Cadeiras de rodas motorizadas

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03 de setembro de 2010
Esta apresentação está baseada primariamente na revisão dos artigos desenvolvidos pelo :

- Human Engineering Research Laboratories, Department of Veterans Affairs (VA) Center of Excellence in Wheelchairs and Associated Rehabilitation Engineering, VA Pittsburgh Healthcare System, Pittsburgh, PA 15206, USA

http://www.herlpitt.org/

Rory A. Cooper, Ph.D., received his B.S. and M.Eng. degrees in electrical engineering from California Polytechnic State University, San Luis Obispo in 1985 and 1986, respectively. He received his Ph.D. degree in electrical and computer engineering with a concentration in bioengineering from University of California at Santa Barbara in 1989. He is FISA & Paralyzed Veterans of America (PVA) chair, Distinguished Professor in the Department of Rehabilitation Science and Technology, and Professor of Bioengineering and Mechanical Engineering at the University of Pittsburgh. He is also a professor in the departments of Physical Medicine and Rehabilitation, and Orthopedic Surgery at the University of Pittsburgh Medical Center Health System. Professor Cooper is director and VA Senior Research Career Scientist of the Center for Wheelchairs and Associated Rehabilitation Engineering, a VA Rehabilitation Research and Development Center of Excellence.
"I have focused my entire professional work toward improving the lives of people with disabilities, their families, and the people who assist them. Much of my work has been focused on providing mobility, but I have also made excursions into accessibility and assistive technology policy. My first line of research was related to manual wheelchairs: their design, usage, and optimization. Over the past decade, I have focused more of my work on electric-powered mobility. This has led to notable contributions to the PAPAW, IBOT, and other robotic mobility devices.

I have worked with colleagues at Carnegie Mellon from nearly my first day in Pittsburgh, as our common research interests formed natural collaborations. I am most excited by the continuum of basic engineering research through translation to clinical/community integration make working on QoLT stimulating and rewarding in Pittsburgh."
Cooper was just 20 when he was hit by truck while cycling. The accident happened in Germany, where he was stationed in the U.S. Army.

His spinal cord was severely injured, leaving him paralyzed from the waist down. “The most challenging part of the recovery process was adapting to a new perception of myself – it takes longer to adapt emotionally,” Cooper said. “The goal of my education at Cal Poly and athletics kept me going.”
When a young Rory Cooper (EE ’85, Master’s in EE ’86) arrived at Cal Poly in a wheelchair, paralyzed from a cycling accident, his professors saw an engineering challenge.

Nearly a decade before the passage of the Americans with Disabilities Act, Electrical Engineering Professor Saul Goldberg and his colleagues modified the lab benches and classroom materials for Cooper, allowing him to fully participate in the curriculum. The result: an accomplished scholar, award-winning athlete, author and lecturer with an international audience, and a professional career that has impacted thousands of wounded veterans.

Cooper has never forgotten it. “That was the best part of my education at Cal Poly – Professor Goldberg fully embraced the notion of ‘adapting the environment’ and working accordingly,” he recalled.
Figure 1. The overall structure of an EPW control system. The control algorithms receive commands from the user-wheelchair interface, sense the environment through onboard sensors, and generate appropriate motor torques for velocity tracking and obstacle avoidance.
<table>
<thead>
<tr>
<th>EPWs</th>
<th>Drive type</th>
<th>Brief Technical Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Two wheel</td>
<td>Middle drive: The chair is maneuverable in small spaces, but front or rear clusters can get stuck on uneven terrain.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Front drive: The overall speeds are slower, but it is very stable for uneven terrain, up and down hills. The open-loop directional dynamics are unstable.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rear drive: The chair is stable and can achieve high speeds but has largest turning radius.</td>
</tr>
<tr>
<td></td>
<td>Four wheel</td>
<td>Ability to transcend unfavorable terrains such as sand and snow, but usually heavy, expensive, and high maintenance. Typically, unsuitable indoors.</td>
</tr>
<tr>
<td>Suspension</td>
<td>Active</td>
<td>Rare in wheelchairs, but technology can be transferred from automobile industry to automatically adjust suspension system according to driving conditions.</td>
</tr>
<tr>
<td></td>
<td>Passive</td>
<td>The vibration exposure of wheelchair users can be reduced through using springs and hydraulic shock absorbers.</td>
</tr>
<tr>
<td>Stabilization</td>
<td>Active</td>
<td>Actively adjust the system center of gravity by adjusting the speed and direction of contact wheels or automatically moving the seat. For example, the balance function of iBOT.</td>
</tr>
<tr>
<td></td>
<td>Passive</td>
<td>Wheelchair users can adjust the stability especially when going up or down hills by shifting body weight or using electronic control to move the seat position.</td>
</tr>
<tr>
<td>Stair climbing</td>
<td>Track based</td>
<td>Simple autonomous stair-climbing operation possible even on irregular stairs, but usually heavy and can cause possible damage to the stairs.</td>
</tr>
<tr>
<td></td>
<td>Wheel-cluster based</td>
<td>Operate on most stairs and relatively compact, but wheel-cluster rotation may cause passenger discomfort.</td>
</tr>
<tr>
<td></td>
<td>Center of gravity modification and wheel-cluster based</td>
<td>Overall good performance with little or no assistance, but need support rails or assistant and must climb backwards.</td>
</tr>
</tbody>
</table>
Table 2. EPW models and manufacturer information. The EPW models listed in the table incorporate advanced control mechanisms, and the unique control of each wheelchair model is briefly described.

<table>
<thead>
<tr>
<th>Device/Product Name</th>
<th>Organization</th>
<th>Location</th>
<th>Unique Control/Performance Feature</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>iBOT 3000 mobility system</td>
<td>Independence Technology, LLC</td>
<td>New York, USA</td>
<td>Dynamically balanced, multiple functions including stair climbing</td>
<td>Commercially available</td>
</tr>
<tr>
<td>E-motion</td>
<td>Ulrich-Alber GmbH</td>
<td>Albstadt-Tailfingen, Germany</td>
<td>Pushrim activated power assist wheelchair (PAPAW)</td>
<td>Commercially available</td>
</tr>
<tr>
<td>Extreme 4 × 4</td>
<td>Magic Mobility, Inc</td>
<td>Rowville, Australia</td>
<td>Four-wheel drive</td>
<td>Commercially available</td>
</tr>
<tr>
<td>ΩmegaTrac</td>
<td>TEFTEC Mobility, Inc</td>
<td>Texas, USA</td>
<td>Adjustable suspension, transmission steered wheelchair</td>
<td>Commercially available</td>
</tr>
<tr>
<td>Series 8</td>
<td>Glide</td>
<td>Balcatta, Australia</td>
<td>Independent suspension</td>
<td>Commercially available</td>
</tr>
<tr>
<td>Trax</td>
<td>Permobil</td>
<td>Tennessee, USA</td>
<td>Four-wheel independent suspension</td>
<td>Commercially available</td>
</tr>
<tr>
<td>Quickie X-tender</td>
<td>Sunrise Medical Inc.</td>
<td>Colorado, USA</td>
<td>Pushrim activated power assist wheelchair</td>
<td>Commercially available</td>
</tr>
<tr>
<td>TDX</td>
<td>Invacare Corp.</td>
<td>Ohio, USA</td>
<td>Step suspension for curb climbing</td>
<td>Commercially available</td>
</tr>
<tr>
<td>iGlide</td>
<td>Independence Technology, LLC</td>
<td>New York, USA</td>
<td>Pushrim activated power assist wheelchair</td>
<td>Commercially available</td>
</tr>
<tr>
<td>NavChair</td>
<td>University of Michigan</td>
<td>Michigan, USA</td>
<td>Three modes of navigation: obstacle avoidance, door passage, and automatic wall following</td>
<td>Research</td>
</tr>
<tr>
<td>TetraNauta</td>
<td>Universidad de Sevilla</td>
<td>Sevilla, Spain</td>
<td>Autonomous navigation in indoor environments</td>
<td>Research</td>
</tr>
<tr>
<td>SPAM</td>
<td>AT Sciences, LLC &amp; University of Pittsburgh</td>
<td>Pittsburgh, USA</td>
<td>PAPAW with obstacle avoidance modules</td>
<td>Research</td>
</tr>
</tbody>
</table>
Figure 2. Velocity control for powered wheelchairs. The motor control algorithm uses driver commands (desired direction and speed signals) and feedback signals to develop control signals for the motor-drive electronics.
Figure 3. PAPAW. This design is a hybrid between a manual wheelchair and an EPW. Each hub houses a permanent magnet dc motor. Power is supplied by either a single custom-designed NiCd battery or a NiMH battery. The unit contains solid-state modules that a trained technician can replace. To date, the system appears reliable.
Figure 4. PAPAW control structure. The five primary functions of the controller include torque scaling, inertia simulation, speed limiting, load-balance compensation, and status monitoring. These functions enable easy and natural maneuverability of the PAPAW.
**Figure 5.** Active suspension control. $m_s$ is the vehicle sprung mass; $k_s$ is the suspension stiffness; $k_t$ is the tire stiffness; $b_s$ is the suspension damping; $x_s$, $x_w$, and $x_r$ are the displacements of the vehicle, wheel, and road. An actuator exerts a force $u$ between the tire and the vehicle based on sensor readings and algorithms.
Figure 6. Balance mode of the IBOT 3000 Transporter. The IBOT operates on two points of contact with the ground, mimicking a human balance model. The wheels continually move back and forth to compensate for changes in the center of gravity and to maintain system stability. The wheelchair enables users to move around at eye level and reach items on high shelves.
Figure 7. The stair mode of the IBOT 3000 Transporter. The user needs to face down the staircase and hold the handrail. Holding the handrail generates the control signal by causing a center of gravity shift. An assistant can use the assist handle to guide stair climbing by shifting the user’s center of gravity.
Figure 8. Wheelchair navigation system architecture. The localization module estimates the wheelchair position with respect to a starting reference configuration, while the sensors provide direct measurement of obstacles. The guidance of the wheelchair is implemented by the user interface connected with the navigation module through a predefined protocol. The navigation module generates the control variables, and the control module translates these control variables into low-level commands for the motors.
Figure 1. Nickel-Metal Hydride (NiMH) provides for a variety of alternative electric-powered wheelchair designs and are an important advancement. Manufacturer: AAT Alber, Albstadt, Germany.
Figure 2. Four-quadrant control for an electric-powered wheelchair.
Figure 3. Basic motor control diagram.
Figure 4. Example graphs of shaping the user interface output.
Figure 5. Direct current motor with right angle drive and optical encoder. Manufacturer: Sunrise Medical, Inc, Carlsbad, CA.
Figure 6. Photograph of a four-wheel drive electric-powered wheelchair with omni-directional front wheels. This chair is designed for indoor and outdoor mobility over a variety of terrains. Manufacturer: Nissin Medical Industries Co., LTD., Aichi, Japan.
Figure 8. Electric-powered wheelchair controller and joystick with integrated infrared communication for operation of external devices. Manufacturer: Delphi, Troy, MI.
Figure 9. Three basic powered wheelchair frame types. Manufacturers: (left to right) Independence Technologies LLC, Endicott, NY; Sunrise Medical, Longmont, CO; Otto Bock, GMBH, Duderstadt, Germany.
Figure 1.
Example of 10 cm curb descent.
Figure 2.
Suspension angle for (a) Quickie XTR (Sunrise Medical; Carlsbad, California) and (b) A-6S (Invacare Corp; Elyria, Ohio). Dotted line represents path along which axle approaches seat. For ease of measurement, we assumed path was linear instead of arced.
Figure 5.
Elastomer suspension system of Barracuda suspension manual wheelchair (Everest & Jennings; St. Louis, Missouri).
Fig. 1. Conceptual model of a wheelchair on an inclined surface with cross-slope.
Fig. 2. Wheelchair axis systems on a slope showing OAP as the slope surface, $C$ represents the wheelchair, $\alpha$ (up/downhill slope of surface) and $\beta$ (side slope of surface) associated with the surface, $\gamma$ (slope along line of EPW motion) and $\phi$ (cross-slope to EPW motion) associated with the wheelchair, and the EPW direction $\theta$. 
Fig. 3. Mathematical representatives of different views of a wheelchair on a slope.
Fig. 4. Open-loop and closed-loop control systems for the model based control of a wheelchair.
Fig. 5. The smart wheelchair platform used in this experiment.
**Fig. 6.** Five different surfaces on which the experiment was conducted.
Fig. 1. Attendant-propelled wheelchair circa 1920s.
Fig. 2. Heavy, folding frame, depot-style chair with no adjustability.
Fig. 3. Ultralight, adjustable manual wheelchair with rigid frame.
Fig. 4. Advanced mid-wheel drive power wheelchair with reclining seat technology.
Fig. 5. Advanced power wheelchair with tilt function.
Fig. 6. The SMART Wheel.
Fig. 9. Photograph of a Pushrim-Activated Power-Assisted Wheelchair (PAPAW).
Fig. 10. The 3000 iBOT Transporter in balance mode.
Fig. 11. A racing wheelchair.
Fig 1. Image of markers placed on HTD during testing.

Fig 2. Stick figure plot from digitized image of markers during sudden braking. (A) Kinematics of the HTD when it falls from an EPW. (B) Kinematics when the dummy remains in the EPW.
Trabalho valendo 1,0 ponto na média final – poderá ser entregue até o dia 15/09.

Trabalho valendo **1,0 ponto na média final** para cada grupo formado na semana passada.

Cada grupo deverá apresentar uma **revisão bibliográfica**, sob a **ótica da especialidade do grupo** (seja Mecânica, Produção, ou Elétrica) dos **artigos listados nesta apresentação**. Os trabalhos de revisão deverão ser feitos no **formato de TCC**.

Deverão entregar até as **24:00hs do dia 15/09** (por email, Moodle, ou documento impresso).
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