Web Application – Utilizing a Pose Estimation and Augmented Reality API for Hand Telerehabilitation

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Background

Hands are pivotal to our everyday lives as we commonly use them to perform activities and interact with objects. Therefore, it is important that the best treatments are available to patients regardless of where they are located. It is known that APIs are becoming increasingly popular to build sophisticated web applications [Qi et al., 2020] along with the growing trend of VR and AR in healthcare regarding telerehabilitation [Berton et al., 2020]. With the contingent nature of technology intertwined with healthcare, we further explore the rapidly growing paradigm of telehealth [Sarsak, 2020]. A solution to remotely rehabilitate patients by tracking hand ROM post-operation through a web application that utilizes Google's MediaPipe API. This analysis is a continuation of our previous study utilizing our mobile application, "DIGITS". Instead, we have built a web application in efforts to increase accessibility while testing consistency across separate platforms.

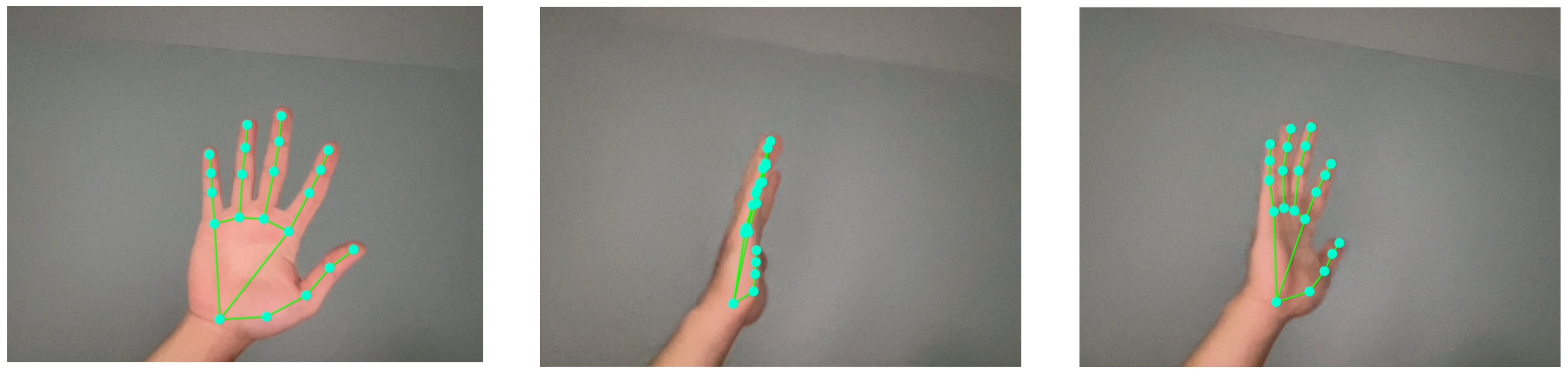
Methods

A USB 2.0 HD UVC webcam with a 1280x720 pixel resolution was used as the input camera. In addition, a React JS web application was built with Google's MediaPipe API to obtain hand ROM data. Google's MediaPipe API is an open-source machine learning framework utilized for object detection and human pose estimation. The hand pose estimation tracks 21 distinct points on the hand (landmarks) where the X,Y, and Z coordinates can be extracted. After extracting the coordinates of each landmark, they were outputted into a CSV file with corresponding timestamps for each respective set of data.

Similar to the previous study conducted using the "DIGITS" mobile app, extracted coordinates were converted to vectors where the angle was calculated between sets of landmarks as seen in our prior study. To compare consistency of accuracy, the degrees of difference, average percentage of error, and standard deviation were calculated and compared between both platforms. This experiment was conducted under a bright light setting at varying distances of 15 and 20 inches from the camera. The subject's hand was propped 90 degrees perpendicular to the view of the camera where flexion and extension in ulnar, palmar, and rota positions were recorded.

Results

Figure 1 – This illustrated the varying positions to collect data: A) Palmar B)Ulnar and C) In motion for Rota



A) B) C)

Figure 2 - The degrees of difference when comparing the web application data to the mobile application data.

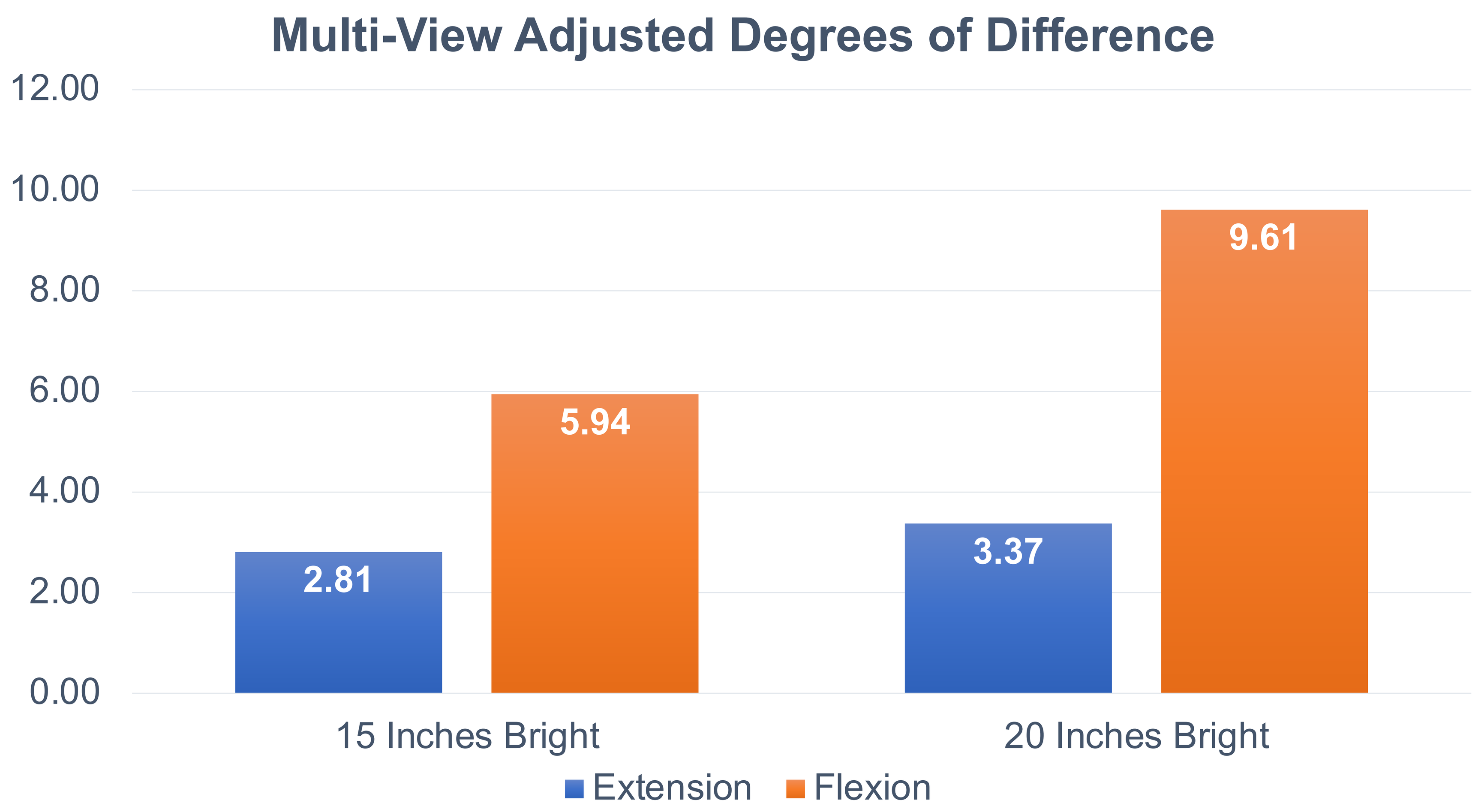


Table 1 – ANOVA analysis and intraclass correlation coefficient were analyzed for extension.

ANOVA - Extension						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	274449.8014	14	19603.55724	5953.884252	5.4788E-294	1.733521818
Columns	101.9510975	17	5.997123382	1.821413227	0.026265186	1.665843772
Error	783.6307235	238	3.292566065			
Total	275335.3832	269				
	ICC	0.996820812				

Table 2 – ANOVA analysis and intraclass correlation coefficient were analyzed for flexion.

ANOVA - Flexion						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	441857.1279	14	31561.22342	123.3194952	1.7951E-100	1.733521818
Columns	5671.100385	17	333.5941403	1.30345584	0.190734745	1.665843772
Error	60911.46548	238	255.9305272			
Total	508439.6938	269				
	ICC	0.869464945				

Conclusion

- Achieved an ICC value of 0.9968 for flexion and a 0.8965 for extension.
- Extension at 15 inches in a bright light setting has a degree difference of 2.81 while at 20 inches in a bright light setting has a 3.37-degree difference.
- Flexion at 15 inches in a bright setting has a 5.94-degree difference while at 20 inches in a bright setting has a 9.61-degree difference.
- Flexion degrees of difference proves to be higher due to hidden digits while in extension all digits are visible providing clear readings.
- Overall, both extension and flexion at 15 inches are within an acceptable range of degree difference according to clinical standards referenced in our prior study.
- For the future, we plan to fully develop the web application and deploy it for further testing and implementation.

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