

# Sequence Labeling for Gait Analysis using LSTM

10-701 Project Presentation

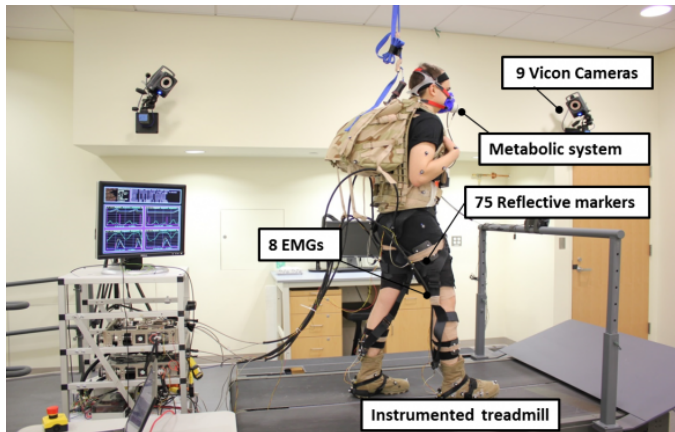
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# Introduction



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

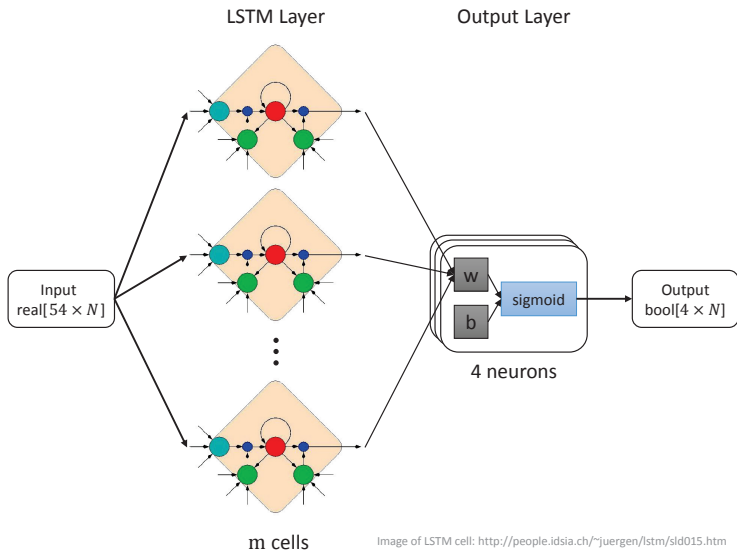
# Introduction

- ▶ **Problem:** Sequence labeling
  - ▶ Input: 3D locus of 18 motion capture markers ( $54 \times N$  reals)
  - ▶ Output:  $\{\text{Left}, \text{Right}\} \times \{\text{Heel Strike}, \text{Toe Off}\}$  ( $4 \times N$  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

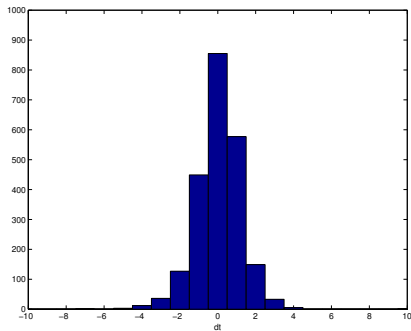
- ▶ Torch/Lua on 1 AWS EC2 GPU instance (g2.2xlarge)
- ▶ Start with LSTM code example by de Freitas
  - ▶ Heavily modified to adapt to our problem setup
  - ▶ Problem: Does not converge fast enough out of the box
  - ▶ Tweaks: Learning rate, mini-batch, regularization, etc.
- ▶ Evaluate algorithm performance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

# Results

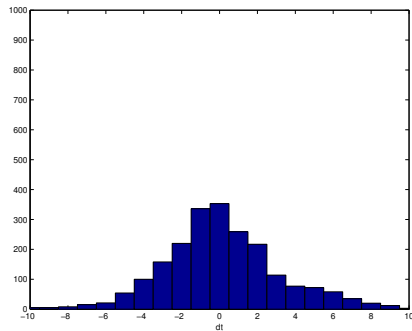
	true deviation		absolute deviation	
	mean	std	mean	std
Foot velocity	4.16	3.74	4.84	2.80
Feed-forward NN	0.07	1.48	0.85	1.21
LSTM	0.10	3.87	2.35	3.08

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

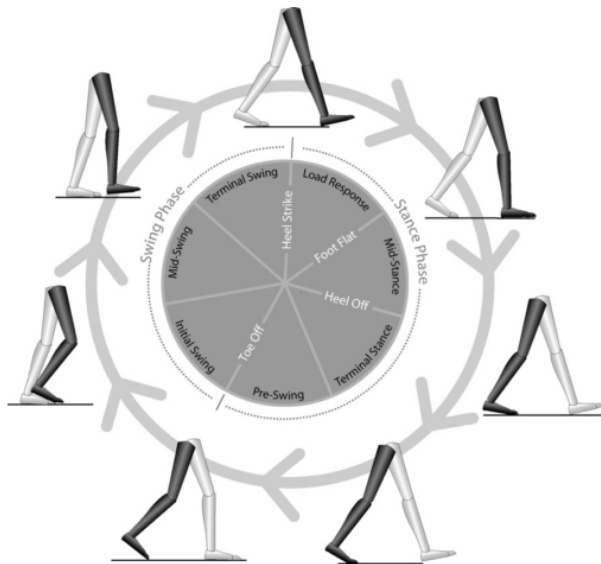


Figure 2: Gait events [Rueterbories et al., 2010]