Eldercare and Rehabilitation Technology for Better Health

Marjorie Skubic, PhD
Professor, Electrical and Computer Engineering
Director, Center for Eldercare and Rehabilitation Technology
University of Missouri

www.eldertech.missouri.edu

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Center for Eldercare and Rehabilitation Technology

- Depth sensor
- Doppler radar
- Bed sensor
- Motion sensors
- Kinect sensor

Injury prevention

Remote physical therapy

Early illness detection

Sports Doctors
Physical Therapists

Nurses
Social Workers

Medical professionals and technology tools for elder care and rehabilitation.
Center for Eldercare and Rehabilitation Technology

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- Nurses
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Squaring the Life Curve

Functional Decline

Time

Functional Ability

Current trend

With proactive care

Rantz et al, Nursing Outlook, 2005
Sensor Network for Health Alerts

Clinical decision support system

Sensor Data

Integration & Data Storage

Detection of Health Change or Functional Decline

Alert Manager

Web portal & Mobile devices

Health change email alert

Alert Feedback

Clinical Care Coordinator

Skubic, et al., IEEE J. of Trans. Eng. in Health & Medicine, 2015
TigerPlace
54 apartments
Designed for Aging in Place

- 65 residents, aged from about 70 to 100
- 90% have a chronic illness
  - e.g., arthritis, heart disease, diabetes, stroke risk
- 60% have multiple chronic illnesses
- Some early stage Alzheimers
- 35% use a walker; some wheelchairs
- Residents tend to be socially active
Squaring the Life Curve

• TigerPlace residents without in-home sensors stay 2 years longer than seniors in comparable housing
• TigerPlace residents with in-home sensors stay 1.7 years longer than those without sensors at TigerPlace

Case Study: Diagnosis & history of depression

Aug. 18 – Sept. 18, 2009

Depression managed & followed by a geriatric psychiatrist

Mar. 26 – April 25, 2010

After personal losses resident reported low energy, had trouble eating, and stopped going to the dining room

Oct. 1 – Oct. 31, 2010

After intervention, resident’s activity pattern increased

S. Wang et al., JBHI, 2012; Galambos et al., Gerontechnology, 2013
illnesses detected early

- urinary tract infections
- pneumonia & other upper respiratory infections
- increasing congestive heart failure
- pain post hospitalization
- delirium
- low blood sugar

Uses a model of early illness recognition to generalize across different health problems

MU Hydraulic Bed Sensor
Captures the ballistocardiogram & respiration

Heise et al., 2011, 2013
Heartbeats detected from bed sensor

Finger sensor

Beat to beat interval

Rosales et al., 2012
New Algorithm:
Computing Energy and locating the peaks

Energy Detection Results

Peak Locations

Finger pulse

Lydon et al, EMBC 2015
Results: Older Adult from TigerPlace

Jan, 2014

Nov, 2014
Validation in the Lab

Walking Speed

Stride Time

Stride Length

Walking Path

Kinect #1

Kinect #2

Camera #1

Camera #2

8.9 m

7.3 m

Vicon

Kinect #1

Kinect #2

webcam
Capturing Gait in the Home

Case Study: Capturing Gait Changes

“Healthy” Husband

Wife with Parkinson’s

Decrease in walking speed Decrease in stride length
Capturing Falls in the Home with Depth Sensors


In-Home Falls:  https://www.youtube.com/watch?v=TFB7YOUmHho
False Alarms in the Home
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Remote Personalized Physical Therapy

In-Home Interface

“Synchronous” HD Video Conferencing with 3D Sensing

PT Interface

Kansas City Home

Calyam et al., 2015.

Senior at Home

Physical Therapy Clinic

Physical Therapist

GENI-enabled Networking
Microsoft Kinect

- Color camera
- Depth camera
- Microphones

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color Camera</td>
<td>1920 x 1080 @ 30 fps</td>
</tr>
<tr>
<td>Depth Camera</td>
<td>512 x 424</td>
</tr>
<tr>
<td>Max Depth Distance</td>
<td>~4.5 m</td>
</tr>
<tr>
<td>Min Depth Distance</td>
<td>50 cm</td>
</tr>
<tr>
<td>Horizontal Field of View</td>
<td>70 degrees</td>
</tr>
<tr>
<td>Vertical Field of View</td>
<td>60 degrees</td>
</tr>
<tr>
<td>Skeleton Model</td>
<td>26 joints</td>
</tr>
<tr>
<td>Skeletons Tracked</td>
<td>6</td>
</tr>
</tbody>
</table>
Remote Physical Therapy – from clinic to home

• More than video conferencing; Includes 3D sensing

In-home “patient” view

Physical therapist view

Controlled by voice commands

Mishra et al., 2015
PT side

Mishra et al., 2015
Eldertech Collaborators

Nursing

Social Work

CS/Engineering

Physical Therapy

Education

Foresite Healthcare

Family Medicine

HMI
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Assessing for ACL Injury Risk
Portable Screening Tool

Stone, Butler, McRuer, Gray, Marks & Skubic, 2013

Initial Contact

Left Valgus (degrees): -9.43
Right Valgus (degrees): -5.76
Knee/Ankle Separation: 0.73

Peak Flexion

Left Valgus (degrees): -10.01
Right Valgus (degrees): -3.75
Knee/Ankle Separation: 0.79

Close
Screening in Area High Schools

168 high school athletes
Exergame Prototypes

Huo et al., 2015
Recognizing Harmful Hand Postures

Savvidou, Li, Willis & Skubic, 2015
Hands are tracked & assessed in depth videos using the Kinect

Li, Savvidou, Willis & Skubic, 2014
Prehab/Rehab Collaborators

CS/Engineering

Medicine

Music

Social Work

Physical Therapy

Occupational Therapy
Our Goal: Healthy Living at Any Age