The Smart Application of Artificial Intelligence(AI), Fuzzy Logic & Neural Networks in the Working of Traffic Signal Lights

[1]V.S.P.Vamsi, [2]V.V.Srikanth, [3]V.D.N.Sravanthi
[1]Assistant Professor in Mechanical Engineering, [2]Assistant Professor in Mechanical Engineering, [3]Assistant Professor in Mechanical Engineering
Abhinav Hi-Tech College of Engineering & Technology

Abstract - **Artificial Intelligence (AI) is a rapidly advancing technology, made possible by the Internet, that may soon have significant impacts on our everyday lives. AI traditionally refers to an artificial creation of human-like intelligence that can learn, reason, plan, perceive, or process natural language. These traits allow AI to bring immense socioeconomic opportunities, while also posing ethical and socio-economic challenges.As AI is an Internet enabled technology, the Internet Society recognizes that understanding the opportunities and challenges associated with AI is critical to developing an Internet that people can trust. Fuzzy Logic (FL) is a method of reasoning that resembles human reasoning. The approach of FL imitates the way of decision making in humans that involves all intermediate possibilities between digital values YES and NO. The conventional logic block that a computer can understand takes precise input and produces a definite output as TRUE or FALSE, which is equivalent to human's YES or NO. In recent years, the number and variety of applications of fuzzy logic have increased significantly. The applications range from consumer products such as cameras, camcorders, washing machines, and microwave ovens to industrial process control, medical instrumentation, decision-support systems, and portfolio selection. Artificial Neural Networks (ANNs) are processing devices (algorithms or actual hardware) that are loosely modeled after the neuronal structure of the mamalian cerebral cortex but on much smaller scales. A large ANN might have hundreds or thousands of processor units, whereas a mamalian brain has billions of neurons with a corresponding increase in magnitude of their overall interaction and emergent behavior. Although ANN researchers are generally not concerned with whether their networks accurately resemble biological systems, some have. For example, researchers have accurately simulated the function of the retina and modeled the eye rather well. Although the mathematics involved with neural networking is not a trivial matter, a user can rather easily gain at least an operational understanding of their structure and function. Traffic signs are divided into three basic categories: regulatory, warning, and guide signs. Traffic lights (or traffic signals) are lights used to control the movement of traffic. They are placed on roads at intersections and crossings.**

keywords - **Artificial Intelligence(AI), Fuzzy Logic, Neural Networks, Traffic Signal Lights**

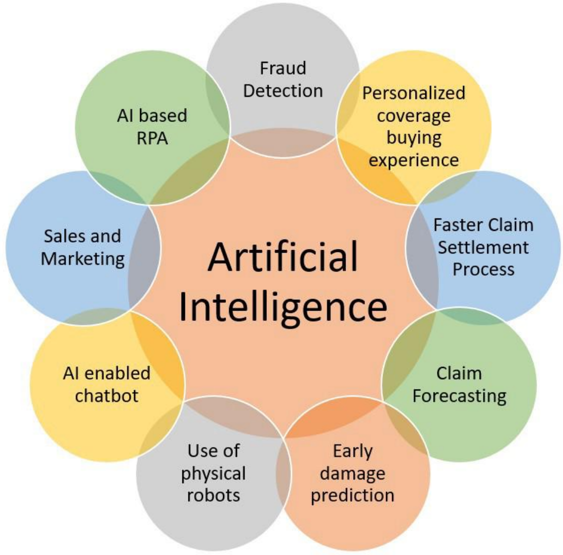
1. Introduction

Artificial Intelligence

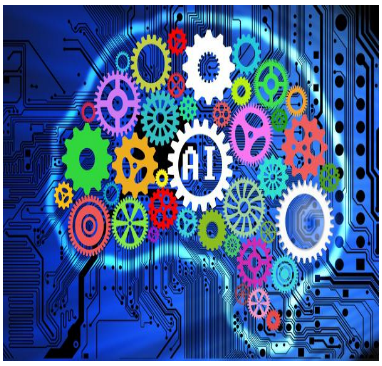
Artificial intelligence (AI) traditionally refers to an artificial creation of human-like intelligence that can learn, reason, plan, perceive, or process natural language.

Artificial intelligence (AI) has received increased attention in recent years. Innovation, made possible through the Internet, has brought AI closer to our everyday lives. These advances, alongside interest in the technology's potential socio-economic and ethical impacts, brings AI to the forefront of many contemporary debates. Industry investments in AI are rapidly increasing, and governments are trying to understand what the technology could mean for their citizens.

The collection of "Big Data" and the expansion of the Internet of Things (IoT), has made a perfect environment for new AI applications and services to grow. Applications based on AI are already visible in healthcare diagnostics, targeted treatment, transportation, public safety, service robots, education and entertainment, but will be applied in more fields in the coming years. Together with the Internet, AI changes the way we experience the world and has the potential to be a new engine for economic growth.



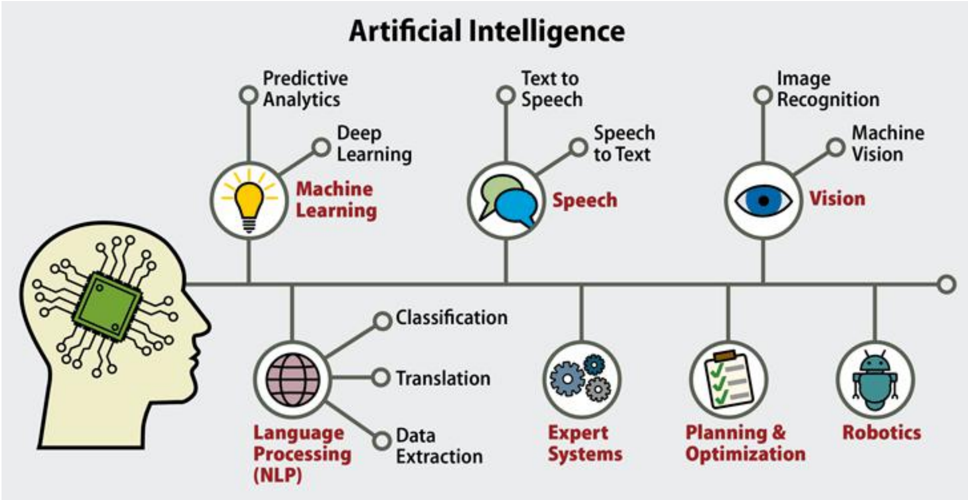
Advances in AI, particularly on the development of new algorithms and models in a field of computer science referred to as *machine learning*, as machine learning is used more often in products and services, there are some significant considerations when it comes to users' trust in the Internet.
Algorithms are a sequence of instructions used to solve a problem. Algorithms, developed by programmers to instruct computers in new tasks, are the building blocks of the advanced digital world we see today. Computer algorithms organize enormous amounts of data into information and services, based on certain instructions and rules. It's an important concept to understand, because in machine learning, learning algorithms – not computer programmers – create the rules**.**
The basic process of machine learning is to give *training data* to a *learning algorithm*. The learning algorithm then generates a new set of rules, based on inferences from the data. This is in essence generating a new algorithm, formally referred to as the machine learning model. By using different training data, the same learning algorithm could be used to generate different models. For example, the same type of learning algorithm could be used to teach the computer how to translate languages or predict the stock market.



<u>Current Uses of AI</u>

Although artificial intelligence evokes thoughts of science fiction, artificial intelligence already has many uses today, for example:

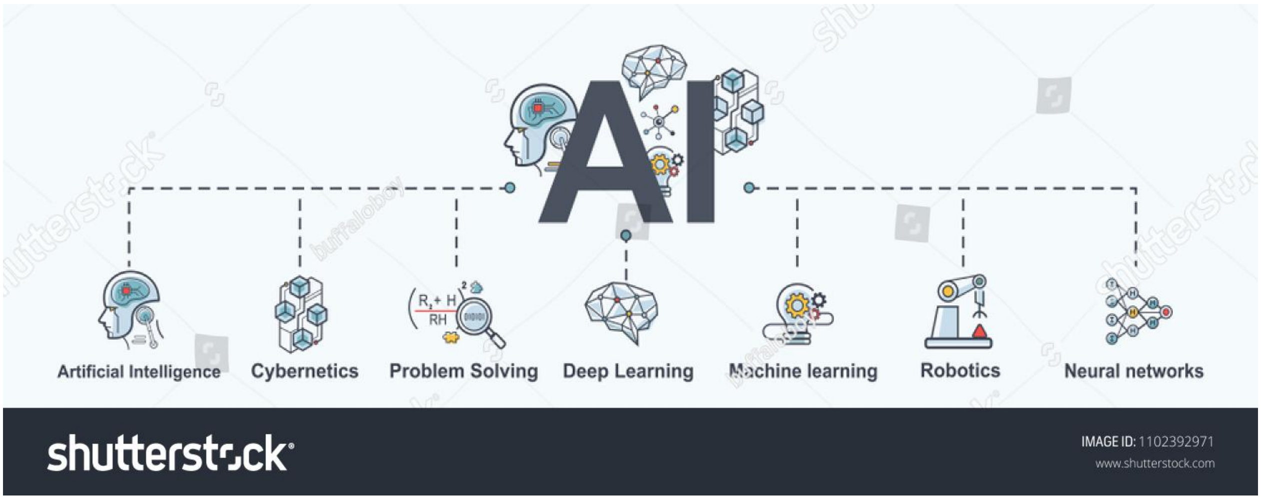
1. **<u>Email filtering</u>**: Email services use artificial intelligence to filter incoming emails. Users can train their spam filters by marking emails as "spam".
2. **<u>Personalization</u>**: Online services use artificial intelligence to personalize your experience. Services, like Amazon or Netflix, "learn" from your previous purchases and the purchases of other users in order to recommend relevant content for you.
3. **<u>Fraud detection</u>**: Banks use artificial intelligence to determine if there is strange activity on your account. Unexpected activity, such as foreign transactions, could be flagged by the algorithm.
4. **<u>Speech recognition</u>**: Applications use artificial intelligence to optimize speech recognition functions. Examples include intelligent personal assistants, e.g. Amazon's "Alexa" or Apple's "Siri".



The Internet Society recognizes that understanding the opportunities and challenges associated with AI is critical to developing an Internet that people trust. This is particularly important as the Internet is key for the technology behind AI and is the main platform for its deployment; including significant new means of interacting with the network.

1. **How machines learn:** Although a machine learning model may apply a mix of different techniques, the methods for learning can typically be categorized as three general types:
2. **Supervised learning**: The learning algorithm is given labeled data and the desired output. For example, pictures of dogs labeled "dog" will help the algorithm identify the rules to classify pictures of dogs.
3. **Unsupervised learning**: The data given to the learning algorithm is unlabeled, and the algorithm is asked to identify patterns in the input data. For example, the recommendation system of an e-commerce website where the learning algorithm discovers similar items often bought together.
4. **Reinforcement learning**: The algorithm interacts with a dynamic environment that provides feedback in terms of rewards and punishments. For example, self-driving cars being rewarded to stay on the road.1

Several issues must be considered when addressing AI, including, socio-economic impacts; issues of transparency, bias, and accountability; new uses for data, considerations of security and safety, ethical issues; and, how AI facilitates the creation of new ecosystems.



At the same time, in this complex field, there are specific challenges facing AI, which include: a lack of transparency and interpretability in decision-making; issues of data quality and potential bias; safety and security implications; considerations regarding accountability; and, its potentially disruptive impacts on social and economic structures.

Machine learning is not new. Many of the learning algorithms that spurred new interest in the field, such as neural networks, are based on decades old research. The current growth in AI and machine learning is tied to developments in three important areas:

1. **Data availability**: Just over 3 billion people are online with an estimated 17 billion connected devices or sensors. That generates a large amount of data which, combined with decreasing costs of data storage, is easily available for use. Machine learning can use this as training data for learning algorithms, developing new rules to perform increasingly complex tasks.

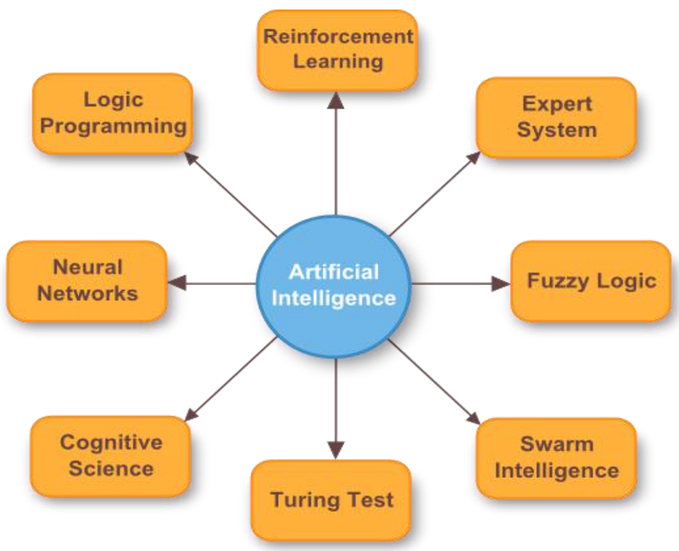
2. **Computing power**: Powerful computers and the ability to connect remote processing power through the Internet make it possible for machine-learning techniques that process enormous amounts of data.
3. **Algorithmic innovation**: New machine learning techniques, specifically in layered neural networks – also known as "deep learning" – have inspired new services, but is also spurring investments and research in other parts of the field.

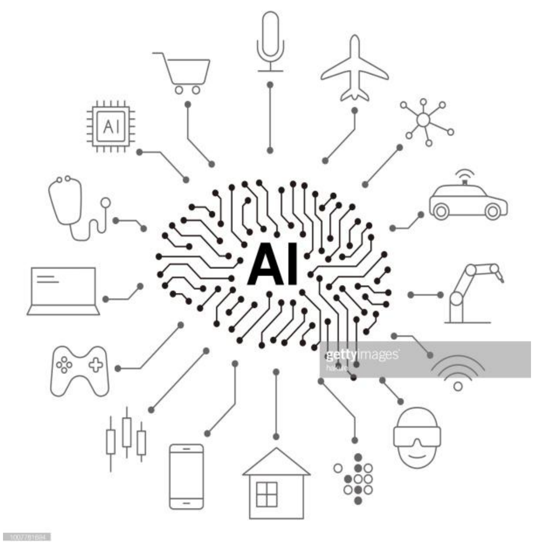
Key Considerations: As machine learning algorithms are used in more and more products and services, there are some serious factors must be considered when addressing AI, particularly in the context of people's trust in the Internet*:*

1. **Socio-Economic Impacts**. The new functions and services of AI are expected to have significant socio-economic impacts. The ability of machines to exhibit advanced cognitive skills to process natural language, to learn, to plan and to perceive, makes it possible for new tasks to be performed by intelligent systems, sometimes with more success than humans. New applications of AI could open up exciting opportunities for more effective medical care, safer industries and services, and boost productivity on a massive scale.
2. **Transparency, Bias and Accountability**. AI-made decisions can have serious impacts in people's lives. AI may discriminate against some individuals or make errors due to biased training data. How a decision is made by AI is often hard to understand, making problems of bias harder to solve and ensuring accountability much more difficult.
3. **New uses for Data**. Machine learning algorithms have proved efficient in analyzing and identifying patterns in large amounts of data, commonly referred to as "Big Data". Big Data is used to train learning algorithms to increase their performance. This generates an increasing demand for data, encouraging data collection and raising risks of oversharing of information at the expense of user privacy.
4. **Security and Safety**. Advancements in AI and its use will also create new security and safety challenges. These include unpredictable and harmful behavior of the AI agent, but also adversarial learning by malicious actors.
5. **Ethics**. AI may make choices that could be deemed unethical, yet also be a logical outcome of the algorithm, emphasizing the importance to build in ethical considerations into AI systems and algorithms.
6. **New Ecosystems**. Like the impact of mobile Internet, AI makes new applications, services, and new means of interacting with the network possible. For example, through speech and smart agents, which may create new challenges to how open or accessible the Internet becomes.

2. Many factors contribute to the challenges faced by stakeholders with the development of AI, including:

1. **Decision-making: transparency and "interpretability"**. With artificial intelligence performing tasks ranging from self-driving cars to managing insurance payouts, it's critical we understand decisions made by an AI agent.
2. **Data Quality and Bias**. In machine learning, the model's algorithm will only be as good as the data it trains on – commonly described as "garbage in, garbage out". This means biased data will result in biased decisions. The problem of minimizing bias is also complicated by the difficulty in understanding how a machine learning model solves a problem, particularly when combined with a vast number of inputs. As a result, it may be difficult to pinpoint the specific data causing the issue in order to adjust it. If people feel a system is biased, it undermines the confidence in the technology.
3. **Safety and Security**. As the AI agent learns and interacts with its environment, there are many challenges related to its safe deployment. They can stem from unpredictable and harmful behavior, including indifference to the impact of its actions. Safety and security considerations must be taken into account in the debate around transparency of algorithmic decisions.





4. **Accountability**. The strength and efficiency of learning algorithms is based on their ability to generate rules without step-by–step instructions. While the technique has proved efficient in accomplishing complex tasks such as face recognition or interpreting natural language, it is also one of the sources of concern.

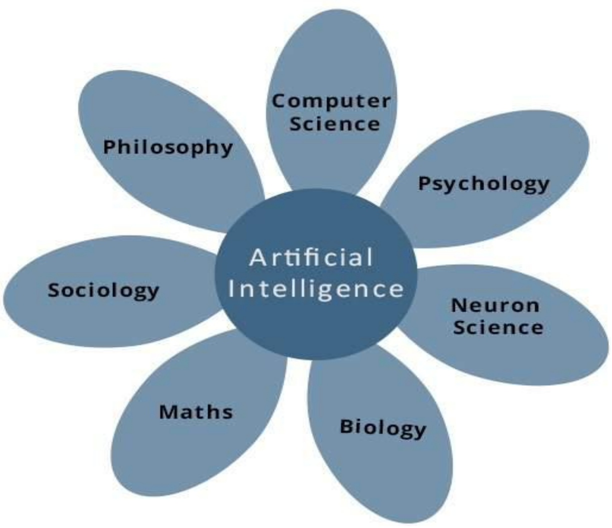
5. **Social and Economic Impact**. It is predicted that AI technologies will bring economic changes through increases in productivity. This includes machines being able to perform new tasks, such as self-driving cars, advanced robots or smart assistants to support people in their daily lives. For consumers, automation could mean greater efficiency and cheaper products. Artificial intelligence will also create new jobs or increase demand for certain existing ones. But it also means some current jobs may be automated in one to two decades. Some predict it could be as high as 47% of jobs in the United States. Unskilled and lowpaying jobs are more likely to be automated, but AI will also impact high-skilled jobs that rely extensively on routine cognitive tasks. Depending on the net-effect, this could lead to a higher degree of structural unemployment. These shifts have helped propel some of the world's fastest emerging economies and supports a growing global middle class. Automation may also impact the division of labor on a global scale. Over the past several decades, production and services in some economic sectors has shifted from developed economies to the emerging economies, largely as a result of comparatively lower labor or material costs. But, with the emergence of AI technologies, these incentives could lessen. Some companies, instead of offshoring geographical division of labor may choose to automate some of their operations locally.
6. **Governance**. The institutions, processes and organizations involved in the governance of AI are still in the early stages. To a great extent, the ecosystem overlaps with subjects related to Internet governance and policy. Privacy and data laws are one example. Existing efforts from public stakeholders include the UN Expert Group on Lethal Autonomous Weapons Systems (LAWS), as well as regulations like the EU's recent General Data Protection Regulation (GDPR) and the "right to explanation" of algorithmic decisions. Other initiatives from the private sector include the "Partnership on AI", established by Amazon, Google, Facebook, IBM, Apple and Microsoft "to advance public understanding of artificial intelligence technologies (AI) and formulate best practices on the challenges and opportunities within the field".

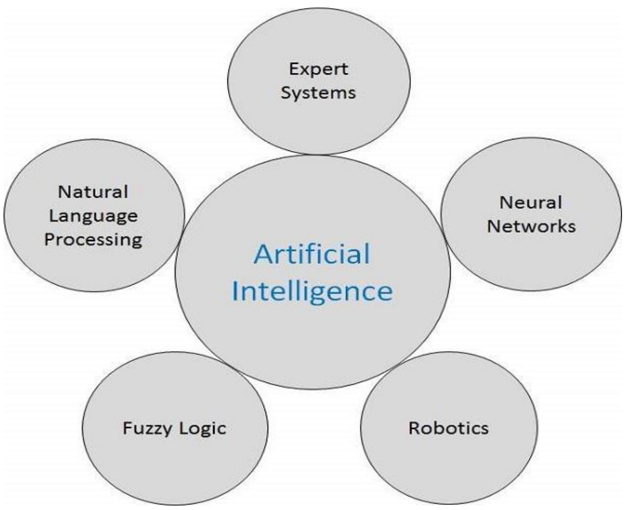
3. Guiding Principles and Recommendations

Principle: AI system designers and builders need to apply a user-centric approach to the technology. They need to consider their collective responsibility in building AI systems that will not pose security risks to the Internet and Internet users.

Recommendations

1. **Adopt Ethical Standards**: Adherence to the principles and standards of ethical considerations in the design of artificial intelligence should guide researchers and industry going forward.
2. **Promote Ethical Considerations in Innovation Policies**: Innovation policies should require adherence to ethical standards as a pre-requisite for things like funding.





Ensure "Interpretability" of AI systems

Principle*:* Decisions made by an AI agent should be possible to understand, especially if those decisions have implications for public safety, or result in discriminatory practices.

Recommendations

1. **Ensure Human Interpretability of Algorithmic Decisions**: AI systems must be designed with the minimum requirement that the designer can account for an AI agent's behaviors. Some systems with potentially severe implications for public safety should also have the functionality to provide information in the event of an accident.
2. **Empower Users**: Providers of services that utilize AI need to incorporate the ability for the user to request and receive basic explanations as to why a decision was made.

Public Empowerment

Principle*:* The public's ability to understand AI-enabled services, and how they work, is key to ensuring trust in the technology.

Recommendations

1. **"Algorithmic Literacy" must be a basic skill**: Whether it is the curating of information in social media platforms or self-driving cars, users need to be aware and have a basic understanding of the role of algorithms and autonomous decision-making. Such skills will also be important in shaping societal norms around the use of the technology. For example, identifying decisions that may not be suitable to delegate to an AI.
2. **Provide the public with information**: While full transparency around a service's machine learning techniques and training data is generally not advisable due to the security risk, the public should be provided with enough information to make it possible for people to question its outcomes.

Responsible Deployment

Principle*:* The capacity of an AI agent to act autonomously, and to adapt its behavior over time without human direction, calls for significant safety checks before deployment, and ongoing monitoring.

Recommendations

1. **Humans must be in control**: Any autonomous system must allow for a human to interrupt an activity or shutdown the system (an "off-switch"). There may also be a need to incorporate human checks on new decision-making strategies in AI system design, especially where the risk to human life and safety is great.
2. **Make safety a priority**: Any deployment of an autonomous system should be extensively tested beforehand to ensure the AI agent's safe interaction with its environment (digital or physical) and that it functions as intended. Autonomous systems should be monitored while in operation, and updated or corrected as needed.
3. **Privacy is key**: AI systems must be data responsible. They should use only what they need and delete it when it is no longer needed ("data minimization"). They should encrypt data in transit and at rest, and restrict access to authorized persons ("access control"). AI systems should only collect, use, share and store data in accordance with privacy and personal data laws and best practices.
4. **Think before you act**: Careful thought should be given to the instructions and data provided to AI systems. AI systems should not be trained with data that is biased, inaccurate, incomplete or misleading.
5. **If they are connected, they must be secured**: AI systems that are connected to the Internet should be secured not only for their protection, but also to protect the Internet from malfunctioning or malware-infected AI systems that could become the next-generation of botnets. High standards of device, system and network security should be applied.
6. **Responsible disclosure**: Security researchers acting in good faith should be able to responsibly test the security of AI systems without fear of prosecution or other legal action. At the same time, researchers and others who discover security vulnerabilities or other design flaws should responsibly disclose their findings to those who are in the best position to fix the problem.

Ensuring Accountability

Principle*:* Legal accountability has to be ensured when human agency is replaced by decisions of AI agents.

Recommendations

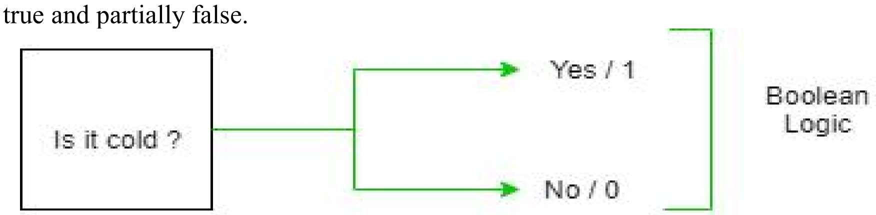
1. **Ensure legal certainty**: Governments should ensure legal certainty on how existing laws and policies apply to algorithmic decision-making and the use of autonomous systems to ensure a predictable legal environment. This includes working with experts from all disciplines to identify potential gaps and run legal scenarios. Similarly, those designing and using AI should be in compliance with existing legal frameworks.
2. **Put users first**: Policymakers need to ensure that any laws applicable to AI systems and their use put users' interests at the center. This must include the ability for users to challenge autonomous decisions that adversely affect their interests.
3. **Assign liability up-front**: Governments working with all stakeholders need to make some difficult decisions now about who will be liable in the event that something goes wrong with an AI system, and how any harm suffered will be remedied.

4. Fuzzy Logic

Introduction

The term **fuzzy** refers to things which are not clear or are vague. In the real world many times we encounter a situation when we can't determine whether the state is true or false, their fuzzy logic provides a very valuable flexibility for reasoning. In this way, we can consider the inaccuracies and uncertainties of any situation.

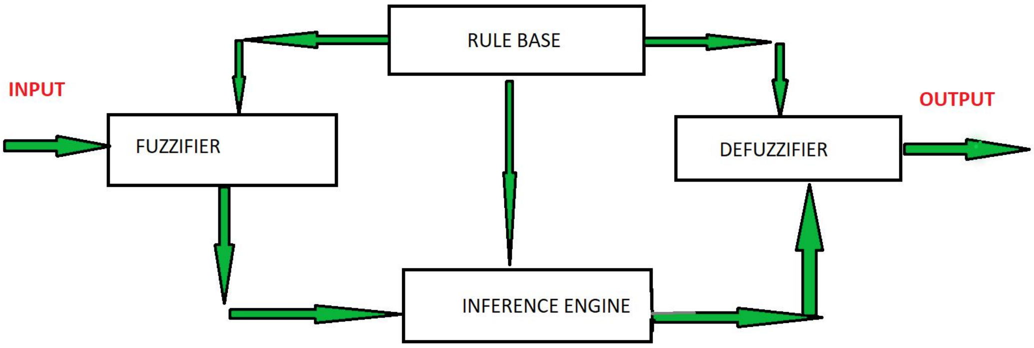
In boolean system truth value, 1.0 represents absolute truth value and 0.0 represents absolute false value. But in the fuzzy system, there is no logic for absolute truth and absolute false value. But in fuzzy logic, there is intermediate value too present which is partially true and partially false.



Architecture

Its Architecture contains four parts :

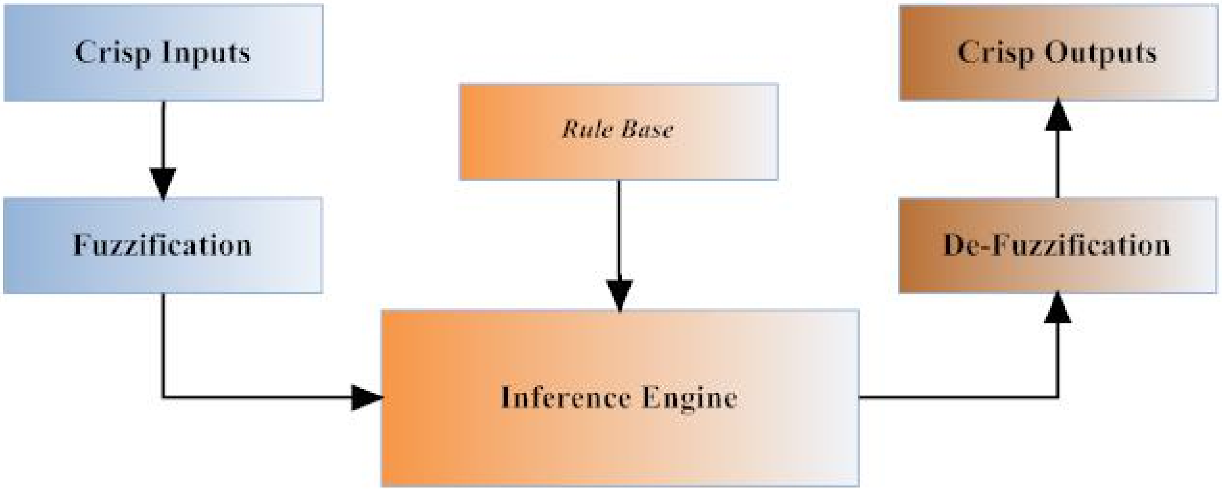
1. **Rule Base:** It contains the aet of rules and the IF-THEN conditions provided by the experts to govern the decision making system, on the basis of linguistic information. Recent developments in fuzzy theory offer several effective methods for the design and tuning of fuzzy controllers. Most of these developments reduce the number of fuzzy rules.
2. **Fuzzification:** It is used to convert inputs i.e. crisp numbers into fuzzy sets. Crisp inputs are basically the exact inputs measured by sensors and passed into the control system for processing, such as temperature, pressure, rpm's, etc.
3. **Inference Engine:** It determines the matching degree of the current fuzzy input with respect to each rule and decides which rules are to be fired according to the input field. Next, the fired rules are combined to form the control actions.
4. **Defuzzification:** It is used to convert the fuzzy sets obtained by inference engine into a crisp value. There are several defuzzification methods available and the best suited one is used with a specific expert system to reduce the error.



FUZZY LOGIC ARCHITECTURE

What is Fuzzy Control?

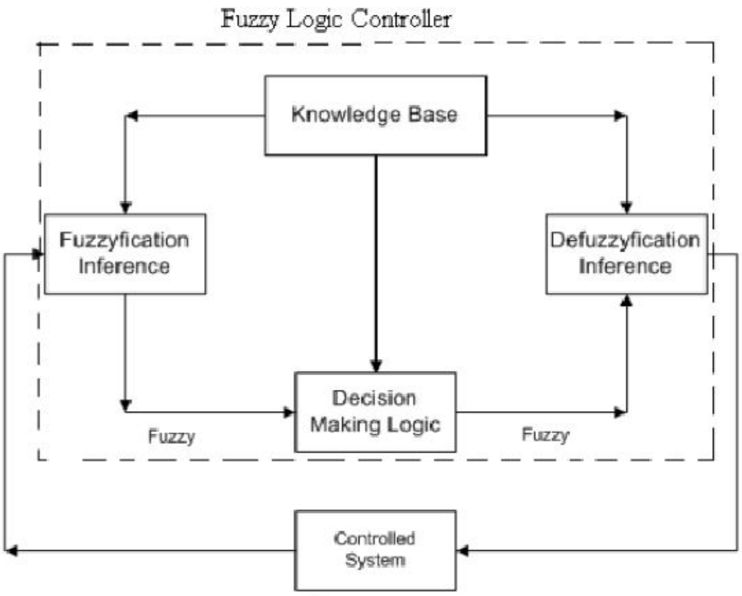
1. It is a technique to embody human-like thinkings into a control system.
2. It may not be designed to give accurate reasoning but it is designed to give acceptable reasoning.
3. It can emulate human deductive thinking, that is, the process people use to infer conclusions from what they know.
4. Any uncertainties can be easily dealt with the help of fuzzy logic.



Membership Function

Definition: A graph that defines how each point in the input space is mapped to membership value between 0 and 1. Input space is often referred as the universe of discourse or universal set (u), which contain all the possible elements of concern in each particular application. There are largely three types of fuzzifiers:

1. Singleton fuzzifier
2. Gaussian fuzzifier
3. Trapezoidal or triangular fuzzifier

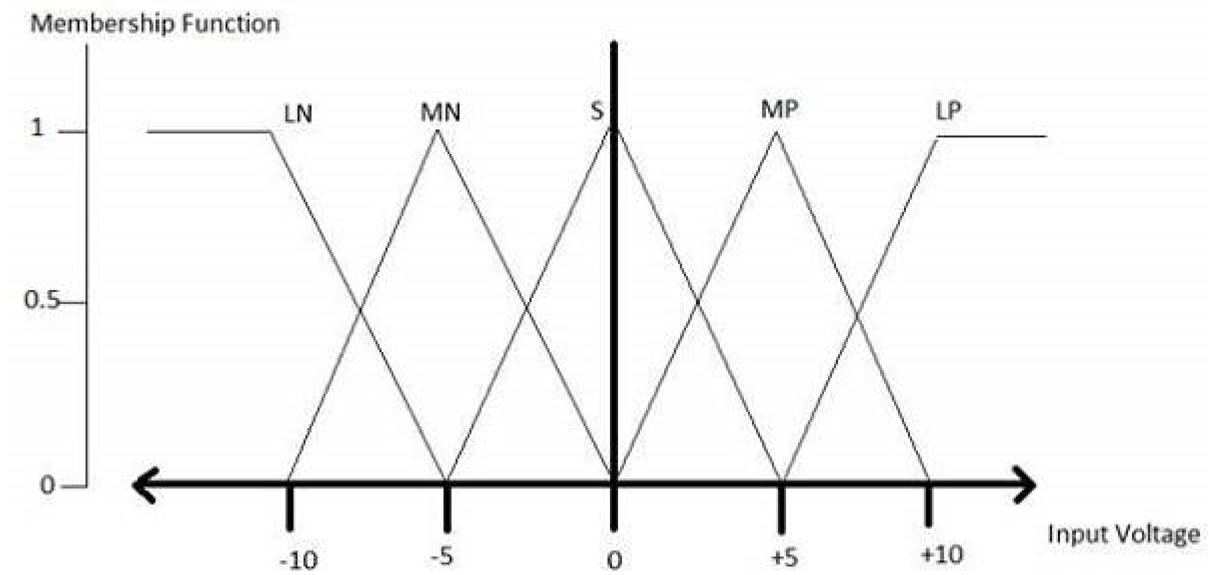


The **membership functions work on** fuzzy sets of variables.

Membership functions allow you to quantify linguistic term and represent a fuzzy set graphically. A **membership function** for a fuzzy *set A* on the universe of discourse X is defined as μ_A:X → [0,1].

Here, each element of *X* is mapped to a value between 0 and 1. It is called **membership value** or **degree of membership**. It quantifies the degree of membership of the element in *X* to the fuzzy set *A*.

1. x axis represents the universe of discourse.
2. y axis represents the degrees of membership in the [0, 1] interval.
3. There can be multiple membership functions applicable to fuzzify a numerical value. Simple membership functions are used as use of complex functions does not add more precision in the output.
4. All membership functions for **LP, MP, S, MN,** and **LN** are shown as below −



The triangular membership function shapes are most common among various other membership function shapes such as trapezoidal, singleton, and Gaussian.
Here, the input to 5-level fuzzifier varies from -10 volts to +10 volts. Hence the corresponding output also changes.

5. What Is Fuzzy Logic?

The term fuzzy mean things which are not very clear or vague. In real life, we may come across a situation where we can't decide whether the statement is true or false. At that time, fuzzy logic offers very valuable flexibility for reasoning. We can also consider the uncertainties of any situation.

Fuzzy logic algorithm helps to solve a problem after considering all available data. Then it takes the best possible decision for the given the input. The FL method imitates the way of decision making in a human which consider all the possibilities between digital values T and F.

6. History of Fuzzy Logic

Although, the concept of fuzzy logic had been studied since the 1920's. The term fuzzy logic was first used with 1963 by Lotfi Zadeh a professor of UC Berkeley in California. He observed that conventional computer logic was not capable of manipulating data representing subjective or unclear human ideas.

Fuzzy logic has been applied to various fields, from control theory to AI. It was designed to allow the computer to determine the distinctions among data which is neither true nor false. Something similar to the process of human reasoning. Like Little dark, Some brightness, etc.

7. Characteristics of Fuzzy Logic

Here, are some important characteristics of fuzzy logic

1. Flexible and easy to implement machine learning technique
2. Helps you to mimic the logic of human thought
3. Logic may have two values which represent two possible solutions
4. Highly suitable method for uncertain or approximate reasoning
5. Fuzzy logic views inference as a process of propagating elastic constraints
6. Fuzzy logic allows you to build nonlinear functions of arbitrary complexity.
7. Fuzzy logic should be built with the complete guidance of experts

8. Description of Fuzzy Logic

Fuzzy logic has two different meanings. In a narrow sense, fuzzy logic is a logical system, which is an extension of multivalued logic. However, in a wider sense fuzzy logic (FL) is almost synonymous with the theory of fuzzy sets, a theory which relates to classes of objects with unsharp boundaries in which membership is a matter of degree. In this perspective, fuzzy logic in its narrow sense is a branch of FL. Even in its more narrow definition, fuzzy logic differs both in concept and substance from traditional multivalued logical systems.

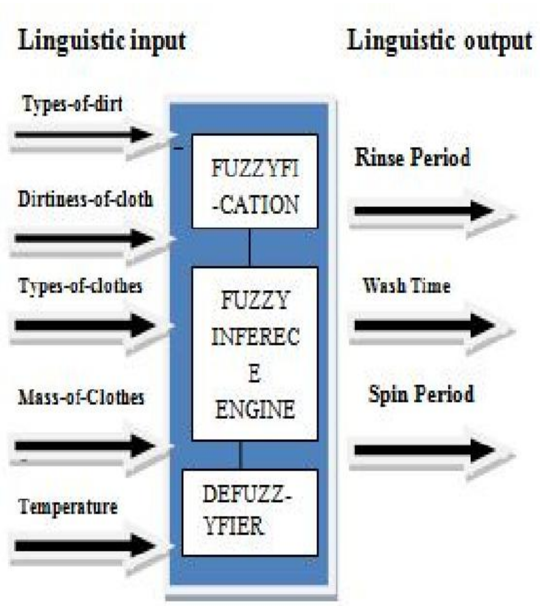
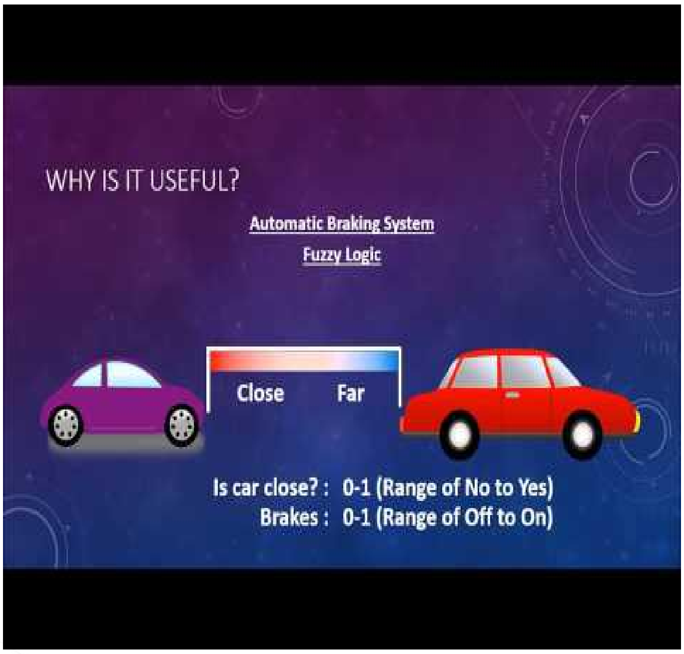
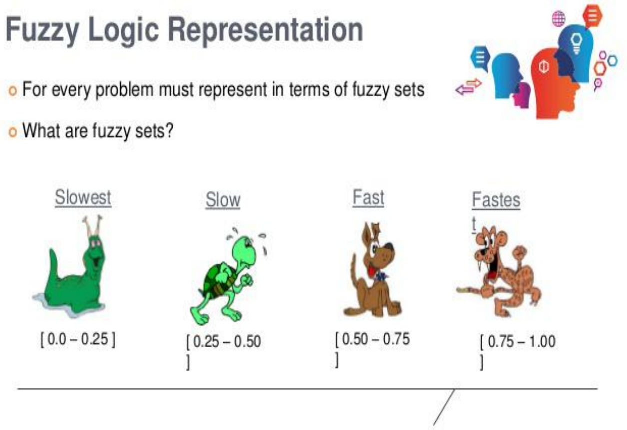
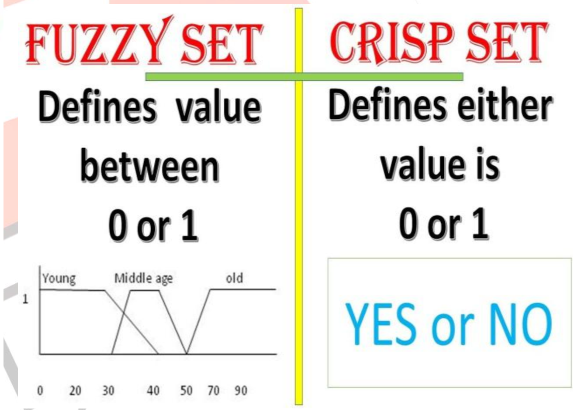


Figure: 4 FLC for Washing Machine



Another basic concept in FL, which plays a central role in most of its applications, is that of a fuzzy if-then rule or, simply, fuzzy rule. Although rule-based systems have a long history of use in Artificial Intelligence (AI), what is missing in such systems is a mechanism for dealing with fuzzy consequents and fuzzy antecedents. In fuzzy logic, this mechanism is provided by the calculus of fuzzy rules. The calculus of fuzzy rules serves as a basis for what might be called the Fuzzy Dependency and Command Language (FDCL). Although FDCL is not used explicitly in the toolbox, it is effectively one of its principal constituents. In most of the applications of fuzzy logic, a fuzzy logic solution is, in reality, a translation of a human solution into FDCL.





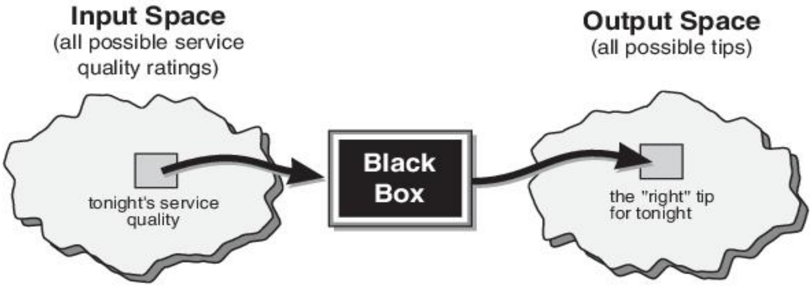
A trend that is growing in visibility relates to the use of fuzzy logic in combination with neurocomputing and genetic algorithms. More generally, fuzzy logic, neurocomputing, and genetic algorithms may be viewed as the principal constituents of what might be called soft computing. Unlike the traditional, hard computing, soft computing accommodates the imprecision of the real world. The guiding principle of soft computing is: Exploit the tolerance for imprecision, uncertainty, and partial truth to achieve tractability, robustness, and low solution cost. In the future, soft computing could play an increasingly important role in the conception and design of systems whose MIQ (Machine IQ) is much higher than that of systems designed by conventional methods.

Among various combinations of methodologies in soft computing, the one that has highest visibility at this juncture is that of fuzzy logic and neurocomputing, leading to neuro-fuzzy systems. Within fuzzy logic, such systems play a particularly important role in the induction of rules from observations. An effective method developed by Dr. Roger Jang for this purpose is called ANFIS (Adaptive Neuro-Fuzzy Inference System).

Fuzzy logic is all about the relative importance of precision: How important is it to be exactly right when a rough answer will do?

Fuzzy logic is a convenient way to map an input space to an output space. Mapping input to output is the starting point for everything. Consider the following examples:

1. With information about how good your service was at a restaurant, a fuzzy logic system can tell you what the tip should be.
2. With your specification of how hot you want the water, a fuzzy logic system can adjust the faucet valve to the right setting.
3. With information about how far away the subject of your photograph is, a fuzzy logic system can focus the lens for you.
4. With information about how fast the car is going and how hard the motor is working, a fuzzy logic system can shift gears for you.
5. A graphical example of an input-output map is shown in the following figure.



An input-output map for the tipping problem:
"Given the quality of service, how much should I tip?"

Determining the appropriate amount of tip requires mapping inputs to the appropriate outputs. Between the input and the output, the preceding figure shows a black box that can contain any number of things: fuzzy systems, linear systems, expert systems, neural networks, differential equations, interpolated multidimensional lookup tables, or even a spiritual advisor, just to name a few of the possible options. Clearly the list could go on and on.

Of the dozens of ways to make the black box work, it turns out that fuzzy is often the very best way. Why should that be? As Lotfi Zadeh, who is considered to be the father of fuzzy logic, once remarked: "In almost every case you can build the same product without fuzzy logic, but fuzzy is faster and cheaper."

9. Importance of Fuzzy Logic

Here is a list of general observations about fuzzy logic:

1. Fuzzy logic is conceptually easy to understand.
2. The mathematical concepts behind fuzzy reasoning are very simple. Fuzzy logic is a more intuitive approach without the far-reaching complexity.
3. Fuzzy logic is flexible.
4. With any given system, it is easy to layer on more functionality without starting again from scratch.
5. Fuzzy logic is tolerant of imprecise data.
6. Everything is imprecise if you look closely enough, but more than that, most things are imprecise even on careful inspection. Fuzzy reasoning builds this understanding into the process rather than tacking it onto the end.
7. Fuzzy logic can model nonlinear functions of arbitrary complexity.
8. You can create a fuzzy system to match any set of input-output data.
9. This process is made particularly easy by adaptive techniques like Adaptive Neuro-Fuzzy Inference Systems (ANFIS), which are available in Fuzzy Logic Toolbox software.
10. Fuzzy logic can be built on top of the experience of experts.

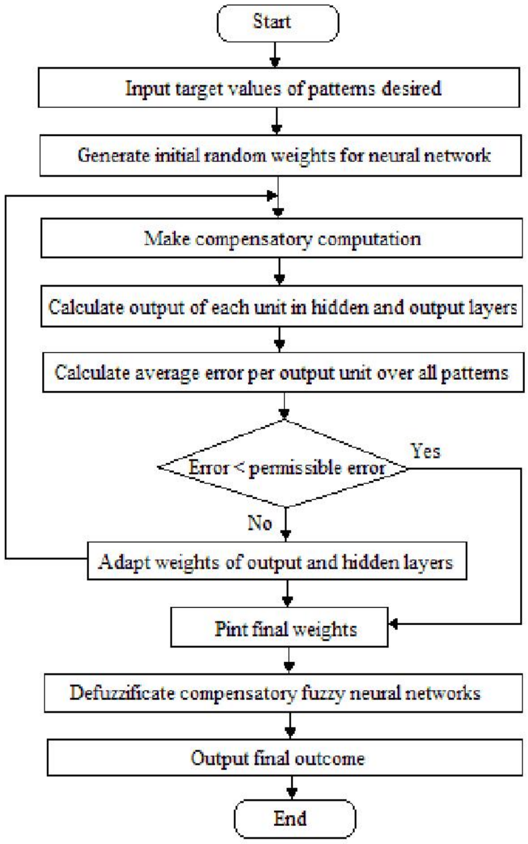


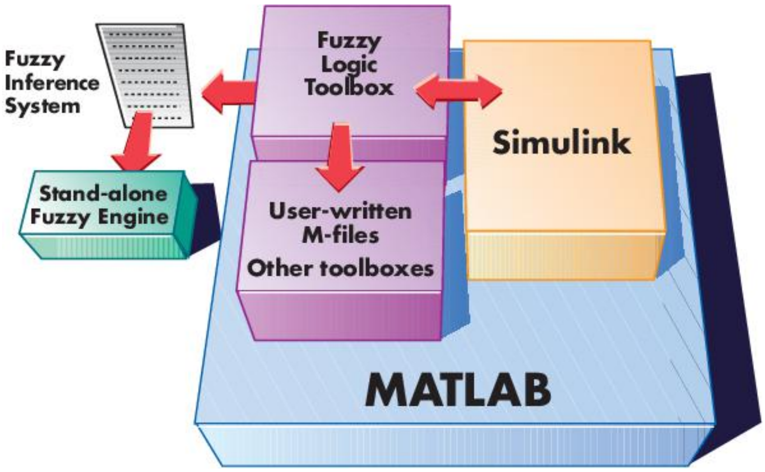
Fig. 4 Flowchart of neural network training by the learning algorithm

11. In direct contrast to neural networks, which take training data and generate opaque, impenetrable models, fuzzy logic lets you rely on the experience of people who already understand your system.
12. Fuzzy logic can be blended with conventional control techniques.
13. Fuzzy systems don't necessarily replace conventional control methods. In many cases fuzzy systems augment them and simplify their implementation.
14. Fuzzy logic is based on natural language.
15. The basis for fuzzy logic is the basis for human communication. This observation underpins many of the other statements about fuzzy logic. Because fuzzy logic is built on the structures of qualitative description used in everyday language, fuzzy logic is easy to use.
16. The last statement is perhaps the most important one and deserves more discussion. Natural language, which is used by ordinary people on a daily basis, has been shaped by thousands of years of human history to be convenient and efficient. Sentences written in ordinary language represent a triumph of efficient communication.

10. What Can Fuzzy Logic Toolbox Software Do?

You can create and edit fuzzy inference systems with Fuzzy Logic Toolbox software. You can create these systems using graphical tools or command-line functions, or you can generate them automatically using either clustering or adaptive neuro-fuzzy techniques.If you have access to Simulink® software, you can easily test your fuzzy system in a block diagram simulation environment.

The toolbox also lets you run your own stand-alone C programs directly. This is made possible by a stand-alone Fuzzy Inference Engine that reads the fuzzy systems saved from a MATLAB session. You can customize the stand-alone engine to build fuzzy inference into your own code. All provided code is ANSI® compliant.



11. Areas of Application of Fuzzy Logic

Aerospace

In aerospace, fuzzy logic is used in the following areas −

1. Altitude control of spacecraft
2. Satellite altitude control
3. Flow and mixture
4. regulation in aircraft deicing vehicles

Automotive

In automotive, fuzzy logic is used in the following areas −

1. Trainable fuzzy systems for idle speed control
2. Shift scheduling method for automatic transmission
3. Intelligent highway systems
4. Traffic control
5. Improving efficiency of automatic transmissions

Business

In business, fuzzy logic is used in the following areas −

1. Decision-making support systems
2. Personnel evaluation in a large company

Defense

In defense, fuzzy logic is used in the following areas −

1. Underwater target recognition
2. Automatic target recognition of thermal infrared images
3. Naval decision support aids
4. Control of a hypervelocity interceptor
5. Fuzzy set modeling of NATO decision making

Electronics

In electronics, fuzzy logic is used in the following areas −

1. Control of automatic exposure in video cameras
2. Humidity in a clean room
3. Air conditioning systems
4. Washing machine timing
5. Microwave ovens
6. Vacuum cleaners

Finance

In the finance field, fuzzy logic is used in the following areas −

1. Banknote transfer control
2. Fund management
3. Stock market predictions

Industrial Sector

In industrial, fuzzy logic is used in following areas −

1. Cement kiln controls heat exchanger control
2. Activated sludge wastewater treatment process control

3. Water purification plant control
4. Quantitative pattern analysis for industrial quality assurance
5. Control of constraint satisfaction problems in structural design
6. Control of water purification plants

Manufacturing

In the manufacturing industry, fuzzy logic is used in following areas −

1. Optimization of cheese production
2. Optimization of milk production

Marine

In the marine field, fuzzy logic is used in the following areas −

1. Autopilot for ships
2. Optimal route selection
3. Control of autonomous underwater vehicles
4. Ship steering

Medical

In the medical field, fuzzy logic is used in the following areas −

1. Medical diagnostic support system
2. Control of arterial pressure during anesthesia
3. Multivariable control of anesthesia
4. Modeling of neuropathological findings in Alzheimer's patients
5. Radiology diagnoses
6. Fuzzy inference diagnosis of diabetes and prostate cancer

Securities

In securities, fuzzy logic is used in following areas −

1. Decision systems for securities trading
2. Various security appliances

Transportation

In transportation, fuzzy logic is used in the following areas −

Automatic underground train operation

1. Train schedule control
2. Railway acceleration
3. Braking and stopping

Pattern Recognition and Classification

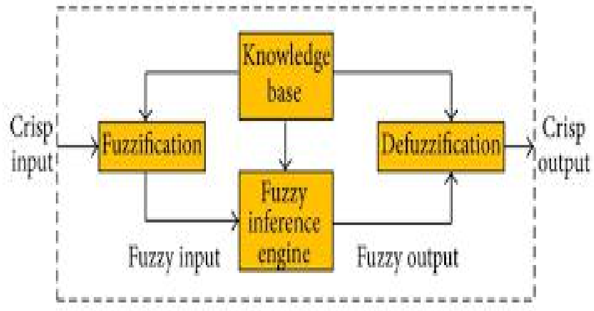
In Pattern Recognition and Classification, fuzzy logic is used in the following areas −

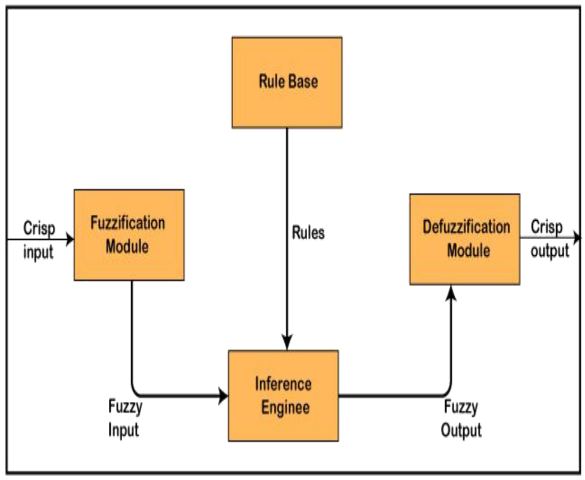
8. Fuzzy logic based speech recognition
9. Fuzzy logic based
10. Handwriting recognition
11. Fuzzy logic based facial characteristic analysis
12. Command analysis
13. Fuzzy image search

Psychology

In Psychology, fuzzy logic is used in following areas −

1. Fuzzy logic based analysis of human behavior
2. Criminal investigation and prevention based on fuzzy logic reasoning





12. Fuzzy Logic vs. Probability

Fuzzy Logic	Probability
Fuzzy: Tom's degree of membership within the set of old people is 0.90.	Probability: There is a 90% chance that Tom is old.
Fuzzy logic takes truth degrees as a mathematical basis on the model of the vagueness phenomenon.	Probability is a mathematical model of ignorance.

Crisp Vs Fuzzy

Crisp	Fuzzy
It has strict boundary T or F	Fuzzy boundary with a degree of membership
Some crisp time set can be fuzzy	It can't be crisp
True/False {0,1}	Membership values on [0,1]
In Crisp logic law of Excluded Middle and Non-Contradiction may or may not hold	In the fuzzy logic law of Excluded Middle and Non-Contradiction hold

Classical Set vs. Fuzzy set Theory

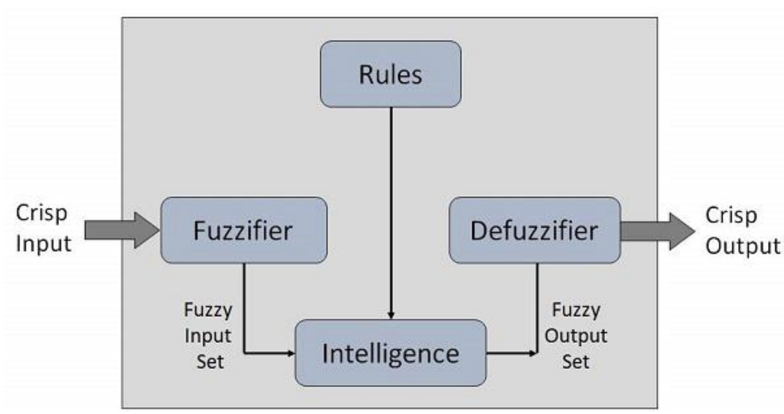
Classical Set	Fuzzy Set Theory
Classes of objects with sharp boundaries.	Classes of objects do not have sharp boundaries.
A classical set is defined by crisp boundaries, i.e., there is clarity about the location of the set boundaries.	A fuzzy set always has ambiguous boundaries, i.e., there may be uncertainty about the location of the set boundaries.
Widely used in digital system design	Used only in fuzzy controllers.

Fuzzy Logic Examples

See the below-given diagram. It shows that in fuzzy systems, the values are denoted by a 0 to 1 number. In this example, 1.0 means absolute truth and 0.0 means absolute falseness.

13. Application Product Areas of Fuzzy Logic

The Blow given table shows how famous companies using fuzzy logic in their products.



Product	Company	Fuzzy Logic

Anti-lock brakes	Nissan	Use fuzzy logic to controls brakes in hazardous cases depend on car speed, acceleration, wheel speed, and acceleration
Auto transmission	NOK/Nissan	Fuzzy logic is used to control the fuel injection and ignition based on throttle setting, cooling water temperature, RPM, etc.
Auto engine	Honda, Nissan	Use to select geat based on engine load, driving style, and road conditions.
Copy machine	Canon	Using for adjusting drum voltage based on picture density, humidity, and temperature.
Cruise control	Nissan, Isuzu, Mitsubishi	Use it to adjusts throttle setting to set car speed and acceleration
Dishwasher	Matsushita	Use for adjusting the cleaning cycle, rinse and wash strategies based depend upon the number of dishes and the amount of food served on the dishes.
Elevator control	Fujitec, Mitsubishi Electric, Toshiba	Use it to reduce waiting for time-based on passenger traffic
Golf diagnostic system	Maruman Golf	Selects golf club based on golfer's swing and physique.
Fitness management	Omron	Fuzzy rules implied by them to check the fitness of their employees.
Kiln control	Nippon Steel	Mixes cement
Microwave oven	Mitsubishi Chemical	Sets lunes power and cooking strategy
Palmtop computer	Hitachi, Sharp, Sanyo, Toshiba	Recognizes handwritten Kanji characters
Plasma etching	Mitsubishi Electric	Sets etch time and strategy

14. Other key application areas of fuzzy logic are as given –

1. Automatic Gearboxes 2. Four-Wheel Steering 3. Vehicle environment control 4. **Consumer Electronic Goods** 5. Hi-Fi Systems 6. Photocopiers 7. Still and Video Cameras 8. Television 9. **Domestic Goods**	10. Microwave Ovens 11. Refrigerators 12. Toasters 13. Vacuum Cleaners 14. Washing Machines 15. **Environment Control** **16.** Air Conditioners/Dryers/Heaters **17.** Humidifiers **18. Automotive Systems**

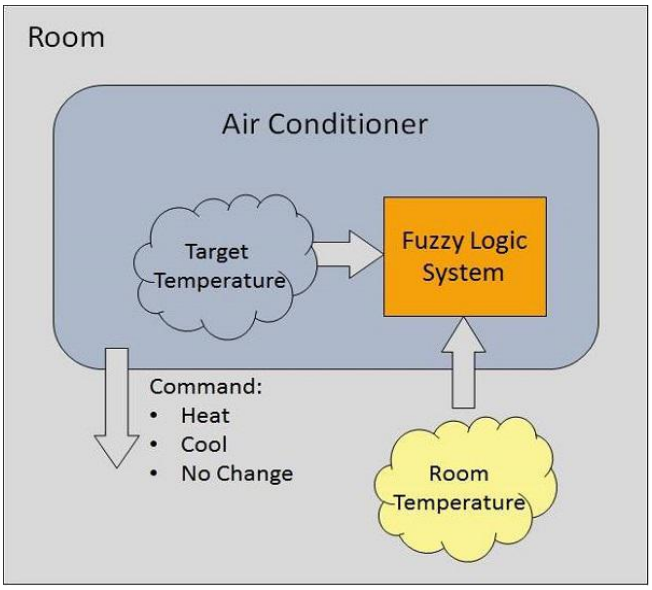
1. It is used in the aerospace field for altitude control of spacecraft and satellite.
2. It has used in the automotive system for speed control, traffic control.
3. It is used for decision making support systems and personal evaluation in the large company business.
4. It has application in chemical industry for controlling the pH, drying, chemical distillation process.
5. Fuzzy logic are used in Natural language processing and various intensive applications in Artificial Intelligence.
6. Fuzzy logic are extensively used in modern control systems such as expert systems.
7. Fuzzy Logic is used with Neural Networks as it mimics how a person would make decisions, only much faster. It is done by Aggregation of data and changing into more meaningful data by forming partial truths as Fuzzy sets.

15. Example of a Fuzzy Logic System

Let us consider an air conditioning system with 5-level fuzzy logic system. This system adjusts the temperature of air conditioner by comparing the room temperature and the target temperature value.

Algorithm

1. Define linguistic Variables and terms (start)
2. Construct membership functions for them. (start)
3. Construct knowledge base of rules (start)
4. Convert crisp data into fuzzy data sets using membership functions. (fuzzification)
5. Evaluate rules in the rule base. (Inference Engine)
6. Combine results from each rule. (Inference Engine)
7. Convert output data into non-fuzzy values. (defuzzification)



Development

Step 1 − Define linguistic variables and terms

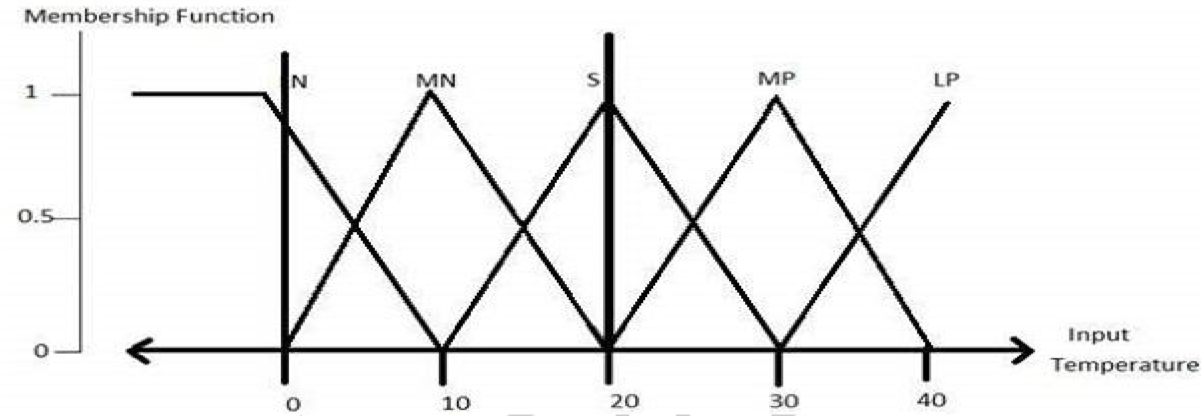
Linguistic variables are input and output variables in the form of simple words or sentences. For room temperature, cold, warm, hot, etc., are linguistic terms.

Temperature (t) = {very-cold, cold, warm, very-warm, hot}

Every member of this set is a linguistic term and it can cover some portion of overall temperature values.

Step 2 − Construct membership functions for them

The membership functions of temperature variable are as shown −



Step3 − Construct knowledge base rules

Create a matrix of room temperature values versus target temperature values that an air conditioning system is expected to provide.

RoomTemp. /Target	Very_Cold	Cold	Warm	Hot	Very_Hot
Very_Cold	No_Change	Heat	Heat	Heat	Heat
Cold	Cool	No_Change	Heat	Heat	Heat
Warm	Cool	Cool	No_Change	Heat	Heat
Hot	Cool	Cool	Cool	No_Change	Heat
Very_Hot	Cool	Cool	Cool	Cool	No_Change

Build a set of rules into the knowledge base in the form of IF-THEN-ELSE structures.

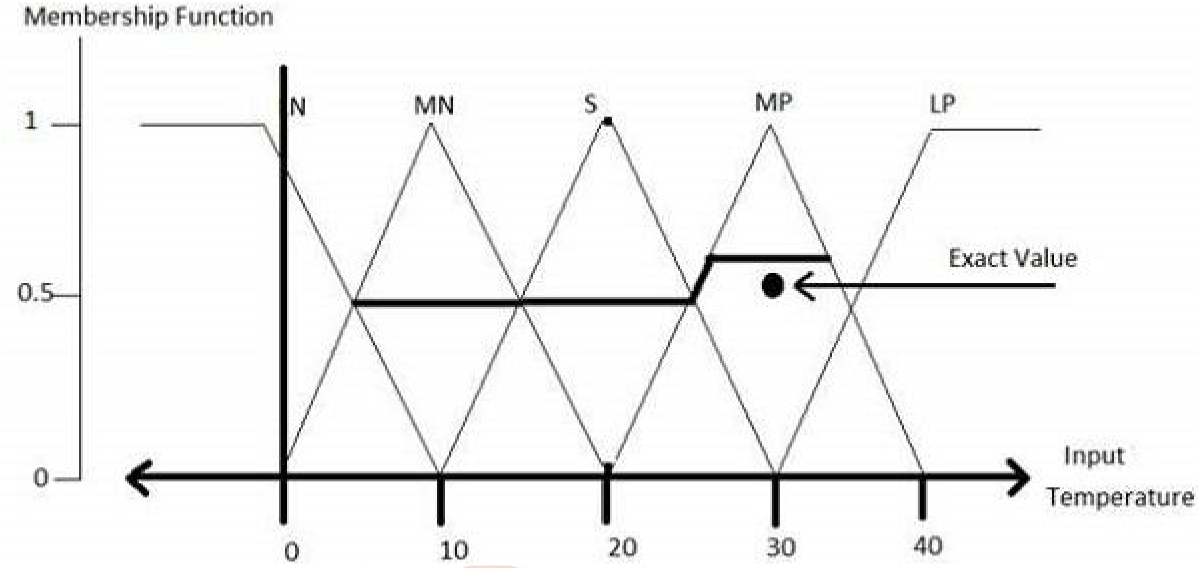
Sr. No.	Condition	Action
1	IF temperature=(Cold OR Very_Cold) AND target=Warm THEN	Heat
2	IF temperature=(Hot OR Very_Hot) AND target=Warm THEN	Cool
3	IF (temperature=Warm) AND (target=Warm) THEN	No_Change

Step 4 − Obtain fuzzy value

Fuzzy set operations perform evaluation of rules. The operations used for OR and AND are Max and Min respectively. Combine all results of evaluation to form a final result. This result is a fuzzy value.

Step 5 − Perform defuzzification

Defuzzification is then performed according to membership function for output variable.



16. Advantages of Fuzzy Logic Systems

1. Mathematical concepts within fuzzy reasoning are very simple.
2. You can modify a FLS by just adding or deleting rules due to flexibility of fuzzy logic.
3. Fuzzy logic Systems can take imprecise, distorted, noisy input information.
4. FLSs are easy to construct and understand.
5. Fuzzy logic is a solution to complex problems in all fields of life, including medicine, as it resembles human reasoning and decision making.
6. The structure of Fuzzy Logic Systems is easy and understandable
7. Fuzzy logic is widely used for commercial and practical purposes
8. It helps you to control machines and consumer products
9. It may not offer accurate reasoning, but the only acceptable reasoning
10. It helps you to deal with the uncertainty in engineering
11. Mostly robust as no precise inputs required
12. It can be programmed to in the situation when feedback sensor stops working
13. It can easily be modified to improve or alter system performance
14. inexpensive sensors can be used which helps you to keep the overall system cost and complexity low
15. It provides a most effective solution to complex issues
16. This system can work with any type of inputs whether it is imprecise, distorted or noisy input information.
17. The construction of Fuzzy Logic Systems is easy and understandable.
18. Fuzzy logic comes with mathematical concepts of set theory and the reasoning of that is quite simple.
19. It provides a very efficient solution to complex problems in all fields of life as it resembles human reasoning and decision making.
20. The algorithms can be described with little data, so little memory is required.

17. Summary of Fuzzy Logic Systems

1. The term fuzzy mean things which are not very clear or vague
2. The term fuzzy logic was first used with 1965 by Lotfi Zadeh a professor of UC Berkeley in California
3. Fuzzy logic is a flexible and easy to implement machine learning technique
4. Fuzzy logic should not be used when you can use common sense
5. Fuzzy Logic architecture has four main parts 1) Rule Basse 2) Fuzzification 3) Inference Engine 4) Defuzzification
6. Fuzzy logic takes truth degrees as a mathematical basis on the model of the vagueness while probability is a mathematical model of ignorance
7. Crisp set has strict boundary T or F while Fuzzy boundary with a degree of membership
8. A classical set is widely used in digital system design while fuzzy set Used only in fuzzy controllers
9. Auto transmission, Fitness management, Golf diagnostic system, Dishwasher, Copy machine are some applications areas of fuzzy logic

10. Fuzzy logic helps you to control machines and consumer products

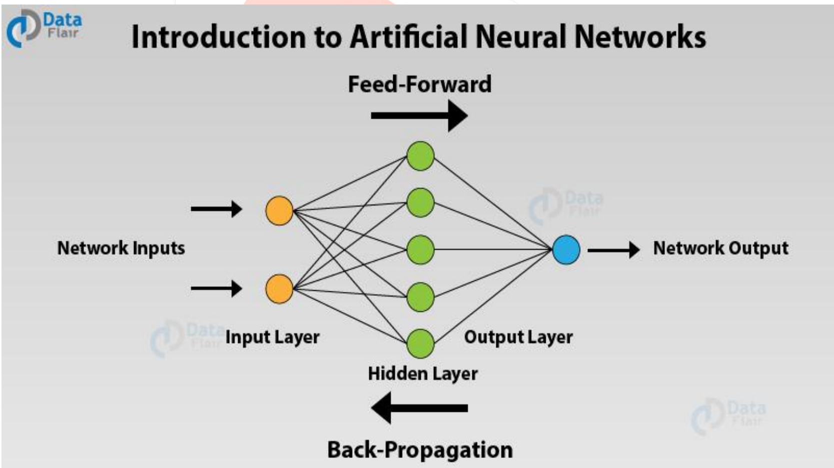
18. Disadvantages of Fuzzy Logic Systems

1. There is no systematic approach to fuzzy system designing.
2. They are understandable only when simple.
3. They are suitable for the problems which do not need high accuracy
4. Fuzzy logic is not always accurate, so The results are perceived based on assumption, so it may not be widely accepted.
5. Fuzzy systems don't have the capability of machine learning as-well-as neural network type pattern recognition
6. Validation and Verification of a fuzzy knowledge-based system needs extensive testing with hardware
7. Setting exact, fuzzy rules and, membership functions is a difficult task
8. Some fuzzy time logic is confused with probability theory and the terms

19. A Basic Introduction To Neural Networks

What Is A Neural Network?

The simplest definition of a neural network, more properly referred to as an 'artificial' neural network (ANN), is provided by the inventor of one of the first neurocomputers, Dr. Robert Hecht-Nielsen. He defines a neural network as:
"...a computing system made up of a number of simple, highly interconnected processing elements, which process information by their dynamic state response to external inputs. In "Neural Network Primer: Part I" by Maureen Caudill, AI Expert, Feb. 1989

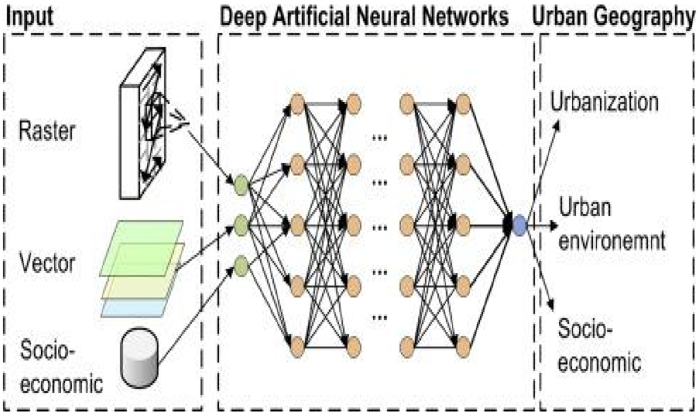


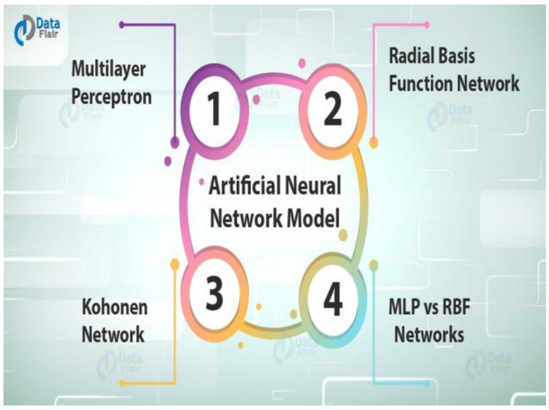
The Basics of Neural Networks

Neural neworks are typically organized in layers. Layers are made up of a number of interconnected 'nodes' which contain an 'activation function'. Patterns are presented to the network via the 'input layer', which communicates to one or more 'hidden layers' where the actual processing is done via a system of weighted 'connections'. The hidden layers then link to an 'output layer' where the answer is output as shown in the graphic below

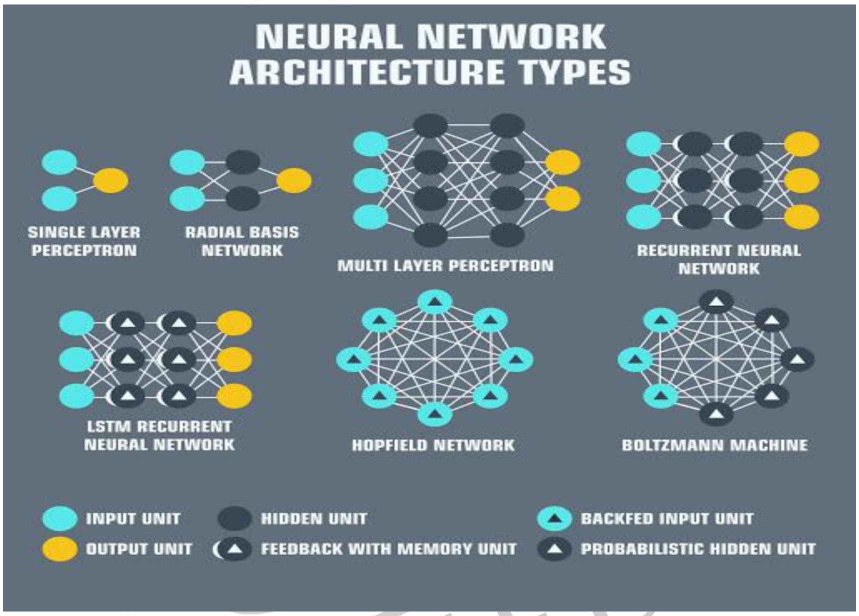
Most ANNs contain some form of 'learning rule' which modifies the weights of the connections according to the input patterns that it is presented with. In a sense, ANNs learn by example as do their biological counterparts; a child learns to recognize dogs from examples of dogs.

Although there are many different kinds of learning rules used by neural networks, this demonstration is concerned only with one; the delta rule. The delta rule is often utilized by the most common class of ANNs called 'backpropagational neural networks' (BPNNs). Backpropagation is an abbreviation for the backwards propagation of error.



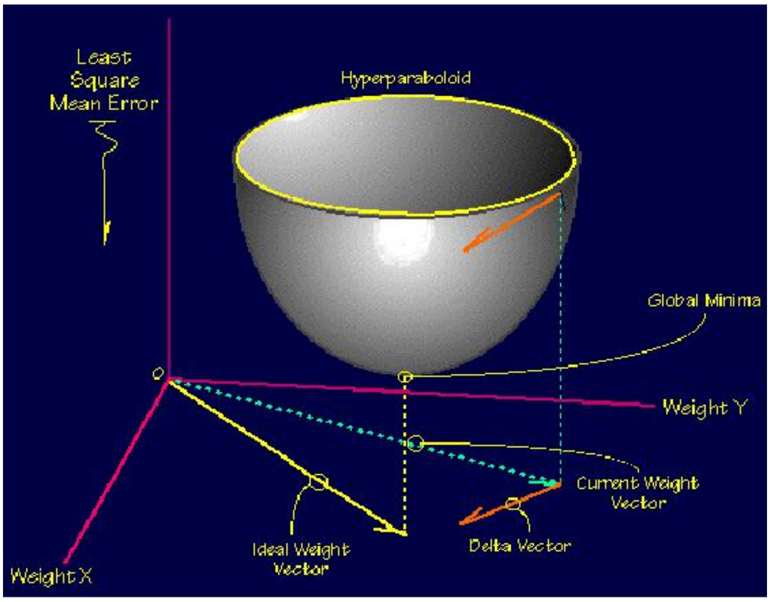


With the delta rule, as with other types of backpropagation, 'learning' is a supervised process that occurs with each cycle or 'epoch' (i.e. each time the network is presented with a new input pattern) through a forward activation flow of outputs, and the backwards error propagation of weight adjustments. More simply, when a neural network is initially presented with a pattern it makes a random 'guess' as to what it might be. It then sees how far its answer was from the actual one and makes an appropriate adjustment to its connection weights. More graphically, the process looks something like this:

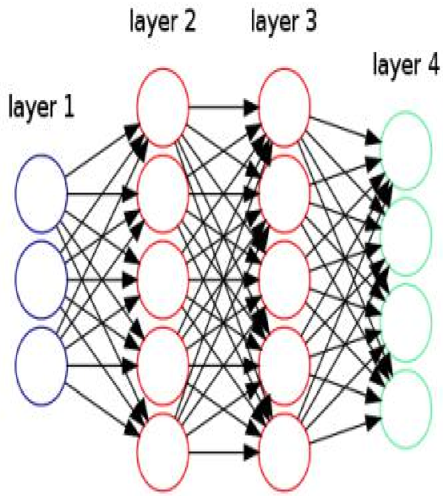


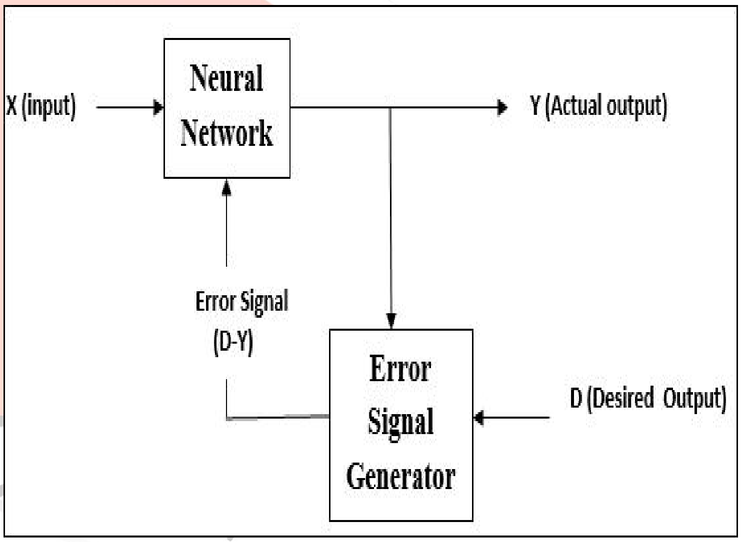
Note also, that within each hidden layer node is a sigmoidal activation function which polarizes network activity and helps it to stablize.

Backpropagation performs a gradient descent within the solution's vector space towards a 'global minimum' along the steepest vector of the error surface. The global minimum is that theoretical solution with the lowest possible error. The error surface itself is a hyperparaboloid but is seldom 'smooth' as is depicted in the graphic below. Indeed, in most problems, the solution space is quite irregular with numerous 'pits' and 'hills' which may cause the network to settle down in a 'local minum' which is not the best overall solution.

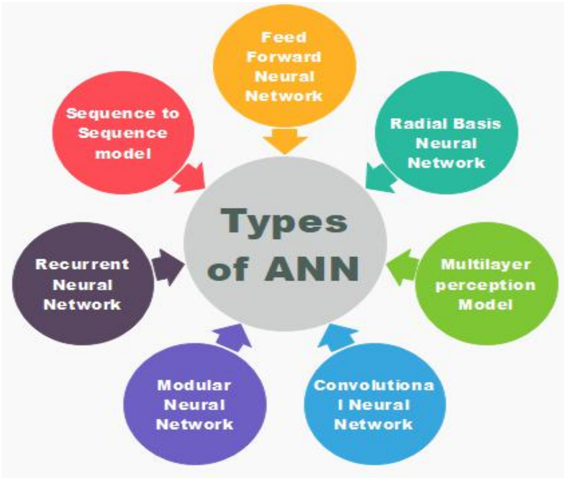


Since the nature of the error space can not be known a prioi, neural network analysis often requires a large number of individual runs to determine the best solution. Most learning rules have built-in mathematical terms to assist in this process which control the 'speed' (Beta-coefficient) and the 'momentum' of the learning. The speed of learning is actually the rate of convergence between the current solution and the global minimum. Momentum helps the network to overcome obstacles (local minima) in the error surface and settle down at or near the global miniumum.





Once a neural network is 'trained' to a satisfactory level it may be used as an analytical tool on other data. To do this, the user no longer specifies any training runs and instead allows the network to work in forward propagation mode only. New inputs are presented to the input pattern where they filter into and are processed by the middle layers as though training were taking place, however, at this point the output is retained and no backpropagation occurs. The output of a forward propagation run is the predicted model for the data which can then be used for further analysis and interpretation.



It is also possible to over-train a neural network, which means that the network has been trained exactly to respond to only one type of input; which is much like rote memorization. If this should happen then learning can no longer occur and the network is refered to as having been "grandmothered" in neural network jargon. In real-world applications this situation is not very useful since one would need a separate grandmothered network for each new kind of input.

20. How Do Neural Networks Differ From Conventional Computing?

To better understand artificial neural computing it is important to know first how a conventional 'serial' computer and it's software process information. A serial computer has a central processor that can address an array of memory locations where data and instructions are stored. Computations are made by the processor reading an instruction as well as any data the instruction requires from memory addresses, the instruction is then executed and the results are saved in a specified memory location as required. In a serial system (and a standard parallel one as well) the computational steps are deterministic, sequential and logical, and the state of a given variable can be tracked from one operation to another.

In comparison, ANNs are not sequential or necessarily deterministic. There are no complex central processors, rather there are many simple ones which generally do nothing more than take the weighted sum of their inputs from other processors. ANNs do not execute programed instructions; they respond in parallel (either simulated or actual) to the pattern of inputs presented to it. There are also no separate memory addresses for storing data. Instead, information is contained in the overall activation 'state' of the network. 'Knowledge' is thus represented by the network itself, which is quite literally more than the sum of its individual components.

21. Working of Neural Networks

Neural networks are universal approximators, and they work best if the system you are using them to model has a high tolerance to error. One would therefore not be advised to use a neural network to balance one's cheque book! However they work very well for:

1. capturing associations or discovering regularities within a set of patterns;
2. where the volume, number of variables or diversity of the data is very great;
3. the relationships between variables are vaguely understood; or,
4. the relationships are difficult to describe adequately with conventional approaches.

22. Advantages of Neural Networks over Conventional Techniques

1. Depending on the nature of the application and the strength of the internal data patterns you can generally expect a network to train quite well. This applies to problems where the relationships may be quite dynamic or non-linear.
2. ANNs provide an analytical alternative to conventional techniques which are often limited by strict assumptions of normality, linearity, variable independence etc.
3. Because an ANN can capture many kinds of relationships it allows the user to quickly and relatively easily model phenomena which otherwise may have been very difficult or imposible to explain otherwise.

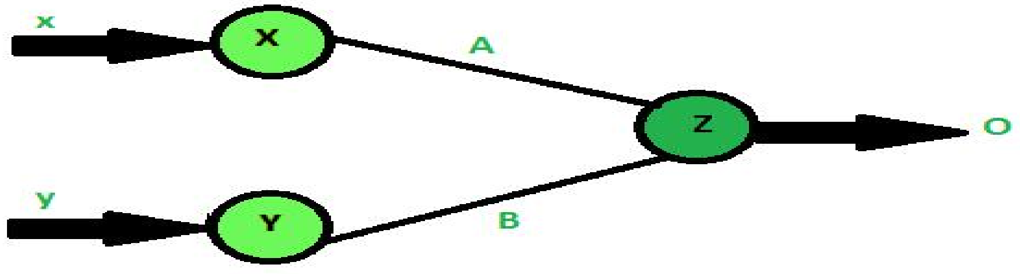
23. Characteristics of Artificial Neural Network

1. It is neurally implemented mathematical model
2. It contains huge number of interconnected processing elements called neurons to do all operations
3. Information stored in the neurons are basically the weighted linkage of neurons
4. The input signals arrive at the processing elements through connections and connecting weights.

5. It has the ability to learn , recall and generalize from the given data by suitable assignment and adjustment of weights.
6. The collective behavior of the neurons describes its computational power, and no single neuron carries specific information .

24. Working of Simple Neuron

Let there are two neurons **X** and **Y** which is transmitting signal to another neuron **Z** . Then , **X** and **Y** are input neurons for transmitting signals and **Z** is output neuron for receiving signal . The input neurons are connected to the output neuron , over a interconnection links (**A** and **B**) as shown in figure .



Architecture of a Simple Artificial Neuron Net

For above neuron architecture , the net input has to be calculated in the way. **I = xA + yB**
where x and y are the activations of the input neurons X and Y . The output z of the output neuron Z can be obtained by applying activations over the net input. **O = f(I) Output = Function (net input calculated)**
The function to be applied over the net input is called *activation function* . There are various activation function possible for this.

25. Application of Neural Network

1. Every new technology need assistance from previous one i.e. data from previous ones and these data are analyzed so that every pros and cons should be studied correctly . All of these things are possible only through the help of neural network.
2. Neural network is suitable for the research on *Animal behavior, predator/prey relationships and population cycles* .
3. It would be easier to do *proper valuation* of property, buildings, automobiles, machinery etc. with the help of neural network.
4. Neural Network can be used in betting on horse races, sporting events and most importantly in stock market .
5. It can be used to predict the correct judgement for any crime by using a large data of crime details as input and the resulting sentences as output.
6. By analyzing data and determining which of the data has any fault (files diverging from peers) called as *Data mining, cleaning and validation* can be achieved through neural network.
7. Neural Network can be used to predict targets with the help of echo patterns we get from sonar, radar, seismic and magnetic instruments .
8. It can be used efficiently in *Employee hiring* so that any company can hire right employee depending upon the skills the employee has and what should be it's productivity in future .
9. It has a large application in *Medical Research* .
10. It can be used to for *Fraud Detection* regarding credit cards , insurance or taxes by analyzing the past records .

26. Areas of Application of Neural Networks

Followings are some of the areas, where ANN is being used. It suggests that ANN has an interdisciplinary approach in its development and .applications.

Speech Recognition: Speech occupies a prominent role in human-human interaction. Therefore, it is natural for people to expect speech interfaces with computers. In the present era, for communication with machines, humans still need sophisticated languages which are difficult to learn and use. To ease this communication barrier, a simple solution could be, communication in a spoken language that is possible for the machine to understand.

Great progress has been made in this field, however, still such kinds of systems are facing the problem of limited vocabulary or grammar along with the issue of retraining of the system for different speakers in different conditions. ANN is playing a major role in this area. Following ANNs have been used for speech recognition −

1. Multilayer networks
2. Multilayer networks with recurrent connections
3. Kohonen self-organizing feature map

The most useful network for this is Kohonen Self-Organizing feature map, which has its input as short segments of the speech waveform. It will map the same kind of phonemes as the output array, called feature extraction technique. After extracting the features, with the help of some acoustic models as back-end processing, it will recognize the utterance.

Character Recognition: It is an interesting problem which falls under the general area of Pattern Recognition. Many neural networks have been developed for automatic recognition of handwritten characters, either letters or digits. Following are some ANNs which have been used for character recognition

1. Multilayer neural networks such as Backpropagation neural networks.
2. Neocognitron: Though back-propagation neural networks have several hidden layers, the pattern of connection from one layer to the next is localized. Similarly, neocognitron also has several hidden layers and its training is done layer by layer for such kind of applications.

Signature Verification Application: Signatures are one of the most useful ways to authorize and authenticate a person in legal transactions. Signature verification technique is a non-vision based technique.

1. For this application, the first approach is to extract the feature or rather the geometrical feature set representing the signature. With these feature sets, we have to train the neural networks using an efficient neural network algorithm. This trained neural network will classify the signature as being genuine or forged under the verification stage.

Human Face Recognition: It is one of the biometric methods to identify the given face. It is a typical task because of the characterization of "non-face" images. However, if a neural network is well trained, then it can be divided into two classes namely images having faces and images that do not have faces.

1. First, all the input images must be preprocessed. Then, the dimensionality of that image must be reduced. And, at last it must be classified using neural network training algorithm. Following neural networks are used for training purposes with preprocessed image −
2. Fully-connected multilayer feed-forward neural network trained with the help of back-propagation algorithm.
3. For dimensionality reduction, Principal Component Analysis (PCA) is used.

27. Limitations of Neural Networks

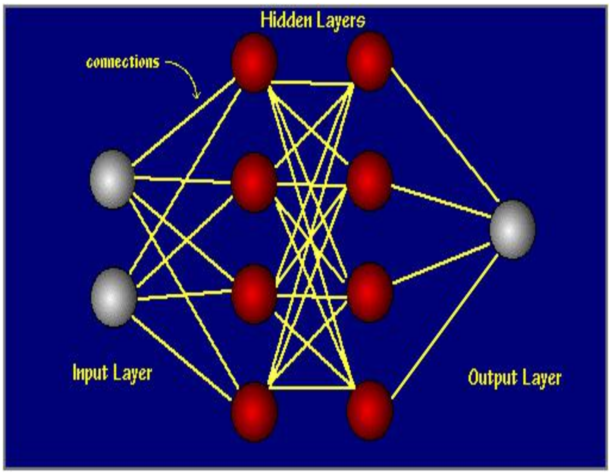
There are many advantages and limitations to neural network analysis and to discuss this subject properly we would have to look at each individual type of network, which isn't necessary for this general discussion. In reference to backpropagational networks however, there are some specific issues potential users should be aware of.

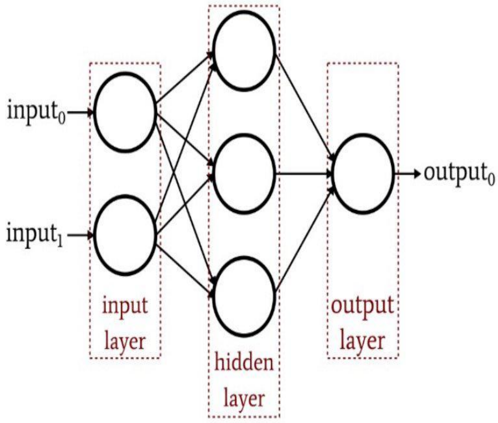
1. Backpropagational neural networks (and many other types of networks) are in a sense the ultimate 'black boxes'. Apart from defining the general archetecture of a network and perhaps initially seeding it with a random numbers, the user has no other role than to feed it input and watch it train and await the output.
2. In fact, it has been said that with backpropagation, "you almost don't know what you're doing". Some software freely available software packages (NevProp, bp, Mactivation) do allow the user to sample the networks 'progress' at regular time intervals, but the learning itself progresses on its own. The final product of this activity is a trained network that provides no equations or coefficients defining a relationship (as in regression) beyond it's own internal mathematics. The network 'IS' the final equation of the relationship.
3. Backpropagational networks also tend to be slower to train than other types of networks and sometimes require thousands of epochs. If run on a truly parallel computer system this issue is not really a problem, but if the BPNN is being simulated on a standard serial machine (i.e. a single SPARC, Mac or PC) training can take some time.
4. This is because the machines CPU must compute the function of each node and connection separately, which can be problematic in very large networks with a large amount of data.
5. However, the speed of most current machines is such that this is typically not much of an issue.

28. Importance of Artificial Neural Networks

We need to understand the answer to the above question with an example of a human being. As a child, we used to learn the things with the help of our elders, which includes our parents or teachers. Then later by self-learning or practice we keep learning throughout our life. Scientists and researchers are also making the machine intelligent, just like a human being, and ANN plays a very important role in the same due to the following reasons

1. With the help of neural networks, we can find the solution of such problems for which algorithmic method is expensive or does not exist.
2. Neural networks can learn by example, hence we do not need to program it at much extent.
3. Neural networks have the accuracy and significantly fast speed than conventional speed.





29. Traffic Signal Lights

Traffic light. A road **signal** for directing vehicular **traffic** by **means** of colored **lights**, typically **red** for **stop**, green for go, and yellow for proceed with caution. Also called stoplight, **traffic signal**.

Traffic control signals are devices placed along, beside, or above a roadway to guide, warn, and regulate the flow of traffic, which includes motor vehicles, motorcycles, bicycles, pedestrians, and other road users.

RED A red signal light means STOP.

A right turn can be made against a red light ONLY after you stop and yield to pedestrians and vehicles in your path. DO NOT turn if there is a sign posted for NO TURN ON RED.

RED ARROW A red arrow means STOP until the green signal or green arrow appears. A turn may not be made against a red arrow.

FLASHING RED A flashing red signal light means exactly the same as a stop sign: STOP! After stopping, proceed when safe and observe the right-of-way rules.

YELLOW A yellow signal light warns you that the red signal is about to appear. When you see the yellow light, you should stop, if you can do so safely. If you can't stop, look out for vehicles that may enter the intersection when the light changes.

FLASHING YELLOW A flashing yellow signal light warns you to be careful. Slow down and be especially alert.

YELLOW ARROW A lighted red arrow is about to appear. Stop if you are not already in the intersection.

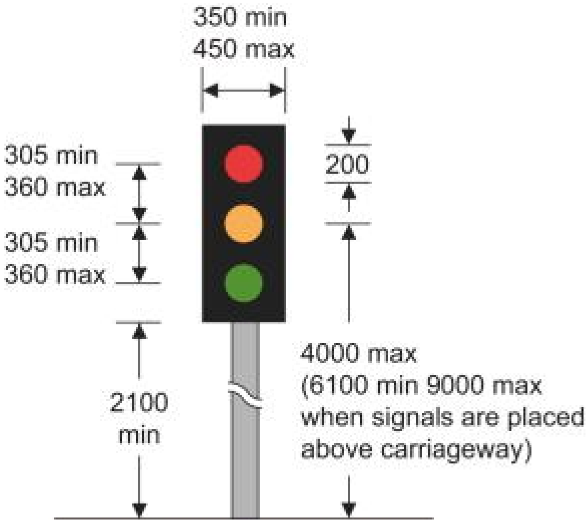
GREEN A green light means GO, but you must first let any vehicles, bicycles, or pedestrians remaining in the intersection get through before you move ahead.

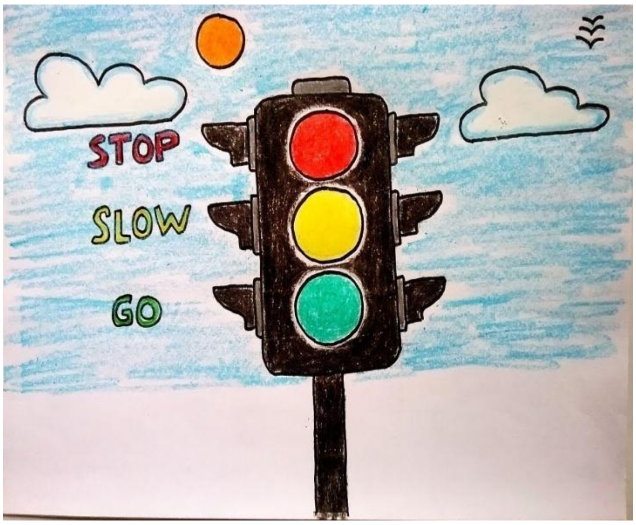
You can turn left ONLY if you have enough space to complete the turn before any oncoming vehicle, bicycle, or pedestrian becomes a hazard. Vehicles turning left must always yield to those going straight from the opposite direction.

Do not enter an intersection, even when the light is green, unless there is enough space to cross completely before the light turns red. If heavy traffic causes you to block traffic, you can be cited.

GREEN ARROW A green arrow means GO, but first you must yield to any vehicle, bicycle, or pedestrian still in the intersection. The green arrow pointing right or left allows you to make a protected turn; oncoming vehicles, bicycles, and pedestrians are stopped by a red light as long as the green arrow is lit.

TRAFFIC SIGNAL BLACKOUT If all traffic signal lights are not working because of an electrical power failure, you must stop at the intersection and then proceed when you know other turning and approaching vehicles, bicycles, or pedestrians have stopped. A blacked-out traffic signal works the same as a four-way stop intersection.

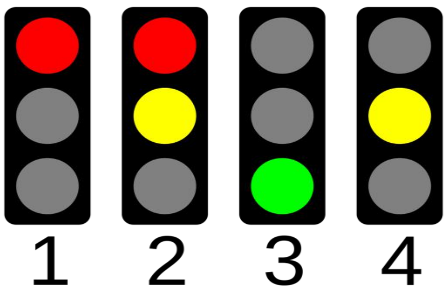




Traffic lights are basically signalling lights placed at crossroads or turning-points to regulate the flow of vehicular traffic. This system is of utmost importance specially in populated traffic zones to avoid accidents and human casualties. That is most cities deploy traffic signals on every road.

Less traffic oriented areas in villages and country side may or may not have traffic signals because the vehicular flow is barely minimum and requires no regulation. Traffic signals generally showcase three colors of light. All these three colors have distinct and well-defined purposes.

1. **Green** color indicates that it is safe to drive and head in the direction shown by the green signal.
2. **Yellow/Orange** color indicates to a driver to slowdown and come to a halt before the crossing line.
3. **Red** color indicates to a driver to stop immediately before the crossing line and not drive ahead.



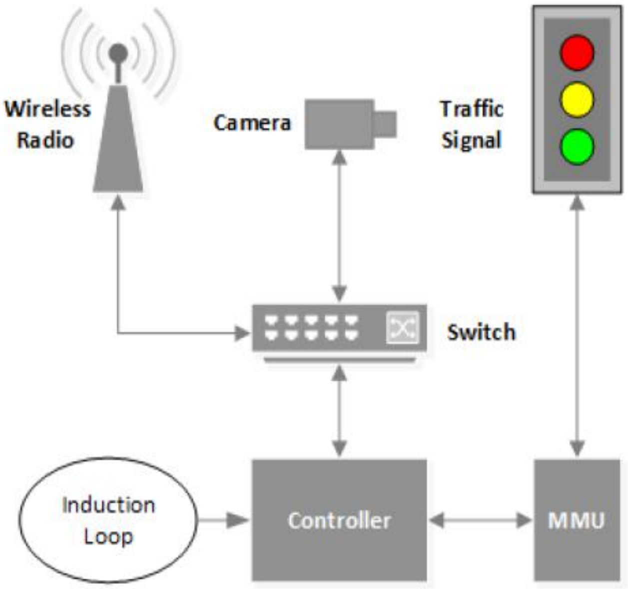
A traffic signal is most commonly a *timer-based* system. The Green, Yellow and Red lights go On and Off at regular and synchronized intervals to start and stop the flow of traffic. The interval to change lights may range between 30 seconds to 120 seconds. However, it varies from city to city and depends on the traffic scenario.
With the advent of technology, traffic signals too have become smart and adaptive. The newer traffic signals are hybrid in nature. They detect and sense the traffic in an area and function accordingly. The lights may change intelligently depending on which roads have fewer or more vehicles.

These systems are nothing but neat arrangements of detector and receiver. Detectors, mostly laid under the road or mounted as camera, sense vehicles on a road and sends a signal to a respective traffic signal. This signal then with consent from other nearby traffic signals decides to change to Green, Yellow or Red.
Many street lights are equipped with Traffic Signal Preemption systems like the 3M Opticom or the Tomar Strobecom. These systems enable emergency vehicles to change the traffic signals from Red to Green, and to change the traffic signals for others from Green to Red. This enables emergency vehicles to travel more quickly and more safely. These systems operate by means of a receiver mounted on the traffic signal and a transmitted mounted inside the emergency vehicle.

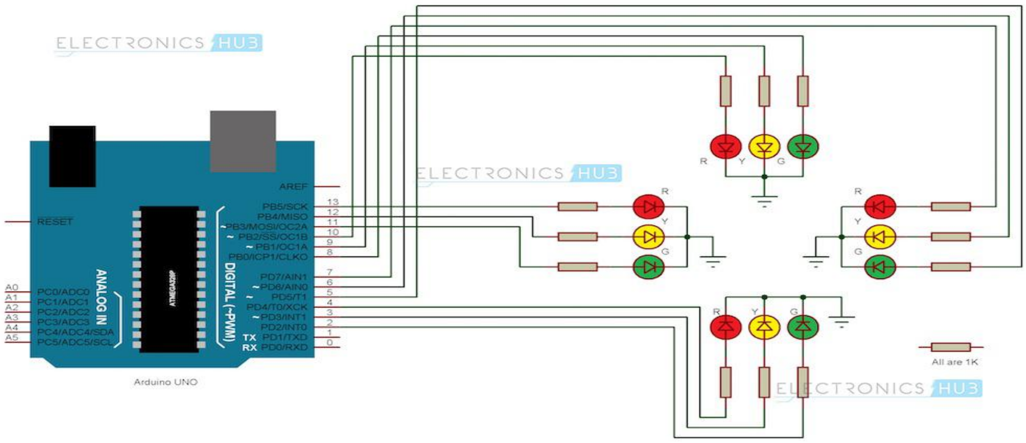
The transmitter is an infrared light which is flashed at the receiver. The transmitter inside the vehicle may transmit a low-priority signal (10 Hz) or a high-priority signal (14 Hz). This technology was at one time limited to authorized law enforcement and emergency organizations — and electronic hobbyists. Recently, vendors such as MIRT – Mobile Infrared Transmitter for Emergency Vehicles have made the equipment available to the general public.

30. Working of Traffic Signal Lights

If you live in a major city, I can take a pretty good guess at one of your most common frustrations: traffic. In city driving, the journey is rarely better than the destination. In most cases, we just want to get where we're going. Traffic is not just frustrating, but it has consequences to the environment as well. All those idling vehicles have an impact on air quality. When you're stuck and sitting behind a long line of cars, it's easy to let your mind wander over solutions to our traffic woes. But, traffic management in dense urban areas is an extremely complex problem with a host of conflicting goals and challenges.



One of the most fundamental of those challenges happens at an intersection, where multiple streams of traffic - including vehicles, bikes and pedestrians - need to safely, and with any luck, efficiently, cross each others' paths. Over the years we've developed quite a few ways to manage this challenge of who gets to go and who gets to wait, from simple signs to roundabouts, but one of the most common ways we control the right-of-way at intersections is the traffic signal.



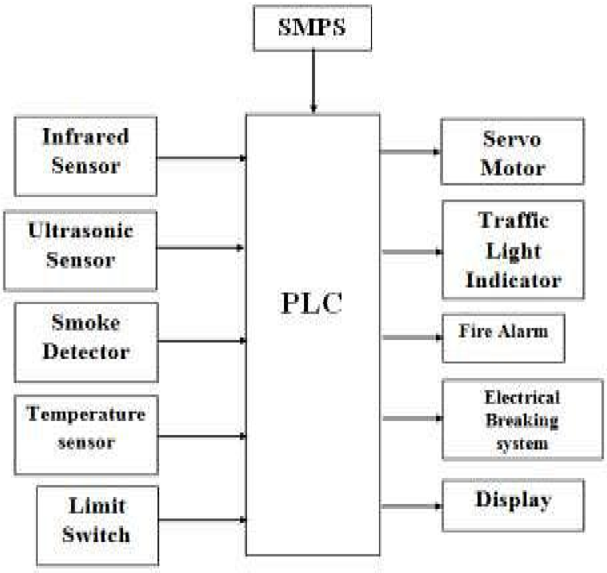
There are a lot of good analogies between cities and human anatomy, and roadways are no exception. Highways are like the aorta with a high capacity and single major destination. Small collector roads are like the capillaries with not much capacity but a connection to every individual house and business. And, in between are the aptly-named arterial roadways, the medium-capacity connections between urban centers.

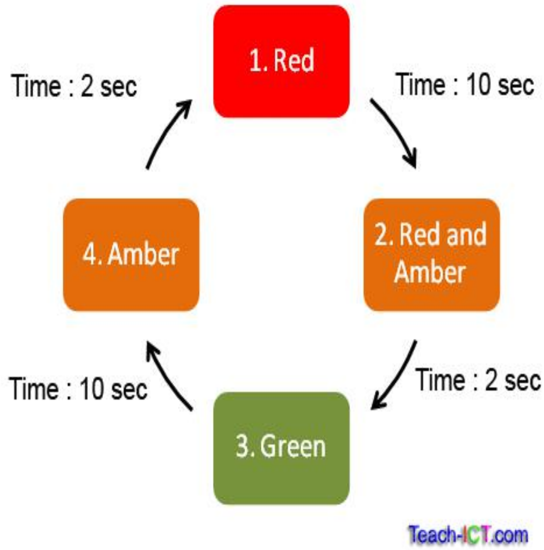
Rather than ramps, overpasses, and access roads to control the flow of traffic, arterial roads use at-grade intersections through which only a few traffic streams can pass at a time. We call this "interrupted traffic flow" for obvious reasons. In most cases, these intersections are the limit to the maximum throughput of the roadway. In other words, increasing the number of lanes or the speed limit won't have any effect on the overall capacity of the road.

The only way to increase the number of vehicles that safely travel from point A to B is to increase the efficiency of the intersection. In addition, these intersections are where a vast majority of accidents occur. For these reasons, traffic engineers put a lot of thought and analysis into the design of intersections and how to make them as safe and efficient as possible.

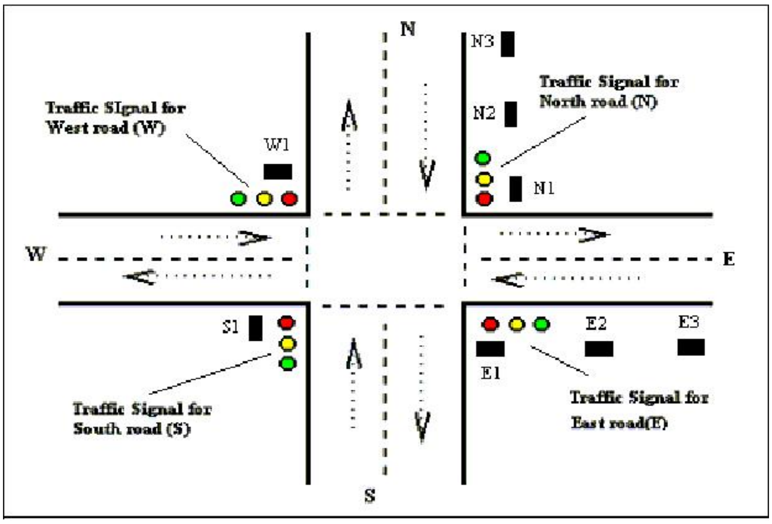
Controlling the flow of traffic through an intersection, otherwise known as assigning right-of-way is an enormous challenge and almost always requires a compromise of numerous conflicting considerations, including space, cost, approach speed, cycle time, sight distance, types and volumes of traffic and human factors like habits, expectations, and reaction times.

Intersections also need to be rigidly standardized so that, when you come to an unfamiliar one, you already know your role in the careful and chaotic dance of vehicles and pedestrians.





From a throughput standpoint, the ideal intersection would cause no interruption in flow whatsoever, but you can't put a high-five interchange on every city block. On the other hand, simple signs are cost-effective and don't require any extra space, but they can't handle a lot of volume because they create an interruption for every single vehicle passing through the intersection.



You can see why traffic signals are so popular. They aren't a panacea for all traffic problems, but they do offer a very nice balance of the considerations we discussed before: Relatively low cost, minimal space requirements, and able to handle large volumes of traffic with only some interruption. In their simplest form, traffic signals are a set of three lights facing each lane of an intersection. When the light is green, that lane has the right-of-way to cross. When the light is red, they don't. The amber light warns that the signal is about to change from green to red. Beyond this basic function, traffic signals can take on innumerable complexities to accommodate all kinds of situations. Let's take a look at a typical intersection here in the U.S. to show how they work.

At each approach to the intersection, there are three directions vehicles can go called movements: right, through, or left. Right and through are usually grouped together as a single movement, so a typical four-way intersection has 8 vehicle and 4 pedestrian movements. These movements can be grouped into phases of the traffic signal. For example, the left turn movements on opposite approaches can be grouped into a single phase because they can both go at the same time without conflicts. Traffic engineers use a ring-and-barrier diagram to sketch out how different phases of the signal are allowed to operate. Here's a ring-and-barrier diagram for our example intersection.

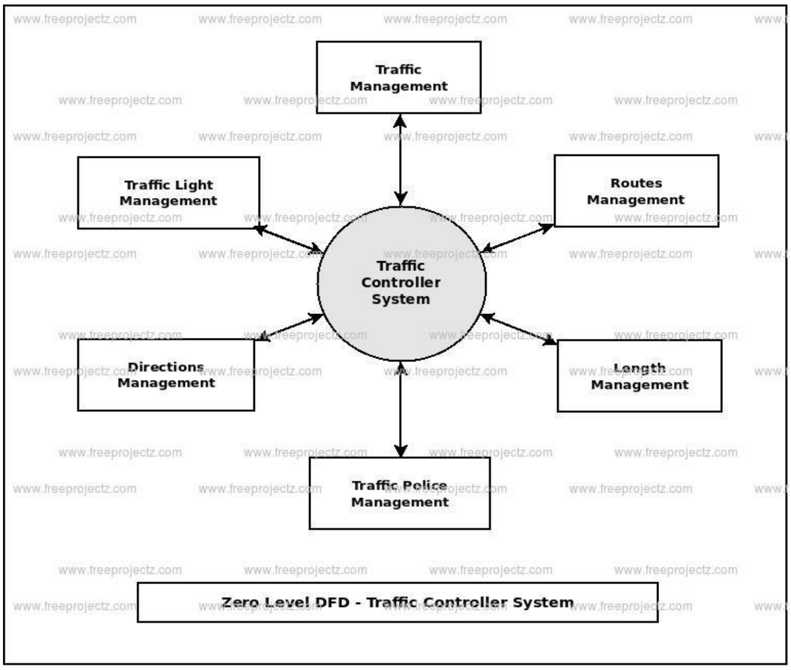
The first phase is the major street left turns, then the major street vehicle and pedestrian through movements, a "barrier" to clear the intersection, the minor street left turns, the minor street vehicle and pedestrian through movements, and finally another "barrier" before the cycle starts again. There are an endless variety of phasing arrangements that traffic engineers use to accommodate various intersection configurations and traffic volumes for each movement. Even the simple decision of whether to use protected or unprotected left turns takes a significant amount of analysis and consideration.

Another important decision is how long each sequence of a phase should last. Ideally, a green light should last at least long enough to clear the queue that built up during the red light. This isn't always possible, especially during peak times on busy intersections. In these cases where the intersection is saturated, the green light might be extended for each phase to minimize the startup and clearance times, which are periods when the intersection isn't being utilized to its maximum capacity. The amber light needs to last long enough for a driver to perceive the warning and decelerate their vehicle to a stop at a comfortable rate.

One second for every 10 miles per hour or 16 kilometers per hour on the speed limit is a general rule of thumb, but traffic engineers also take into account the slope of the approach and other local considerations when setting the timing for yellow lights. In most places in North America, you are allowed to enter an intersection for the full duration of a yellow light, which means there needs to be a time when all phases have a red light to allow the intersection to clear. This clearance interval is usually about a second but can be adjusted up or down based on speed limit and intersection size.

So far we've only been talking about signals on a set timing sequence, but most traffic signals these days are more sophisticated than that. Actuated signal control is the term we use for signals that can receive input from the outside and use that information to make decisions about light timing and sequence on the fly. These types of signals rely on data from traffic detection systems. These detectors can be video cameras or radars, but most commonly they are inductive loop sensors embedded into the road surface. These are essentially large metal detectors which simply measure whether or not a car or truck is present, sometimes to the annoyance of bicycles, scooters, and motorcycles that may be too small to trigger the loop. Whatever the type of sensor, they all feed data into an equipment cabinet located nearby. You've probably seen hundreds of these cabinets without realizing their purpose.

Inside this cabinet is a traffic signal controller, essentially a simple computer that is programmed with specific logic to determine when and how long each light will last based on the information from the detectors. Actuated control gives a traffic signal much more flexibility to handle variations in traffic load. For example, if a nearby road is closed and traffic rerouted through a signal that doesn't normally see such a high demand, it may need to be reprogrammed before the closure. A light equipped with actuated control will simply see the additional traffic and adjust its phasing accordingly. Same thing with special events, like concerts and sport games, that create huge traffic demands on irregular schedules, and even seasonal changes in traffic, like in major tourist destinations. Actuated systems can also keep you from waiting at a long light when no one's crossing in the other direction. Finally, actuated control can help by giving priority to emergency vehicles and public transportation by using specialized detectors, like infrared or acoustic sensors, that communicate directly with certain types of vehicles.

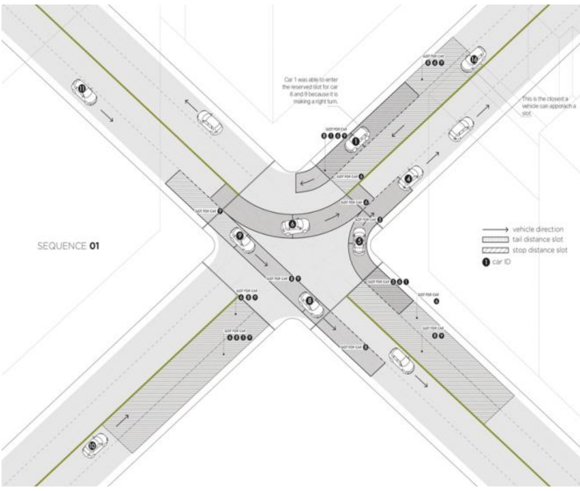


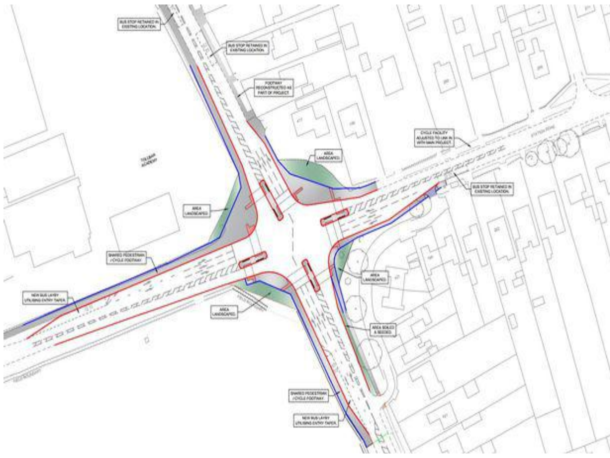
But, actuated control isn't the end of the complexity. After all, it still treats each intersection as an isolated entity, when in reality each signal is a component of a larger traffic network. And each component of the traffic network can have impact, sometime a major impact, on other components in the system. Take the classic example of two signals closely spaced in a row on a major roadway. If one signal gives a green but the next one doesn't, cars can back up. If they back up far enough, they can sit through multiple cycles at an intersection without being able to pass through until the light beyond clears.

It's a frustrating experience for anyone: a signal is inadvertently, but significantly, reducing the capacity of an adjacent signal. One solution to this problem is signal coordination where lights can not only consider the traffic waiting at their intersection but also the status of nearby signals. This is a very common configuration on long corridors with relatively minor, but frequent cross streets. The signals on the major road are timed so that a large group of vehicles, called a platoon by traffic engineers, can make it all the way through the corridor without interruption.

This type of signal coordination can significantly increase the volume of traffic that can pass through intersections, but it really only works on stretches of road that don't have a other sources of traffic interruptions like driveways and businesses. If the platoon can't stick together, the benefits of coordinating signals mostly get lost.

The obvious next step in efficiency is coordination of most or all the signals within a traffic network. This is the job of adaptive signal control technologies, or ASCT. In adaptive systems, rather than individual groups of lights, all the information from detectors is fed into a centralized system that can use advanced algorithms, like machine learning, to optimize traffic flow throughout the city. These types of systems can dramatically reduce congestion, but they're only just starting to be implemented in major urban areas. As sensors become more ubiquitous and computing power increases, traffic management may slowly but surely be relegated from civil engineers to software developers and data scientists. But, that also means that ASCT systems may be more vulnerable to security threats, a scary thought if they're controlling the signals for an entire city.





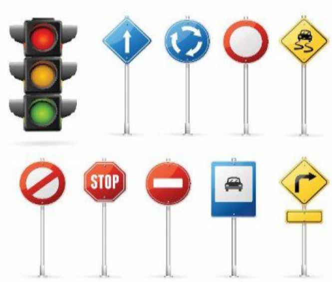
On the complete opposite side of centralization, many believe that self-driving cars are the next revolution in traffic management. If every vehicle could communicate and coordinate with every other vehicle on the road, interrupted traffic control could eventually become a thing of the past. But don't get your hopes too high. In dense urban areas, traffic congestion is often self-limiting. Especially during peak times, for every one person on the road, there are many more at work or at home waiting for the congestion to clear up before they head out.

This latent demand means that any increase in capacity will quickly be filled up with more traffic, bringing the congestion back to the same level it was before. However we accommodate it now or in future, traffic will continue to be one of the biggest challenges in our urban areas and traffic signals will continue to be one of its solutions.

31. Follow Traffic Safety Rules & Regulations, and Safety Will Serve You Very Well

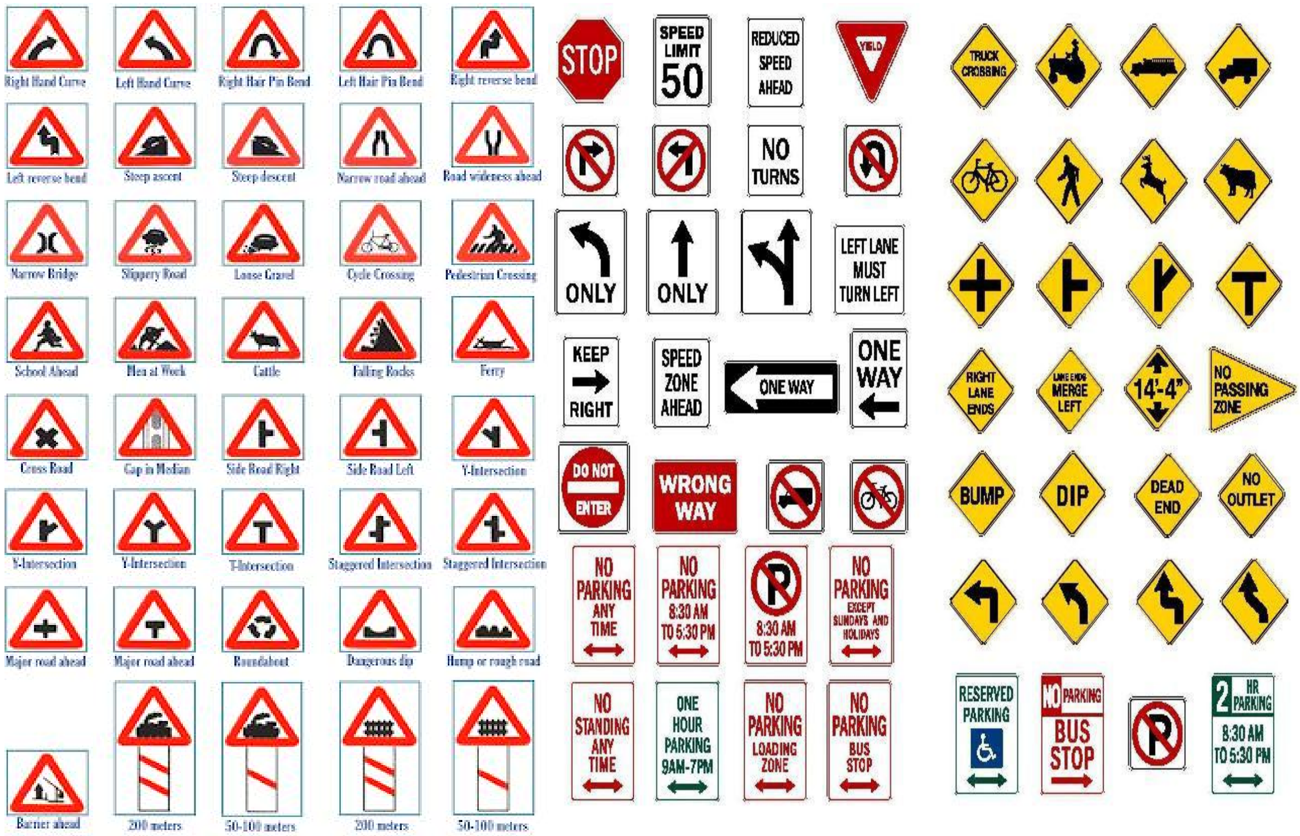
1. Never Drink & Drive.
2. Always Wear Seat Belt.
3. Keep a **Safe** Distance from the vehicle ahead.
4. Always Avoid Distractions.
5. Never Break Red Signal.
6. Always Drive Within Speed Limit.
7. Avoid the Drowsiness While **Driving**.
8. Watch Out For Drivers On the **Road**.
9. **Keep To Your Left –** Always drive or ride on the left side of the road and let other vehicles overtake you from the right side.
10. **Stay Left When You Turn Left –** When turning towards left, start with approaching the curb from the left-most lane and ensure there's enough distance for oncoming vehicles to pass.
11. **Turn Right –** Come to the centre of the road before you start turning right but when going around the curb, try to stay towards the left-most part of your lane to avoid contact with oncoming traffic.

12. Always Overtake from the right side.
13. When being overtaken by another vehicle, never increase your speed to prevent the other driver from overtaking you.
14. Be extra careful on intersections. Also, when passing through them, ensure your vehicle doesn't cause inconvenience to other road users.
15. **Right of Way-** Always give a right of way to vehicles on intersections by letting them continue without stopping in that particular direction in which you are about to proceed.
16. **Emergency Vehicles –** It is your responsibility to give way to emergency services vehicles such as fire engines and ambulances.
17. Pedestrians have the right of way at pedestrian crossings or zebra crossings.
18. **"U" Turns-** U-turns can only be taken when there is no warning sign nearby you give a proper indication to other vehicle drivers that you are going to take a U turn
19. **Indicators –** Always use indicators to let other road users know about the planned change in the direction of travel. If your vehicle indicators get damaged without any warning, use hand signals
20. **Parking –** Make sure you don't park your vehicle in a way it causes any hurdle or disturbance to any other road users.
21. **Registration –** Your vehicle's registration plate should be visible at all times. In case it is broken or damaged, you need to get it replaced at the earliest. Driving a vehicle with its registration number not being visible is a serious offence.
22. **One way Roads –** Always drive only in the permissible direction on a one-way road. Also, never park your vehicle in reverse on a one way street.
23. **Stop Lines –** Always stop your vehicle behind the stop lines. On roads with no stop lines, make sure your vehicle comes to a halt before the Zebra-crossing.



24. **Towing –** No vehicles should be towed closer to other vehicles on the road. However, vehicles that are mechanically disabled and those confiscated by the police are exceptions to this rule.
25. **Noise –** Drivers should not horn needlessly or excessively or use them in no-honking zones like hospital zones and school zones, etc. Also, one should not drive with non-OEM-spec silencers
26. Traffic Lights and Signs should be always obeyed. One should respect instructions given by a traffic cop when there are no traffic lights available.
27. **Following Distance –** Always keep a safe distance from the vehicle in front of you as this will give you enough time to come to a stop in case the vehicle in front brakes suddenly.

28. **Right of way on Steep Roads –** When going up on an incline, you have the right of way as it might be difficult for you to stop and regain momentum. The vice versa holds true when you're driving downhill.
29. **Obstruction of View –** You should always have a clear view of the road ahead. Therefore, your car's windshield shouldn't have stickers that might obstruct your view.
30. Passing Pedestrians Do not drive at more than 25 km/hr, when you passing a procession, meeting, strike, or a march.
31. **Tractor and Goods Carriages –** It is prohibited to carry passengers on a tractor or a goods carrier
32. **Loading –** Overloading a vehicle is not only dangerous but even illegal. Therefore, one should not carry more than a permissible number of passengers or excessive luggage that the vehicle isn't designed to carry.
33. **Dangerous Materials –** One should not carry explosives, inflammable or harmful substances as they are a fire hazard.
34. **Driving in Reverse –** When driving in reverse, you should make sure you do not cause annoyance to any other people on the road.
35. **Essential Documents –** Always carry the following documents – Driving license, Registration certificate of the vehicle, Insurance certificate, fitness certificate (in case of commercial vehicle), tourist permit (in case of commercial vehicle) and PUC certificate.
36. **Additional Regulations –** In addition to the above, the drivers should be aware of al the road safety rules, such as those of speed limit, one-way streets, etc.
37. Following chart shows the traffic signals chart that we must know:



32. Conclusions & Recommendations

- Encourage greater data access for researchers without compromising users' personal privacy,
- Invest more government funding in unclassified AI research,
- Promote new models of digital education and AI workforce development so employees have the skills needed in the 21st-century economy,
- Create a federal AI advisory committee to make policy recommendations,
- Engage with state and local officials so they enact effective policies,
- Regulate broad AI principles rather than specific algorithms,
- Take bias complaints seriously so AI does not replicate historic injustice, unfairness, or discrimination in data or algorithms,
- Maintain mechanisms for human oversight and control, and
- Penalize malicious AI behavior and promote cybersecurity.

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