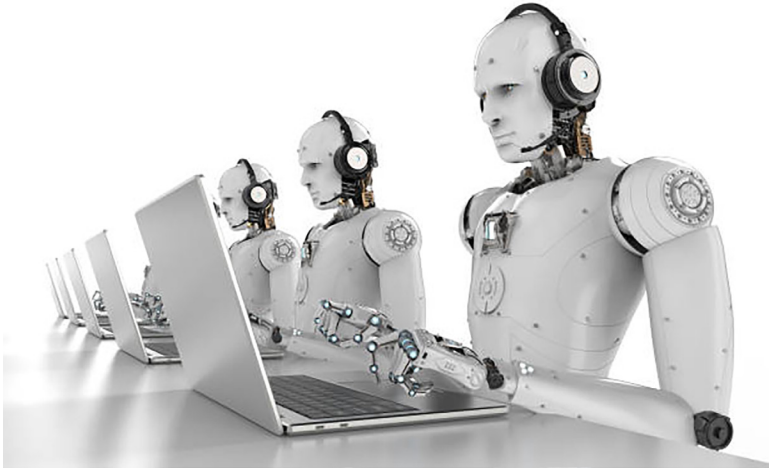


Figure 5.1: *Quality education is largely contingent on quality administration*

A significant portion of an individual's personality and knowledge is influenced by the educational environment and institutions they

have attended. The sheer amount of time and effort parents put into finding the best school for their children is representative of this fact. The same also applies to finding the perfect university that will shape a student's career and other future endeavors. Educational institutions play a huge role in not only determining the academic prowess of a student but also a number of personality traits such as confidence, teamwork, and leadership necessary both in the workplace and outside.

Premier institutions across the globe are run by highly esteemed principals and deans having years and even decades of experience in the field of education. Their leadership is defined not only by their strong foundation in their respective fields but also by their profound understanding of students' psychologies, their needs and wants, and their ability to address tricky situations rooted in finding the balance between a child's life as a student and a human being. Running such institutions involves handling multiple dimensions of education in tandem with each other, such as recruiting instructors, managing student admissions, overseeing infrastructure, and so on. We are again faced with a familiar problem! Here, we again see a large number of variables being handled by a single human to solve some particular problem. Whenever such a situation arises, we have seen that using a machine to figure out the optimal solution works better in the long run. Machine learning algorithms are so versatile that they can even help in tackling the tricky problems we mentioned previously that all educational institutions face from time to time. In this chapter, we will unpack a number of such techniques that will help administrators of educational institutions, such as principals, deans, coordinators, technicians, and so on, to solve multiple challenging situations faced in such institutions in a streamlined and time-efficient manner, thereby alleviating their own workload to an extent.

Structure

In this chapter, we will cover the following topics:

- Common tasks encountered by administrators at institutions
- Machine learning use-cases and applications

- Machine learning in the relation between government and educational institutions
- Project ideas for the reader

Objectives

This chapter describes the different tasks and challenges faced by administrators at various educational institutions throughout the academic year. While we explore the intricacies associated with each of them, we also try to figure out how the task can be accomplished by a structured plan to minimize time, effort, and resources in doing so. The primary focus will be on figuring out machine learning algorithms that might be suited to the particular situation and how institutions can procure the necessary technological resources to reap their benefits. The chapter also talks briefly about how the government can be of assistance in this context and how a collaborative effort between the government and schools aided by machine learning can go a long way in shaping the educational vision of a nation.

Educational activities around the year

Schools and universities across the world today house and impart education to 1,000–2,000 students per batch nowadays. For each batch, the task of imparting knowledge is entrusted with roughly 50–100 instructors and lab assistants. It goes without saying that managing such a huge student population and workforce is a mammoth task for the administration of any institution. But the story does not end here. There are many other tasks apart from managing human resources that administrators are faced with day-in and day-out throughout the year. Let us look at them one by one.

Managing student admissions

"You all want to know the secret formula for getting in. To do your job well, an admissions officer must be on the receiving end of an entire nation's application panic, endure the frustration of all the parents who just realized there isn't room for every organically fed, well tutored offspring. Of course everyone thinks we're sadists, that we like saying no. We are in this job for one reason, to say yes."

– Tina Fey, playing Portia Nathan,
an admissions officer in the movie
"Admission" (2013)

During a school's early years, student admissions are relatively on a lower scale as the school is still in the process of building a reputation for itself. During this phase, managing student admissions is a somewhat simple task as the school is not overwhelmed by a large influx of student applicants during the peak season of the start of the academic year. The administrators are well aware of the school infrastructure and the number of students that it can support per incoming batch. As the years pass with school, the number of students that have been studying in the same increase as a result of the school's increasing reputation and also the word-of-mouth publicity that the school has earned. When the school observes that the number of students is increasing, it should start working on expanding its infrastructure to support the growing number of students per batch. A new problem that the school is now faced with is that the number of students that are applying to take admission into the school often surpasses the amount of students that the school's infrastructure can now support. It is a common observation that infrastructure grows at a slower pace than the number of applicants for almost every school across the world. In such a situation, the school has to make a decision on which students to intake and which applications to reject.

Therefore, the school's new problem is not only about expanding its infrastructure but also about deciding on which students will finally take into the new batch.

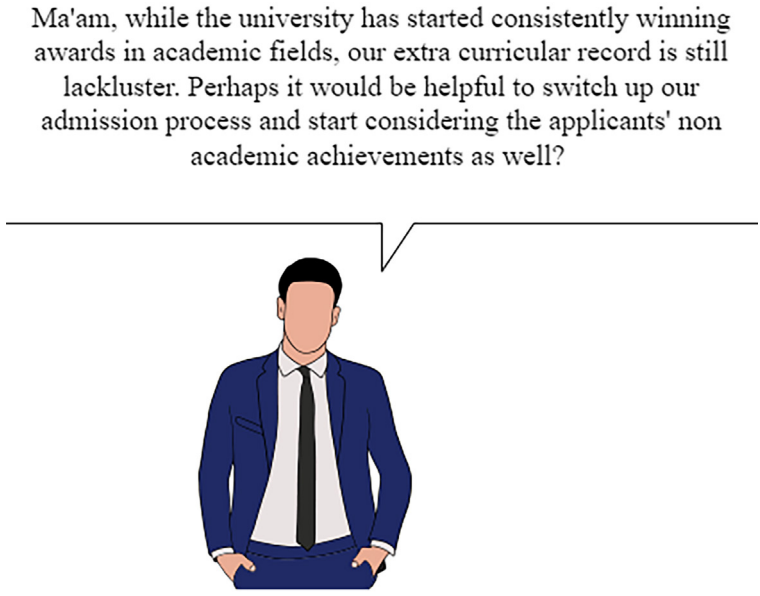


Figure 5.2: *Professor M. has a suggestion!*

In this process, the administrators need to consider a large number of variables at once. It has to decide on which factors it should screen and consider the student applications. There are a number of parameters to be taken into account when considering a student for admission into the school, such as their performance in the previous school, co-curricular achievements, and often an admission test and interview. Which factors to give more weightage to and which to prioritize less is another challenge in itself. We will be discussing how to handle such a large number of variables in order to prioritize student applications in the forthcoming sections and how machine learning can be useful in such a situation.

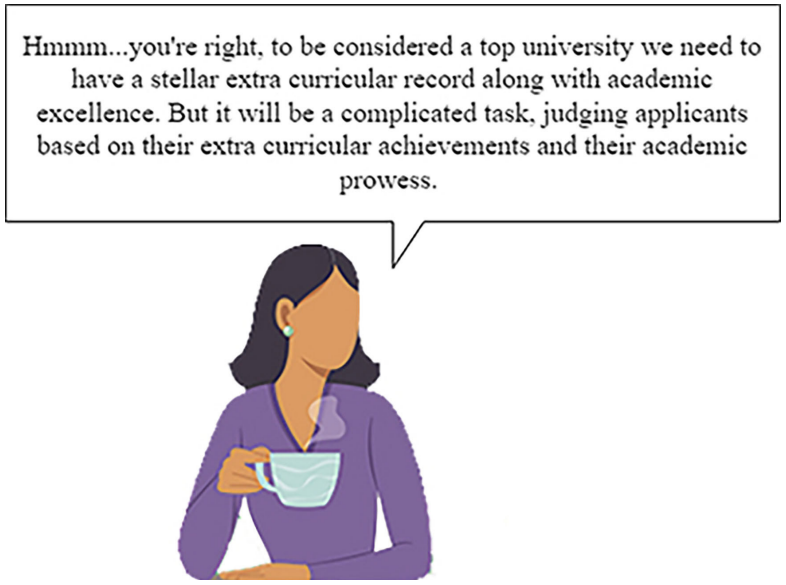


Figure 5.3: *Seems like the principal likes Professor's M. although she seems a bit concerned about its execution*

Staff recruitments

It goes without saying that managing a large school requires experienced and efficient staff consisting of teachers, lab assistants, librarians, technicians, accountants, and so on. To handle the recruitment of such a large team will require a robust and efficient system, such that the recruitment will not only be transparent and fair but also that only the best out of the best will be taken into the workforce. This requirement becomes even more pronounced when it comes to the recruitment of teachers. A school's performance depends to a large extent on the quality of instructors that it uses. The teachers' prior experience in teaching and research is of paramount importance when it comes to importing quality knowledge to the students.

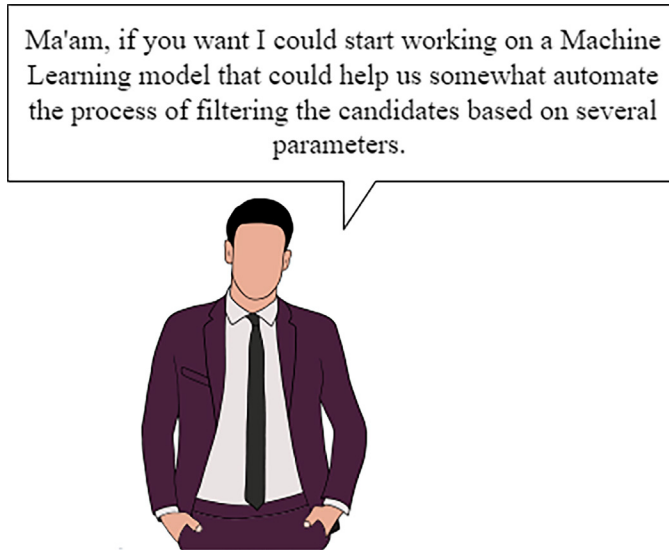


Figure 5.4: *Professor M. always has an idea in mind!*

Figure 5.5: *We have got the green signal!*

It is this experience that helps them to clear students' doubts as well as to prepare them for curricular and competitive examinations. An example of this fact can be seen in the recruitment of teachers in the coaching institutes of Kota, India. Whenever a new institute in Kota

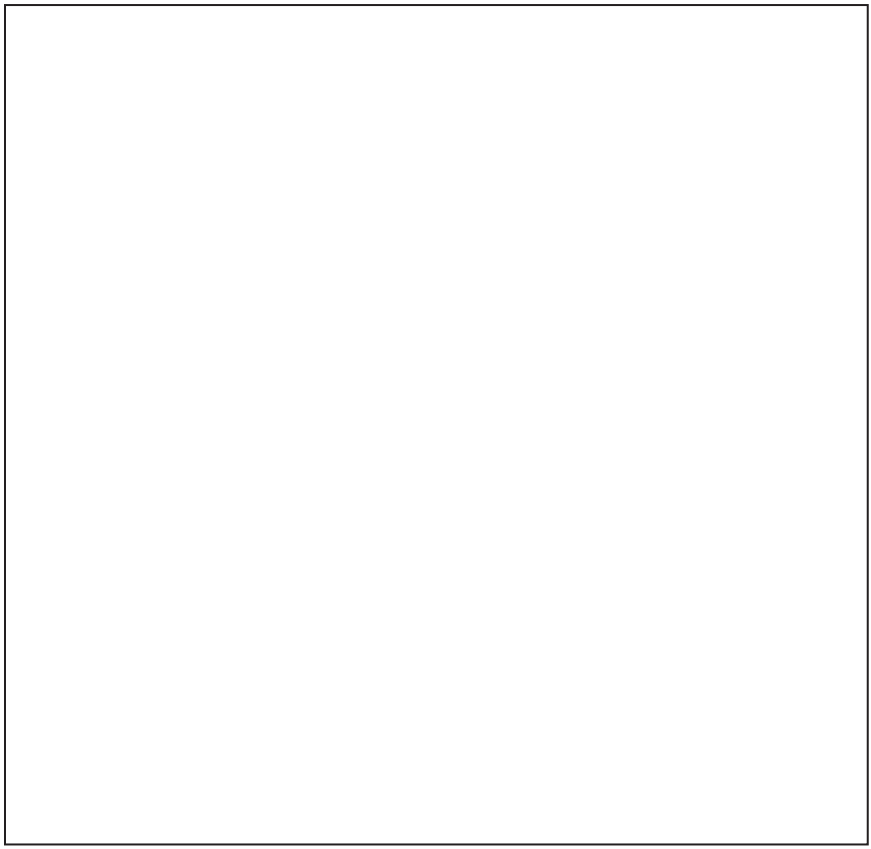
advertises itself, it almost always mentions that its faculty comprises the teachers that, once employed, were in the most premier institutes of the city. This makes parents, as well as students, believe that the instructors teaching in a particular institute are one of the best because they have gained their experience from the best institutes that existed previously or might even be thriving now. It naturally gives them confidence that their own performance will be boosted, and they will be able to reap the benefits of their hard work through the guidance of such teachers.

Figure 5.6: *The principal seems to be intrigued by machine learning models already*

Institutes, schools, and universities follow a similar pattern and work on recruiting teachers from the best institutes across the world while putting a high emphasis on the research profile of instructors suited to the particular department and the overall vision of the institution. As difficult as the job of recruiting might seem to be in the first instance, it is fortunate that we have machine learning techniques that can help us to ease this mammoth task. We will be discussing how existing machine learning algorithms can help in different phases of recruitment, such as screening applications and resumes, as well as conducting interviews.

Time for fun!

List down the processes and parameters observed by you during your admission or recruitment to a school or university. Which things do you think could have been improved using technology?



Infrastructure management

In order to run a medium to large-scale school or university, it is required that the institution houses a number of state-of-the-art facilities and infrastructure, such as spacious classrooms, laboratories, music rooms, and playgrounds and gymnasiums. The requirements might differ from the nature of the institution and its overall goals and motto. Institutions these days are so advanced that they also house remote teaching facilities and e-learning facilities so as to keep up with the pace of the modern world. However, the number of such

facilities that can be offered often depends on the finances of the school, as well as the number of students that are currently enrolled. For example, if a new school has an enrollment of 10 students per batch or grade, then it does not make sense to build a swimming pool. However, it does make sense to build such facilities, such as swimming pools, gymnasiums, large-scale laboratories, libraries, and so on, as and when the number of students increases and when the finances of the school are stable enough to build as well as to maintain this infrastructure. To decide on which resources and facilities to prioritize and which ones to plan for the future is another task that is often faced by educational administrators. In such a situation, machine learning algorithms can help to recommend facilities and infrastructure based on the current needs as well as help in sorting out the finances related to the same.

Machine learning use-cases

Now that we have discussed the various problems that educational administrators are encountered with throughout the year, it is time to discuss some solutions for the same. We will be employing machine learning techniques suited for each situation, where we propose new solutions as well as propose enhancements of the existing solutions that administrators often use. Let us look at the different use cases of machine learning in educational administration through the perspective of students, teachers, and the administration.

Managing student admissions

As we saw in the previous section, managing student admissions is a mammoth task in any institution, especially for the ones which have been there for some time and now see the influx of a large number of students each year. Two solutions seem the most obvious to tackle this situation. One of them is to expand the infrastructure of the institution so as to support the growing population of students. This solution might seem infeasible for institutions that might not be financially sound to execute such an expansion. Even for institutions that might be backed by strong financial sources, the rate of expansion needs to match the rate of growth of the student population. With each passing year, the number of students who apply for a reputed

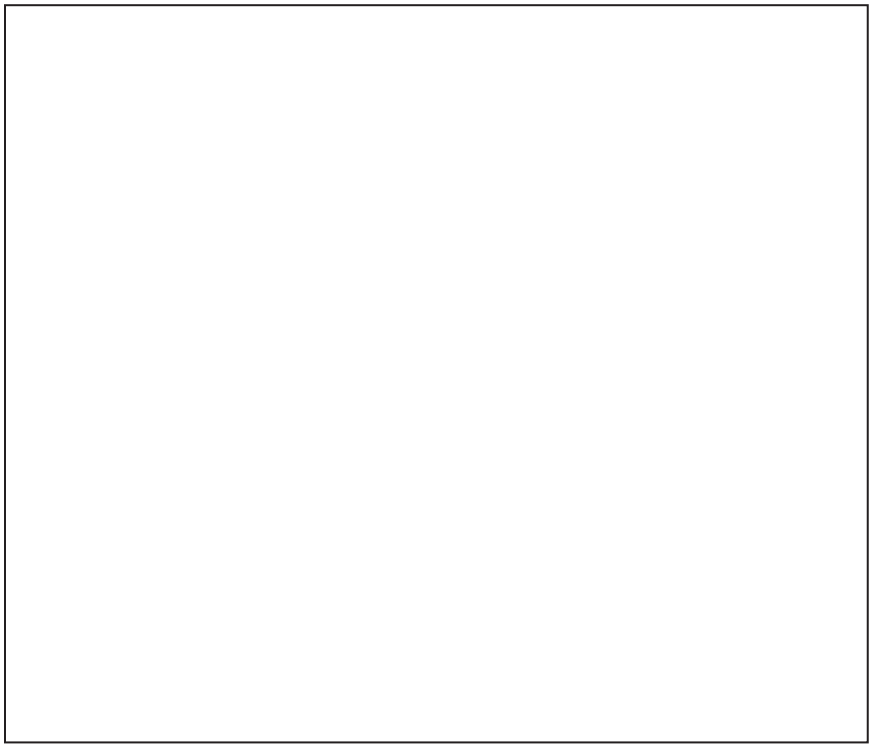
institution naturally increases owing to the growing reputation of the institution. However, infrastructure growth can take place at a relatively constant pace, given the constraints of labor and technological logistics. On an overall, this solution though seeming perspective at first glance, actually might not be really fruitful.

The other solution is to filter student applications. This is the most widely accepted solution in schools across the world, where only a select number of students are allowed to take admission at the start of each academic year. There are different modes through which institutions conduct this selection process. Many institutions conduct their own admission examination, which tests the applicants based on their previous academic curriculum. While each primary or secondary school has its own standards and syllabus for such an admission examination, universities generally conduct this examination based on a syllabus that is common across different school boards and is conducted at a national or even international level. Popular examples of such examinations in India are BITSAT (for admission into the campuses of Birla Institute of Technology and Science Pilani), VITEEE (for admission into the campuses of Vellore Institute of Technology), JEE Advanced (for admission into the Indian Institutes of Technology), AIIMS (for admission into the campuses of the All India Institute of Medical Sciences), and so on. There are other national entrance examinations, such as JEE Main, NEET, and various state entrance examinations, such as West Bengal JEE, Gujarat CET, and so on, that many universities consider screening applicants for their new batch of students. Other examinations, such as SAT, GRE, TOEFL, and so on, are recognized in universities spread across the globe. Many of these schools and universities often conduct an interview with the student and even their parents as a further round of screening. Many other factors, such as academic performance in previous grades or school passing examinations, achievements in sports and cultural activities, involvement in social services, and so on, are taken into account while deciding whether or not to accept a student's application. The preceding solution seems to be reasonably feasible for any institution if they have enough workforce and time to screen all applications, each of them differing on a large number of variables. But workforce and time are both expensive and scarce in today's world! Is there a way that we can automate this entire

process and entrust a machine to carry out the screening procedure? That is exactly what we are going to find out now using machine learning algorithms.

Time for fun!

Suggest some innovative methods to ease the process of testing students on the spot during admissions. Put your thinking hats on, and try to incorporate machine learning into your approach!



What we basically have in hand is a classification problem. You may wonder what we are trying to classify. We are trying to classify student applications into strong and weak categories, where the institution is interested in selecting only the students who fall into the strong category. While categorizing an application as strong or weak is a very subjective and contextual question, we need to be objective in our approach when we want a machine to classify the applications. We need to specify certain criteria or parameters on which our algorithm should base the classification of a particular application

that is provided to it as the input. Selection of these parameters is a task that is perhaps best accomplished by the administrators of the institution as they best know the goals and student population of their institution. Again, we cannot take into consideration a large number of parameters as most of these will not be of much importance for every institution. Another problem associated with considering a large set of parameters to classify applications is that many machine learning algorithms perform poorly in a situation where they are tasked with considering the sheer amount of variables before making decisions. There is a popular issue associated with the domain of machine learning called the "curse of dimensionality," which talks about how a large number of dimensions (or parameters) in the input data can render each data point to look roughly similar to each other, and that it becomes difficult to separate out clusters of certain data points from the entire dataset in such a situation. Therefore, parameter selection is one of the most important steps when it comes to designing any machine learning model for a classification system. For example, an engineering school might be interested in the scores that the applicant has achieved at school in the subjects of mathematics and sciences. A journalism school might be more interested in the student's scores in subjects related to language and humanities and also achievements in extracurricular activities such as public speaking, debating, and so on. Students entering through quotas such as sports and athletics are assessed highly on their achievements in sports events at regional and national levels. Therefore, we see a different set of parameters suited to each school which makes parameter selection such an important and customized process. The dataset for training the model can be the collection of applications from previous years and labeling each application as finally selected or not. This label will be used by the model to learn whether a particular set of values for each of the parameters amounts to a strong application or not. As we have seen before, this mode of learning falls under the category of supervised learning. A good choice for a machine learning model in this context is an **artificial neural network** (**ANN**). The ANN takes as input the specified parameters and associates weights to each of the parameters based on their relative importance. Finally, through a series of non-linear activation functions and an intricate network of neurons interconnected to each other through weighted connections, the ANN produces an output that is representative of

the chances p of the application being a strong application. It is up to the administrators to decide the threshold of p above which to qualify an application as strong or not. Once the model has been trained on the dataset from previous years and its accuracy has been validated using an appropriate validation dataset, it can be used to predict the chances of a new application being classified as a strong application.

Recruiting staff and teachers

The workforce of any educational institution has a huge responsibility of not only imparting knowledge to the students but also handling the institution's other day-to-day activities. These may include tasks such as overseeing lab sessions, procuring the resources and technologies for them, conducting examinations, managing accounts, and so on. Staff for such daily activities requires not only skillful but also efficient individuals who can be trusted to make arrangements within deadlines and in a manner that is complementary to the academic calendar. The recruitment process therefore has to be extremely well thought of, similar to the case of planning student admissions.

Applications for such posts generally come in huge numbers, and different positions are suited to a different sets of skills. It is required that selection for these positions is done based on the skills that are being possessed by the candidate and that candidates be judged on the basis of prior experience and relevant achievements in their previous workplaces. For example, the candidate's merits in the subjects of science would be prioritized over their experience with physical education when we are recruiting a science teacher for a primary school. If an IT technician has to be recruited, then skills such as expertise in computers, networks, and often cybersecurity have to be taken into account. The post for a receptionist would perhaps be filled by someone possessing strong communication skills and good knowledge of their workplace, namely the institution in which they are working. We begin to see a situation similar to the one we saw in the situation of shortlisting student applications for admission. We see that there are different sets of parameters that have to be considered for each position that we are trying to fill. In each case, we need to select the set of relevant parameters that might

be of importance when selecting a candidate for a particular position. We once again return to the previous problem of parameter selection, which again rested with the education administrators of the institute, especially the recruitment managers. Here, the situation is a bit more nuanced than the situation of student admissions. However, we not only need to decide upon which candidates to recruit but also on the level of their post and the pay scale based on their experience. Let us consider this problem in a two-fold fashion. First, we solve the problem of segregating the strong candidates from the weak ones, which is the familiar classification problem. Next, we solve the problem of grouping the selected candidates to award a particular position to them in the institution as well as decide an appropriate compensation for them.

Time for fun!

Do you think a robot can be used to conduct interviews for candidates applying for jobs at an institute? What could be some interesting and funny loopholes where you think that the approach might not work? List them down!

The first problem of classification of applications into strong and weak categories can be solved by the methods of parameter selection and use of ANNs, as discussed in the previous sections. We introduce the application of another popular machine learning algorithm called **Support Vector Machine** (**SVM**) which might prove to be helpful in this context. SVMs are also supervised machine learning algorithms and have been extensively used in the industry for binary and multi-class classification problems. Because our problem is related to the classification between two classes, strong and weak, we are dealing with a binary classification problem. The SVM we discuss here solves such a binary classification problem. The SVM, when trained on an input dataset, is capable of learning a decision boundary between the two categories of datapoints. If we consider the datapoints to be points on a two-dimensional plane, we are considering a classification problem where each of the datapoint has only two parameters. The datapoints are distributed across the plane based on coordinates determined by their respective parameter values. The SVM finds datapoints that are closest to the boundaries between the clusters of respective categories of datapoints. These datapoints are generally difficult to classify as they could belong to either of the categories and are also called support vectors (hence, the name of the algorithm!) The SVM determines a separating line (the decision boundary) between these support vectors such that the two categories of datapoints are separated by the line. The same problem can be generalized to higher dimensions where the datapoints carry a large number of attributes, where the decision boundary is known by the general terminology of separating hyperplanes. The SVM, therefore, segregates our dataset of applications into strong and weak candidates.

Next, we solve the problem of appropriating a position and compensation for each of the selected candidates. If we look closely, we observe that grouping candidates with similar experience and profile for a particular position is similar to the problem of clustering these candidates into a number of groups based on certain parameters such as experience level, skills, achievements, and so on. For example, all candidates with experience of less than five years in ERP development can be grouped into one cluster, whereas candidates with experience between 5 and 10 years in ERP development and network administration can be grouped into another cluster. Yet

another cluster of candidates can be formed having experience of more than 10 years in more advanced skills. We see that a number of such clusters can be formed, and an appropriate position and pay scale can be assigned to the candidates in each of the clusters. Clustering algorithms such as K-means clustering are useful in such situations where it can cluster the dataset into appropriate clusters even in the presence of parameter sets of sizes up to 8–10. Hence, the task of recruiting staff and assigning them to appropriate positions in their respective departments has been solved by this two-fold approach using machine learning!

Infrastructure and inventory management

An institution is not only characterized by the merits of its teachers but also by the facilities and infrastructure that it offers its students. Education thrives in an environment that is equipped with the required materials to execute the concepts taught in the classrooms. In this regard, the environment is also characterized by the rooms in which this exchange of knowledge takes place. Spacious classrooms, comfortable seats, proper ventilation, ample lighting, and so on are factors that greatly improve the learning process for students across all age groups. Most schools today aim for these basic requirements in infrastructure, whereas there are others that have advanced towards air-conditioned classrooms and stair lecture theatres.

While these form the basic requirements for fostering productive learning in general, there are other infrastructures that need to be provided that differ from subject to subject and domain to domain. Science subjects almost always require a laboratory to perform experiments based on concepts learnt in lectures. Courses related to computer science require a computer lab for hands-on experience, workshops encourage hands-on experience in activities, such as carpentry, welding, casting, and so on, and music rooms for pursuing the different instruments and vocal practice in a controlled setting; these are few examples of how different fields require their own ground for exploring the field in deeper detail and gain interest in the same. Imagine a music class looking at just theories about high notes and low notes without listening to a single chord on an

actual guitar! Playgrounds and gymnasiums also form essential infrastructural elements that most parents today prioritize when looking for the perfect institution for their wards. For some schools which are financially very affluent, the establishment of such facilities is not a very big deal, and they can do that as and when the demand increases. However, for most medium-scale schools giving a green signal for all the facilities at once is a bit of a challenge due to financial and infrastructural constraints. For the installation of many of such amenities, it is required that the institution's walls be expanded, which is often tolling in terms of both time and money. In most cases, the institution has to prioritize the execution of some facilities at a point of time and plan the others for the future. How does one get to know what provisions to incept with immediate action and which ones to shelve? Does machine learning have an answer for us? Definitely!

Let us take the example of a situation where the school needs to decide between building a swimming pool and a science laboratory. In this case, it has two options that are quite different from each other. One will be used for physical education purposes, and the other will be used for academic purposes related to the field of science. The administrators should decide on what factors the prioritization of the two projects should be done. It is a difficult question at first glance to check whether building the swimming pool will bring in more benefits for the school or will the building of the science laboratory become of more importance. We can start by considering a few factors which readily come to our mind. One of them is the relative popularity of the two things among students. If more students would like to have a swimming pool, then perhaps the school should go with the option of building a swimming pool first and shelving the science laboratory for the future. However, if we compare the academic results between different schools, it is generally the case that most of the schools that have produced good academic results in the past few years have always had a science laboratory. However, many of these schools have not had a swimming pool in the first place. We are assuming that for the school administration, academic results are of paramount importance, and the same applies to the students as well as their parents. If the academic results for the students are consistently good, it is probable that the students should perhaps

be able to find good career paths and should be able to have a safe future ahead. When we are considering the set of benefits, we should perhaps also consider what costs we are incurring in this process. When we are building a swimming pool or science laboratory, it will incur a number of fixed and variable costs. The fixed costs may include the land that is required to build the facility, and the variable cost will encapsulate costs such as labor, raw materials, and construction time. Finally, what is of importance to us is if the projected benefits exceed the costs that we have incurred in building the facilities. What we have basically done is known as cost-benefit analysis in technical terms. This is a popular technique that is used worldwide across industries in deciding whether or not to pursue a particular project. In this scenario, we have taken a very layman's approach in doing the cost-benefit analysis. Firms use more intricate techniques to do the same process by employing consultants to find out the various benefits that the project will bring in for the firm and what costs will be incurred while building and executing the project.

Where does machine learning come into the picture? We just saw that we need to project the different benefits of building a particular project, for example, the swimming pool or the science laboratory, for performing the cost-benefit analysis. We need to compare the results between different schools having a swimming pool and a science laboratory, or maybe either one of them. What matters most to us in this scenario is academic results. Let us say we observe that academic results were better in schools, having a science laboratory over the schools having just a swimming pool. Then, it is intuitive that building a science laboratory generally brings in more benefits for the school in the future. What if we want to quantify the benefits that we want? We would perhaps want to see the rate at which admissions have progressed over the years for schools having science laboratories over swimming pools. What we are basically doing is called regression in machine learning. Regression is a process of finding a projected or estimated value for a continuous variable at a future point of time using the input parameters and the values of the continuous variable in the existing dataset.

Since we already have the cost sheet with us, we can now compare the total cost with the total monetary benefits and decide on what project to move ahead with. Therefore, the task at hand has been

made it easier to decide between which projects to pursue first and which to save for the future by performing a systematic cost-benefit analysis by taking in machine learning into the picture for greater efficiency and accuracy.

It goes without saying that machine learning does play an important role in easing the task of educational administrators in different problems that we face day in and day out. By introducing machine learning into the picture, we have found that both time and efficiency can be optimized in order to achieve the desired result. Machine learning produces mathematical results using data sets that have been provided to it, and thus, it is quantifying real-world facts with greater efficiency and less cost.

Government and educational institutions

A nation is said to be run by a government that formulates its various laws and administrative policies and executes them. Often governments consist of a number of ministries that handle different aspects of running the nation, such as health, finance, textiles, transport, and education. The education ministry is entrusted with ensuring proper educational facilities and policies are executed throughout the nation. Many of the educational institutions across the country receive assistance from the government in the form of grants, funds, and scholarships for their smooth functioning and for fostering the education of students from poor financial backgrounds. In this section, we will discuss a few ideas in which government officials can collaborate with educational institutions across the country to coordinate different events in the interest of nationwide education across different domains and demographic backgrounds.

Conducting national entrance examinations

Almost every country has its own national entrance examination into its various disciplines, such as engineering, medicine, sciences, or the humanities. Each of these entrance examinations has questions set

by premier institutions of the country and has been conducted by the government across the nation for many years through a common mode and framework. In the age of information technology, these national entrance examinations have begun to be conducted over computers rather than the conventional pen and paper-based mode. This gives more flexibility in selecting the questions that have to be presented to the candidate, as different pools of questions can be formed from a large bank of questions. Randomly selected sets of questions are presented to the candidates whose difficulty level is moderated across sets. Such a technique helps in the reduction of malpractices during examinations and also helps in conducting multiple shifts of the examination rather than having to adjust all candidates into a single seating. Machine learning algorithms such as artificial neural networks and decision trees can be used to determine the difficulty level of questions and to separate the difficult questions from the moderate and easy ones. Thus, automatic labeling of the questions into easy, moderate, and difficult can help to form different sets of questions in a normalized format at greater efficiency and less cost. In this manner, such large-scale entrance exams can be conducted in a smoother and more streamlined fashion with lesser involvement of the human workforce in time-taking tasks such as labeling of questions, setting question papers, and conducting exams through pen and paper-based modes.

Conducting educational surveys

One of the most important follow-up tasks of policymaking is to take feedback on what on policies that have been formulated and how they have been executed. Education ministries across countries often experiment with new curriculum or examination policies to test if they are making improvements in the students' learning process. In this scenario, it is required that they follow up on the results of the students by taking feedback from schools. One of the most popular ways to do this is to take surveys across schools, which may be either filled up by school administrators or by each individual student enrolled in the school. However, the information that has to be extracted from the survey is often different from the collected raw data. We sometimes need to collate data into meaningful forms using data pre-processing methods such as selecting important

parameters, grouping multiple parameters into one, group data according to some other parameters, and so on. In such scenarios, machine learning can be of use in which we can do tasks such as parameter reduction using techniques such as **Principal Component Analysis** (**PCA**) and **Singular Value Decomposition** (**SVD**), which are statistical methods to reduce data from high-dimensional data into low-dimensional data while preserving the maximum amount of information that the data contains. Therefore, instead of having to invest human effort and time in performing such data pre-processing tasks, we can have machine learning algorithms do the job for us so that humans can focus on more nuanced jobs, such as finding meaningful results out of curated information.

There are many more ways in which governments can collaborate with educational institutions for the advancement of education. The use of machine learning in such collaborations further enables this advancement to be fostered at a much faster rate and use lesser manpower, thereby also cutting down on costs and logistics.

Project ideas

We have discussed extensively about how machine learning can be used to ease tasks related to managing educational institutions and in fostering collaborative activities between governments and educational institutions. We now present a few project statements to stimulate your brain to put these ideas into action!

To develop a network intrusion detection system

Many schools today completely rely on an internal computer network that is used to coordinate their activities. However, a cyber attack on any one of the computers is sufficient to bring down the entire system. It is extremely important that all incoming traffic into the network be scanned for malicious content that might be a potential trigger for a cyber attack. Machine learning is today used for applications such as intrusion detection in computer networks based on the traffic contents, source of the traffic, duration of communication, and many

other factors. Develop a model to classify incoming traffic as genuine or malicious using the KDD dataset as the training dataset.

To develop a student application shortlisting system

As the title of the project suggests, you need to develop a system that can classify student applications for admission into strong and weak categories. You can take ideas from *Managing student admissions*, where we have discussed this scenario in detail. Necessary parameters for classification can be taken from the same section, whereas we encourage you to think of more parameters that are commonly considered by schools and universities in shortlisting students. While the artificial neural network approach has been discussed in the chapter, we also encourage you to develop an SVM-based classification model to implement this problem statement.

To develop a random question set generator

We discussed generating random question sets for competitive examinations based on difficulty level normalization in *Conducting national entrance examinations*. Your task is to develop such a generator that selects questions from a question bank, and in each set, it maintains a fair share of easy, moderate, and difficult questions. The algorithm should figure out the difficulty level of new questions based on the features of questions that it has learned from the labeled training dataset.

Conclusion

In this chapter, we have discussed how different tasks that are faced by educational administrators throughout the year often become tiring and time-consuming when it comes to managing medium- to large-scale educational institutions. Tasks such as managing student admissions, recruiting staff, expanding infrastructure, and many others are often time-taking and require significant investment in

labor and resources. With regard to these problems, machine learning algorithms can help in reducing the time, labor, and resources that have to be invested to accomplish these tasks. One of the most important tasks, which is to manage student admissions, has been tackled using machine learning techniques like artificial neural networks and can also be implemented using other classification algorithms such as support vector machines. The same idea has been used in other tasks, such as recruiting staff and teachers for different departments across the institution. Also, deciding the appropriate position and compensation for the recruited staff according to their experience and skills has been done using clustering algorithms, techniques similar to which are widely used across industries today. Expansion of infrastructure and appropriation of time and resources for the most required facilities have been done using cost-benefit analysis enhanced through machine learning.

Toward the closing of this chapter, we also discussed how government education ministries can collaborate with institutions across the country in fostering better education opportunities for everyone. Mammoth tasks such as conducting national-level entrance examinations and conducting national surveys have always been difficult whenever they were executed using conventional methods such as pen and paper-based examinations and human intervention for information extraction from raw data. It observed that even these tasks could be greatly improved by using machine learning algorithms for question set generation based on difficulty level normalization and extracting useful information from raw data automatically through dimensionality reduction techniques such as PCA and SVD.

In summary, we can say that machine learning can be of use in almost every field related to education, be it for educational administrators or for government agencies. The use of machine learning algorithms has been of great benefit in industries, and the same can be realized in the educational sphere because it uses rich mathematical background and quantitative methods to reduce time, money, and human effort to ease routine tasks as well as devise new and novel methods for jobs which have been traditionally time-consuming and tiresome.

Chapter-end word grid!

Find words related to the chapter in the following word grid.

A	W	W	X	T	U	M	M	L	J	P	I	G	P	E	N	K	M
Y	S	K	K	C	I	N	T	E	R	V	I	E	W	B	B	E	M
J	X	E	X	T	R	A	C	U	R	R	I	C	U	L	A	R	E
C	L	U	S	T	E	R	I	N	G	G	P	Y	M	A	U	O	A
G	Y	S	B	B	Q	O	G	D	I	J	N	G	W	M	U	M	C
H	Q	E	G	J	D	U	P	Q	N	E	W	K	X	V	R	F	K
M	C	O	S	T	B	E	N	E	F	I	T	R	L	K	Y	R	J
G	L	Q	I	N	F	R	A	S	T	R	U	C	T	U	R	E	R
B	I	S	U	P	P	O	R	T	V	E	C	T	O	R	D	F	T
R	D	L	E	L	A	B	O	R	A	T	O	R	I	E	S	O	L
D	X	X	W	L	J	A	D	M	I	S	S	I	O	N	S	W	W
D	I	M	E	N	S	I	O	N	A	L	I	T	Y	T	N	U	P

Exercises

1. **Fill in the blanks.**
   a. _____ talks about how a large number of parameters in the input dataset can render each datapoint to look roughly similar to each other.
   b. An SVM determines a separating line, called _____, between the support vectors such that the two categories of datapoints are separated by the line.
   c. An ANN takes as input the specified parameters and associates _____ to each of the parameters based on their relative importance.
   d. Parameter reduction can be achieved using techniques like _____ and _____.
   e. Machine learning algorithms such as _____ and _____ can be used to determine the difficulty level of questions and to separate the difficult questions from the moderate and easy ones.

2. **For each of the following statements, indicate whether they are true or false. If the statement is true, write "T" in the box next to it. Else, write "F" in the box.**

   a. When a school observes that the number of students is increasing, it should start working on expanding its infrastructure to support the growing number of students per batch. ☐

   b. SVM stands for Smooth Vector Models. ☐

   c. SVMs fall in the category of supervised machine learning algorithms. ☐

   d. A school's performance only depends on the students enrolled in it, and the prowess of its instructors hardly matters. ☐

   e. Designing new and innovative question papers to test the students' learning inside-out is often an intimidating and time-consuming task. ☐

3. **Answer the following questions briefly.**

   a. Mention the important activities that educational institutes perform all year round to run the institute effectively.

   b. What are the parameters that top-notch institutes look for in student applications for admissions? Which of these can be assessed and analyzed using machine learning techniques?

   c. What problems are faced by teachers in content delivery while using conventional methods of teaching? Are there any reasons that you think which does not encourage them to switch to modern technology, especially machine learning techniques?

   d. How do you think a school's performance depends on the instructors teaching there? How can machine learning be used to find this correlation?

   e. Suggest an application of clustering algorithms in grouping schools based on infrastructural amenities. Give details of your approach.

   f. We used Support Vector Machines in this chapter to classify students' applications. What other machine learning

algorithms do you think could prove effective in such a binary classification problem?

g. What would be your approach in classifying students' applications if it is required to classify the applications into three categories: accepted, rejected, and on-hold?

h. "Video recordings of candidates answering a set of questions can be used for assessing their suitability for a job." Comment on this statement from the perspective of a machine learning engineer.

i. What difficulties do you think one would face if they use generative adversarial networks for generating question papers for entrance tests? Can you also suggest some suitable solutions for the same?

j. Explain how clustering algorithms can be used for assessing the results of a nationwide educational survey to obtain useful information from the survey.

4. **Draw the flow diagram of a university admissions pipeline using machine learning algorithms to filter applications based on two different criteria: marks in high school and achievements in sports. Do you think you should use more than one model in this scenario? Why or why not?**

5. **Many firms today use AI-assisted resume screeners to shortlist applicants for job interviews. How will you use transfer learning to adapt this approach to the setting of an educational institute? Give details of your approach and the necessary modifications.____**

6. **Conducting entrance examinations on a national level is a mammoth task. Conducting the same on an international level is an even more daunting task! What modifications do you think should be made to machine learning techniques used in conducting national-level examinations to suit them for an examination conducted across different continents?**

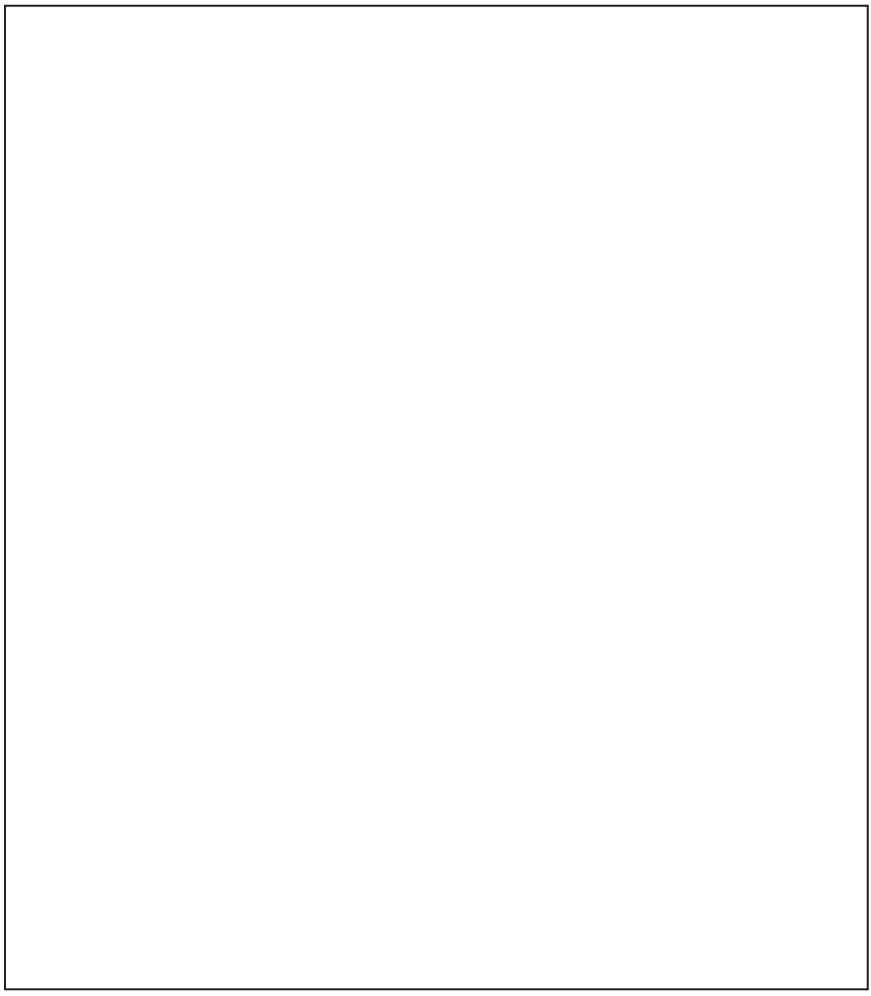
7. **PCA and SVD are common approaches for dimensionality reduction in machine learning. How do you think you can use these in refining data collected from a survey from a country with a huge population of people from several backgrounds? What are the pre-refinement steps that you will take to ensure that your refined data does not lose precious information content?**

8. **Match the following columns.**

Column A	**Column B**
a. Student admissions	a. Randomized questions
b. Staff recruitments	b. Extracurricular activities
c. Large-scale surveys	c. Proportional to admissions
d. Infrastructure expansion	d. Selection and stratification
e. Entrance examinations	e. Dimensionality reduction

Column A	**Column B**
a. Support vector machines	a. Weights and biases
b. Principal Component Analysis	b. Binary Classification
c. K-means	c. Clustering
d. Artificial Neural Networks	d. Dimensionality reduction
e. Decision trees	e. Multi-class classification

9. Make a mind map to summarize all the concepts covered in this chapter.



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