Overview of HERL
Assistive Robotics
Research

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And
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Participatory Action Design - Paradigm

- User Need Identification
- Story Boards
- Initial User Data
- Technical Data (Safety)
- Prototype Systems (Capabilities)
- Demonstration Studies (Effectiveness)
- Consumer Trials (Acceptance & Cost)
- Best Practice Evidence (Policy)
- FDA Approval (if applicable)
- Insurance Coverage (if applicable)
- Standard of Care (if applicable)
- Community Participation
- Employment
- Living Healthy
**Coaching Safe Behavior**

(Data from 8 subjects)

<table>
<thead>
<tr>
<th></th>
<th>Baseline (n=96)</th>
<th>Intervention (n=308)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSF Usage Frequency (times/day)</td>
<td>$15 \pm 16$</td>
<td>$23 \pm 22$</td>
</tr>
<tr>
<td>Driving Distance (km/day)</td>
<td>$1.8 \pm 2.3$</td>
<td>$1.7 \pm 2.1$</td>
</tr>
<tr>
<td>Spearman’s rho</td>
<td>$0.322^{**}$</td>
<td>$0.551^{**}$</td>
</tr>
</tbody>
</table>

Spearman’s rho values indicate a significant correlation between variables.

*Note: ** denotes statistical significance.*
TAWC Questionnaire

- Automatically appear at 4:00pm every day
- Generate alert on the notification bar
- Answers are stored into database

Check whether users have answered the TAWC each day
Data will be uploaded with SVSC data as well
PerMMA
Wheelchair Mounted Robotic Manipulator

Learning Effect on the Task Board

Task Completion Time

Keyboard

Joystick

User Interface

Task Board Result

Minimum Task Completion Time

Keyboard

Joystick

User Interface
Smart Phone Robotic Arm Interface
MEBot - Problem Statement

- 2010, 3.6 million people 15+ years old used a wheelchair (Brault, 2012)
- 2003, 100,000 wheelchair related injuries were treated in an emergency room (Xiang, 2006)
- Estimation of 330,000 use an EPW (Kaye, 2000)
- Tips and falls account for 65-80% of the injuries (Xiang, 2006)
- Causes include loss of traction, being immobilized, or the loss of stability (Salatin, 2011)
Previous Design – Personal Mobility and Manipulation Appliance II (PerMMA II)

- Six wheeled EPW
  - Front and rear wheels move up and down via pneumatic actuators
  - Drive wheels mounted to a carriage system
    - Move up and down with pneumatic sleeve spring
    - Move forward and backward with electric linear actuator
Robots for Wheeled Mobility: MeBot (GEN-1)
CAREN System to Assess Mobility

Upper Level Control

- $\dot{x}, \dot{y}, \ddot{w}_{\text{accel}}$
- $\dot{\Theta}, \dot{\phi}_{\text{gyro}}$
- Complementary filter
- Rot (x, \theta)
  $\begin{bmatrix} 1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & 1 \end{bmatrix}$
- Rot (y, \phi)
  $\begin{bmatrix} 1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & 1 \end{bmatrix}$
- Trans ($X_o$)
  $\begin{bmatrix} X_0 \\ 0 \\ 0 \end{bmatrix}$
- $u_{\text{ref, i}}$

Lower Level Control

- $\dddot{x}, \dddot{y}, \dddot{w}$
- $\Theta, \phi$
- Complementary filter
- $\dddot{u}_{\text{i, i}}$
- $K_P$
- $K_D \cdot \frac{d(u(error)_{i})}{dt}$
- $u_i$
- $\Theta_{a}, \phi_{a}$
MEbot Self-Leveling Video

- Seat marker plane
- CAREN Platform plane
# MEBot and PerMMA II design comparison

<table>
<thead>
<tr>
<th>Comparison Item</th>
<th>MEBot</th>
<th>PerMMA II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to perform curb climbing</td>
<td>30 seconds</td>
<td>2 minutes and 30 seconds</td>
</tr>
<tr>
<td>Maximum curb height</td>
<td>8 inches</td>
<td>6 inches</td>
</tr>
<tr>
<td>Horizontal drive wheel movement</td>
<td>14 inches</td>
<td>7 inches</td>
</tr>
<tr>
<td>Vertical drive wheel movement</td>
<td>8 inches</td>
<td>3.3 inches</td>
</tr>
<tr>
<td>Number of actuators</td>
<td>4 pneumatic actuators, 2 electronic actuators</td>
<td>4 pneumatic actuators, 2 pneumatic sleeve springs</td>
</tr>
<tr>
<td>Air supply</td>
<td>High Pressure Air</td>
<td>Compressed CO2</td>
</tr>
<tr>
<td>Ground clearance</td>
<td>1-9 inches</td>
<td>0.5-3.8 inches</td>
</tr>
<tr>
<td>Driving wheel camber</td>
<td>Steel mounted, tight fit axle housing</td>
<td>Aluminum mounted, loose fit axle housing</td>
</tr>
</tbody>
</table>
Focus Group Prototype Evaluation

- Methodology – Data Collection
  - Questionnaire broken into parts

- Part A - Personal Demographics
- Part B - Current Wheelchair Information
- Part C - Power Wheelchair Training and Accidents
- Part D - Outdoor Driving Characteristics
- Part E - MEBot applications
- Part F - MEBot Control Interface
Focus Group Results

- Overall dimensions similar to Group 4 EPW
- Advanced features
  - Curb climbing
  - Self-leveling
  - Traction control
  - Selectable drive wheel positioning
Traction Control and Surface Compensation

\[ F = \frac{F_r}{N_r} \]

Reference Model

Wheelchair Inv. Kinematics

Low-Level Controller

PDF AT 72.1 inch/s² DECELERATION

SLIP RATIO

PDF AT 28.8 inch/s² DECELERATION

SLIP RATIO

PDF AT 50.4 inch/s² DECELERATION

SLIP RATIO

PDF AT 72.1 inch/s² DECELERATION

SLIP RATIO
Robotic Assisted Transfers

Number of subjects (y-axis) able to transfer with a certain gap (x-axis)

- Gap: 16"+, 13"+, 10"+, 7"+, 4"+, 1"+

Heights (in)

Number of Subjects
Wounded Warrior Home

Innovative home design offers Wounded Warriors at Fort Belvoir an accessible safe haven.

Welcome Home

Update: laundry facilities page 20
Streamlining housing referral page 22
Special section: Outdoor spaces page 26

09/29/11
Promote Reintegration

**EAT-LIVE-PLAY KITCHEN:**
The healing powers of healthy food, daily family reunions at the island, laughter and good times. Family life is lived in the kitchen, and in this case, the kitchen is fully adjustable from stove and oven setup, to cooking surface and shelves. The design is a culinary command post, building in the ability to mirror activities in the rest of the house — even outside. (A tremendous benefit to anyone with a disability.) This entire kitchen is not just wheelchair accessible, we think it's more like wheelchair exceptional.

**EAT-LIVE-PLAY KITCHEN:**
Adjusted to low height for people in seated positions, children and individuals that require frequent rest breaks.
KitchenBot – Increasing independence for cooking and cleaning - video
We must work together

"... a life with a disability is still a life after all, to be enjoyed and lived to the fullest."

— Holllyn D’Ell

Minstrel, magazine of the able-disabled, November 1987

At the Center for Assistive Technology (CAT), we know that living with a disability brings changes. Disability need not prevent you from enjoying the life you want to live. The team of professionals at CAT provides innovative solutions for individuals with disabilities who need assistive technology for mobility, hearing, speech, and other everyday needs.

A joint program of UPMC and the University of Pittsburgh, CAT has emerged as a leader and innovator in the assistive technology industry. CAT is located on UPMC’s Oakland campus in Pittsburgh and offers services at sites throughout the region. Whatever your assistive technology needs, CAT can provide you with a bridge to independence and an opportunity to live life to the fullest.
Research lab offers job training for wounded warriors

A joint research program between VA and the University of Pittsburgh that studies wheelchairs and related technology is now helping to train disabled Veterans for careers in machining.

The program is called Fabrication of Assistive Technology Program for Wounded Warriors. It’s run by the Human Engineering Research Laboratories, a collaboration between the VA Pittsburgh Healthcare System and the University of Pittsburgh School of Health and Rehabilitation Sciences.

The program is being launched this fall with the help of a $100,000 donation from Highmark Blue Cross Blue Shield.

Created by director Rory Cooper, PhD, and education and outreach project director Mary Goldberg at HERL, the program will prepare participants to pass a basic machining exam. The participants will also get on-the-job training at local companies, which could lead to permanent, full-time jobs.

To learn more about HERL, visit www.herl.pitt.edu.

1. Shop supervisor Garret Grindle shows Veteran Keniel Martinez how to smooth the burnt steel on a stainless plate.
2. Veterans (from left) Keniel Martinez, Shawn O’Donnell, Artem Lazczynski, Gary Retherage, and Adam Benjamin Campbell listen to Garret Grindle explain how to operate a drill press.
3. Veterans Michael Malloy and Keniel Martinez watch as Grindle demonstrates a task on the drill press.

Photos by Bill George
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Adversity → Advantage

A^4

Action → Accomplishment