Project Proposal

Project Name:Item Retrieval Robotics Assistant

Team Members:

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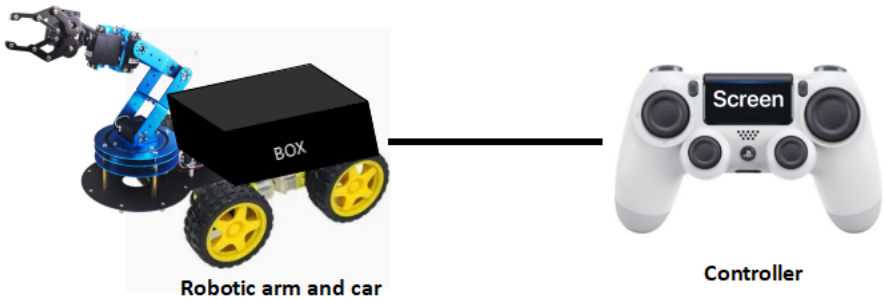
Introduction

- **Problem**
  When someone with a leg injury or mobility issues needs to retrieve items from another room at home, it can be quite inconvenient. Without assistance from others, they often need to rely on crutches or wheelchairs to reach the location of the item and pick it up, then return. While this may seem like a simple task, for those with limited mobility it can be very exhausting and inconvenient. Therefore, having a device that can help these individuals retrieve and deliver items they need would make their lives much easier.

- **Solution**
  Our project is a remote-controlled car equipped with a robotic arm, designed to enable people to retrieve objects without the need to move. Users can operate the movement of the car and the robotic arm using joysticks on the controller. The remote controller features a screen that displays the camera feed from the robotic arm, allowing users to see the car's surroundings and select items they want to pick up. After the robotic arm picks up an item, it will flip backwards and put the item into the box on the car. In addition, for items stored at heights, users can utilize the telescopic function of the robotic arm to reach the item. Moreover, by rotating the gripper of the robotic arm, users can open cabinets and drawers to retrieve items inside.

- **Visual Aid**



Robotic arm and car

Controller

- **High-level requirements list**

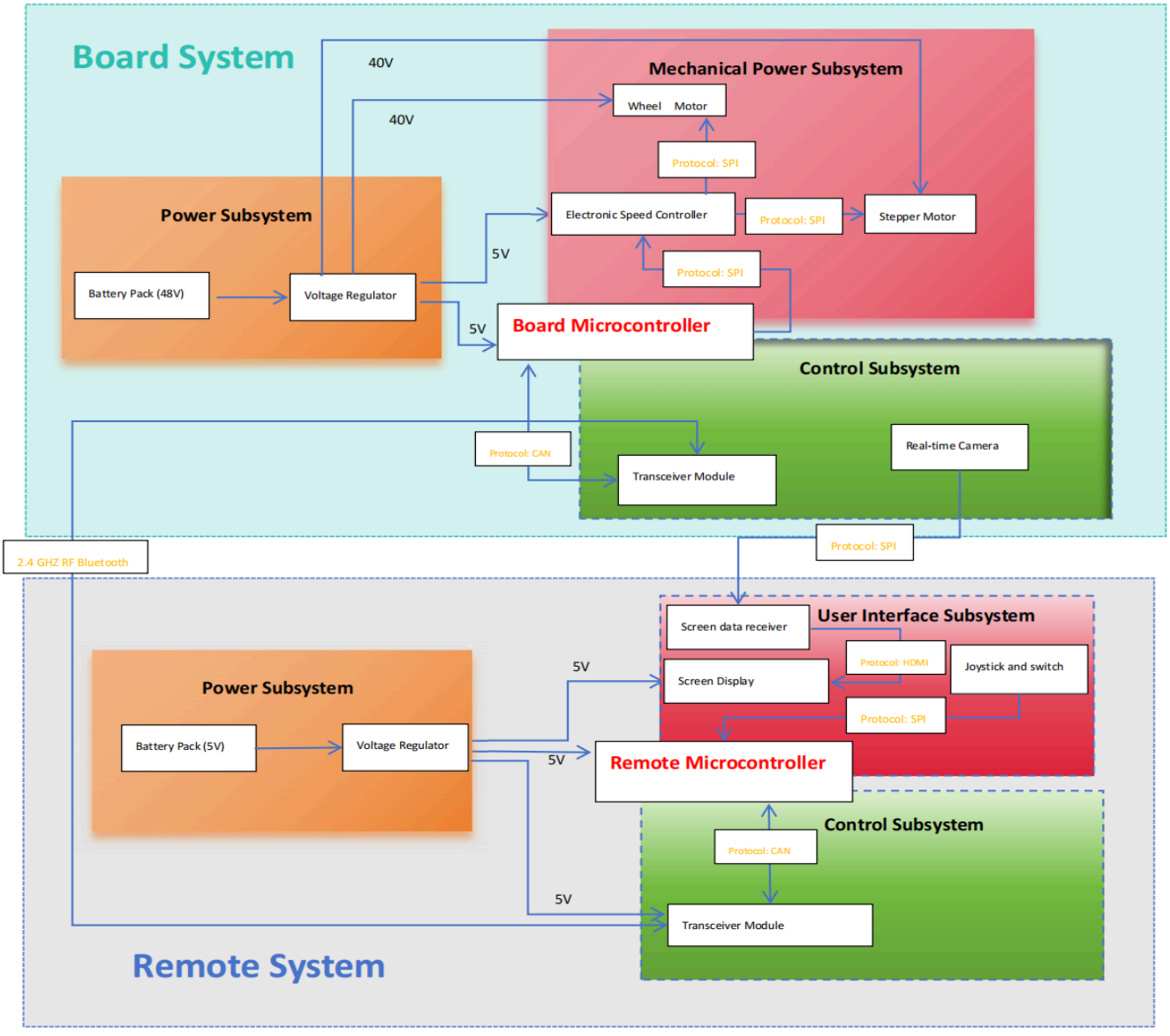
➢ **The robotic arm must be able to successfully pick up and place items such as bottles, books, or small tools, weighing up to 2 kilograms into the box on the car.The arm must maintain stability and precision during the pickup, ensuring no damage to items or pick up failure during the task.**

➢ **The telescopic function of the robotic arm should be able to extend to a minimum of 1.2m and successfully retrieve items placed at elevated heights.The extension must ensure to securely lift objects without losing grip or stability at full extension.**

➢ **The gripper must be capable of rotating at least 90 degrees and successfully open cabinets or drawers, while the car provides enough traction and stability to pull them open, allowing access to stored items.**

Design

- **Block Diagram**



- **Subsystem Overview**
  There are two systems in the block diagram: Board System and Remote System, and each system is separated into three subsystems. The Board System is used to control all functions in the car with a robotic arm, and the Remote System is used to control all functions in the remote controller. The Power subsystem in the Board System provides energy for both mechanical subsystem and electronic subsystem. Mechanical Power Subsystem could receive the signals from the board MCU to give instructions to car wheels and the robotic arm. Also, The Control Subsystem in the Board System can transmit signals to and receive signals from the Remote controller, and these signals will be the input into the Board MCU to decide the step. In the Remote System, Power subsystem offers energy to support User Interface Subsystem and Control Subsystem. By the User Interface Subsystem, the car with a robotic arm could interface with the user; for example, the user could watch the screen to view the environment around the car by real-time camera arranged on the car, and the user can use a joystick and switch to control the car with a robotic arm. For the Control Subsystem in Remote System, it serves as the function of receiving signals which are about instructions for the car with a robotic arm from the Remote MCU and transmitting these signals to the Board System.

- **Subsystem Requirements**
  In the Board System, there are three subsystems: Power subsystem, Mechanical Power subsystem and Control subsystem. In the Board Power subsystem, the battery pack could provide 48 V electricity with 500 A current, and the voltage regulator regulates the electricity and separates it into 40 V electricity which offers power support to Mechanical Power subsystem and 5 V electricity which offers power support to the Electronic part in the Board System. In the Board Mechanical Power subsystem, wheel motors would drive the car to move in any direction, and stepper motors will allow the robotic arm to have enough torque to pick arms and place items weighing up to 2 kgs into one box, which will achieve the first high-level requirement. Also, stepper motors will provide support for the telescopic function of the robotic arm in order to make the robotic arm extend to minimum 1.2 meters, which will achieve the second high-level requirement. What's more, the protocol between Electronic Speed controller and motors is SPI to make sure they could communicate with each other successfully. In the Board Control subsystem, the transceiver module transmits signals to and receives signals from the transceiver module in Remote System by the bluetooth with 2.4GHZ. Then, when the transceiver module receives signals of instructions from the remote controller, the transceiver will interact with the Board MCU by Controller Area Network (CAN) which is one communication protocol. Finally, the battery pack must provide 48 V electricity with 500 A current, and the protocol: bluetooth with 2.4GHZ, SPI and CAN need to be set correctly; otherwise, some subsystems in the Board System would fail to function.

In the Remote System, there are three subsystems: Power subsystem, User Interface Subsystem subsystem and Control subsystem. In the User Interface Subsystem, joystick and switch as peripherals interacting with the Remote MCU by SPI are used to control the movement of the car and the rotation of the robotic arm, which can achieve the third high-level requirement to rotate at least 90 degrees and successfully open cabinets or drawers. What's more, the Real-time camera will send image data into the screen data receiver by the protocol SPI, and the screen data receiver could send image data to one LCD through HDMI so the user could view the environment around the car. In the RemotePower subsystem, the battery pack could provide 5 V electricity with 2 A current, and the voltage regulator regulates the electricity to offer power support to the Electronic part and LCD display in the Remote System. In the Remote Control subsystem, when the transceiver module receives signals of instructions through Controller Area Network (CAN) from the Remote MCU, the transceiver module transmits signals of instructions to the transceiver module in the Board System by the bluetooth with 2.4GHZ. Then the Board System will work to make the car with a robotic arm execute instructions. Finally, the battery pack must provide 5 V electricity with 2 A current, and the protocol: bluetooth with 2.4GHZ, SPI and CAN need to be set correctly; otherwise, some subsystems in the Remote System would fail to function.

- **Tolerance Analysis**
  One aspect of your design that poses a risk to successful completion of the project is the image data transmitting from the real-time camera to screen data receiver. When the car with a robotic arm is driven far away from the remote controller, some image data may be lost during the process transmission from the real-time camera to screen data receiver through SPI protocol, which causes the problem of unclear or discontinuous pictures appearing in the video of the LCD.

  Suppose we use a 3.5-inch display with a resolution of 480x320 pixels and the frame rate of 15 fps.
  Data rate = 480 * 320 * 3 bytes/pixel * 15 fps = 69.12 Mbps
  Usually, the SPI data rate is around 10 - 20 Mbps to guarantee stable communication.
  Since 69.12 > 20, we might need to use video compression to reduce the data rate within the SPI's range.

Ethics and Safety

According to IEEE Code of Ethics and ACM Code of Ethics, our project addresses several key ethical principles:

1. **Privacy Protection**
   The device's use of a camera for navigation could violate user privacy. To comply with the ethical principle of IEEE code 1 that protects the privacy of others, the camera feed is directly connected to the screen on the controller which is exclusively used by the user. Since the video feed is not transmitted eternally and the camera doesn't have a video recording function, this can only be viewed by the user which minimizes the risk of unauthorized access or misuse of the camera system.

2. **Public Safety**
   We commit to ensuring that our project "Item Retrieval Robotic Assistant" prioritizes the safety and health of its users. This aligns with the ethical principle of IEEE code 1 that holds paramount the safety, health, and welfare of the public. The robotic arm is controlled directly by the user and will be equipped with force-limiting features to prevent excessive force when handling items. This could reduce the risk of injury to items, furniture and humans.

3. **Respect for Others**
   In the development process, we will ensure that all team members and contributors are treated fairly and respectfully. This aligns with the ethical principle of treating all persons fairly and with respect. Our project ensures that the design is inclusive and accessible to all users, particularly those with disabilities.

4. **Improving Understanding of Emerging Technologies**
   Our project contributes to improving society's understanding of how emerging technologies can enhance the quality of life for individuals with mobility issues. This aligns with the ethical principle of IEEE code 2 which is enhancing individuals' and society's understanding of the potential and societal impacts of both conventional and emerging technologies, including intelligent systems.

5. **Support for Colleagues and Upholding Ethics**
   During the development of our project, we commit to supporting all team members in adhering to the ethical standards, aligning with the principle of IEEE code 10 that assisting colleagues in adhering to this code of ethics, work to ensure its enforcement, and refrain from retaliating against those who report violations.. We will create an open and respectful environment where ethical issues can be resolved without the fear of retaliation.

6. **Honesty and Trustworthy**
   Regarding ACM code 1.3 that a computing professional should be open and fully disclose all relevant system capabilities, limitations, and potential issues to the appropriate stakeholders. Our project team will provide clear documentation on how the device functions, including potential risks or limitations. In addition,

users will be fully informed about the device’s operational boundaries, ensuring they can make the right decisions when using the system