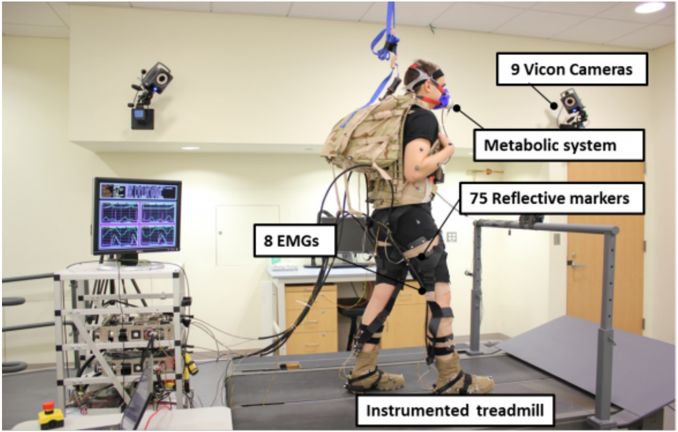
Sequence Labeling for Gait Analysis using LSTM

10-701 Project Presentation

Pablo Iturralde
Yin Zhong
Jakob Bauer

April 27, 2015

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: $\{\text{Left, Right}\} \times \{\text{Heel Strike, Toe Off}\}$ (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:
  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. Algorithm that generalizes to healthy and pathological subjects, treadmill and over-ground walking
- Proposed solution: LSTM-based RNN
  - Shown to work with timeseries data in sequence labeling and prediction tasks
  - Can possibly learn and exploit temporal correlations of data

Network architecture

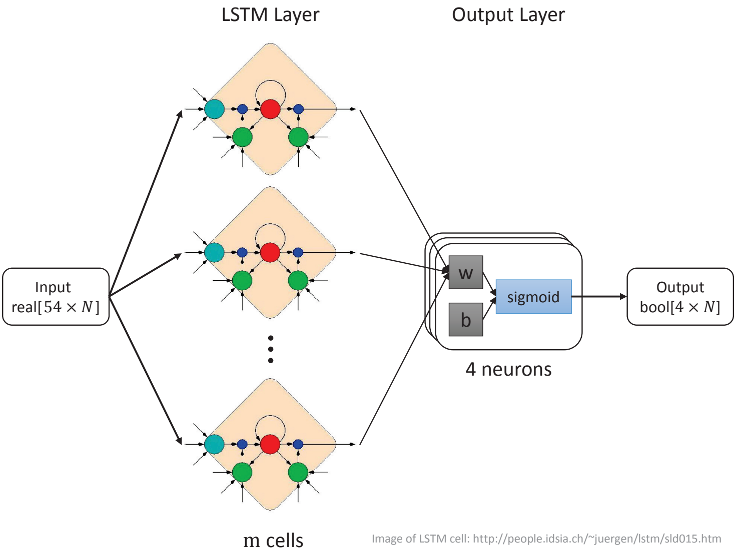


Image of LSTM cell: http://people.idsia.ch/~juergen/lstm/sld015.htm

Implementation

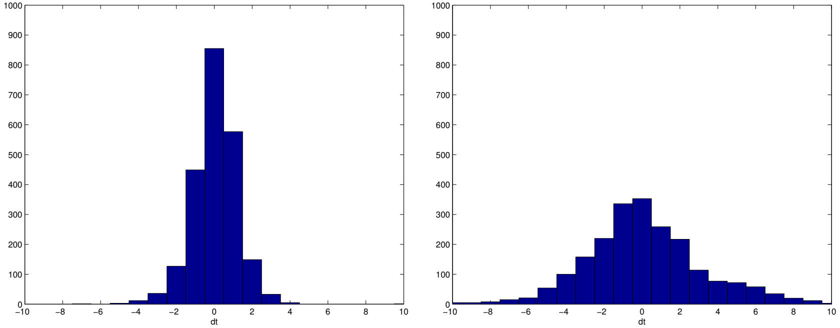
- Torch/Lua on 1 AWS EC2 GPU instance (g2.2xlarge)
- Start with LSTM code example by de Freitas
  - Adapted to our problem setup
  - Parameter tweaking to achieve convergence
  - Improved results through adaptive gradients, mini-batch, regularization.
- N-fold cross-validation to evaluate performance
- Further work:
  - Explore alternative network configurations
  - Assess time/space invariance
  - Generalize to stroke subjects and over-ground trials

Results

	deviation (frames)	
	mean	std
Foot velocity	4.84	3.74
Feed-forward NN	0.85	1.48
LSTM	2.35	3.87

Table 1: Comparison of results for $N = 30$, $T = 25\,\mathrm{s}$.

Results



(a) Feed-forward NN (b) LSTM

Figure 1: Absolute deviations, $N = 30,\ T = 25\,\mathrm{s}$.

Q&A

Thank you for your attention!

Human Gait Cycle

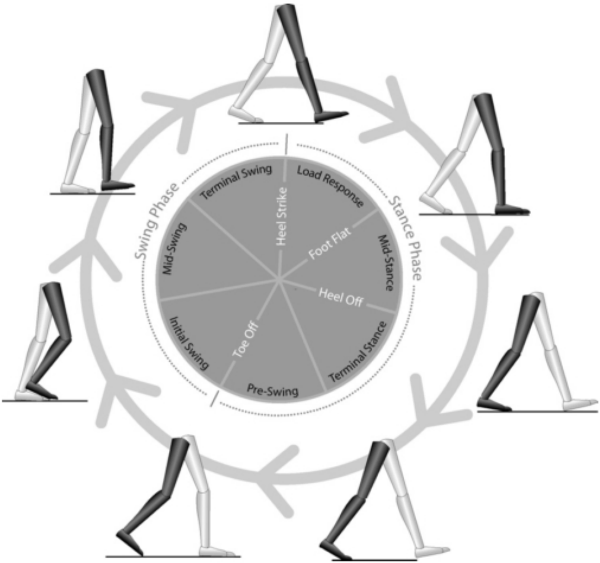


Figure 2: Gait events [Rueterbories et al., 2010]