AGING IN PLACE

National Institutes of Health
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PANEL 3

Health transition trajectories: Data to action
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TECHNOLOGIES TO SUPPORT PHYSICAL HEALTH

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PHYSICAL THERAPY

A growing need

- By 2030, 4% of the population will experience a stroke at a cost of over $180 billion
- In 2004 there were 450,000 total knee replacements and 230,000 total hip replacements
- In 2006 250,000 rotator cuff surgeries
- In 2009 250,000 anterior cruciate injuries
- Six or more months of rehabilitation commonly required
Is it on correctly
A Lifetime of Apps
The smartphone of the future will be a constant companion, coach, collaborator, and advisor.
Iterative, Multi-Perspective Users-Centered Design

*Example: Seating Coach*

Focus groups

Wizard of Oz studies

Usability testing

Home deployment

output (avatar)

user preferences panel

outputs (video & graphical)

user’s social context settings

wheel chair user

clinician

spreadsheet-based prescription input

Kiviat graph summary output

graphical trend feedback
QoLT project pipeline

- **User Centered Design Prototype**
  - Smart Orthotics
  - Gastro-enterology
  - Vital Clip
  - Walker stride coach

- **Robust Prototype**
  - Woodworking Angle Gage
  - Office Ergonomics

- **Laboratory Prototype**
  - Ergobuddy
  - Wheelchair Propulsion
  - PT Coach
  - Carpal Tunnel Coach
  - Stroke Rehabilitation Coach

- **Field-deployed System**
  - IMPACT
  - MemExerciser
  - HeadCoach

- **Commercial Product**
  - First Person Vision
  - Seating Coach

**Examples**:
- Walker Stride Coach
- Physical Therapy Coach
- Stroke Therapy Coach
- HeadCoach
- Seating Coach
Health Kiosk

physical form and user interactions

Early prototype (for proof of functionality)

Developing prototype (for usability testing)

Mature prototype (for field deployment)

time

blood pressure measurement instructions

video loop

single screen with multiple steps

sequence of screens with 1 step each
STROKE REHABILITATION EXERCISES

- Normalized Hidden Markov Model recognizes correct and erroneous exercise movements
- Encouragement and corrections are provided by audio and textual feedback

Kinect
Game Suite for Stroke Rehabilitation

Combination of several games

“Bow and Arrow”: relates to the Reach a Light Switch exercise

“Fishing”: relates to Bring a Cup up to the Mouth exercise

Clinician interface for adjustment of thresholds
STROKE REHABILITATION WITH EMOTION DETECTION

User

Coach

“Do you want to start with the exercise?”

Yes / No

Start Exercise N

You are doing very well. Let’s keep going

“Would you like to take rest for 15 seconds and continue”

Yes / No

Start – Exercise N +1

How are you doing?

Patient’s response

Stop Virtual Coach

Emotion Detection (Neutral Detected)

Word Spotting (Yes detected)

Emotion Detection (Angry Detected)
VIRTUAL COACH TEAM COMPOSITION

- Biomedical Engineering
- Computer Science
- Electrical and Computer Engineering
- Human-Computer Interaction
- Nursing
- Occupational Therapy
- Physical Therapy
- Psychology
- Rehabilitation Engineering
- Robotics
A TALE OF TWO PASSAGES

Nursing Home, CHF

- Medications – doctors did not check each others list
- Model of what going on in body not conveyed
  - Confusing to be told one day to drink as much as you like, next day no water
- Extraordinary Measures
  - Dialysis to remove water
  - Doctor told him going to amputate both legs without checking with family – passed away six hours later

Independent Living, Hospice

- Loss of control
  - Once in nursing home under nursing home doctor who did not return calls
  - Had to work with physical therapist to get release
  - Blood sugar reading – if can not do herself have to go into nursing home
  - Wanted to do feeding tube
- Lack of sensitivity
  - Placed in room next to where her husband died, roommate pleading to die
- Hospice
  - Removed IV, medications, talking and sipping ice chips in 24 hours
  - Did not know of home care possibility – passed away in a home setting with children, community events
A TALE OF TWO PASSAGES – POTENTIAL TECHNOLOGIES

Nursing Home, CHF

- Medications - Communications
- Model of what going on in body not conveyed – Descriptive Models
- Extraordinary Measures
  - Dialysis to remove water – Descriptive Models
  - Doctor told him going to amputate both legs without checking with family – Communications

Independent Living, Hospice

- Loss of control
  - Under nursing home doctor who did not return calls - Communications
  - Had to work with physical therapist to get release - Communications
  - Blood sugar reading – if can not do herself have to go into nursing home – Virtual Coaches
- Lack of sensitivity
  - Placed in room next to where her husband died, roommate pleading to die - History
- Hospice
  - Removed IV, medications, talking and sipping ice chips in 24 hours - Descriptive Models
  - Did not know of home care possibility – Match
RESEARCH BARRIERS

• Fundamental Knowledge
  – Individual differences and unpredictability
  – Models of noise and uncertainty
  – Contextual variability
  – Complex Interactions

• Technology
  – Safety assurance
  – Robustness and Generality
  – Interoperability
  – Multidisciplinary collaboration challenges

• Technology Integration
  – Privacy concerns
  – Market factors
  – User acceptance
  – Demonstrating value
RESEARCH QUESTIONS

• How can technology be made more engaging thereby avoiding early abandonment
• How can complexity of interactions be simplified
• How can technology adapt as my ability changes
• How can technology interactions be personalized
• How can technology motivate to change behavior
• How can interactions be more like exchanges with humans
• How can the technology interactions modify interaction within a session as my mood changes
• How can technology ease the burden of caregivers
• How can the support team (doctors, nurses, engineers) be unified and synchronized from design to implementation to development
How to make technology adapt to my needs as my abilities change

Machine Learning

Virtual Coaches

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