Gait Speed Intent Recognition

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Introduction

- This study aims to predict the speed that someone intends to walk by analyzing their leg movements.
- The goal of our research is to create wearable robotic systems that adapt to how people naturally move.

Mahalanobis distance

- Consider the equation:

$$x(p, t) \sim N(\mu(p, t), \Sigma(p, t))$$

- Where P is defined as:
- Preliminary results showed that dividing the gait cycle into these four phases resulted in greater accuracy and responsiveness than considering the whole gait cycle without phase divisions.

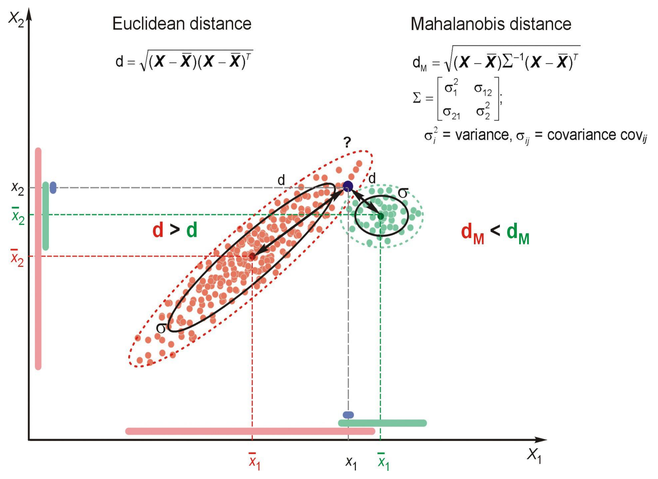
$$p = \begin{cases} 1 & \text{if Right Double Support} \\ 2 & \text{if Right Single Support} \\ 3 & \text{if Left Double Support} \\ 4 & \text{if Left Single Support} \end{cases}$$

- t represents the number of time steps since that phase began, N symbolizes a Gaussian distribution, μ is the mean vector of the distribution, and **Σ** is the covariance matrix of the distribution.
- To add data to the model one observation at a time, the mean and covariance estimates after the nth training observation are computed recursively via:

$$\mu_n = \frac{(n-1)\mu_{n-1} + x_n}{n}$$

$$\Sigma_n = \frac{(n-1)\Sigma_{n-1} + (x_n - \mu_n)(x_n - \mu_n)^T}{n}.$$

- Real-time intent identification is done by comparing new data so this gait model by calculating the Mahalanobis distance (MD)
- The larger the MD the larger the desired change in gait speed



Methodology

- We are designing an experiment in which subjects walk on a treadmill wearing an Xsens motion capture suit which reports their joint angles
- A MATLAB program commands a Bertec treadmill to run the predetermined speed profile shown in Fig 1.
- Each subject will first follow a model training procedure
- In the subsequent testing phases, the model will predict speed adjustments in real time based on incoming joint angle data.
- We then test the accuracy of the model's predictions by comparing the system's predictions to the treadmill's actual speed, measuring how closely they match.

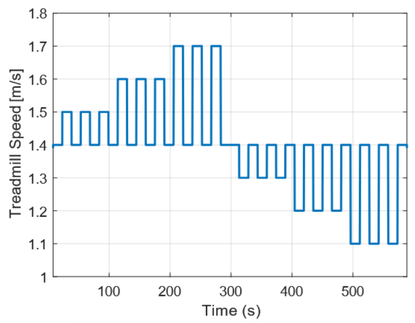


Fig 1: Treadmill Speed Profile

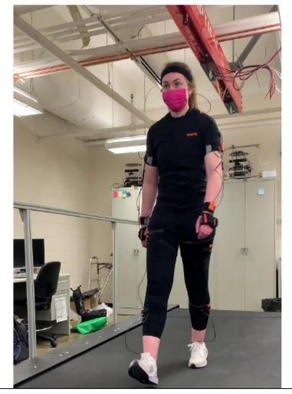


Fig 2: Example subject

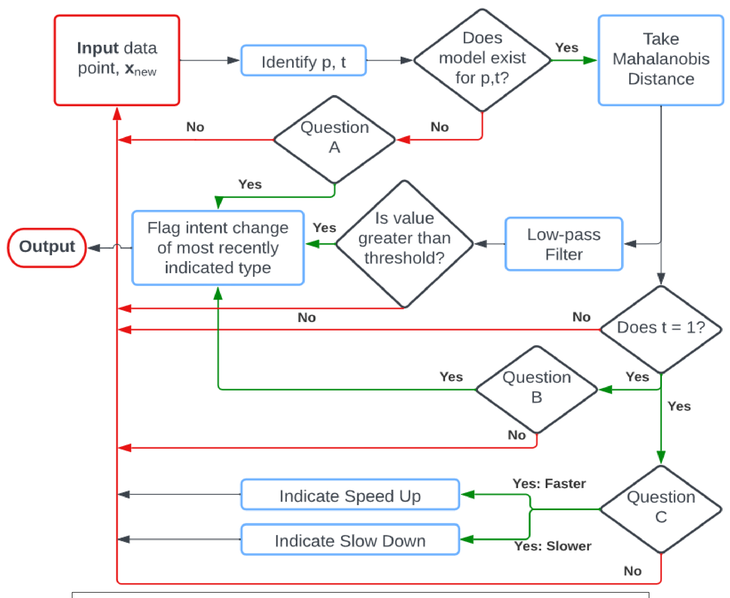


Fig 3: Decision flowchart

Xsens

Fig 4: New motion Capture suit

What's next

- We are nearing the end of the experimental design/setup phase and will soon test our first pilot subject

References

- Higgins, T. M., Bresingham, K. J., Schmiedeler, J. P., & Wensing, P. M. (2023). Data-efficient human walking speed intent identification. Wearable Technologies, 4. https://doi.org/10.1017/wtc.2023.15

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