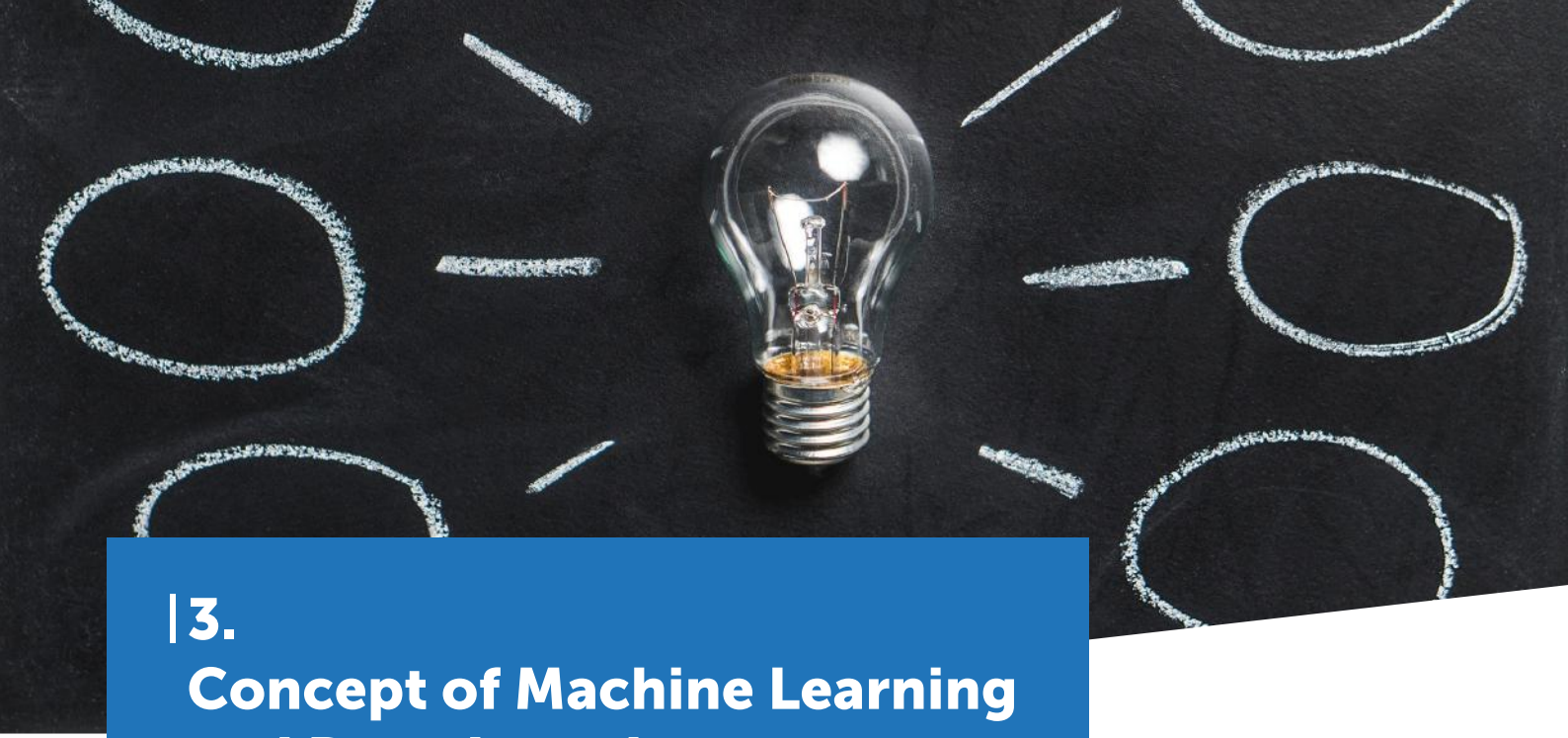

3. Concept of Machine Learning and Deep Learning

Types of Machine Learning

Machine learning is one of the most promising approaches to Artificial Intelligence. It allows a system to perform specific tasks by learning from past data instead of being explicitly programmed. Let's suppose one has a massive collection of furniture, including lots of chairs, desks, dressing tables, and we need to detect the chairs only. One approach would be to map out the specific criteria that explicitly define characters of a chair and detect the chairs from the pile of furniture. The criteria could be something like:

If an image has
- *4 legs*
- *Flat surface to sit on*
- *Backrest*

These three seem to be the sufficient criteria to detect chairs and will perform well on the following chair.

Yes, It's chair !!

But what about these chairs?

??

??!!!!

Our predefined set of criteria could not cover these new types of chairs. To detect the second office chair, we need to go back and alter the criteria accordingly. For the third designer chair, we might not get common criteria because it's completely unique! This shows why we need a completely different strategy of learning from examples, and this is where Machine Learning comes in.

Arthur Samuel, one of the pioneers in machine learning, defines Machine Learning as the *field of study that gives computers the ability to learn without being explicitly programmed.* In this chair detection scenario, **instead of defining the criteria apriori, we would provide it with data and make it learn.** The data contains thousands of sample images of chairs. This way, we are making the machines learn from the data provided. The data is provided with the results so that the model learns to map the relationship between the inputs and outputs without being explicitly programmed.

Deep Learning

Deep learning is another most promising and emerging machine learning technique that is inspired by the way a human brain filters information, basically learning from examples. **Deep learning uses multiple layers of neurons progressively to extract higher-level features from the raw input.** Suppose in a cat classification problem, raw inputs may be the edges and dots of the picture of animals and extracted high level inputs may be the position of nose, eyes, ears, and so on. This is inspired by the working mechanism of the human brain so it is mostly used in applications that people generally do. Some of the practical examples of deep learning are Virtual Assistants (Siri, Cortana), chatbots, face recognition, machine translations.

Types of Machine Learning

There are three main types of Machine Learning: Supervised, Unsupervised, and Reinforcement Learning. Let's briefly discuss and formulate an applicable example for each of them.

Supervised Learning

Let's start with an example illustrating the working of supervised learning to predict if a given image is of an apple or not.

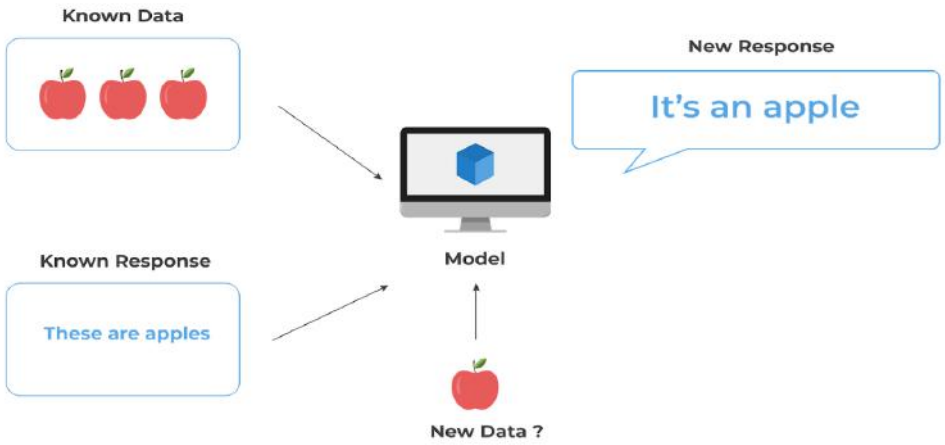

Figure: Supervised learning

First, the images, along with their corresponding labels (1 if the image is apple, 0 otherwise), are passed to the model for training. The pixel values of each image can act as input features for the machine learning model. Note that these images contain positive as well as negative samples. In our case, it includes images of apples as well as images that are not of apples. Then the model learns a mapping from the input features to their corresponding labels. When a new unseen image is passed to the model, it needs to predict the corresponding label correctly. In the figure, a new image of an apple is passed to the model, and it correctly predicts it as an apple.

In supervised learning, **you pass the samples containing the input features and their desired outputs to the machine learning model for training.** The model then learns a mapping from the input features to the desired output. You aim to produce a mapping, accurate enough so that the algorithm can predict the output as correctly as possible whenever a new test input is given. As the desired output passed during the training supervises the model to learn the required mapping, this learning method is called **supervised learning.**

There are two essential techniques of Supervised Learning: Regression, and Classification. **Regression deals with the prediction of real values such as height and weight, whereas Classification deals with the prediction of discrete values such as the presence of a disease or not.**

In the above example, the model predicts the fruit as an apple from the provided input image. Since the output is a discrete label or value, it is a classification model. Some common classification models are classifying a tissue as cancerous or non-cancerous, classifying mail as spam or not spam.

Let's quickly go through an example of a regression model. The difference is only in terms of the output. In regression, we have a continuous real value output.

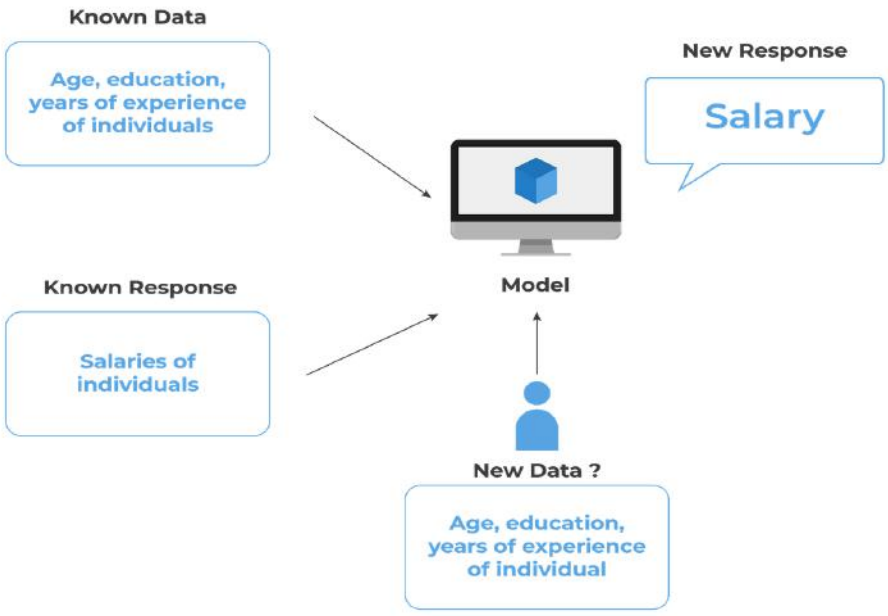

Figure: Supervised learning; Regression

An example of a regression model is a model that predicts salary when features like age, education level, and years of experience are provided as input. We have a data set with features as age, education level, and years of experience. The label is the salary of each individual. We train the model with this dataset, and our model is now ready to predict the salary of any individual provided his age, education level, and years of experience. This is how regression deals with real-valued outputs. One of the most common examples of regression models is the stock price prediction model used by online trading sites to make investment decisions.

Unsupervised Learning

As opposed to supervised learning, in unsupervised learning, **you pass the samples containing only the input features to the machine learning model.** The model then extracts different useful features and patterns from the data. As the desired output is no longer supervising the learning process, this learning method is called unsupervised learning. Two of the most popular unsupervised learning problems are:

- **Clustering** - Segregating data based on the similarity between the examples of the data set.
- **Data transformations** - Reducing the dimension of data.

The following example illustrates the working of supervised learning to cluster images of different fruits.

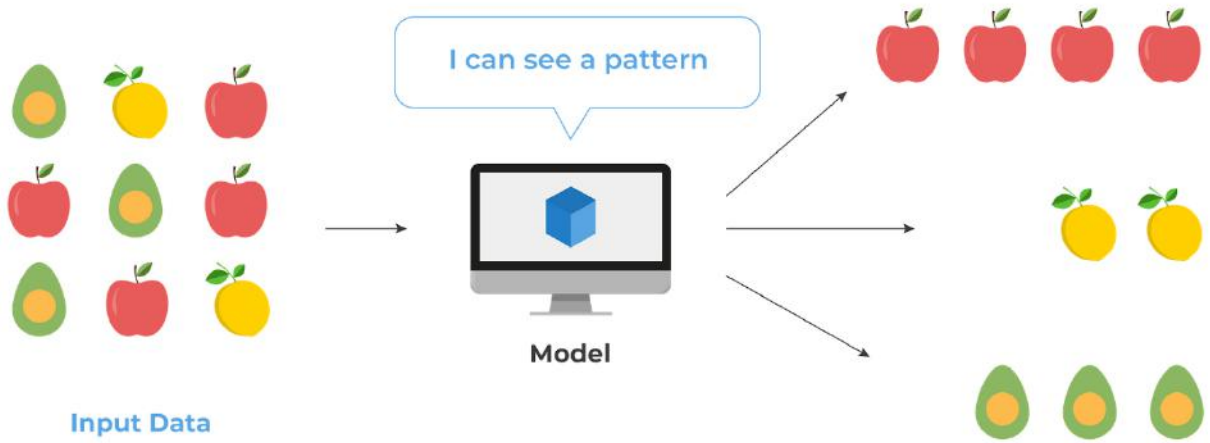

Figure: Unsupervised learning; Clustering

The model takes images of different fruits and analyzes them to find some information and patterns in the images. It learns that the images of the same fruit are quite correlated to the other images. As a result, the model has found three clusters corresponding to the three fruits: apple, orange, and avocado present in the data.

The clustering technique of unsupervised learning is used for segmentation in different fields such as Insurance, earthquake studies, and marketing. Customer segmentation is one of them, where we discover groups of similar customers based on various characteristics and their preferences. Similarly, dimensionality reduction techniques reduce the dimensionality of high dimensional data by transforming its large set of features into a smaller one without losing much of the information. The image below shows the dimensionality reduction from 3D to 2D without losing critical information.

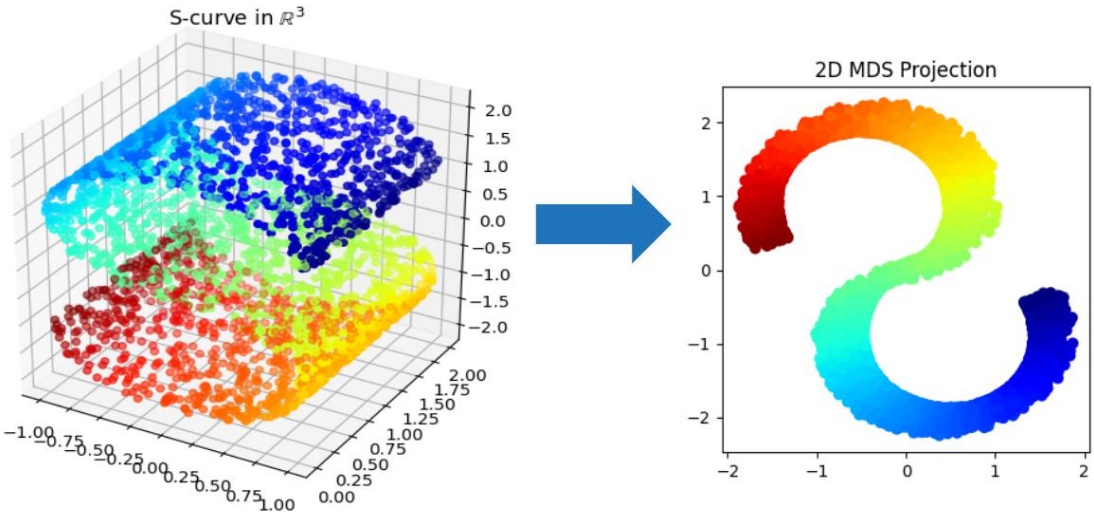

Figure: Dimensionality reduction(Mapping 3D to 2D curve)

Reinforcement Learning

Reinforcement Learning is the type of machine learning where the machine learns on its own using observations gathered from the interaction with its environment.

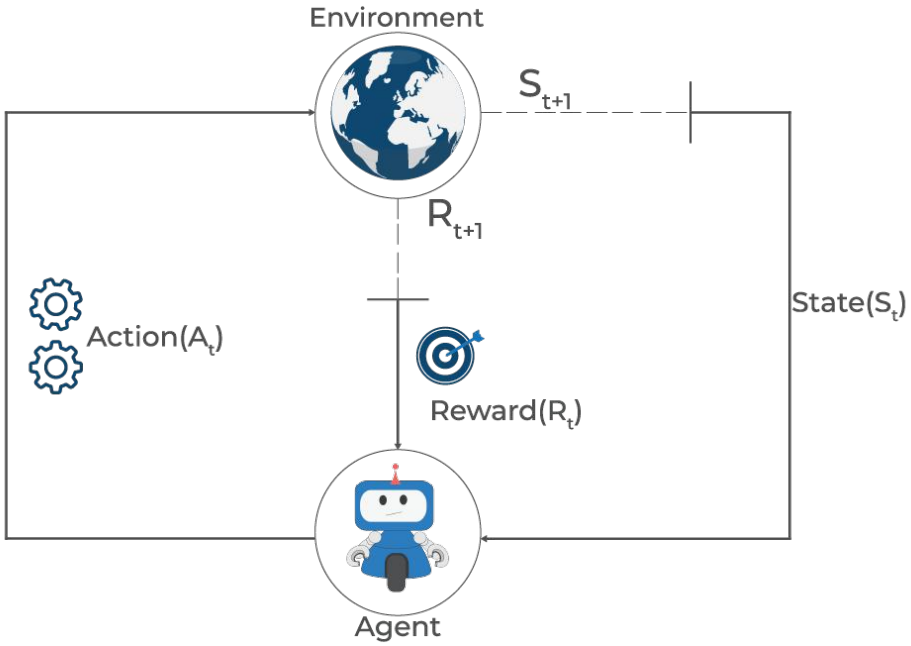

Figure: Unsupervised learning; Clustering

Reinforcement learning problems consist of an agent working in an environment. The agent interacts with the environment in discrete time steps. For each action taken by the agent, the environment responds with the reward for the action and the next state for the agent. **The agent learns to choose the actions such that it collects maximum rewards from the environment.**