



# Evaluation of Various Sensing Modalities for Accurate Measurement of Neck Flexion Angle during Ear Surgery



JOHNS HOPKINS  
WHITING SCHOOL  
of ENGINEERING

JOHNS HOPKINS  
WHITING SCHOOL  
of ENGINEERING

Team Members: Zihao Lin, Millan Patel  
Mentors: Dr. Deepa Galaiya, Dr. Russell Taylor  
Computer Integrated Surgery II, Spring 2022

## Introduction

- Surgeon's operating posture can contribute to chronic pain
- Goal:** Accurately measure the surgeon's neck flexion angle while performing ear surgery, comparing the postural ergonomics of traditional "heads down" surgery and "heads up" endoscopic surgery.



Microscopic



Open Surgery

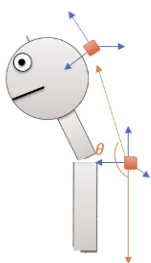


Endoscopic

## Problem

- Persistent neck flexion, extended periods of static posture, and the long-time use of microscopes/magnifiers increase risk of discomfort, cervical musculoskeletal strain, and chronic pain
- Can also be a root cause of middle and lower back pain
- 87% of survey laparoscopic, ophthalmic, and general surgeons reported prevalence of musculoskeletal symptoms in the neck and shoulders (Capone)

## Solution



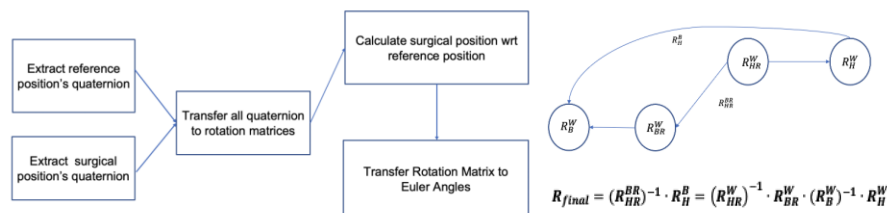
Two Inertial Measurement Units (IMUs) were utilized, with one banded to the forehead and the other attached to the back.

Neck flexion angle was indicated by the pitch angle between the two IMUs, and the mathematical model is derived as following

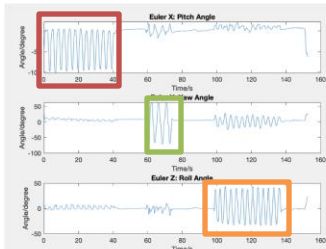
## Citations

- Du, Y., Shih, C., Fan, S. et al. An IMU-compensated skeletal tracking system using Kinect for the upper limb. *Microsyst Technol* 24, 4317–4327 (2018).
- Lakhiani C, Fisher SM, Janhofer DE, Song DH. Ergonomics in microsurgery. *J Surg Oncol*. 2018;118(5):840–844. doi:10.1002/jso.25197
- Vaisbuch Y, Aaron KA, Moore JM, et al. Ergonomic hazards in otolaryngology. *Laryngoscope*. 2019;129(2):370–376. doi:10.1002/lary.27496
- Wong K, Grundfast KM, Levi JR. Assessing work-related musculoskeletal symptoms among otolaryngology residents. *Am J Otolaryngology*. 2017;38(2):213–217. doi:10.1016/j.amjoto.2017.01.013
- Wang R, Liang Z, Zihni AM, Ray S, Awad MM. Which causes more ergonomic stress: Laparoscopic or open surgery?. *Surg Endosc*. 2017;31(8):3286–3290. doi:10.1007/s00464-016-5360-5
- Zihni AM, Cavallo JA, Ray S, Ohu I, Cho S, Awad MM. Ergonomic analysis of primary and assistant surgical roles. *J Surg Res*. 2016;203(2):301–305. doi:10.1016/j.jss.2016.03.058
- Nguyen NT, Ho HS, Smith WD, et al. An ergonomic evaluation of surgeons' axial skeletal and upper extremity movements during laparoscopic and open surgery. *Am J Surg*. 2001;182(6):720–724.

## Solution



## Outcomes and Results



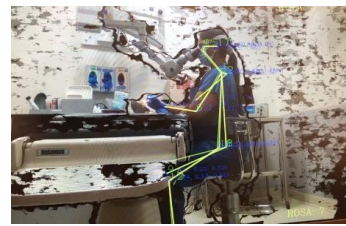
Pitch: "shaking yes"

Yaw: "shaking no"

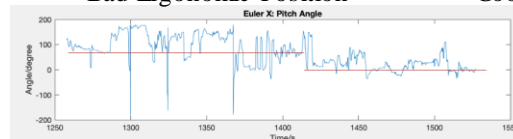
Roll: "shoulder to shoulder"



Bad Ergonomic Position

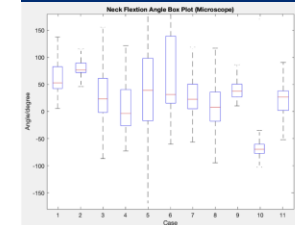


Good Ergonomic Position

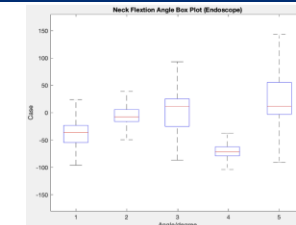


Neck Flexion Angles:  
Bad Position: 50-100°  
Good Position: 0-30°

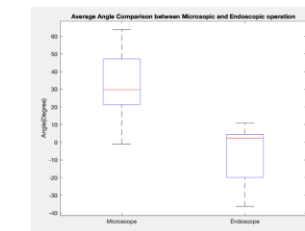
## Outcomes and Results



Microscopic Operation

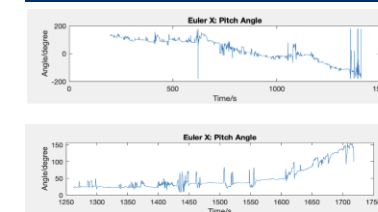


Endoscopic Operation



Average Neck Flexion Angle in  
Microscope Scenario: 33.3744°  
Endoscope Scenario: -7.0667°  
Endoscopic surgery yields smaller neck angles compared to microscopic surgery.

## Future Work



1. Prevent the gradual drift in the average pitch angle as the surgery progressed. (physical sliding/inmate bias)

2. Sample a larger pool to make better comparisons between physicians at varying points in their careers.
3. More testing and better methods are expected to filter out noise
4. Interested in surgery phase which has largest neck flexion angles and the according actions taken by surgeons.

## Lessons Learned

1. Matrix transformation and applying quaternion to calculate Euler angle.
2. Time management
3. Presenting research updates

## Credits and Acknowledgements

Data analysis and progress reports split evenly among Zihao and Millan  
Special thanks to our mentors Dr. Galaiya and Dr. Talyor for their guidance and input. Also thank you to Hyonoo Joo (Johns Hopkins Med Student) for helping with surgical data collection.