MID NOTES

ARTIFICIAL INTELLIGENCE

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BSSE

8TH SEMESTER

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What is artificial intelligence?

Artificial intelligence (AI) is a wide-ranging branch of computer science concerned with building smart machines capable of performing tasks that typically require human intelligence.

What are examples of artificial intelligence?

- Siri, Alexa and other smart assistants
- Self-driving cars
- Robo-advisors
- Conversational bots
- Email spam filters
- Netflix's recommendations

Self-awareness in AI

Once Theory of Mind can be established in artificial intelligence, sometime well into the future, the final step will be for AI to become self-aware. This kind of artificial intelligence possesses human-level consciousness and understands its own existence in the world, as well as the presence and emotional state of others. It would be able to understand what others may need based on not just what they communicate to them but how they communicate it.

Self-awareness in artificial intelligence relies both on human researchers understanding the premise of consciousness and then learning how to replicate that so it can be built into machines.

Applications of artificial intelligence in business

Robot-assisted surgery:

Robotic surgeries have a very minuscule margin-of-error and can consistently perform surgeries round-the-clock without getting exhausted. Since they operate with such a high degree of accuracy, they are less invasive than traditional methods, which potentially reduces the time patients spend in the hospital recovering.

Better recommendations:

This is usually the first example that people give when asked about business applications of AI, and that's because it's an area where AI has delivered great results already. Most large e-commerce players have incorporated Artificial Intelligence to make product recommendations that users might be interested in, which has led to considerable increases in their bottom-lines.

Optimizing search

All of the e-commerce depends upon users searching for what they want, and being able to find it. Artificial Intelligence has been optimizing search results based on thousands of parameters to ensure that users find the exact product that they are looking for.

Intelligent Robots

Robots are able to perform the instructions given by a human.

Self-driving cars:

These use a combination of computer vision, image recognition and deep learning to build automated skill at piloting a vehicle while staying in a given lane and avoiding unexpected obstructions, such as pedestrians.

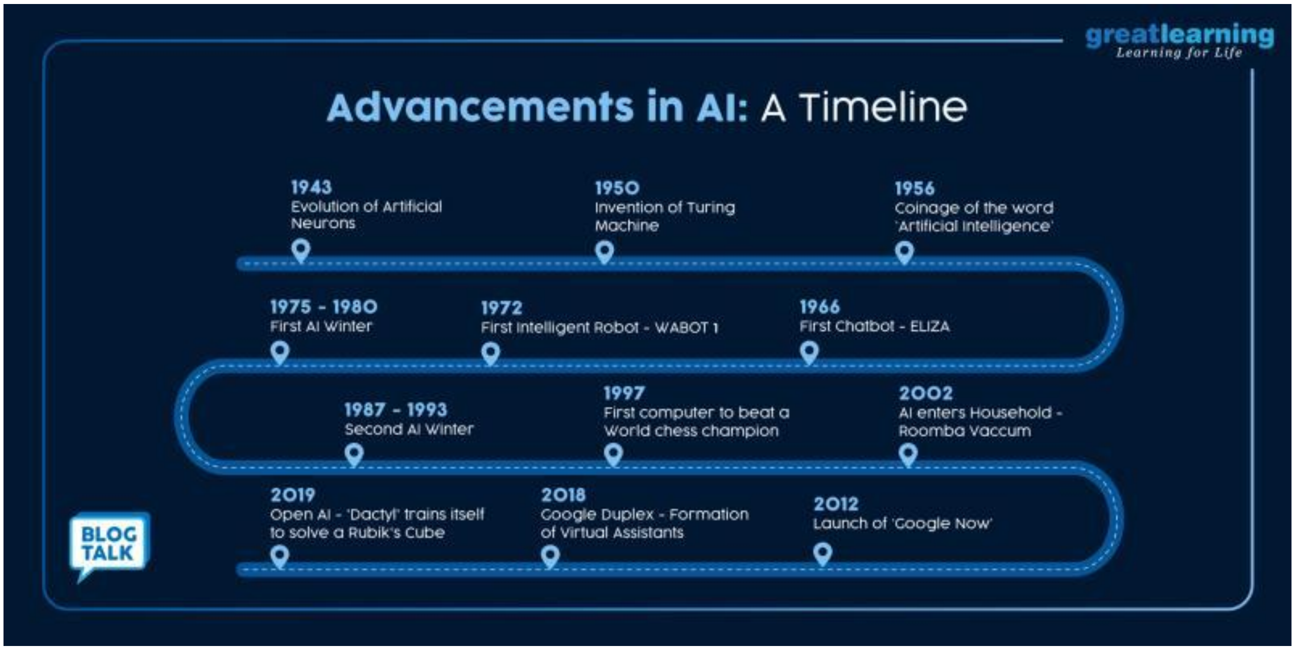
AI in business

Robotic process automation is being applied to highly repetitive tasks normally performed by humans. Machine learning algorithms are being integrated into analytics and CRM platforms to uncover information on how to better serve customers.

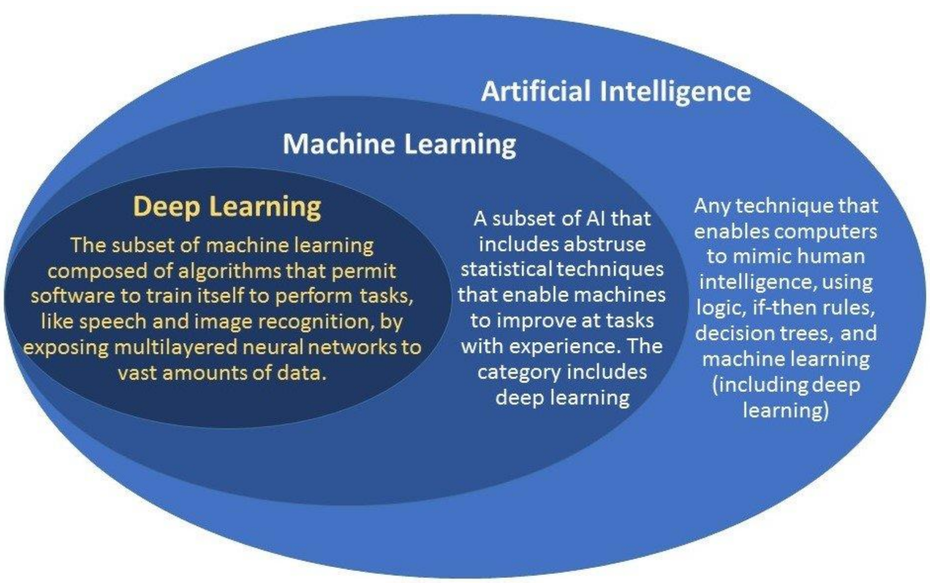
History of Artificial Intelligence (AI)

Artificial Intelligence technology is much older than you would imagine and the term "AI" is not new for researchers. The term "AI" was first coined at Dartmouth college in 1956 by a scientist called Marvin Minsky.

The below picture depicts an advancement in AI



What is the relationship between AI, ML, and DL?



Problem Solving Techniques

In artificial intelligence, problems can be solved by using searching algorithms, evolutionary computations, knowledge representations, etc. In general, searching is referred to as finding information one needs.

The process of problem-solving using searching consists of the following steps.

- Define the problem
- Analyze the problem
- Identification of possible solutions
- Choosing the optimal solution
- Implementation

Properties of search algorithms

Completeness

A search algorithm is said to be complete when it gives a solution or returns any solution for a given random input.

Optimality

If a solution found is best (lowest path cost) among all the solutions identified, then that solution is said to be an optimal one.

Time complexity

The time taken by an algorithm to complete its task is called time complexity. If the algorithm completes a task in a lesser amount of time, then it is an efficient one.

Space complexity

It is the maximum storage or memory taken by the algorithm at any time while searching.

Difference between Supervised and Unsupervised Learning

Supervised Learning	Unsupervised Learning
Supervised learning algorithms are trained using labeled data.	Unsupervised learning algorithms are trained using unlabeled data.
Supervised learning model takes direct feedback to check if it is predicting correct output or not.	Unsupervised learning model does not take any feedback.
In supervised learning, input data is provided to the model along with the output.	In unsupervised learning, only input data is provided to the model.
The goal of supervised learning is to train the model so that it can predict the output when it is given new data.	The goal of unsupervised learning is to find the hidden patterns and useful insights from the unknown dataset.
Supervised learning needs supervision to train the model.	Unsupervised learning does not need any supervision to train the model.
Supervised learning can be categorized in **Classification** and **Regression** problems.	Unsupervised Learning can be classified in **Clustering** and **Associations** problems.
Supervised learning can be used for those cases where we know the input as well as corresponding outputs.	Unsupervised learning can be used for those cases where we have only input data and no corresponding output data.
Supervised learning model produces an accurate result.	Unsupervised learning model may give less accurate result as compared to supervised learning.
Supervised learning is not close to true Artificial intelligence as in this, we first train the model for each data, and then only it can predict the correct output.	Unsupervised learning is more close to the true Artificial Intelligence as it learns similarly as a child learns daily routine things by his experiences.
It includes various algorithms such as Linear Regression, Logistic Regression, Support Vector Machine, Multi-class Classification, Decision tree, Bayesian Logic, etc.	It includes various algorithms such as Clustering, KNN, and Apriori algorithm.

Swarm intelligence

Swarm intelligence (SI) is the collective behavior of decentralized, self-organized systems, natural or artificial. The concept is employed in work on artificial intelligence. The expression was introduced by Gerardo Beni and Jing Wang in 1989, in the context of cellular robotic systems.

SI systems consist typically of a population of simple agents or boids interacting locally with one another and with their environment. The inspiration often comes from nature, especially biological systems. The agents follow very simple rules, and although there is no centralized control structure dictating how individual agents should behave, local, and to a certain degree random, interactions between such agents lead to the emergence of "intelligent" global behavior, unknown to the individual agents. Examples of swarm intelligence in natural systems include ant colonies, bee colonies, bird flocking, hawks hunting, animal herding, bacterial growth, fish schooling and microbial intelligence.

The application of swarm principles to robots is called swarm robotics while swarm intelligence refers to the more general set of algorithms. Swarm prediction has been used in the context of forecasting problems. Similar approaches to those proposed for swarm robotics are considered for genetically modified organisms in synthetic collective intelligence.

Applications

Swarm Intelligence-based techniques can be used in a number of applications. The U.S. military is investigating swarm techniques for controlling unmanned vehicles. The European Space Agency is thinking about an orbital swarm for self-assembly and interferometry. NASA is investigating the use of swarm technology for planetary mapping. A 1992 paper by M. Anthony Lewis and George A. Bekey discusses the possibility of using swarm intelligence to control nanobots within the body for the purpose of killing cancer tumors. Swarm intelligence has also been applied for data mining and cluster analysis. Ant based models are further subject of modern management theory.

Types of search algorithms

Now let’s see the types of the search algorithm.

Based on the search problems, we can classify the search algorithm as

- Uninformed search
- Informed search

Informed Search	Uninformed Search
It uses knowledge for the searching process.	It doesn’t use knowledge for searching process.
It finds solution more quickly.	It finds solution slow as compared to informed search.
It may or may not be complete.	It is always complete.
Cost is low.	Cost is high.
It consumes less time.	It consumes moderate time.
It provides the direction regarding the solution.	No suggestion is given regarding the solution in it.
It is less lengthy while implementation.	It is lengthier while implementation.
Greedy Search, A* Search, Graph Search	Depth First Search, Breadth First Search

Uninformed search algorithms

The uninformed search algorithm does not have any domain knowledge such as closeness, location of the goal state, etc. it behaves in a brute-force way. It only knows the information about how to traverse the given tree and how to find the goal state. This algorithm is also known as the Blind search algorithm or Brute -Force algorithm.
The uninformed search strategies are of six types.

They are-

- Breadth-first search
- Depth-first search
- Depth-limited search
- Iterative deepening depth-first search
- Bidirectional search
- Uniform cost search

Let's discuss these six strategies one by one.

Informed search algorithms

The informed search algorithm is also called heuristic search or directed search. In contrast to uninformed search algorithms, informed search algorithms require details such as distance to reach the goal, steps to reach the goal, cost of the paths which makes this algorithm more efficient.

Here, the goal state can be achieved by using the heuristic function.

The heuristic function is used to achieve the goal state with the lowest cost possible. This function estimates how close a state is to the goal.

Examples

1. Greedy best-first search algorithm
2. A* search algorithm

Constraint satisfaction problem

A constraint satisfaction problem (CSP) is a problem that requires its solution within some limitations or conditions also known as constraints. It consists of the following:

- A finite set of variables which stores the solution (V = {V1, V2, V3,....., Vn})
- A set of discrete values known as domain from which the solution is picked (D = {D1, D2, D3,.....,Dn})
- A finite set of constraints (C = {C1, C2, C3,......, Cn})

Examples of problems that can be modeled as a constraint satisfaction problem include:

- Type inference
- Eight queens puzzles
- Map coloring problem
- Maximum cut problem
- Sudoku, Crosswords

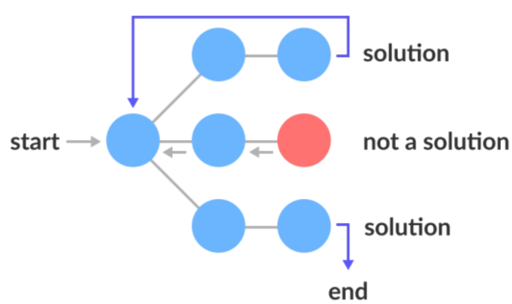
Solution of Constraint satisfaction problem

Backtracking

- A backtracking algorithm is a problem-solving algorithm that uses a brute force approach for finding the desired output.
- The Brute force approach tries out all the possible solutions and chooses the desired/best solutions.
- The term backtracking suggests that if the current solution is not suitable, then backtrack and try other solutions. Thus, recursion is used in this approach.

State Space Tree

A space state tree is a tree representing all the possible states (solution or nonsolution) of the problem from the root as an initial state to the leaf as a terminal state.



How uncertainty is handled in AI

Uncertainty:

Till now, we have learned knowledge representation using first-order logic and propositional logic with certainty, which means we were sure about the predicates. With this knowledge representation, we might write A→B, which means if A is true then B is true, but consider a situation where we are not sure about whether A is true or not then we cannot express this statement, this situation is called uncertainty.

So, to represent uncertain knowledge, where we are not sure about the predicates, we need uncertain reasoning or probabilistic reasoning.

Causes of uncertainty:

- Information occurred from unreliable sources.
- Experimental Errors
- Equipment fault
- Temperature variation
- Climate change.

How it can be avoided

Probabilistic reasoning is a way of knowledge representation where we apply the concept of probability to indicate the uncertainty in knowledge. In probabilistic reasoning, we combine probability theory with logic to handle the uncertainty.

We use probability in probabilistic reasoning because it provides a way to handle the uncertainty that is the result of someone's laziness and ignorance.

In probabilistic reasoning, there are two ways to solve problems with uncertain knowledge:

- Bayes' rule
- Bayesian Statistics

Robotic arm

A robotic arm is a type of mechanical arm, usually programmable, with similar functions to a human arm; the arm may be the sum total of the mechanism or may be part of a more complex robot. The links of such a manipulator are connected by joints allowing either rotational motion (such as in an articulated robot) or translational (linear) displacement

Types

Cartesian robot / Gantry robot:

Used for pick and place work, application of sealant, assembly operations, handling machine tools and arc welding. It is a robot whose arm has three prismatic joints, whose axes are coincident with a Cartesian coordinator.

Cylindrical robot

Used for assembly operations, handling at machine tools, spot welding, and handling at die casting machines. It is a robot whose axes form a cylindrical coordinate system.

Spherical robot / Polar robot:

Used for handling machine tools, spot welding, die casting, fettling machines, gas welding and arc welding. It is a robot whose axes form a polar coordinate system.

SCARA robot:

Used for pick and place work, application of sealant, assembly operations and handling machine tools. This robot features two parallel rotary joints to provide compliance in a plane.

Articulated robot:

Used for assembly operations, diecasting, fettling machines, gas welding, arc welding and spray painting. It is a robot whose arm has at least three rotary joints.

Parallel robot:

One use is a mobile platform handling cockpit flight simulator. It is a robot whose arms have concurrent prismatic or rotary joints.

Anthropomorphic robot: It is shaped in a way that resembles a human hand, i.e. with independent fingers and thumbs.

Knowledge Base & Inference Engine

In the field of artificial intelligence, an inference engine is a component of the system that applies logical rules to the knowledge base to deduce new information. The first inference engines were components of expert systems. The typical expert system consisted of a knowledge base and an inference engine. The knowledge base stored facts about the world. The inference engine applies logical rules to the knowledge base and deduced new knowledge. This process would iterate as each new fact in the knowledge base could trigger additional rules in the inference engine. Inference engines work primarily in one of two modes either special rule or facts: forward chaining and backward chaining. Forward chaining starts with the known facts and asserts new facts. Backward chaining starts with goals, and works backward to determine what facts must be asserted so that the goals can be achieved.

Knowledge Base

It contains domain-specific and high-quality knowledge.

Knowledge is required to exhibit intelligence. The success of any ES majorly depends upon the collection of highly accurate and precise knowledge.

What is Knowledge?

The data is collection of facts. The information is organized as data and facts about the task domain. Data, information, and past experience combined together are termed as knowledge.

Components of Knowledge Base

The knowledge base of an ES is a store of both, factual and heuristic knowledge.

Factual Knowledge − It is the information widely accepted by the Knowledge Engineers and scholars in the task domain.

Heuristic Knowledge − It is about practice, accurate judgement, one's ability of evaluation, and guessing.

Inference Engine

Use of efficient procedures and rules by the Inference Engine is essential in deducting a correct, flawless solution.

In case of knowledge-based ES, the Inference Engine acquires and manipulates the knowledge from the knowledge base to arrive at a particular solution.

In case of rule-based ES, it –

- Applies rules repeatedly to the facts, which are obtained from earlier rule application.
- Adds new knowledge into the knowledge base if required.
- Resolves rules conflict when multiple rules are applicable to a particular case.

To recommend a solution, the Inference Engine uses the following strategies –

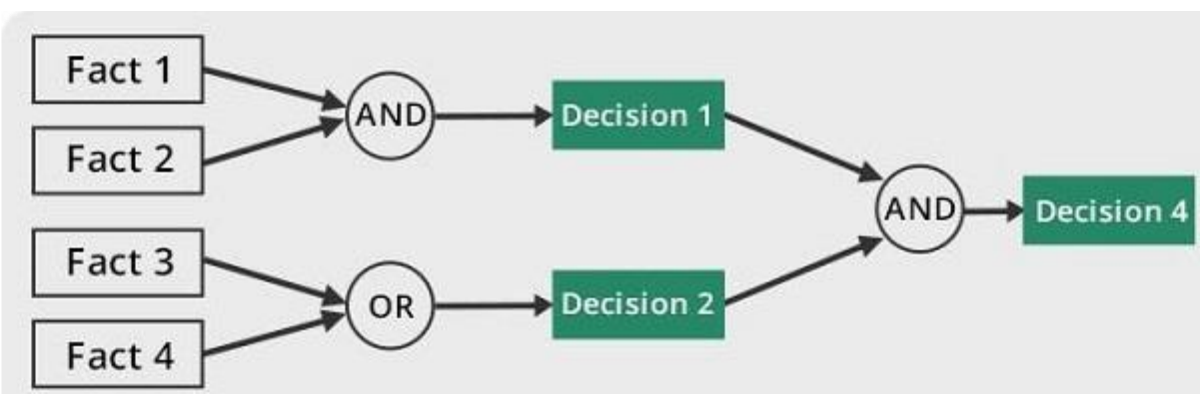
- Forward Chaining
- Backward Chaining

Forward Chaining

It is a strategy of an expert system to answer the question, **"What can happen next?"**

Here, the Inference Engine follows the chain of conditions and derivations and finally deduces the outcome. It considers all the facts and rules, and sorts them before concluding to a solution.

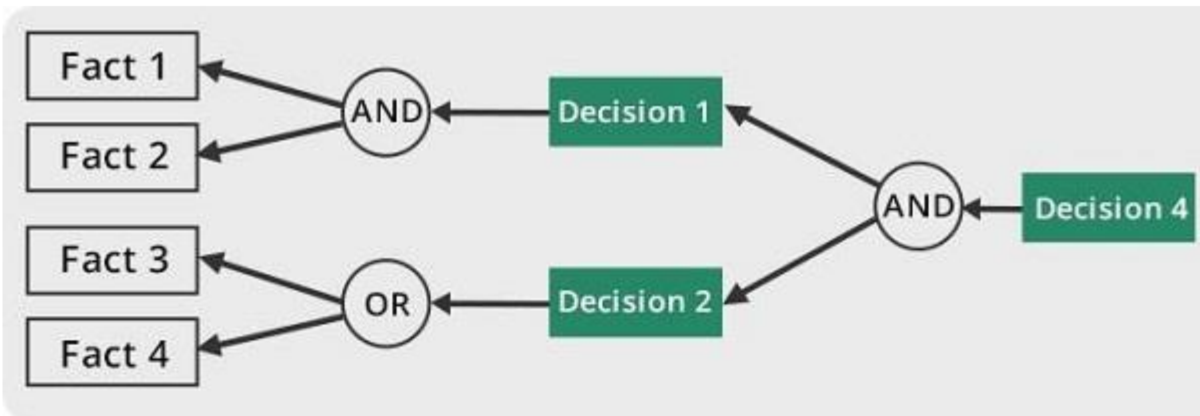
This strategy is followed for working on conclusion, result, or effect. For example, prediction of share market status as an effect of changes in interest rates.



Backward Chaining

With this strategy, an expert system finds out the answer to the question, **"Why this happened?"**

On the basis of what has already happened, the Inference Engine tries to find out which conditions could have happened in the past for this result. This strategy is followed for finding out cause or reason. For example, diagnosis of blood cancer in humans.



Challenges of self-driving cars. Key reasons self-driving cars are not a reality

Today, we see the driverless cars a reality after a constant research and development effort for past fifty plus years. Still, there are a lot of challenges in designing a fully autonomous system for the driverless cars.

1. Road conditions

Road conditions could be highly unpredictable and vary from places to places. In some cases, there are smooth and marked broad highways. In other cases, road conditions are highly deteriorated – no lane marking. Lanes are not defined, there are potholes, mountainous and tunnel roads where external signals for direction are not very clear and likewise.

2. Weather conditions

Weather conditions play another spoilsport. There could be a sunny and clear weather or rainy and stormy weather. Autonomous cars should work in all sorts of weather conditions. There is absolutely no scope for failure or downtime.

3. Traffic conditions

Autonomous cars would have to get onto the road where they would have to drive in all sorts of traffic conditions. They would have to drive with other autonomous cars on the road, and at the same time, there would also be a lot of humans. Wherever humans are involved, there are involved a lot of emotions. Traffic could be highly moderated and self-regulated. But often there are cases where people may be breaking traffic rules. An object may turn up in unexpected conditions. In the case of dense traffic, even the movement of few cms per minute does matter. One can’t wait endlessly for traffic to automatically clear and have some precondition to start moving. If more of such cars on the road are waiting for traffic to get cleared, ultimately that may result in a traffic deadlock.

4. Accident Liability

The most important aspect of autonomous cars is accidents liability. Who is liable for accidents caused by a self-driving car? In the case of autonomous cars, the software will be the main component that will drive the car and will make all the important decisions. While the initial designs have a person physically placed behind the steering wheel, newer designs showcased by Google, do not have a dashboard and a steering wheel! In such designs, where the car does not have any controls like a steering wheel, a brake pedal, an accelerator pedal, how is the person in the car supposed to control the car in case of an untoward incident? Additionally, due to the nature of autonomous cars, the occupants will mostly be in a relaxed state and may not be paying close attention to the traffic conditions. In situations where their attention is needed, by the time they need to act, it may be too late to avert the situation.

5. Radar Interference

Autonomous cars use lasers and radar for navigation. The lasers are mounted on roof top while the sensors are mounted on the body of the vehicle. The principle of radar works by detecting reflections of radio waves from surrounding objects. When on the road, a car will continuously emit radio frequency waves, which get reflected from the surrounding cars and other objects near the road. The time taken for the reflection is measured to calculate the distance between the car and the object. Appropriate action is then taken based on the radar readings. The principle of radar works by detecting reflections of radio waves from surrounding objects. When on the road, a car will continuously emit radio frequency waves, which get reflected from the surrounding cars and other objects near the road. The time taken for the reflection is measured to calculate the distance between the car and the object. Appropriate action is then taken based on the radar readings. When this technology is used for hundreds of vehicles on the road, will a car be able to distinguish between its own (reflected) signal and the signal (reflected or transmitted) from another vehicle? Even if multiple radio frequencies are available for radar, this frequency range is unlikely to be insufficient for all the vehicles manufactured.

6: Cybersecurity will likely be an issue

"Another issue is cybersecurity," says Kalra. "How do you make sure these cars can't be hacked? As vehicles get smarter and more connected, there are more ways to get into them and disrupt what they're doing."

This shouldn't be impossible to fix. Software companies have been dealing with this issue for a long time. But as Vox's Timothy Lee has written, it will likely require a culture change in the auto industry, which hasn't traditionally worried much about cybersecurity issues.

Olson raises a related issue: Many car enthusiasts already modify their own vehicles to improve performance. What happens if they do this for self-driving cars and inadvertently compromise the computers' decision-making ability? "Just as an example, someone puts on oversized wheels that distorts' the cars sense of how fast it's going," he notes. "It's hard to stop anyone from doing that."

7: Limitations of Sensors

In many ways, the sensors on the cars are more effective than human senses - and they need not have a blind spot nor are they limited to seeing during the daylight. However, sensors do have their failings.

8: Social Acceptability

Of course, to be fully embraced, they will also need to be accepted by the drivers themselves. The government isn't the only one the developers need to convince. While many people dislike driving, many more love driving and won't be willing to give up their favorite pastime easily.

It's not just convincing people to give up their passion for driving, it's also convincing them that the technology is safe. And while technology is proving to be incredibly safe and to make far fewer errors than humans, they are not foolproof and accidents have occurred. These tend to be highly publicized and often make people think it is more dangerous than really is.

In conclusion, self-driving cars are coming, and it's only a matter of time before they overcome their many teething problems.