Progress Report: Quantifying Spasticity

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with Olivia Sutton and Tony Wang

Client: Dr. Jack Engsberg

The Need

A device that can accurately quantify spasticity for cerebral palsy patients

Modified Ashworth Scale

Description: Current standard examination that qualitatively characterizes spasticity

Pros:

- Cheap, convenient, easy, versatile

Cons:

- Very inaccurate and unrepeatable
- Hard to gain the intuition required to perform well

Grade	Description
0	No increase in muscle tone
1	Slight increase in muscle tone, manifested by a catch and release or by minimal resistance at the end range of motion when the affected parties moved in flexion or extension
1+	Slight increase in muscle tone, manifested by a catch, followed by minimal resistance throughout the remainder (less than half) of the range of motion
2	More marked increase in muscle tone through most of the range of motion, but the affected part is easily moved
3	Considerable increase in muscle tone, passive movement is difficult
4	Affected part is rigid in flexion or extension

American Academy of Orthotists and Prosthetists, 2013

Project Scope

Design a device (hardware+software) needed to measure the three major parameters that factor into spasticity: range of motion, velocity, and force

Chosen Design Features

Characteristic	Specification
Cost	Less than $200
Portability	Does not require external power supply.
Accuracy	Able to distinguish between at least 5 categories of spasticity
Reliability	Less than 10% error between repeated trials of the same patient on the same joint

Characteristic	Specification
Versatility	Must accommodate a shin or wrist ranging from 15 cm to 45 cm in circumference
Size	Ideally no larger than 21.6 x 19 x 5 cm
Training	Must not require more than 10 minutes of training for a physician to effectively use.
Ease of Use	Must have a simple interface and a corresponding test that can be quickly performed

Design Alternatives

- Range of Motion
- Velocity
- Resistive Force

Range of Motion and Velocity Sensing Devices

- Xbox Kinect
- Dartfish
- Accelerometer
- Smartphone Accelerometer

Xbox Kinect

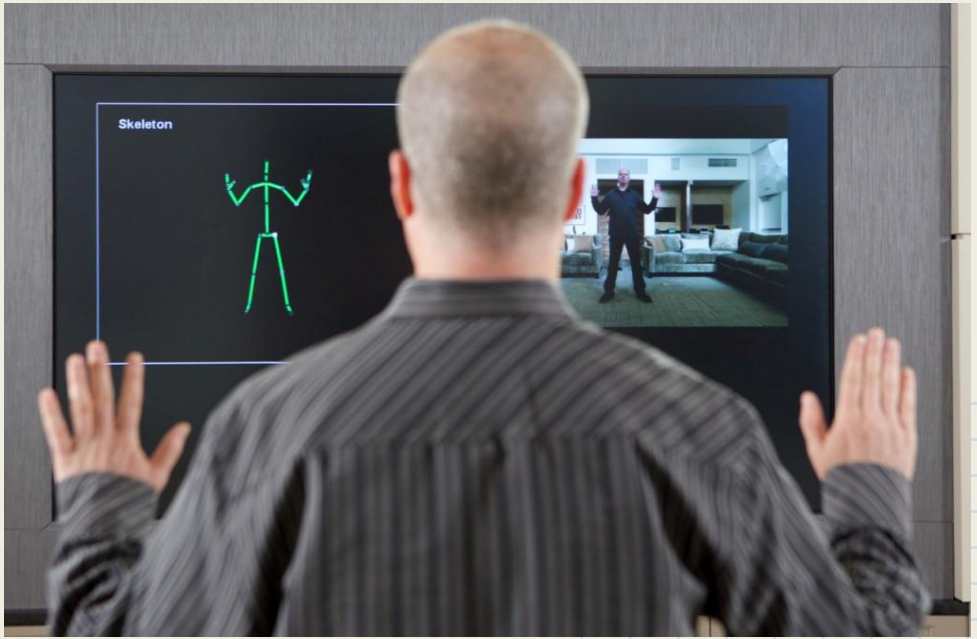
Description: Camera system that can connect to a computer to track and record movement

Pros:

- Easily connected to any computer

Cons:

- Lacks portability
- Physician performing test may make it inaccurate



Medical Expo (2014)

Dartfish

Description: Software program that analyzes a recorded video and has the ability to track arm or leg movement

Pros:

- Accurate and reliable
- Can be used on many platforms

Cons:

- Expensive (>$1000)
- Not portable and long time associated with each test

Ambra Solutions (2014)

Accelerometer

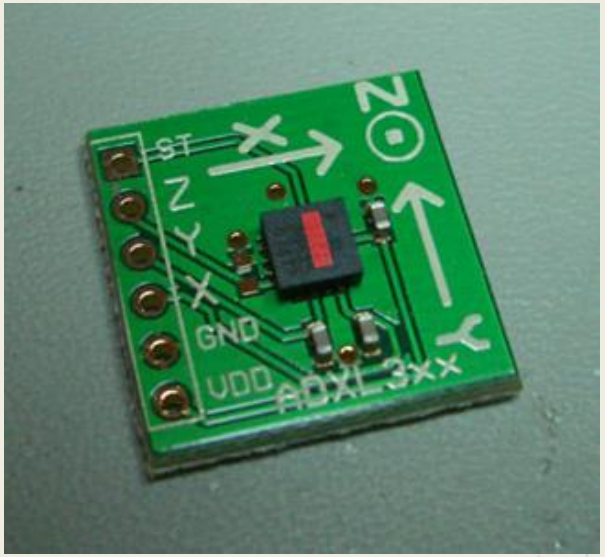
Description: A device that is able to measure acceleration due to gravity

Pros:

- Cheap and easily portable
- Easy for physician to use

Cons:

- An additional component to the hardware
- Less accurate



Protolab (2007)

Smartphone Accelerometer

Description:

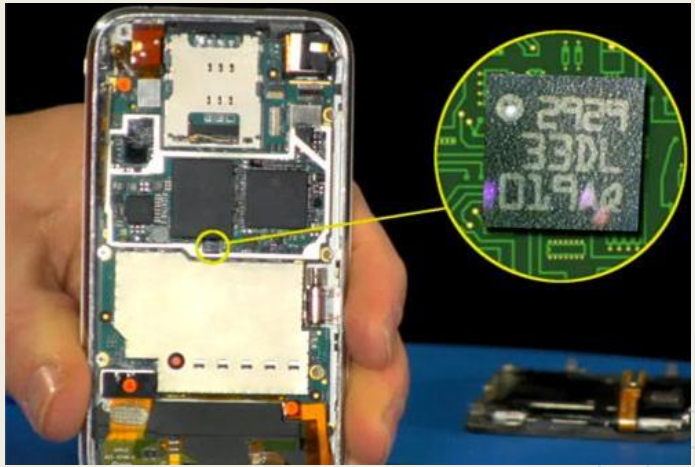
- Silicon-based accelerometer chip seated inside center of phone
- Measures proper acceleration

Pros:

- Reliable; relatively small and light
- Most clinicians already carry a smartphone with them
  - convenient; no addition cost
- Software is Java-based, lots of programming support

Cons:

- Less accurate



http://www.engadget.com/2012/05/22/the-engineer-guy-shows-how-a-smartphone-accelerometer-works/

Velocity

Velocity	Weight	Xbox Kinect	Dartfish	Accelerometer	Smartphone Accelerometer
Cost	6	3	0	8	10
Due Date	5	2	0	7	10
Portability	10	0	0	9	10
Software	6	2	7	5	8
Accuracy	10	8	10	7	7
Reliability	10	9	10	7	7
Versatility	7	10	10	7	7
Size	9	0	0	10	8
Ease of Use	10	3	0	9	9
TOTAL (max 730)		310	312	572	609

Range of Motion

Range of Motion	Weight	Xbox Kinect	Dartfish	Accelerometer	Smartphone Accelerometer
Cost	6	2	0	8	10
Due Date	5	2	0	6	10
Portability	10	0	0	9	10
Software	6	3	7	5	8
Accuracy	10	8	10	8	8
Reliability	10	9	10	7	7
Versatility	7	10	10	7	7
Size	9	0	0	10	8
Ease of Use	10	3	1	10	10
TOTAL (max 730)		310	322	587	629

Force Measurement Devices

- Stretch Transducer
- Strain Gauge
- Force-Sensing Transducer

Stretch Transducer

Description: Type of force transducer that changes resistance when physically stretched

Pros:

- Versatile
- No risk of losing force data

Cons:

- Expensive
- Difficult for a physician accustomed to the Modified Ashworth Scale test to use

Strain Gauge

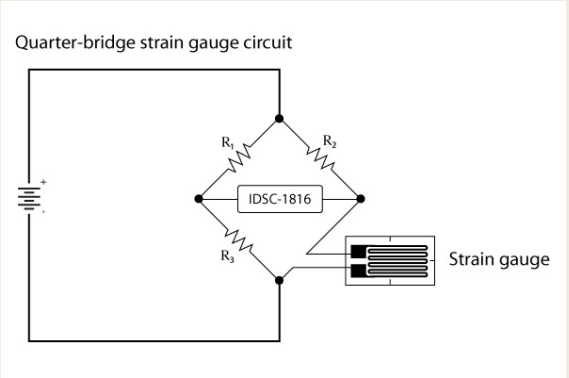
Description: Type of force transducer that measure strain by detecting amount of deformation on a material

Pros:

- Less complex hardware
- Accurate and easily portable

Cons:

- Expensive
- Many variabilities and prone to errors



Amplicon Systems (2014)

Force Sensing Transducer

Description: Type of force transducer that changes resistance when pressure is applied onto sensor

Pros:

- Accurate
- No moving parts on hardware

Cons:

- Need a unique hardware design

Adafruit (2014)

Force

Force	Weight	Stretch Transducer	Strain Gauge	Force Sensing Transducer
Cost	6	7	5	9
Due Date	5	4	8	10
Portability	10	8	10	10
Software	6	8	8	8
Accuracy	10	9	7	9
Reliability	10	9	5	8
Versatility	7	10	10	10
Size	9	7	10	10
Ease of Use	10	5	7	8
TOTAL (max 730)		553	568	662

Chosen Final Design

Category	Weight	Device			
		Video-monitoring system	Modified Ashworth Scale	Stand-alone device	Smartphone + force transducer
Velocity:		Dartfish	n/a	accelerometer	smartphone accelerometer
Force:		force-sensing transducer	n/a	force-sensing transducer	force-sensing transducer
Range of motion:		Dartfish	n/a	accelerometer	smartphone accelerometer
Cost	6	0	10	6	8
Due Date	5	3	10	8	10
Portability	10	0	10	9	9
Software	6	3	0	8	9
Accuracy	10	10	0	9	9
Reliability	10	10	0	7	7
Versatility	7	10	9	7	7
Size	9	0	10	10	10
Training	8	2	5	9	9
Ease of Use	10	3	10	9	9
TOTAL (max = 810)		349	530	689	703

Chosen Final Design

Smartphone + Force Sensing Transducer

Hardware:

- All the force measured on active force sensing area
- Size no larger than physician pocket
- Secure Smartphone

Software:

- Centralized location for data processing

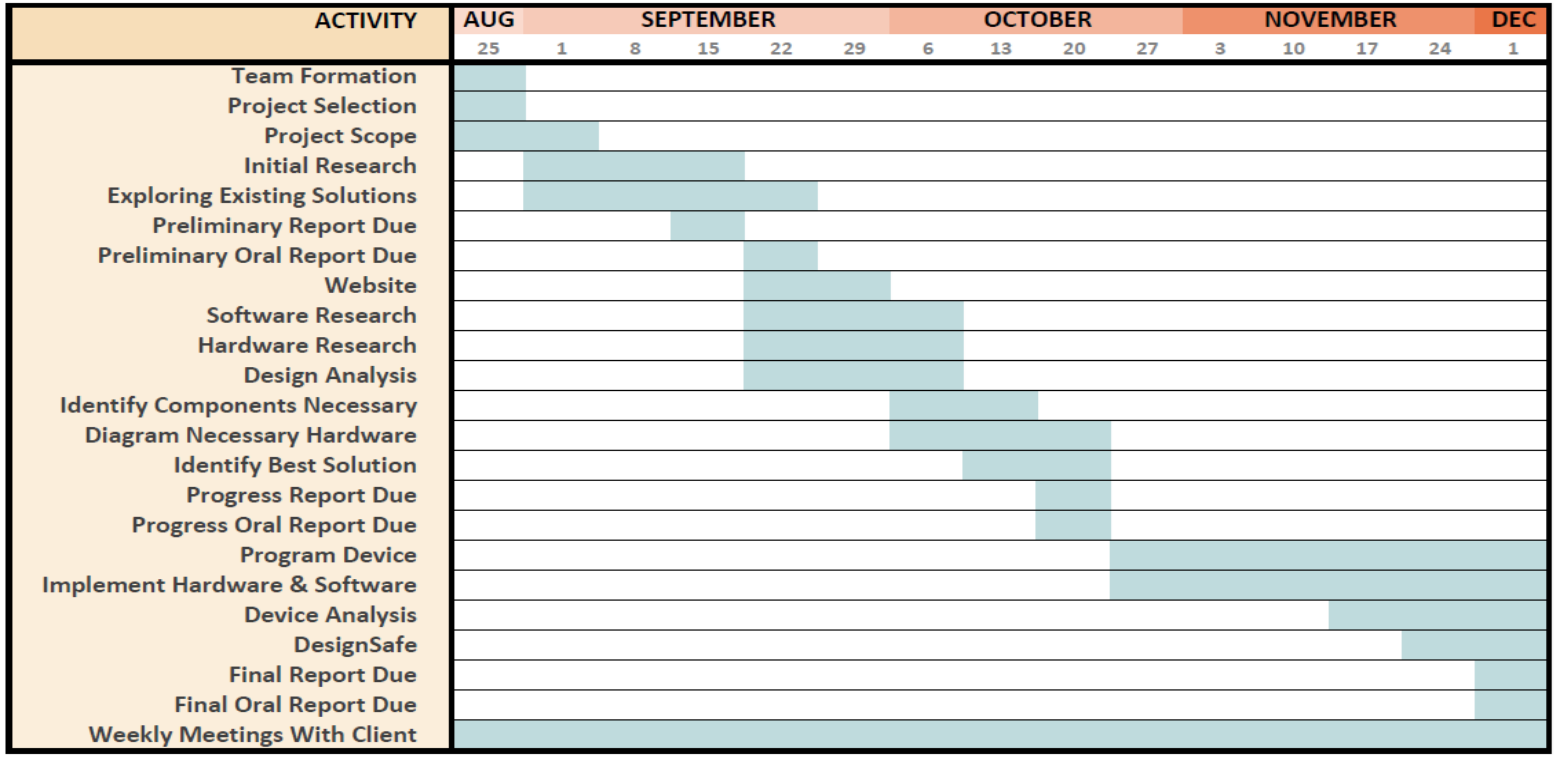
Chosen Final Design

Smartphone + Force Sensing Transducer

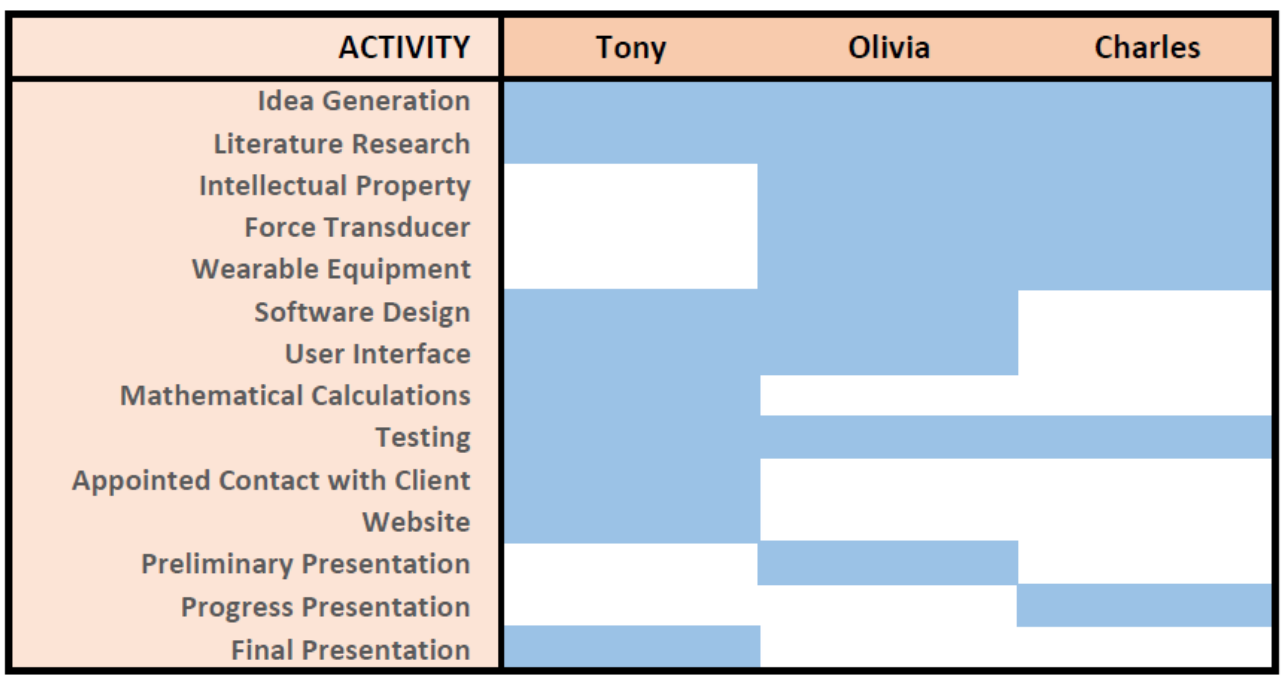
More hardware specifics:

- Intuitive use for physicians
- Flexible metal with foam to increase comfortability
- Aesthetically pleasing

Updated Design Schedule



Updated Team Responsibilities



ACTIVITY	Tony	Olivia	Charles
Idea Generation	■	■	■
Literature Research	■	■	■
Intellectual Property		■	■
Force Transducer		■	■
Wearable Equipment		■	■
Software Design	■	■	
User Interface	■	■	
Mathematical Calculations	■		
Testing	■	■	■
Appointed Contact with Client	■		
Website	■		
Preliminary Presentation		■	
Progress Presentation			■
Final Presentation	■		

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