Head Tracker

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Abstract

Young children have difficulty focusing and lying in one spot without moving while an MRI machine scans their brain; they must be trained to hold almost perfectly still while the scan is taking place. Using patient feedback and stopping a movie or other attractive feature for the patient when they move past a certain desirable threshold can train subjects to remain still. This device will detect very slight patient movements and stop playback when a threshold is exceeded.

Background

Client's Research

- Organization of the brain during child development
- Areas of focus:
  - methodological improvements for resting- state functional connectivity
  - changes in functional connectivity during childhood and adolescence
- Uses MRI for research

MRI

- Produces detailed images of internal structures
- Powerful magnetic field aligns protons of the body
- Radio waves sent to the body for protons to absorb
- Protons spin and emit energy that is picked up by coil
- Image slices put together to generate 3D image
- Blood flow changes and glucose consumption are used to detect specific brain activities

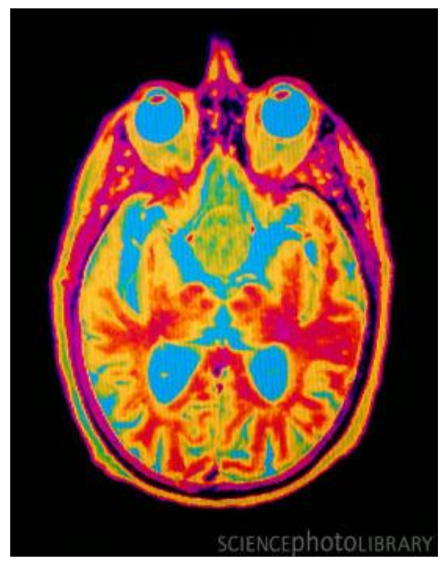


Figure 1: Example of a colored MRI image [2]

Problem Motivation

For accurate, clear images to be created, the subject must remain still in the MRI scanner. Even very small movements can distort the image enough to make the data unusable. The MRI scanner costs $500/hour to run in addition to technicians running the machine and attempting remove blurred data samples. For this reason, any data loss results in a significant loss of productivity. To train subjects to remain still, MRI simulators are utilized to familiarize subjects with the scanner environment. Current head tracking systems are too expensive to be cost effective.

Requirements

•Have the ability to detect movement in 6 degrees of freedom
•Fit into the MRI simulator, approximately 4 cm size restrictions
•Non-ferrous materials must be used if the device is to be used in an actual MRI instead of simply the simulator
•Accuracy must be as precise as .1 degrees of rotational movement
•Feedback must be given to the subject when they exceed the threshold of 1 degree of rotation to alert them that they must stop moving
•Total system should cost less than $500

Budget

Item	Vendor	Price
Microcontroller	Arduino	$17.00
Inclinometer	Level Developments	$150.47
LED	Lab	N/A
Headband	Wal-Mart	N/A

Final Design

- Arduino microcontroller
- 3D-MEMS-based dual axis inclinometer
- Velcro headband
- LED subject feedback
- Sterile paper beneath headband

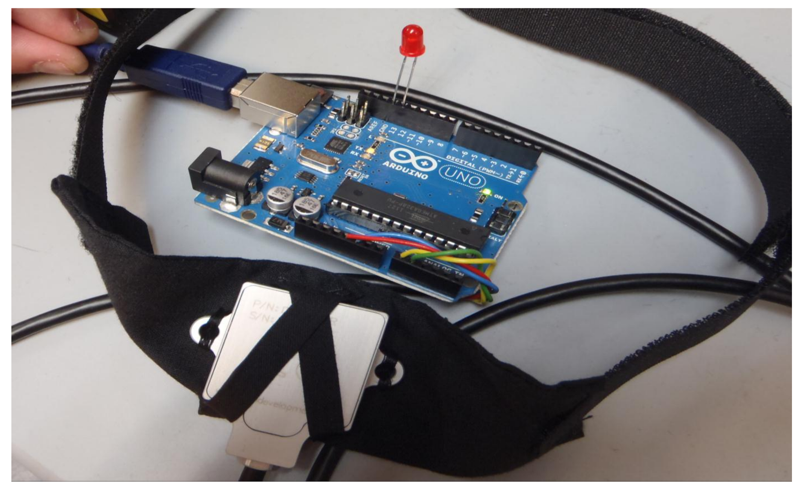


Figure 2: Final design

Fabrication

Device

- A 2-axial 3D-MEMS-based inclinometer is secured to a Velcro head strap
- The head strap has sufficient Velcro to accommodate varying head sizes
- The analog output from the inclinometer is routed to the Arduino microcontroller
- Data processing then occurs with the Arduino to calculate angle and output feedback when appropriate

Arduino Microcontroller and Code

- The Arduino microcontroller samples the analog inclinometer output value at a rate of 100 Hz
- The analog input is converted into angle of rotation through the equation:

$$\propto = \arcsin\left(\frac{Vout - Offset}{sensitivity}\right)$$

where Offset is equal to the device output at 0° and sensitivity is 35 mV/°

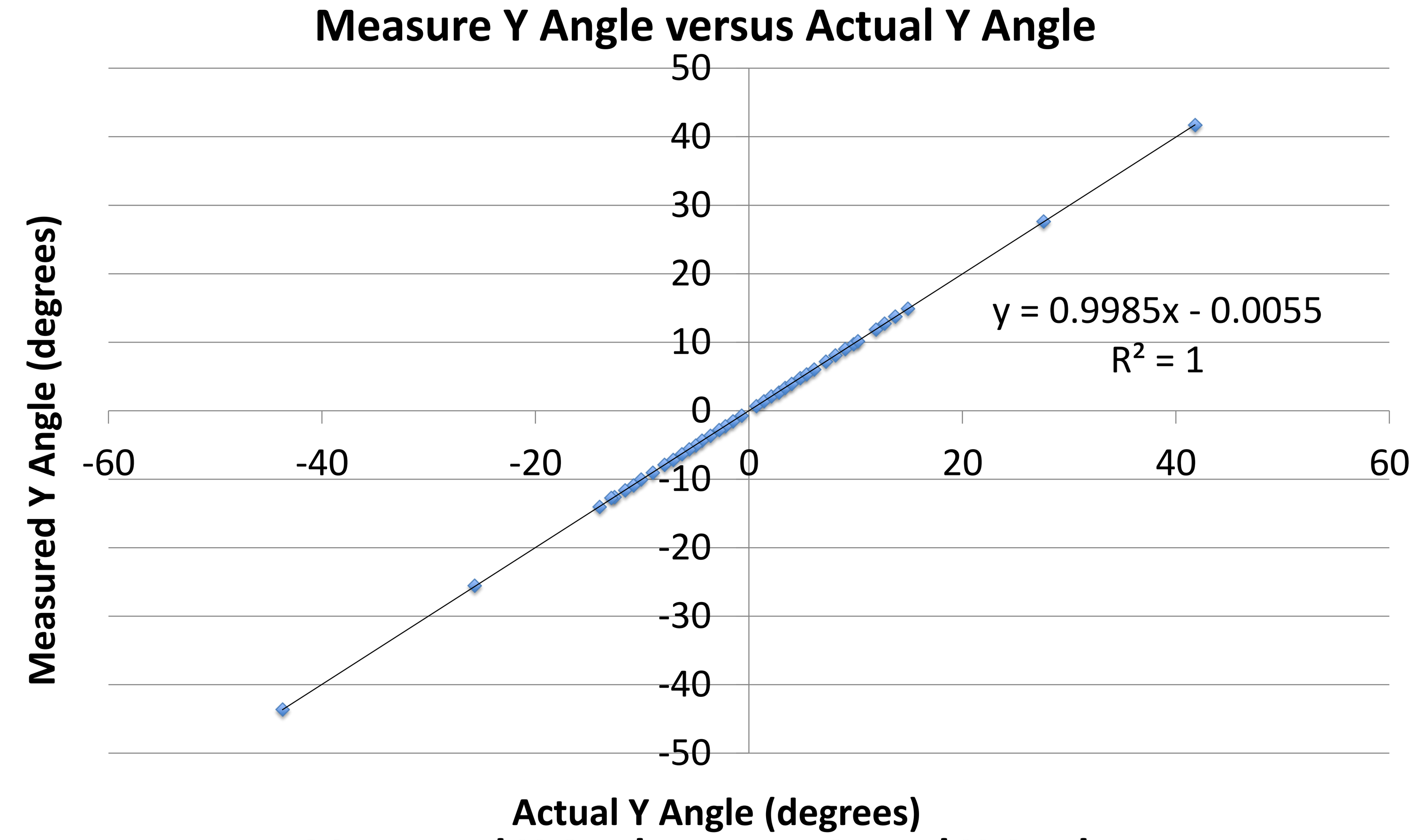
- A constant calibration returns an average angle of rotation for both X and Y axis for the last 10 sample readings
- When the current angle reading is 1° above the calibration value the subject feedback turns on until they are once again settled into a steady state.

Testing

- Inclinometer output compared to angle gage reading
- 45 measurements at varying intervals for both axis
- Testing angles include optimal range

Figure 3: Testing set up

Results



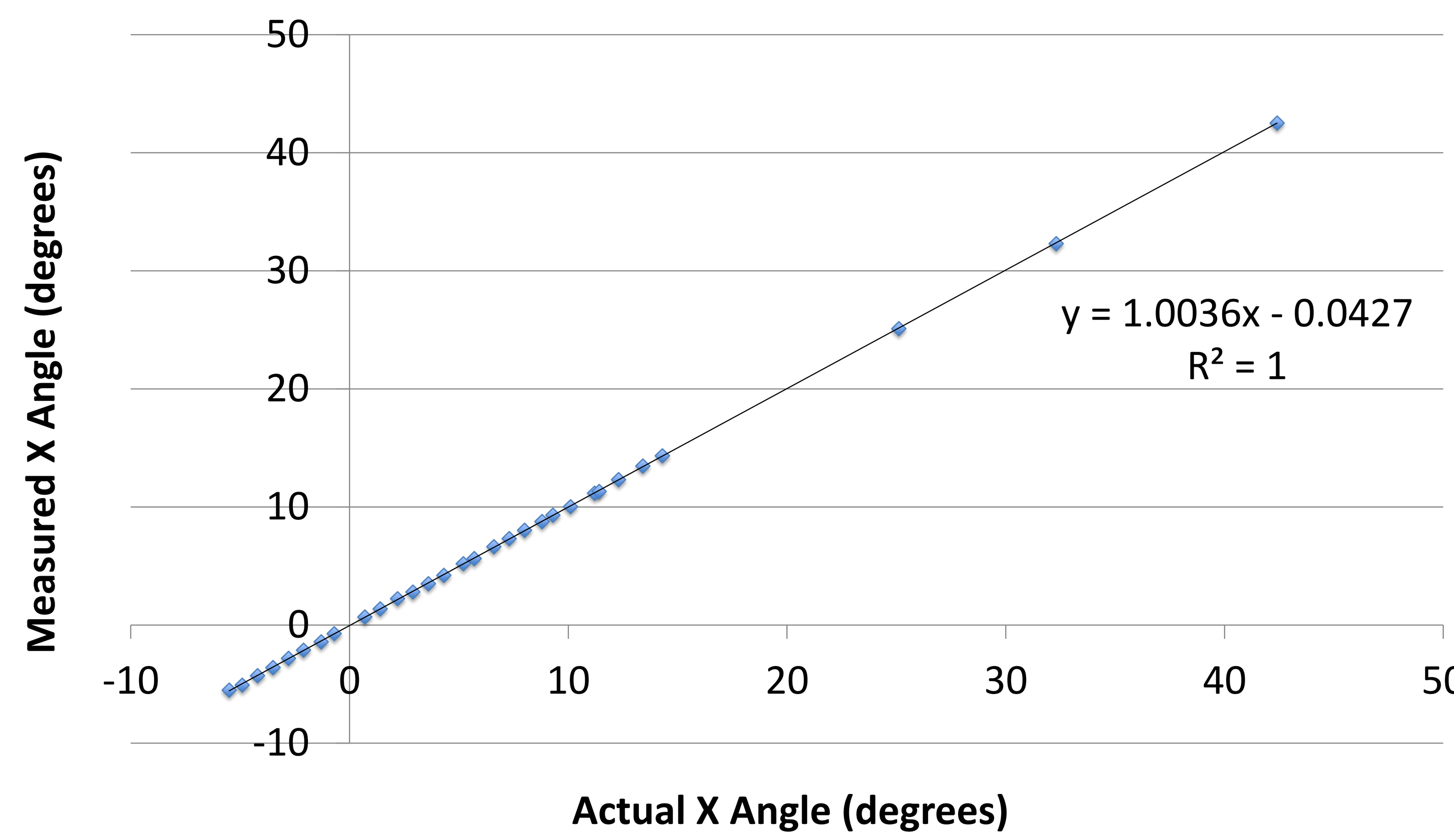


Figure 4: Calibration and accuracy testing for inclinometer

Future Considerations

- Sensor with 6 DOF
- Interfacing with video feedback
- Graphical researcher feedback

Acknowledgements

Advisor: Dr. Thomas Yen
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