# CAT405 Intelligent Computing Major Project
## *Final Presentation*

***IC23240103*: *AI-Based Multi-camera Markerless Motion Capture with Joints Angle & REBA Calculation***
**(FREEMOCAP++)**

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# Project Description

This project was a revised version of the previous title “AI Based multi-camera markerless motion capture” and after further consideration with my supervisor, we decided to extend the functionalities of the already existing open-source motion capture system named “*Freemocap*”.

The project aims to develop an existing AI-based multi-camera markerless motion capture system capable of accurately tracking human movement with an additional functionality of calculating joint angles & REBA score calculation for ergonomic risk assessments. By employing markerless motion capture technology, I aim to overcome these limitations and provide a more natural solution for motion analysis purposes. Additionally, by also employing multiple(3) cameras I expect to see an improvement in the accuracy and precision of the captured joints detections & pose estimation.


# Problem Statement

- Reliance on only a single camera limits accuracy and tracking alignment. To improve usability, it is crucial to explore displaying specific joint angles in a specific way that supports REBA score calculation using multiple cameras and a suitable mathematical formula.

- Multiple cameras may lead to inaccuracies and misalignments due to the current markerless technology limitations. Extracting and displaying joint angles from the existing data can enhance the interpretation of motion capture results. This requires refining data processing algorithms to accurately calculate and present specific joint angles.

- With the newly addition of the joint angles, there is a potential to calculate the REBA posture score of a specific body pose. This method leverages existing algorithm to provide an accurate score calculation contributing to improved motion capture accuracy and reliability.

# System Objectives

- **Multi-Camera Integration (3 cameras)**

To successfully incorporate multiple cameras into the motion capture system, with a focus on optimizing camera placement and synchronization to achieve further accuracy.

- **Calculate Joint Angles & REBA Score Between Frames with High-Precision**

With a suitable mathematical algorithm and sufficient captured data from the motion-tracking system, it will be able to provide additional insight & information to the users.

- **Developed an Improved/Extended UI**

Develop a more functional UI with added functionalities that allow users to visualize the additional data and view the results for further analysis or integration to a wide range of users from researchers to animators.

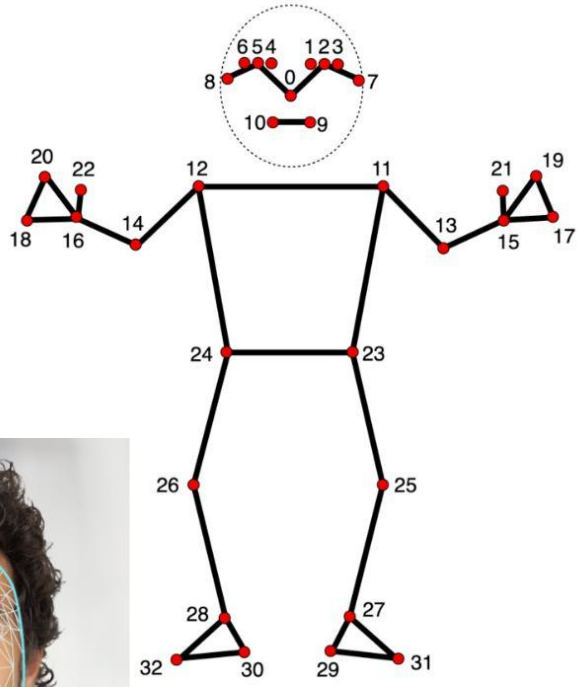
# Highlight(s) of IC Components

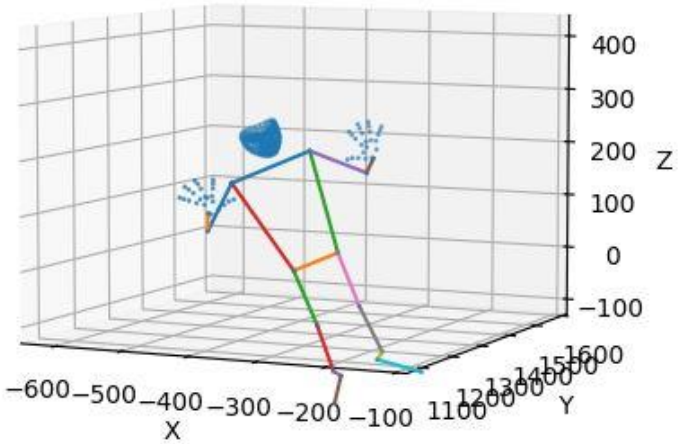
**Existing Components:**

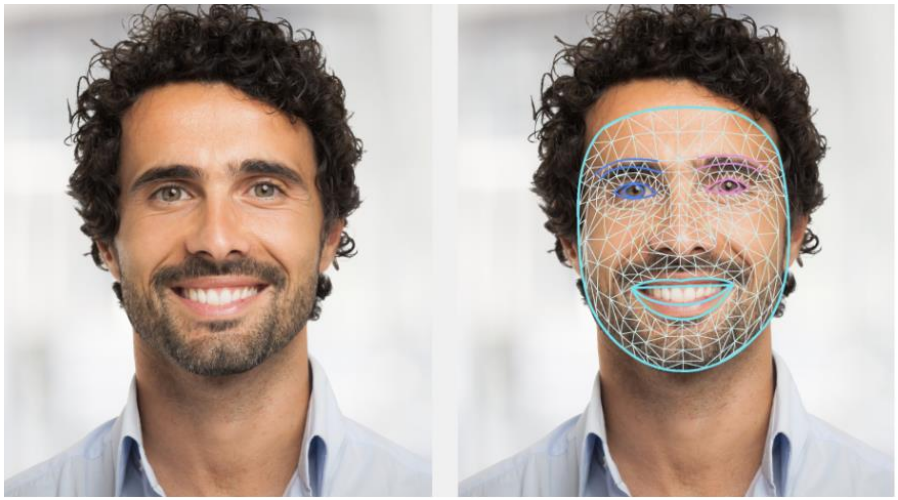
- Mediapipe Blazepose CNNs (Blazepose detector & Blazepose Landmarks) for pose estimation and landmark detection.
- Mediapipe Blazeface for face landmark detection.
- Anipose Multiple Camera Calibration & 3D Reconstruction.

**Added/Extended Component:**

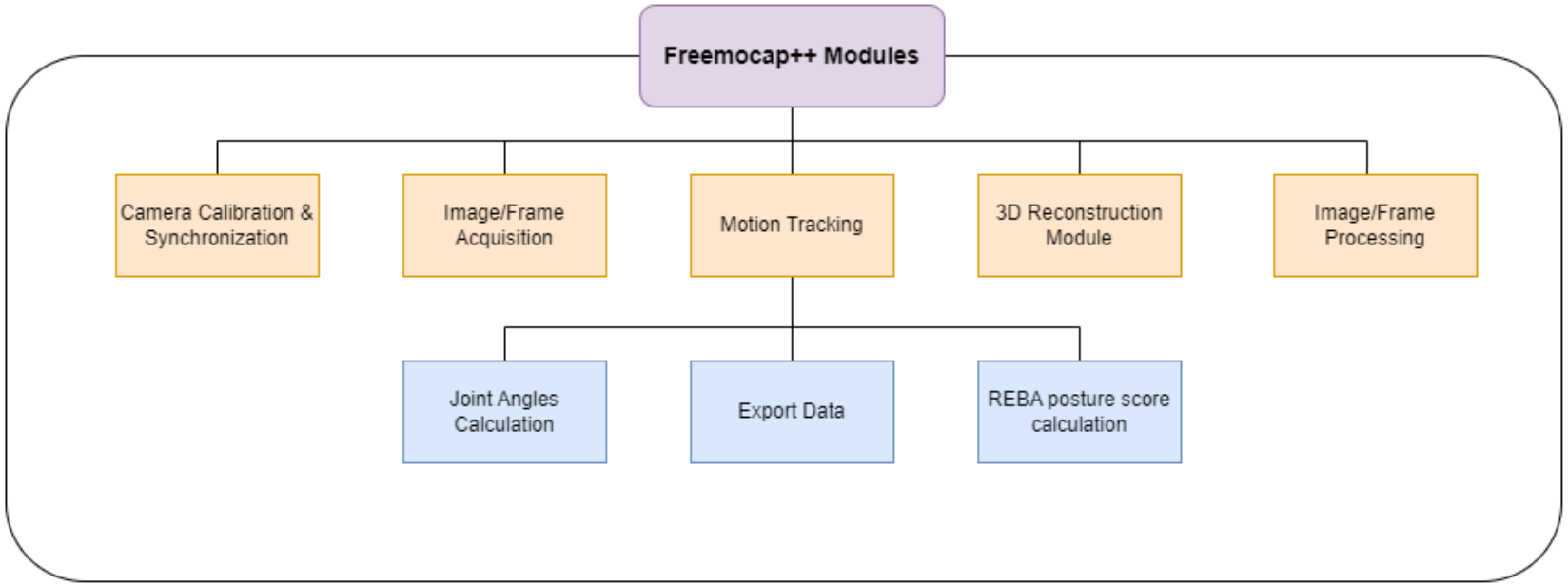
- Dynamic Programming Algorithm & OOP.
- Joint Angles & REBA Calculation.



# Module Diagram




Freemocap++ consists of 5 existing modules and 3 additional modules:

- **Camera Calibration & Synchronization**
- **Image/Frame Acquisition**
- **Motion Tracking**
- **Image/Frame Processing**
- **3D Reconstruction**
- **Joint Angles Calculation**
- **Export Data**
- **REBA Calculation**

# Project Implementation / Discussions

How:

- Get data & coordinates from *'mediapipe_body_3d_xyz.csv'* file that has been produced after the motion capture process.
- Use multiple methods and classes to obtain the specific joint angles needed for REBA calculation.
- Generated a separate .csv file containing the list of angles from each frame of the recordings.
- Calculate REBA score with the calculated angles data + user input to check certain limbs condition necessary for the calculation.
- After user has inputted the conditions, run the REBA calculation, then save each frame score to the same .csv file containing the list of angles.
- Get data from that .csv file and display it through the 'Data Viewer' tab of Freemocap++.
- Link each frame data to the corresponding rows & columns and display it dynamically along the frames.

Why:

- Add a functionality that can be used to do ergonomic assessment with minimal human interaction & time.
- Display the data dynamically so user can get a clear visual seamlessly.
- Improve the existing system in a way that is beneficial in a certain area/industry.

# Conclusion

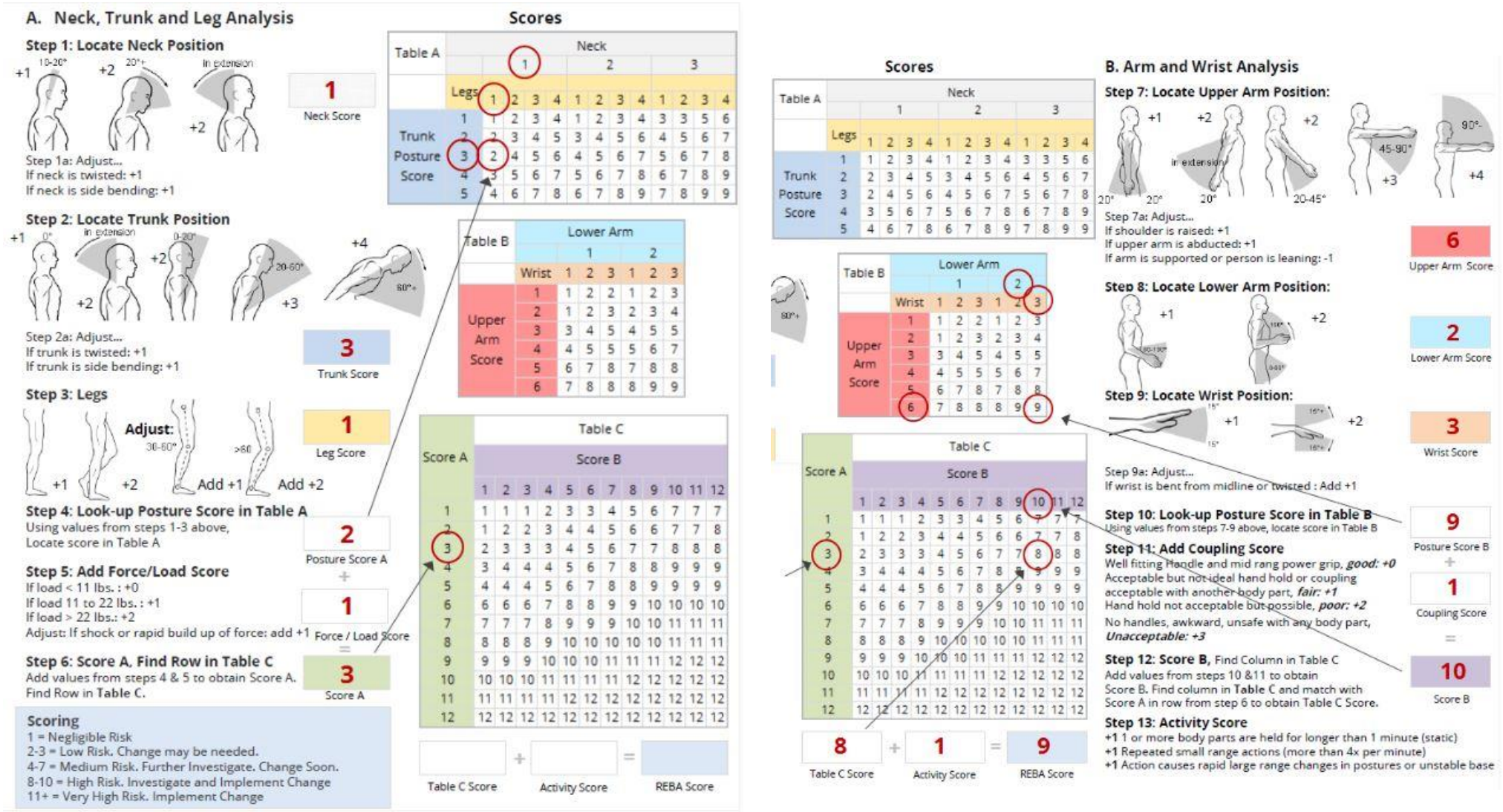
**Conclusion:**

- Current project is 100% done and have satisfied the project objectives.
- Existing modules from the existing software are already 100% done.
- Joint angles & REBA score calculation module are 100% done.
- The additional modules integration with the UI is 100%done (Might need to improve it a bit).
- The motion capture data is relying on the calibration file, the condition of the camera, and the lighting.
- Markerless motion capture system using multiple cameras does indeed produce a relatively accurate detection with minimal area of errors (±70%), but marker-based system is still the best option to achieve a more accurate & life-like result.
- To provide more insight and functionality to the existing system 'Freemocap', I've added several functionalities using data manipulation & OOP for ergonomic risk assessment.

**Future Plan:**

- Train a model to automatically recognize certain gestures that are related to REBA (neck twisting, trunk side bending, wrist rotating, etc).
- An improved UI & UX experience.
- Better cameras to support higher quality of recordings.
- Minimize User Input/Interaction.
- Collaboration with the actual developers(?).

# Appendix (If any)



# System Demo Summary

https://youtu.be/lxysiKUfYXw

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# Thank You