Motorized Fixation to Tubular Retractor in Brain Surgery

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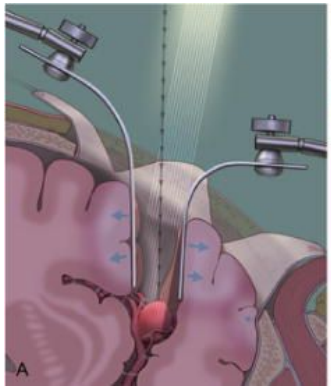
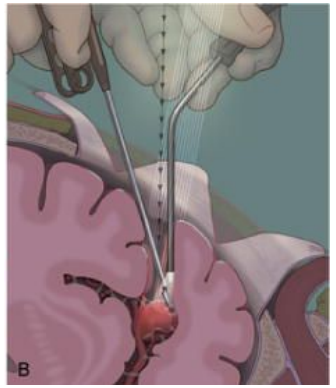
Clinical Motivations

Problem: Surgical site accessibility in microneurosurgery.

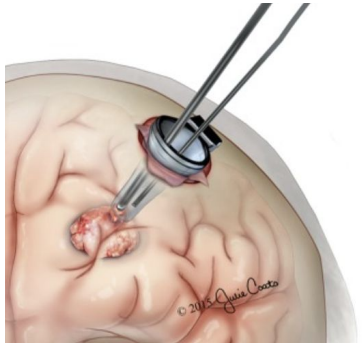
- ➢ Tubular retractors reduce secondary trauma, allow for maximum visibility[1].
- ➢ Tubular retractor designs have limited maneuverability in deep intracranial sites[1].
- ➢ Blunt dissection force as small as 0.4 N can lead to injury[2].

Goal: Improve the tubular retractor repositioning process to minimize extraneous forces exerted on brain tissue and improve usability.





Speltzer et al. (2012)



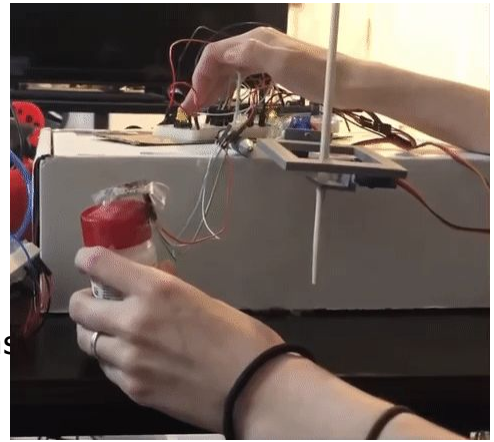
White et al. (2017)

1. Shapiro et al. (2020)
2. Marcus et al. (2014)

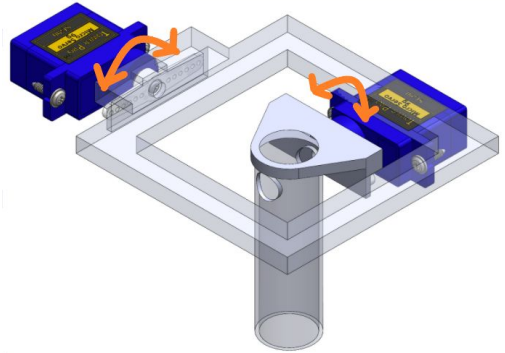
Solution

Method: Add **motorized fixation** to retractor, allowing for smooth and **precise** movements. Create **intuitive** motion control system for surgeons.

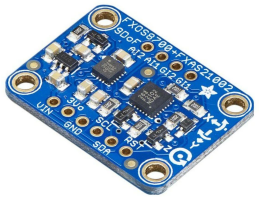
Surgeons **synchronously** realign retractor to same orientation as with a



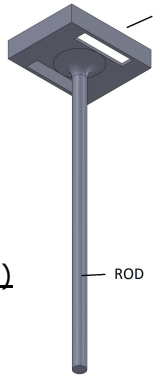
Computer Aided Design (CAD) of Physical Attachment



- 2 DoF provided by servos (pitch & roll)
- Inner platform holds the tubular retractor
- 2-Axis gimbal



9 DoF Inertial Measurement Unit (IMU)
- 3 DoF Magnetometer
- 3 DoF Accelerometer
- 3 DoF Gyroscope
- Measures Orientation



CAD of Calibration Tool
- IMU is stored in the "POD"
- Surgeon holds tool by the "ROD" like a typical surgical instrument

When a surgeon wants to realign the retractor, the button is held, and the relative angle the tool is moved is matched by the attachment

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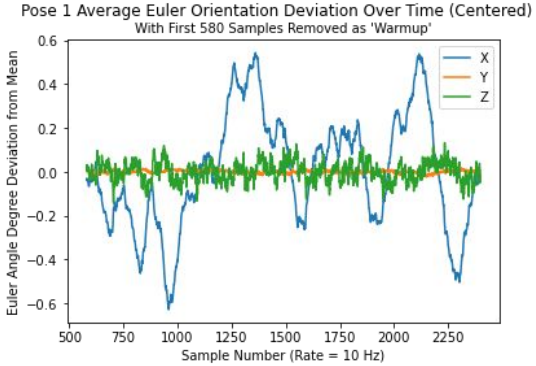
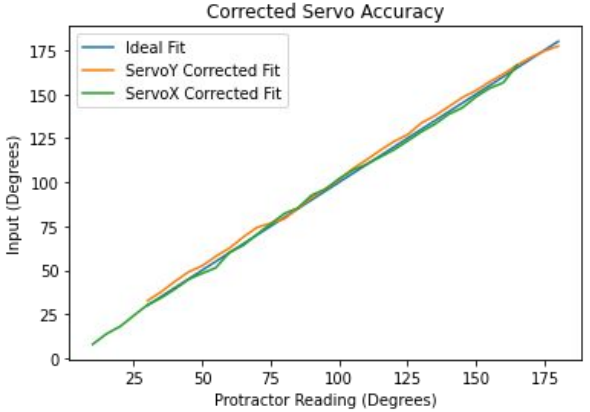
Challenges

IMU Accuracy



Filter	Axis	Average Absolute Deviation (degrees)
Mahony	X	0.1063
	Y	0.0064
	Z	0.0246

Motor Accuracy



Input Correction	Overall Error
f(x) = 0.868 x + 0.0008 x² - 4.38	1.46 degrees
f(y) =1.013 y -17.06	2.41 degrees

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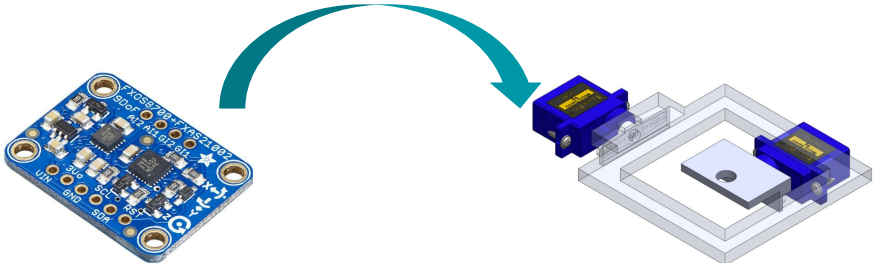
Assessment

Overall Accuracy:

Axis	Mean Absolute Error (Degrees)
X-Axis (Outer Servo)	3.50211
Y-Axis (Inner Servo)	2.17714

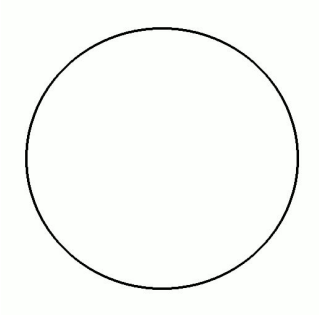


Sensor reading

End effector orientation

Usability Trials:

Participants were asked to trace a circle using the calibration tool. During the trial, certain points were sampled and the distance from the circle was calculated.



RMS error over all participants: 2.667 ± 1.656 mm

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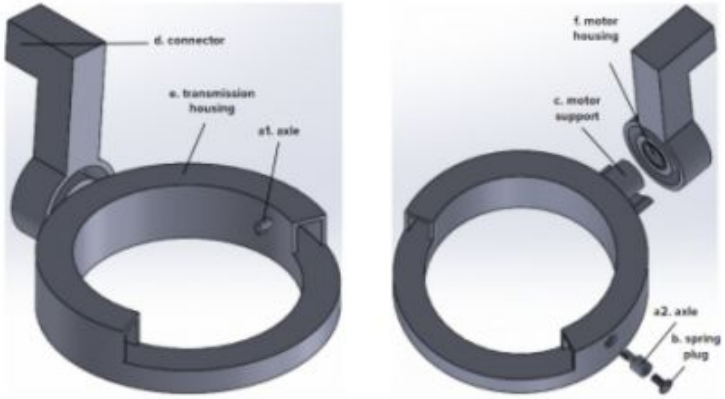
Next Steps

Update Physical Attachment



New CAD of Physical Attachment designed for manufacturability and compactness to fit into surgical field, and transition to DC motors for smoother control

Continuation of Project

The full private code base with documentation will be handed over to our corporate sponsors, CortiTech, which Mark is a part of.

The immediate next steps include implementing and testing the updated physical attachment (left), refining and testing force limiting features, benchtop & animal testing, and gathering additional surgeon feedback

Questions

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[2] Marcus HJ, Zareinia K, Gan LS, Yang FW, Lama S, Yang GZ, Sutherland GR. **“**Forces exerted during microneurosurgery: a cadaver study.**”** Int J Med Robot. 2014 Jun;10(2):251-6. doi: 10.1002/rcs.1568. Epub 2014 Jan 16. PMID: 24431265; PMCID: PMC4377085.

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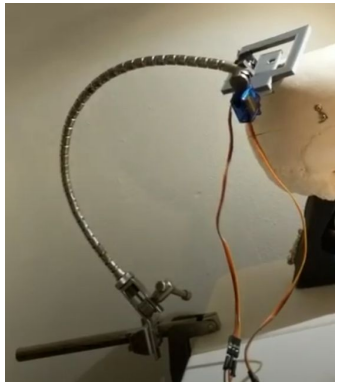
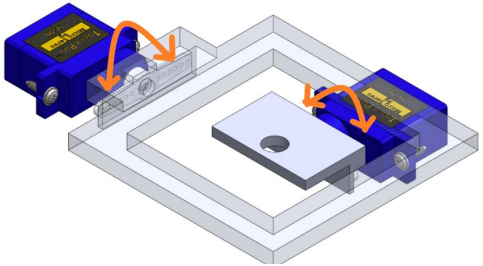
Appendix



Attachment to Leyla Arm, a currently used retractor system



Fixation with a retractor in place through which the surgeon inserts an instrument

Calibration object augmented design. Left to right: iterations