Study and Integration of Different Parameters Applicable to Autonomous Vehicle and Check Different Aspects to Ensure Safety in Autonomous Vehicles

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Abstract - *A self-driving automobile, sometimes known as an automatic car, is an autonomous vehicle. After countless attempts since the development of the remote control automobile, this vehicle has attained driverless mode. Automation technology has been evolving day by day for decades, and it is now being used in all facets of everyday human existence. Humans are currently addicted to automation and robotics technology in areas such as agriculture, medicine, transportation, automobile and manufacturing industries, information technology, and so on. Literature evaluations were performed to determine what technology and methods are used in autonomous vehicles, aswell as the gap between them. As several countries around theworld prepare to roll out the technology that will take over driving functions from testing to commercial phases, safety measures and regulations remain a major concern. Furthermore, the projected transfer in driving responsibilities from a human to an autonomous vehicle motivates researchers to investigate and analyze liability and safety risks.*

***Key Words*: Self-driving, robotics technology, safety risks, commercial phases.**

1. INTRODUCTION

Automation has been dominating the manufacturing industry. With the use of IoTs and RPA languages, Industry 4.0 has made it feasible to combine manufacturing industries with advanced technologies through training machines. Now, as a result of the progress, we have yet another unfathomable technology. Autonomous cars are vehicles that have been automated in the realm of mobility and transportation.

With the invention of the remote controlled car, autonomous cars became a dream for many people. These autonomous vehicles include not only cars but also trucks, buses, and other vehicles in which a human passenger is not necessary to assume control of the vehicle at any point or be present in the vehicle at all. A self-driving automobile can go anywhere a traditional car can go and accomplish everything a skilled human driver can do. This concept became a reality thanks to a number of factors that are required to take over the streets; automakers are increasingly incorporating technologies that assist drivers in both driving and maintaining their vehicles. In order to make the project possible, certain parameters have been marked, including the following technologies:

1. Adaptive Cruise Control
2. Ego
3. Failure, Mode and Effects Analysis(FMEA)
4. Global Navigation Satellite system(GNSS)
5. Hazard and Operability study(HAZOP)
6. Inertia Measurement Unit(IMU)
7. Light Detection & Ranging(LIDAR)
8. Model Predictive Control(MPC)
9. National Highway Traffic SafetyAdministration(NHTSA)
10. Operation Design Domain(ODD)
11. Object and Event Detection and Response(OEDR)
12. Proportional Integral Derivative Control(PID)
13. Radio Detection & Ranging (RADAR)
14. Sound Navigation & Ranging (SONAR)

The considerable systems have been taken into account. To have a better understanding of three critical themes that must be addressed when driving, such as:

1. Perception

2. Predication
3. Decision making

Yet there are no legal rules and regulations introduced for utilization of EV. However, partially autonomous vehicles, such as automobiles and trucks with varied levels of automation, from brake assistance to lane change and parking assistance, with some models even having a driver, are available. Although it is still in its early stages, autonomous driving technology is becoming more ubiquitous and has the potential to completely revolutionize our transportation system.

1.1. Explanation:

1. Adaptive Cruise Control (ACC):

ACC is a system that uses a control mechanism to govern longitudinal speed. ACC can maintain a safe driving pace or change its speed to keep a safe driving distance from othervehicles.
For eg: a. Distronic plus display on Mercedes-Benz S class;
b. Mitsubishi- LIDAR-based distance detecting system on Japanese market dubbed " Distance Warning" by debonair.

Fig.1: Adaptive cruise control

2. Eg
o:

A name for a vehicle that is controlled independently, as opposed to other cars or objects in the scene, to express thesense of itself. The most common version is ego-vehicle, which means self-vehicle.

3. Failure, Mode & Effects Analysis (FMEA):

From the ground up, a failure analysis strategy that explores individual causes and their implications on higher-levelsystems.
A process' failure modes are the numerous ways in which it can fail. The numerous ways in which these failures may result in waste are referred to as effects. These are used to identify, prioritise, and limit different failure modes.

4. Global Navigation Satellite system(GNSS):

All satellite systems that provide real-time position estimation are referred to by this term. Global position estimation has been defined. The Global Positioning System (GPS) in the United States is one sort of GNSS, while GLONASSin Russia is another.

Fig.2.: Global Navigation Medium

5. Hazard and Operability study(HAZOP):

A type of FMEA that employs the usage of guiding words to generate a list of potential failures. The main goal is to review the design in order to select a design and to resolve any concerns that may arise. To break down a complicated process into a series of smaller portions called 'nodes,' which are then individually inspected.

6. Inertia Measurement Unit(IMU):

A sensor device is made comprised of an accelerometer and a gyroscope. The IMU monitors acceleration and angular velocity and can be used to estimate state by combining itsdata with that of other sensors.

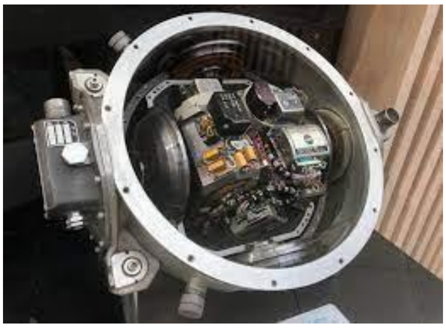
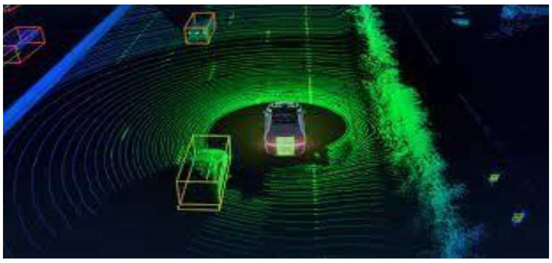


Fig.3: Inertia Measurement Unit

7. Light Detection & Ranging(LIDAR):

A method of measuring distance that includes shining laserlight on a target and measuring the reflected light with a sensor. Using the difference in laser return time and wavelength, computerised 3D representations of targets can be created. To make the most of the information provided in order to make better decisions.



8. Model Predictive Control(MPC):
MPC is a more advanced form of process control that reacts to dynamic models of processes, most commonly linear empirical modules times a lot to be optimised, while also taking into account additional time slots. MPC has the ability to foresee future occurrences and respond with control actions.

9. National Highway Traffic Safety Administration(NHTSA): A national agency with 12 framework to structure for safety assessment for autonomous driving.

10. Operation Design Domain(ODD):
The set of conditions under which a system is meant to function. A self-driving car, for example, may have two control systems: one for city driving and the other for interstate travel.

11. Object and Event Detection and Response(OEDR):
The ability to recognise and react to objects and events thathave an immediate impact on the task.

12. Proportional Integral Derivative Control(PID):
- The proportional gain scales the control output in proportion to the amount of mistake.
- Integral gain which scales the control outside base onamount of accumulated error.
- Derivative gain which scales the control output based onerror rate of change.

13. Radio Detection & Ranging (RADAR):
A sensor that detects range and movement by sending out radio waves and monitoring the return line and signal shifts

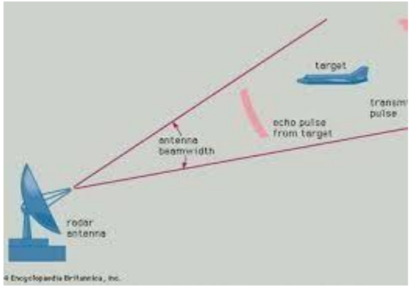


Fig. 5.: RADAR

14. Sound Navigation & Ranging (SONAR):
A type of sensors which detects range and movement by transmitting sound waves and measuring return times andshift of reflected signal.

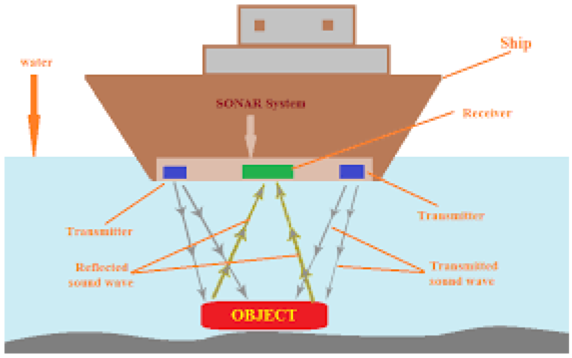


Fig. 6. SONAR

2. Taxonomy of Driving:

This classification of system is done based on the requirements. For driving decisions and actions:

- Perception of Environment:

To identify environment mobility criteria like climate, surface, pedestrians, tracking car motion to predict future motions, planning destinations from A to B and controllingvehicle simultaneously.

A. Operation Design Domain:
Environmental, geographical, and time-of-day constraints, aswell as the presence or absence of specified traffic or route elements, are all operating factors that a driving automation system or feature is meant to work under. The driver's attention and action requirements are addressed by the ODD.
B. Conditions fulfilling Driving task:
a. Lateral control- Steering along with simultaneous navigation.
b. Longitudinal control- Acceleration and braking are handledby this function.
c. Object and Event Detection and Response: This function act

as detecting and reacting parameter. This works with the help of sensors. This includes various sensors to detect various parameters.

3. The Hardware

They're in charge of detecting environmental factors and relaying that information to the onboard computer. Cameras, RADAR, SONAR, and LIDAR are currently the most popular.

1. Camera with stereoscopic capabilities
It's also known as a stereo camera since it uses two or more lenses to create frames from various perspectives. You can gain a sensation of depth (3D) in this way, emulating human eyesight.

2. A camera that can detect infrared light.
In low-light or no-light situations, the infrared camera enables for precise viewing. This technology uses sensors to identify things based on temperature variations, capturinginfrared light that is invisible to the naked eye.

3. RADAR
Radar sends out radio waves in a specified direction that bounce off of obstructions. You can estimate size and distance by measuring the speed and intensity of the return.

4. SONAR
Sonar is similar to radar in that it uses sound waves to detect objects. Instead of radio waves, sound waves are used, which are inaudible to the human ear.

5. LIDAR:
LIDAR functions similarly to the two previous devices. On the
other hand, laser pulses are employed to scan the environment, resulting in hundreds of dazzling dots. In addition to having a faster signal, LIDAR allows you to cover abigger region, 360 degrees, and with more precision.

6. GPS, speedometer, and odometer:
It is required to equip the vehicle with current maps and regulate its location in order for it to navigate itself through cities. As a result, GPS equipment will be linked with the speedometer and odometer. As a result, even in the absence of a satellite, the computer calculates its position.

4. The software

A self-driving automobile has a body with features that provide physical input such as driving, seeing, and communicating and software that controls the process and chooses whether to drive, accelerate, stop, or park. Three categorized system autonomous vehicle software: perception,planning, and control.
For building software programming languages are available widely. Python is an easy language which requires basic knowledge of Algebra, Statistics and Physics.

5. Planning:

The autonomous vehicle's ability to make specific judgments in order to attain higher-order goals is referred to as the planning system. And the self-driving car knows what to do in a certain situation, such as pause, move, or slow down. The planning system works by combining collected environmental data (from sensors and V2X components) with defined policies and expertise about how to move in the environment (e.g., do not drive over pedestrians, slow down when approaching a stop sign, etc.) to help the car decide what action to take (e.g., overtake another vehicle in order toreach the destination, etc.).
The human brain's frontal lobe processes think and make decisions like what to dress in the morning or what to go for fun on the weekend, just like the autonomous car planningsystem.

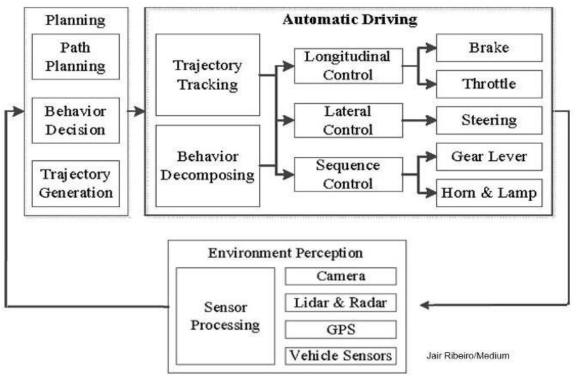


Fig.7: Flow Card

6. Control

The control system is in charge of transforming the goals andpriorities of the planning system into actions. In this situation, the control device informs the required inputs' hardware (actuator leading to the required motions). When a self-driving car realises it needs to slow down as it approaches a red light, it turns that knowledge into practise braking. The cerebellar processes in humans provide a similar purpose. The cerebellum is in charge of the brain's motor control system. When the purpose is to eat, it motivates us to chew.

7. Artificial Intelligence and Connectivity

Artificial Intelligence would be in charge of gathering all internal and exterior sensor signals, monitoring driving, advising the owner of maintenance requirements, making modest gadget tweaks and enhancements, and learning from failure. Connectivity with other self-driving cars allows for the exchange of ideas and solutions. Vehicle automation is achievable thanks to such technologies.

9. Safety Reports

The analysis of safety parameters is done by posing certain fundamental questions that provide answers to critical safety needs.

Where am I? (Perceiving the environment around you)

Point: 1. Designing three dimensional map of virtual street,lane, highways, curbs, etc.

Point 2: Rather of relying on GPS, Waymo uses real-time sensor data to cross-reference their pre-built maps.

What's around me? (Processing that information)

Point 1: Sensors and software detecting objects around vehicles. Range upto 300 m in all the direction.

What will happen next? (Predicting how others in environment behave)

Point 1: For every dynamic object, predicts future movement based on current speed and trajectory.

Point 2: Possible predicted path are marked for each and other object.

Point 3: Even for blocked lane up a head.

What should I do? (Making driving decisions based on the information)

Point 1: Gather all sort of information required to take an appropriate route software selects exact trajectory, speed, lane & steering maneuver needed to progress along this route safety. Predicting and constantly monitoring environment at 360 degree are able to respond quickly andsafety to any changes on road.

10. Safety Program:

1. Behaviour Safety:
a. Influencing decisions and actions.
b. Vehicles obeyed traffic laws, maintained safety, and anticipated the expected and unforeseen.
c. To fully comprehend, a combination of functional analysis, simulation tools, and on-road driving is used.

2. Functional Safety:
Ensure that the vehicle operates safely when a system failsor malfunctions so that it can be repaired.
For example, when the primary computer fails, the secondary computer kicks in to ensure vehicle safety as wellas steering and braking criteria.

3. Crash Safety:
a. With features such as air bags, seat restraints to reduceinjury or prevent death.
b. The Federal Motor Vehicle Safety Standard covers crashsafety.

4. Operational Safety:
a. The interaction of vehicles and passengers.
b. Hazard analysis, current testing, and best practises from a variety of industries are used to determine whether a product is safe.

5. Non-collision Safety:
We consider physical safety for a variety of people who maycome into contact with the vehicle.

Safety Frame work:

1. Fault Tree is the first.
2. Framework for preliminary analysis.
3. Deductive failure analysis should be performed on allavoidable faults in a stable extended, top-down flow.
4. Intermediate nodes are probable root event triggers thatare logic gates (Boolean logic).
5. Probability and logic gates can be used to build a methodology.

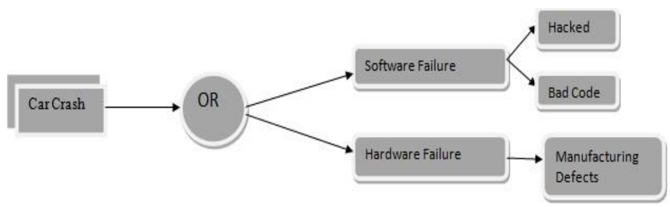


Fig.8.: Safety Fault tree

Probabilistic Fault Tree Analysis:

1. Assign probabilities to fault leaves.
2. Use logic gates to constructs failure tree.

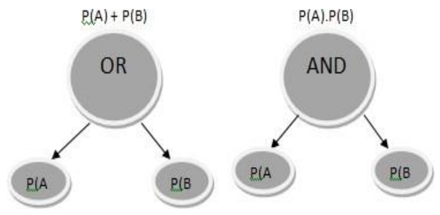


Fig.9: Probabilistic Fault Tree

Failure Mode and Element Analysis:

1. Bottom-up process, individual cause's analysis (Risk Assessment Criteria)
2. Failure Mode: Failure probability in methods.

FMEA idea:
Categorize failure modes by priority:

a. How serious are their effects?
b. How frequently do they happen?
c. How easily can they be detected?

Eliminate or reduce failure, starting with top priority:
Steps:1
1. Discuss with field experts.
2. Create FMEA
table.Steps:2
1. Lists failure modes.
2. Higher the value higher the priority
isRPN= S.O.D
Where, S= Severity: Physical crash (S=10)
O: Occurrence= whenever construction encountered (O=4)D: Detection = Can check status monitor to identify if this happens with certainty (D=10)
RPN=400

Similarly,
Sign perception failure (RPN)= 100
GPS synchronization failure (RPN)= 300Incorrect motion Prediction (RPN)= 150
Final (RPN) List:
1. Control Failure
2. GPS failure
3. Motion prediction
4. Sign
Perception
<u>Steps:3</u>
1. For each failure mode
2. Identify effects
severity<u>Steps:4</u>
1. For Each root cause
2. Occurrence

<u>Steps:5</u>
1. For each prevention method
2. Detection.

HAZOP: A variation FMEA
1. Operational and Hazard Analysis
2. "Imagination" is required in the qualitative brainstormingprocess.
3. Uses guide phrases to kick start brainstorming.
4. Invoked in complex "processes"
5. Enough design data is available, and the design is unlikely to change much.
Functional Safety is defined as:
1. Safety due to absence of unreasonable risk.
2. Only concerned about malfunctioning system.ASIL D-Strigent

ASIL A- Strigent

11. Conclusion:

1. Self-driving cars look to be a significant step forward in transportation technology. They're a brand-new all-media capsule that allows you to text to your heart's content whilebeing secure.
2. Self-driving car technology is still evolving, and automobile software is still being updated. Though the concept of a driverless car started it all, more semi-autonomous features will develop, reducing traffic congestion and improving safety by allowing for faster reactions and fewer errors.
3. There is still a long way to go from self-driving cars with varied levels of autonomy to fully autonomous vehicles. Modern AI technologies and machine learning development, on the other hand, are rapidly progressing in this direction, and this is what is propelling the sector forward. Top automakers like GM, Ford, and Tesla are nearing the end of their self-driving vehicle testing, indicating that we are about to experience a paradigm shift in the way we commute.
4. The road is still difficult, with various obstacles along the way. The perception of the environment continues to be the most difficult obstacle to dependable, smooth, and safe driving. Customer acceptance, societal impacts, communication technologies, ethical issues, planning, standards, and policy are just a few of the study questions that will need to be addressed and solved. Software issues like system security and integrity have also surfaced as major concerns that must be addressed. This has a number of policy ramifications, including the difficulty for policymakers in streamlining and regulating a wide range ofvehicles with varying operating limits.

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