Rehabilitation Robotics and Assistive Robots

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Assistive Robots

Outline

• Mobility aids
  – Locomotion
  – Navigation
• Manipulation aids
  – Interaction with the physical world
  – Therapeutic aids (medical devices)

Theme

– Aids for people with physical disabilities
Mobility Aids: Potential/Future

- > 5 million wheelchair users in the U.S.
- Safe and reliable mobile robotic assistive devices.
- Intelligent homes, buildings communicate with smart wheelchairs
- Extend to other assistive devices (e.g. scooters)
Mobility Aids: State of the Art

- All-Terrain Chairs
- Tracked Systems (Ishimatsu, Hirose)
- Wheeled/Legged Systems (Krovi, Kumar, Wellman)
- Independence iBot (Johnson and Johnson)
Mobility Aids: Significant Accomplishments

• Intelligent chairs
  – Automated navigation tasks/behaviors

• Input modalities to mobile systems provide access to users who may lack fine motor control
  – Gesture recognition, voice command, vision-based interaction, sip and puff devices

• Ability to drive on all terrains (stairs/curbs)
Intelligent wheelchairs

- Miller and Slack (TinMan II): performs tasks such as turning and moving forward, contains an obstacle avoidance mode that overrides the user’s commands
- Kuno, et.al. (Osaka Univ.): direction of face movement controls the system’s motion
- Yanco, et.al. (Wheelesey): path following while avoiding obstacles
- Simpson, Levine, et.al. (NavChair): wall following modes
- Patel et al (Penn SmartChair): combines deliberative and reactive behaviors
Challenges

Research
• Understanding human intention and adapting to it
• Control for human-in-the-loop navigation

Technology
• Flexible input devices
• Inexpensive
  – Why does a good wheelchair cost as much as a top-of-the-line BMW?
Manipulation Aids
Manipulation Aids

Current
- Prosthetic arms
- Feeders
- Robots

PROVAR Assistive Robot System (VA Palo Alto)

Raptor (Applied Resources)

Manus (Exact Dynamics)

Winsford Feeder
Therapeutic Aids: Examples

Schematic (Stanford)

Lokomat (Hocoma)

UCLA/UCI

MIT Manus
Potential

- Exercise machines for neurologic patients

Figure 5  Robots are facilitating an emerging synergy in which an improved understanding of the computational mechanisms and neural substrates of motor learning will drive improvements in motor rehabilitation.

Reinkensmeyer
Potential/Scope

• Robots can teach the nervous system in ways that help it to learn to control movement (better than existing training techniques.)

• The human nervous system itself is an adaptive robotic controller, amenable to re-programming

• Robots can serve as aids for manipulation, locomotion while maximizing neural recovery (robot works itself out of a job)
Accomplishments

• Active movement assistance by the robot is less important, rather repetitive effort by the patient is the primary stimulus for recovery (Reinkensmeyer, Kahn and Rymer at UCI)

• Robot interact with stroke patients to encourage them to exercise the affected limb(s) (Mataric, et al).
Accomplishments

• Mass customization for assistive devices

• Assistive technology (robots, graphics, video games) for stroke rehabilitation (Krebs, Hogan, et al)

• Neuro-rehabilitation (and assessment/evaluation) (Burgar, Lum, Van der Loos)
Accomplishments

• Robotic training algorithms can speed-up learning of a motor skill in healthy subjects (Reinkensmeyer, UCI)

• Demonstrated the feasibility of web-base robotic, tele-movement training (Reinkensmeyer UCI; Krovi, Buffalo)
Challenges (Research)

• Identify movement training algorithms that maximize motor learning and neural recovery, by combining robotics, brain imaging, and neurocomputational modeling

• Automated tools to aid the diagnosis and assessment process (parametric to enable customization)

• Safe and effective human-robot interaction for hands-off assistive robotics
  – find, track, follow, and understand the activity of the patient
  – provide appropriate feedback
  – motivate, engage patient
Challenges (Technology)

• Develop combined therapeutic/assistive rehabilitation robotic systems that are lightweight enough to be worn while performing activities of daily living.
• Inexpensive, safe, back-driveable robots
Challenges: Overarching

• No funding agency owns assistive technology
• U.S. Investments are not comparable to Europe, Japan
• Economics (insurance/health care)