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A Theoretical Understanding of Journey towards Smart Autonomous Vehicles from Smart only Vehicles

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ABSTRACT

The growth of smart cities is accelerating. Information and communication technology (ICT) is digitally reshaping our surroundings. The environment, governance, energy, transportation, and other sectors are all impacted by the digital transition. To better understand how millennials are embracing autonomous vehicles (AV), which are the wave of the future of transportation, a systematic theoretical understanding of the approach of evolution of smart autonomous vehicles is presented. By 2035, autonomous driving could create $300 billion to $400 billion in revenue Millennials are a crucial target of this business because they are eager to accept new technologies and transportation options.

Keywords: Autonomous Vehicles, transportation, intelligence, ADAS, Safety

1.0 Introduction

Smart vehicles revolutionize travel. Technology enhances vehicle safety. Smart cars revolutionize transportation. Smart vehicles connect to advanced driver-assistance systems (ADAS) and autonomous driving. Affordable, green, safe cars. Smart cars benefit drivers and society. Cars' future. Smart cars use sensors, computers, and connections. Smart cars connect through autonomous driving, ADAS, and networking. Car ADAS.[1][12] Smart vehicles use technologies for safety and efficiency. Smart cars are safe, efficient, connected, and sustainable. Lane Departure Warning (LDW), Autonomous Emergency Braking (AEB), and Adaptive cruise control (ACC) prevent accidents. [2][14][5]Enhanced engine, emission, connection, and real-time data optimization. Improved vehicles. Smart vehicles: pros and cons. Self-driving cars save time, reduce errors, and assist the elderly. Smart cars help with transportation. Smart cars: cost-effective, eco-friendly, safe. Travel planning. Vehicle classification (VC) predicts car quality. VC pneumatic tube vehicle statistics 1920. Air tubes weigh axles and pivots. No good for rapid, busy routes. Further magneto loop detectors detected VC. Vehicles gain popularity. Speed is two loops. Unable to detect circles. Hub and automobile sensors use piezoelectricity. Framework-free Weight-In-Motion (WIM) piezo locators. [8]Asphalt temperature and speed impact piezoelectric sensors. Radar length, height, and estimation characterize vehicles. Radars are less sensitive to swings but can't handle much activity. Wide vehicle light IR sensor profiles. Car acoustics monitor speed, infrared sensors study nature.

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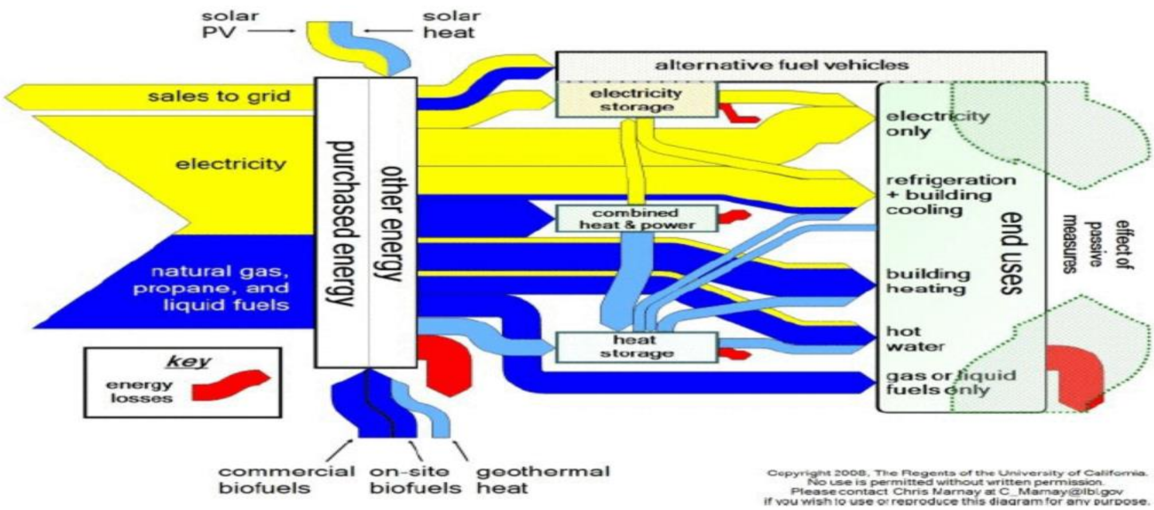
Fixed position sensor technologies provide valuable data. Vision measures axle, weight, and brand. The camera detects vehicle movement. Global Positioning System (GPS) devices are accurate but don't have vehicle details. Smartphones and GPS devices record vehicle kinematics, causing real-time monitoring and categorization errors. Global VC is unreliable. Cloud or car networks could replace VC applications.

2.0 Literature Review

There has been a developing body of investigation on shrewd vehicles for a long time. A few of the key regions of inquire about in this field incorporate:

- **Vehicle-to-vehicle (V2V) communication**: This innovation permits vehicles to communicate with each other in order to share data almost their area, speed, and eagerly.[1] V2V communication can be utilized to make strides security by avoiding mischances, and it can moreover be utilized to make strides activity stream by planning the developments of vehicles.
- **Brilliantly transportation frameworks (ITS)**: This term alludes to a wide extent of advances that can be utilized to progress the effectiveness and security of transportation frameworks.[6][16][3] Keen vehicles are a vital portion of ITS, and they can be utilized to gather information about activity conditions, optimize activity stream, and give drivers real-time data approximately their surroundings.
- **Independent driving**: Usually the extreme objective of shrewd vehicles inquires about. Independent vehicles are vehicles that can drive themselves without any input from a human driver.[12][18][21]Independent driving is still in its early stages of advancement, but it has the potential to revolutionize transportation by making it more secure, more proficient, and more helpful.



Source: DERMS Definition: Coordination of Interconnected DERs (Credit: DER 2008) [image source link]

Automotive technology, networking, and AI have advanced smart automobiles in recent years. This literature review analyzes smart vehicle research, concentrating on major topics, technical advances, and difficulties.

1. **Evolution of Smart Vehicles:** Smart vehicles concept has evolved over time, with early research primarily focusing on basic vehicle automation and driver assistance systems. Pioneering work by researchers like Raj Rajkumar and Sebastian Thrun laid the foundation for subsequent developments in autonomous vehicles.
2. **Connectivity and V2X Communication:** Smart vehicles rely on Vehicle-to-Everything (V2X) communication for enhanced safety and efficiency. [4]This section reviews studies on V2X technologies, their integration with smart vehicles, and their impact on traffic management, safety, and vehicle-to-infrastructure interactions.[21][15]
3. **Artificial Intelligence and Machine Learning:** Machine learning plays a crucial role in the development of smart vehicles.[6][13] This section delves into research related to deep learning, reinforcement learning, and other AI techniques used for perception, decision-making, and control in autonomous vehicles.[12][4]

2.1 DER-CAM

Distribution Energy Resources Customer Adoption Model (DER-CAM) is GAMS MILP. The simulated site's yearly energy service costs and CO_2 emissions are reduced via utility electricity and natural gas purchases, amortized capital, and DG investment maintenance.[2][3] The study will optimize multi-objective cost-CO_2 reduction. Energy purchases, on-site conversion, electrical and thermal renewable harvesting, and end-use efficiency are technology-neutral DER-CAM. Strategy examines simultaneous results.[4] Heated cooling lowers peak load, on-site generation, demand, and TOU energy expenses. End-use energy loads, electricity and natural gas prices, and DG investment choices are site-specific model inputs.

Smart vehicles offer numerous benefits to drivers, passengers, and society as a whole. Here are some ways in which smart vehicles are useful:

1. **Improved Safety**: Smart vehicles are equipped with ADAS, which helps drivers avoid accidents and reduces the risk of injuries and fatalities.
2. **Increased Efficiency**: Smart vehicles use advanced sensors and communication technologies to optimize driving patterns, reducing fuel consumption and emissions.

Smart vehicles use a range of advanced technologies to enable autonomous driving, including:

1. **Sensors**: Sensors abound. Microwaves reflect car radars. Photosensors or ultrasonic sound waves that reflect off moving objects may detect burglar alarms' broken light beams. Others monitor chemicals or pressure (barometers, smoke detectors).

Smart vehicles rely on a range of sensors to gather information about the vehicle, the environment, and the driver. Here are some of the most common types of sensors used in smart vehicles and their uses:

1. **Camera**: Cameras are used to capture images and videos of the vehicle's surroundings, allowing the vehicle to detect other vehicles, pedestrians, and obstacles. They are commonly used for lane departure warnings, pedestrian detection, and rearview cameras.[4]
2. **Lidar**: Lidars use laser beams to detect objects in the vehicle's surroundings, creating a 3D map of the environment. They are commonly used for autonomous driving, obstacle detection, and collision avoidance.

Sensors are a crucial component of smart vehicles, providing information about the environment, vehicle performance, and driver behavior. Here are some ways in which sensors are useful in smart vehicles:

1. **Environment Detection**: These sensors provide the vehicle with information about the environment, enabling it to react appropriately to traffic and road conditions changes.[8]

2. **Driver Assistance**: Sensors can detect when the driver is getting drowsy or distracted and provide alerts to help them stay focused on the road. They can also monitor the driver's heart rate, blood pressure, and other physiological indicators to detect signs of fatigue or stress.

Overall, sensors are essential to the operation of smart vehicles, providing critical information about the environment, vehicle performance, and driver behavior. Using sensors, smart vehicles can improve safety, optimize performance, and provide a more comfortable and enjoyable driving experience.

1. **Control Systems**: These control systems can also communicate with other vehicles and infrastructure to coordinate driving behavior.

Smart vehicles use advanced control systems to manage and regulate various functions of the vehicle. These control systems are designed to optimize performance, improve safety, and enhance the driver's experience.[18] Here are some ways in which smart vehicles are useful in control systems:

1. **Vehicle Stability Control**: Smart vehicles use sensors to monitor the vehicle's speed, acceleration, and other parameters to detect instability and take corrective action. [12]This system helps improve vehicle stability and prevent accidents.
2. **Chassis Control**: Smart vehicles use chassis control systems to manage the vehicle's suspension, steering, and braking.[7] These systems adjust the vehicle's response to driving conditions to improve handling, stability, and safety.

Overall, smart vehicles are useful in control systems as they integrate advanced technologies, such as sensors, algorithms, and communication systems, to optimize performance, improve safety, and enhance the driver's experience.[12]

3. **Machine Learning**: Machine learning is a critical technology that enables smart vehicles to operate autonomously and make intelligent decisions based on data.[3] Here are some ways in which machine learning is helpful in smart vehicles:
    1. **Object Detection**: Smart vehicles use cameras, radar, and lidar sensors to detect objects around the vehicle. Machine learning algorithms can analyze this data to identify and classify objects, such as pedestrians, other vehicles, and road signs.[12]
    2. **Decision-Making**: Smart vehicles use control systems to make decisions based on data from sensors and other sources. [8]Machine learning can help these systems make more intelligent decisions by analyzing data and predicting outcomes. For example, machine learning can help a smart vehicle decide when to change lanes to avoid traffic congestion or when to slow down to conserve energy.

Overall, machine learning is a critical technology that enables smart vehicles to operate autonomously, make intelligent decisions based on data, and provide personalized assistance to drivers.

4. **Mapping and Localization**: Smart vehicles use high-definition maps and localization technology to determine their position on the road and navigate to their destination.

Overall, smart vehicles enable autonomous driving through a combination of advanced sensors, control systems, machine learning, and mapping and localization technology.[17] These technologies can improve safety, reduce driver workload, and enable more efficient use of transportation infrastructure.

3. **Sustainability**: Smart cars optimize driving patterns and fuel use to lessen environmental effects. Autonomous driving technology may also improve transportation infrastructure efficiency, cutting congestion and pollutants.

Smart vehicles can help in sustainability in several ways, including:

1. **Reducing fuel consumption**: Smart vehicles use advanced technologies like ADAS and connected sensors to optimize driving patterns, reduce idling time, and minimize unnecessary

acceleration and braking. [5]These features can help reduce fuel consumption, resulting in fewer emissions and a lower carbon footprint.

2. **Promoting electric vehicle adoption**: Many smart vehicles are electric or hybrid, making them a more sustainable transportation option than traditional gas-powered vehicles.

3.0 Hardware Related to Smart Vehicles

There are several types of hardware that are related to smart vehicles, including:

1. **Sensors**: Smart vehicles rely on a variety of sensors to collect data about their surroundings. These may include cameras, radar, lidar, ultrasonic sensors, and more.

Sensors play a critical role in the manufacturing of smart vehicles. They are used to collect data and monitor various aspects of the vehicle throughout the production process. Here are some specific ways in which sensors help in the manufacturing of smart vehicles:

1. **Quality control**: Sensors can be used to monitor the quality of components and materials during the manufacturing process.[5][18] For example, sensors can be used to detect defects in welds, measure the thickness of coatings, or check for the correct alignment of parts.
2. **Performance testing**: Sensors can be used to test the performance of the vehicle during the manufacturing process. For example, sensors can be used to measure the acceleration, braking, and handling characteristics of the vehicle.

These sensors report vehicle distance, speed, location, and other automobiles, pedestrians, and objects. This data guides vehicle acceleration, steering, and braking for safety and efficiency.[6] Smart automobiles use several sensors to gather data and run effectively. Common smart vehicle sensors:

1. LiDAR (Light Detection and Ranging)
2. Cameras (including visible light cameras, thermal cameras, and infrared cameras)
3. Ultrasonic sensors
4. GPS (Global Positioning System)
5. IMU (Inertial Measurement Unit)
6. Wheel speed sensors
7. Li-ion battery sensors
8. Blind Spot Detection sensors
9. Lane Departure Warning sensors.

4.0 LiDAR

The LiDAR sensor emits short pulses of laser light in the direction of travel. These pulses of light hit objects in the surrounding environment, such as other vehicles, pedestrians, and buildings, and bounce back to the LiDAR sensor. This map provides the vehicle with information about the location, size, and position of nearby objects, which can be used to adjust the vehicle's speed and direction to avoid collisions.[4][2] In addition to measuring distance, LiDAR can also be used to detect the reflectivity of objects in the surrounding environment. LiDAR has become a critical component of smart vehicles as it can provide precise data about the vehicle's surroundings in real-time. Here are some ways in which LiDAR is used in smart vehicles and how it can be helpful:

1. **Obstacle Detection and Collision Avoidance**:
   LiDAR can help smart vehicles detect and avoid obstacles in their path, such as other vehicles, pedestrians, and stationary objects.

2. **Road Condition and Signage Detection**:
   LiDAR can also be used to detect road conditions, such as potholes and cracks, which can help to prevent accidents and prolong the life of the vehicle. [5]Additionally, LiDAR can detect road signs and traffic lights, which can help smart vehicles make informed decisions about speed and direction.

5.0 RADAR

In simple terms, it is similar to LiDAR but uses radio waves instead of laser light. [3]In a RADAR system, a transmitter emits radio waves, which travel through the air and bounce off objects in their path, such as other vehicles, buildings, and terrain features.

RADAR can be used for a variety of purposes, including:

1. **Navigation and Localization**:
   RADAR can be used to determine the location of a vehicle by comparing the received radio waves with a map of the surrounding environment. This can be particularly useful in areas where GPS signals are weak or unavailable.
2. **Weather Detection**:
   RADAR can be used to detect and track weather patterns, such as rain, snow, and hail. This information can be used to warn drivers of hazardous road conditions and to help meteorologists track weather patterns.

Cameras: These are critical components of smart vehicles as they provide real-time visual data about the vehicle's surroundings.

1. **Object Detection and Identification**:
   Cameras can help smart vehicles detect and identify objects in their path, such as other vehicles, pedestrians, and stationary objects. [6]By generating accurate 3D maps of the surrounding environment in real-time, cameras can provide the vehicle with information about the size, distance, and position of nearby objects, which can be used to adjust the vehicle's speed and direction to avoid collisions.
2. **Lane Departure Warning**:
   Forward-facing cameras can be used to implement lane departure warning systems in smart vehicles.

There are several types of cameras used in smart vehicles, including:

1. **Forward-facing cameras**:
   These cameras are typically mounted on the front of the vehicle and are used to detect and identify objects in the road ahead. [8]They can be used for various applications, including lane departure warnings, traffic sign recognition, and pedestrian detection.

Front-facing cameras are a critical component of smart vehicles as they provide real-time visual data about the road ahead. By using front-facing cameras, smart vehicles can detect and avoid obstacles, navigate complex environments, and make informed decisions about speed and direction, making driving safer and more efficient. Here are some ways in which front-facing cameras are helpful for smart vehicles:

- **Lane Departure Warning**:
  Lane departure warning systems in intelligent cars may be implemented using front-facing cameras. [7][9]Cameras are used by lane departure warning systems to identify when a car is veering off its lane and notify the driver.

- **Traffic Sign Recognition**:
  In smart cars, traffic sign recognition systems may be implemented using front-facing cameras. Utilizing cameras, traffic sign recognition systems can detect and recognise traffic signs including stop signs and speed limit signs, giving drivers crucial information about the road ahead.[5]

2. **Rear-facing cameras**:
   Rear cameras are a critical component of smart vehicles as they provide real-time visual data about the area behind the vehicle. [6]By using rear cameras, smart vehicles can detect and avoid obstacles, navigate tight spaces, and park safely, making driving safer and more efficient. Here are some ways in which rear cameras are helpful for smart vehicles:
   - **Rear Cross-Traffic Alert**:
     Rear cameras can be used to implement rear cross-traffic alert systems in smart vehicles. Rear cross-traffic alert systems use cameras to detect and identify vehicles approaching from the sides while backing up, providing the driver with a warning to avoid collisions.[17]
   - **Trailer Hitch Assistance**:
     Rear cameras can be used to assist the driver while hitching a trailer to the vehicle. By providing a view of the hitch and trailer, rear cameras can assist the driver in aligning the hitch and attaching the trailer safely.

3. **Side-view cameras**:
   Side-viewing cameras are a critical component of smart vehicles as they provide real-time visual data about the sides of the vehicle.[11] By using side-viewing cameras, smart vehicles can detect and avoid obstacles, navigate complex environments, and make informed decisions about changing lanes, making driving safer and more efficient. Here are some ways in which side-viewing cameras are helpful for smart vehicles:
   - **Intersection Safety**:
     Side-viewing cameras can be used to improve intersection safety in smart vehicles. By providing a view of the sides of the vehicle, cameras can help the driver detect and avoid collisions with other vehicles and pedestrians while turning or crossing intersections.[13]
   - **Parking Assistance**:
     Side-viewing cameras can be used to assist the driver while parking in tight spaces. By providing a view of the sides of the vehicle, cameras can help the driver avoid collisions with other vehicles and obstacles while parking.

Interior-facing cameras are another important component of smart vehicles as they provide real-time visual data about the occupants of the vehicle. By using interior-facing cameras, smart vehicles can detect and respond to the needs of the occupants, as well as provide additional safety features. Here are some ways in which interior-facing cameras are helpful for smart vehicles:

- **Passenger Monitoring**:
  Interior-facing cameras can be used to monitor the passengers in the vehicle, providing additional safety features such as detecting unbuckled seat belts or alerting the driver if a passenger is interfering with their driving.[3]
- **Personalization**:
  Interior-facing cameras can be used to personalize the driving experience for each occupant of the vehicle. For example, the system can recognize the driver and automatically adjust the seat, mirrors, and other settings to their preferences.

4. **Surround-view cameras**: Surround-view cameras, also known as 360-degree cameras, are a vital component of smart vehicles as they provide a comprehensive view of the vehicle's surroundings.[13][5]By using multiple cameras, smart vehicles can obtain a complete picture of the vehicle's environment, enabling the driver to maneuver safely and efficiently. Here are some ways in which surround-view cameras are helpful for smart vehicles:
   - **Parking Assistance**:
     Surround-view cameras can be used to provide parking assistance in smart vehicles. By displaying a top-down view of the vehicle, the driver can see the entire parking space and maneuver the vehicle with precision.
   - **Blind Spot Detection**:
     Surround-view cameras can also be used to implement blind-spot detection systems in smart vehicles. By displaying a live feed of the vehicle's surroundings, the driver can be alerted to any obstacles in their blind spot.

Night vision cameras are an important component of smart vehicles as they provide visibility in low-light conditions. [9]By using night vision cameras, smart vehicles can detect obstacles and hazards that may be difficult to see with the naked eye, improving driver safety and reducing accidents. Here are some ways in which night vision cameras are used in smart vehicles:

- **Obstacle Detection**:
  Night vision cameras can be used to detect obstacles in low-light conditions. By providing real-time visual data, the system can alert the driver to the presence of obstacles such as debris or other vehicles, reducing the risk of accidents.

- **Improved Visibility**:
  Night vision cameras can improve visibility in low-light conditions, making it easier for the driver to see the road ahead. This can be particularly useful in areas where streetlights are scarce or where there are no streetlights at all.[11]

2. **Processing units**: The data collected by sensors must be processed in order to be helpful to the vehicle. Smart vehicles rely on powerful processing units such as microcontrollers, microprocessors, and GPUs to make sense of this data.
3. **Communication hardware**: Smart vehicles need to communicate with other vehicles, infrastructure, and the cloud in order to function properly.[7] This may include Wi-Fi, Bluetooth, cellular, and other communication technologies.

6.0 Algorithms

There are many algorithms used in smart vehicles. Here are some examples:

1. SLAM (Simultaneous Localization and Mapping)
2. A* Algorithm (used in path planning)
3. Kalman Filter (used for sensor fusion and localization)
4. Neural Networks (used in machine learning and computer vision)
5. Decision Trees (used in object detection and classification)
6. PID (Proportional Integral Derivative) Controller (used in control systems)
7. Particle Filters (used in localization and tracking)
8. Deep Reinforcement Learning (used in decision-making and control)
9. Genetic Algorithms (used in optimization problems)
10. CNN (used in CV for image and OR)

7.0 SLAM (Simultaneous Localization and Mapping)

The SLAM algorithm works by continuously updating a map of the environment and estimating the system's position based on the sensor data. As the system moves through the environment, it updates the map and refines its estimate of its own position. SLAM can be used in a variety of applications, such as autonomous vehicles, mobile robots, and drones. [11]It is particularly useful in scenarios where GPS is not available, such as indoor environments or in areas with poor GPS reception.

There are many variations of the SLAM algorithm, each with its own strengths and weaknesses. Some of the most common variations include EKF SLAM (Extended Kalman Filter SLAM), FastSLAM, and GraphSLAM.

The SLAM algorithm is very helpful for smart vehicles because it allows them to create a map of their environment and determine their own position within that environment.[14] This is important for a variety of reasons, including:

1. **Navigation**: Smart vehicles need to be able to navigate their environment safely and efficiently. By using SLAM to create a map of the environment, the vehicle can plan its route and avoid obstacles.
2. **Localization**: Smart vehicles need to be able to determine their own position within their environment. SLAM allows the vehicle to estimate its position based on sensor data, even in environments where GPS is not available or unreliable.[15]
3. **Autonomous Driving**: SLAM is a key component of many autonomous driving systems. [3]By combining SLAM with other algorithms, such as object detection and path planning, smart vehicles can navigate their environment without human intervention.

8.0 Neural Networks

Filter matrix dimensions are commonly 3X3 or 5X5. To maintain weight, the filter matrix varies throughout training. CNN exchanges weights. The same weights may indicate two network modifications. Sharing parameters saves processing space and helps the network learn. Dynamic HydraNets may use multiple CNN networks for different goals. Blocks or networks branches.[4][17] HydraNet-input task-specific CNN. Consider self-driving automobiles. Some input datasets have static trees, road fences, off-road lanes, traffic signals, and roads. Different branches train inputs. The gate selects inference branches and the combiner evaluates outputs. Since inference input was ambiguous, Tesla altered this network. It was fixed by Tesla experts utilizing a common backbone. Regularly updated ResNet-50 blocks share backbones. Neural networks can be very helpful in smart vehicles, as they allow the vehicle to make more accurate and informed decisions in real time. Here are some ways that neural networks can be used in smart vehicles:

1. **Object detection**: Neural networks can identify and classify other automobiles, pedestrians, traffic signs, and signals. This information may avoid collisions and manage traffic.
2. **Image and video analysis**: Neural networks can analyze the images and videos captured by the vehicle's cameras to identify potential hazards, such as obstacles in the road, and make decisions based on that analysis.

9.0 PID Controller

PID controllers employ criticism in mechanical control systems and other constant-control applications. A PID controller calculates a mistake value e(t) as the difference between a desired setpoint (SP) and a measured prepare variable (PV) and applies a remedy based on relative, essential, and subsidiary terms (P, I, and D separately), then the title.

1. **Tuning** – These effects are best addressed by circular tuning. Each control application must calculate "K" from the whole circle's response characteristics outside the controller. [12]Their measuring sensor, ultimate control component (such a valve), signal delays, and technique identify them. Inexact constant values are commonly supplied to understand programming, but "bumping" the approach by changing a setpoint and seeing the framework reaction refines them.
2. **Control activity** – The scientific display and down-to-earth loop above use coordinate control for all terms, with increasing positive control yielding adjustment error. Reversing action is negative remediation. [17]If the stream circle valve opens 100–0% for 0–100% control yield, reverse controller action. Switches operate certain control systems and final components. Disasters should open fail-safe cooling water valves 100%; 0% controller yield should trigger this.

According to this model:

- PID controls are explained in Industrial Batch Temperature Control. Closed-system Industrial Batch Heat Controls fail warmth. PIDs manage heat supply and profit all operations. Electric ovens need precise heating for baking and frying.
- A proportional term produces proportionate errors. To change values, “Kp” multiplies error. Gain proportional to Kp.
  Kpe(t) = Pout

Error output may alter significantly with high proportional gain constants. High Kp causes system instability. A modest proportional gain produces output with high error values, making the system insensitive. A little boost slows the system. A sensitive system requires responsive language and modifications. Gain inversely impacts steady-state error, which proportional control controls.

If the parameters of a PID controller

- Gain
- Integral term
- Derivative term

If picked inaccurately, the PID controller can be insecure which means that its output is not precise or accurate. Instability is the result of significant unnecessary gain, especially when the system has high latency, in other words, if the system lags, gain amplifies the instability factor.[2]

9.1 A* Algorithm (used in path planning)

The A* algorithm has several advantages:

1. The A* method will identify the shortest route from the start node to the target node if the heuristic function is admissible (meaning it never overestimates the real cost) and consistent (satisfies the triangle inequality).[17]
2. Fast Execution: In situations with numerous barriers or complicated terrain, the A* method is frequently faster than Dijkstra's algorithm or breadth-first search.
3. Flexibility: The A* algorithm may handle various surroundings and barriers with different heuristic functions.[12][2]

A* Pathfinding is used in smart automobiles. Heuristic search evaluates paths based on target distance and environmental impact. The A* algorithm safely steers smart automobiles between starting and terminating points. A search tree with map nodes is made. [13]The programme chooses the optimum tree-based destination path. A* handles dangerous circumstances well, making it excellent for smart automobiles. The software evaluates the cost of parameters to create a barrier-free, short path.

10.0 Particle Filters

Smart vehicle localization using particle filters is common. Many smart car applications, such as navigation, autonomous driving, and real-time traffic analysis, depend on vehicle localization.[8][2] Particle filters determine the vehicle's location and orientation using GPS, odometry, and camera data and a probabilistic model of the surroundings. The probabilistic model portrays vehicle locations as particles. The technique updates particle probability distributions using sequential Monte Carlo based on sensor readings.

Here's how particle filters help in localizing smart vehicles:

1. **Robustness**: Particle filters are robust to noise and sensor errors, as they use a probabilistic model that can account for uncertainty in sensor measurements.[11]
2. **Real-time performance**: Particle filters can provide real-time localization estimates, which is critical for many smart vehicle applications.
3. **Accuracy**: Particle filters can provide accurate localization estimates, even in challenging environments such as urban areas with tall buildings that can interfere with GPS signals.

11.0 Kalman Filter (used for sensor fusion and localization)

Kalman channels can predict urban real-time activity. Other vehicles and fix-sensors may use it. Because CVs don't need a foundation or organization, vehicle data is cheaper than sensors. CV innovation is accurate except that. Linking vehicles may impede access [13]. Lump estimate approaches need measurable information to predict each step in the Kalman channel, which is recursive. [11]Storing final state changes expectations. Simplifies activity forecasts. Famous for smart car sensor fusion and localization, Kalman Filter. Iteratively estimating system status from noisy sensor inputs.[10][3] Control, navigation, and tracking employ Kalman Filter. [12]Smart car Kalman Filters may employ sensor data for vehicle localisation. GPS, gyroscopes, and accelerometers detect vehicle speed and direction. Kalman Filter noise and poor data management aid sensor fusion and localization. By accounting for sensor data flaws, Kalman Filter predicts system state better than single sensor readings. Smart automobiles fuse and localize sensors using the Kalman Filter. [6]The Kalman Filter enhances sensor-based vehicle condition assessment.

12.0 Applications of Smart Vehicle

Delivery and logistics: Smart vehicles can be used to optimize delivery and logistics processes by using real-time traffic data to determine the most efficient routes, reducing delivery times, and improving the accuracy of delivery tracking.[14][9] Smart vehicles have the potential to revolutionize transportation in many ways, including:

1. **Lowering carbon emissions**: Smart vehicles can optimize their speed and route to reduce fuel consumption and emissions. They can also be designed to run on electric or hybrid power, further reducing their environmental impact.[13][7]
2. **Increasing accessibility**: Smart vehicles can be designed to accommodate people with disabilities, making transportation more accessible and inclusive for everyone.

3. **Enhancing comfort and convenience**: Smart vehicles can be equipped with a range of features to enhance the comfort and convenience of passengers, such as climate control, entertainment systems, and advanced driver assistance features.[12][3]

12.1 Agriculture

Smart vehicles can bring significant benefits to agriculture by automating tasks and increasing efficiency. Here are some ways in which smart vehicles can help in agriculture:

1. **Improved precision and accuracy**: Smart vehicles can use sensors and mapping technologies to precisely plant, spray, and harvest crops, reducing waste and increasing yield.
2. **Reduced labor costs**: By automating tasks, smart vehicles can reduce the need for manual labor, freeing up time and resources for other important tasks.[12][21]

12.2 Mining

Smart vehicles have a range of potential applications in mining, particularly in underground mines. Here are some ways in which smart vehicles can help in mining:

1. **Reduced environmental impact**: Smart vehicles can use electric or hybrid power, reducing emissions and minimizing the environmental impact of mining operations.
2. **Improved precision and accuracy**: Smart vehicles can use sensors and mapping technologies to precisely drill, blast, and transport materials, reducing waste and increasing yield.[15]

Public transportation: Smart vehicles can be used to improve public transportation by optimizing routes, reducing wait times, and improving accessibility for people with disabilities.[16] Here are some ways in which smart vehicles can help in public transportation:

1. **Real-time traffic data**: Smart vehicles can use real-time traffic data to determine the most efficient routes and avoid traffic congestion, reducing travel times for passengers.
2. **Reduced emissions**: Smart vehicles can be designed to run on electric or hybrid power, reducing emissions and making public transportation more environmentally friendly.[19][18]

Emergency services: Smart vehicles can be used by emergency services to respond to emergencies more quickly and efficiently, using real-time traffic data to avoid congestion and reach their destination faster. Here are some ways in which smart vehicles can help in emergency transportation:[20]

1. **Real-time traffic data**: Smart vehicles can use real-time traffic data to determine the most efficient routes to the scene of an emergency, reducing response times.
2. **Automated driving**: Smart vehicles can be designed to operate autonomously, allowing emergency responders to focus on patient care rather than driving.[21]
3. **Improved accessibility**: Smart vehicles can be designed to accommodate people with disabilities, ensuring that all patients have access to emergency transportation when they need it.

Entertainment: Smart vehicles can be equipped with entertainment systems, allowing passengers to watch movies, play games, and browse the internet while on the road. Here are some ways in which smart vehicles can help in entertainment:

1. **Comfort features**: Smart vehicles can be designed with a range of comfort features, such as climate control, heated seats, and massaging seats, that enhance the passenger experience.
2. **Gaming systems**: Smart vehicles can be equipped with gaming systems that allow passengers to play games during their travels.[22][17]

3. **Personalization options**: Smart vehicles can be designed to provide personalized entertainment options based on individual passenger preferences, making travel more enjoyable and engaging.

13.0 Conclusion

In conclusion, smart automobiles' new characteristics may change transportation. Smart vehicles benefit logistics, farming, mining, crisis management, and traveler safety and efficiency. By automating and enhancing processes, smart vehicle sensors, cameras, and computers save time. Cross-breed or electric control may limit discharges, transportation, and other effects. Auto maintenance may be simpler with smart cars.[20] Smart cars may reduce outflows, increase energy output, and enhance transportation efficiency using electric or half-breed control, energy optimisation, and real-time activity data. Cars will benefit from tech. Smart cars can benefit lives, businesses, and sustainability.

References

1. International Energy Agency. (2020). Global EV Outlook 2020. Retrieved from https://www.iea.org/reports/global-ev-outlook-2020
2. Singh, N., Singh, T. P., & Azzopardi, B. (2024). Advances in Autonomous Navigation Through Intelligent Technologies. In Title of the Book (Page No: 10-259). Apple Academic Press. (In press)
3. Sawa, M., Singh, N., & Ravi, R. (2023). A Secure And Efficient Approach to Smart City Initiatives. In Title of the Book (page numbers 97-241). Future Connected Technologies. (In press)
4. Chauhan, P., Singh, N., & Prateek, M. (2022). An Efficient Path Planning Algorithm for Networked Robots using Modified Optimization Algorithm. In Title of the Book (page numbers 23-219).
5. Singh, N., Prateek, M., Chauhan, P., & Choudhury, T. (2022). An Optimized Self-Learning Algorithm for Autonomous Navigation in an Unknown Environment. Journal of Green Engineering, 2020, Volume(II)
6. Dhakal, T., Kangwon National University, & Min, K.-S. (Year of Publication). Macro Study of Global Electric Vehicle Expansion. Foresight STI Gov, 15, 67–73.
7. Elmenshawy, M., & Massoud, A. (2020). Modular Isolated DC-DC Converters for Ultra-Fast EV Chargers: A Generalized Modeling and Control Approach. Energies, 13, 2540.
8. Shibl, M., Ismail, L., & Massoud, A. (2021). Electric Vehicles Charging Management Using Machine Learning Considering Fast Charging and Vehicle-to-Grid Operation. Energies, 14, 6199.
9. Lytras, M. D., Visvizi, A., & Jussila, J. (2020). Social media mining for smart cities and smart villages research. Soft Comput, 24, 10983–10987.
10. Morvaj, B., Lugaric, L., & Krajcar, S. (2011). Demonstrating smart buildings and smart grid features in a smart energy city. In Proceedings of the 2011 3rd International Youth Conference on Energetics (IYCE), Leiria, Portugal, 7–9 July 2011.
11. Qaisar, S. M., & Alyamani, N. (2022). A Review of Charging Schemes and Machine Learning Techniques for Intelligent Management of Electric Vehicles in Smart Grid. Management of Smart Cities, 51–71.
12. Axelsson, K., & Granath, M. (2018). Stakeholders' stake and relation to smartness in smart city development: Insights from a Swedish city planning project. Government Information Quarterly, 35, 693–702.

13. Shokravi, H., Shokravi, H., Bakhary, N., Heidar Rezaei, M., Koloor, S. S. R., & Petru, M. (2020). Vehicle-assisted techniques for health monitoring of bridges. Sensors (Basel), 20. (Under review).
14. Shokravi, H., Shokravi, H., Bakhary, N., Koloor, S. S. R., & Petru, M. (2020). Application of the Subspace-based Methods in Health Monitoring of the Civil Structures: A Systematic Review and Meta-analysis. Applied Science, 10, 3607.
15. Sotheany, N., & Nuthong, C. (2017). Vehicle classification using neural network. In Proceedings of the 2017 14th International Conference Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology (ECTI-CON), Phuket, Thailand, 27–30 June 2017; IEEE: Piscataway, NJ, USA, pp. 443–446.
16. Siddiqui, N., & Husain, M. S. (2016). CTS: A credit based threshold system to minimize the dissemination of faulty data in vehicular adhoc networks. International Journal of Control Theory and Applications, 9, 8499–8508.
17. Kim, C.-W., Chang, K.-C., McGetrick, P. J., Inoue, S., & Hasegawa, S. (2017). Utilizing moving vehicles as sensors for bridge condition screening-A laboratory verification. Sensors and Materials, 29, 153–163.
18. Velazquez-Pupo, R., Sierra-Romero, A., Torres-Roman, D., Shkvarko, Y. V., Santiago-Paz, J., Gómez-Gutiérrez, D., ... Romero-Delgado, M. (2018). Vehicle detection with occlusion handling, tracking, and OC-SVM classification: A high-performance vision-based system. Sensors (Switzerland), 18, 374.
19. Ji, Q., Jin, B., Cui, Y., & Zhang, F. (2017). Using Mobile Signaling Data to Classify Vehicles on Highways in Real Time. State Key Laboratory of Computer Sciences, Institute of Software, Chinese Academy of Sciences, Beijing, China; University of Chinese Academy of Sciences, Beijing, China; Institute of Electrical and Electronics Engineers Inc., Piscataway, NJ, USA, pp. 174–179.
20. Sain, C., Banerjee, A., Biswas, P. K., & Padmanaban, S. (2020). A state-of-the-art review on solar-powered energy-efficient PMSM drive smart electric vehicle for sustainable development. In Advances in Greener Energy Technologies (pp. 231–258). Springer: Singapore.
21. Nisha, K. S., Gaonkar, D. N., & Jayalakshmi, N. S. (2023). Operation and control of multiple electric vehicle load profiles in bipolar microgrid with photovoltaic and battery energy systems. Journal of Energy Storage, 57, 106261.
22. Mohammed, S. S., Titus, F., Thanikanti, S. B., Sulaiman, S. M., Deb, S., & Kumar, N. M. (2022). Charge Scheduling Optimization of Plug-In Electric Vehicle in a PV Powered Grid-Connected Charging Station Based on Day-Ahead Solar Energy Forecasting in Australia. Sustainability, 14, 3498.