Determining Risk Level for Workers Lifting Objects

Kristian Snyder

NIOSH

Members

Kristian Snyder
snyderks@mail.uc.edu

Advisor
Dr. Rashmi Jha
jhari@ucmail.uc.edu

Abstract

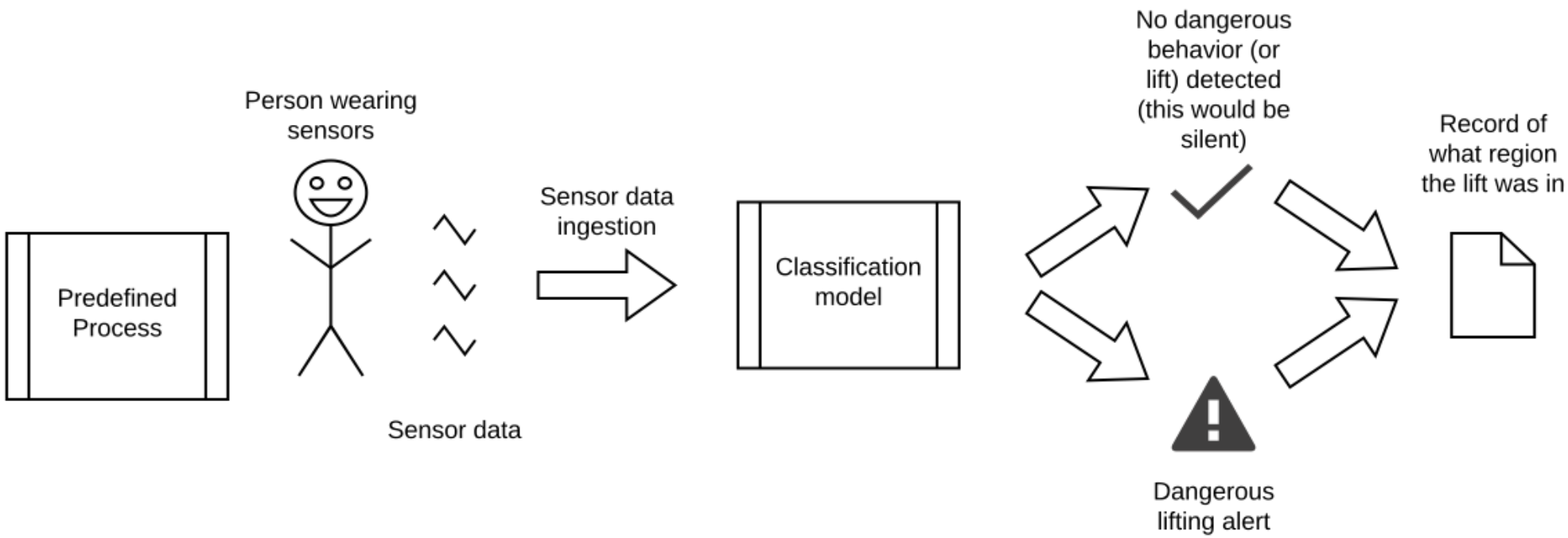
This project consists of **classifying accelerometer and gyroscope data** to **determine relative risk** of a person lifting a box off of a flat surface **using machine learning.** Data consists of **720 trials** collected by NIOSH of subjects lifting the same object from various positions.

If successful, this model could be used to **quickly identify issues when lifting** in the workplace and affordably **reduce workplace injury** without invasive exoskeleton-style sensor clusters as what currently exists.

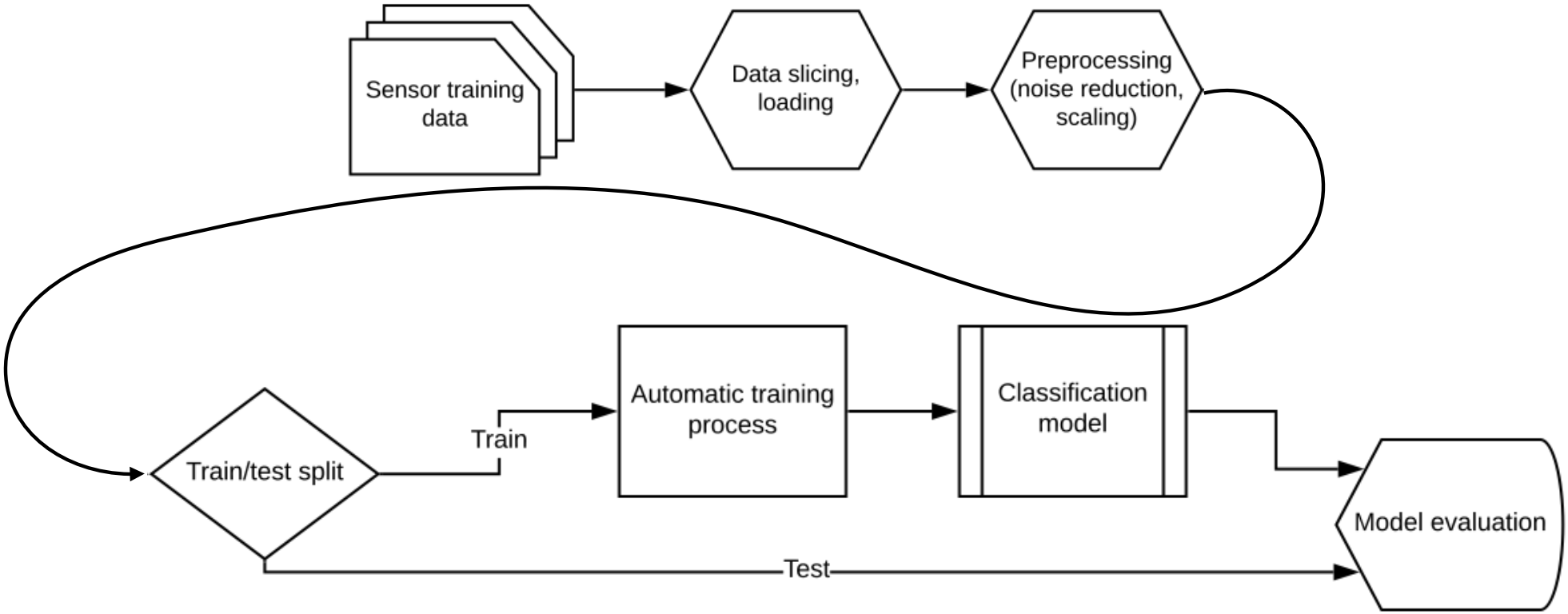
User Stories

- As a worker, I want to be notified when I lift a box incorrectly so that I can avoid hurting myself.
- As a supervisor, I want to be notified what incorrect zones my employees are lifting in so that I can correct the process to reduce this.
- As a researcher, I want to be provided a portable model to classify this data so that I can port it to different use-cases.
- As a researcher, I want to be able to train many different models to find the best-performing parameters.
- As a researcher, I want to understand what sensors are providing the most significant data to focus the model on them.

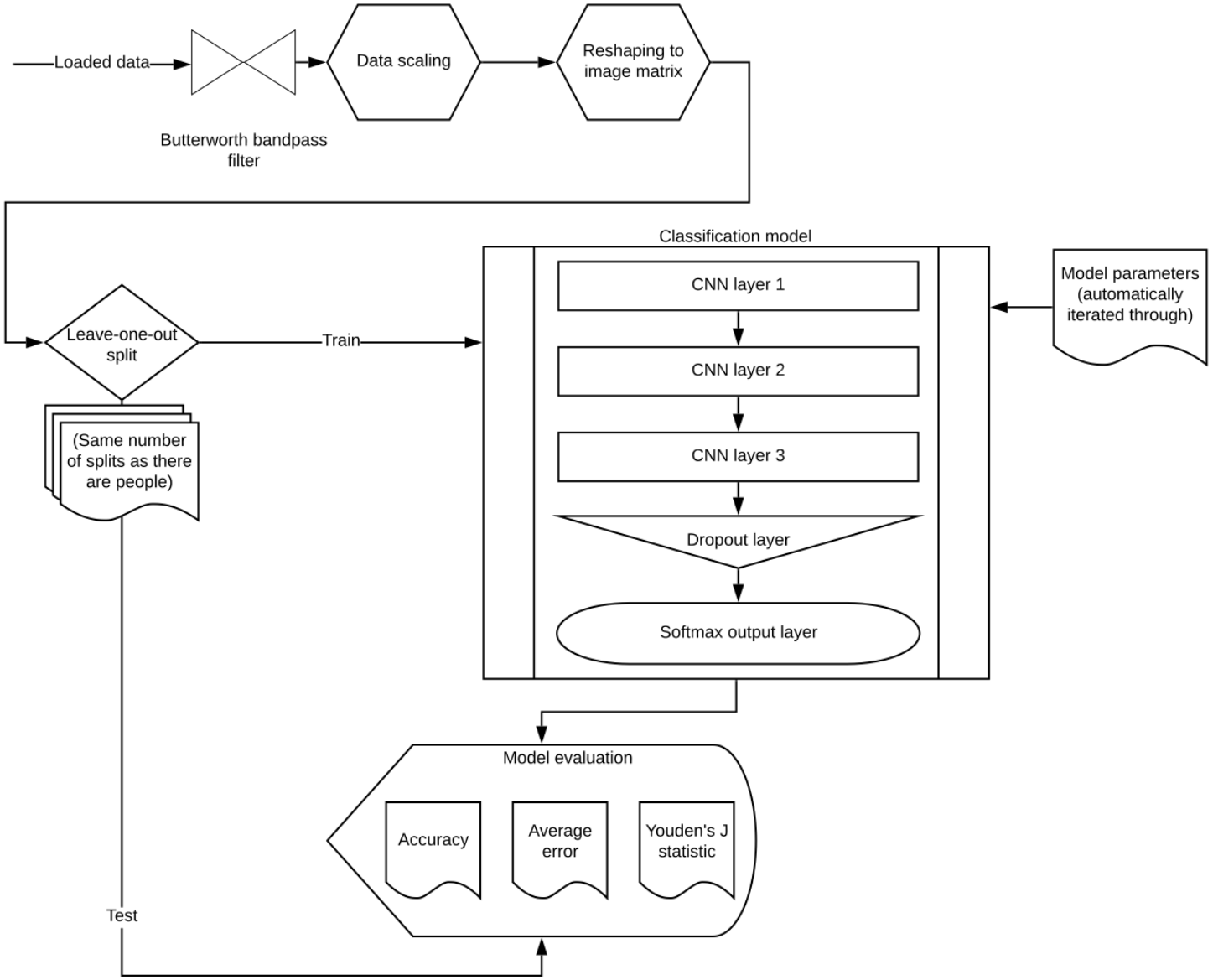
Design


Predefined Process
Person wearing sensors
Sensor data
Sensor data ingestion
Classification model
No dangerous behavior (or lift) detected (this would be silent)
Dangerous lifting alert
Record of what region the lift was in

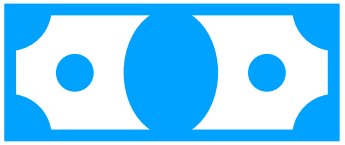
Design


Sensor training data
Data slicing, loading
Preprocessing (noise reduction, scaling)
Train/test split
Train
Automatic training process
Classification model
Model evaluation
Test

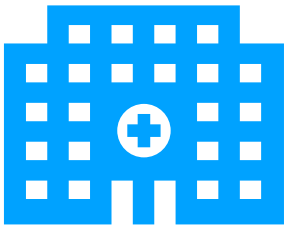
Design


Loaded data
Butterworth bandpass filter
Data scaling
Reshaping to image matrix
Classification model
CNN layer 1
CNN layer 2
CNN layer 3
Dropout layer
Softmax output layer
Model parameters (automatically iterated through)
Leave-one-out split
Train
(Same number of splits as there are people)
Model evaluation
Accuracy
Average error
Youden's J statistic
Test

Constraints



Sensors need to be low-cost so it is worth the expense



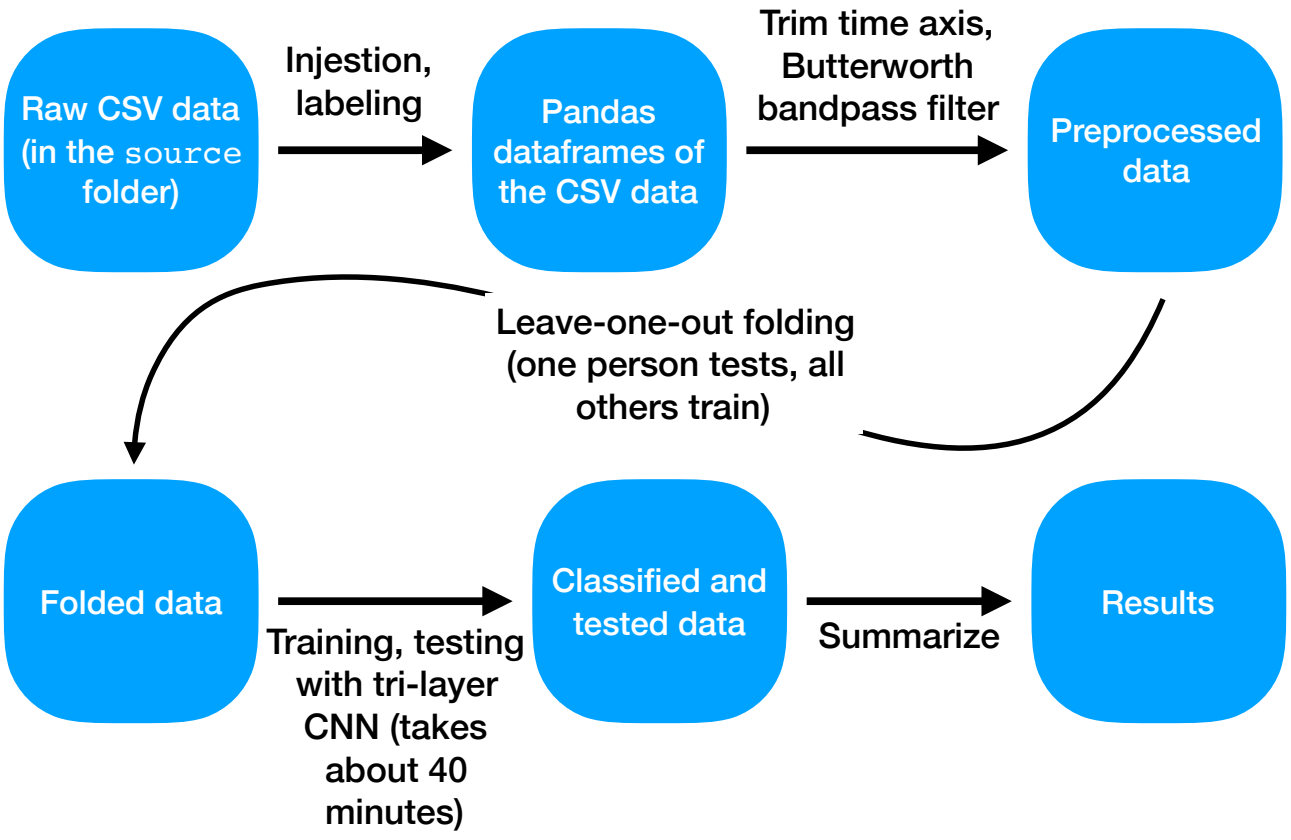
Model needs to quickly recognize dangerous behavior to reduce back pain

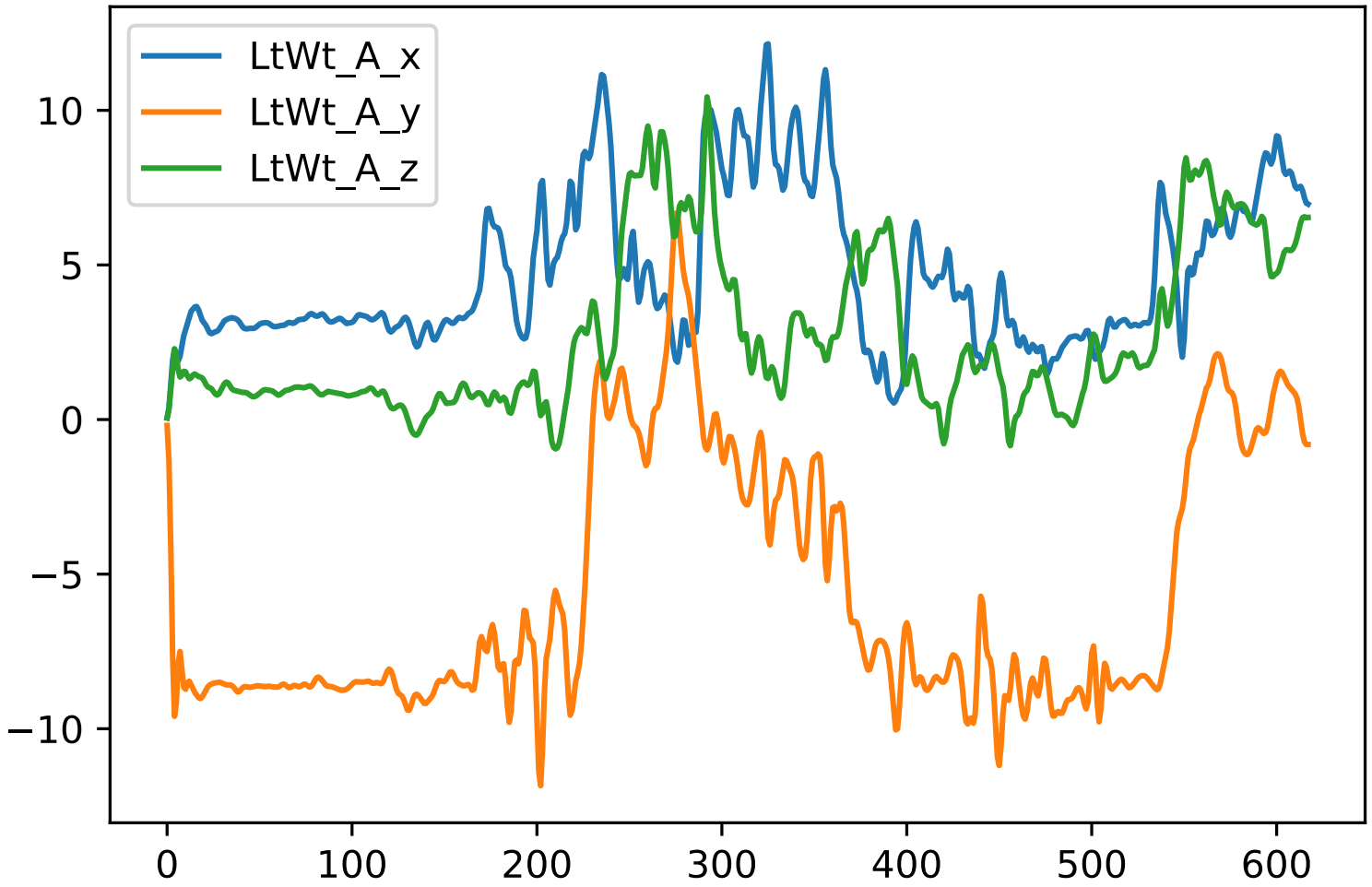
Model can’t miss too many bad lifts because of the trust placed on it

Project Status

What's the pipeline?

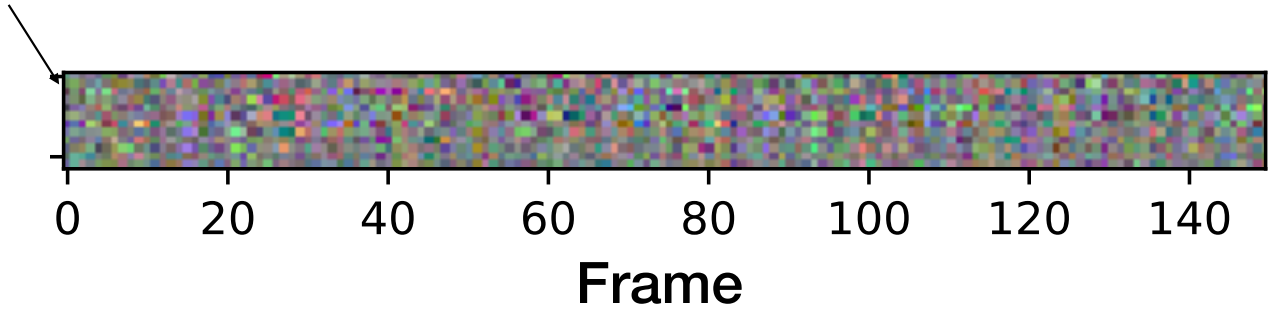
Not shown: lots of data reshaping, conversion to fit the format Keras wants




LtWt_A_x
LtWt_A_y
LtWt_A_z
10
5
0
−5
−10
0
100
200
300
400
500
600

Creating images

Each row is a sensor



Each pixel is a point in time:
Red is X, green is Y, blue is Z

This embeds time into the image itself by placing the pixels in rows, organized by time.

Current results achieved (averaged over multiple runs):

Overall accuracy: ~44%
Low accuracy: ~33%
Medium accuracy: ~36%
High accuracy: ~53%
Youden J Statistic: 0.11

Current results achieved (averaged over multiple runs):

Overall accuracy: ~~~44%~~ **90%**

Low accuracy: ~33%

Medium accuracy: ~36%

High accuracy: ~53%

Youden J Statistic: 0.11

End-of-term Goals

- Develop a system to automatically test various model and preprocessing parameters for the machine learning model
- Develop multiple train-test methods
- Design a strategy to encode and save trained models for later application
- Create and test a wide range of configurations of the model
- Research methods to visualize salience mapping for CNN input data

Timeline

Training, framework development

Oct 15 — Dec 15

In-depth visualization, analysis

Nov 1 — Jan 15

Portability, next steps

Jan 1 — Mar 1-Apr 1

Expo Demo

- Display the speed of the classifier - show it classifying a test trial live
- Sample of the hardware involved
- Description, diagrams of the end model and data collection process

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