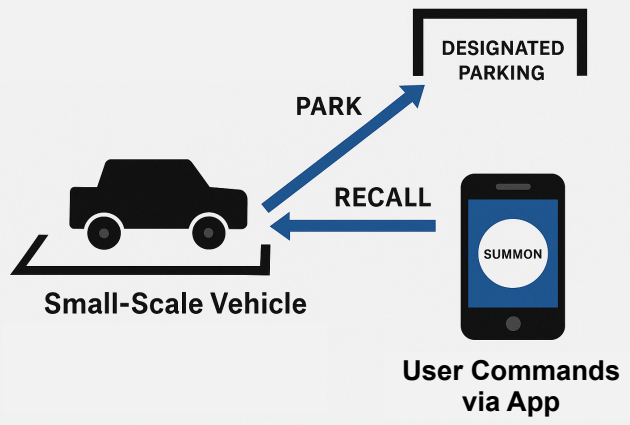
Intelligent Parking and Vehicle Recall System



Automated parking and vehicle summon systems represent an important class of advanced driver assistance technologies in the contemporary automotive industry. The aim of this project is to understand and implement the basics of an intelligent vehicle parking and recall system. Students are expected to design and build a small-scale vehicle prototype, including chassis, steering, and drive systems, capable of maneuvering within a compact testbed.

The design must have the following features:

- The system must detect obstacles, boundaries, and parking spaces within the environment in order to manage vehicle control and actuation in real time.
- The vehicle must autonomously park itself into a designated space on the board without human intervention.
- The system must support a “summon” feature, enabling the vehicle to return to a user-defined position on the board upon command.
- The system must achieve trajectory generation, parking maneuvers, and safe navigation, ensuring smooth and collision-free operation.
- A mobile application must be developed to allow users to issue commands (e.g., start parking, summon vehicle) and monitor system status via Bluetooth or Wi-Fi.

The system must respect the following performance criteria:

- The vehicle must function reliably within a **2m × 2m testbed**, with all sensing and control tuned for this bounded environment.
- The vehicle must operate at **low, safe speeds** (e.g., <0.5 m/s) to allow accurate control and safe interaction during testing.
- The system must achieve **final parking position accuracy within ±5 cm** of the designated spot.
- The system is required to detect and avoid **static obstacles at least 5 cm in diameter/height** placed within the testbed.
- The test environment will be **indoors with stable lighting** and a flat surface.
- The vehicle must be powered by an **onboard battery** that supports at least **15 minutes of continuous operation** per test session.
- Once a command is issued via the mobile app, **all vehicle actions must be autonomous**, without manual intervention.

- The vehicle should be **compact (<30 cm length)** to allow realistic maneuvering within the scaled environment.
- Wireless control (Bluetooth/Wi-Fi) must operate reliably within a **minimum range of 3 meters** from the testbed.
- The system must include a **manual emergency stop function** (via hardware button or app) to immediately halt vehicle operation.

Some possible extra features of the system are the following:

- Use camera and computer vision tools to identify free parking spaces instead of relying on predefined slots.
- Extend the system to detect and safely navigate around **moving obstacles** (e.g., another toy car or pedestrian mock-up).
- Implement communication protocols to allow **multiple vehicles** to share the same board without collisions.
- Integrate intelligent algorithms to minimize travel time or optimize parking maneuvers.
- Integrate a **large language model (LLM)** to enhance decision-making in perception or path planning, e.g., by analyzing sensor data streams to predict optimal maneuvers.
- Provide an advanced app with real-time visualization of the vehicle's path, sensor data, or a virtual joystick for semi-autonomous control.