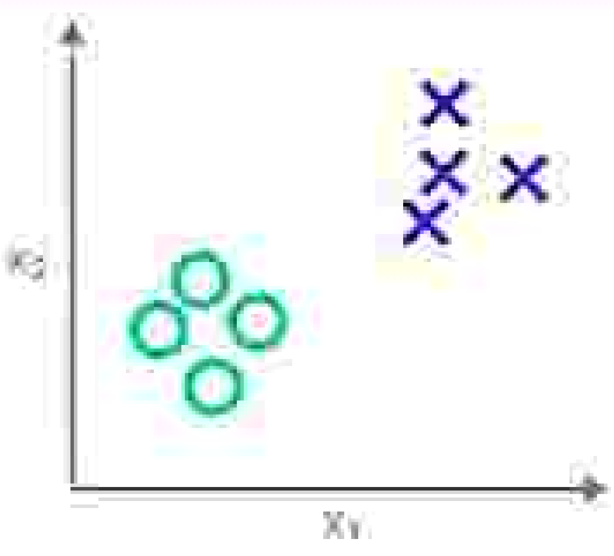
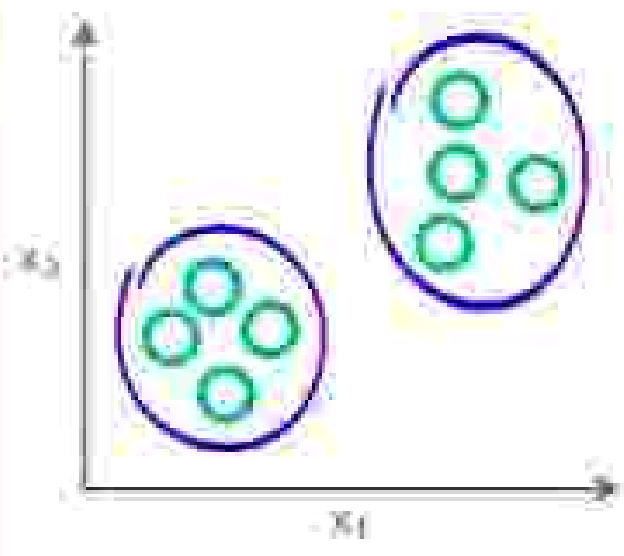
Module test 5 & 6

1. Differentiate between supervised and unsupervised Learning.
2. What is reinforcement learning? Explains its types. 5-36
3. Write short note on PAC Learning 5-46
4. What are the applications of Artificial Intelligence 1-7
5. Write a short note on NLP. 6-1
6. Write a short note on Statistical learning 5-46
7. What is the difference between Problem solving agent and Planning agent? 5-2
8. What are different types of Planning? Explain any two types with an example ? 5-1
9. What are Problems Robotics can solve 6-10

	Supervised	Unsupervised
Input data	Labeled	Unlabeled
Training Process	Model receives input data and ground-truth label during training	Model receives only input data without ground-truth label during training
General Purpose	Predict an outcome	Gain insight from the data
Computational Complexity	Less computationally demanding	More computationally demanding
Time Complexity	More time consuming	Less time consuming
Performance	More accurate	Less accurate
Number of Classes	Known in advance	Unknown, the result can be arbitrary

Supervised learning	Unsupervised learning
Input data is labeled	Input data is unlabeled
Has a feedback mechanism	Has no feedback mechanism
Data is classified based on the training dataset	Assigns properties of given data to classify it
Divided into Regression & Classification	Divided into Clustering & Association
Used for prediction	Used for analysis
Algorithms include: decision trees, logistic regressions, support vector machine	Algorithms include: k-means clustering, hierarchical clustering, apriori algorithm
A known number of classes	A unknown number of classes





5.16.3 Reinforcement Learning

5.16.3(A) Learning from Rewards

- Reinforcement learning is based on occasional rewards. Reinforcement learning agent does not have the exact output for given inputs, but it accepts feedback on the desirability of the outputs. This feedback can be provided by the environment or the agent itself.
- Feedback generally occurs after a sequence of actions, so there can be a delay in getting respective improved action immediately.
- Reinforcement learning agent knows that the results are right (or wrong), but it does not know what action caused the results.
- Reinforcement learning is very similar to sequential decision problems, except that the rewards for each state are not known ahead of time (although they can be observed when they occur)
- The agent may not start out with a transition model, so it doesn't necessarily know what to expect as the outcome of each action it executes.

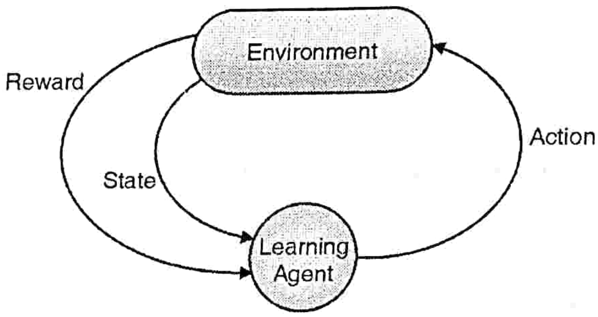


Fig. 5.16.5 : Reinforcement Learning

5.16.3(B)Passive Reinforcement Learning:

- Passive reinforcement learning is when we want an agent to learn about the utilities of various states under a fixed policy. Since the choices for each state are predetermined, passive reinforcement learning is not particularly useful for letting an agent learn how it should behave in an environment, but it's useful for us to learn as one step on the way to active reinforcement learning.
- One way to take advantage of the Markov property of our problem, without requiring us to have a transition model, is to use an algorithm called Temporal Difference Learning. Intuitively, if we move from an arbitrary state \(s\) to a subsequent state \(s'\) that has a higher utility, we should update the utility of state \(s\) to be a little bit higher, since it's on the way to a better state.

- Similarly, if s' has a lower utility than s, we should reduce the utility of s. This means that whenever we take a step, we can calculate the difference in utilities, and adjust the utility of the last state we were in accordingly.

This leads us to the following algorithm for passive reinforcement learning without a transition model:

1. Initialize all state utilities $U(s)$ to zero $\forall s$, and initialize the current state.
2. Take a step (i.e., choose an action a) according to the fixed policy, noting the reward r. Call the old state s and the current state s'.
3. Now update $U(s)$ according to the following formula, where α is a small constant called the learning rate: $$U(s) \leftarrow U(s) + \alpha(r + U(s') - U(s))$$
4. Repeat from step 2 until you reach a terminal state.

5.16.3(C)Active Reinforcement Learning

- In the active reinforcement learning task, we want to learn utilities not just for the sake of learning utilities, but in order to figure out which actions are the best ones to choose. So now, unlike in the passive case, our choices of actions are not predetermined. This makes an active reinforcement learner more powerful, but also adds some complications when we try to formalize our process into an algorithm. Not only will we need to choose our action on every turn, we'll also have to make sure that our choices ensure that we can find a pretty good policy.
- We're still calculating utilities as reward-to-go, so our process still has the Markov property, which means that our state utilities must observe the following constraint:
- $$U(s) = R(s) + \max_a \sum_{s'}P(s'|s,a)U(s')$$
- This just says what we've been saying all along: from any given state (s), look at every action (a) that you can execute from that state. According to the transition model ($P(s'|s,a)$, that is, the probability that state s' is the outcome if we execute action a from state s), weight the utility ($U(s')$) of all of the possible outcomes of action a, and add them up. This is your expected utility of that action. Now choose the action that has the best expected utility ($\max_a$), and add that to the reward for being in state s. This gives you the utility of state s. This equation is called the Bellman equation.
- If you think about this equation in the context of trying to learn a good policy, it might make sense for us to choose the best action we know about on every turn, and to use the outcome of that action to update the utility of state s. But consider the scenario your mother always warned you about: if your favorite meal as a child is chicken tenders and macaroni and cheese, then eating that meal when you're hungry is the choice that maximizes your reward (it's your favorite!). If you always choose the action that you currently know maximizes your reward, you have no chance to discover better options, if they exist. So to find a good policy, we have to risk some bad outcomes for the possibility that some actions might lead to better outcomes than we know about already. This gives us the problem of how to balance exploitation (making choices that we know help us out) against exploration (finding out how valuable are the choices that we haven't yet made).
- The easiest strategy for striking this balance is to just take a random action sometimes (for technical reasons, we need to take the random action decreasingly often as our agent learns). A slightly more sophisticated way is to define an exploration function, $f(u, n)$. This will influence the perceived value of the actions that determine its input. This way, we can just choose the best action; but now, less-visited states will look better than they actually are.

5.20 PAC Learning

- Probably Approximately Correct Learning Model that was introduced by L.G Valiant, of the Harvard University, in a seminal paper [1] on Computational Learning Theory way back in 1984.
- The PAC model belongs to that class of learning models which is characterized by learning from examples. In these models, say if f is the target function to be learnt, the learner is provided with some random examples (actually these examples may be from some probability distribution over the input space, as we will see in a short while) in the form of (X, f (X)) where X is a binary input instance, say of length n, and f (X) is the value (boolean TRUE or FALSE) of the target function at that instance.
- Based on these examples, the learner must succeed in deducing the target function f which we can now express as $f : \{0, 1\}^n \rightarrow \{0, 1\}$.
- The PAC criterion is that our learner produces a high accuracy learner with high probability :

$$P(|R(h) - \hat{R}(h)| \leq \epsilon) \geq 1 - \delta \qquad \text{... (1)}$$

- Suppose we have a learner that produces a hypothesis $h \in H$ given a sample of N training examples. The algorithm is called consistent if for every ϵ and δ, there exists a positive number of training examples N such that for any distribution p*, we have that :

$$P(|R(h) - \hat{R}(h)| > \epsilon) < \delta \qquad \text{... (2)}$$

- The sample complexity is the minimum value of N for which this statement holds. If N is finite for some learning algorithm, then H is said to be learnable. If N is a polynomial function of $\frac{1}{\epsilon}$ and $\frac{1}{\delta}$ for some learning algorithm, then H is said to be PAC learnable.

1.6 Applications of Artificial Intelligence

- You must have seen use of Artificial Intelligence in many SCI-FI movies. To name a few we have I **Robot, Wall-E,** The Matrix Trilogy, Star Wars, etc. movies. Many a times these movies show positive potential of using AI and sometimes also emphasize the dangers of using AI. Also there are games based on such movies, which show us many probable applications of AI.
- Artificial Intelligence is commonly used for problem solving by analyzing or/and predicting output for a system. AI can provide solutions for constraint satisfaction problems. It is used in wide range of fields for example in diagnosing diseases, in business, in education, in controlling a robots, in entertainment field, etc.

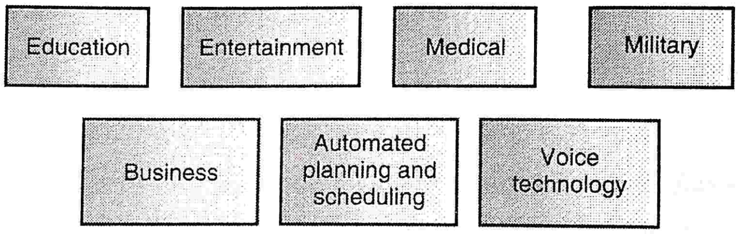


Fig. 1.6.1 : Fields of AI Application

- Fig. 1.6.1 shows few fields in which we have applications of artificial intelligence. There can be many fields in which Artificially Intelligent Systems can be used.

1. **Education**

Training simulators can be built using artificial intelligence techniques. Software for pre-school children are developed to enable learning with fun games. Automated grading, Interactive tutoring, instructional theory are the current areas of application.

2. **Entertainment**

Many movies, games, robots are designed to play as a character. In games they can play as an opponent when human player is not available or not desirable.

3. **Medical**

AI has applications in the field of cardiology (CRG), Neurology (MRI), Embryology (Sonography), complex operations of internal organs, etc. It can be also used in organizing bed schedules, managing staff rotations, store and retrieve information of patient. Many expert systems are enabled to predict the decease and can provide with medical prescriptions.

4. **Military**

Training simulators can be used in military applications. Also areas where human cannot reach or in life stacking conditions, robots can be very well used to do the required jobs. When decisions have to be made quickly taking into account an enormous amount of information, and when lives are at stake, artificial intelligence can provide crucial assistance. From developing intricate flight plans to implementing complex supply systems or creating training simulation exercises, AI is a natural partner in the modern military.

5. **Business and Manufacturing**

Latest generation of robots are equipped well with the performance advances, growing integration of vision and an enlarging capability to transform manufacturing.

6. ***Automated planning and scheduling***

Intelligent planners are available with AI systems, which can process large datasets and can consider all the constraints to design plans satisfying all of them.

7. ***Voice Technology***

Voice recognition is improved a lot with AI. Systems are designed to take voice inputs which are very much applicable in case of handicaps. Also scientists are developing an intelligent machine to emulate activities of a skillful musician. Composition, performance, sound processing, music theory are some of the major areas of research.

8. ***Heavy Industry***

Huge machines involve risk in operating and maintaining them. Human robots are better replacing human operators. These robots are safe and efficient. Robot are proven to be effective as compare to human in the jobs of repetitive nature, human may fail due to lack of continuous attention or laziness.

6.1 Natural Language Processing (NLP)

University Questions

Q. Write short note on natural language Processing. **MU - May 10**

Q. Explain different components of natural language processing. **MU - Dec. 19**

As the name suggests, Natural Language Processing, involves machines or robots to understand and process the language that human speak, and infer knowledge from the speech input. It also involves the active participation from machine in the form of dialog i.e. NLP aims at the text or verbal output from the machine or robot. The input and output of an NLP system can be speech and written text respectively.

6.1.1 Components of NLP

Mainly there are two components of NLP.

1. **Natural Language Understanding (NLU)**

   In this part of the process, the speech input gets transformed into the useful representations in order to analyse various aspects of the language. As the natural language is very reach in forms and structures, it is also very ambiguous. There can be different forms of ambiguities like **lexical ambiguity**, which is a very basic i.e. word level ambiguity. For example the "document" can be a noun or verb. It's a complicated process. Secondly, there can be **syntactical ambiguity**, which is about parsing the sentence. For example, a sentence like "Madam said on Monday she would give an exam". Thirdly, there can be **referential ambiguity**. Check a sentence, "Meera went to Geeta. She said "I am Hungry"."Who is hungry, is not well referred from this sentence. In many cases we observe that one sentence can have meanings. And reversely, many sentences mean the same. Hence NLU a complicated process.

2. **Natural Language Generation (NLG)**

   In order to generate the output text, the intermediate representation requires to be converted back to the natural language format. Hence, in this process there are multiple sub processes involves. They are as follow :

a) **Text Planning :** It includes extracting relevant contents from knowledge base.

b) **Sentence planning :** This process involves selecting correct words, forming meaningful sentence following language grammar and setting tone for the same.

c) **Text Realization :** This is the process of mapping the planned sentence into a structure.

5.21 Introduction to Statistical Learning

- Statistical learning refers to a vast set of tools for understanding data. These tools can be classified as supervised or unsupervised. Broadly speaking, supervised statistical learning involves building a statistical model for predicting, or estimating, an output based on one or more inputs.
- Problems of this nature occur in fields as diverse as business, medicine, astrophysics, and public policy. With unsupervised statistical learning, there are inputs but no supervising output; nevertheless we can learn relationships and structure from such data.

- At the beginning of the nineteenth century, Legendre and Gauss published papers on the method of least squares, which implemented the earliest form of what is now known as linear regression. The approach was first successfully applied to problems in astronomy. Linear regression is used for predicting quantitative values, such as an individual's salary.
- In order to predict qualitative values, such as whether a patient survives or dies, or whether the stock market increases or decreases, Fisher proposed linear discriminant analysis in 1936. In the 1940s, various authors put forth an alternative approach, logistic regression. In the early 1970s, Nelder and Wedderburn coined the term generalized linear models for an entire class of statistical learning methods that include both linear and logistic regression as special cases.
- Let us consider a simple example. Suppose that we are statistical consultants hired by a client to provide advice on how to improve sales of a particular product. The Advertising data set consists of the sales of that product in 200 different markets, along with advertising budgets for the product in each of those markets for three different media: TV, radio, and newspaper.
- The data are displayed in Fig. 5.21.1. It is not possible for our client to directly increase sales of the product. On the other hand, they can control the advertising expenditure in each of the three media. Therefore, if we determine that there is an association between advertising and sales, then we can instruct our client to adjust advertising budgets, thereby indirectly increasing sales.
- In other words, our goal is to develop an accurate model that can be used to predict sales on the basis of the three media budgets.
- The advertising budgets are input variables while sales input is an output variable. The input variables are typically denoted using the variable symbol X, with a subscript to distinguish them. So X1 might be the TV budget, X2 the radio budget, and X3 the newspaper budget.
- The inputs go by different names, such as predictors, independent variables, features, or sometimes just variables. The output variable—in this case, sales—is variable often called the response or dependent variable, and is typically denoted using the symbol Y.

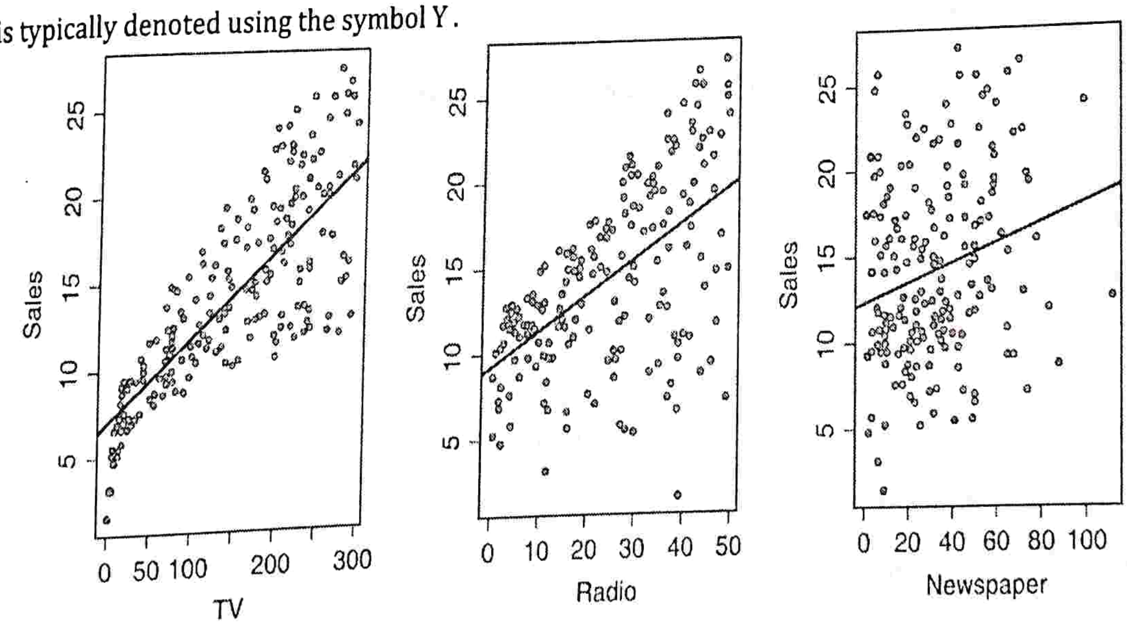


Fig. 5.21.1

- The Advertising data set. The plot displays sales, in thousands of units, as a function of TV, radio, and newspaper budgets, in thousands of dollars, for 200 different markets.

5.2.1 Problem Solving and Planning

University Questions

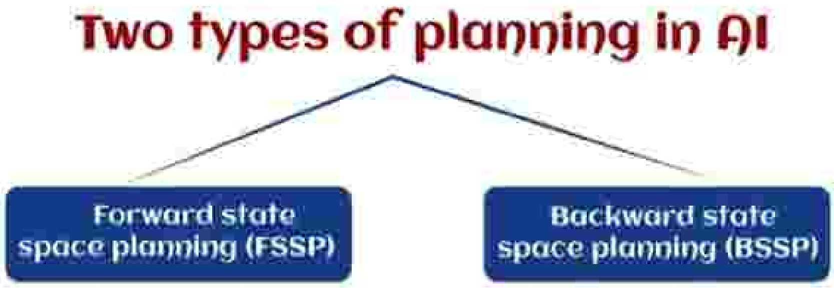
Q. How planning problem differs from search problem? **MU - Dec. 12, Dec. 13**

Q. Compare and contrast problem solving agent and planning agent. **MU - Dec. 15, May 16.**

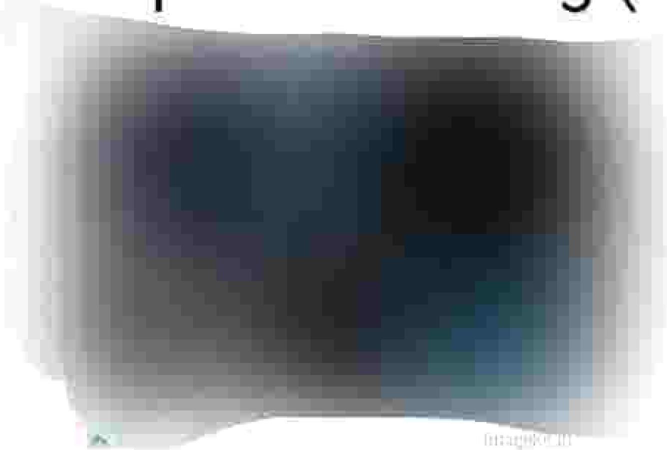
- Generally problem solving and planning methodologies can solve similar type of problems. Main difference between problem solving and planning is that planning is a more open process and agents follow logic-based representation. Planning is supposed to be more powerful than problem solving because of these two reasons.

- Planning agent has situations (i.e. states), goals (i.e. target end conditions) and operations (i.e. actions performed). All these parameters are decomposed into sets of sentences and further in sets words depending on the need of the system.
- Planning agents can deal with situations/states more efficiently because of its explicit reasoning capability also it can communicate with the world. Agents can reflect on their targets and we can minimize the complexity of the planning problem by independently planning for sub-goals of an agent. Agents have information about past actions, presents actions and the important point is that it can predict the effect of actions by inspecting the operations.
- Planning is a logical representation, based on situation, goals and operations, of problem solving.

Planning = Problem solving + Logical representation



1. Forward State Space Planning (FSSP)



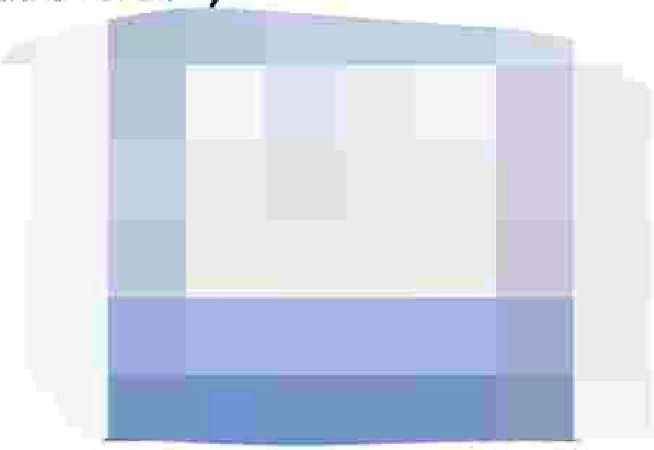
FSSP behaves in the same way as forwarding state-space search. It says that given an initial state S in any domain, we perform some necessary actions and obtain a new state S' (which also contains some new terms), called a progression. It continues until we reach the target position. Action should be taken in this matter.

- **Disadvantage**: Large branching factor
- **Advantage**: The algorithm is Sound

2. Backward State Space Planning (BSSP)

BSSP behaves similarly to backward state-space search. In this, we move from the target state g to the sub-goal g, tracing the previous action to achieve that goal. This process is called regression (going back to the previous goal or sub-goal). These sub-goals should also be checked for consistency. The action should be relevant in this case.

- **Disadvantages**: not sound algorithm (sometimes inconsistency can be found)
- **Advantage**: Small branching factor (much smaller than FSSP)



So for an efficient planning system, we need to combine the features of FSSP and BSSP, which gives rise to target stack planning which will be discussed in the next article.

model, ... structure, and designing. ...each responsible for a specific step in the structure design: creating the

6.7.3 Problems Robotics can solve

1. **Security**

Robots are being proposed as security agents as they can protect humans. Currently, robotics companies are working on pairing robot guards with human security consultants. A very famous company in this field is Knightscope in the United States that has autonomous security robots capable of assisting human security guards with real-time, actionable intelligence. These robots can help with crimes such as armed robberies, burglaries, domestic violence, fraud, hit, and runs, etc.

2. **Space Exploration**

There are many things in space that are very dangerous for astronauts to do. Humans can't roam on Mars all day to collect soil samples or work on repairing a spaceship from the outside while it's in deep space! In these situations, robots are a great choice because there are no chances for the loss of human life then. So space institutions like NASA frequently use robots and autonomous vehicles to do things that humans can't. For example, Mars Rover is an autonomous robot that travels on Mars and takes pictures of Martian rock formations that are interesting or important and then sends them back on Earth for the NASA scientists to study.

3. **Entertainment**

Robots can play a big role in the entertainment industry. They can be used behind the sets in movies and serials to manage the camera, provide special effects, etc. They can be used for boring repetitive tasks that are not suitable for a human as cinema is, after all, a creative industry. Robots can also be used to do stunt work that is very dangerous for humans but looks pretty cool in an action movie. Theme parks like Disney World are also using autonomous robots to enhance the magical experience of their customers.

4. **Agriculture**

Agriculture is the sector that is the basis of human civilization. However, agriculture is also a seasonal sector that is dependent on ideal weather conditions optimal soil, etc. Moreover, there are many repetitive tasks in agriculture that are just a waste of farmer's time and can be performed more suitable by robots. These include seeding, weed control, harvesting, etc. Robots are usually used for harvesting the crops which allow farmers to be more efficient. An example of a robot that is used to remove weeds in farms is the Ecorobotix. It is powered by solar energy and can be used to target and spray weeds using a complex camera system.

5. **Health Care**

Robots can help doctors in performing operations more precisely, be used as prosthetic limbs, provide therapy to patients, etc. The possibilities are limitless. One example of this is the **da Vinci robot** that can help surgeons in performing complex surgeries relating to the heart, head, neck, and other sensitive areas. There are other robotic devices that are created like exoskeletons that can be used to provide additional support for people undergoing rehabilitation after spinal injuries, strokes, etc.

6. **Underwater Exploration**

Robots are a great option for exploring places that humans cannot reach easily, like the depths of the ocean. There is a lot of water pressure deep in the ocean which means humans cannot go that down and machines such as submarines can only go to a certain depth as well. A deep underwater is a mysterious place that can finally be explored using specially designed robots. These robots are remote-controlled, and they can go into depths of the ocean to collect data and images about the aquatic plant and animal life.

7. **Food Preparation**

There are robots that even can cook and create complete meals for you! These robot chefs can create food using hundreds of different recipes. All humans need to do is choose the recipe they want and provide the robot with pre-packaged containers of all the ingredients that are needed for that recipe. The robot can then cook the food on its own. Moley Robotics is one such robotics company that has created a robotic kitchen with a robot that can cook like a master chef! So no worries if you can't cook food. Because now a robot can!

8. **Manufacturing**

There are many repetitive and common tasks in the manufacturing industry that don't require any usage of the mind like welding, assembly, packing, etc. These tasks can be easily done by robots while leaving the mentally challenging and creative tasks to humans. These robots can be trained to perform these repetitive and monotonous tasks with precision under the guidance and supervision of a human. This option is also best for the manufacturing processes that are dangerous and may be harmful to humans.

9. **Military**

Robots also have many applications in the military. They can be used as drones to keep surveillance on the enemy, they can also be used as armed systems to attack the opposing forces or as Medicare agents to help friendly forces. Some of the popular robots used in the Military sector include MAARS (Modular Advanced Armed Robotic System) which looks like a tank and contains tear gas and lasers to confuse enemies and even grenade launcher for desperate situations. DOGO is also a tactical combat robot that has a camera for spying on the activities of the enemy and a 9-millimeter pistol for emergency situations!

10. **Customer Service**

- There are robots that are developed to look exactly like humans for cosmetic purposes. These robots are primarily used in the field of customer service in high visibility areas to promote robotics. One such example is Nadine, a humanoid robot in Singapore that can recognize people from previous visits, make eye contact, shake hands, continue chatting based on previous meetings, etc. Another such customer service robot is Junko Chihira in Japan, a humanoid robot working at the tourist information center in Aqua City Odaiba, a shopping center on Tokyo's waterfront.
- Robots are used for everything ranging from security guards, chefs, doctor's assistants, customer service agents, and even a one-man army in war! There are many other applications of robots as well because of their precision and programming to perform various tasks that are dangerous, boring, or repetitive to humans. All in all, robots can be the perfect helper for humans and solve many problems in different industries.