The Shirpur Education Society's

R. C. Patel College of Engineering and Polytechnic, Shirpur

Department of Mechanical Engineering

NAME OF COURSE: - Emerging Trends in Mech Engg

CODE OF COURSE: - 315363

SEMESTER: - ME-5K (TYME)

Unit - 3 Autonomous Vehicles

14 Marks

SUBJECT TEACHER

Mr. Anil S. Patil

Unit 3 - Autonomous Vehicles.

3.1) Autonomy in mobility systems (Autonomous vehicles)

A) Levels = Their are 6-Levels i.e. Level 0 - Level 5, based on the driving task performed by vehicle. These six levels are defined by SAE J3016 - Society of automotive engineers.

Level 0 = No automation

- Driver has fully responsible for driving.
- Warnings may be given by vehicle like seat belt reminder, forward collision warning, but vehicle has no control over it.
- Some features of such level of vehicle includes automatic emergency braking, parking sensors, anti-lock braking system, electronic stability control.

Eg - Conventional cars without driver-assistance.

Level 1 = Driver assistance

- Vehicle can assist the driver with steering or acceleration or braking. At a time vehicle either can assist ~~for~~ with steering or with acceleration/retardation.
- Driver has fully responsible for driving
- Driver need to keep eye on road & pay attention to all controls.
- Depends on drivers need, he can switch on or off the driver assistance.

Eg - Adaptive cruise control (ACC) & Lane keeping assist (LKA) are good examples of driver assistance.

Level 2 = Partial Automation

- Vehicle can control both the steering and acceleration/retardation under certain conditions.
- Though vehicle assist driver for both steering as well as acceleration/retardation, still driver has to remain fully prepared to take control over vehicle at any time.
- Vehicle can be able to keep lane, adaptive cruise control & auto-parking, driver is still fully responsible to take corrective actions when needed.

Eg - Tesla auto pilot, Ford blue Cruise, GM Super cruise.

Level 3 = Conditional Automation -

- Vehicle on its own performs all driving tasks under specific condition.
- Driver is not needed her for continuous monitoring the road, but the vehicle can request driver to take over it in certain conditions.
- Vehicle can perform tasks like automated lane keeping, Traffic jam pilot, Environmental monitoring, driver availability monitoring etc.

Eg - Mercedes-Benz drive pilot, Audi A8L (Traffic Jam

Level 4 = High automation =

- In this level, the vehicle can operate by its own without intervention by human. in specific areas or conditions called Operational Design Domain or ODD.

- In any emergency condition where system can not continue to work, vehicle can stop vehicle safely without human intervention.
- Driver may take control of vehicle if he needed, but it is completely optional.

Eg - Autonomous shuttle buses, Robotaxis operating in designated designed areas.

Level 5 = Fully Automation =

- Vehicle can control all driving tasks under all road conditions, environmental obstacles, & all weather conditions.
- No human required, neither human intervention needed.
- Do not needed steering wheel, ~~wheels~~, pedals.
- Vehicles of this level are under development, not used by public till this time.

Components =

1) Sensors =

a) RADAR (Radio detection & ranging)

RADAR uses burst of sound to detect the distance, speed, direction of motion of nearby vehicles. It measures the time taken by ~~sound~~ emitted sound to get returned to the sensor.

Radars well in heavy fog, rain and heavy snow also.

b) LIDAR (Light detection & ranging)

Similar to the radar but it utilises laser beams to measure distance, speed, direction of nearby vehicles. Ranges upto 200m.

It can create accurate 3D map of the surrounding environment. Can be operated well

low light but has issues arises when working in fog, rain or snow.

c) Cameras = Cameras can capture a 2D-motion pictures in the form of multiple frames to detect the distance, speed & motion, direction of motion of nearby surrounding objects. It also detect the lane markings, traffic signs, & moving humans etc

d) Ultrasonic sensors = For assistance in parking as well as for obstacle or moving object detection ultrasonic sensors used. Ultrasonic sound waves emitted by sensor can be sensed back if they bounce back & time required is calculated, the distance.

2) GPS (Global positioning system) & HD Maps

GPS determines live status of vehicle & work with HD digital maps. HD maps has vast data set in which it includes lane marking, traffic signal, speed limit, road curvature etc. By using combination of GPS with HD maps accuracy of navigation improves.

3) Perception system = In this system the data received from sensors, GPS etc get collected & processed. By analysing input it can identifies and classifies the objects such as moving vehicle, trucks, bus etc or pedestrian or cyclist in addition to that it identifies road signs & traffic signals. For high accuracy it combines data received from all sensors to identify exact position of vehicle with environmental condition it surrounded by.

4) Decision making system = From previous step the data processed used to predict safe driving action.

It can perform vehicle activities like planning ~~sought~~ routes, changing lanes, stopping when no signal, overtaking other vehicles & detection & avoiding the obstacles. All this activities going on by identifying movement of other objects near ~~vehicle~~ vehicle.

5) Control system & actuators =

Based on data processed already, now planned actions converted to the actual movement of vehicle. Controls may be setup by steering, acceleration & retardation (braking).

To convert received planned action actuators are used. Actuators can convert received instruction to actual movement of steering, acceleration, braking etc.

6) Use of AI & ML =

Use of AI & ML allow the vehicle to make proper decisions based on previously recognized patterns. Also, it improves the performance of vehicle by continuous learning through models.

7) Power supply = Batteries used in vehicle use to provide electrical supply needed for sensors, actuators, controllers etc. It has parts like battery, battery management (BMS) system etc.

Benefits of automation =

1) Improvement in road safety - Reduction in accidents caused by drivers mistakes, fatigue, overspeeding, highway hypnosis etc.

2) Traffic flow management = Enhances the traffic flow through ~~by~~ integrating information from IoT tools.

3) Environmental & economic benefit =
Use of algorithms for smooth driving reduces the fuel ~~econ~~ emmissions, by providing proper ratio of fuel & gear. Also, it is beneficial for economy due to optimized fuel consumption.

4) Reduced transportation charges = Reduction in maintenance, less skillful driver needed, less expences related to accident cause in reduction in charges req. for transportation.

5) Improved parking = Self parking solved problems like less parking area, time required to park vehicle etc.

3.2) Systems used in autonomous vehicles =

Advanced Driver Assistance system (ADAS) & full self driving (FSD)

ADAS =

Advanced driver assistance system is electronic based safety related system which helps driver in driving safely & efficiently. ADAS uses sensor data as input, AI & ML to monitor live traffic, environment, warnings for different situations to control vehicle safe driving. Still driver has responsible for controlling vehicle. At any point of time driver can take control over ADAS system.

Features of ADAS =

i) Adaptive cruise control (ACC)
ii) Automatic emergency braking (AEB)
iii) Lane keeping assistance.
iv) Blind spot detection (BSD)
v) Traffic sign recognition (TSR)

vi) Parking assistance.
vii) Forward collision warning (FCW)
viii) Driver monitoring system.
ix) Night vision system.
x) Adaptive light control

Advantages of ADAS =

i) Road safety.
ii) Reduction in accidents by silly mistakes.
iii) Prevent collision.
iv) Control over lane keeping
v) Enhanced driving confort.
vi) Base for fully automating driving vehicle.

Limitations of ADAS =

i) Need driver attention in certain conditions.
ii) Performance decreases in conditions like bad weather, poor road quality etc.

Full Self-Driving (FSD)

FSD is an advanced automation technology that enables driver to drive without his intervention. It is more capable system than ADAS. It enables vehicle to be drive through city, on highways by recognizing traffice signals, road signs, HD maps, live traffic recognition, changing lanes properly, parking system, all these activities dosnt need much human intervention. Driver only need to intervine for certain working condition where needed.

FSD utilises sensors such as camera, RADAR, LIDAR, GPS, powerful computing system, AI & ML to

identify surrounding environment to make proper decisions for controlling vehicle. FSD technology is now ~~its~~ in its initial phase, manufacturers are working on it to make is safer, more smarter, & reliable.

Eg- i) Tesla Full Self-driving (supervised)
ii) Waymo driver
iii) Mercedes-Benz drive pilot
iv) Baidu Apollo go
v) General motors super cruise.

3.3) Applications of autonomy in other mobility systems=

1) Autonomous Trains=

Autonomous trains are trains the work automatically with very less or no human intervention. These trains uses sensors like camera, communication channel, AI & ML & automatic train control to control train safely & effectively. Onboard computers monitors speed of train, its location, track condition, driving environment, while doing all these it can controll acceleration, braking & stopping train at stations.

Features of autonomous trains =

i) Auto train operations
ii) Auto speed control (Acceleration, braking)
iii) Automatic braking & stopping
iv) Track & surrounding monitoring
v) Real time data exchange with control room.
vi) Precise station stopping.

Levels of autonomous trains =

i) GoA 0 (Grade of Automation 0)
Manual – Driver is essential for controlling
– No automation.

ii) GoA 1 = Manual Driving with automatic protection.
- Driver is responsible for controlling train.
- Automatic train protection (ATP) system used to avoide overspeeding & collisions.

iii) GoA 2 = Semi automatic train Operation (STO)
- Driver act as observer, he only take control in emergency conditions.
- Other controlling actions like starting, accelerating, braking, stopping at station has been controlled automatically.

iv) GoA 3 = Driverless train operation (DTO)
- No need of driver for controlling train.
- Train attendant may be appointed to take care of passengers.

v) GoA 4 = Unattended train operation (UTO)
- No driver appointed, nor train attendant present on train.
- All controlling actions can be managed by computer system automatically.

Advantages =
i) Increased safety by eliminating human mistakes.
ii) Time bound operations.
iii) Good operational efficiency.
iv) lower cost of maintenance & operational cost.
v) Smooth & comfort in journey.
vi) Better utilisation of railway infrastructure.

Eg - GoA 2 = Delhi metro
GoA 3 = Paris metro
GoA 4 = Dubai metro, Copenhagen metro & sydney metro.

2) Autonomous ships=

Auto. ships also known as Maritime Autonomous Surface Ships (MASS), are vessels that can navigate & performing operations with very less human intervention or no intervention of humans.

For monitoring environment, making proper decisions & safety control over ship, they utilise sensors, GPS, RADAR, LiDAR, Sonar, Cameras, communication system, AI & ML & advance computing system.

Ther ships can automatically perform activities like planning best suited route, collision avoiding, weather monitoring, & optimization in fuel consumption. Through advanced communication channels ships communicate with nearby ships, ports, control centers to ensure safety & efficient operation.

Features of autonomous ships=

i) Auto route planning & navigation.
ii) Object detection & collision avoidance
iii) Automatic speed & steering control.
iv) Weather monitoring
v) Remote monitoring & control
vi) Fuel & energy optimization.

Levels of autonomous ships=

International Maritime Organization (IMO) defines 4 levels of autonomy as

Level 1 = Automated Processes
- Humans i.e. crew is responsible for all controls
- Automated systems assist the crew for operations.

Level 2 = Remote controlled with crew onboard =
- Crew members are present on ship for any emergency situation.
- Ship actually controlled from remote location by proper strong communication channel.

Level 3 = Remotely controlled without crew onboard.
- No need of crew on ship.
- Ship operated from control room through strong communication channel.

Level 4 = Fully autonomous ship =
- No human intervention.
- All operations can be performed automatically by onboard computer system.

Advantage =
i) Improved safety by less human error.
ii) Reduced operational & maintenance cost.
iii) Optimized fuel consumption, (economic)
iv) Transportation efficiency improved.
v) Navigation accuracy improved
vi) Ensure 24 by 7 operation with less or no human intervention.

Eg -i) Rolls-Royce autonomous ship research & remote vessel technology.
ii) Mitsubishi Heavy industries autonomous navigation system.
iii) Kongsberg maritime autonomous shipping technologies. etc.

Autonomous Aircrafts = (Unmanned Aircraft System) UAS.

Autonomous aircraft also known as Unmanned aerial vehicles (UAVs) or UAS, these arecrafts fly with very less or no human intervention.

These aircrafts uses sensors like cameras, GPS, RADAR, LiDAR, AI & ML, communication channels, onboard strong computing system to navigate, find obstacles in environment & to complete assigned activity with safety & accuracy.

Parts of autonomous aircrafts =

i) Unmanned aircraft – flying vehicle
ii) Ground control station.
iii) Communication channel.

These aircrafts can takeoff, land, navigate, complete assigned work, avoids collision all activities can be performed by itself.

Features of autonomous aircraft =

i) Auto. take off & landing
ii) Navigation using GPS.
iii) Objects detection in environment & collision avoidance
iv) Real time data transmission through strong & safe communication channels.
v) Auto route planning.
vi) Remote monitoring controlling

Levels of autonomous aircrafts =

Level 1 = Remote controlled
- Human needed for controlling aircraft.
- Using remote control, all the activities controlled

Level 2 = Assisted flight

- Pilot can focus more on his mission by controlling assessories.
- Onboard computer provides stable movements, altitude hold & navigation using GPS.

Level 3 = Semi-autonomous =

- Pilot is only appointed for supervision purpose.
- Aircraft follows the pre-programmed flight path. In addition to it aircraft can takeoff & land automatically without human intervention

Level 4 = Fully autonomous.

- No human needed
- All activities like takeoff, navigation, maintaining altitude, collision avoidance & landing can be performed by aircraft using strong computing system.

Advantages =

i) Improved safety, by less human errors.
ii) No risk of human life in risky areas.
iii) Less operational cost.
iv) Continuously monitors & surveillance done.
v) Increased accuracy in achieving targets.
vi) fast data transmission & collection.

Eg = i) MQ-9 Reapter = Military UAV = US
ii) RQ-4 Global Hawle = High alt reco- = US
nnaissance
iii) Parrot Anafi = Photography & = France
mapping
iv) Bayraktar TB2 = Military UAV = Turkey
v) DJI Phantom = Photography & = China
mapping

vi) DJI Mavic-3 = Photography, inspection, surveying = China

vii) Zipline delivery drone = Medical supply delivery = US

viii) Amazon Prime Air drone = Package delivery = US

Indian UAVS

i) Tapas BH-201 (Rustom-II) By DRDO - Medium alt surveillance & reconnaissance

ii) Nishant by DRDO - Battlefield surveillance & intelligence.

iii) Lakshya by DRDO - Pilotless target aircraft for military training

iv) Rustom-1 by DRDO - Technology demonstrator & surveillance.

v) Netra V2 by IdeaForge (India) - Surveillance, search & rescue, law enforcement

vi) Switch UAV by Ideaforge (India) - Surveillance, mapping & defence operations.

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