# Human Gait Symmetry Analysis Via Inertial Measurement Unit

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## Introduction

Gait symmetry refers to the similarity in behavior of bilateral limbs during a gait cycle. A symmetric gait pattern can be compromised due to the presence of pain, or as a consequence of an underlying physical or neurological impairment.

Over time, an asymmetric pattern may predispose humans to the development of musculoskeletal problems.

## Problem Statement

Clinically, assessments of gait symmetry are performed via observation which fails to accurately quantify bilateral symmetry. Moreover, current high-end motion capture systems provide data to assess symmetry, however, these systems can be expensive and lack portability.

As a solution, the present project proposes a cost-effective, portable alternative leveraging inertial measurement units (IMU) to automatically quantify bilateral gait symmetry.

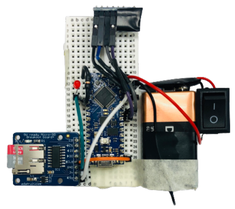
## Project Description

Our project consists of two parts:

1. A wearable system which records measurements of shank angles over time and stores the data in a SD card.
2. A developed MATLAB program which takes the measured data as input and automatically displays a weighted score of gait symmetry for multiple gait features.

## Equipment

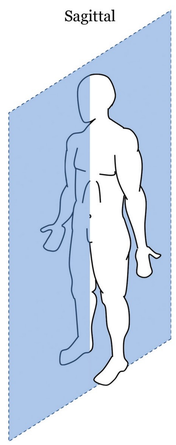
| Component | Function | Cost |
|---|---|---|
| MPU6050 | Measures angles | $6 |
| Arduino Nano | Implements logic | $12 |
| SD Card Module | Stores Data | $7 |
| Total Cost (2 units) | | $50 |



## Theory

In gait analysis, the repetitive motion of one leg can be describe by a gait cycle. A cycle can be divided into two phases: stance phase and swing phase. The stance phase starts with an initial contact, also known as a heel-strike (HS), and ends when the toe comes off the ground, also known as a toe-off (TO). The swing phase starts with a toe-off and ends with a heel-strike of the same leg.

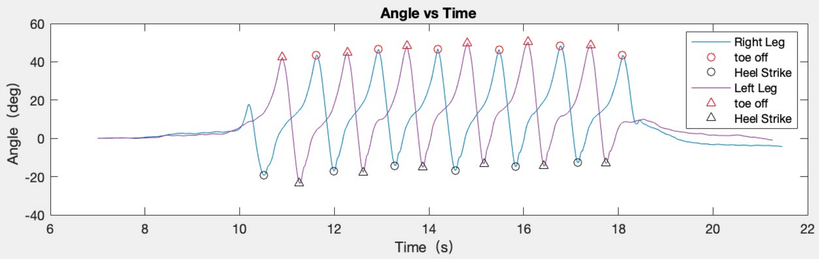
## Measurements of Kinematics




Time markers for toe-off and heel-strike points can be obtained by measuring shank angles on the sagittal plane over time. In a gait cycle, defining counter-clockwise rotation as positive. A toe-off is characterize by a maximum angle and a heel-strike is characterize by a minimum angle.

The MATLAB program, which takes angles as a function of time, automatically detects time markers for TO and HS points. Next, it uses the time markers to calculate the following parameters for each lower limb: **Gait Cycle Time, Stance Time, Swing Time, Stance Amplitude.**

## Results




| | Right Leg Average | Left Leg Average | Ratio Index | Symmetry Index |
|---|---|---|---|---|
| Stride Time (s) | 1.2783 | 1.2707 | 0.0060 | 0.0060 |
| Stance Time (s) | 0.9285 | 0.9340 | 0.0059 | 0.0059 |
| Swing Time (s) | 0.3550 | 0.3390 | 0.0451 | 0.0461 |
| Stance Amplitude (°) | 62.7200 | 64.7667 | 0.0316 | 0.0321 |

## Quantifying Gait Symmetry

Gait symmetry can be measured by comparing right and left parameters in the following manner:

$$Symmetry\ index\ (SI) = \frac{|L - R|}{0.5 \times (L + R)} \times 100\%$$

Generally used in healthy subjects because an average of both limbs is used as a reference.

$$Ratio\ index\ (RI) = \left(1 - \frac{R}{L}\right) \times 100\%$$

Generally used in patients with underlying physical or neurological impairment. Limitations of this index are its low sensitivity and relatively low asymmetry.

I=0 indicates full symmetry. I>100% indicates asymmetry.

## Conclusion

Our system is shown to be reliable in confirming gait symmetry in healthy subjects. While promising, future testing and verification of performance with irregular gaits is required before transferring to a clinical environment.

## Acknowledgments

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References :
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