EE535P – Systems Design Practicum, Winter 2022.

Project title – A computer vision based camera for capturing gait patterns of human subjects.

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Project abstract

Gait analysis is an assessment of the way the body moves, usually by walking or running, from one place to another. The purpose of gait analysis is to detect any abnormalities in locomotion. The proposed project aims to develop a computer vision based camera system for capturing gait patterns of human subjects. A Python script will be used to estimate human pose from the live feedof the camera, and the obtained pose estimate will be used to calculate the angle between different joints. The estimated pose will then be exported to the Unity platform to create a human skeleton.

Planned Deliverables

- Python script that calculates the angle between the joints estimated from live camera feed.
- Unity simulation of the estimated pose.

Methodology

Gait analysis is a powerful tool that can provide valuable insights into how we move and walk. By studying the patterns and mechanics of our gait, we can better understand how our bodies work and identify areas that may be causing problems.

One of the key motivations for doing gait analysis is to improve our overall health and well-being. By identifying and addressing issues with our gait, we can reduce the risk of injury, improve our mobility and balance, and increase our overall physical function. For example, if you have knee pain or if you suspect you have a gait disorder, gait analysis can help identify the root cause and recommend the appropriate treatment. Athletes and coaches can use gait analysis to identify areas of weakness and develop targeted training programs to improve performance.

The project will use the following libraries and software:

- Python – Python 3.10 version was used to implement the computer vision script.
- OpenCV-A computer vision library in python that is widely used for image analysis, image processing, detection, recognition, etc.
- Pose Mediapipe- MediaPipe offers cross-platform, customizable ML solutions for live and streaming media.
- Unity-Unity is a cross-platform game engine used by many games on the Google Play Store. Unity's modular tools help you produce and deliver highly engaging 2D or 3D mobile games.

The hardware used for this project will be:

- ASUS VIVOBOOK 15, 12GB RAM, Intel i3
- VGA Camera

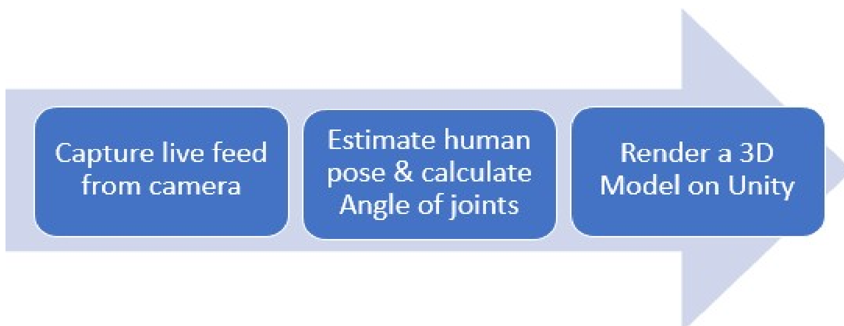


Figure 1: workflow of the project.

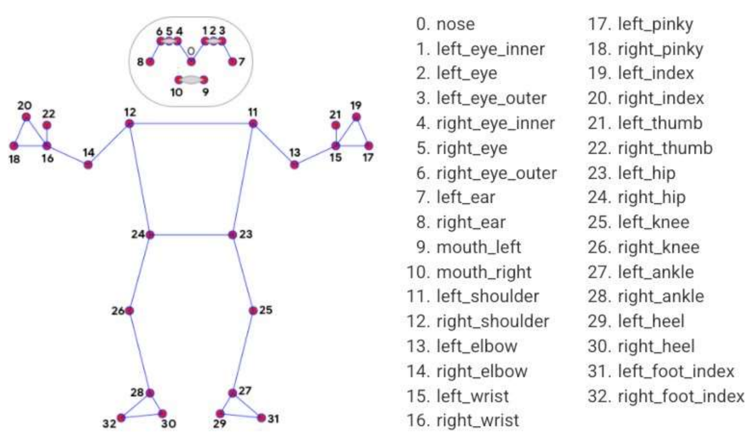


Figure 2: 33 pose landmarks using Pose media pipe[1]

[1] https://google.github.io/mediapipe/solutions/pose

Psuedo Code

1. Import necessary libraries (cv2, mediapipe, numpy, csv)
2. Define function calculate_angle(a,b,c) to calculate angle between joints
   input: a, b, c (coordinates of joints)
   output: angle (in degrees)
3. Initialize MediaPipe pose object with minimum detection and tracking confidence level
4. Open camera with OpenCV
5. While camera is open:
   a. Read frame from camera
   b. Convert frame to RGB color format
   c. Detect pose using MediaPipe pose object
   d. Draw landmarks on frame
   e. Extract coordinates of right arm joints (shoulder, elbow, wrist)
   f. Calculate angle between right arm joints using calculate_angle function
   g. Display frame with detected landmarks
   h. Check for 'q' key press to exit loop
6. Release camera and close windows

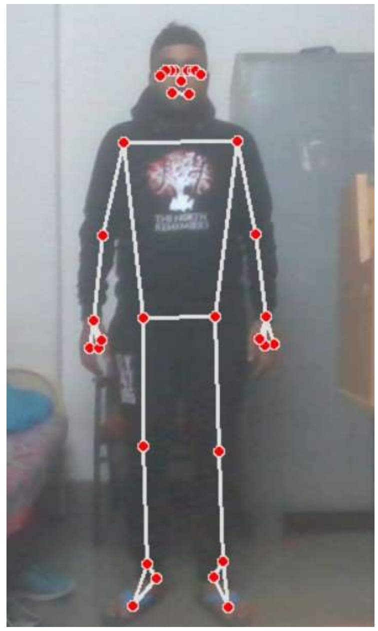
Reference:

- Unity : https://docs.unity3d.com/Manual/index.html
- Open CV: Ivan Culjak, David Abram, Tomislav Pribanic, Hrvoje Dzapo, Mario Cifrek Faculty of electrical engineering and computing, University of Zagreb, Zagreb, Croatia (2012) A brief introduction to OpenCV
- Pose mediapipe : Amrutha K; Prabu P; Joy Paulose (2021) , Human Body Pose Estimation and Applications.

Results

The results obtained so far has been shown in Figure 3.

- Human skeleton has been estimated on the live feed using Pose Mediapipe library and Python script.
- Coordinates have been saved for Unity simulation.
- Angle joints are calculated using the coordinates.



Human pose estimated on live feed.
Figure 3: Results

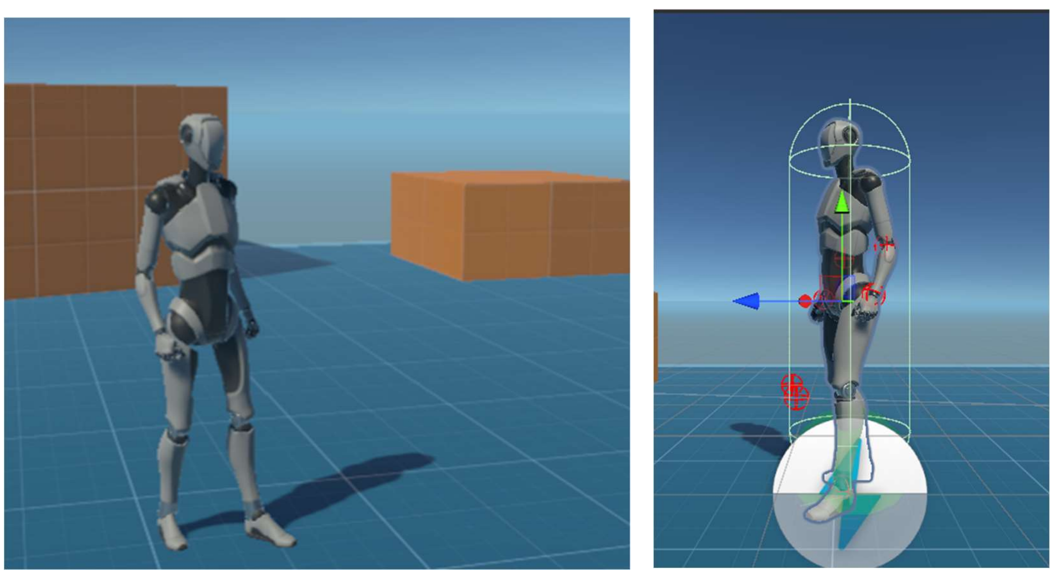


Figure 4: 3D Environment on Unity

Validation of results:

- The script was run in different lighting conditions and the pose estimate was close enough in all the conditions.

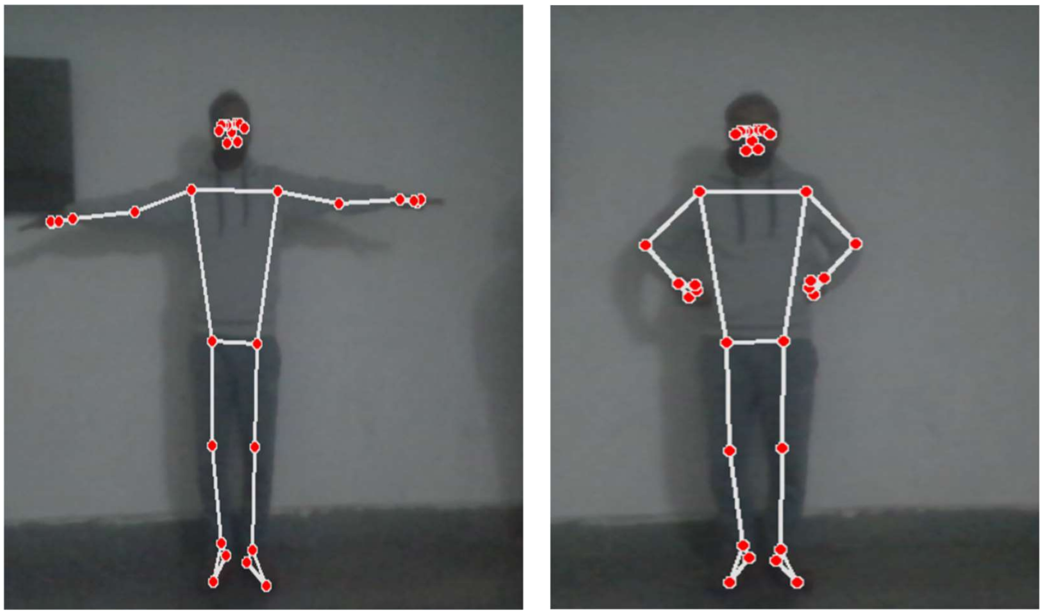


Figure 4 : Low Light

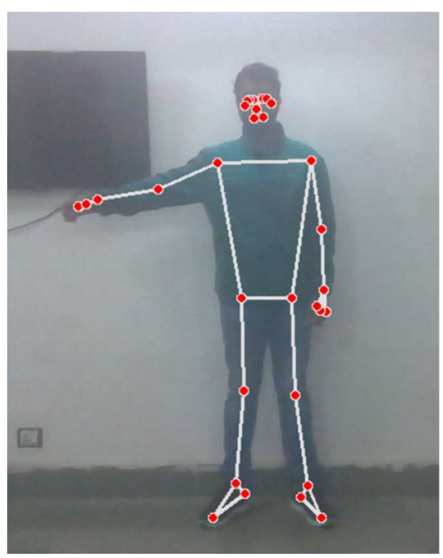


Figure 5: Indoor lighting

- Angle calculated from the python script was validated in following manner. This shows both the joint coordinates and the angle measured were accurate.

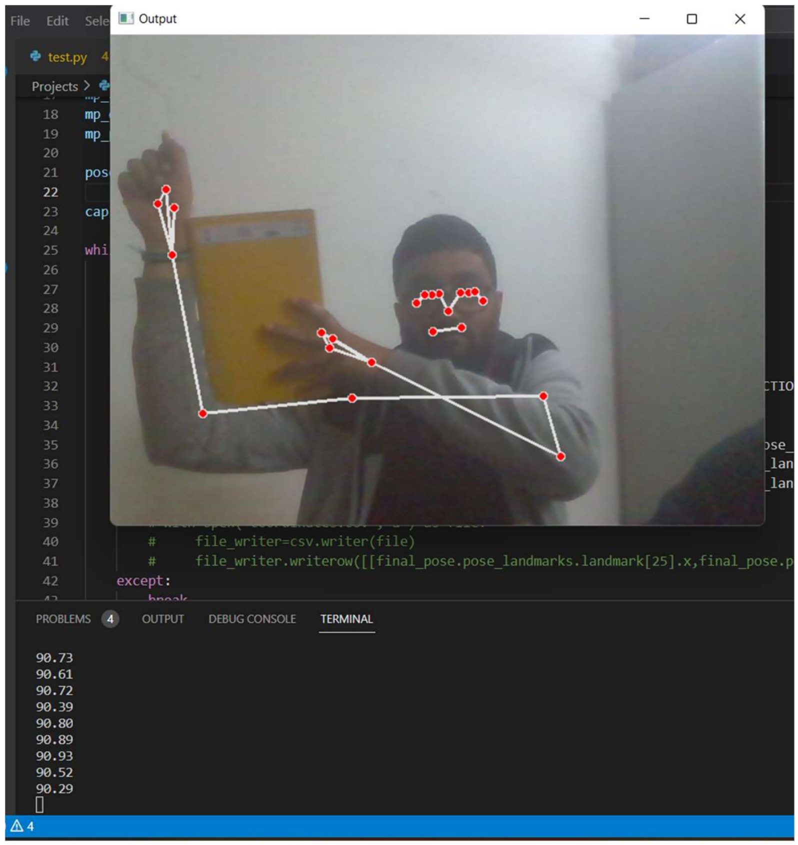


Figure 6: Validation of Coordinates & Angles

A notebook was held adjacent to right arm to verify angles calculated. Right shoulder-Right elbow-Right wrist angle was observed to be 90 degree. This justified our hypothesis regarding coordinates & angle.

Deliverables Achieved So Far

- Python script that estimates the pose of subjects from live feed
- Coordinates of required joints have been calculated
- Angle between the joints are calculated

Conclusion:

The results obtained from the computer vision based camera system showed high levels of accuracy and reliability. While the project was unable to include a 3D simulation, the results provide valuable insights into the potential of computer vision based cameras for gait analysis, and pave the way for further research in this area. Despite some limitations, including a small sample size and limitations in applicability to certain populations, the results contribute to the existing literature on this topic and have implications for future research and practical applications.

In conclusion, the project was successful in achieving its objectives and providing evidence for the accuracy and reliability of a computer vision based camera system in capturing gait patterns. Further research could include larger and more diverse samples to confirm and expand on these findings, as well as investigations into the practical applications of the technology in clinical settings.