Project Runway

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Introduction

What is a Gait Lab?

Gait refers to the manner in which a person walks. A gait lab qualifies a person's gait by measuring forces and joint angles over a single gait cycle. The information obtained from gait analysis is clinically valuable and has a number of applications such as rehabilitation therapy and sports analysis.

Our Project

Conventional gait labs are expensive and cost around £100k, which precludes their use in clinical setting, especially in developing countries. Our aim is to develop a gait lab system affordable enough for routine clinical use in low-income countries. To achieve this, our system incorporates image recognition technology for the calculation of joint angles, as well as Inertial Measurement Unit to monitor hip sway.

Specifications

System

- Has a margin error of 5-30mm for position and 1° for joint angles
- Cost less than £1500
- Able to plot graphs as a function of time
- Able to analyse 1 gait cycle

User

- Data collection takes less than 20 min
- User friendly and intuitive GUI
- Usable in Windows operating system

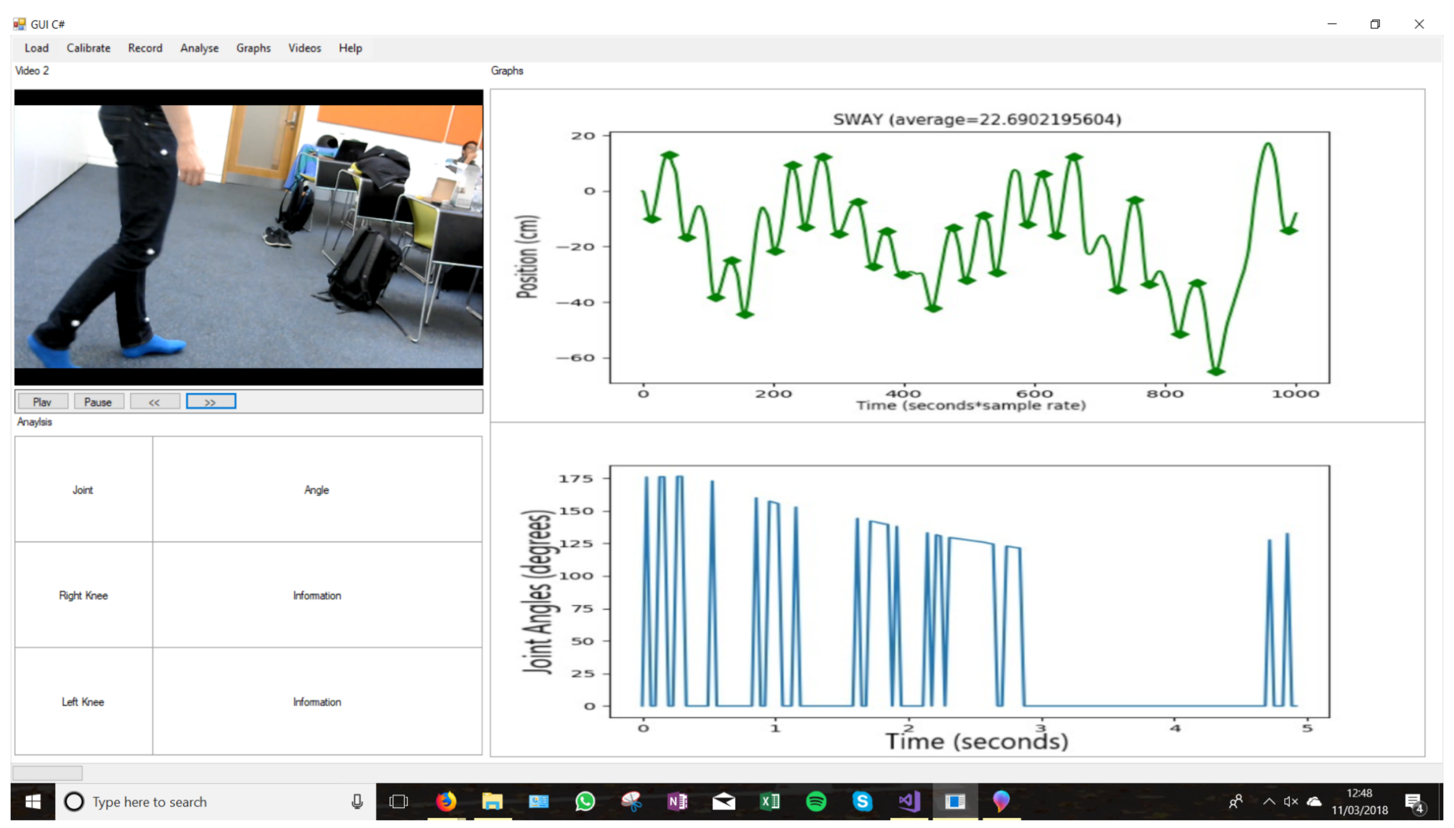


Figure 1: Graphic User Interface

Product Design

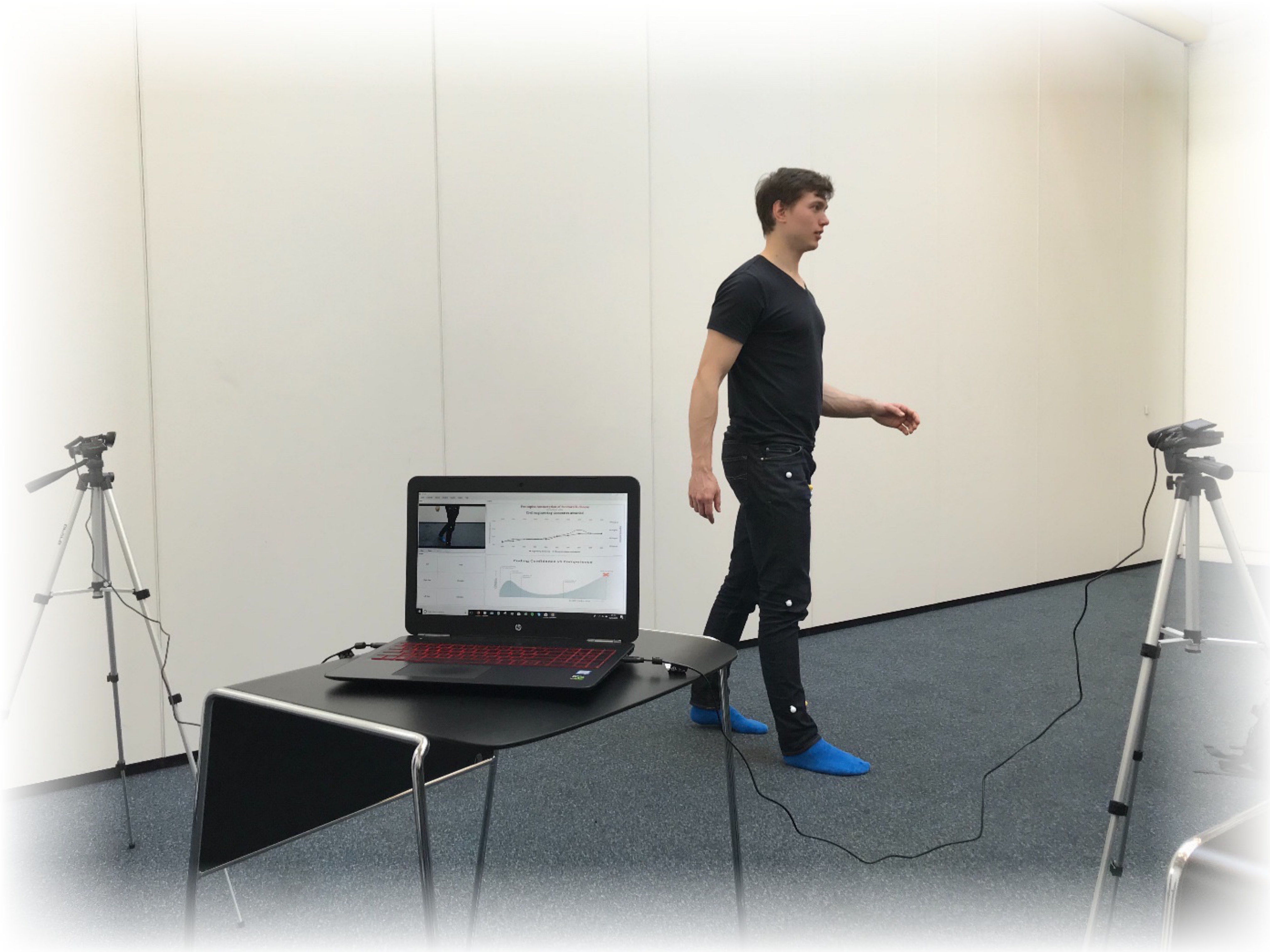
Image Recognition

1. The system is calibrated using a chessboard
2. A region of interest is extracted from each frame from which marker candidates are obtained
3. Candidates are classified as "white marker", "yellow marker" or "not a marker"
4. Markers from previous frame are matched to current frame to track marker paths over time
5. Joint angles are calculated from these markers using variables collected from calibration

Initial Measurement Unit

1. The circuit in Figure 3 is strapped to the hip
2. Linear and angular acceleration are measured using the IMU and sent to the Arduino module
3. Data is sent via Bluetooth module to a personal computer and saved onto a file
4. During post-processing, noise is filtered and drift is removed
5. The acceleration data is integrated to obtain position and is plotted against time

Figure 2: System Setup



Testing

Marker Detection

The binary classification of the accuracy of the marker detection code was tested on an independent image data set. An accuracy of 98.7% was obtained. Testing for colour detection and marker path tracing accuracies is in progress.

3D Positioning

The accuracy of the joint angle measurement module was tested by measuring known angles on a protractor using this module. Angle accuracy varied depending on the distance from the camera, but on average angles were accurate to about 3°.

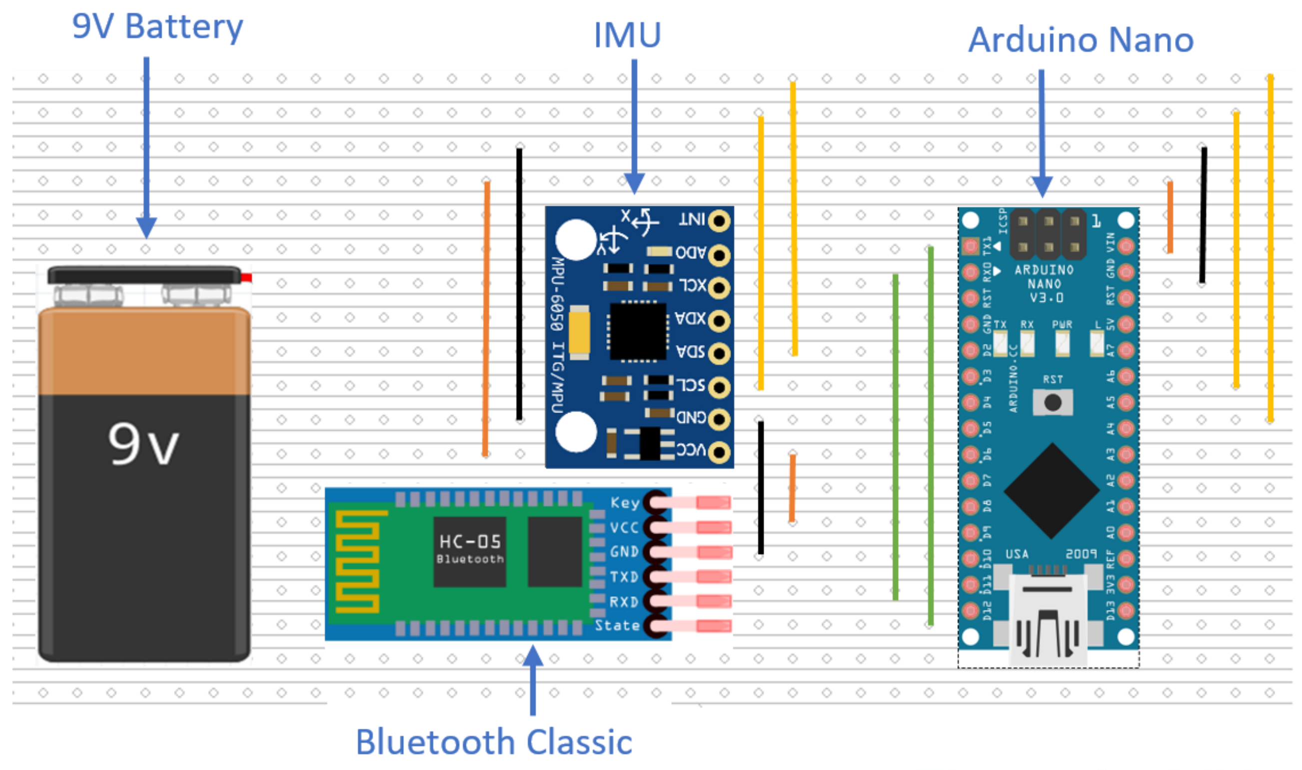


Figure 3: IMU

Evaluation and Developments

- Integration of more than two cameras is still unstable due to hardware issues
- Joint angle accuracy is still below the system requirements. Higher resolution cameras that maintain a high FPS could be a solution
- The IMU precision can be increased by using a better IMU and a custom strap and case to reduce noise
- The IMU data collection will be more stable with a PCB
- 20 minutes is required to collect data from patients. It may be ideal for this time to be shortened
- The calibration procedure is complex as a 2D object is used. A 3D object visible to all cameras could reduce calibration time
- Graphs are currently in a jpg format. A more interactive format can allow for a better visualisation of data
- An option to print images, graphs and relevant formations could be helpful to clinicians

Conclusion

The product we have made is a suitable development base for low-cost gait labs, and is able to perform essential functions. In order for it to be ready for deployment we will primarily need to improve the current hardware, which limits the accuracy of our system.

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