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360 Degree Posture Detection In Mobile And Desktop Version Of Aasan

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360 DEGREE POSTURE DETECTION IN

MOBILE AND DESKTOP VERSION

OF AASAN

by

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ABSTRACT

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Dhruva Malik, B. S. Computer Science

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A lot of working people spend their time doing desk jobs. This results in various complications and problems with age. Early on development of bad posture can be fixed before it becomes a habit and. As a result, people may develop inadequate spine posture, which can cause profound implications such as back pain if not corrected at an early stage.

"Aasan" the name of the application comes from a Sanskrit word meaning posture, and as the goal of it is to eliminate the wrong posture practices among the world, this name gives the app a meaningful and purpose driven feeling. Aasan enables our tema to gather and analyze video input from the user's phone using machine learning and computer vision to notify the users when the posture is not in the correct position. The camera uses 360° posture detection, that has been developed to further assist consumers, giving the best possible results towards bad and good posture detection. A detailed study can be

undertaken with the use of kinesiology methodologies to determine the underlying cause of any irregularity of the spine which allowed Aasan to suggest various solutions towards many posture problems.

With increased stress and decreased awareness, our posture can easily deteriorate, and so the idea of a web-app for Aasan came around. Aasan uses a combination of machine learning algorithms and computer vision techniques to understand and predict the coordinates of joints in the human body. Aasan can analyze the posture of a person, giving them recommendations to improve it. Aasan also provides users feedback from chiropractors and industry health professionals. Thus, this project is believed to be a culmination of features that can help anyone at any age to make big or small corrections in their posture and help them to live a healthier and pain-free life.

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CHAPTER 1

INTRODUCTION

1.1 Background

Almost everyone has experienced backpain due to incorrect posture. Incorrect posture seems to grow with time and becomes a chronic source of pain and bodily problems. People are aware of the impacts of bad posture, yet do not make conscious efforts to change these bad habits. Bad posture leads to not having confidence, which further leads to low self-esteem. This decreases the productivity of the employee, which is a great loss for the organization. We aim to develop a unique application that will support people to improve their posture by using the cellphone's camera to monitor the user while they are seated and notify them whenever they get into a bad posture. Although there are various other posture correction applications on app stores, almost all of them involve some expensive tracker placed on the body and do not seem to use the vast capabilities of machine learning and computer vision.

With increasing amounts of stress and decreasing amounts of awareness, our posture deteriorated easily. Here, Aasan comes to play with using a combination of machine learning algorithms and computer vision techniques to understand and predict the coordinates of joints in the human body.

Aasan can help in user's understanding the importance of good posture and how to use that app to develop and consult professionals from the industry to help the users improve their posture. Thus, Aasan aims to help the general public, by supporting a good cause.
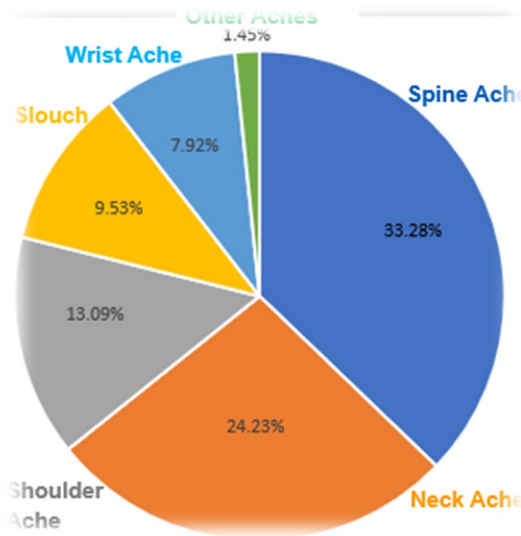
Figure 1.1: Body Pain Chart

1.1.1 Honors Project Responsibilities

In order to complete the capstone project, creation of an additional component that provides 360° view of the user is vital in providing users with optimal experience by providing a higher predictive accuracy. On creating the desktop version of Aasan, for the honors project that allowed users to have another platform and be able to use the built-in/USB webcam. In addition to that, implementation of the same features in the mobile application with front and back camera of a phone/tablet was also accomplished as a part of the project. The real benefit of implementing this feature is that in our application making Aasan a multiplatform providing the user to get their posture checked at their convenience without requiring too much from their side.

1.1.2 Honors Project Tools

This Honors project utilizes the same tools as the rest of the application. This project used Java programming language and developed the mobile application in Android Studio while the programming for the desktop version was done in Python using Streamlit, and OpenCV and MediaPipe. The project involves the implementation of a Firebase database for the backend. Google's ML Kit Vision Application was utilized as the backbone of our mobile application. In the mobile application some changes were made to the default application so that the posture detection would work using our machine learning model using the front and back camera with a 360° video input. On the other hand, the desktop version was built from ground up and adding multi camera input was hard for the system to recognize. But after, clearly stating the differences in the code for the video input, the integrated USB/Built-in webcam part was performing posture detection seamlessly.

1.2 Value Proposition

There are various telehealth services available nowadays, but what separates us from everyone else is that, with Aasan there are no more excuse for the user to be lazy and not perform posture analysis and correct themselves. A lot of people do not actively participate in posture correcting techniques because of various excuses even if the facilities are provided. In many situations the user may say that they do not want to use a mobile application, that is why the creation of a desktop version was started; in other cases, they may say the phone gets too hot and uses too much computational power, that is why the creation of a lighter model was initiated. The team's belief in Aasan is that it is a next generational application that can help everyone all around the world is improving their

posture thus increasing their productivity while performing tasks and a better life ahead of them.

Contradicting the common belief, Aasan, is an application can provide a very big change in our society making people improve their Aasan with a 360° solution to understanding and getting a professional advice from technicians in the industry.

CHAPTER 2

TECH STACK

2.1 Android Studio and Firebase

Though there are other excellent tools for developing mobile applications, android studio and Java stood out for multiple reasons. One of the most popular programming languages for mobile apps is Java. Sun Microsystems created it in 1995 as an object-oriented language. All other coding systems convert code into instructions using a compiler; however, Java converts code into bytecode, which is subsequently interpreted by the Java runtime environment, which is more efficient than the former. This is a simple language to learn, having English-like grammar and less complicated vocabulary. It features a robust API, XML parsing, database connectivity, networking, and utilities, and it offers about everything a developer may want. This is an open-source project that is also freely accessible.

In recent years, Android has been successful in maintaining Java at the forefront. Code for Android applications can be built using both Android APIs and Java. These apps are known as native apps since they are created with native tools. The official integrated development environment for Android application development is Android Studio. It is based on IntelliJ IDEA, a Java integrated development environment for software development that includes code editing and developer tools. This is significantly simpler than cross-platform frameworks like React and Angular, which make state management extremely difficult.

Android Studio adds to IntelliJ's strong code editor and developer tools by providing a configurable Gradle-based build system, a fast and feature-rich emulator, and a single environment where you can create for all types of Android devices. It has Google Cloud platform compatibility built in, making it simple to combine Firebase with Google Cloud messaging and App Engine.

Though there are many fantastic tools for developing mobile applications, android studio and java stood out for various reasons. Android Studio was utilized to take advantage of certain performance improvements right away. The greatest Mobile Backend as a Service (MBaaS) platform is Firebase.

It's a medium that connects online and mobile apps to cloud storage and backend APIs on the backend. It keeps track of every data in the database in real time. As a result, data interchange to and from the database is simple and speedy. Because this platform provides everything from databases to analytics to crashing reports, debugging our program many times to fix all the faults was simple. Firebase is used for safe login, storing conversation in a real-time database, and storing photos in the Cloud Storage section of this service. The team was able to link all these sub-departments together using a single unique UserID, which is a global variable established by the authentication portion and serves as the primary link.

Mobile Version   Desktop Version
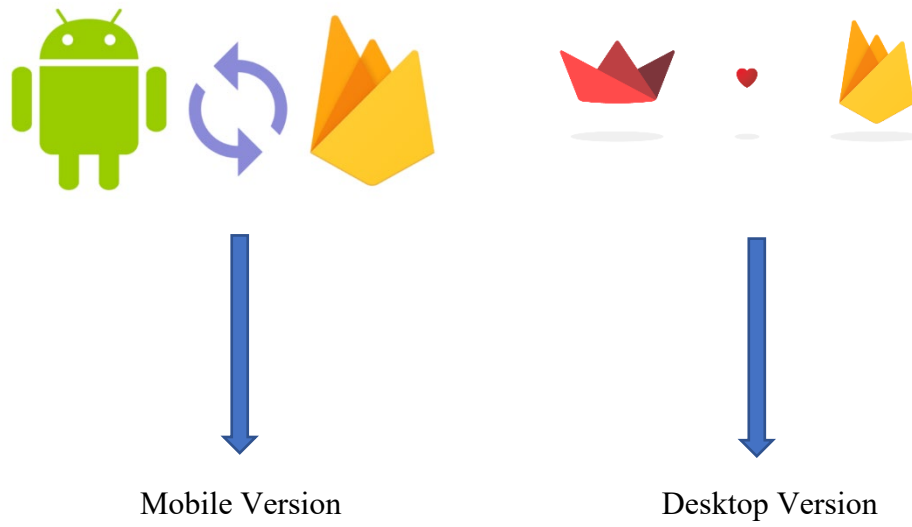
Figure 2.1: Firebase and Android Integrated   Figure 2.2: Firebase and Streamlit Integrated

<u>2.2 StreamLit and Python</u>

Streamlit allows the writing of the application similar to writing a python code. Streamlit has a distinctive data flow, any time something changes in the code or anything needs to be updated on the screen, Streamlit reruns the python script entirely from the top to the bottom. This happens when the user interacts with the widgets like a select box or drop-down box or when the source code is changed. If there are some costly operations while rerunning the web app, like loading data from databases, Streamlit can be used with st.cache method to cache those datasets, so that it loads faster. Streamlit is an open-source python library for creating and sharing web apps for data science and machine learning projects. The library can help you create and deploy the data science solution in a few minutes with a few lines of code. Streamlit can seamlessly integrate with other popular

python libraries used in Data science such as NumPy, Pandas, Matplotlib, Scikit-learn and many more.

Python offers concise and readable code. While complex algorithms and versatile workflows stand behind machine learning and AI, Python's simplicity allows developers to write reliable systems. Developers get to put all their effort into solving an ML problem instead of focusing on the technical nuances of the language. Implementing AI and ML algorithms can be tricky and requires a lot of time. It's vital to have a well-structured and well-tested environment to enable developers to come up with the best coding solutions. To reduce development time, programmers turn to several Python frameworks and libraries. A software library is pre-written code that developers use to solve common programming tasks. In this honors project Python and Streamlit play a very important role. The Streamlit has been used to make the frontend of the desktop version of Aasan and python has been used to talk to the database as well as used in the making of the lighter posture detection algorithm and the machine learning algorithm.
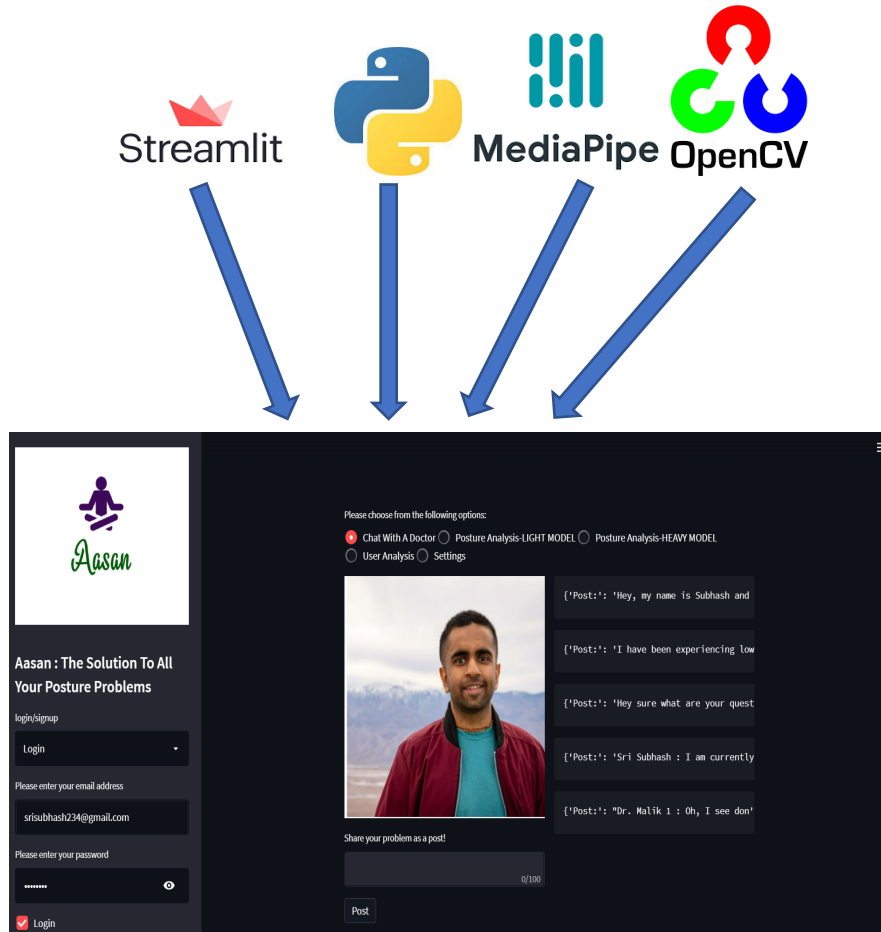
Figure 2.3: Streamlit and Python's Aasan Desktop Version

CHAPTER 3

METHODOLOGY

The plan is to use deep learning and machine learning to formulate the many back problems with the help of Google's ML vision kit, in addition to using machine learning models for posture recognition. With the use of 360o posture assessing algorithms, Aasan can offer treatments, notices, and analyses that the user can utilize in a variety of ways, including consultation with professionals and a greater understanding of how their posture is maintained. Implementing a cross platform all around posture detection and analysis capacity, as done in this honors project through an android and web application, will greatly assist people and have a societal influence.

Once all the data has been gathered, the team has programmed analysis tools to perform a comprehensive analysis and come up with a well-defined flow as to which problem can lead to other serious issues if not addressed, as well as the associated side effects for each circumstance, yielding better results in terms of posture analysis and suggestive corrective measures to aid the algorithm in future prediction.

3.1 Authentication

In today's technological world, cybersecurity plays a critical role in safeguarding high-value assets of all kinds and ensuring that personal data is always kept safe. All websites are now requiring cookies, and all browsers contain trackers of various types, including advertising, analytics, and error gathering. Throughout this process, it is essential to make sure that no software crosses the limits and extracts more data than what it really

needs in the first place. That is the main reason why, the team did not try to setup my own authentication system, and instead decided to rely on the world class security system of Firebase with safe exit strategies. The web application's authentication is made of three parts, which is the SignIn page, SignUp page, and the forget password page, which provides a smooth transition to the users to utilize our application without any worries. These pages are all designed to only work with the safest internet protocol such as the HyperText transfer Protocol Secure. It is an internet communication protocol that protects the integrity and confidentiality of data between the user's computer and the site. As the safety of the health data is crucial, we are encrypting the data transferred through packets to keep it secure from eavesdroppers by converting the password to a long-generated string of 16 characters, and the other trusted endpoint can only crack as it has the key to it. From the production point of view, we wanted to make sure that our customers experience minimal to zero down time during the crucial moments. To suffice the earlier stated goal, we have developed mechanisms to effectively thwart a distributed denial of service attack by any number of coordinated hackers. By any chance, the user forgets their password, they receive an email automatically to their registered email ID to create a new password that can be used every time as a fresh start from that moment onwards. Overall, the users utilizing this application have nothing to worry about and can stay assured that all their security needs are being taken care of.

3.2 Real Time Database

Firebase Authentication is necessary to grant read/write privileges to users via security rules. Security rules have yet to be covered, but it is important to know that security rules rely on a users' authentication status.

Firebase ships with its own email/password auth as well as OAuth2 integrations for Google, Facebook, Twitter, and GitHub. Property auth systems can be integrated with Firebase Authentication to grant users access to data without forcing them to create an account outside of the existing systems.

Firebase also allows for anonymous auth sessions, which are typically used to persist small amounts of data while waiting for a client to authenticate with a permanent auth method. These anonymous sessions can be configured to last days, weeks, months, even years… until the user logs in with a permanent login method or clears their browser
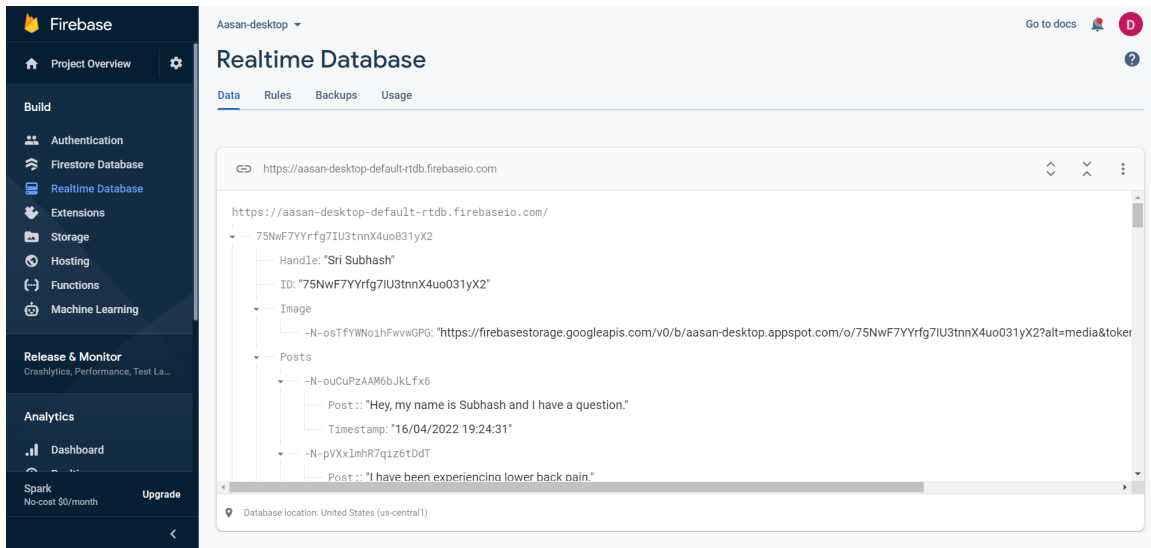

Figure 3.1: The Realtime Database

3.3 Streamlit and 360° Posture Detection Models

On performing extensive research, going over various studies on types of incorrect postures, and understanding the capabilities of posture correcting techniques, the team was able to come up with the perfect combination of exercises for different types of posture errors. These tailored exercises to various patients will help them in improving their posture and our two models will provide users with a quantifiable alternative on the use of their computing power, and multiple video source inputs. The lighter model uses basic geometrical angles to predict the posture while the ml model uses previously used data for predicting.

The database allows the team to keep the users information but also helps in maintaining real time posture score and movements of the user. With all this combined in one app, Aasan will provide the best possible solution to bad posture eliminating the degrading consciousness of bad posture from society.

On receiving a coordinate of human body, the team is able to train the ml model on good and bad posture. Additionally, normalizing the data points allowing the model to be universally useful and capable of detecting and fixing bad postures of any size of a person.

Figure 3.2: Desktop Version Lighter Model

As seen above the OpenCV model that uses the Mediapipe is able to deliver the posture recognition from both the left and right side of the user. While the machine learning model is slightly more robust, we are able to do almost 360° detection using it. The light posture detection model uses less computational resources and a lower accuracy; however, the machine learning model uses more resources and results in a better accuracy.
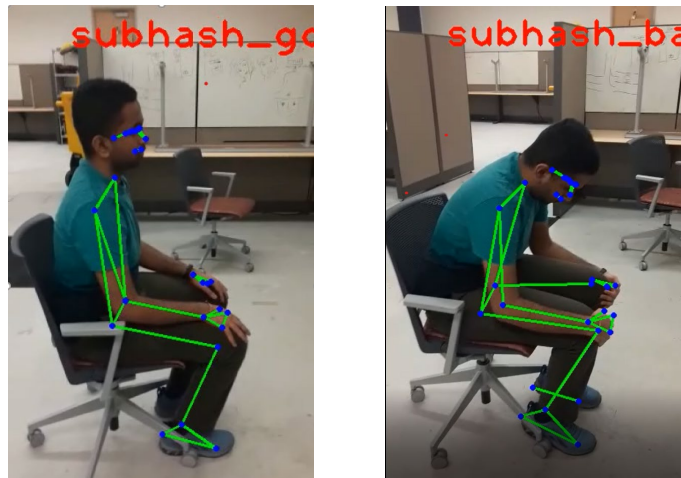

Figure 3.3: Machine Learning Model Performing Posture Detection

CHAPTER 4

HOSTING

As the entirety of this project was powered with Firebase, our team had to use Google for hosting the application. Other Cloud platforms such as AWS, Azure and oracle was not compatible to setup. The entire procedure of hosting with Firebase went smoothly. Firebase has a relatively liberal option of 10GB in its free tier. Our project ended up being just below 1GB when rendered as an optimized build project. After the app was developed with the latest production standards, Firebase was signed into, and chatting commenced to receive help.

<u>4.1 Difficulties with Hosting</u>

During our phase one of testing, Firebase threw errors. The team began to realize that it is not able to access the database properly due to an error in the chain commands for parsing. Firebase works asynchronously, this means that the call always returns immediately, without blocking the code to wait for a result. The results come sometime later, whenever they are ready. Hence, after logging in, the user details initially used to not appear in the next screen.

CHAPTER 5

CONCLUSION

This opportunity allowed the team to realize the team's remarkable talent, which had could have gone untapped. The team is grateful to the Honors College team for supporting me throughout the process. Android Studio, Streamlit, and Firebase are all amazing tools that have taught the team how to use and respect them while developing large-scale applications. The team was shocked by the proficient co-ordination. Although there was an introductory learning curve with language structure and the rationale of these apparatuses, that rapidly exceeded its benefits.

5.1 Android Studio and Firebase Conclusion

Android Studio was a huge leap after coding directly on Java. The added functionality paved the way for a simpler design. Each page of the application was split into two components such as the design (XML) component.

Google's Firebase is a fantastic solution that was tremendously beneficial to our team. Other backend platforms need the developer to set up server locations and maintenance expenditures, as well as manage load balancers. All of this is handled automatically by Firebase. As a result, the team was able to combine the Firebase Database, Authentication, and Storage platforms to make it easier to organize all the communications per user pair. The team was able to create a unique project that was not only functional but also secure and safe thanks to Firebase authentication. Based on personal experience,

everyone should begin their Cloud adventure by utilizing Firebase to its maximum potential.

<center>5.2 Streamlit Conclusion</center>

The team created Aasan using Java in Android Studio that stores the user's data in Firebase and implements the python machine learning model with Tensorflow by creating a TFLite model using BlazePose do detect human body coordinates.

- There are two versions of the app that allow the following things:

- 360 degrees analysis of the user's posture

multiple video inputs sources such as the mobile camera and a laptops' built-in/USB webcam.

This project provided an opportunity to develop multiple lighter OpenCV models integrated with StreamLit and Firebase that will serve as the desktop version of Aasan. On recording the users posture they are provided a reward token to boost incentive to maintain posture. Side by side, an analysis of the user's past posture will be presented as a graph that will help them understand the techniques better. After rigorous testing and use of the ml model under various circumstances, the team were able to produce a 98% accuracy on detecting of good/bad posture. On top of that we have other models developed:

- Neural network with pretrained model (BlazePose) : 95% accuracy

- OpenCV Cascade: 80% accuracy

The OpenCV model, that serves as the lighter model also provides a decent accuracy giving an alternative option to the heavy machine learning model that allows the user to use multiple video inputs.

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APPENDIX A

STREAMLIT CODE MANAGEMENT PRACTICES

1. Designing the layout of the desktop version: Aasan gave the team the opportunity to implement Streamlit and use various features provided as it converts Python to React and thus the calculating and placing the UI wherever possible and needed were things the honors project was focused on to show 360° video analysis. The screen activity that was made as a part of the honors project involved the user signing up as well as logging in to give their preliminary information.

   This sensitive information is being received from the input and directly transferring it to the firebase and simultaneously handling the logged in user. As it is connected to the Firebase and also to the Webrtc that helps us take the video input and perform posture analysis, we can thus use it for all purposes but must be sure not to overlap any functionality that may lead to various errors.

2. Asynchronous Buttons: This was done by placing buttons and on click options where needed and the team had set them for various places that needed to be used for accepting data for the user as it can be the user statistics where the user get statistical understanding of how his posture has been maintained over the past few weeks. These onclick asynchronous buttons also help the user change between the radio buttons placed on the webpage and by this they can choose from between the options of chat with doctor, receive 360° posture analysis using various model, or going to settings.

3. Data Flow and Integration of 360° Video Input: The data was collected at the video input interface, which was done by implementing Webrtc, this incorporated the built in and USB webcam feature that this honors project was supposed to incorporate. Apart from this, several development hours went into storing the data and running the machine learning models and statistical analysis in order to perform user statistics in

Aasan. This had thus been far challenging as expected. Capturing data and storing it in real time and then sending alerts on the screen   for all angles of the user was done in both the web application and the android application. This data was continuously stored in the firebase and thus real time maintenance of the data was the top priority.

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BIOGRAPHICAL INFORMATION

Dhruva Malik is an undergraduate student studying Computer Science at the University of Texas at Arlington. He has participated in two internships during his college career; the first one at a medium-sized company called Bashpole Software Inc., and the second one at Tenaska Power Services as a Data Scientist Intern. These internships were helpful in gaining knowledge of how products are developed in the industry and the agile team management methodologies, which helped Mr. Malik succeed far better than his expectations. Dhruva Malik has also worked as an undergraduate research assistant at The Innovative Data Intelligence Research Laboratory. He worked on multiple projects in the fields of Blockchain and Computer Vision and won the HackTX (UT Austin hackathon) in 2021. He also plans to work in the industry for a few years to explore all areas and find the optimal field of interest. Later, he would love to pursue his masters in that field and try to make significant contributions to the global community.