Spasticity Quantification

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Group 11
Final Presentation
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The Need

- Millions of people in the United States alone have some degree of muscle spasticity
  - Can result from cerebral palsy, seizures, injuries to brain or spinal cord
  - Characterized by the velocity-dependent resistance of muscle
- Must be able to measure muscle spasticity to determine patient-specific treatment options
  - Physical therapy
  - Pharmacological drugs to reduce spasticity

Current Methods

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

“Engsberg Method”

Description: KinCom dynamometer was used to measure force, range of motion, and velocity to quantitatively characterize spasticity

Pros:

- Objective, accurate, reproducible

Cons:

- KinCom is not portable, expensive, occupies large space

Engsberg et al. (1996). Archives of Physical Medicine and Rehabilitation.

Project Scope

- Design a device (hardward + software) that:
  - Measures resistance to movement (force), range of motion (angle), and velocity
  - Incorporates three parameters into one final spasticity value
  - Is accurate, reliable, and reproducible
  - Is low cost to build
  - Is portable, small, light-weight

Design Analysis

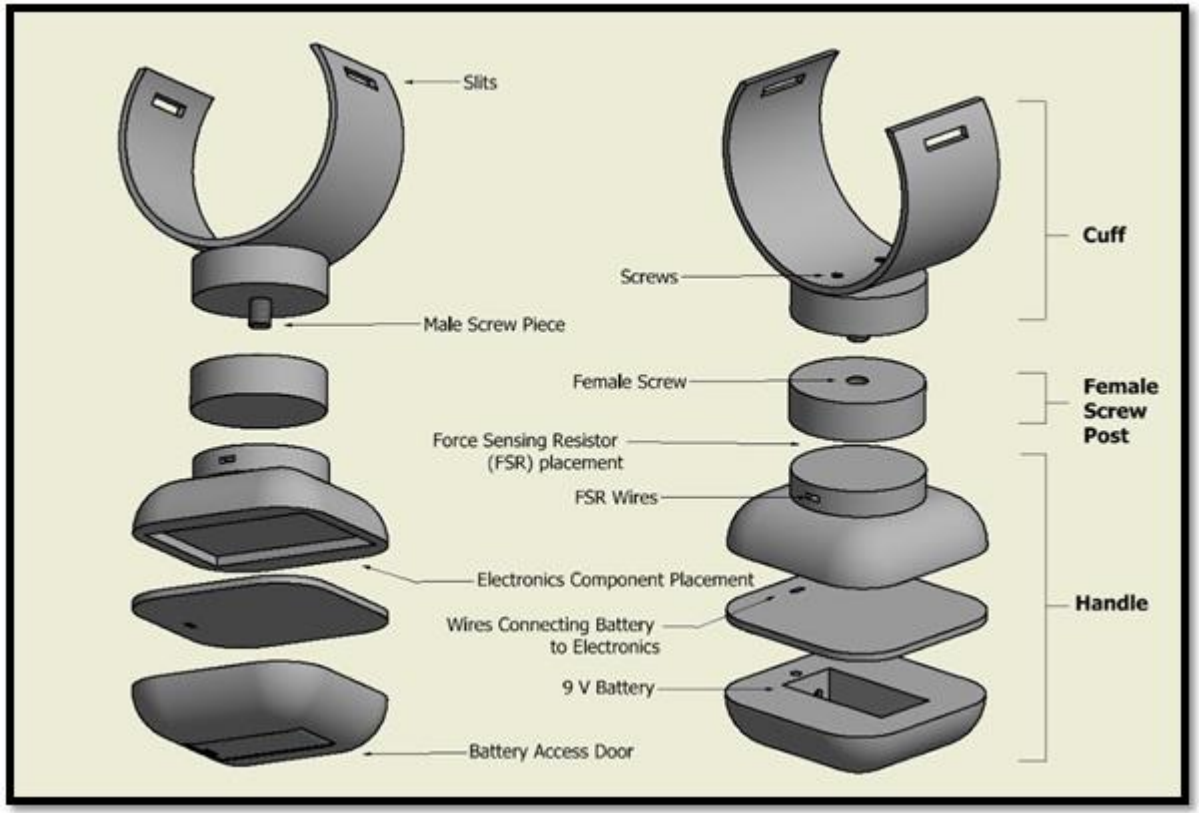
Characteristic	Original Specification	Outcome
Cost	< $200	$74.39
Portability	Lasts at least 10 hours	Lasts 27 hr
Accuracy of FSR	< ±1N	±0.2N
Accuracy of Accelerometer	< ±0.05g	±0.0153g
Accuracy of Velocity	< 5%	< 2.5%
Reliability of FSR	< 10% between trials	2% between trials
Reliability of Accelerometer	< 10% between trials	0.28% between trials
Size	< 21.6cm x 19cm x 5cm (average size of a physician's coat pocket)	13.5cm x 8cm x 8cm and can be disassembled

Design Analysis

Characteristic	Original Specification	Outcome
Weight	< 0.5 kg	0.432 kg
Training	< 10 minutes	< 10 minutes
Versatility	Accommodate limb size of 15 cm to 45 cm in circumference. Measure force from 0N to 200N.	Accommodates limb size of 13cm to 35cm in circumference. Measures forces from 0N to 200N.
Durability	Withstand 200N in compression and 30N in tension	Withstands > 200N in compression and 60.48N in tension
Ease of Use	Duration < 10 minutes	Depends on # of tests, but likely < 10 min
Frequency	> 10 Hz	10 Hz
Power Consumption	< 1 W	0.25W
Range	< 5 m away	10 m away
Memory	< 2 kilobytes	2 kilobytes
Bandwidth	< 2 Mbps	2 Mbps

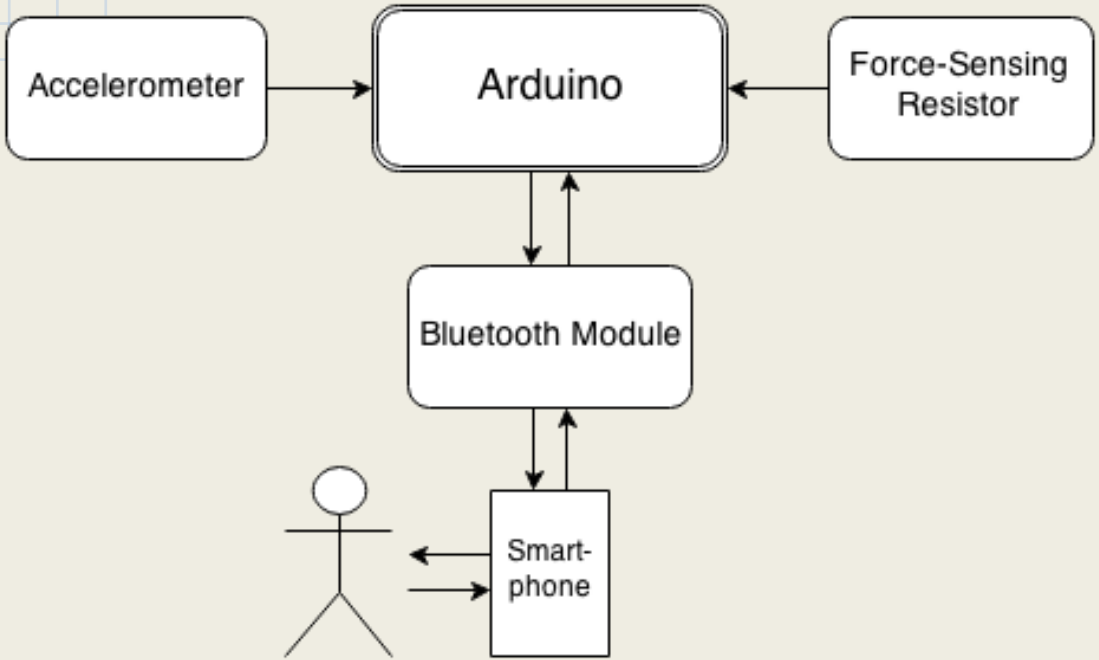
Final Product

Final Design



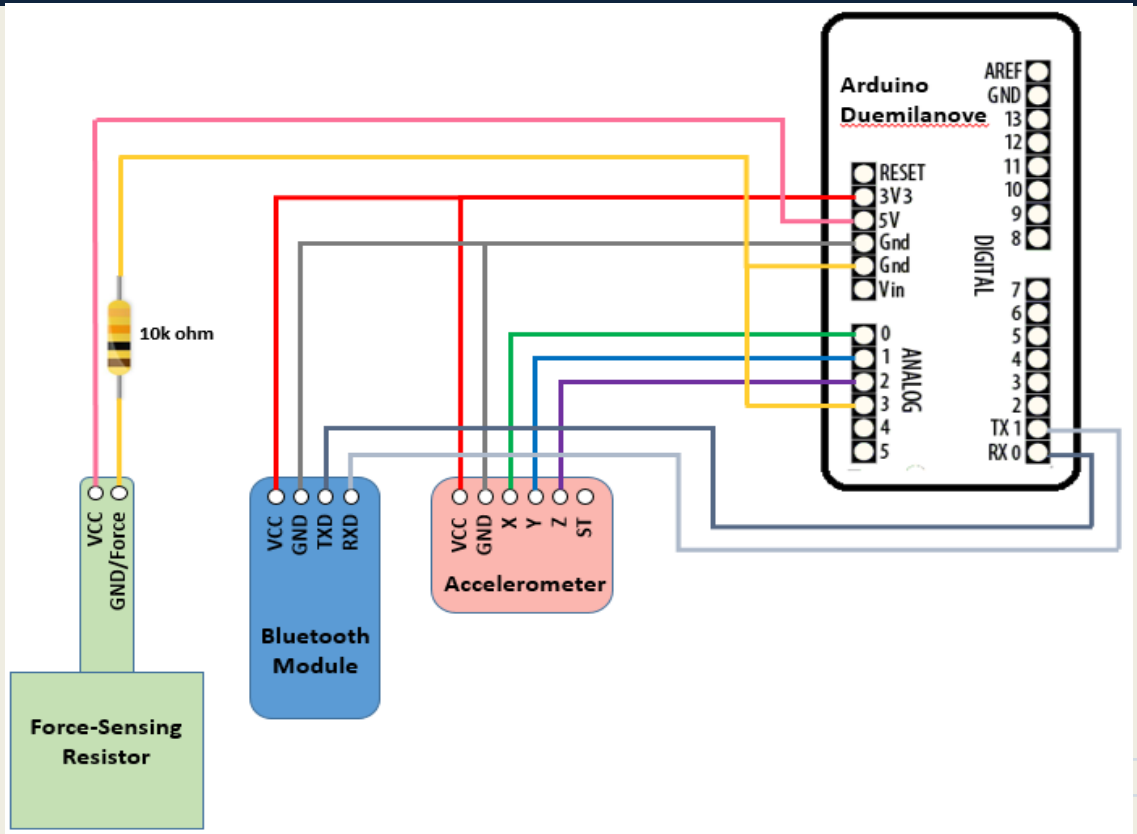
Part	Cost	Manufacturer
Handle including Battery Cover	$12.09	Proto Labs
Handle Assembly Glue	$0.03	IPS Corporation
Velcro	$0.56	VELCRO
Flexible Cuff	$3.50	Inventables
Female Screw Post	$2.35	Proto Labs
Male Screw Piece	$4.46	Proto Labs
Elastic Strap	$0.30	Dritz
Double Sided Tape	$0.42	3M
Screws	$0.54	Grainger
TOTAL:	**$24.25**	

Software General Layout

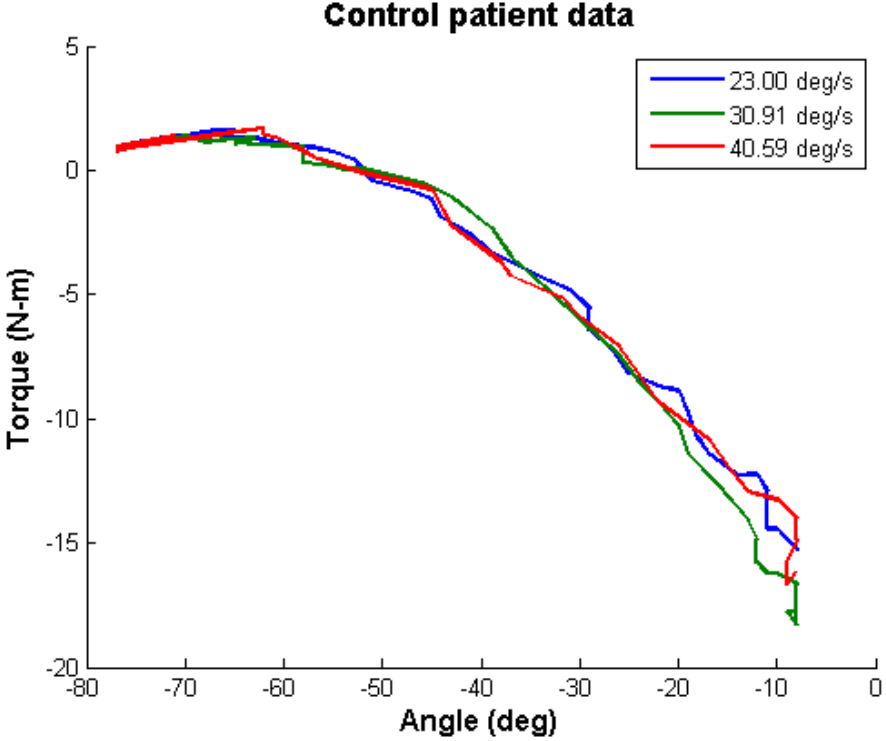


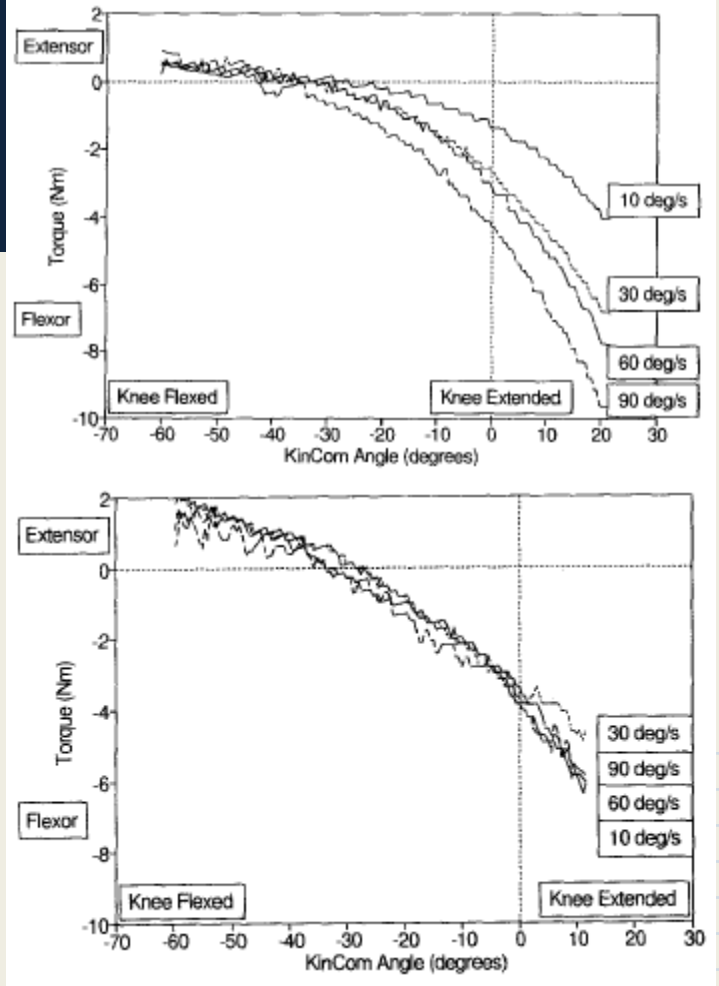
Part	Cost	Manufacturer
Arduino	$19.99	Arduino
Battery Terminal Connector	$1.29	Sparkfun Electronics
Bluetooth Module	$6.65	Bluetooth
Wire	$0.08	Radioshack
Accelerometer	$14.95	Sparkfun Electronics
Force Transducer	$5.50	Interlink Electronics
Battery	$1.68	Energizer
TOTAL	**$50.14**	

Circuit Diagram



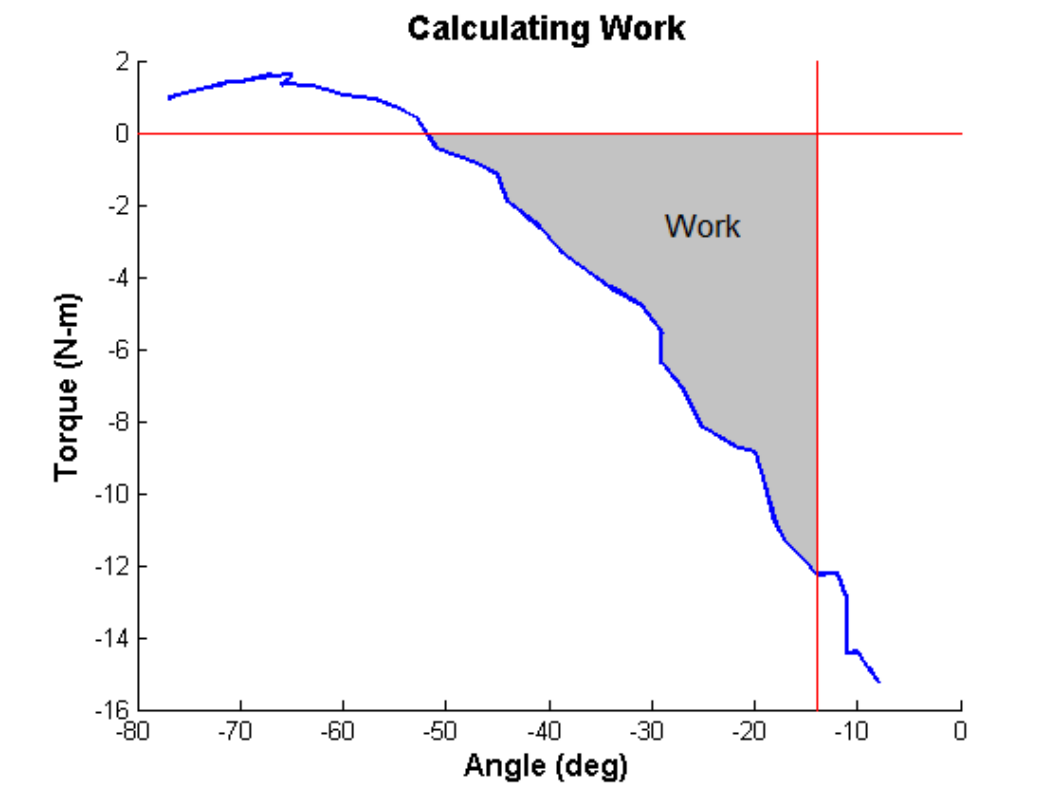
Collecting Data



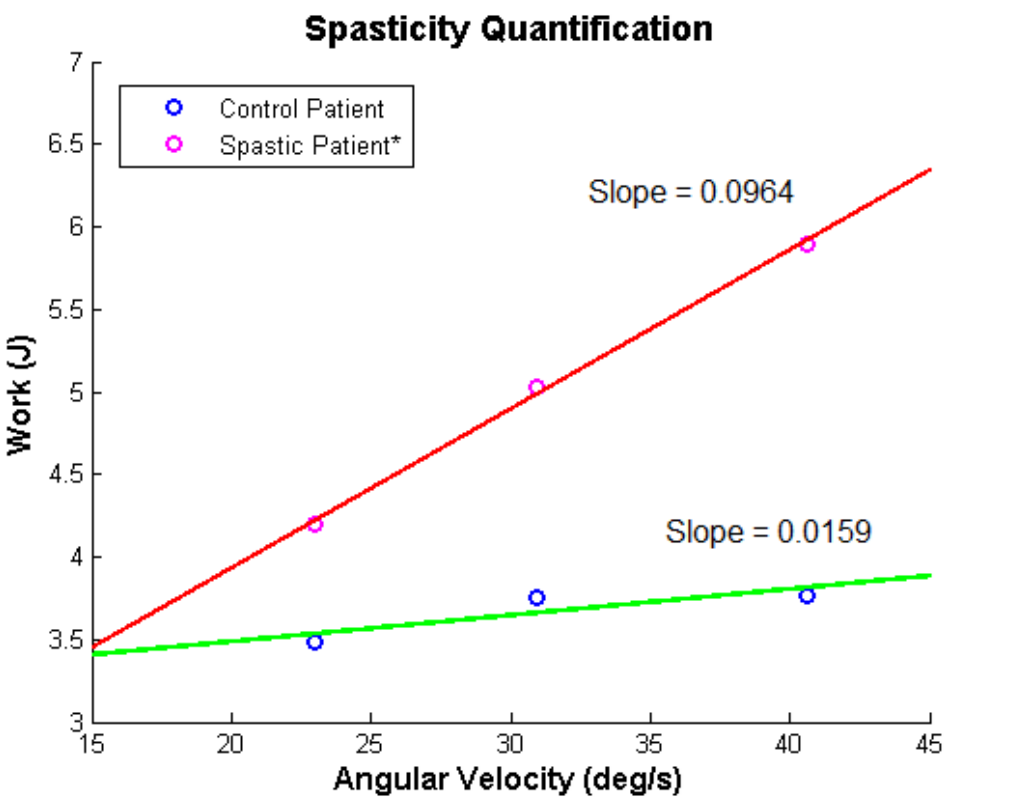


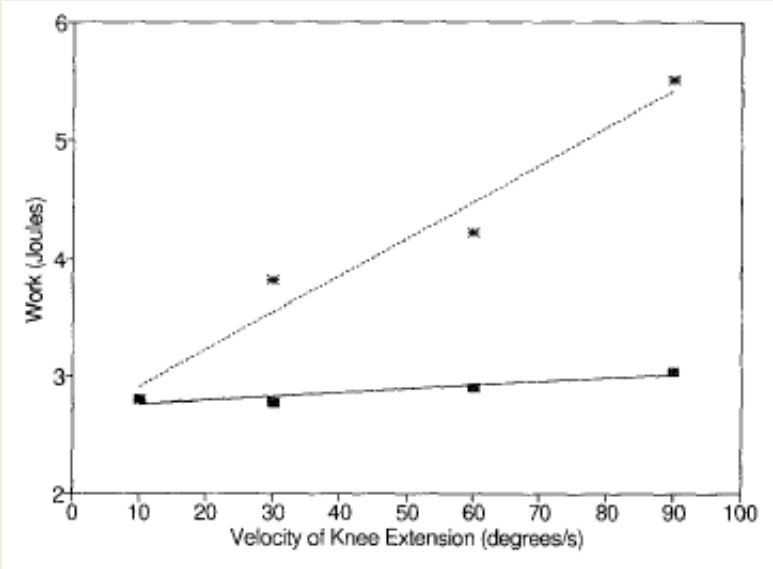
Engsberg et al. (1996). Archives of Physical Medicine and Rehabilitation.

Calculating Work



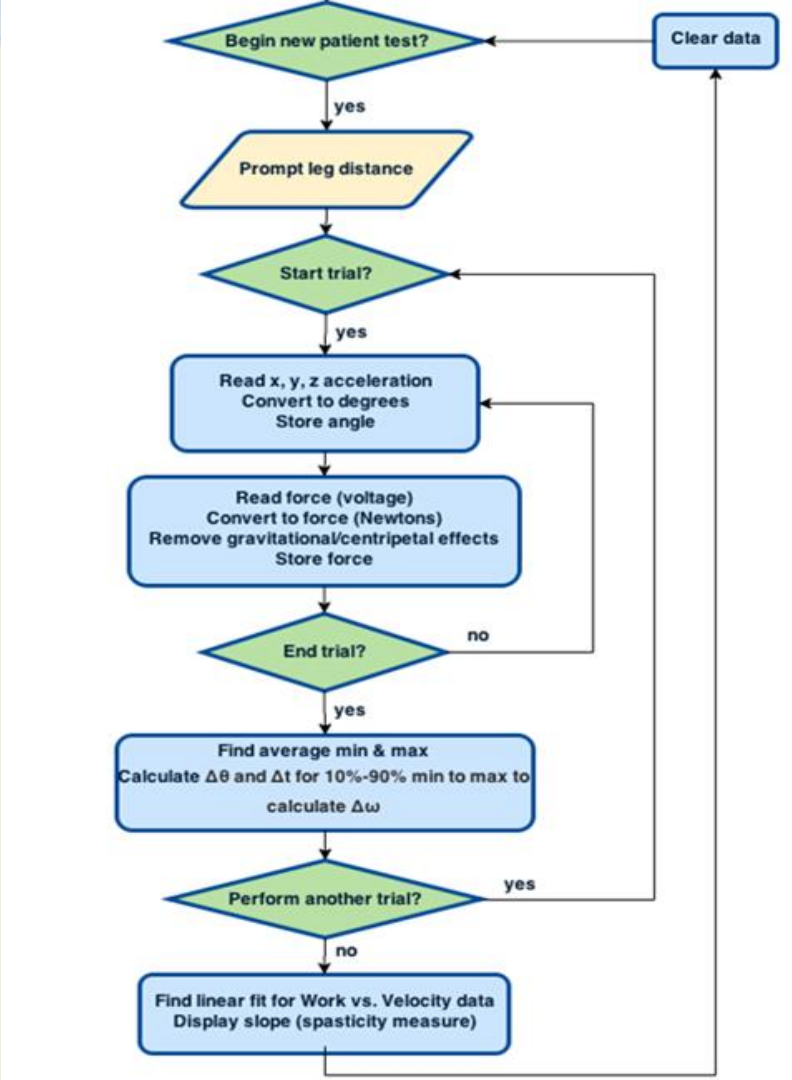
Linearization (Spasticity Value)





Engsberg et al. (1996). Archives of Physical Medicine and Rehabilitation.

* hypothetical data


Begin new patient test?
Clear data
yes
Prompt leg distance
Start trial?
yes
Read x, y, z acceleration
Convert to degrees
Store angle
Read force (voltage)
Convert to force (Newtons)
Remove gravitational/centripetal effects
Store force
End trial?
no
yes
Find average min & max
Calculate Δθ and Δt for 10%-90% min to max to calculate Δω
Perform another trial?
yes
no
Find linear fit for Work vs. Velocity data
Display slope (spasticity measure)

Safety and Ethical Considerations

- **Chemical**
  - Use of alkaline batteries presents unlikely risks of exposure to dangerous chemicals
  - Battery usage warnings included with device
- **Electrical**
  - Water exposure presents unlikely risk of sparks or shorting
  - Waterproofing will occur, isolating electronics from the elements
- **Mechanical**
  - Incorrect testing methods can cause injury to the physician or patient
  - Thorough video and written instructions for device usage will be included with device
- **Diagnostic**
  - Incorrect testing without retesting or incorrect data interpretation could lead to unnecessary side effects of an incorrect diagnosis

Conclusions

- Prototype accomplished:
  - Measured force, angle, and velocity accurately and precisely
  - Integrated three components together and used novel methodology to quantify spasticity
  - Durable, portable design and intuitive to use
  - Costs only $74.39
- Intellectual Property
  - Physical Device: Utility Patent
  - Method of spasticity quantification: Utility Patent
  - Software: Trade Secret
  - Distribution channel initially through hospitals, physicians, clinics

Conclusions

- Learned to:
  - Assemble a team of diverse talents
  - Communicate professionally with professors and companies to help with custom parts, resolve technical issues
- Things we would have changed:
  - Avoid constricting ourselves to one original idea
    - Most intuitive design is not the always the best design
- Future directions:
  - Conduct clinical trials to differentiate between different spasticity levels
  - Client wishes to further develop and market device, with our group retaining 60% of all future profits

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Questions?