Clinical evaluation of machine learning approaches for the classification of gait using static & dynamic algorithms in comparison to human performance

Viswadeep Sarangi[1], Adar Pelah[1], William Edward Hahn[2], Elan Barenholtz[2], Thomas Stone[3] & Dimitar Kazakov[4]

[1] Dept. of Electronic Engineering, University of York
[2] Center for Complex Systems and Brain Sciences, Florida Atlantic University
[3] Cambridge Clinical Movement Laboratory, Cambridge University Hospitals
[4] Dept. of Computer Science, University of York

Musculoskeletal (MSK) disorders such as osteoarthritis account for a loss of 36 million workdays & 1% reduction in Gross national Product (GNP) in the UK. Stroke, the biggest cause of mobility impairment costs £9 billion to the UK, annually [1]

The style of one's walking (gait) carries information about identity, gender, emotional affect and health. Gait is a highly reliable biomarker for diagnosis & rehabilitation progress monitoring of MSK and neurological conditions [2]

Learning Models to Evaluate

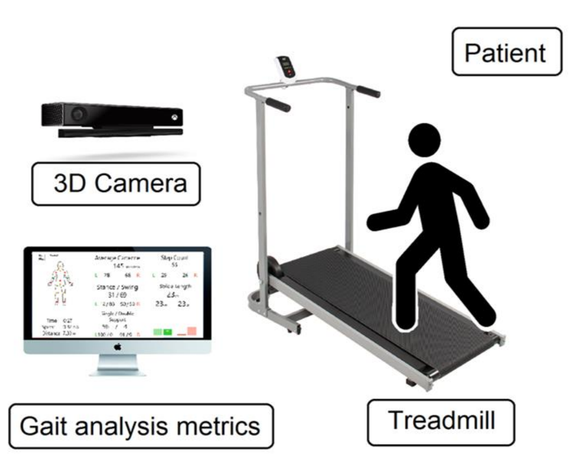
Motion Perception based Dynamic Models

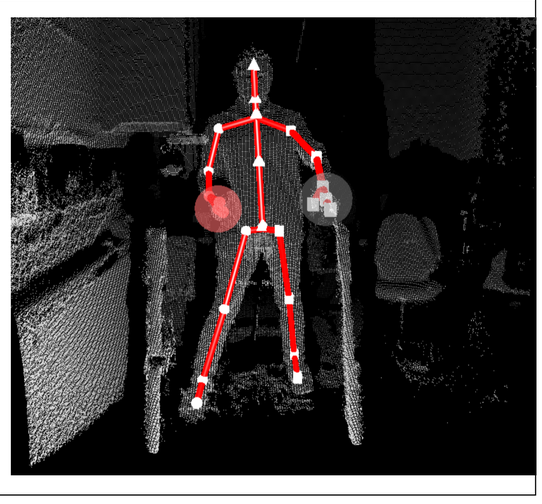
- Human Perception
- Long Short Term Memory (LSTM) [3]

Gait Metrics based Static Models

- Support Vector Machine (SVM) [4]
- Decision Trees (DT) [5]
- Feed Forward Neural Network (FFNN)

Setup





Evaluated On

41 Healthy Subjects (26 M, 15 F); 18-50 years old
12 mins of walking per subject

Models evaluated for gender discrimination from gait. Gender as a proxy for any underlying condition that manifests itself in gait.

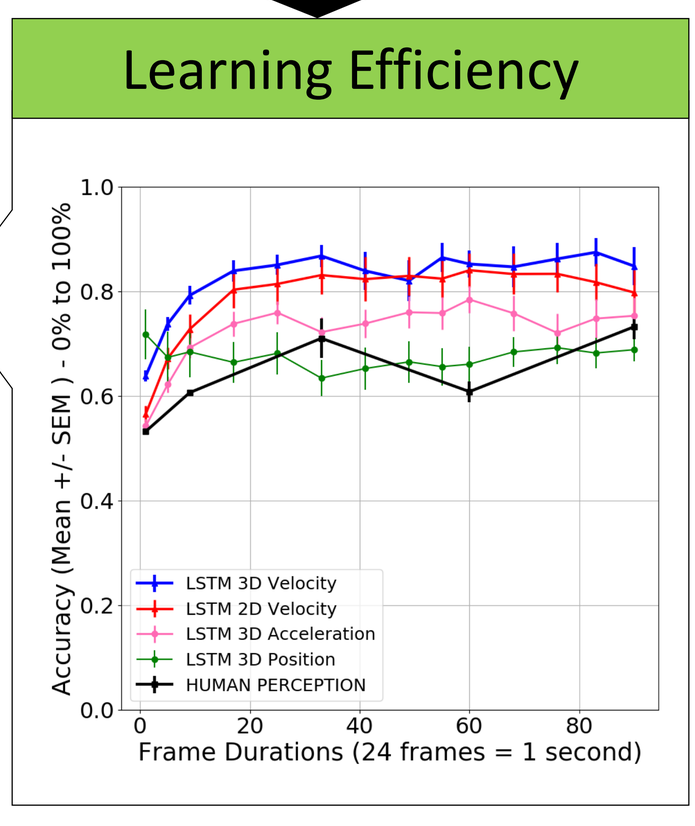
Input data types:

- Humans - Point Light Animation (PLA) [6]
- LSTM - Raw Motion & derivatives
- Static Models - Clinical Gait Metrics (CGM)
- Static Models - Path Signatures [7]

Results

Learning Model	Data Type	Accuracy (%)
LSTM	**Velocity**	**88 +/- 0.99**
LSTM	Position	84 +/- 0.98
LSTM	Acceleration	77 +/- 0.67
HUMANS	**PLA**	**74 +/- 0.35**
DT	**Path Sig.**	**73 +/- 0.97**
FFNN	CGM	61 +/- 1.48
SVM-Poly.	CGM	55 +/- 1.23
SVM-Linear	CGM	54 +/- 0.86
SVM-RBF	CGM	51 +/- 0.43
DT	CGM	45 +/- 0.82

Learning Efficiency



Conclusion

- LSTM based neural networks are the best dynamic models for gender classification from gait with limited data availability
- Path Signatures offer interpretability along with decent classification performance
- LSTM based networks have a higher learning efficiency than humans at an objective humans might be expected to perform well on from an evolutionary perspective [8]

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