HomeRover

Reach beyond your limits.

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The Existing Infrastructure for Limited Mobility aid is lacking.

Individuals with mobility challenges face:

- Difficulty getting into/out of chairs
- Unsteadiness while walking
- Increased susceptibility to falls
- Exacerbated by picking things up

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Existing solutions for object retrieval:

- Have a limited range
- Expensive
- Only exist in research labs

(HealthInAging.org, Olaya et al.)

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HomeRover

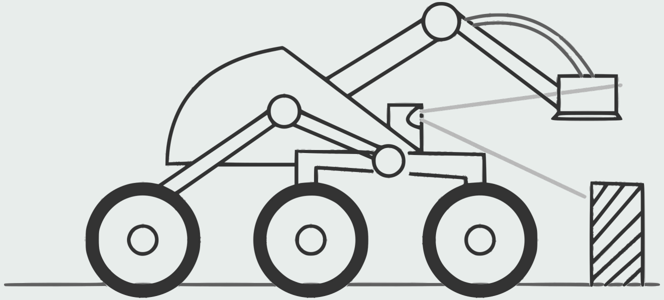
HomeRover aims to address this need.

Mission: Provide a cost-effective, intuitive method of object retrieval for individuals with mobility challenges

HomeRover is a user-assisted autonomous robot that features:

- An **interface** for user navigation of the rover to an object's general vicinity
- **Autonomy** in operating within the vicinity to pick up the object
- Ability to **return** object back to the user

ECE Areas: Software Systems, Circuits



HomeRover

Use Case Requirements

User Control

- Roundtrip transmission to and from Rover <100 milliseconds
- Control center reaction to user input <20 milliseconds
- Raspberry Pi screen displays footage from the rover and simple user interface.
- Contains forward, backward, left, right keys and a pickup button
- Minimum battery life 1 hour

Autonomous Item Detection/Pickup

- Successfully pick up item 80% of the time
- Can detect an item and position for pickup within 30 cm, within 10 seconds.
- Suction capable of lifting > 700 grams
- Can detect and pick up
    - Books
    - Tablets
    - Cell Phones
    - Medication boxes

Use Case Requirements

Rover Hardware

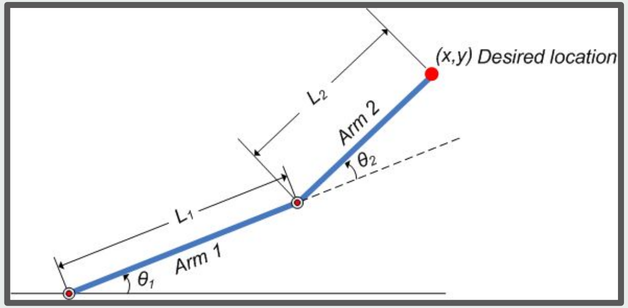
- Communication with motors <20 milliseconds from receiver to motor
- Communication with suction claw <20 milliseconds from receiver to stepper
- Vehicle is capable of driving on carpet, hardwood and tile (with non-mirror finish)
- Cost <$450 for a home market
- Minimum battery life 1 hour

Safety Considerations

- Materials are durable and safe for household use
- System can withstand spills
- Robot must move at safe household speeds <1 m/s

Technical Challenges

- **Ease of Control/User Satisfaction:**
  - Control scheme must be simple and intuitive.
  - Robot must move at at-home speeds.
- **Identification of Object:**
  - Reasonable time scale.
  - Smooth Operation.
  - Distance Threshold Monitoring
  - **Accuracy will be key.**
- **Risk Mitigation**
  - End-Effector Modulation
    - Suction
    - ER Fluid
    - Gate System



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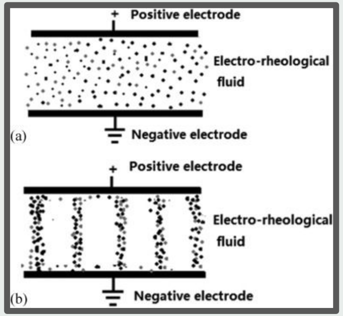

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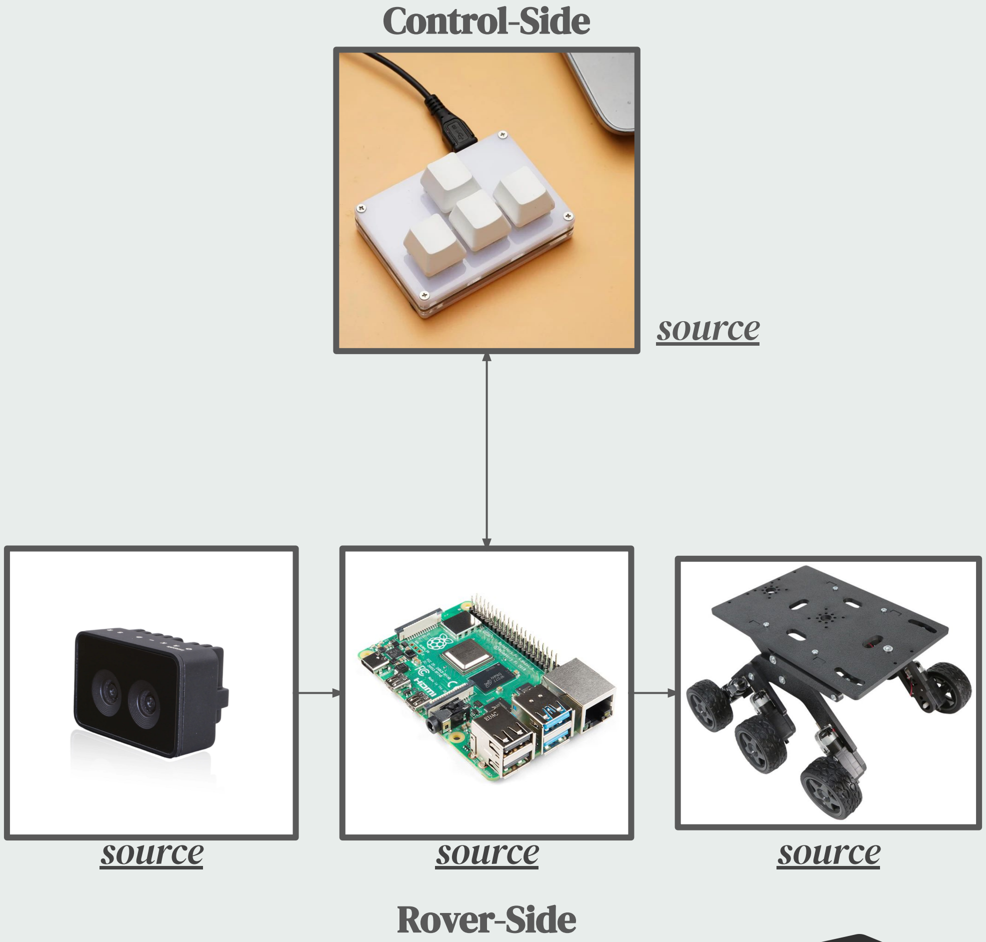
Implementation Scheme

Control-Side:

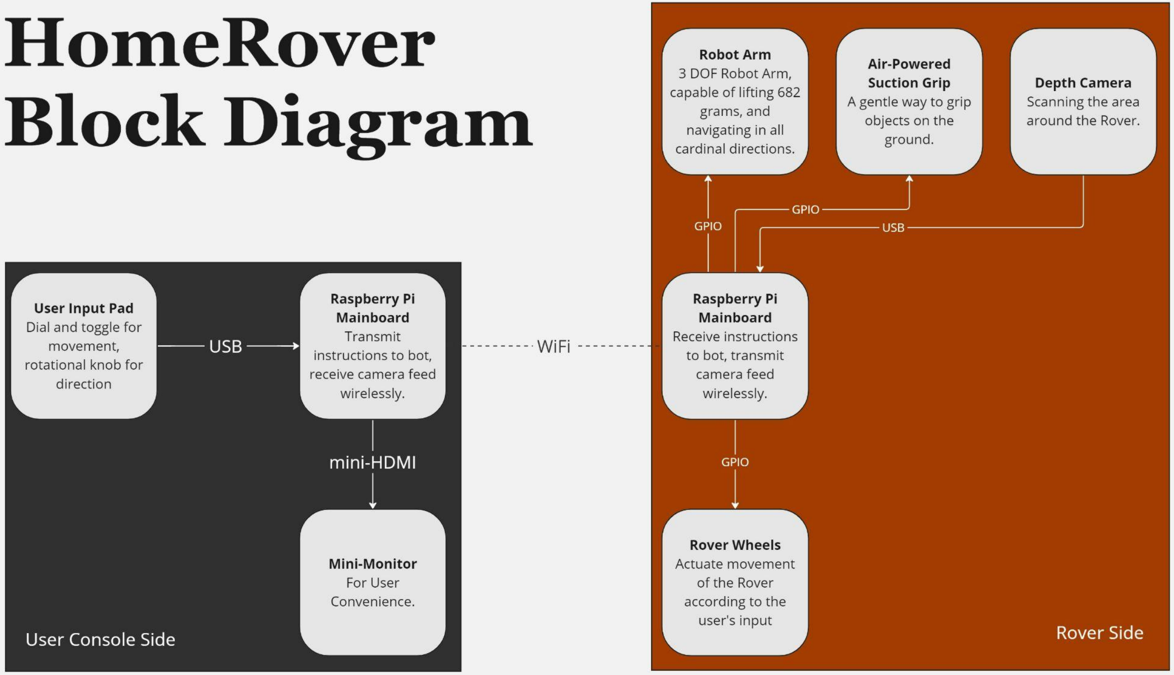
- Simple Interface:
  - Arrows for movement
  - Knob for direction
  - Buttons for object interactions

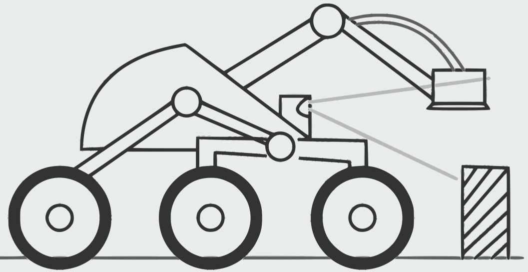
Rover-Side:

- Via Wi-Fi, receives instructions from Control-Side.
- Sensing and Object Detection:
  - OAK-D SR depth camera
  - Minimum distance of 20 cm.
- Actuation:
  - Custom designed Rover with Integrated Robot Arm



HomeRover Block Diagram





Testing, Verification and Metrics

Requirement	**Method**	**Target**
Transmission Latency	Record time of data transmission between the two RPI using simulation time	<100ms
Control Center Latency	Record time between pressing button and response in terminal, using slow motion iPhone camera (240 fps)	<20ms
Pick up weight	Have the suction arm pick up an iPad	>682g
Pick up accuracy	Multiple trials with each of the items listed	≥80%
Item Detection range	Multiple trials with items at different ranges	0.33 meters

Testing, Verification and Metrics cont.

Requirement	**Method**	**Target**
Driving on different flooring	Drive the rover over carpet, tile and hardwood	>0.5m/s and ≥80% success
Cost	Sum all the components	≤$450
Receiver to Motor Latency	Send signals through the RPi and time how long it takes for motor to respond, using slow motion iPhone camera (240 fps)	<20ms
Receiver to suction claw Latency	Send signals through the RPi and time how long it takes for stepper to respond, using slow motion iPhone camera (240 fps)	<20ms
Battery life	Record time between each recharge	>1 hour

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Division of Labor

Hayden:

- **Rover Navigation** - Rover architecture and movement, communication protocol
- **Control Suite architecture** - simple PCB design for keypad.

Varun:

- **Item Retrieval** - Robot arm design, intra-Rover communication protocol
- **Robot Arm architecture** - kinematics design for smooth movement.
- **End Effector Design** - pickup mechanism

Nathan

- **Object Identification** - Camera to Robot arm architecture, intra-Rover communication protocol.
- **User Interface** - Design for Control Suite

Schedule

Varun's Tasks

- Finalize picking-up mechanism
- Design robot arm
- Kinematics Scheme
- Finalize comm protocol Intra-Rover
- Fabricate Rover Chassis 3
- Integration 4
- Improving user experience/slack

Hayden's Tasks

- Design rover (4 wheels, camera mounts, nav capability)
- Design and finalize control booth
- Kinematics Scheme
- Raspberry Pi WiFi communication scheme (Control Booth to Rover and back
- Fabricate Rover Chassis 3
- Integration 4
- Improving user experience/slack

Nathan's Tasks

- Set up programming and connect with RPi
- Experiment with depth camera
- Depth camera able to detect objects
- Mockup User Interface Design for control suite
- Finalize comm protocol intra-Rover (kinematic translation to arm)
- Identify how far objects are on Raspberry Pi, in accordance with intra-Rover
- Setup RPi Display
- Display Live Feed of camera on rover
- Integration