Using Wearable Devices to Detect Stability and Prevent Falls in the Elderly

Peter J. Gilgunn
Assistant Research Professor of Electrical and Computer Engineering
Carnegie Mellon University
Outline

• Cost of Senior Falls
• Current Practices in Fall Prevention
• Technological Solutions

• Cygnetiqs Fall Prevention
  • CIRC-funded project
  • Stability monitor
  • Intervention
Challenge of Senior Falls in US

• Every 17 s a senior is treated in an ER for a fall

• Every 30 min a senior dies from a fall-related injury

• 2012 direct medical costs $30B for falls in seniors

Source: http://www.cdc.gov/HomeandRecreationalSafety/Falls/index.html

• Go to SFU TIPS YouTube Video clips
  • Prof. S. Robinovitch
  • Simon Fraser University, Technology for Injury Prevention in Seniors
Challenge of Senior Falls – Many Causes

Dizziness/Disorientation

Risk Behavior

Trip Hazards

Causes:
vestibular deficiency, prior injury,
medication, nutrition, incorrect
eyeglass prescription, illness,
lighting, color pattern, noise
Cost of Senior Falls

Total Personal Healthcare Per-capita Spending 2006

Source: Centers for Medicaid and Medicaid Services, Office of the Actuary, National Health Statistics Group
Cost of Senior Falls

Lifetime Medical Costs of Fatal Fall-Related Injuries in 2005

Source: Centers for Disease Control and Prevention [http://www.cdc.gov/homeandrecreationalsafety/Falls/data/cost-estimates.html](http://www.cdc.gov/homeandrecreationalsafety/Falls/data/cost-estimates.html)
Cost of Senior Falls

Lifetime Medical Costs of Non-Fatal Fall-Related Injuries Treated in ERs and Released in 2005

Total Treated
Male 320,381
Female 684,905

Total Costs=$149 M

Source: Centers for Disease Control and Prevention http://www.cdc.gov/homeandrecreationalssafety/Falls/data/cost-estimates.html
Cost of Senior Falls

Lifetime Medical Costs of Non-Fatal Fall-Related Injuries Treated in ERs and Hospitalized in 2005

![Bar chart showing lifetime medical costs for different age groups and genders.](chart.png)

**Total Treated**
- Male: 102,464
- Female: 208,658

**Cost in $M**
- 65-69: 400
- 70-74: 200
- 75-79: 600
- 80-84: 1,400
- 85+: 300

Source: Centers for Disease Control and Prevention [http://www.cdc.gov/homeandrecreatonsafety/Falls/data/cost-estimates.html](http://www.cdc.gov/homeandrecreationalssafety/Falls/data/cost-estimates.html)

DHTI Wearables 10-28-14

© Peter J Gilgunk 2014
Additional Costs of Senior Falls

- Disability costs
- Reduced quality of life of senior who fell
- Work loss
- Emotional impact on family members
- Property damage
- Lowered property values
- Community anxiety
- Judicial and litigation costs
Cost of Senior Falls – Future Increases

Source: US Census Bureau, Census 2000 Summary File 1 and 2010 Census Summary File 1
Pittsburgh-Specific Demographic Trend

Source: University of Pittsburgh, Center for Social and Urban Research, 2003
Based on 2000 Census Data
Current Practice in Fall Prevention

- Intensive nursing intervention in care settings
  - Intake checklists and periodic assessments
  - Attending activities of daily living (ADL)
  - Senior activity restriction
- Environmental control
- Physical exercise
- Dietary supplements
- Surgery

Action Towards Changing Practices

• CDC STEADI (Stopping Elderly Accidents, Death and Injuries) Tool Kit

• PCORI (Patient-Centered Outcomes Research Institute) with NIA and NIH
  • 2013 - Clinical Trial of a Multifactorial Fall Injury Prevention Strategy in Older Persons
  • $30M over 5 years to single team (Harvard, Yale, David Geffen School of Medicine), Year 1 - $7.6M
  • Claude D. Pepper Older Americans Independence Centers
  • 6000 adults 75 years and older
  • 10 trial sites covering each US region
  • Physician-patient customized programs
Technological Fall Prevention

- Fall detection sets the bar too low
- Physiotherapy post-event is too late
- Active intervention is needed

- Posture Monitor and Coach
  - OPAL - APDM founded 2007
  - Lift – Lumo founded 2011

- Activity Monitoring
  - Bodymedia/Jawbone
  - Sensogram Technologies

Lift
Multiple OPALS
Arm band
Sensotrack
Cygnetiqs

• Balance technology and analytics
• Posture stability analysis and intervention
• CIRC-Funded – kicked off Jan. 2014

Packaging
Bio-physics

Hardware

Smartphone
Integration

Machine
Learning

Peter J Gilgunn
Assistant Research
Professor of ECE

Zhou Yurui
Research Assistant
MS Student ECE

Yu-Chi Chen
Research Extern
MS ECE

Anuva Kulkarni
Research Assistant
MS Student ECE
Cygnetiqs Fall Prevention Goals

- Prolong senior independence
- Improve quality of life by reducing anxiety
- Reduce injury and death
- Reduce economic impact
Cygnetiqs – System Design

• Three components
  • 6-axis inertial measurement unit
  • Quad core multi-threaded Smartphone
  • Mobile tablet server

Sensor: acceleration and angular speed
Bluetooth Low Energy
Smartphone: UI, classification and intervention
Wi-Fi
WAMP Server: database and machine learning
Cygnetiqs - Specifications

• ±2g acceleration on 3 axes
• ±250°/s angular velocity about 3 axes
• 16 bit output per channel
• Transmit 110 samples per second per sensor axis
• 1m BLE range
• Coin battery operated
• Hearing aid form factor
• 14 g with battery
• Stability classification rate < 1 s
Classifier output: Probability of Stability

- ADL training sets
- Window and stride optimization
- Manifold partition: stable motion, stable stillness, and unstable
- Intervention called on a duration of instability
Summa

• Senior falls have a broad societal impact

• Wearables can augment fall prevention strategies

• Wearables can enable human-machine collaboration

• Warrants full-scale product development effort

• Save lives and reduce costs
Acknowledgments

• The Cygnetiqs system was built through a grant from Carnegie Mellon University through the CMU-SYSU Collaborative Innovation and Research Center (CIRC)