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Using Lab-of-things in Wearable Computing Research and IoT Education

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Acknowledgements:
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Microsoft

Motivation: Home Automation for Paralysis Patients

12,000 Spinal Cord injuries/year

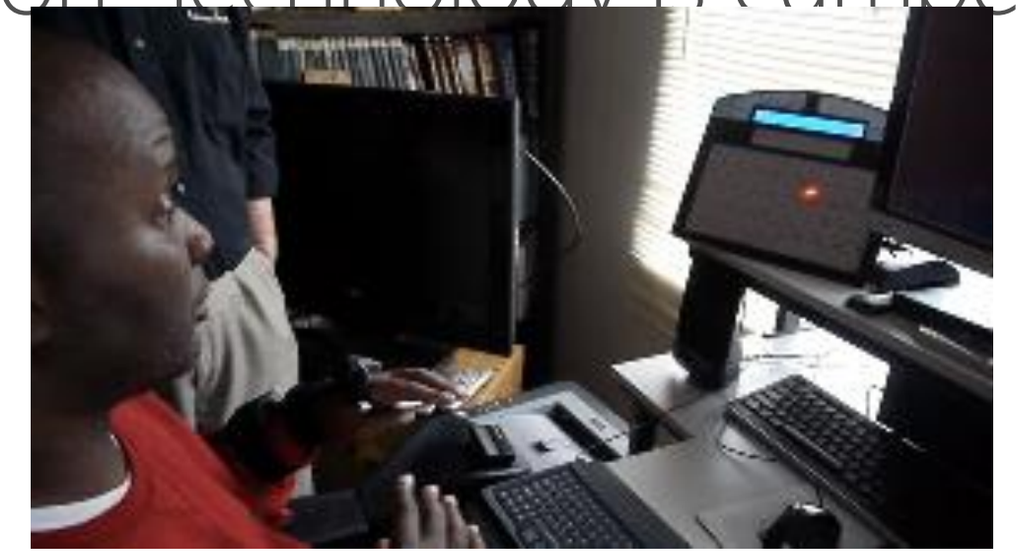
lifetime costs vary
from 1-2 million

Estimated Lifetime Costs by Age of Injury

Severity of Injury	25 Years Old	50 Years Old
High Tetraplegia (C1-C4)	$4,53,182	$2,496,856
Low Tetraplegia (C5-C8)	$3,319,533	$2,041,809
Paraplegia	$2,221,596	$1,457,967
Incomplete motor function at any level	$1,517,806	$1,071,309

can we reduce the dependence on assistive care facilities?

Motivation: Technology is cumbersome and expensive



Laser-based keyboard

Interview-based study on the usability of these systems
10 patients (SCI, TBI, Scleroderma, PI]

It was wireless, which, the idea was good, but how it was implemented it was just a big clutter of stuff -- SCI patient [sip-n-puff nurse calling system]

I could switch the TV on…usually took a while.. The channels went up and I couldn't adjust the volume - on the laser-based TV control system

Non-intrusive wearable sensors for environmental control

Wheechair pads

Pillow covers

Clothing

Gesture Recognition

Environmental Control

(controlling appliances, nurse calls, making 911 calls)

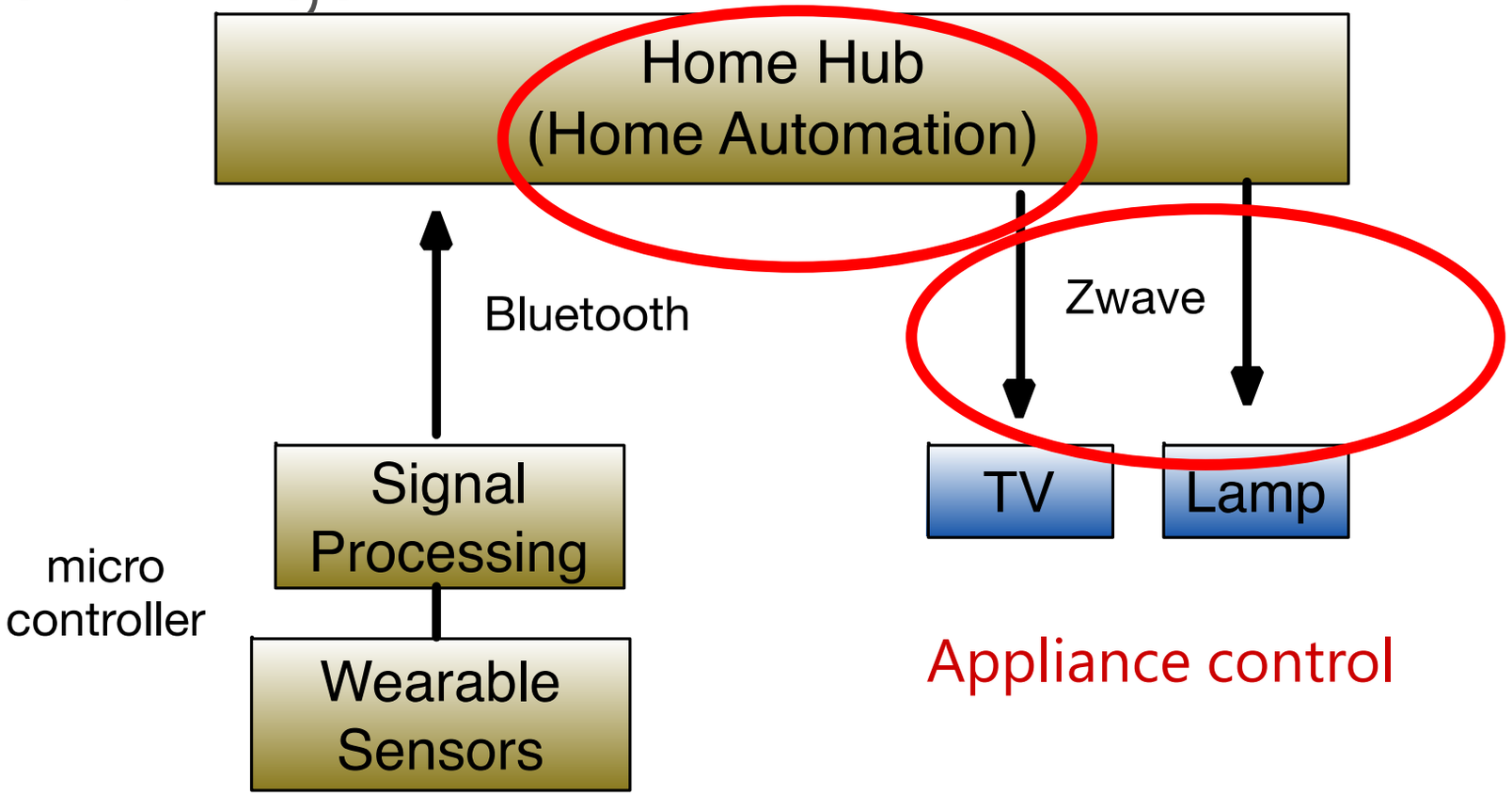
Challenges

- Design wearable and durable proximity sensors
  - proximity sensing as touch may cause skin abrasion
  - non-intrusive sensors that meld into environment
  - low power consumption

- Adaptive Signal Processing
  - sensors should detect gestures irrespective of patient position and environmental noise

Why Lab of things

Lab-of-things

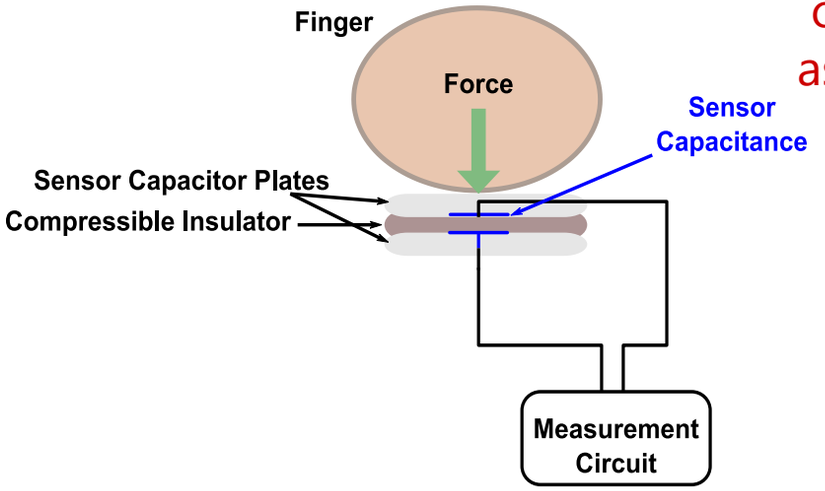


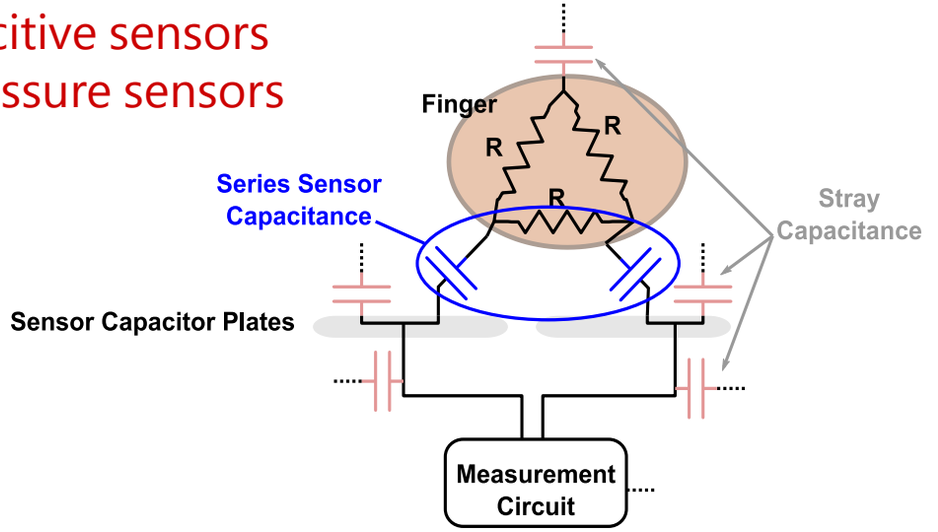
Appliance control

Allows focus on the core research component

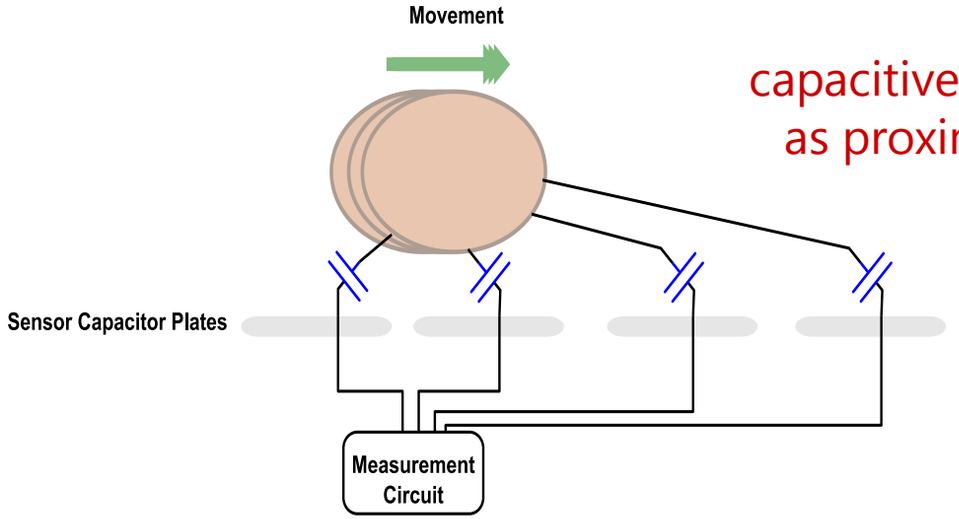
Capacitive Sensors Arrays as Proximity Sensors

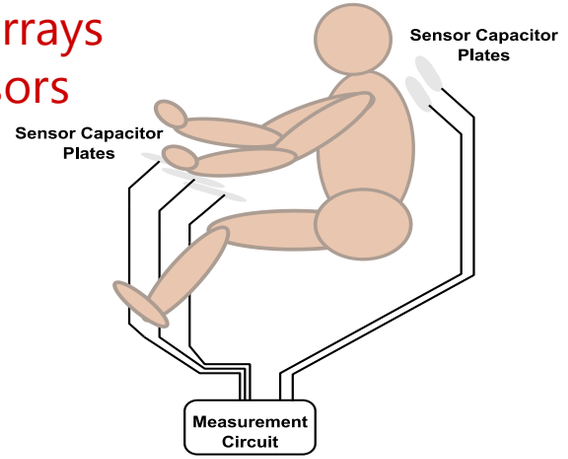
capacitive sensors
as pressure sensors



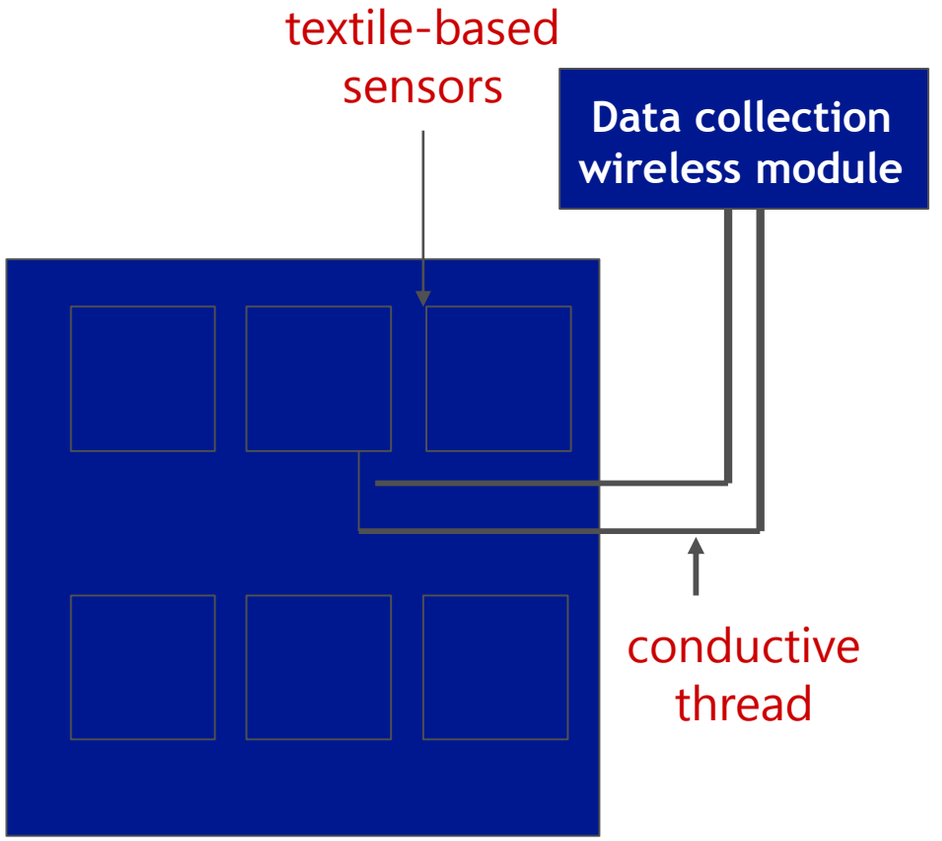


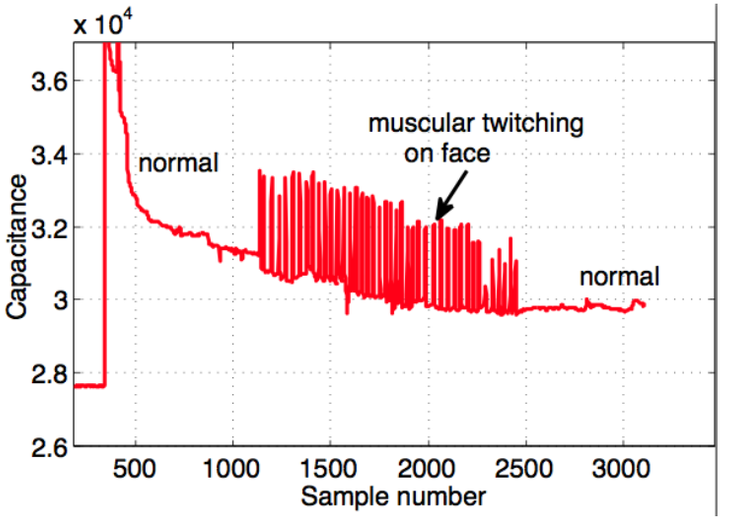
capacitive sensor arrays
as proximity sensors

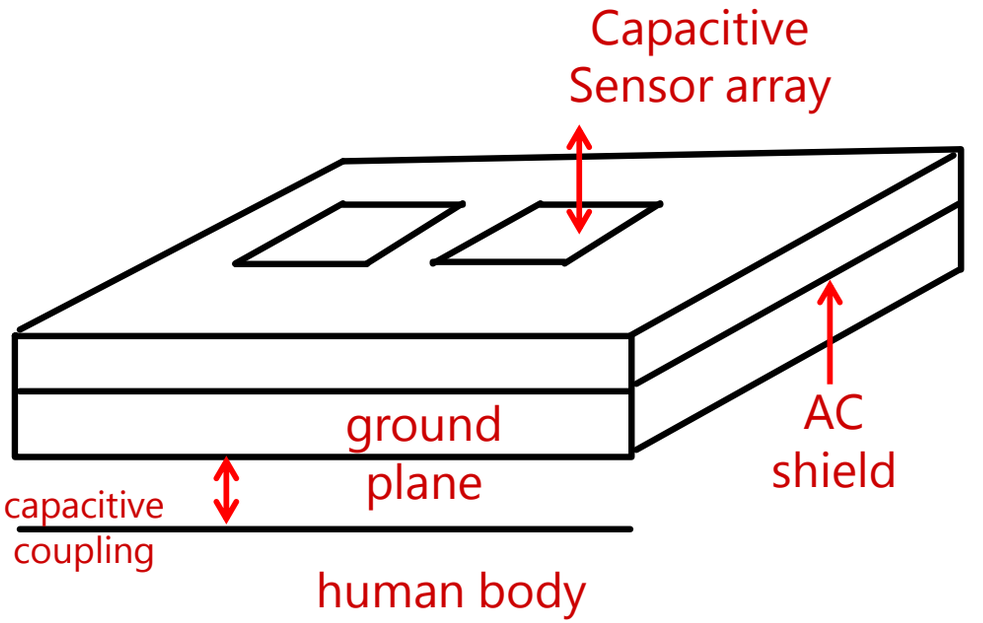




Textile-based Capacitive Sensors

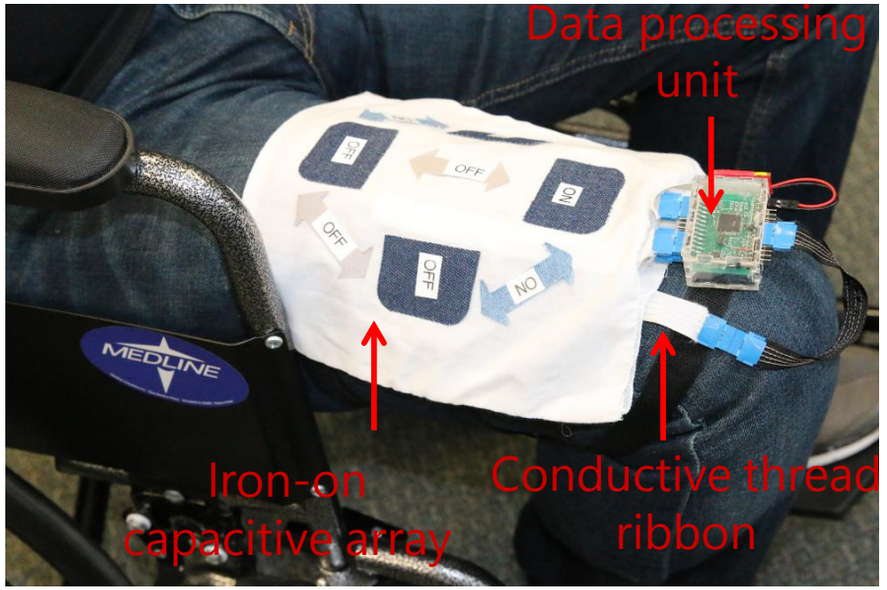


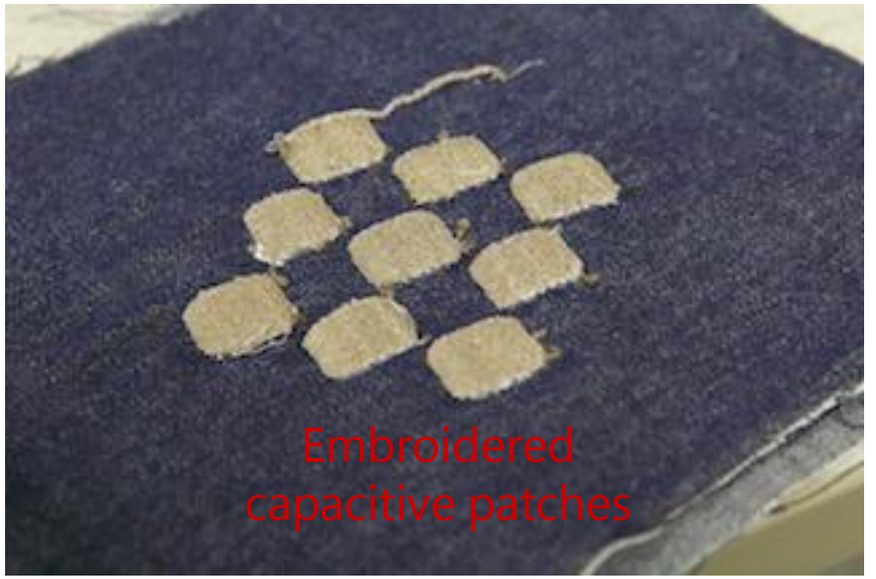


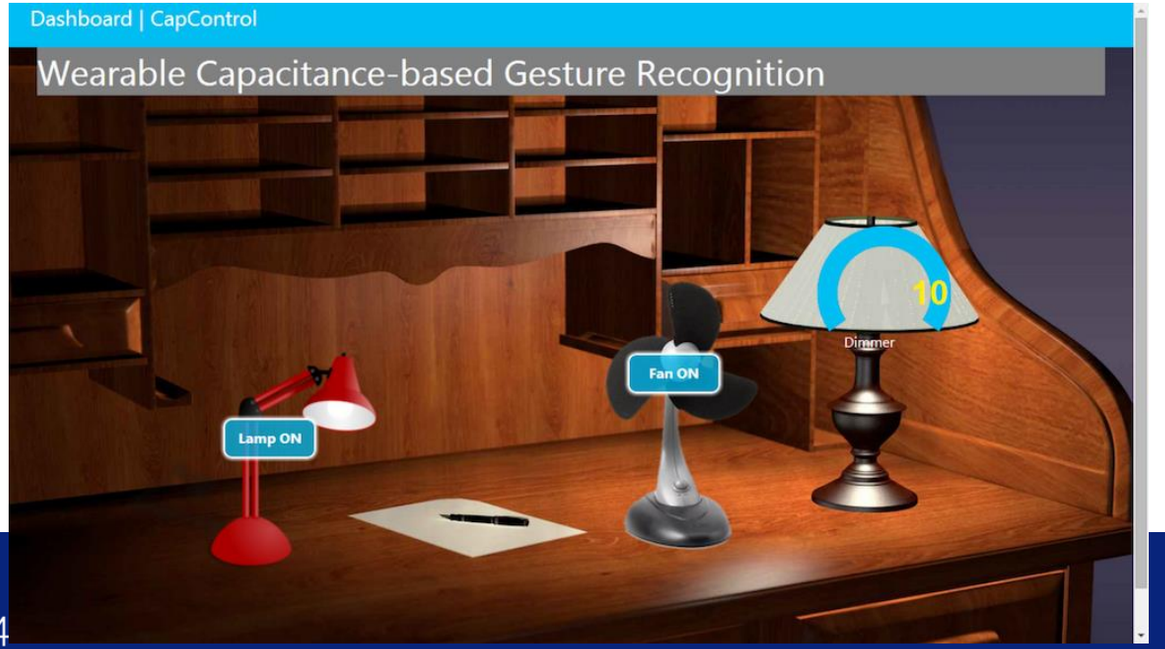


Raw capacitance is measured between the plate and human body

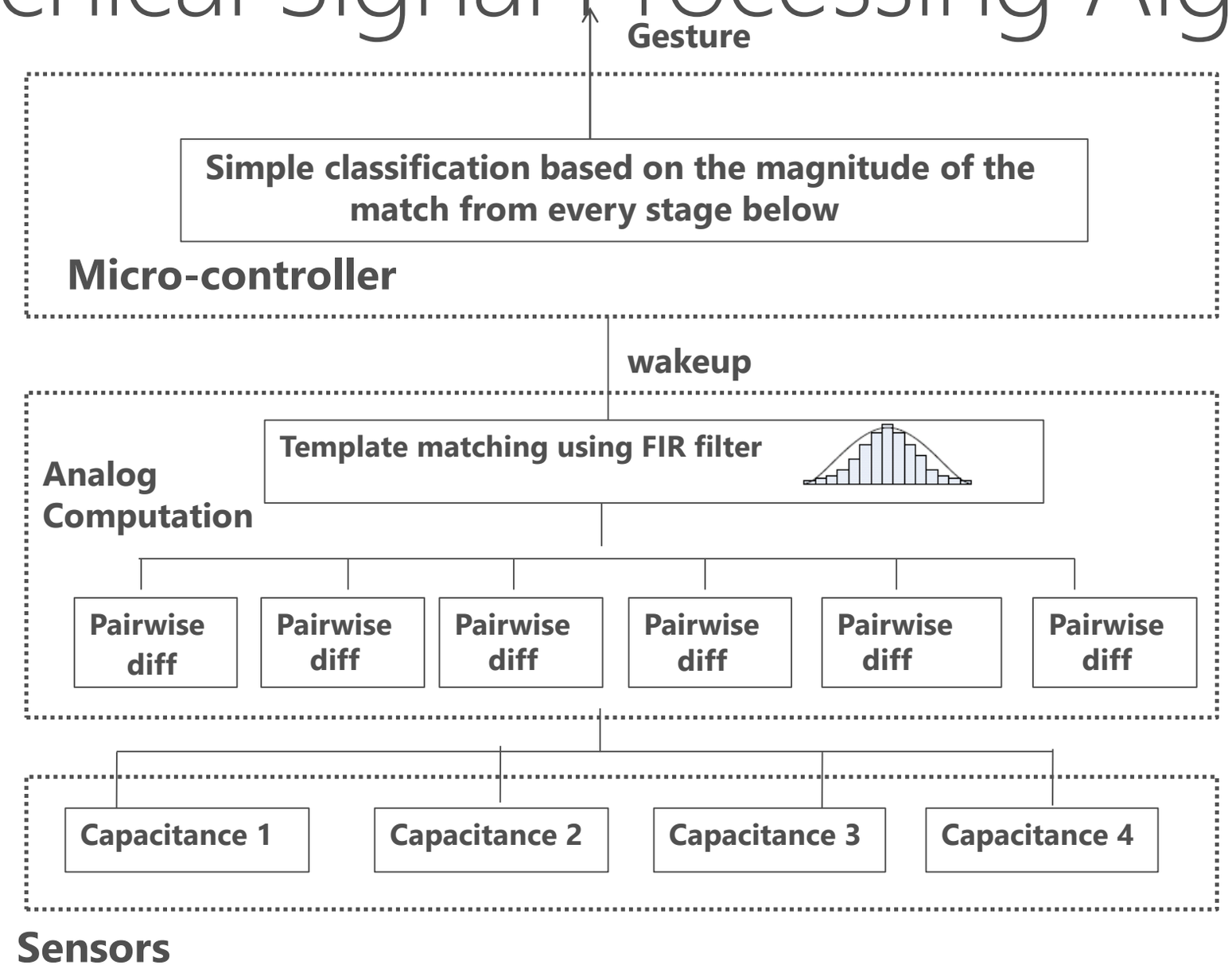
Hardware Prototype





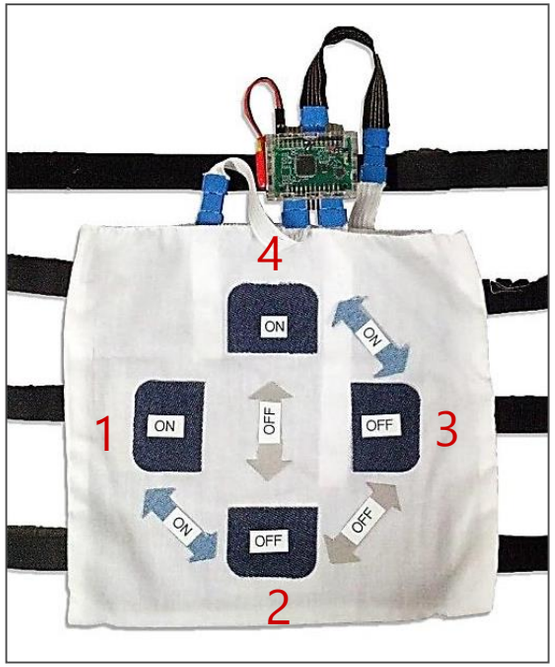


Hierarchical Signal Processing Algorithm

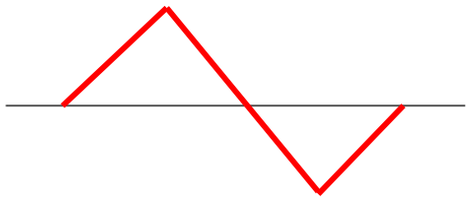


Example Pattern matching

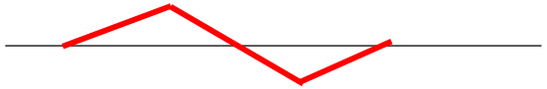
Gesture = Swipe (1,4)



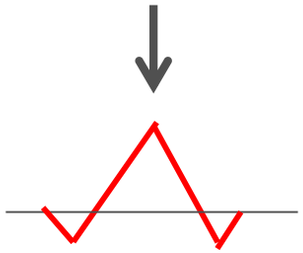
diff (1,4)

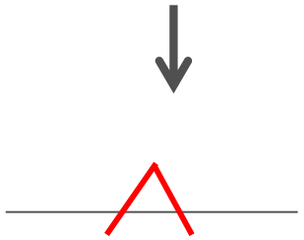


diff (2,3)



FIR :: template =





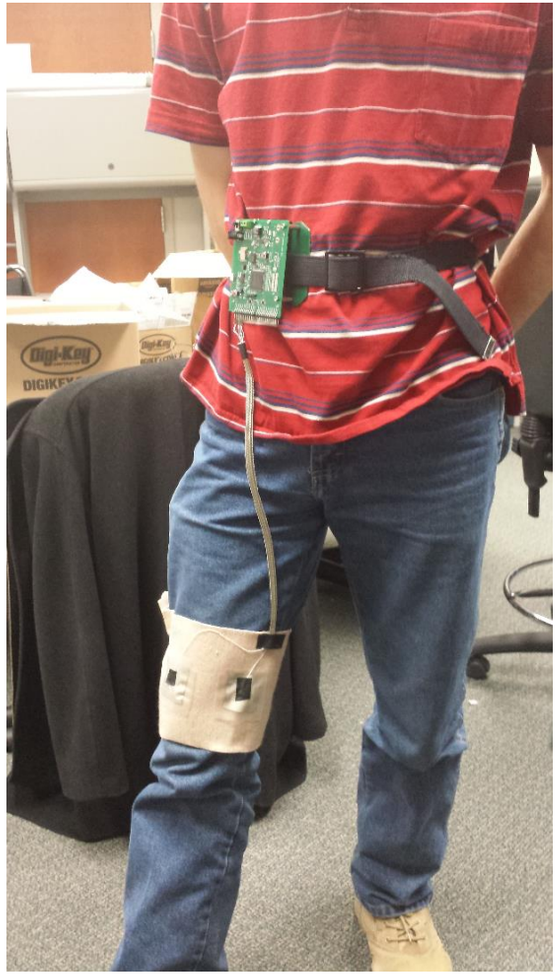
FIR magnitude output

0.8

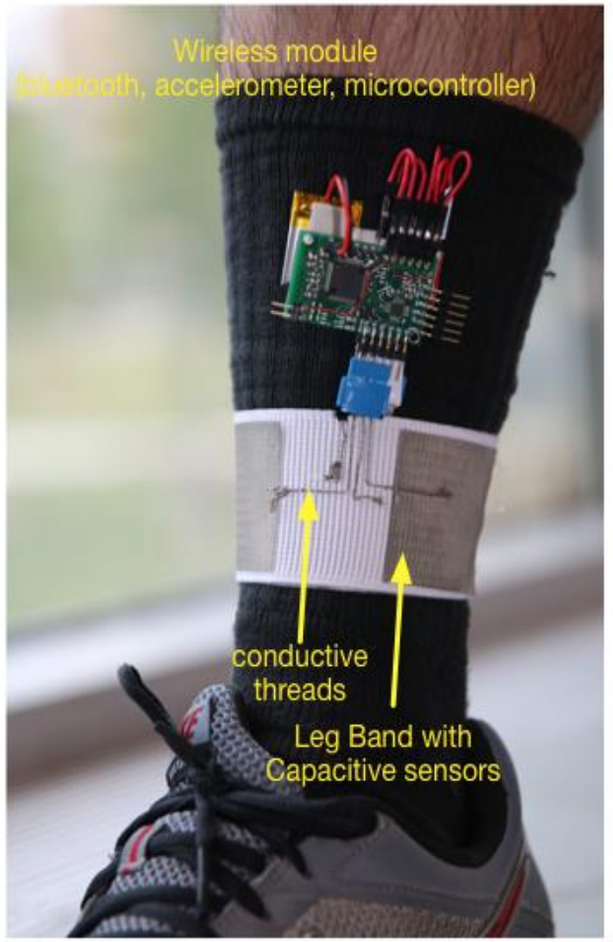
0.6

Gesture

Other applications



Gait Analysis



Ankle and leg flexing motion for Rest Less Leg Syndrome

Using Lab-of-things for Classroom Teaching

- Taught a “Systems for Smart Home Automation” course
  - Spring 2014
  - 20 students (mix of graduate and undergraduate)
  - Computer Science and Computer Engineering majors
  - All material available:

    http://www.csee.umbc.edu/~nilanb/teaching/691

- Use lab-of-things as the platform for teaching home automation
  - Initial learning curve for C# and .Net concepts like .Net remoting, System.AddIn, WCF.
  - Final project where students had to demonstrate their learning through a demoable Lab-of-things project

Syllabus divided into four modules

Cloud storage, web services, Remote access

Working with actual sensors
[z-wave, cameras, kinect, energy meters, .Net Gageteer]

Basics of HomeOS (core of LoT)
[Applications, Drivers, Scouts, ports, roles, Application domains]

Basic of C#, .Net concepts
[WCF, System.AddIn, Unsafe Code, Attributes]

Sample Project completed in a month's time

https://www.youtube.com/watch?v=mxvA2bmWMqY&feature=youtu.be

Conclusions

- Used lab of things for building wearable gesture recognition system
  - Use textile-based capacitive sensors as proximity sensors
  - Hierarchical signal processing algorithm for gesture detection.
  - Lab-of-things provided the tool that made integrating our sensors with a home automation system seamless

- Use Lab-of-things for classroom teaching
  - Students were able to produce fairly complex projects in less than a month time.
  - Some initial learning curve especially in learning .Net concepts

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Microsoft

Save the planet and return
your name badge before you
leave (on Tuesday)