Embedded System

Autonomous Car

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Description

An autonomous car system is a technological solution that enables a vehicle to drive itself without human intervention. It uses a combination of sensors, software, and hardware to perceive its environment, make decisions, and control the vehicle's movement. The system can detect road signs, traffic lights, other vehicles, pedestrians, and obstacles, and respond appropriately to avoid collisions and navigate to the destination. Autonomous car systems can improve safety, reduce traffic congestion, and increase accessibility to transportation for people who cannot drive. However, the development and deployment of autonomous car systems also raise concerns about cybersecurity, legal and regulatory frameworks, and societal impacts that need to be addressed.

Functional requirements

Here are some functional requirements for an autonomous car system:

Navigation: The system should be able to navigate the car from one location to another using a predefined destination and route.

Obstacle Detection and Avoidance: The system should be able to detect obstacles in the car's path using sensors such as cameras, lidar, radar, and ultrasonic sensors. The system should then make decisions to avoid the obstacle by either slowing down, stopping, or changing direction.

Lane Detection and Keeping: The system should be able to detect the lanes on the road and keep the car within the lanes using cameras and image processing algorithms.

Traffic Sign Recognition: The system should be able to detect and interpret traffic signs, such as stop signs, yield signs, and speed limit signs.

Pedestrian Detection: The system should be able to detect and track pedestrians, cyclists, and other objects on or near the road.

Emergency Braking: The system should be able to detect and respond to emergency situations, such as sudden stops or obstacles in the car's path, by activating the car's emergency braking system.

Communication: The system should be able to communicate with other cars on the road and with the surrounding infrastructure, such as traffic lights and road signs.

User Interface: The system should have a user-friendly interface to allow users to input destinations, adjust settings, and monitor the car's performance.

Redundancy: The system should have redundant systems and backup plans in case of system failures or malfunctions.

Safety: The system should prioritise safety and ensure that the car and its passengers are protected at all times.

System requirements

The system requirements for an automated car can vary depending on the level of automation and the specific features that are included. However, here are some general requirements that an automated car would need:

1. Sensors: An automated car would need a variety of sensors to detect its surroundings, including cameras, radar, lidar, and ultrasonic sensors. These sensors would need to be able to detect objects in all directions and at varying distances.

2. Processing power: The car's onboard computer would need to be powerful enough to process the data from the sensors in real-time and make decisions about how to navigate the environment.

3. Mapping and localization: The car would need to have access to detailed maps of the environment and be able to accurately determine its location within those maps.

4. Communication: The car would need to be able to communicate with other vehicles and infrastructure, such as traffic lights and road signs, to coordinate its movements and avoid collisions.

5. Actuators: The car would need a variety of actuators, such as motors and brakes, to control its movements and respond to changing conditions.

6. Redundancy: To ensure safety, an automated car would need redundant systems for critical functions, such as braking and steering, in case of a failure.

7. Cybersecurity: An automated car would need to be designed with strong cybersecurity measures to prevent hacking and ensure the safety of its passengers.

8. Regulatory compliance: The car would need to comply with all relevant regulations and standards for automated vehicles, including those related to safety, emissions, and data privacy.

Real-Time requirement

Real-time requirements are of utmost importance for automated cars, as these vehicles rely on the ability to process data from sensors and make decisions in real-time to ensure safe and efficient operation. Without meeting these requirements, automated cars would not be able to respond quickly enough to changes in the environment, potentially leading to accidents and other safety issues.

Therefore, it is essential to establish detailed real-time requirements for automated cars to ensure that they can operate effectively and safely. Here are some of the most critical real-time requirements that must be met for automated cars to function properly and provide the benefits that they promise:

1. Response time: The system must be able to respond to changes in the environment within a very short time frame, typically measured in milliseconds. This includes detecting and responding to obstacles, changes in traffic patterns, and other unexpected events.

2. Predictability: The system must be predictable in its behaviour, meaning that it should respond consistently to similar situations. This is important for ensuring that the car behaves in a safe and predictable manner, which is essential for building trust in the technology.

3. Determinism: The system must be deterministic, meaning that it should always produce the same output for a given input. This is important for ensuring that the car behaves predictably and reliably, which is essential for safety.

4. Scheduling: The system must be able to schedule tasks and allocate resources in real-time to ensure that critical tasks are completed on time. This includes tasks such as processing sensor data, making decisions, and controlling the car's movements.

5. Fault tolerance: The system must be fault-tolerant, meaning that it should be able to continue operating even in the event of a failure or error. This is important for ensuring that the car can continue to operate safely even if a component fails.

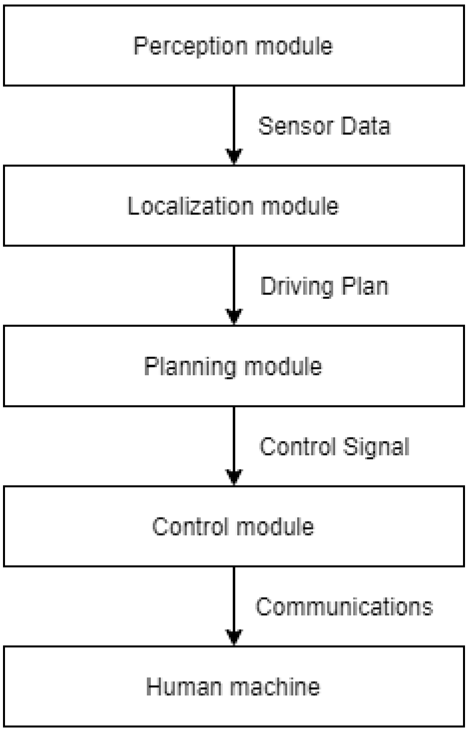
6. Redundancy: The system must have redundant components for critical functions, such as braking and steering, to ensure that the car can continue to operate safely in the event of a failure.

7. Performance: The system must be able to perform its tasks within the required time frame, without causing delays or other issues that could impact safety or efficiency.

8. Security: The system must be designed with strong security measures to prevent hacking and ensure the safety of its passengers.

High level model

Here's a high-level model of an autonomous car system:



1. Perception: The perception module is responsible for sensing the environment using various sensors such as cameras, lidars, radars, and ultrasonic sensors. The data from these sensors is processed and analysed to create a real-time 3D map of the surrounding environment.

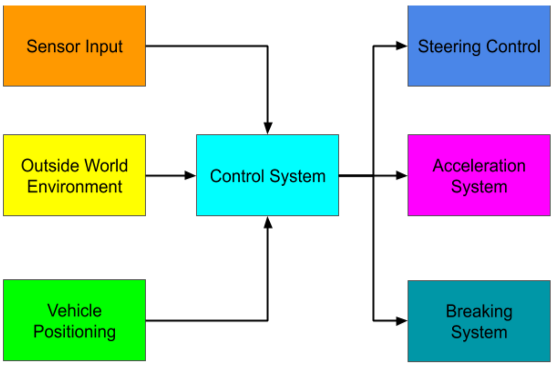
2. Localization: The localization module uses the 3D map created by the perception module to determine the vehicle's precise location and orientation relative to the surrounding environment.

3. Planning: The planning module uses the localization and perception data to generate a driving plan that can safely and efficiently navigate to the destination. The plan takes into account factors such as traffic, road conditions, and the vehicle's capabilities.

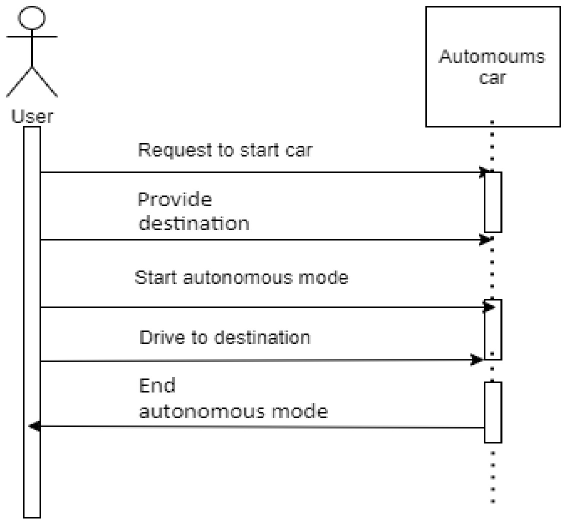
4. Control: The control module executes the driving plan generated by the planning module, controlling the vehicle's acceleration, braking, and steering to ensure safe and efficient driving.

5. Human-machine interface: The human-machine interface allows the vehicle to communicate with passengers and other road users. It can provide information about the vehicle's status, destination, and driving behaviour, as well as receive input from passengers and other road users.

1.Block Diagram



2. Sequence Diagram



Operating system

Hardware and communication

The chosen hardware platform for the system is the Arduino Uno microcontroller. The cost of the Arduino Uno board is affordable, making it a popular choice for prototyping projects. The specific microcontroller to be used is the microchip ATmega328P, which is the main component of the Arduino Uno board. The memory required for the system includes 32KB of flash memory for storing the program code, 2KB of SRAM for temporary data storage, and 1KB of EEPROM for non-volatile data storage. The Arduino Uno provides a variety of input and output ports, including digital and analog I/O pins, which can be utilised to connect and control various sensors, actuators, and peripherals in the system. Additionally, the Arduino Uno supports serial communication, enabling interaction with external devices through UART.

Pseudo code for Obstacle detection and avoidance

Step 1: Read data from obstacle detection sensors

Step 2: Determine if an obstacle is present

Step 3: Determine the type of obstacle

Step 4: Determine the best course of action based on the obstacle type

Step 5: Continue driving if no obstacle is present