Enhancing Everyday Life with Assistive Robotics

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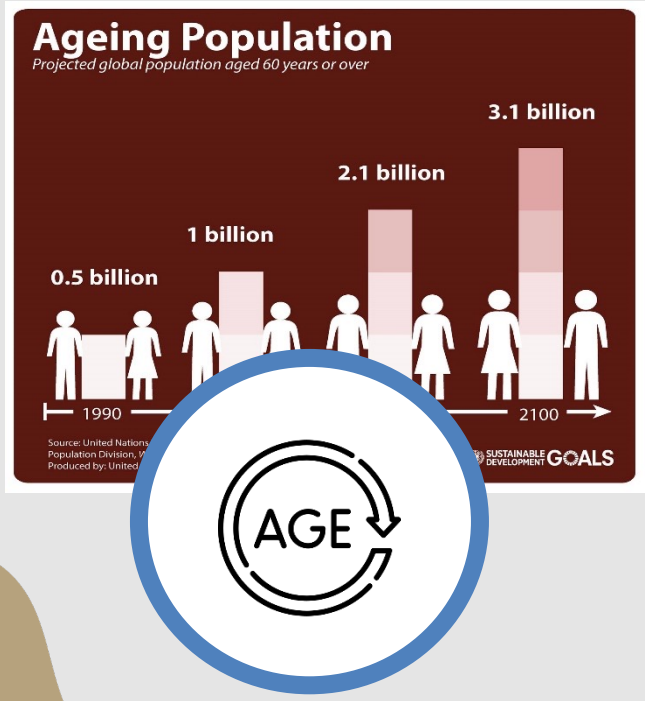
WHY WE NEED ASSISTIVE ROBOT ?



By 2050, over 16% of the global population will be over 65, with higher proportions in developed countries.

•Growing number of young adults require physical, sensory, and learning disability support.
•Demand for healthcare staff is rising, exacerbated by pandemic-related shortages, while existing workers face burnout, underscoring the urgency for sustainable solutions

•Nursing workforce aging compounds increased demand challenge.
•Substantial socio-economic cost of care provision necessitates innovative healthcare service delivery approaches.

Meet Claudia: Empowering Independence Through Robotics

Background:

- Age & Profession: 54, Social Worker
- Living Status: Independent, solo homeowner

Challenges:

- Visual Impairment - Severe glaucoma complicated by diabetes
- Mobility - Reduced mobility due to a recent fall and increased frailty
- Emotional Health - Experiences loneliness, daughter lives abroad

Claudia's Assistive Needs: Enhanced Support

Physical Assistive Task:

- Medication reminder
- Well-being check
- Navigation assistant
- Object Detection
- Object Retrieval

Social Assistive Task:

- Medication Management
- Well-being check
- Exercise reminder and Assistance
- Social Interaction

PART A: Physical Assistive Task

- Medication Managment
- Navigation and Object Detection
- Safety Monitoring and Rapid Response System
- Object Detection and Retrival

Task Scenario:

Morning Routine:

1.Medication Reminder and Assistance:

- **Time:** 8:00 AM
- **Action:** The assistive robot, equipped with a programmed schedule, reminds Claudia to take her morning medication for diabetes and other . It navigates to the medication location, retrieves the correct package, and brings them to Claudia at her breakfast table.
- **Feedback:** Claudia confirms medication intake through a simple voice command or a press of a button on the robot.

2.Well-being Check:

- **Time:** 8:15 AM
- **Action:** Post-medication, the robot initiates a brief well-being check. It asks Claudia questions regarding her sleep quality, pain levels, and general feeling.
- **Feedback:** Claudia responds verbally, and the robot records this information to monitor any significant changes over time, alerting her healthcare provider if necessary.

Task Scenario:

Mid-Morning:

3.Navigation Assistance to Home Office:

- **Time:** 9:00 AM
- **Action:** Claudia decides to move to her home office to start her work. The robot assists by guiding her through the safest path in the house, avoiding obstacles and notifying her of steps or uneven surfaces.
- **Feedback:** The robot provides audio cues and gentle physical guidance using its frame.

4.Object Detection and Retrieval:

- **Time:** 10:30 AM
- **Action:** While working, Claudia needs several items from around her house, including her work files, a notebook, and her phone. She requests these items verbally, and the robot uses its object detection capabilities to locate and retrieve them efficiently.
- **Feedback:** Claudia directs the robot through voice commands, and the robot confirms each action verbally.

Robot Description

Physical Assistive HARE Model

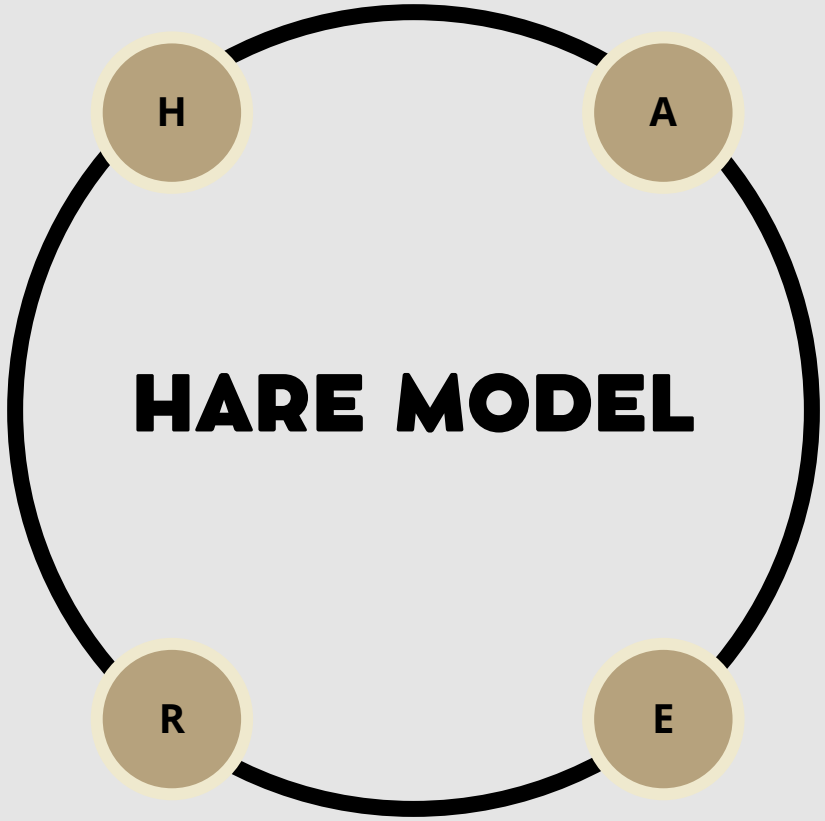
Human

- **Claudia's Needs and Conditions**:

  Health Monitoring: The robot reminds Claudia to take her medications regularly and performs daily well-being checks.
  Emergency Response: Equipped with sensors to medical emergencies, immediately alerting emergency services and Claudia's family.

- **Accessibility and Comfort**:

  Voice and Touch Interaction: Adaptations for her partial sight, including voice command functionality and simplified interfaces with feedback.



Physical Assistive HARE Model

Activity

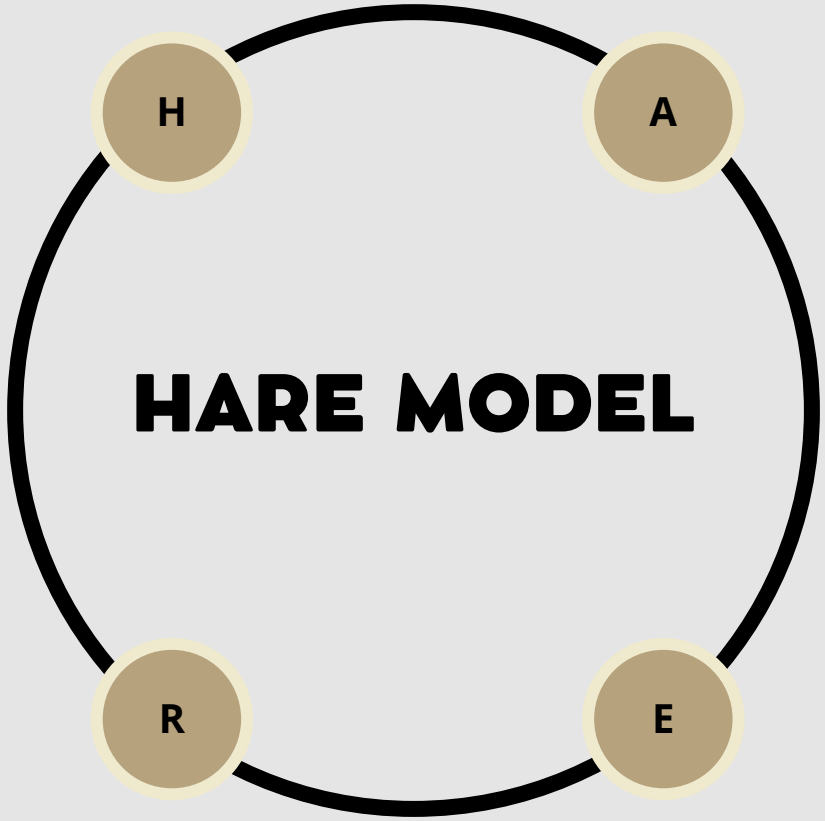
- **Daily Tasks**:

  Object Retrieval: The robot identifies and retrieves daily essentials like keys, remote controls, glasses, and medication using a precision grasping mechanism.

  Navigation Assistance: Guides Claudia safely around her home, providing audio cues to warn of obstacles and aid in free movement.

- **Social Engagement**:

  Connectivity Tools: Helps Claudia stay connected with her daughter and friends through easy-to-use communication apps integrated into the robot's system.

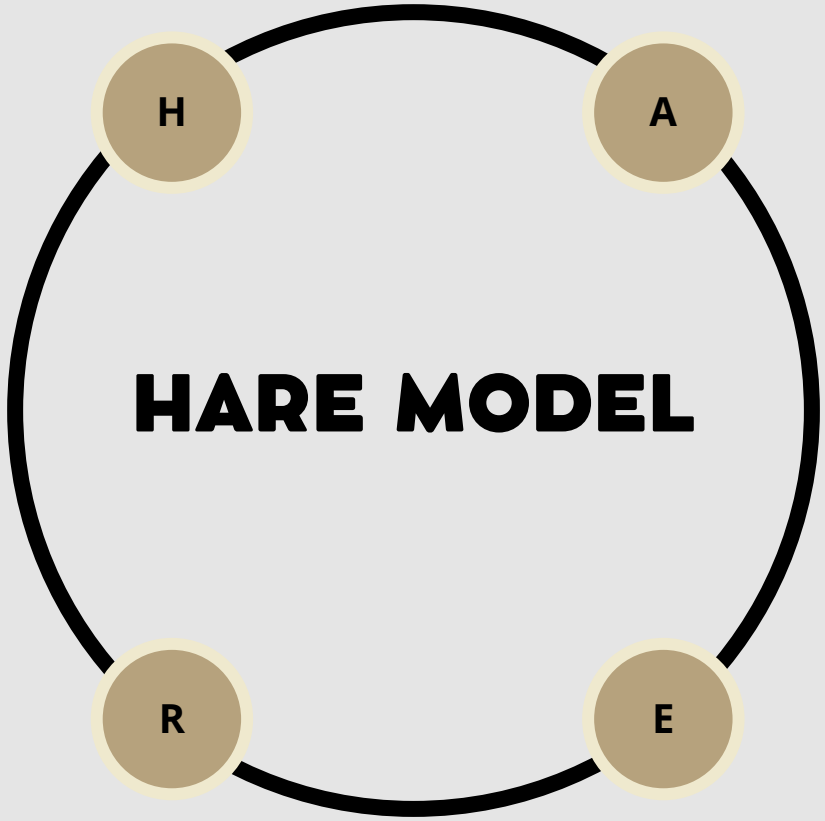


Physical Assistive HARE Model

Robot

- **Specifications and Features**:
  Compact Design: The robot's size and mobility are suited for a one-bedroom flat, ensuring it moves and operates efficiently without taking up much space.
  Advanced Sensory Capabilities: Utilizes an RGBD camera for depth sensing and object recognition, integrated with AI to adapt to Claudia's home environment.

- **Safety and Usability**:
  Preventative Measures: Designed to prevent tipping and falls, maintaining a low center of gravity and retracting its manipulative arms when not in use.
  User-Friendly Interface: Features a straightforward interface on a connected Android tablet that displays the layout of the flat, locations of objects, and robot status.

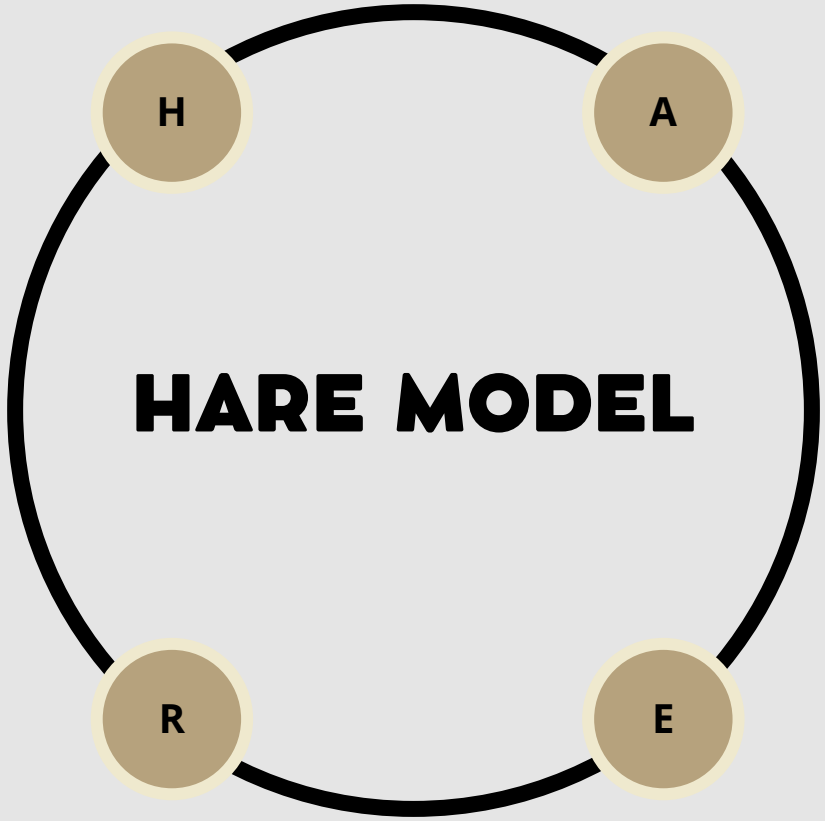


Physical Assistive HARE Model

Environment

- **Home Adaptation**:
  - **Smart Home Integration**: Automated systems control lighting, heating, and electronic devices, adjustable via the robot or Claudia's tablet.
  - **Safety Optimizations**: Ensures pathways are clear of obstacles and that doors and windows are securely locked, enhancing Claudia's security.

- **Personalized Setup**:
  - **Customization**: Settings and routines customized to Claudia's preferences and daily schedule, ensuring the robot acts proactively to assist with tasks.
  - **Onboarding and Support**: Claudia receives comprehensive training on how to interact with the robot and ongoing support, including regular updates and maintenance.



Physical Assistive Room Layout and Recommendation

- Living Room:
  - Rearrange furniture for clear pathways.
  - Add more plug-in lamps for better visibility.

- Kitchen:
  - Move essentials to lower shelves and counters.
  - Place anti-slip mats in front of the sink and stove.

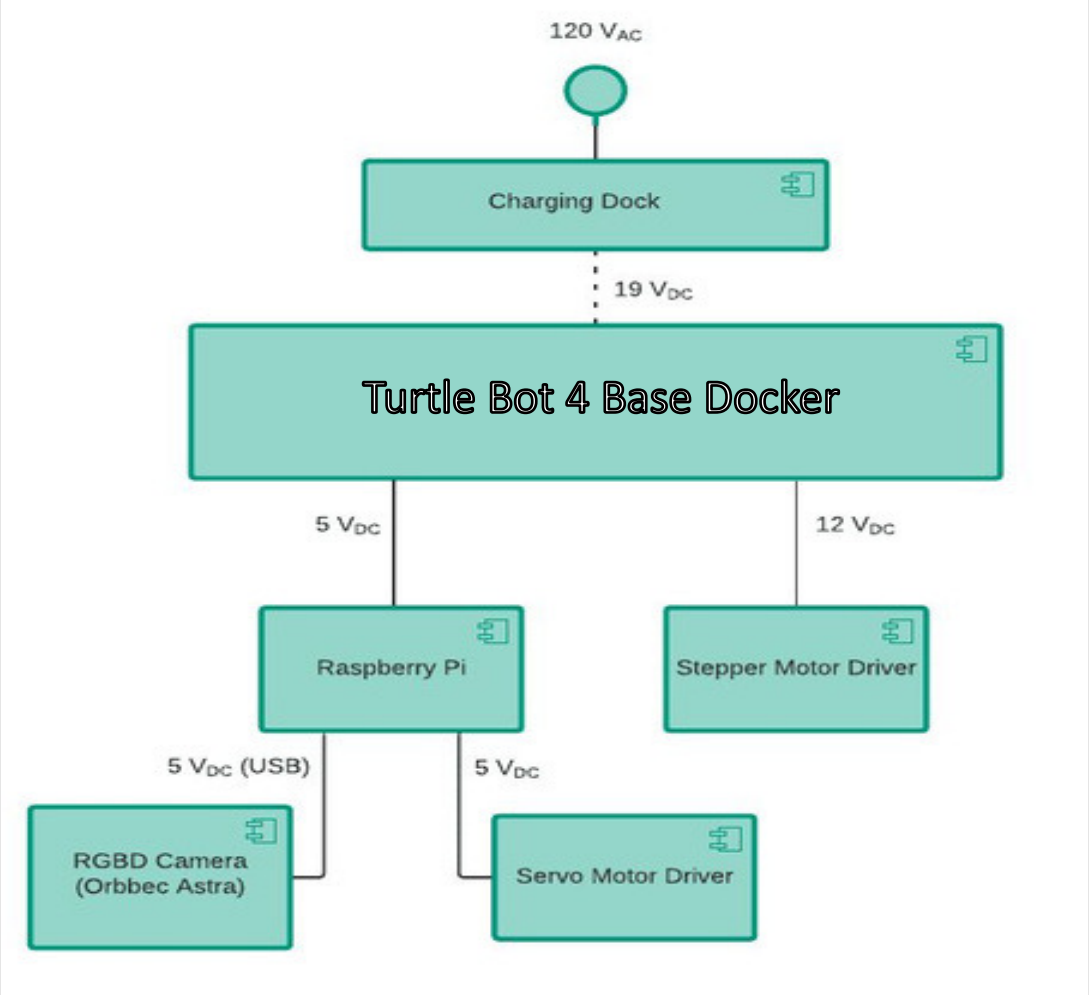
- Bedroom:
  - Ensure bed has accessible space around it.
  - Install plug-in night lights for nighttime navigation.

- Bathroom:
  - Install suction cup grab bars near the toilet and shower.
  - Use a rubber bath mat for slip prevention.

- General Enhancements:
  - Secure loose rugs with double-sided tape.
  - Organize cords away from walkways.
  - Use smart plugs for easy control of appliances and lights.

- Doorways and Hallways:
  - Keep clear of any clutter to maintain easy access throughout.

Physical Assistive Task Scenario



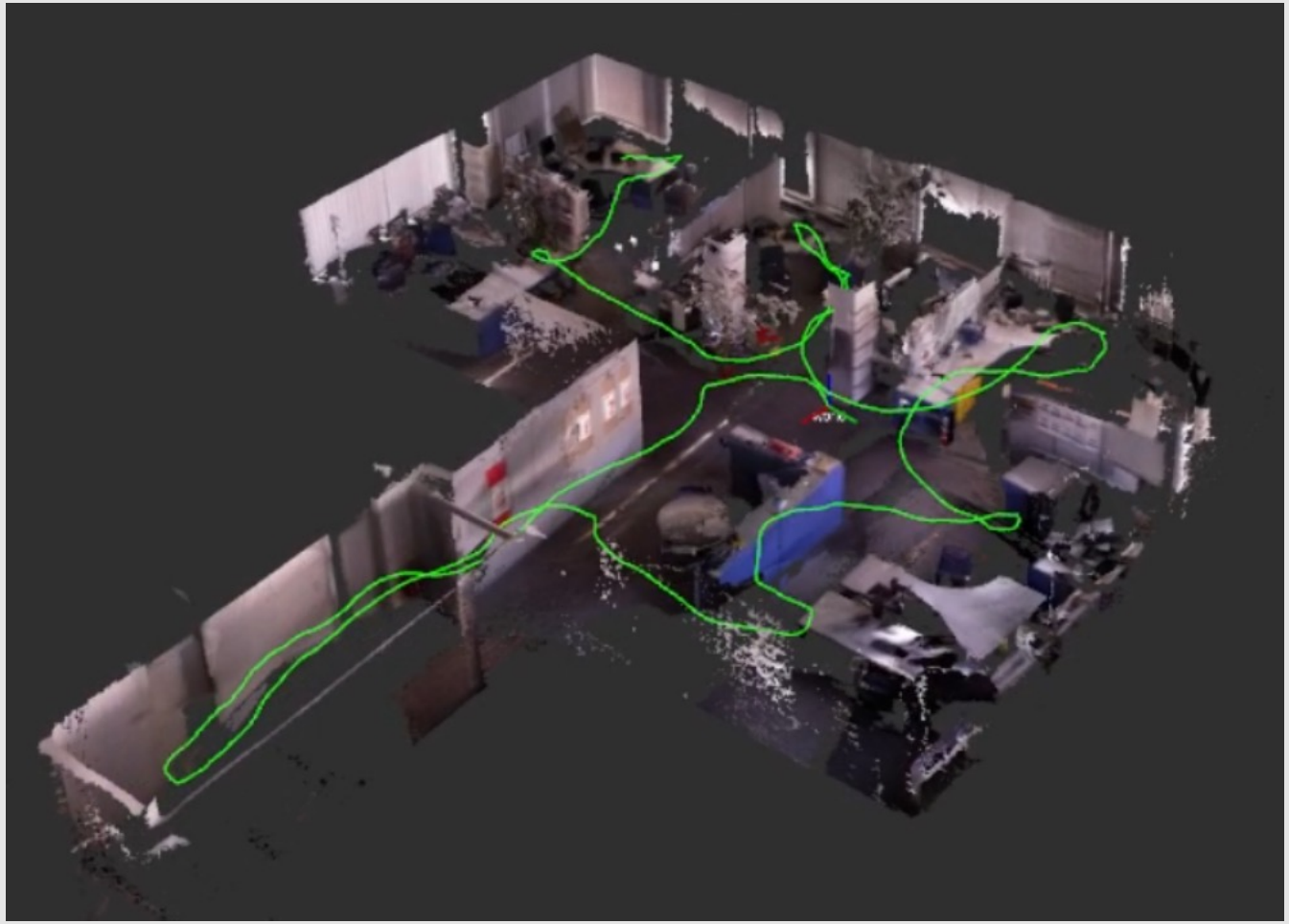
Physical Assistive Task Demonstration

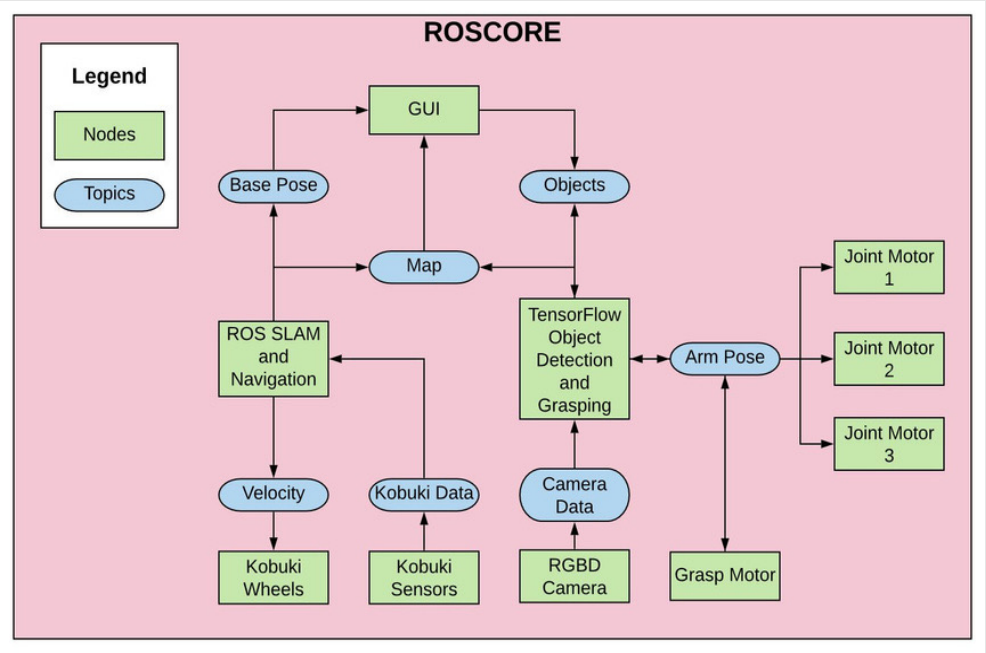
Voice Activated

Greetings and Well Being check

Robot using Slam Capabilities

Robot using Slam Capabilities

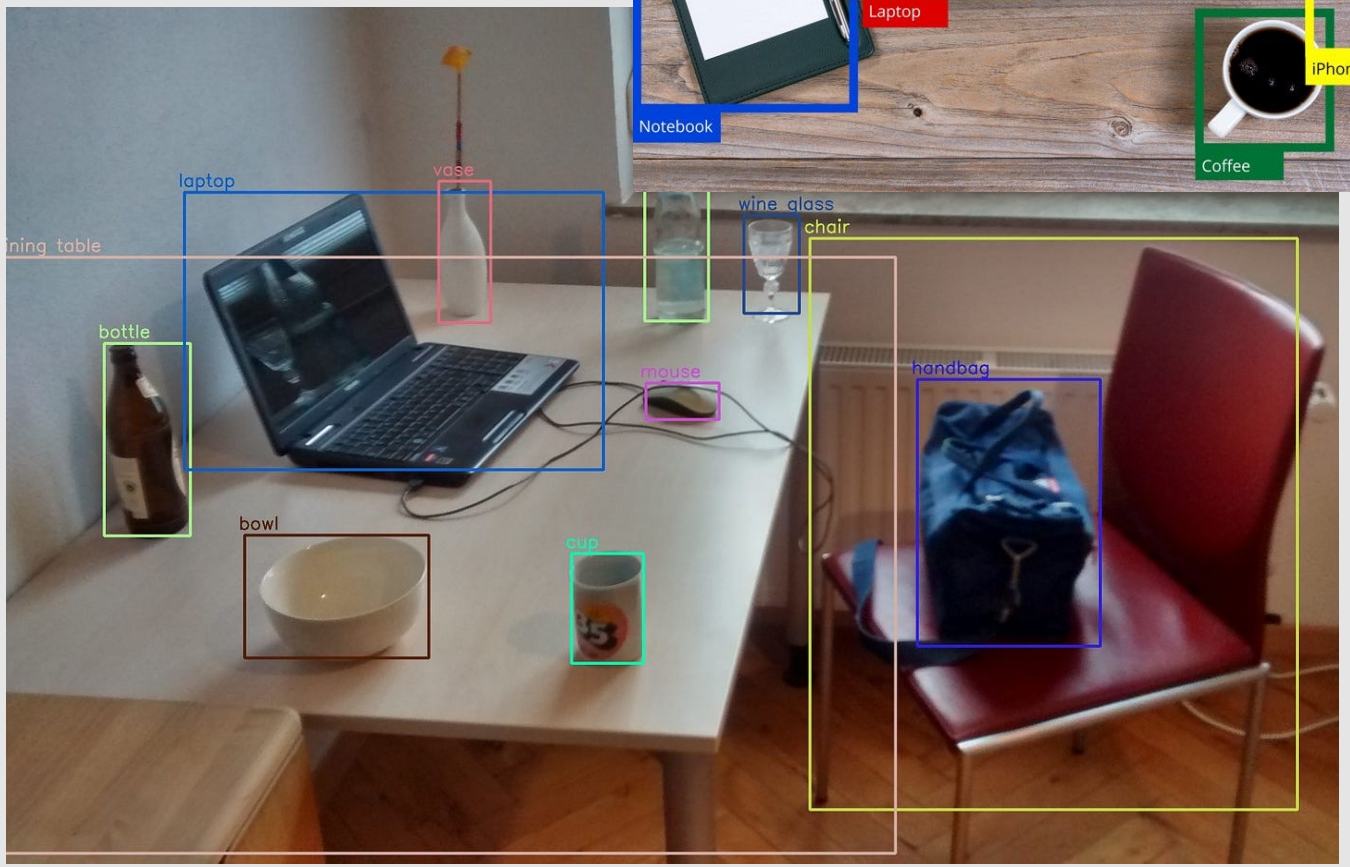




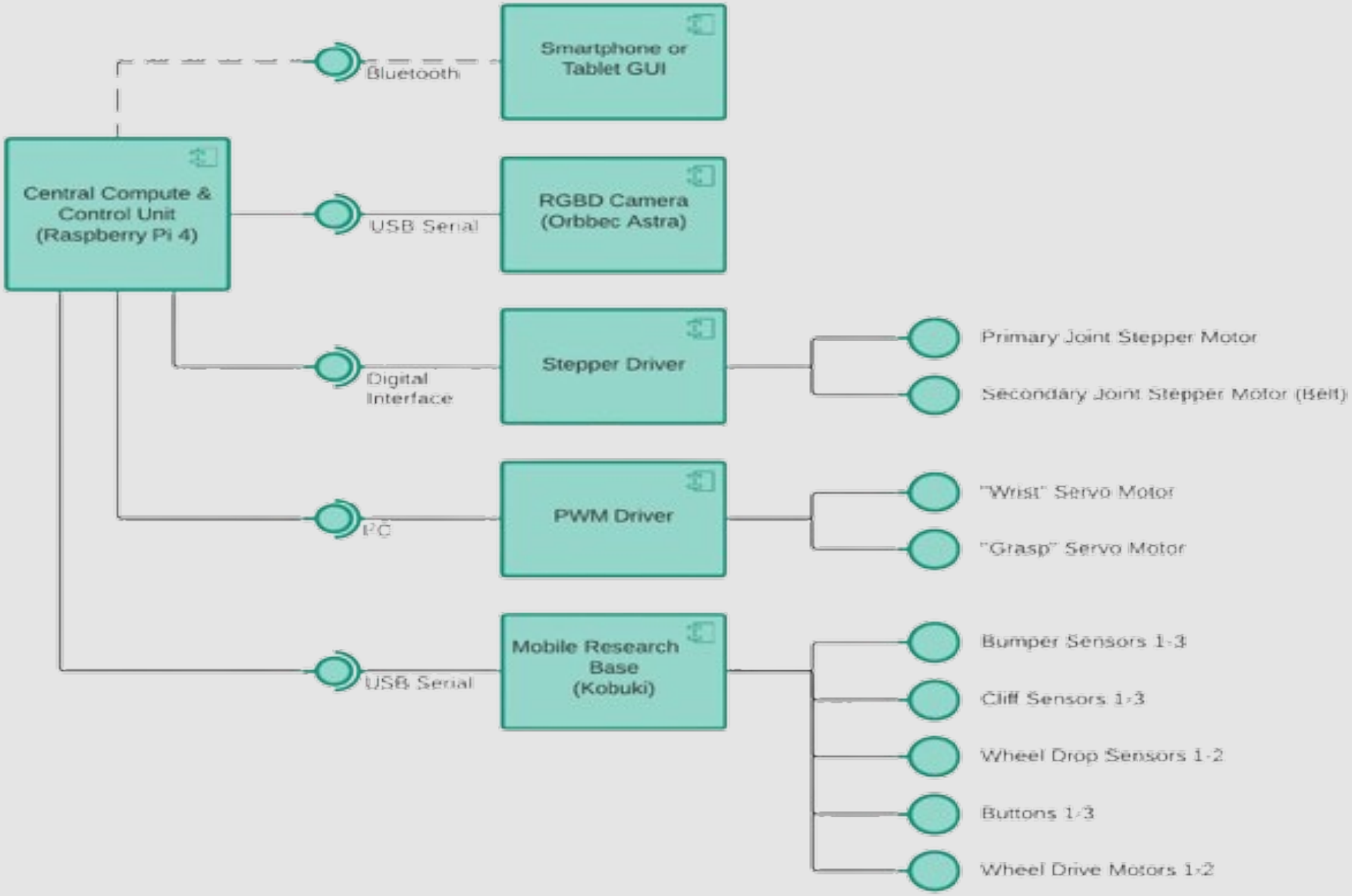
Physical Assistive Task Demonstration

3D Camera and Tensor Flow for Object Detection

TensorFlow



Robot Hardware Capabilities



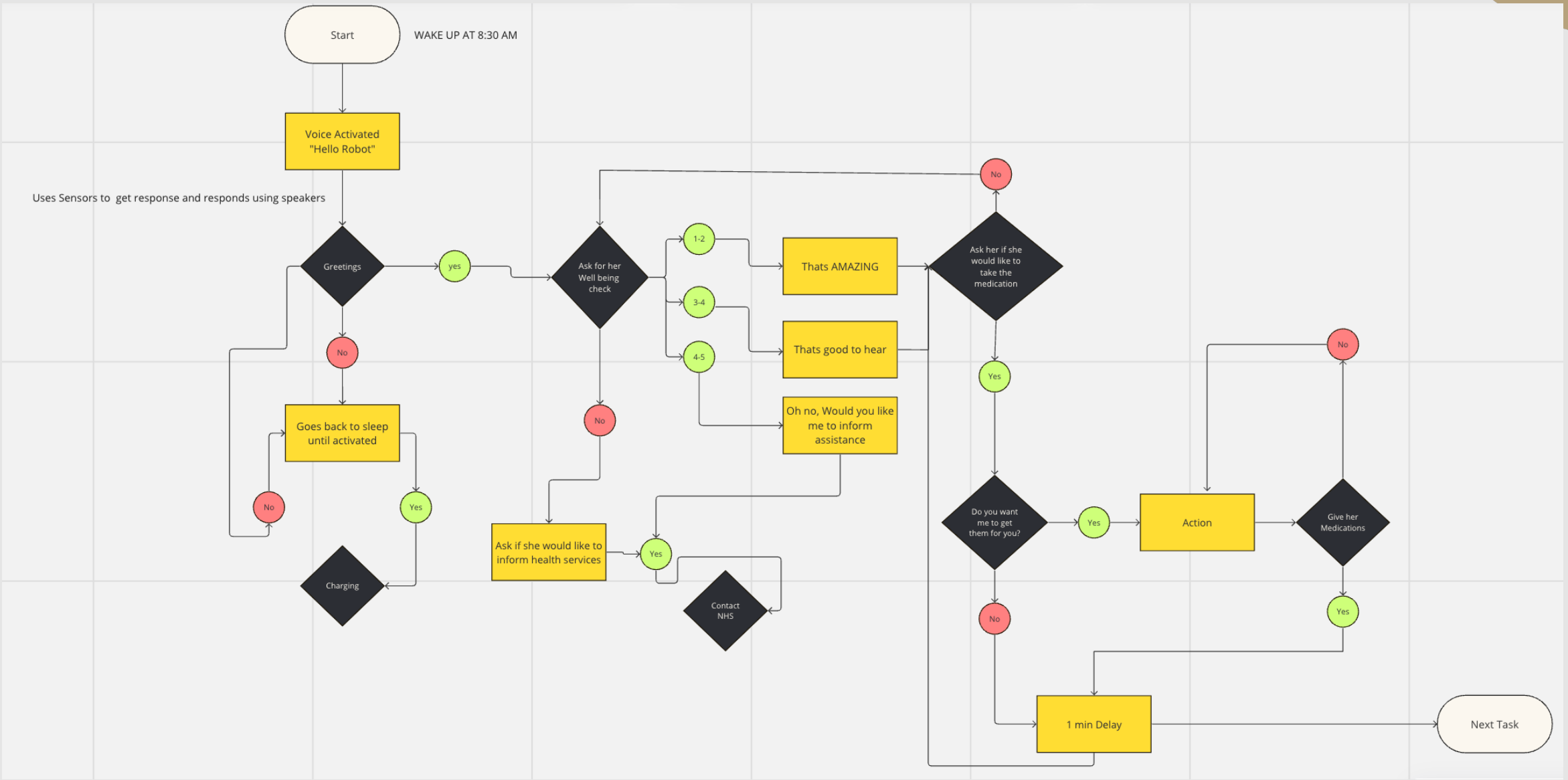
List Of Sensors and Components

3D- Camera

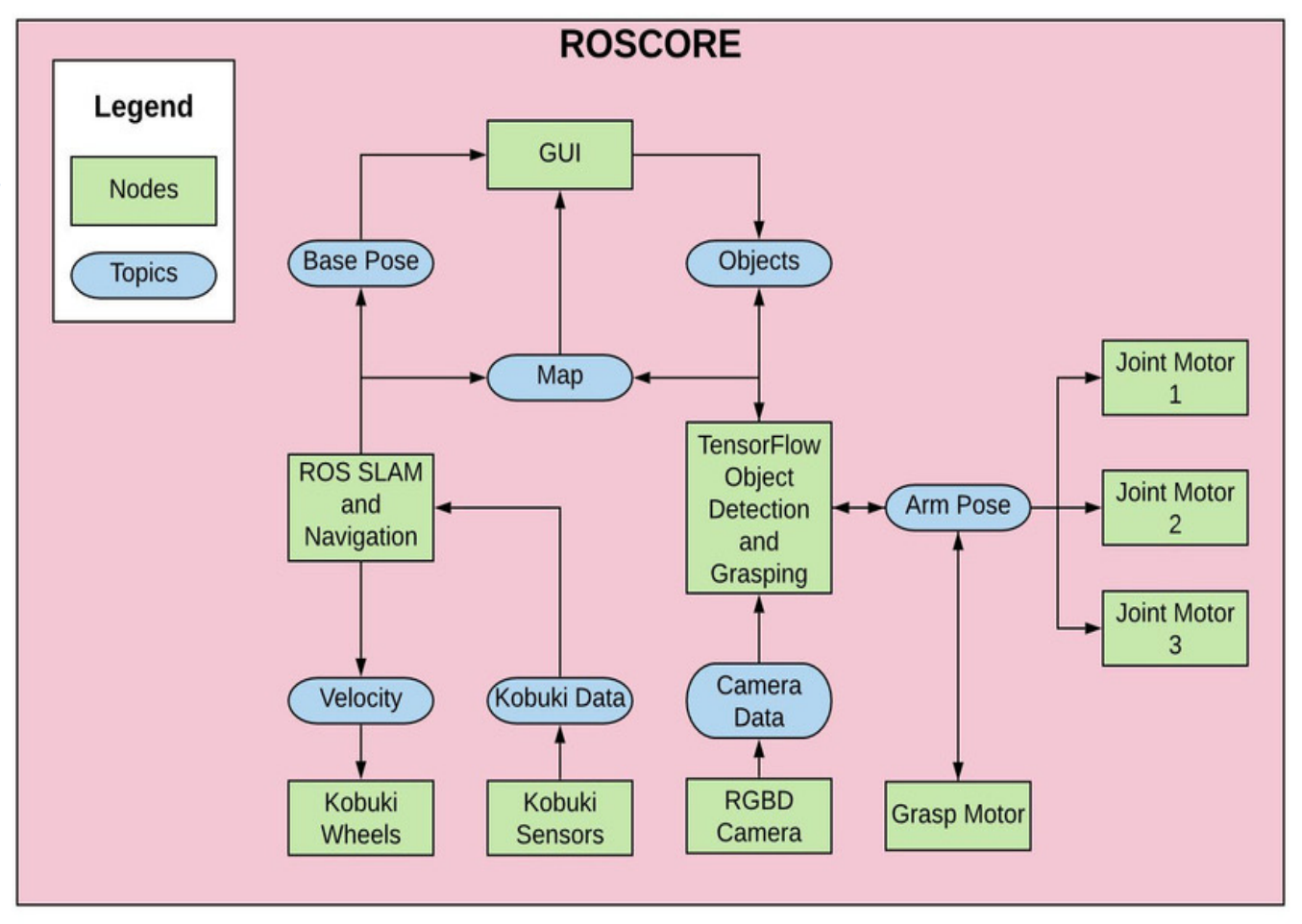
Manipulator

Turtle Bot 4

Overview of Assistive Task- FlowChart



Overview of Assistive Task- FlowChart



Physical Assistive Critical Limitations

- **Adaptability Limitations:** Limited adaptability to new environments or tasks that deviate from its programmed behaviors.
- **Grasping Ability:** Restricted to small, specific items like keys and glasses; struggles with irregular, heavy, or awkwardly placed objects.
- **User Interface Challenges:** Interface may be difficult for visually impaired users without specialized accessibility features.
- **Mobility Limitations:** Designed for flat surfaces; may struggle with uneven terrain, thresholds, or narrow spaces.
- **Software Limitations:** Susceptible to bugs affecting navigation, object detection, and task execution; limited natural language processing capabilities.
- **Physical Presence and Noise**: May be disruptive in smaller or quieter living spaces due to its size and operational noise.

Physical Recommendation For Improvement

•**Advanced Manipulation Capabilities**: Upgrade the grasping mechanism with adaptive grippers capable of handling diverse objects.

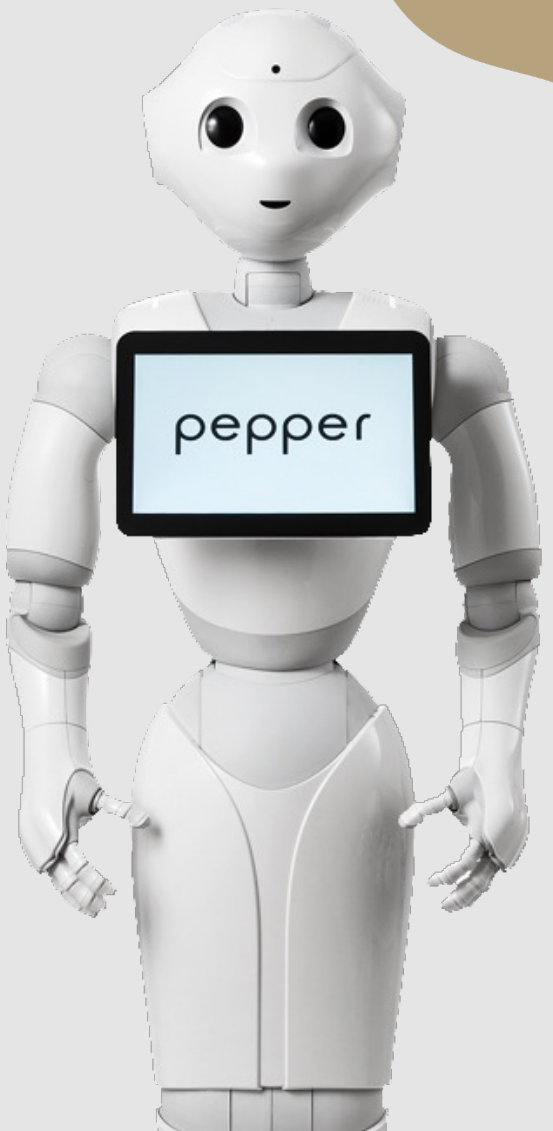
•**Enhanced User Interface**: Integrate accessibility features such as voice control and customizable interfaces, improving usability for visually impaired individuals like Claudia.

•**Improved Mobility**: Develop the robot's ability to navigate uneven terrain and confined spaces, enhancing its functionality across various home environments.

•**Software Reliability and AI Enhancement**: Focus on regular software updates, bug fixes, and enhancing natural language processing to boost performance and user interaction quality.

PART B: Social Assistive Task

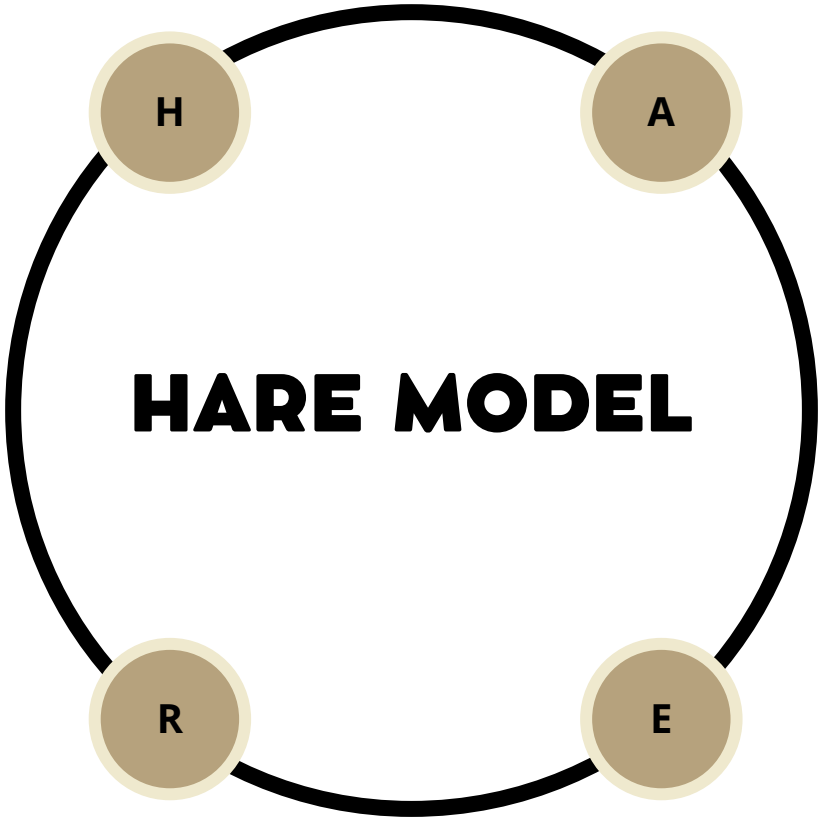
- Medication Managment
- Exercise Reminders and Guidance
- Social Interaction



Social Assistive HARE Model

Human

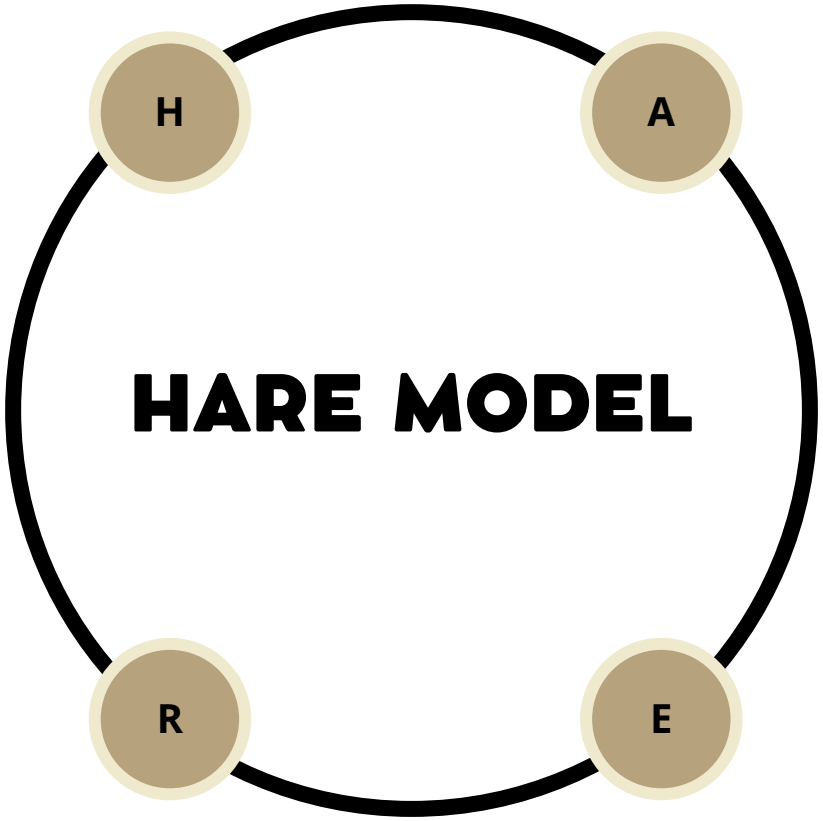
Demographics: 54, female, living alone
Adaptability: Adjusting to vision loss
Workload: Part-time from home
Skills: Social work expertise
Physical Capabilities: Limited by frailty
Sensory Capability: Partially sighted
Cognitive Capability: Intact, requires medication reminders
Physical Capabilities: Limited by frailty
Prior Experiences: Reduced confidence post-fall
Self-confidence: Diminished after vision loss
Personality Traits: Resilient, independent
Attitude: Maintain independence



Social Assistive HARE Model

Activity

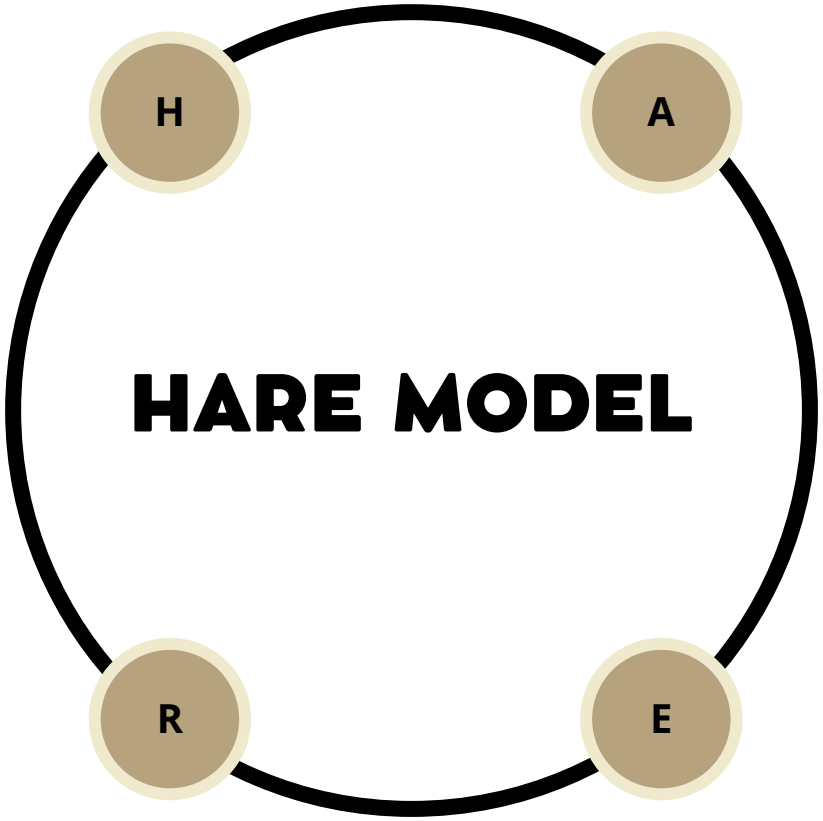
- **Emergency Alert**
- **Companionship**
- **Locating everyday items**
- **Medication Reminder**
- **Exercise Prompting**
- **Fall Detection**



Social Assistive HARE Model

Robot

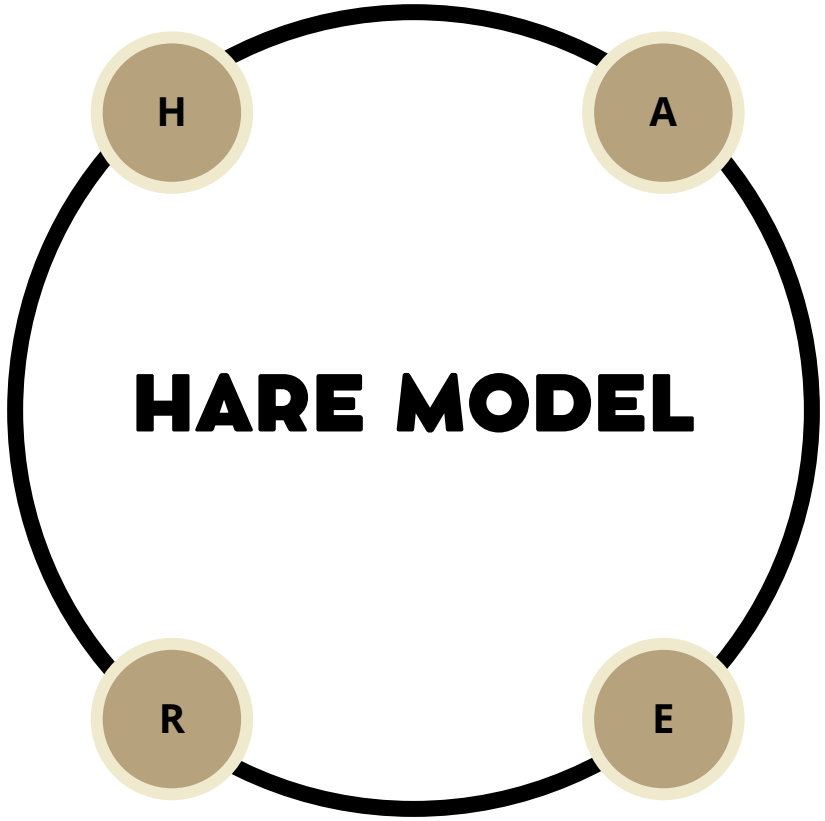
- **Reliability: High, with regular updates**
- **Automation: Semi-autonomous interaction**
- **User Interface: Voice-command interface, tactile response for the visually impaired**
- **Adaptability: Personalized reminders for medication and exercise**
- **Anthropomorphism: Human-like interaction**
- **Physicality: Safe navigation**
- **Modalities: Customizable speech, visual aids with high contrast for visibility**



Social Assistive HARE Model

Environment

- Customization: Allowing Claudia to personalize settings and preferences on assistive devices to better suit her needs and preferences.
- Training and Support: Providing training and ongoing support to help Claudia effectively use the assistive technology and navigate her environment with confidence.
- Regular Assessment: Conducting periodic assessments to ensure that Claudia's needs are being met and making any necessary adjustments to the assistive devices or environment.



Introducing Pepper

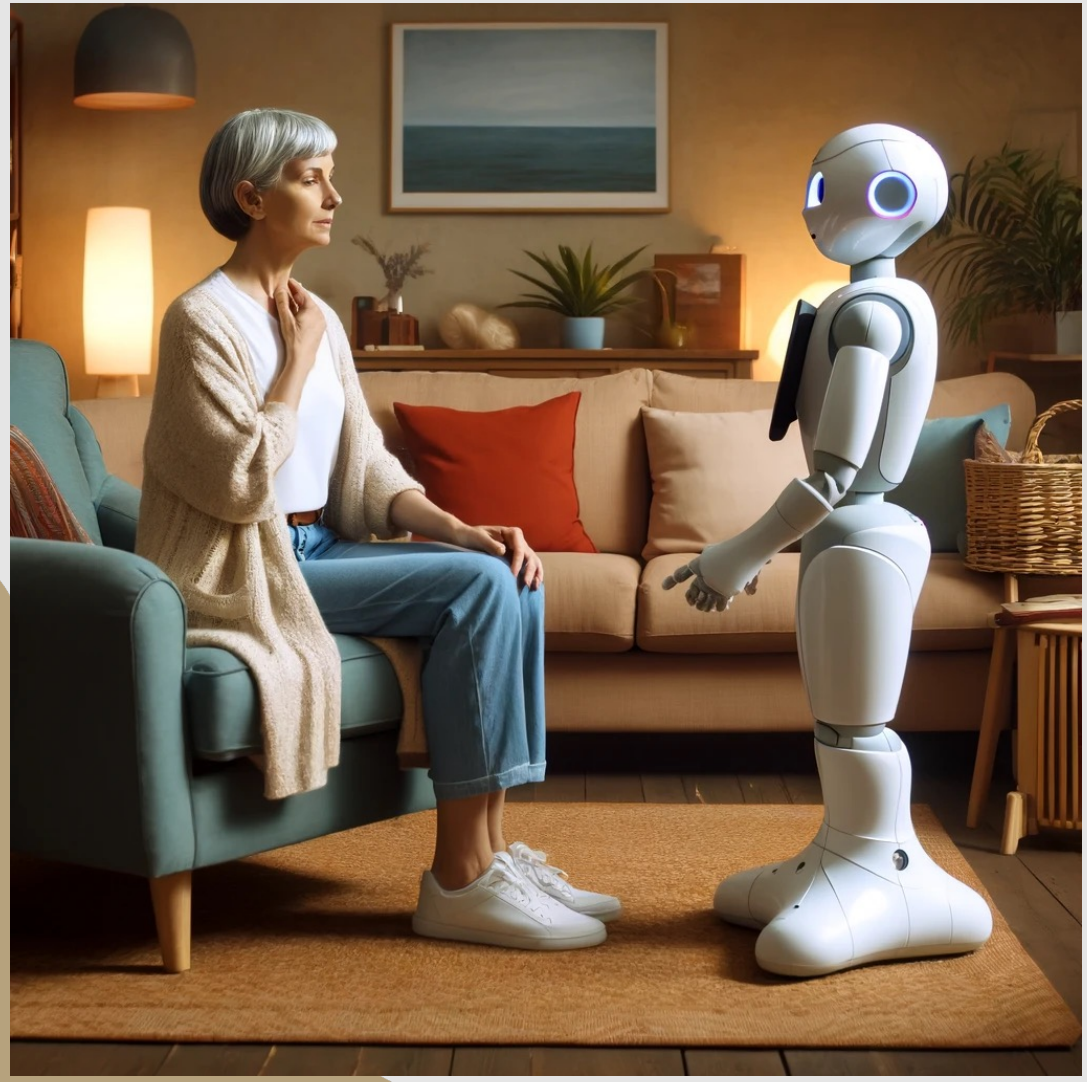
- Human Interaction: Best within 1m range.
- Speech Recognition: Works well but may struggle with background noise.
- Working Temperature: 5-35°C operational range.

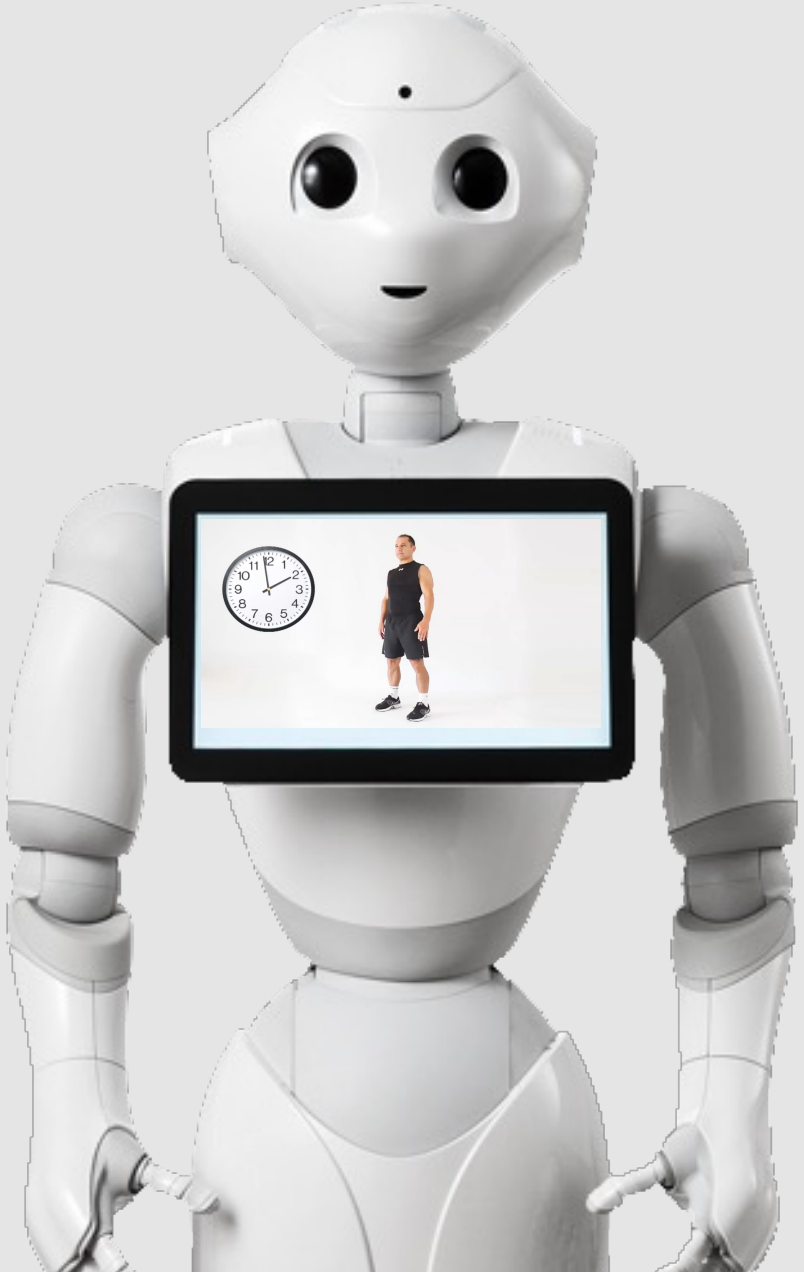
Medical Reminder Demo Video

Vision Fixator Demo Video

Vision Fixator Exercise Demo

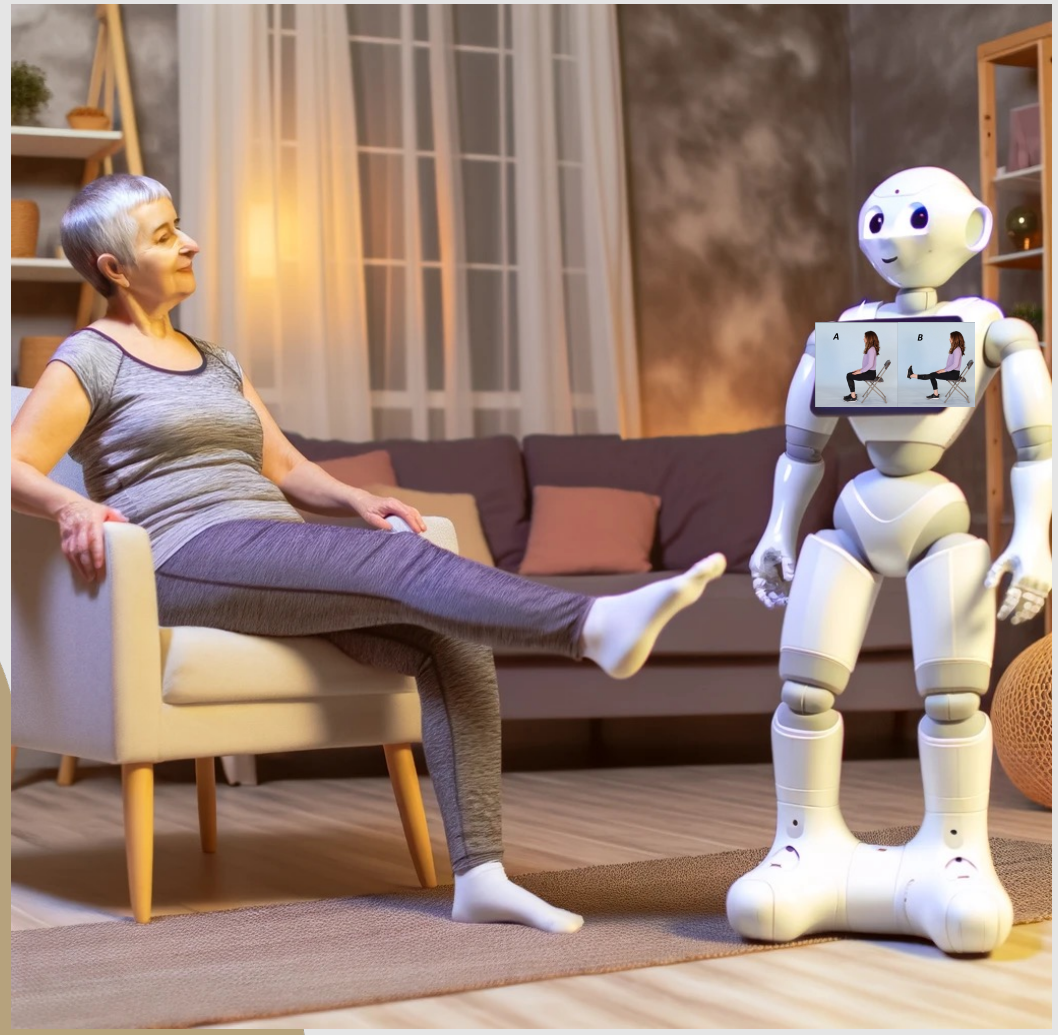
Breathing Exercise

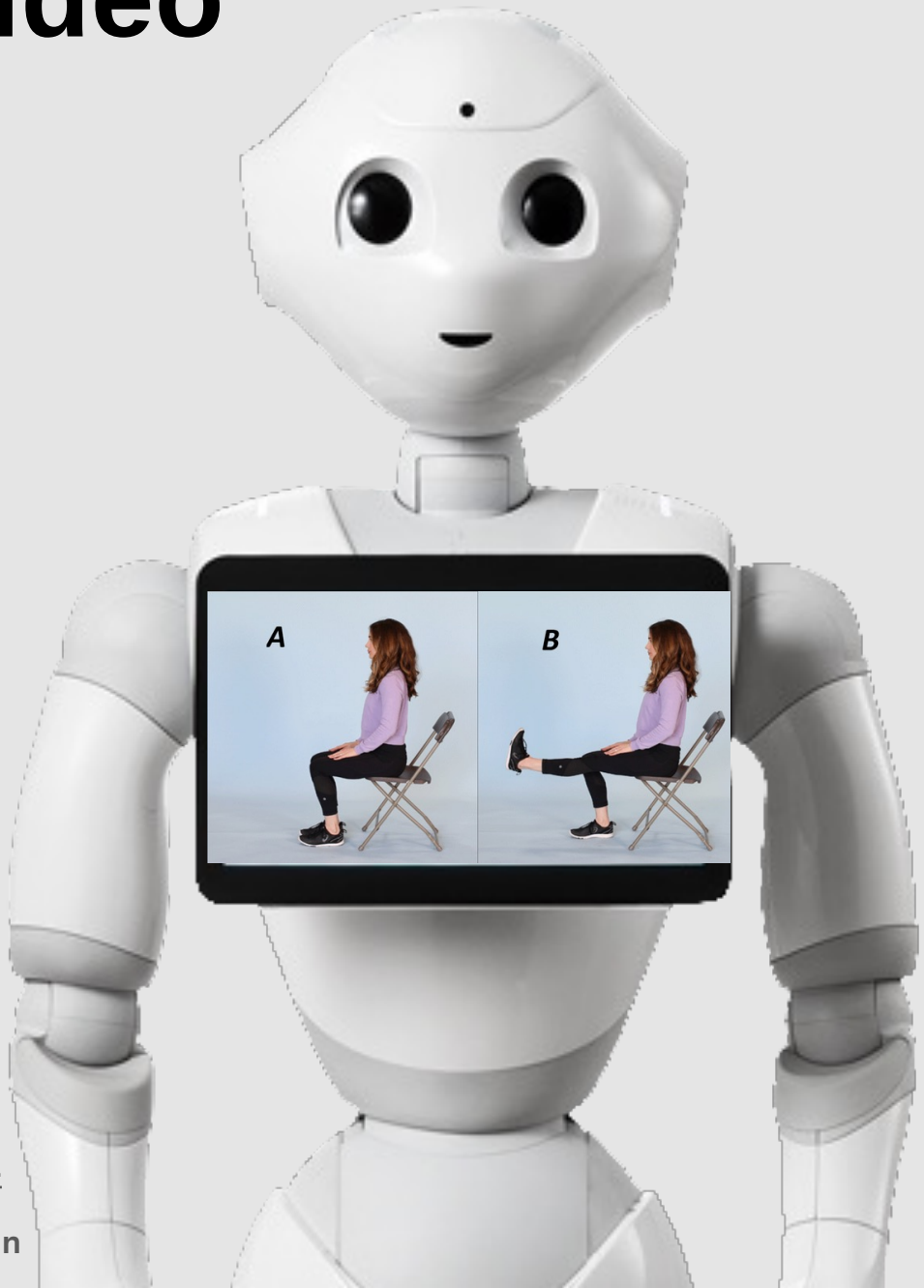




Breathing Exercise Demo

Leg Excercise Demo Video





[3] https://glaucoma.org/articles/exercise-diet-and-other-lifestyle-changes-for-people-living-with-glaucoma
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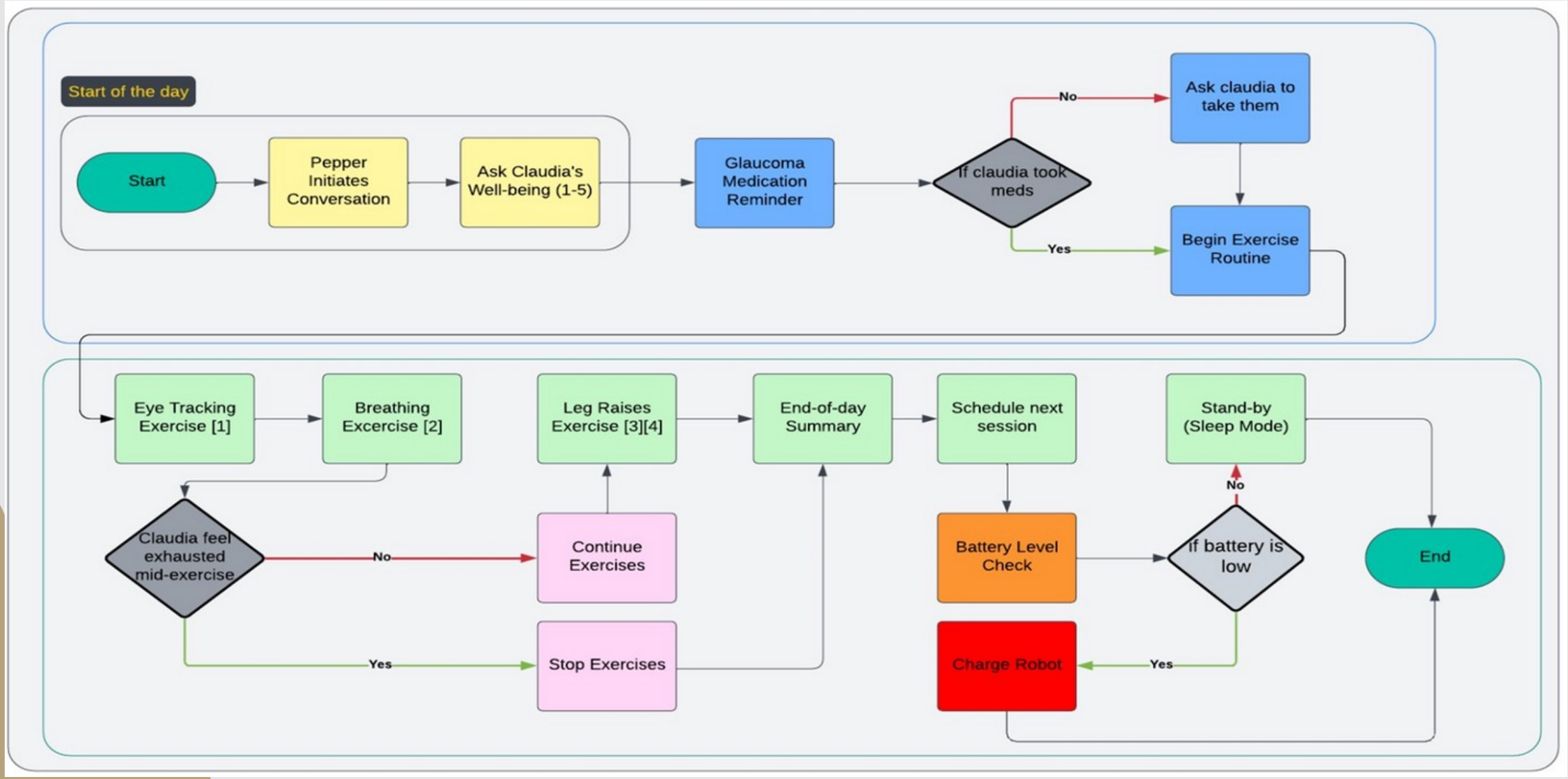
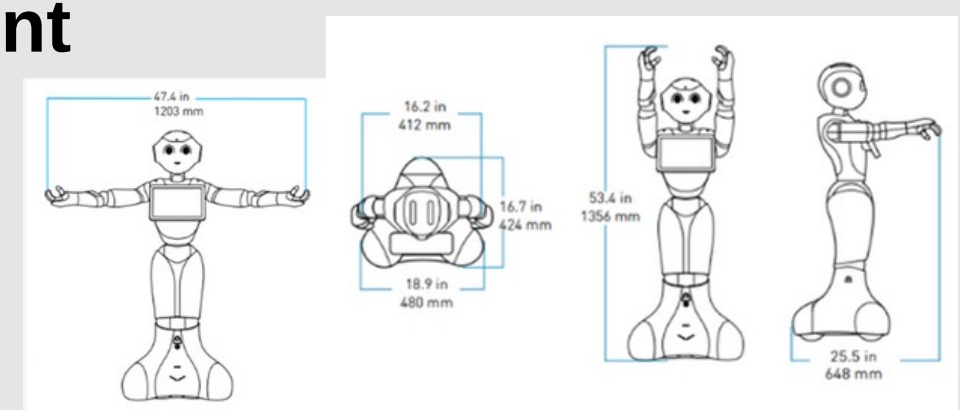
Leg Exercise Demo

Socially Assistive Robotic System Design



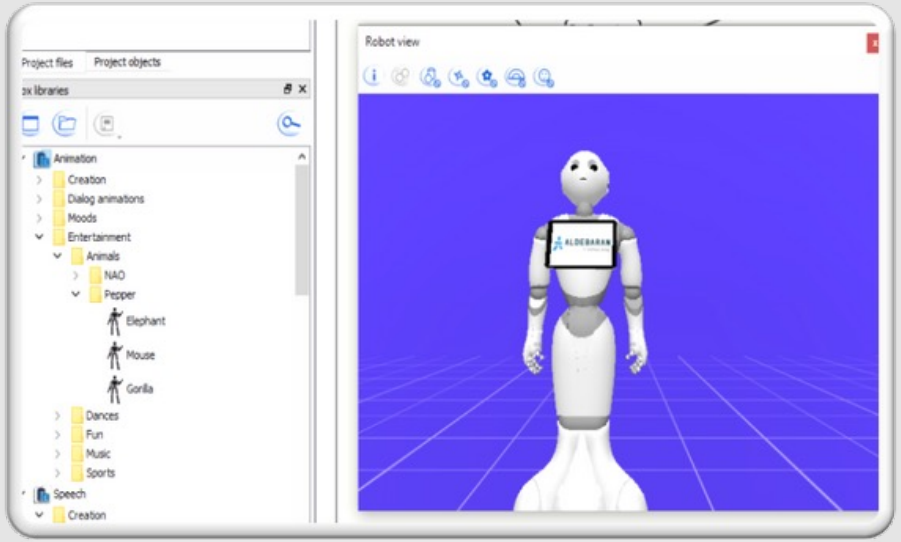
Social Recommendation For Improvement



Adaptability - Pepper might have limited ability to adapt to new tasks or changes in Claudia's condition

Limited Grasping Ability – object manipulation

User Interface Challenges - for visual impairment patients like Claudia



Robot Mobility Limitations -

- Uneven Terrain
- Narrow Spaces

Software Limitation –

- Choregraphe Application Bugs
- Natural Language Understanding

- Bug #33227 Frequent remote disconnection.
- Bug #32793 Choregraphe - Timeline box - Red bar not displayed when clicking on green Play button.
- Bug #35668 Choregraphe - Mac only - Doesn't display an error message when there is errors in Python files.
- Bug #34338 Choregraphe - Project properties: No speaker icons.
- Bug #35289 Choregraphe - Timeline curves are messed up after a zoom in/zoom out.
- Bug #35919 Choregraphe - Robot view freezes when selecting animation box in box library and animation previous isn't visible.

Social Recommendation For Improvement

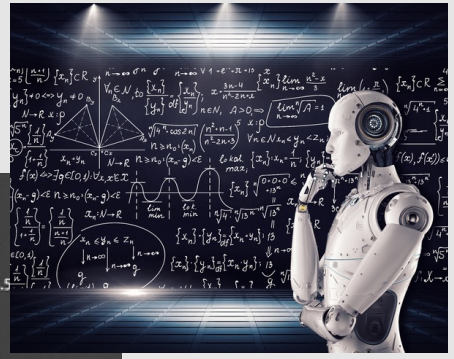
Enhanced Adaptability - Integrate machine learning algorithms

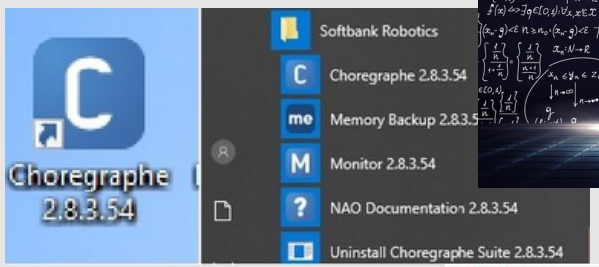
Improved Grasping Ability - Upgrade the robotic arm

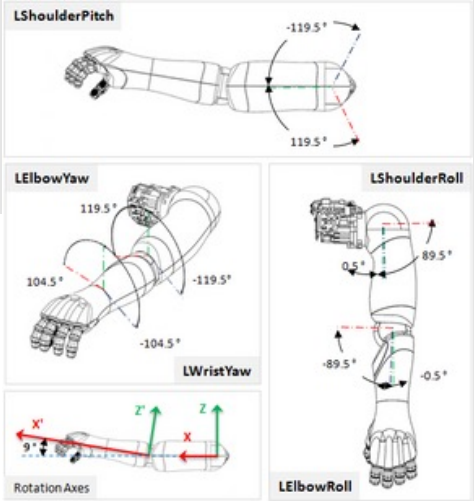
User Interface Optimization - Develop and integrate voice-controlled interfaces and haptic feedback systems

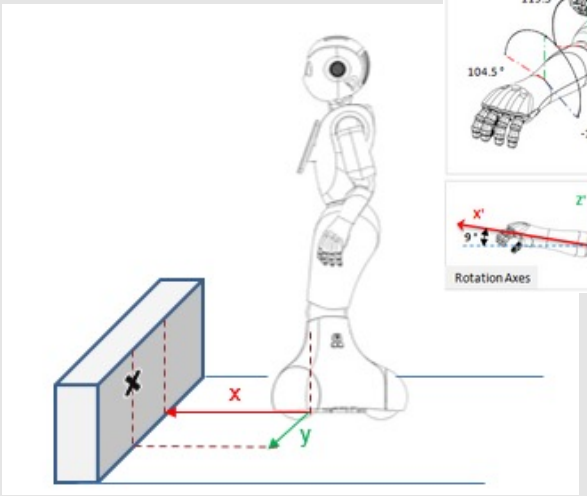
Mobility Enhancements - Equip Pepper with better navigation sensors and algorithms

Software Improvements - Regular updates and bug fixes for the Choregraphe application









Safety and Key Design Considerations

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[10] https://glaucoma.org/articles/exercise-diet-and-other-lifestyle-changes-for-people-living-with-glaucoma
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