Team A1
AutoChargeX

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Use Case – Introduction

Problems

- Wired charging is cumbersome and requires users to stay close to a power source.
- Wireless charging often fails if the device is not perfectly aligned with the charging pad.
- Existing chargers are limited to charging one device at a time, causing inefficiency in multi-device environments.

Our Solution

Build a **smart charging table** that automatically detects and aligns with electronic devices such as your iphone, allowing seamless wireless charging for multiple devices without manual intervention.

Use Case – Elaboration

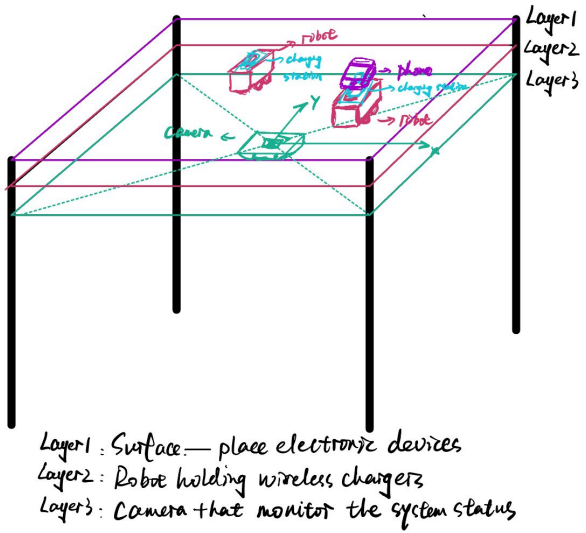
Target Customers:

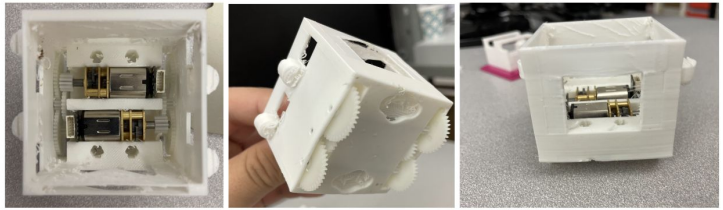
Home Users – The smart charging table is ideal for households, allowing family members to conveniently charge their devices without needing to search for cables or perfectly align their phones on charging pads.

Other possible application environments: **public/school libraries, office desks, lounges, etc**

ECE areas:

Embedded Systems, Power Electronics, Software and Sens
CV, Control System, Signal Processing, Robotics





Sample Robot

User-Case Requirements

Device Detection

1. The system should detect devices within a 1 cm error margin across the entire surface area
2. Detection should occur within 1 second of a device being placed on the table.

Charging Initiation

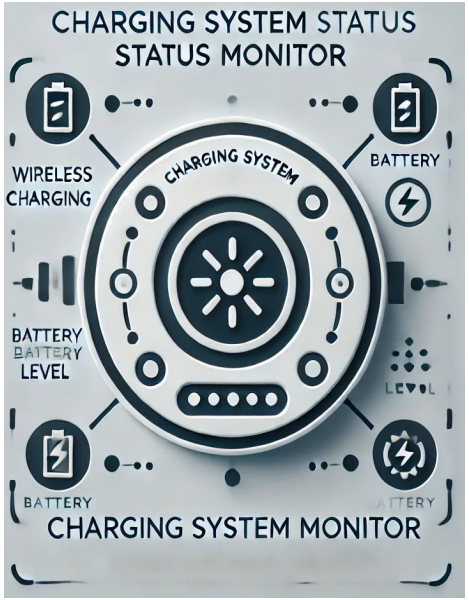
1. Charging should begin within 2 seconds of alignment being achieved.
2. The system should support Qi-certified wireless charging, providing up to 15W of power.

Alignment and Movement

1. The charging pad must move to the detected device position within 10 seconds.
2. The charging pad is aligned within 2 cm of the device's wireless charging coil.

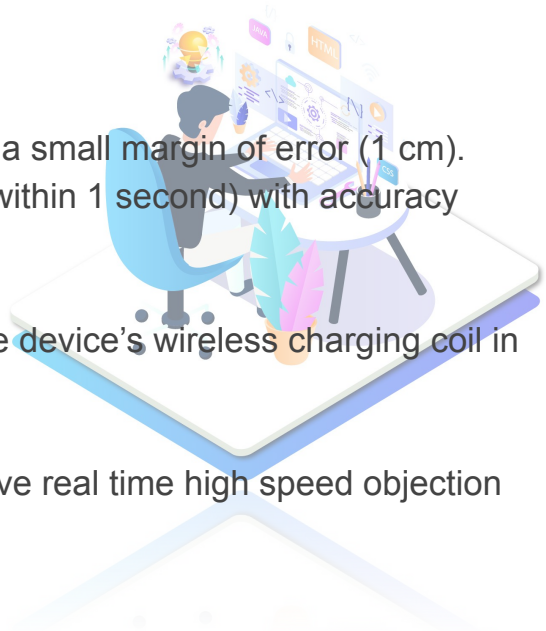
Safety Considerations

1. The system automatically stop charging if the device's temperature exceeds 45°C.
2. The system detect objects obstructing the charging pad and halt movement to avoid damage.

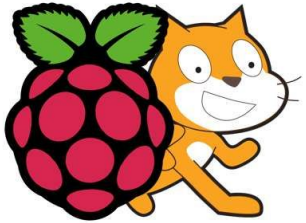


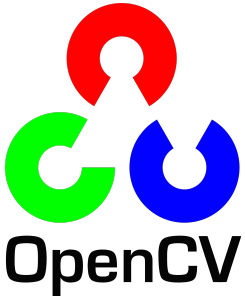
Technical Challenges

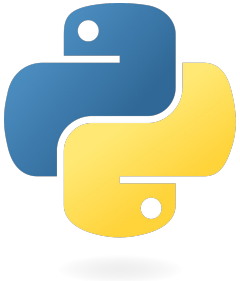
- **Device Detection Accuracy**
  - Achieving accurate device detection across a large surface with a small margin of error (1 cm).
  - The sensors need to sense the presence of the device quickly (within 1 second) with accuracy above 98%.
- **Positioning and Alignment**
  - The charging pad needs to move accurately to within 2 cm of the device’s wireless charging coil in under 10 seconds.
- **Communication**
  - Maintaining fast communication between different parts to achieve real time high speed objection detection and control signal transmission.



Solution Approach

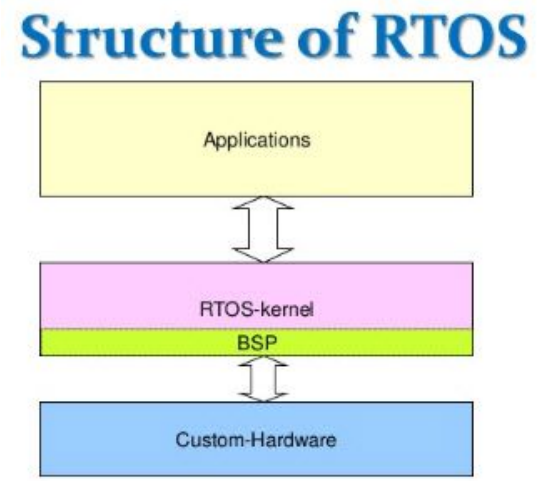






Hardware

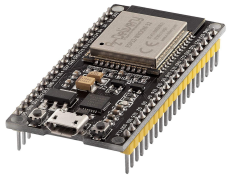
- **Sensors**: Camera (for vision-based object detection), proximity sensors (for precise location).
- **Charging pad**: robot with encoders and linear motors for precise movement and charging.
- **Processor**: Raspberry Pi for control and image processing.
- **Wireless Charging Module**: Qi-certified charger for universal compatibility.



Software

- **Image Processing**: OpenCV for device detection.
- **Control Algorithms**: Motor control and trajectory planning for movement accuracy.
- **Sensor Fusion**: Combining sensor data for reliable detection and positioning.
- **Communication**: Real-time OS (RTOS), I2C or SPI for fast, low-latency data transmission between components.
- **App**: customized app for charging notifications and convenient user interface

Solution Approach



Layer - Robots with Charging Pad

- linear motors and encoders for precise movement across the table.
- Motor control algorithms for trajectory planning and precise movement.
- I2C or SPI protocols and RTOS to enable low-latency communication between the robot’s sensors and the central control system.

Layer - Object Detection

- Cameras and proximity sensors to scan the table surface and detect the presence of chargeable devices.
- OpenCV for real-time object detection and device recognition.
- Data from the camera and sensors are transmitted to the Raspberry Pi via I2C or SPI protocols.

Key Technical Challenges Addressed

Device Detection Accuracy

- Dual-layer detection using computer vision and proximity sensors to ensure quick, accurate detection within 500 milliseconds.

Positioning and Alignment

- robots with feedback from encoders and linear motor to move within 2 cm accuracy in under 10 seconds.

Communication

- RTOS, I2C or SPI for managing fast data flow between sensors, motors, and control unit.

Preliminary Testing & Validation

1. When the device is place onto the table, CV system should detect the device in 1 second, with correctness > 98%

2. CV system should return a coordinate position of the device with L2 precision < 1cm

3. The underdesk robot could move to the desire device location within 10 second

4. The underdesk robot should move to the desire position with L2 prevision < 2cm

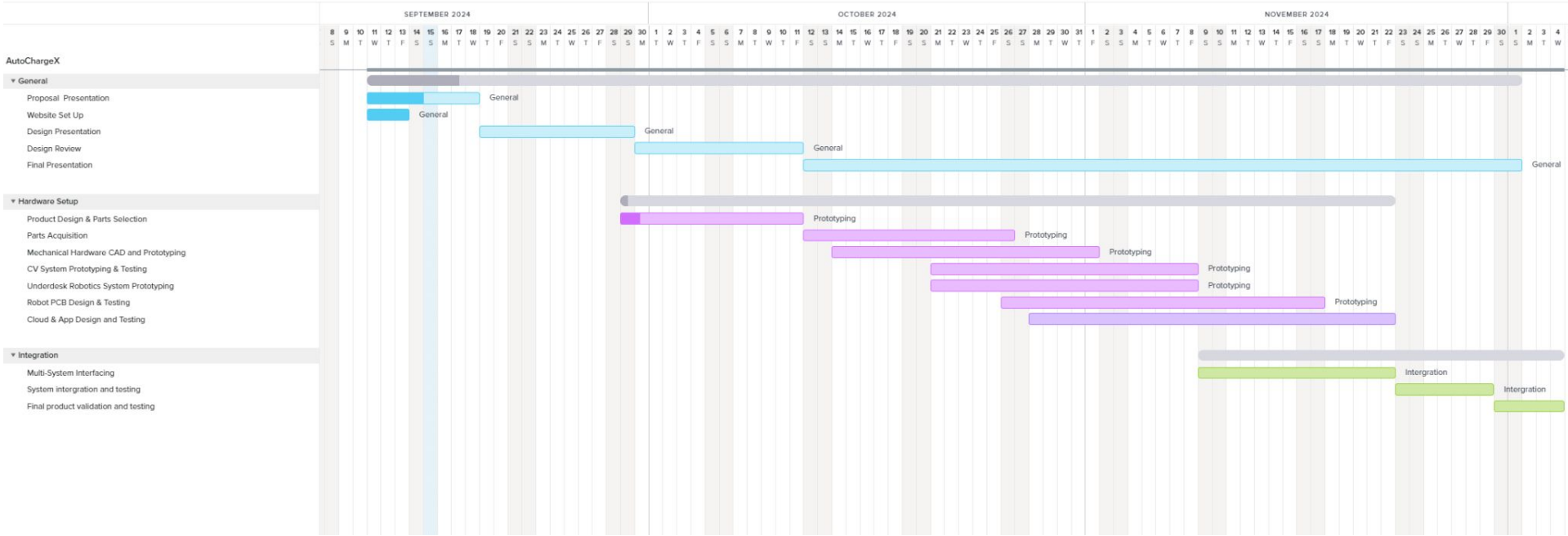
5. Charging testing with different devices

6. Edge-case testing with device in any location on the designed charging surface

Tasks and Division of Labor

Name	Steven Zhang	Yikang Cheng	Bohan Huang
Expertise	CAD, Embedded System, Robotics	Computer Vision, App Design, Cloud Deploy	Robotics, Control, Embedded System
Tasks in charge	General Team Leader, Mechanical Design Leader	Computer Vision & Cloud Server Division Leader	Robotics System & PCB Division Leader

Schedule


SEPTEMBER 2024
OCTOBER 2024
NOVEMBER 2024
AutoChargeX
General
Proposal Presentation
Website Set Up
Design Presentation
Design Review
Final Presentation
Hardware Setup
Product Design & Parts Selection
Parts Acquisition
Mechanical Hardware CAD and Prototyping
CV System Prototyping & Testing
Underdesk Robotics System Prototyping
Robot PCB Design & Testing
Cloud & App Design and Testing
Integration
Multi-System Interfacing
System intergration and testing
Final product validation and testing
General
Prototyping
Intergration

Minimum Viable Product

1. Three-layered table system: The surface of the table (transparent), the robot operation platform (transparent), the camera hub
2. Wireless Charging Module: Abasic Qi-certified wireless charging system capable of providing up to 15W for compatible devices.
3. Automated Device Alignment: Utilize dual sensors to detect the device's position on the table and move the charging pad to align within a 3 cm accuracy margin.
4. Robot Movement: Robot navigate to the device and place the charging pad directly beneath the detected device for alignment within 15 seconds.
5. Feedback Control Software: A software the monitor the status of the whole system, allowing testers to view and edit parameters.