Gait Event Detection Using an LSTM Network
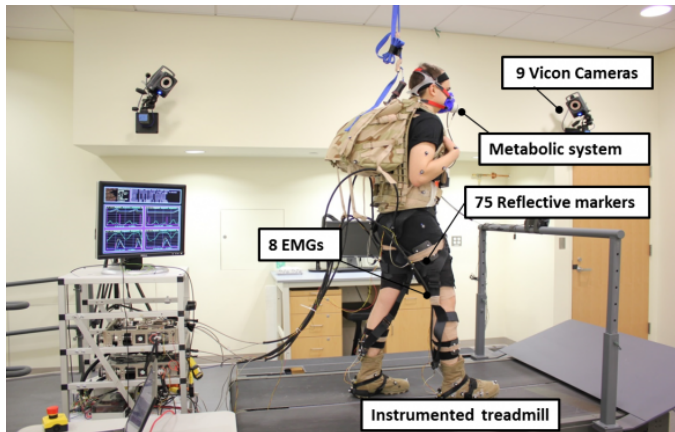
10-701 Project Presentation

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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

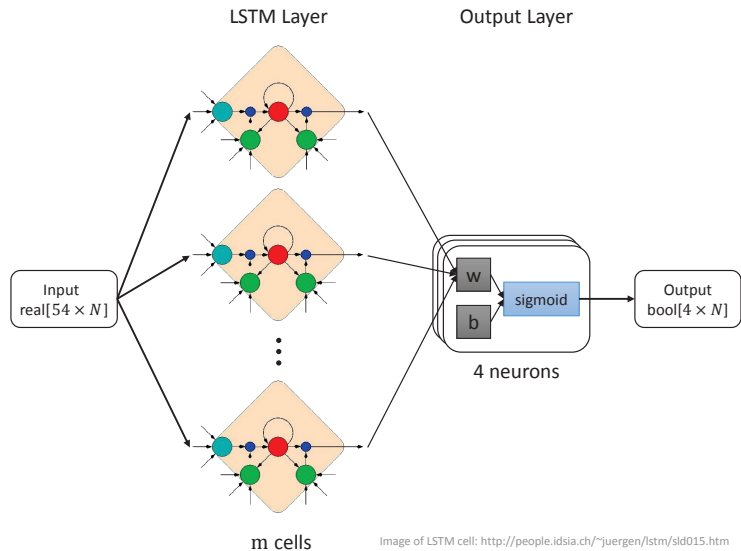# Introduction

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

LSTM Layer

Output Layer

Input
real[54 × N]

4 neurons

Output
bool[4 × N]

w

b

sigmoid

m cells

Image of LSTM cell: http://people.idsia.ch/~juergen/lstm/sld015.htm

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.
- Evaluation of algorithm performance:
  - Correctly predicted events: $t_{\mathrm{true}} - t_{\mathrm{pred}}$
  - Gross mis-prediction: total time of mispredicted state
- Further work:
  - Explore alternative network configurations
  - Improve time/space invariance
  - Generalize to unhealthy subjects and/or over-ground trials

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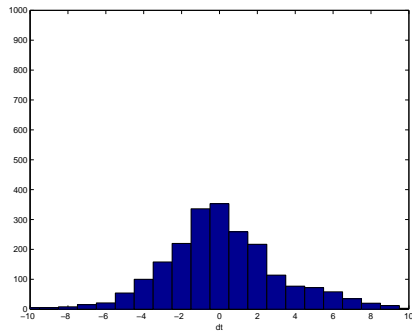
	deviation		mistake	
	mean	std	mean	std
Foot velocity	4.84	3.74	2260.2	560.4
Feed-forward NN	0.85	1.48	211.1	204.5
LSTM	2.35	3.87	306.6	360.5

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

Results
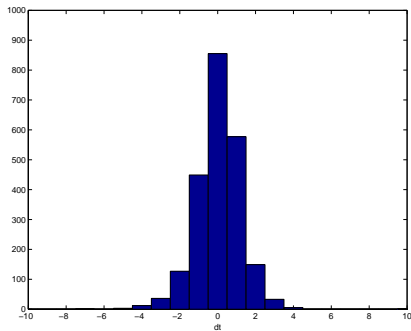
(a) Feed-forward NN   (b) LSTM

Figure 1: Absolute deviations, $N = 30$, $T = 2.5$ s.
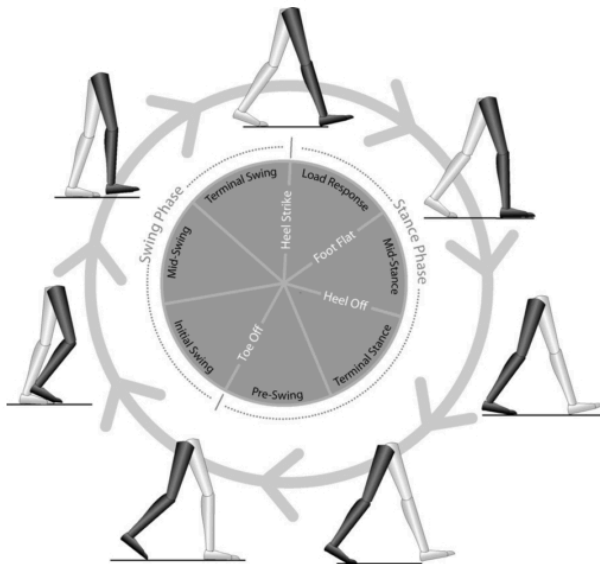
Thank you for your attention!

Human Gait Cycle

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