Reviewing knowledge about Deep Learning and Reinforcement Learning

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Online course address:https://www.coursera.org/learn/deep-learning-reinforcement-learning/

Outline

1. **Introduction to Neural network Basis**
2. **Introduction to Reinforcement learning**
3. **Introduction to Autoencoders and GAN**

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Introduction to Neural Network Basis

- **There are many Deep learning approaches（with more being developed)**

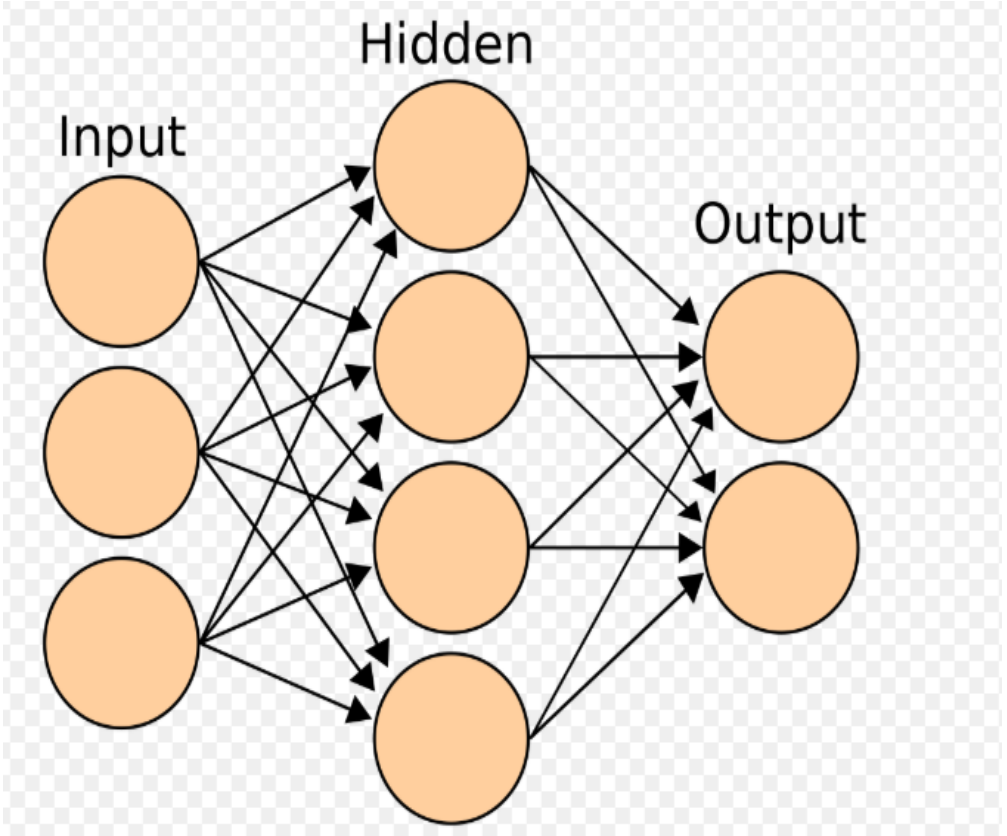
Method	Use case
Neural network models: Multi-Layer Perceptron,Feedforward Network	**Applied to many traditional predictive problems** (classification and regression,tabular data)
Recurrent Neural Networks (RNN,LSTM)	Useful for modeling sequences(times-series forecasting,sentence prediction)
Convolutional Neural Networks(CNN）	Useful for feature and object recognition in visual data(images,video).Also applied in other contexts(forecasting)
Unsupervised Pre-trained Networks: Autoencoders,Deep Belief Networks,and Generative Adversarial Networks	Many uses including generating images,labeling outcomes,dimensionality reduction

Introduction to Neural Network Basis

- **Definition:A neural network is composed of multiple layers of interconnected processing units called neurons. Each neuron receives inputs, processes them using weights and an activation function, and passes the output to the next layer.**

- **A typical neural network consists of:**
  - **Input Layer(e.g. dataset)**
  - **Hidden Layers**
  - **Output Layer(e.g. classification labels)**

pic1.1
digit images about number(input layer)

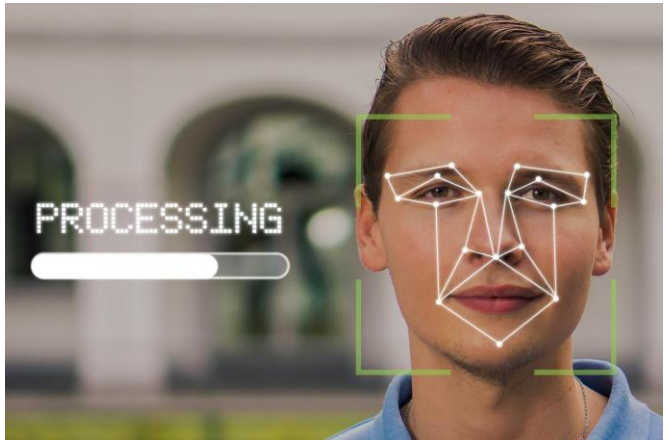


Introduction to Neural Network Basis

- **Application**：Neural networks play a crucial role in modern technology, powering applications such as face recognition, autocorrect, predictive searches, and self-driving cars.

- **What neural network does in face recognition**

  - **Feature Extraction**: Convolutional Neural Networks (CNNs) identify key facial features from images.
  - **Classification**: The network compares these features to a database to recognize the person.



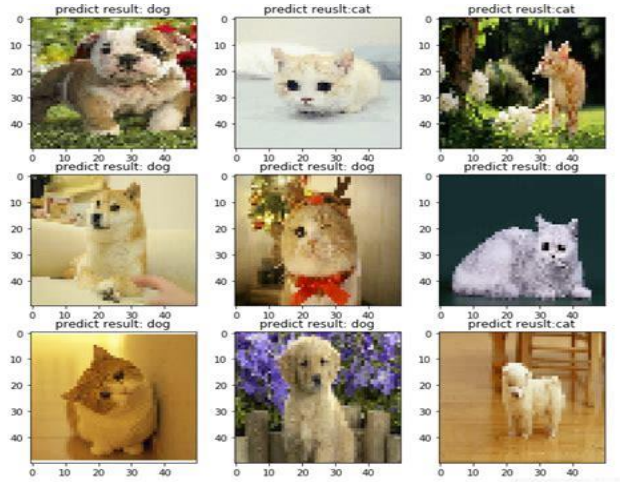
- **How neural network does in self-driving cars**

  - **Object Detection:** CNNs detect and classify objects like pedestrians and traffic signs.
  - **Path Planning:** Recurrent Neural Networks (RNNs) predict object movements for navigation decisions.

Introduction to Neural Network Basis

- **CNN(Convolutional Neural Networks）** are a special type of artificial intelligence designed to recognize patterns in images.Like recognizing cats and dogs. CNNs analyze small sections of an image to figure out what the whole image represents. This way, they can recognize a cat no matter if it’s big or small, or if it’s facing left or right.

CNN can recognize different types of cats and dogs

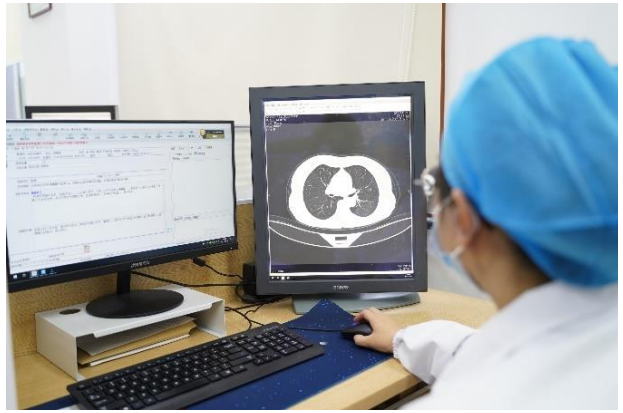


- **RNN(Recurrent Neural Networks)** are a type of artificial intelligence designed to process sequences of data, like sentences or time series.
- Imagine you're reading a book. Each word you read helps you understand the next word better because of the context provided by the previous words.RNN works similarly.For example:
  - The bat flew in the sky → bat refers to the animal
  - He swung the bat → it means a baseball bat

→ **RNNs help computers understand text meaning more accurately by processing words one by one and remembering the context from previous words.**

Introduction to Neural Network Basis

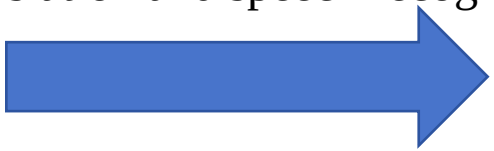
- **Real word application about Neural Network**
  - The Lung Nodule AI Screening System utilizes **convolutional neural networks (CNNs)** to analyze CT scans in seconds, detecting small nodules (1-3mm) with high accuracy. It generates structured reports, assisting doctors in diagnosis.
  - Key Benefits
    - Fast & Efficient: Saves time, reducing workload.
    - High Accuracy: Minimizes missed diagnoses.
    - Doctor + AI: Enhances reliability through human verification.
    - Early Detection: Improves patient outcomes.

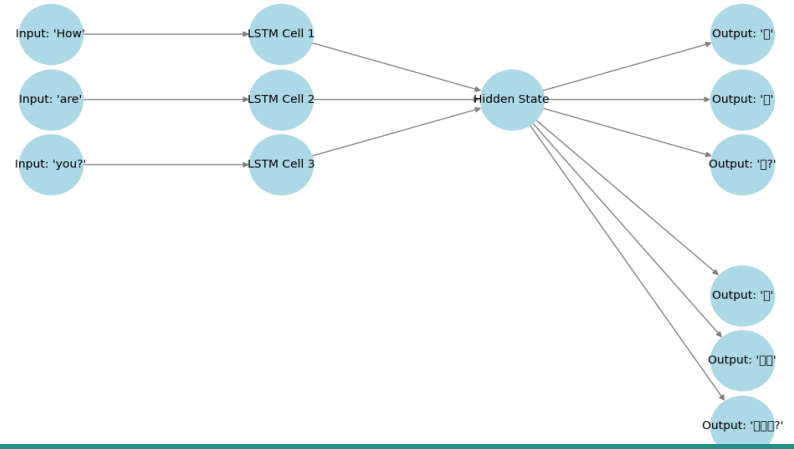


Many hospitals in china use this system now,and it helps a lot.

Introduction to Neural Network Basis

- **Long Short-Term Memory Networks(LSTM):**
- **Definition:**LSTMs are a special type of recurrent neural network (RNN) designed to remember information for a long time.
  - **Machine Translation**: LSTMs are used to translate sentences from one language to another, improving the accuracy of translations.
  - In this image, the hidden state acts as a memory that aggregates information from the LSTM cells, retaining context to generate the final output sequence.
  - The differences between LSTM and RNN
    - RNN is simple but struggles with long sequences and efficiency. ➡ used for simple time series forecasting.
    - LSTM has a more complex structure with memory cells, handles long-term dependencies well, and is better for complex tasks like translation and speech recognition.





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Introduction to Reinforcement learning

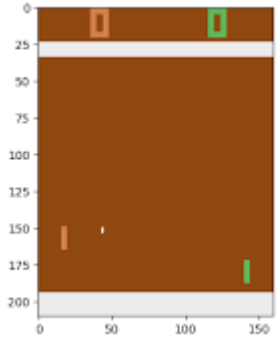
- Definition:**Reinforcement Learning (RL)** is a type of machine learning where an **agent** learns to make decisions by taking actions in an **environment** to maximize cumulative **rewards**. The agent interacts with the environment, receives feedback in the form of rewards or penalties based on its actions, and uses this feedback to improve its future decision-making.
- Now , advances in deep learning have led to many recent reinforcement learning developments. For example in 2013 researchers from DeepMind developed the system to play **Atari games** and actually beat humans in Atari games.

Atari Breakout reinforcement learning

The agent is hitting bricks to try to break the wall

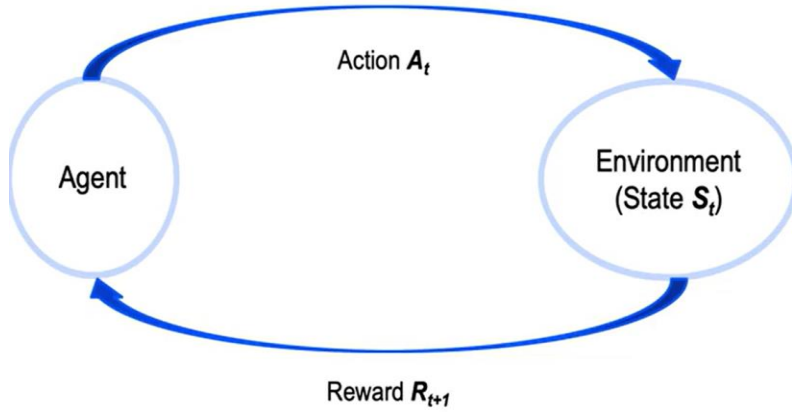
Atari Space Invaders reinforcement learning

Agents are shooting aliens to try to stop them from invading Earth



Atari Pong reinforcement learning

The agent is controlling the paddle, trying to defeat the opponent.



Agent learns to estimate rewards based on actions over time

Introduction to Reinforcement learning

✓ **In 2017 the AlphaGo system defeated the world champion in Go. So for the first time, the machines were able to be a human champion in a complex game such as Go using reinforcement learning.**

✓ **How AlphaGo use reinforcement learning?**

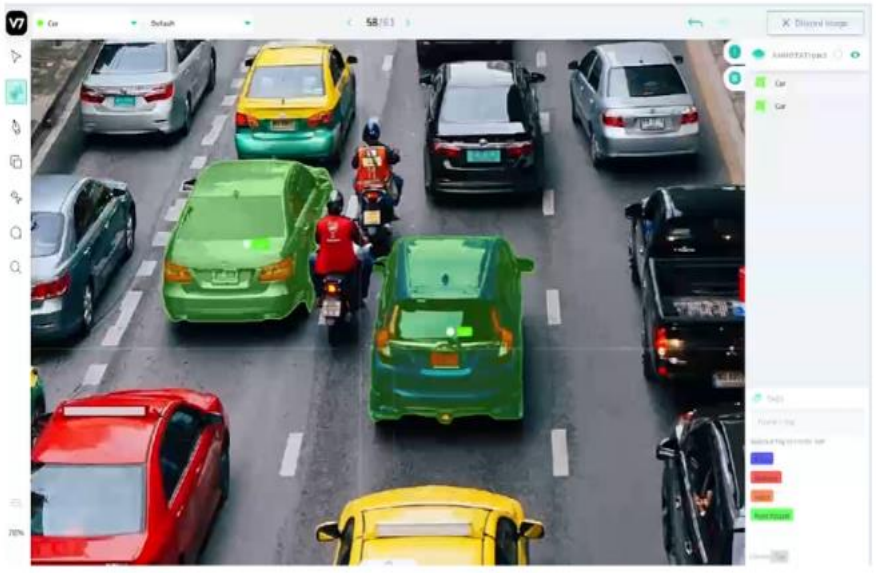
1. Self-Play:AlphaGo plays against itself to generate training data and learn from its mistakes.
2. Policy and Value Networks:
   - **Policy Network:** Suggests the next move.
   - **Value Network:** Evaluates the potential outcome of the game.
3. **Monte Carlo Tree Search (MCTS):** Combines reinforcement learning with MCTS to simulate future moves and outcomes.
4. **Reward System:** Receives rewards based on game outcomes (win/loss) to reinforce successful strategies.

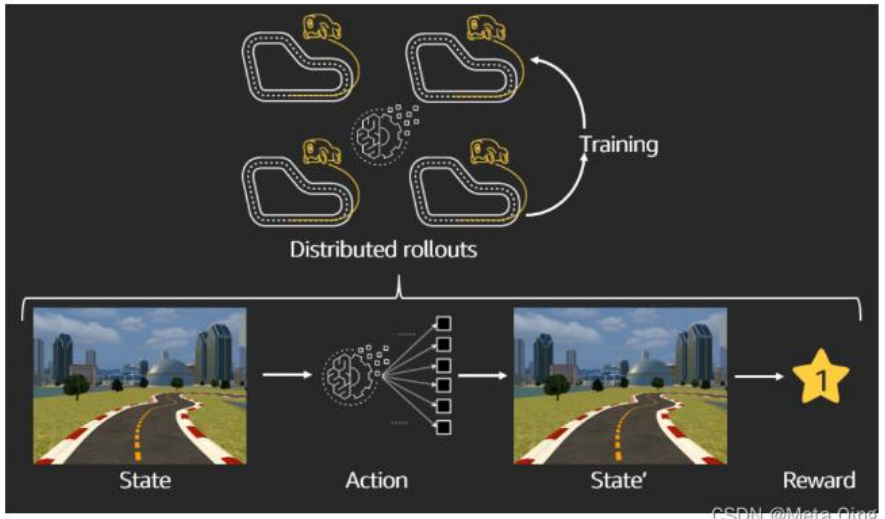
In May 2017, Alphayed a three-game match against Chinese chess player Ke Jie, and AlphaGo won **3-0.**

Introduction to Reinforcement learning

- **Some real world applications about RL.**

  - **Auto-cars**
    - Autonomous cars use reinforcement learning by continuously interacting with a simulated environment, where they take actions (steering, braking, acceleration) based on their current state, receive rewards for good decisions, and improve through trial-and-error training across multiple simulations.



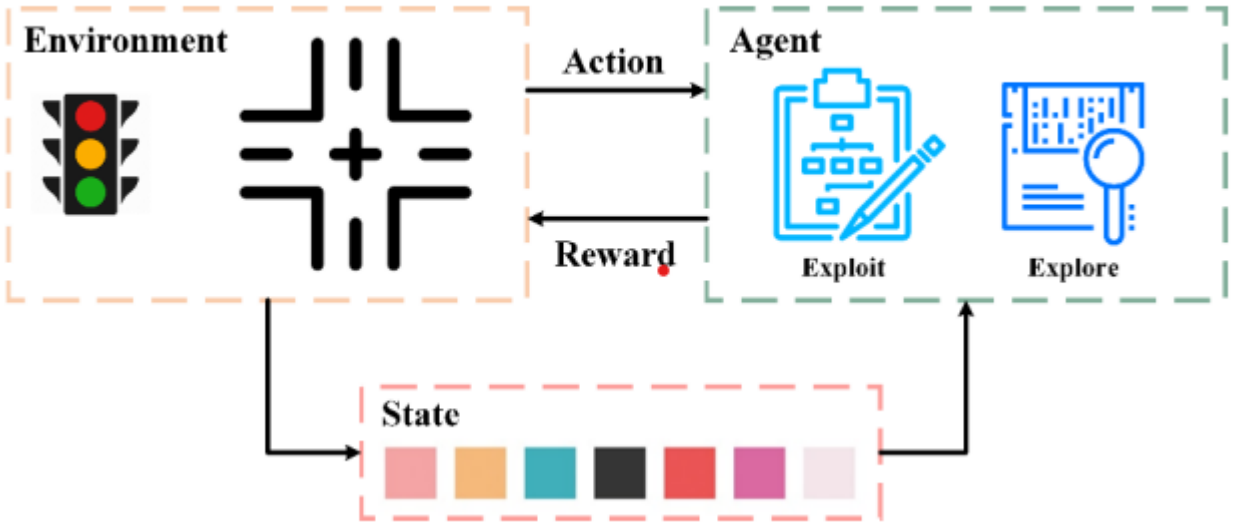


自动驾驶汽车中的深度强化学习

Based on this pic,Driving zones, traffic handling, keeping to speed limits, and avoiding collisions are important factors.

Introduction to Reinforcement learning

- **Traffic light control:** With the acceleration of urbanization and the increase in household car ownership, traffic congestion has become a huge problem, especially in metropolitan areas.
- Reinforcement learning is a trend data-driven adaptive traffic signal control method. The training goal of these models is to learn a policy using a value function that optimizes the control of traffic lights based on the current traffic state.



Decisions need to be **dynamic** and depend on the arrival rate of traffic from **different directions**, which should be different at different times of the day.

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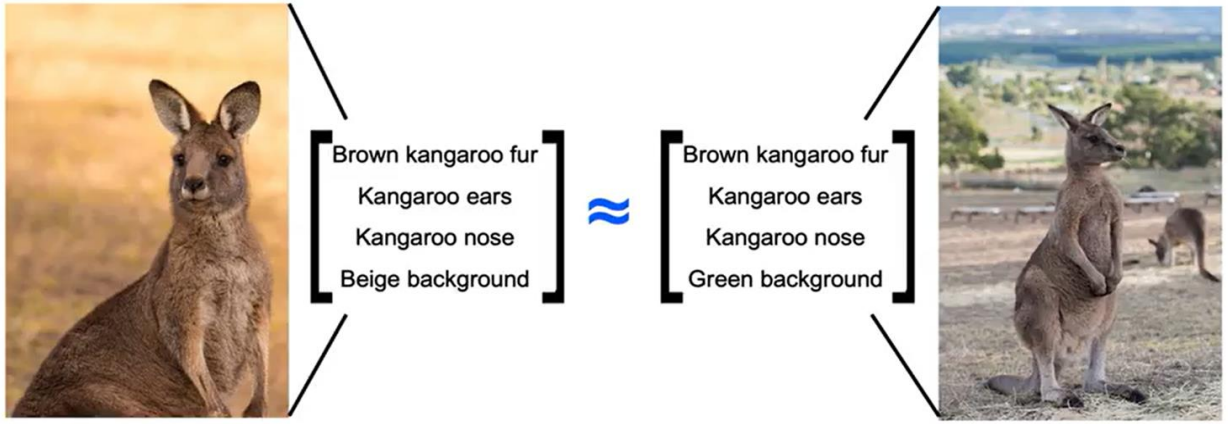
Introduction to Autoencoders and GAN

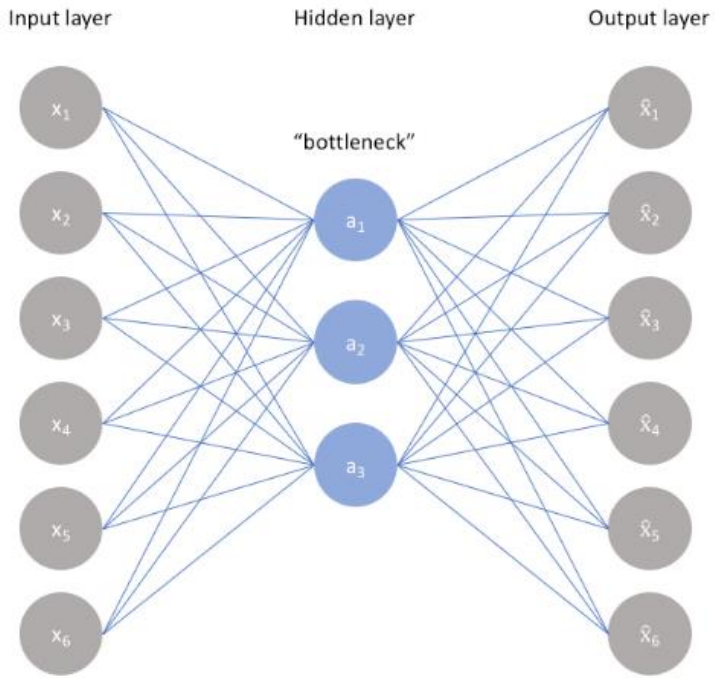
- **Autoencoders**:Autoencoders are a type of deep learning model that helps us understand and simplify complex data.



- For example, think about two pictures of kangaroos. Instead of comparing every single pixel (which can be overwhelming), an autoencoder helps us focus on the key features that make these images similar, like the shape of the kangaroo and its fur color, while ignoring unnecessary details like the background. This way, we can quickly determine if the two images are alike without getting lost in the tiny details.

Introduction to Autoencoders and GAN

- The **aim** of an autoencoder is to learn a lower-dimensional representation (encoding) for a higher-dimensional data, typically for dimensionality reduction, by **training the network** to capture the most important parts of the input image.
- Autoencoders consist of an encoder and a decoder. The encoder compresses the input data into a lower-dimensional representation (embedding), while the decoder reconstructs the original data from this representation.
- **The architecture as a whole looks something like this:**



  - **Bottleneck:** A module that contains the compressed knowledge representations and is therefore the most important part of the network.

Introduction to Autoencoders and GAN

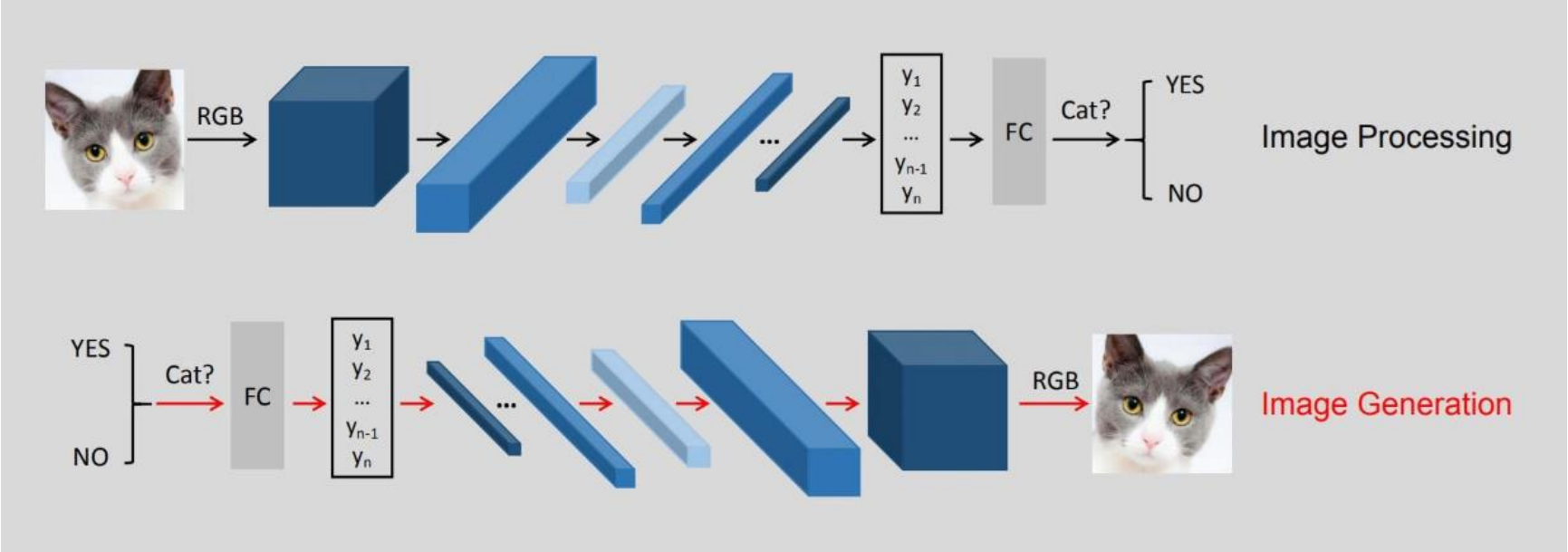
- **Real-world application about Autoencoders**

  - **Image Compression:Autoencoders can be used to compress images by reducing their size while retaining important features. For instance, in online photo storage services, autoencoders can help save space by creating a smaller representation of images, making it easier to store and share them without losing quality.**

Three levels of JPG compression. The left-most image is the original. The middle image offers a medium compression, which may not be immediately obvious to the naked eye without closer inspection. The right-most image is maximally compressed.

Introduction to Autoencoders and GAN

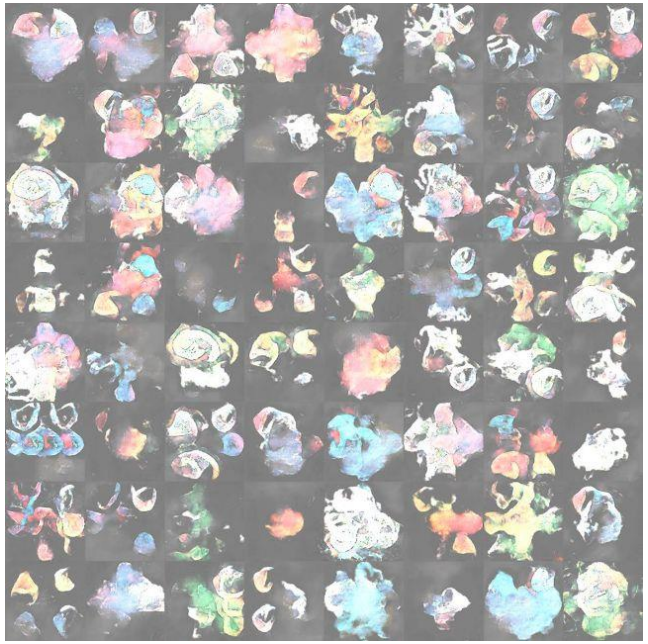
- **GAN**:**Generative Adversarial Networks**, orGANs, are like a game between two players: a generator and a discriminator. The generator's job is to create new images that look real, while the discriminator's job is to tell the difference between real images and the fake ones created by the generator.
- How GAN works:For example, if the generator creates a picture of a cat, the discriminator will analyze it and say, "This looks like a real cat" or "No, this is fake!" Over time, the generator learns from the feedback and improves its creations, making them harder for the discriminator to identify as fake. This back-and-forth process helps both networks become more skilled, leading to the generation of very realistic images.



Introduction to Autoencoders and GAN

- Real-world application about GAN
- Generative models refer to using models to generate new cases based on existing samples. For example, based on an existing set of photos, a set of new photos that are similar but slightly different from them are generated.
- Some people have tried to use GAN to generate characters like Pokemon, such as the pokeGAN project and the use of deep convolutional GAN to generate Pokemon projects. But so far, there has been little success.

An example of GAN generating an animated face. Image from “Using GAN to generate animated characters”.



Examples of GAN-generated Pokémon characters. Image from the pokeGAN project.

Thanks for listening