

Sequence Labeling for Gait Analysis using LSTM

10-701 Project Presentation

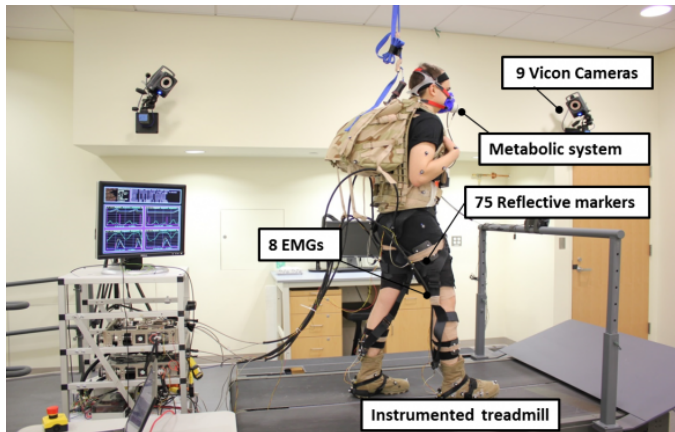
Pablo Iturralde

Yin Zhong

Jakob Bauer

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Introduction



from <http://biodesign.seas.harvard.edu/soft-exosuits>

Goal: Accurately detect gait events (heel strike, toe off) in video-based motion capture data of human walking gait

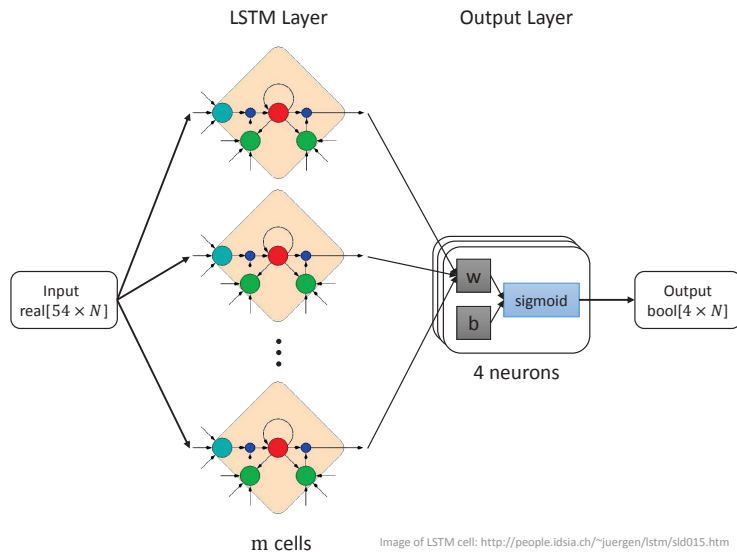
Introduction

- ▶ **Problem:** Sequence labeling
 - ▶ Input: 3D locus of 18 motion capture markers ($54 \times N$ reals)
 - ▶ Output: $\{\text{Left, Right}\} \times \{\text{Heel Strike, Toe Off}\}$ ($4 \times N$ bools)
- ▶ **Dataset:**
 - ▶ 8 subjects \times 3 trials \times 10 000 samples @ 100 Hz
 - ▶ Ground truth from force plates on treadmills

Our Approach

- ▶ Objectives (by order of priority):
 1. Gross mis-predictions should be avoided even with the presence of input noise
 2. Number of manually-picked parameters (window size, threshold, filter cutoff, etc.) should be minimal and insensitive
 3. Empirical feature-engineering should be minimal
 4. Algorithm should generalize to all (healthy) subjects regardless of training set used
- ▶ Proposed solution: LSTM-based RNN
 - ▶ Robust recognition of periodic patterns and precise timing
 - ▶ Can possibly exploit inter-gait-cycle dependence

Network architecture



Implementation

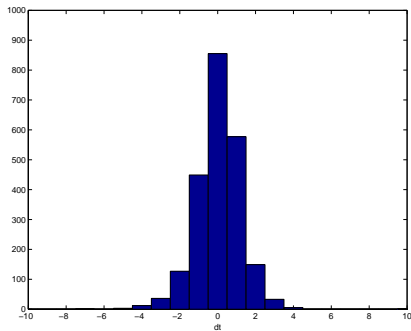
- ▶ Torch/Lua on 1 AWS EC2 GPU instance (g2.2xlarge)
- ▶ Start with LSTM code example by de Freitas
 - ▶ Heavily modified to adapt to our problem setup
 - ▶ Problem: Does not converge fast enough out of the box
 - ▶ Tweaks: Learning rate, mini-batch, regularization, etc.
- ▶ Evaluate algorithm performance on separate testing datasets
- ▶ Further work:
 - ▶ Explore alternative network configurations
 - ▶ Improve time/space invariance
 - ▶ Generalize to unhealthy subjects and/or over-ground trials

Results

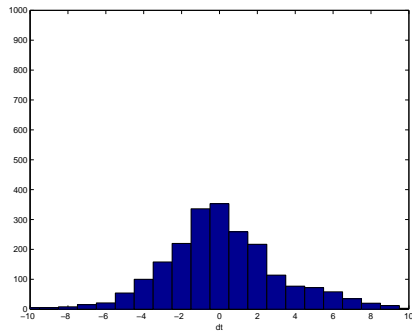
	deviation		mistake	
	mean	std	mean	std
Foot velocity	4.84	3.74	2260.2	560.4
Feed-forward NN	0.85	1.48	211.1	204.5
LSTM	2.35	3.87	306.6	360.5

Table 1: Comparison of results for $N = 30$, $T = 2.5$ s.

Results



(a) Feed-forward NN



(b) LSTM

Figure 1: Absolute deviations, $N = 30$, $T = 2.5$ s.

Thank you for your attention!

Human Gait Cycle

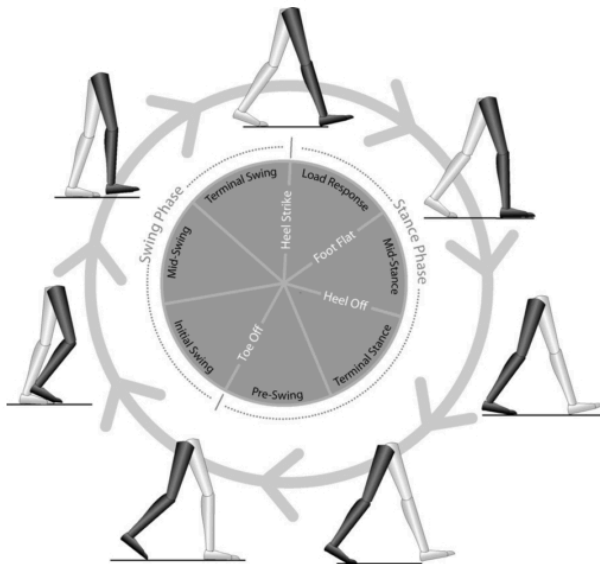


Figure 2: Gait events [Rueterbories et al., 2010]