Quality of Life Technology Center
a National Science Foundation Engineering Research Center

QoLTbots

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Outlines

- What are QoLTBots?
- Why QoLTBots?
- How are QoLTBots working?
- Future directions of QoLTBots?

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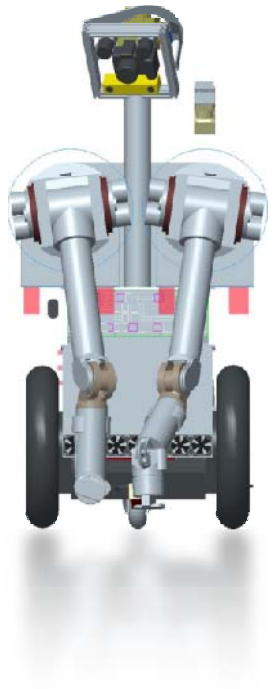
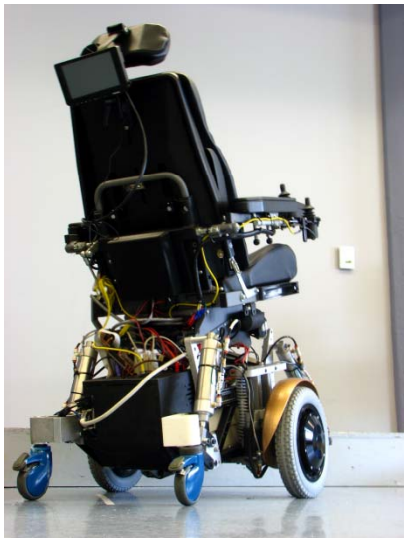
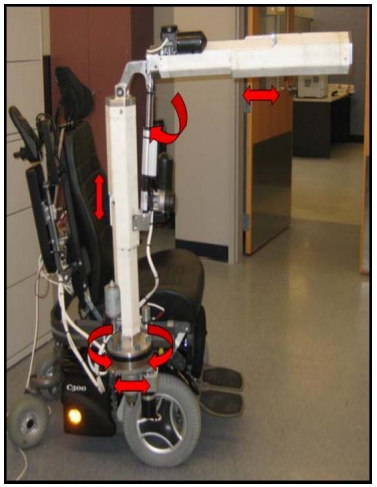
What are our QoLTBots?







The goal of the QoLTbots project is manipulation and mobility assistance that supports independent living

Robots “learning” from human behavior and activity

Enhance independence and participation

Providing tools to augment clinicians and caregivers

HERB

Home Exploring Robot Butler (HERB) is a bimanual mobile manipulation platform, with two Barrett WAM arms atop a completely redesigned chassis with a Segway RMP 200 base.

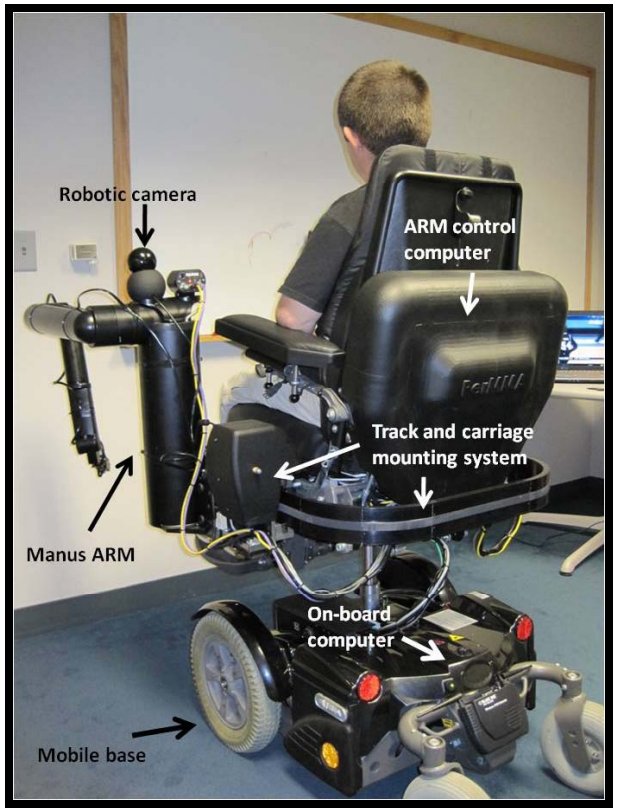
Algorithms for constructing manipulator trajectories in the presence of multiple heterogeneous constraints.

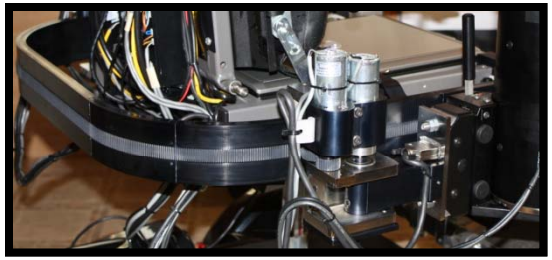
Using collision information opportunistically to improve manipulator and robot localization

Learning spatial and temporal cues from human observation for efficient handoffs

Machine learning techniques for model and compute long-term and short-term trajectories of people

PerMMA Gen I





The Personal Mobility and Manipulation Appliance (PerMMA) integrates intelligent mobility and dexterous robotic manipulation to provide enhanced assistant for people with disability in essential ADL tasks.

Mobility: PerMobil C500

+

Bimanual Manipulation: ARMs

Customized features:

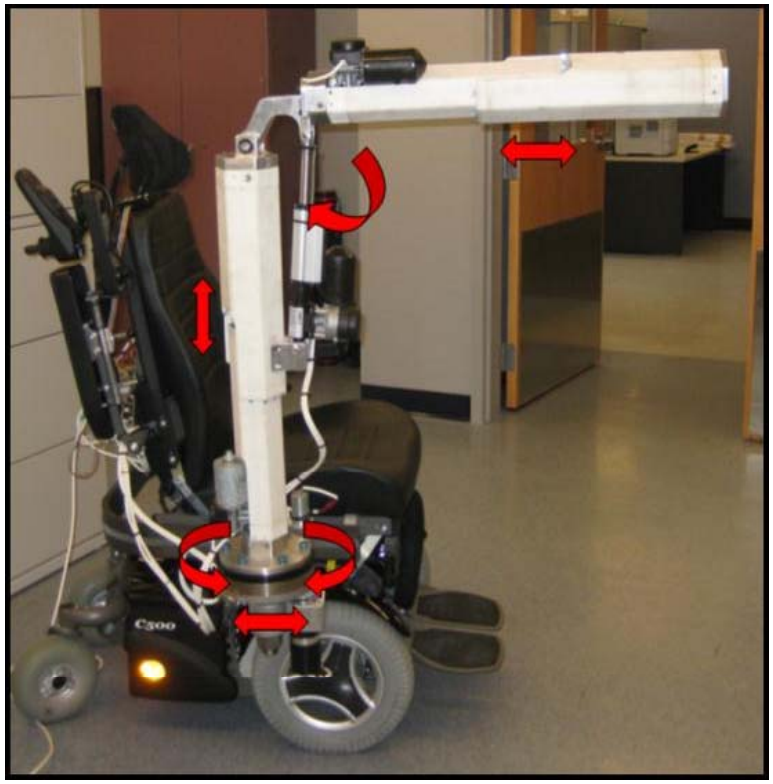
Traction control of mobile base
Webcams for visual feedback
Wifi+3G network connection

PerMMA Gen II

- Small footprint and maneuverability for indoor usage
- Active control of center of mass safely and robustly traverse the vast majority of terrains that are relevant to power wheelchair users
- Active suspension to overcome low back pain and injuries caused by WBV
- Reconfigurable driving wheels position to overcome limitations of current power wheelchair with only one drive style thus to provide optimized user driving experience
- Autonomous and semi-autonomous modes that are effective while enabling power wheelchair users to maintain a feeling of control

Strong Arm (aka Transfer Arm)

- Develop a robotic system and strategies that will allow the transfer of a person from one seating surface to another
- A solution for moving everyday objects
- Four joint segments, powered by electric actuators
- Direct interaction user interface
- A commercially available transfer sling can be attached to the most distal segment of the Strong Arm
- Manifold control for stability and safety



What are QoLTBots working on?

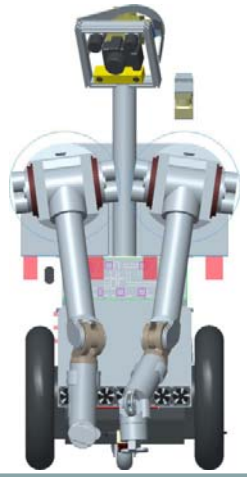
End-User Participatory Action Design

Clinician Perspective

Object recognition and registration

Structure discovery

Learning manipulation goals from experience



Physics-based clutter reconfiguration

Environmental barriers overcome

Assistive Teleoperation

Assistive Transfers

Business/Reimbursement Models

Form and functional design

QoLTBots team composition

- Design
- Human-Computer Interaction
- Mechanical Engineering
- Electrical Engineering
- Occupational Therapy
- Physical Therapy
- Rehabilitation Engineering
- Computer Science
- Robotics
- Prosthetics

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Significance

•Over 10 million Americans reported a daily activity limitation in 2005 Census.

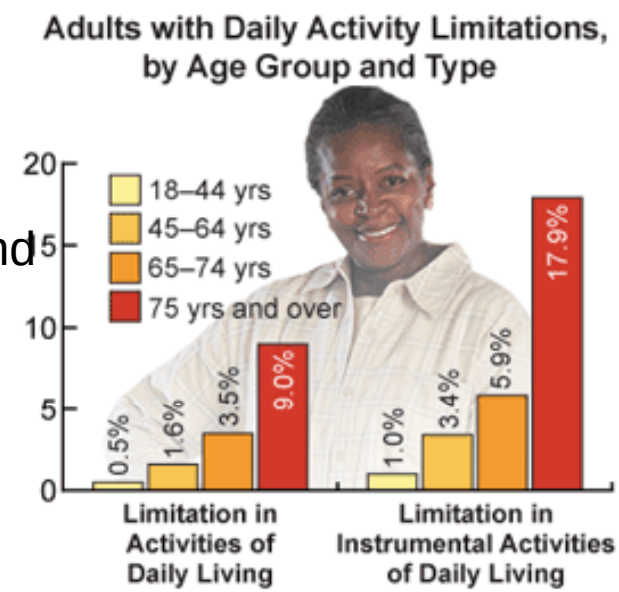
•Almost 16 million people had difficulty with lifting grocery bags, and 7 million had problems grasping a drinking glass.

•About 1.1 million Americans have been experiencing severe lower and upper extremities impairments.

•There are also a growing number of persons needing personal assistance as they get older and experience increased pain or fatigue.

•The physical environmental barrier preventing users

- •Visiting friends and family
- •Carrying out more activities
- •Community participation



Robotic Mobility and Manipulation

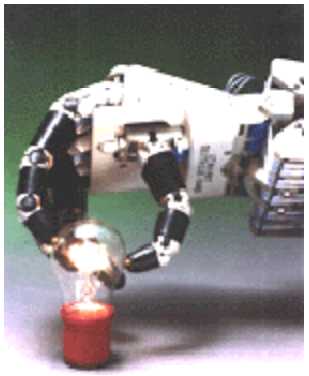
- 10% of the about 2 million wheelchair user are using powered wheelchair for mobility
- Powered wheelchair has similar characteristics as a mobile robot

iBot

TopChair

Wheelesley

BioChair



Utah/MIT hand

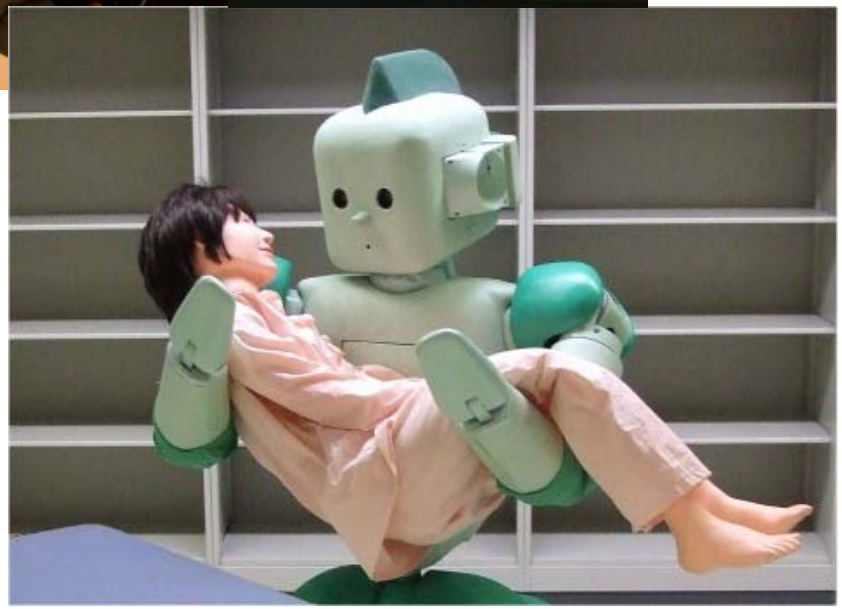
Vanderbilt arm

DLR hand

WAM arm

DEKA arm

Care Robots



Our Robots


iARM
Myomo
Armeo
The Phantom Omni Arm
MANUS
PHANTOM
PerMMA
StrongArm
JACO
The New WAM™ Arm.
Simply the most advanced robotic arm.
HERB
Kinect
HandSOME
HAMSTER
AcceleGlove
mPower 1000
Romibo
CAREN
LokoMat
SnackBot
Companion
Lego-Mindstorm

What is needed?

A fearsome future…?

Or just great fun…?

Research to support development of care applications: user requirements (patient and caregiver), ethical issues, how can technology be embedded in care practice, etc…

User evaluations: usability, safety issues, acceptance, etc…

(Cost-)Effectiveness research

Implementation research

Educational and training programs

……

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Asimov's Laws of Robotics

First law (Human safety):

- A robot may not injure a human being, or, through inaction, allow a human being to come to harm.

Second law (Robots are slaves):

- A robot must obey orders given it by human beings, except where such orders would conflict with the First Law.

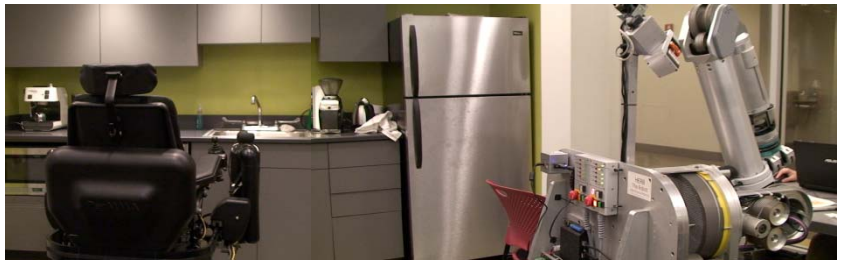
Third law (Robot survival):

- A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

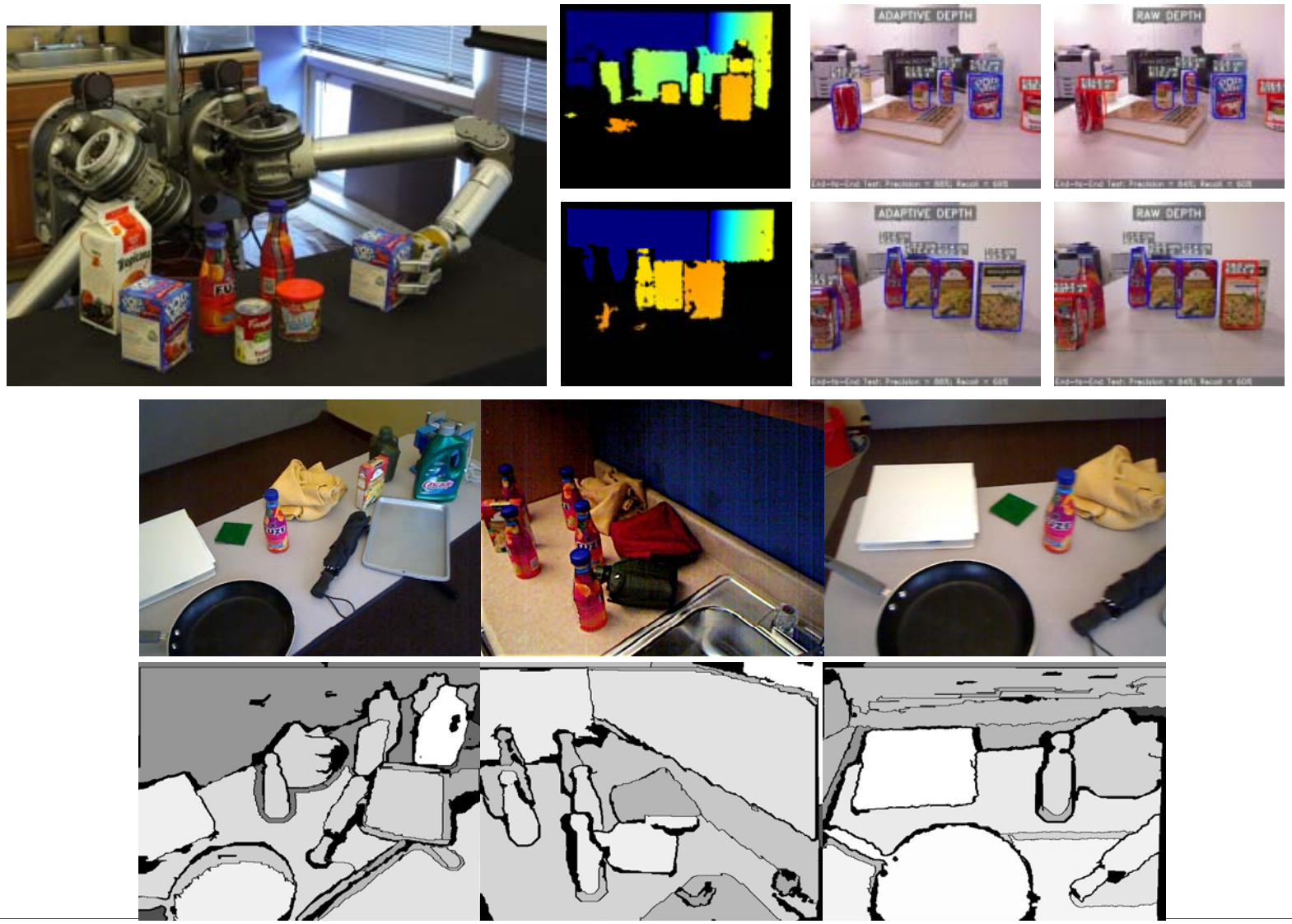
These laws are simple and straightforward, and they embrace the essential guiding principles of a good many of the world's ethical systems.

But: They are extremely difficult to implement!!!

Design and System Integration



Object Recognition and Model of Data



Autonomous Control

Plan arm motions that satisfy task constraints

Manipulate in real-world clutter and uncertainty

How can a robot learn to do better

When and how should a robot assist

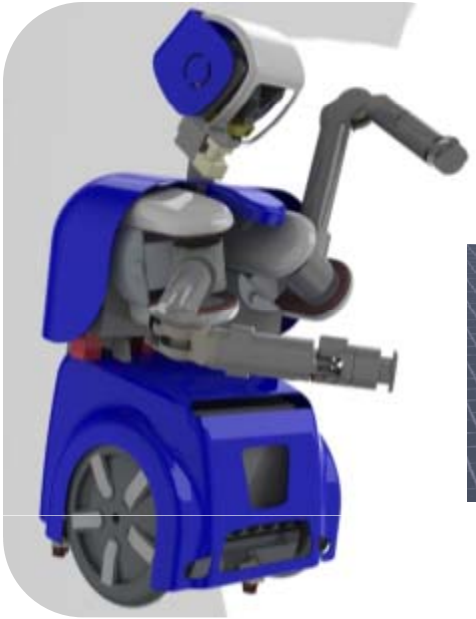
HERB / PerMMA Sharing ……

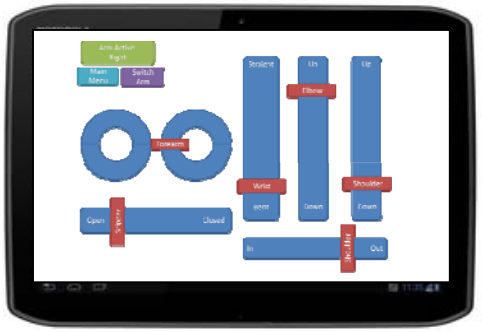
- Algorithms such as position robot control, robot status feedback
- MOPED for object recognition
- OpenRave models for simulation
- CBiRRT with TSR chains for path planning
- Approaches to telepresence.
- End-user data.
- Touch-screen tablet local user interface.
- Working on easily detachable shell components.

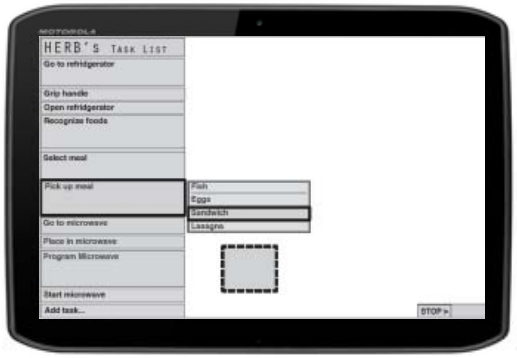
HERB and PerMMA shell and interface design

Building an expressive shell and usable interface for HERB and PerMMA

- Work with interaction designer, HERB base design off Snackbot.
- Fiberglass and plastic shell composed of easily-detachable parts.
- Preliminary task-level interface design for touch screen tablet.





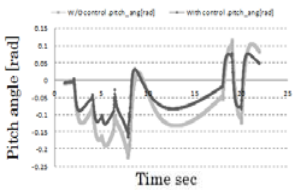


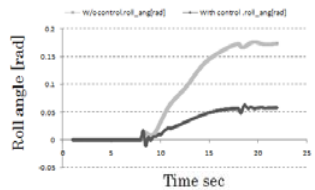
Local user control

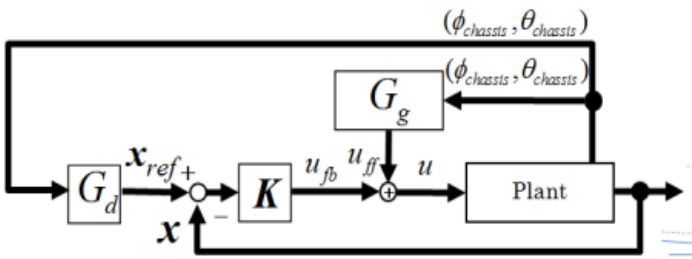
- 16 participants
  - 11male and 5 female
  - All participants had both lower and upper extremity impairment and use a wheelchair.
- Results
  - Intellakeys system and physical sliders were rejected
  - User prefer voice and tablet
  - The UI is drafted from w/c user and will be improved with collaboration of HCI people

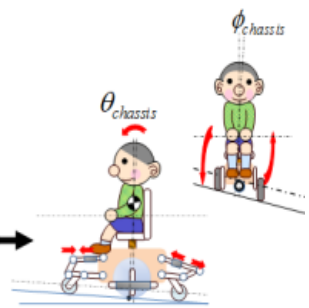
PerMMA shops at Staples with voice and tablet interface

PerMMAII Curb and Leveling Simulations









Control Model

- The control system uses a **Torque-Proportional control**. A torque T_h is applied by the user/computer. T_h is filtered through a low pass filter to smooth the torque. Proportional Control (K) and delay (e^{-ts}) is added into the system to vary the response of the system. (Figure 2)
- Figure 3 shows an equation that calculates the required torque the driving wheels need to climb the curb once in contact with the edge

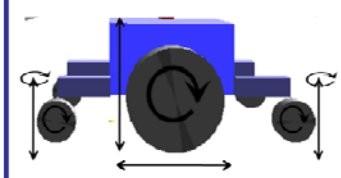


Fig1. Degrees of Freedom. n =4

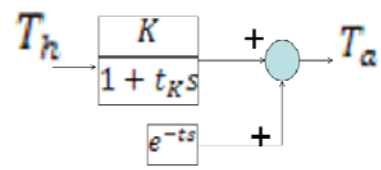


Fig2.. Control Diagram for Pneumatics System

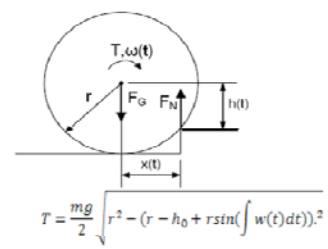


Fig3. Equation to calculate torque during climbing sequence

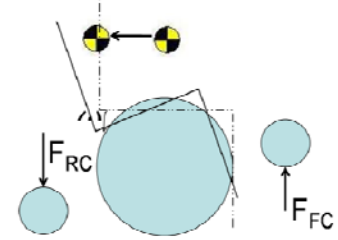


Fig4. Shifting Center of Mass

Evaluations

Outcomes?

Standardization?

Canonical Tasks?

Outcome measures?

Strong-Arm

Bed Transfer

Shower Transfer

Toilet Transfer

Lounge Chair Transfer

Strong-Arm: User Focus Group Results

- 16 participants
  - 11male and 5 female
  - All participants had both lower and upper extremity impairment and use a wheelchair.
- Results
  - 25% of participants strongly agreed make their life easier;
  - 81% agreed it was important that this technology be developed.
  - 94% disagreed when asked if using this technology would be embarrassing to use.

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QoLTBots future plans

- Assistive teleoperation interfaces and algorithms
- Human-robot physical collaborative manipulation
- Intuitive user interfaces
- Synchronized two-arm manipulation on HERB
- Algorithms for autonomous stability under uneven terrain
- PerMMA 1 Automation and testing with users in natural environment
- PerMMA 2 evaluation
- Strong-arm clinician studies

Thank you

Questions and Comments?