Stroke Feedback System
Progress Report

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Client: Dr. Alex Carter

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Stroke Rehabiliation: Neurophysiological Hypothesis

- Hypothesis that brain shuts down ineffective motor pathways (Liepert 2000)
- Need device to provide feedback in response to activation of successful motor neuron pathway
- Hypothesis that multi-modal feedback is key for recognition of successful pathways

Project Need

- Feedback amplifier for use in proof-of-concept experiments to test effectiveness of multimodal feedback
- Focus on fine finger movement (finger flexion and pinching movement)

Design Specifications

- System Specifications
  - Sampling rate: 100 Hz
  - Measurement Resolution: 5 degrees
  - System must not harm patient
  - Powered by wall outlet, computer, or battery pack
- Design Specifications
  - Weight on hand: <200 g
  - Total weight: < 5 kg
  - Palm Breadth: 67-95mm
- Feedback Specifications
  - At least 2 forms (auditory, tactile, visual)
  - Must be detectable by the user

Design Alternatives

Analysis Process

- Inclusive Systems

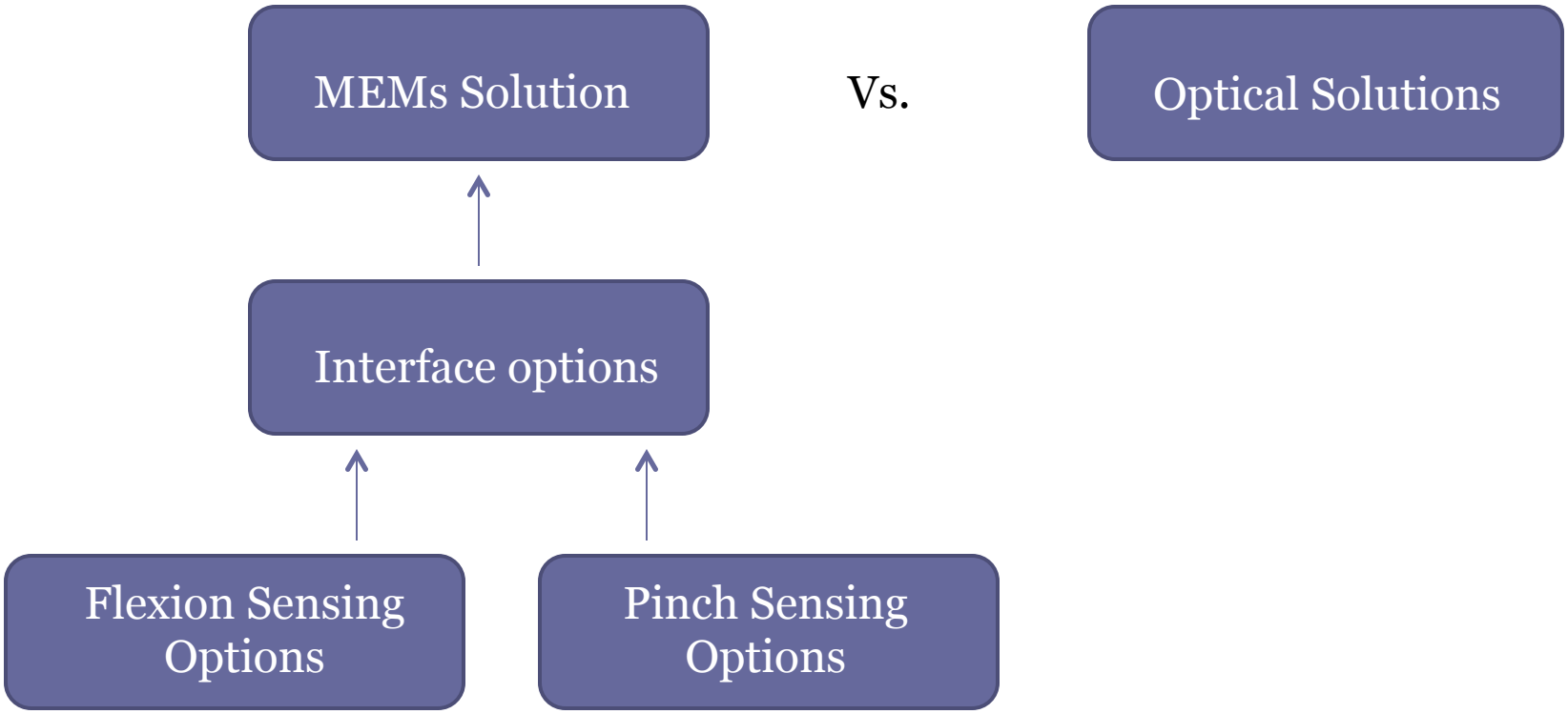
MEMs Solution

Vs.

Optical/Magnetic Solutions

Analysis Process

- Bottom-up design approach to MEMs system



Flexion Sensor Options

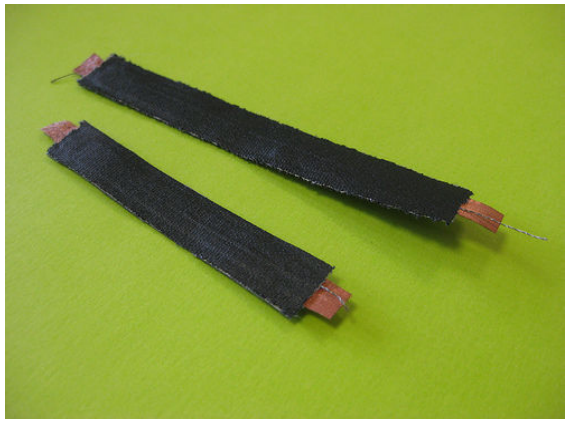
Flex Sensing Resistors

- Resistance of sensor varies with the degree of flexion
- Positioned lengthwise across each finger
- Main drawback:
  - Sensors are prone failure at connection ends

http://www.adafruit.com/products/1070?gclid=CNCh4ZW2vroCFaUWMgodUWsAjQ

Pressure Sensitive Conductive Material

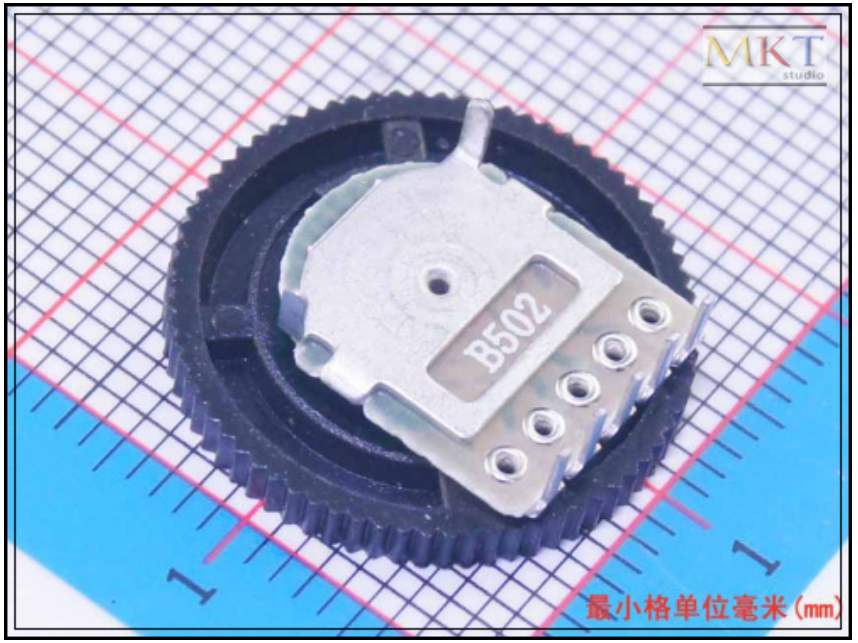
- Conductive material whose resistance varies with pressure applied
- Positioned similarly to flex sensing resistor
- Main drawback
  - Does not readily provided function



http://www.adafruit.com/products/1361 ;

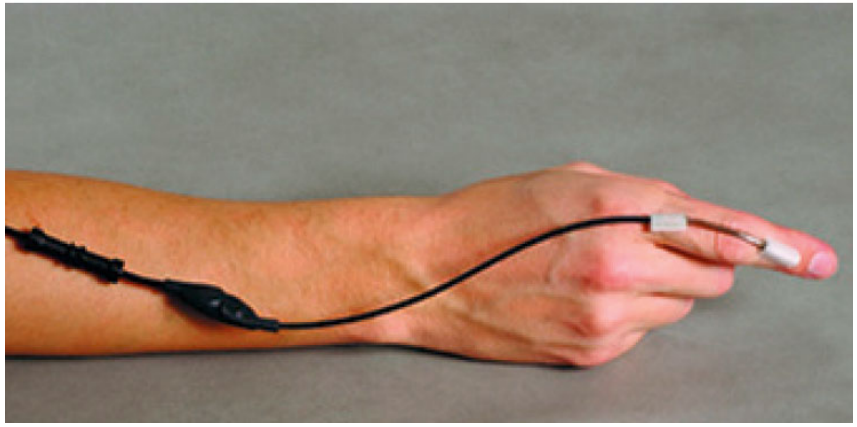
Potentiometer

- Angle of flexion around a joint can be related to angle of rotation of wheel
- Placed on lateral side of interphalangeal joint
- Main drawbacks
  - Impedes normal hand posture and movement due to required placement
  - Fragile



Digital Goniometer

- Measures angle of flexion
- Main drawbacks
  - Signal acquisition requires proprietary hardware and software



Inertial Measurement Unit

- Uses combination of accelerometers and gyroscopes to detect finger movement
- Placed on posterior side of middle phalanx
- Main drawbacks
  - Movement detection not specific to finger flexion
  - Feedback integration would be very involved

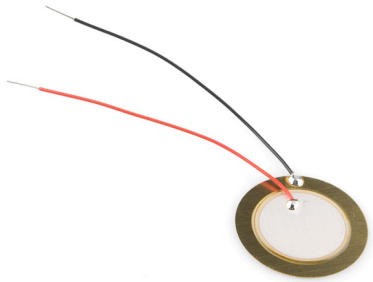
Flexion Sensor Analysis

	Weight	Flex Sensing Resistor	Gyroscope / Accelerometer IMU	Goniometer	Potentiometer	Pressure Sensitive Material
Portability	*8*	10	10	10	10	10
Weight	*8*	10	9	6	10	10
Cost	*5*	8	3	5	10	10
Durability	*2*	8	10	7	5	9
Temporal Resolution	*8*	10	10	9	10	10
Spatial Resolution	*8*	10	5	10	9	9
Power Consumption	*6*	8	10	10	10	8
Software Involvement	*8*	10	5	4	10	10
Patient Interface	*10*	9	7	3	5	10
Total		594	477	441	562	608

Pinch Sensor Options

Piezoelectic Sensor

- Produces a charge in the material when deformed
- Main drawback
  - Suffers from hysteresis

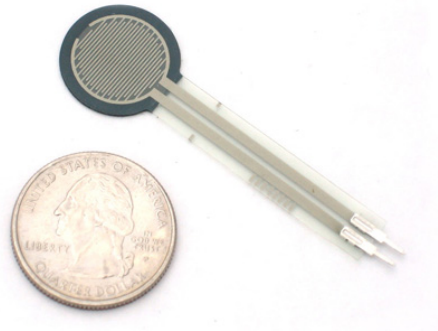


Tactile Switch

- Pinch movement depresses button on switch turning it on
- Main drawback
  - Might be too small

Force Sensing Resistor

- Sensor whose resistance changes when a force is applied
- Main drawback
  - Relatively large compared to fingertip.



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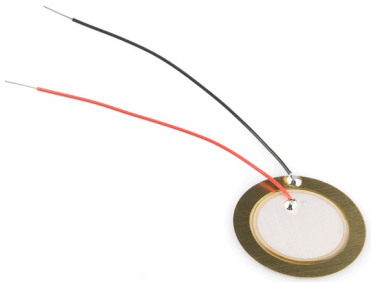

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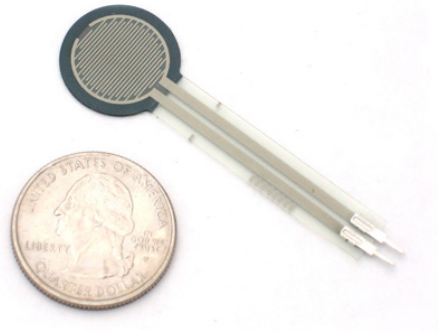


MEMs Interface Options

Glove

- Advangtages
  - Very easy setup
  - One object
- Main drawbacks
  - Accessibility is very low
  - Hygiene issues

Discrete Parts

- Advangtages
  - Very Accessible
  - More freedom in integration of components
  - Parts can be easily cleaned
- Main drawbacks
  - More complicated setup
  - Pinching/discomfort

MEMs Interface Analysis

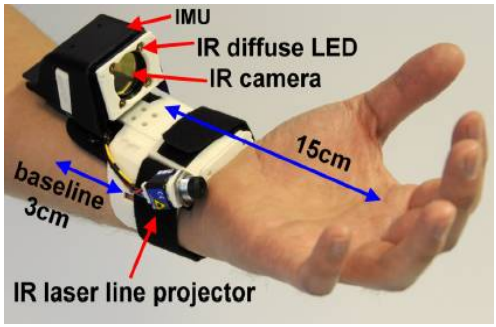
	Weight	Glove	Discrete Components
Accessibility	10	1	8
Safety	9	7	8
Sanitation	9	5	7
Customizability	5	2	9
Cost	6	10	8
Weight	8	8	8
Ease of Setup	10	10	7
Ease of part integration	7	5	9
Total		337	423

Optical/Magnetic Solution Options

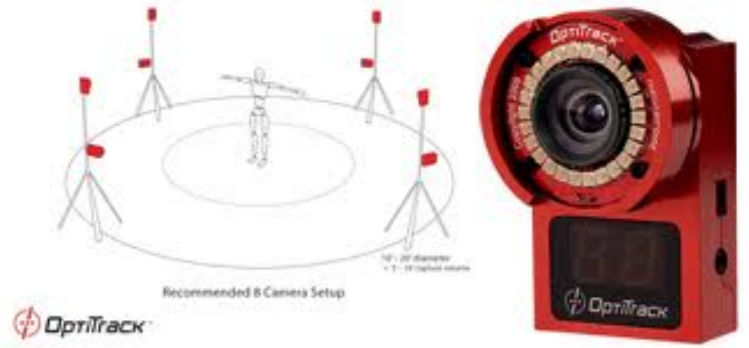
Optical Solutions

LEAP Motion

Microsoft Digits

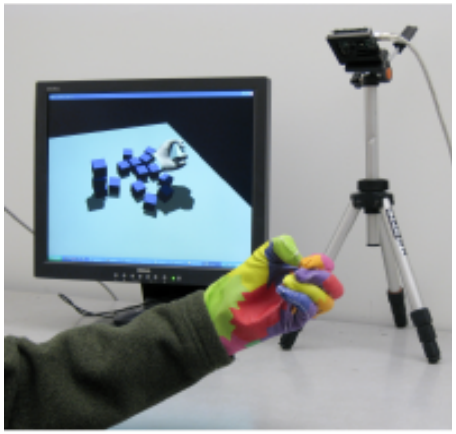


Optitrack



3gearsystems

Color Glove



trakSTAR

Final Design Analysis

	Weight	MEMS Design	LEAP Motion	3Gearsystems	Microsoft Digits	Ascension trakSTAR	Optitrack	Color Glove
Cost	4	10	7	5	6	2	1	5
Portability	8	10	8	6	7	3	0	6
Spatial Resolution	7	5	10	8	7	9	9	5
Temporal Resolution	5	10	8	4	5	9	8	1
Software Involvement	8	10	6	6	1	4	4	3
Patient Accessibility	9	7	9	10	10	10	8	10
Therapist Accessibility	8	8	10	9	8	5	3	9
Feedback Integration	10	10	8	8	8	8	8	8
Total		512	491	434	396	382	315	374

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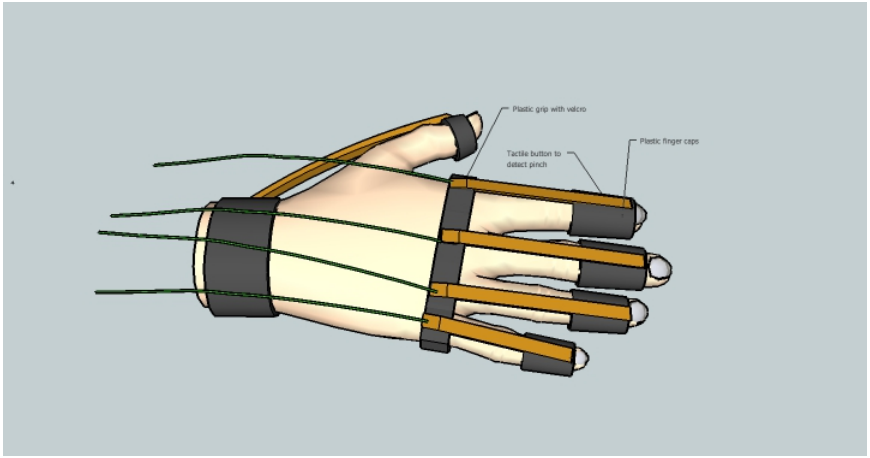
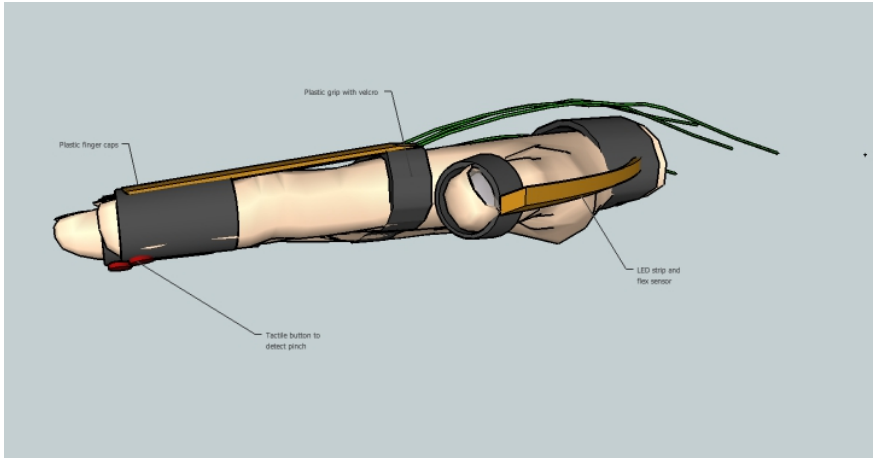
MEMs Design

- Flexion Sensor: Conductive Material
- Pinch Sensor: Tactile Switch
- Integration: Discrete Parts





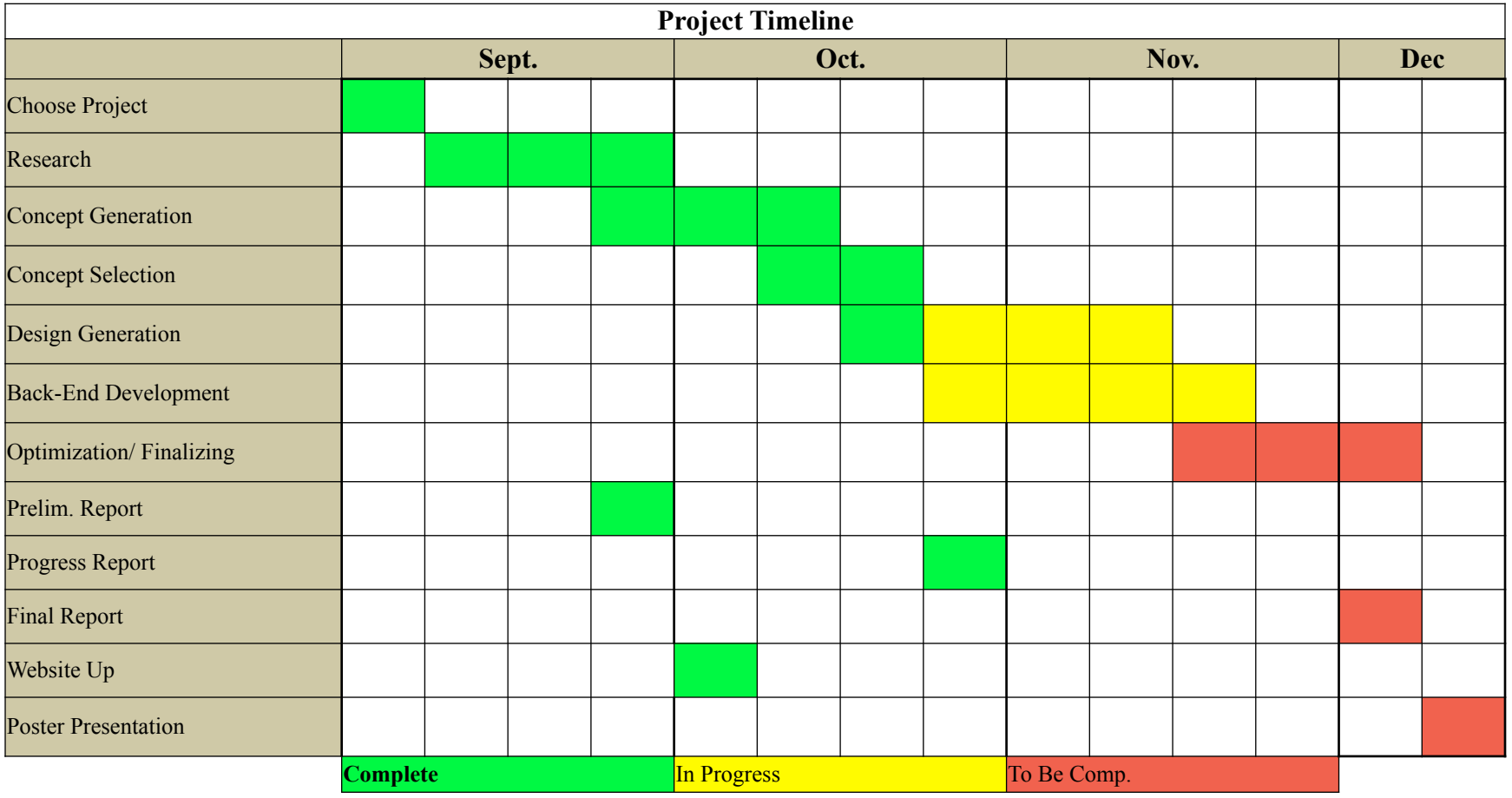
Feedback Integration

- Feedback needs to be as localized as possible
- Feedback for finger flexion:
  - Auditory- different sounds for movement of each finger
  - Visual- lights on across fingers that vary with degree of flexion
- Feedback for pinch movement:
  - Auditory- singular sound upon completion of motion
  - Tactile- vibration localized to finger used in motion
- Controlled by microcontroller

Responsibilities

Assignment of Responsibility			
Andrew Acevedo	Ben Glassman	Brandon Maddy	All
designSAFE	CAD	Website	Client Interaction
Cost Analysis	Material Acquisition	Microcontroller Circuit Design	Patient Observation
Microcontroller Programming	Prototype Physical Interface Construction	Calculations/Models	Prototype Construction
		Final Report	Poster Construction

Updated Schedule



References

- Liepert, Joachim, et al. "Treatment-induced cortical reorganization after stroke in humans." *Stroke* 31.6 (2000): 1210-1216.

Questions?