Human Activity Recognition using Deep Learning (Tensorflow)

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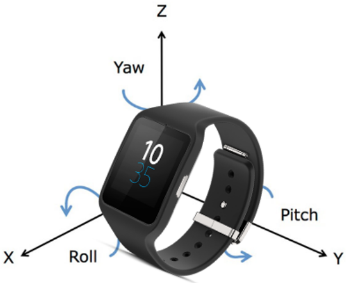
Human Activity Recognition (HAR)

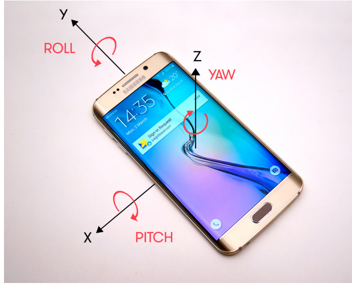
- Challenging time series classification task
- Predicts the movement of a person based on sensor data
- Traditional methods involve deep domain expertise and feature extraction
- Recent methods use deep learning which **automatically learns features** from the raw sensor data

Sensor Modalities

Smartphones and Wearables (IMU)

- Accelerometer (A)
- Gyroscope (G)
- Magnetometer (M)

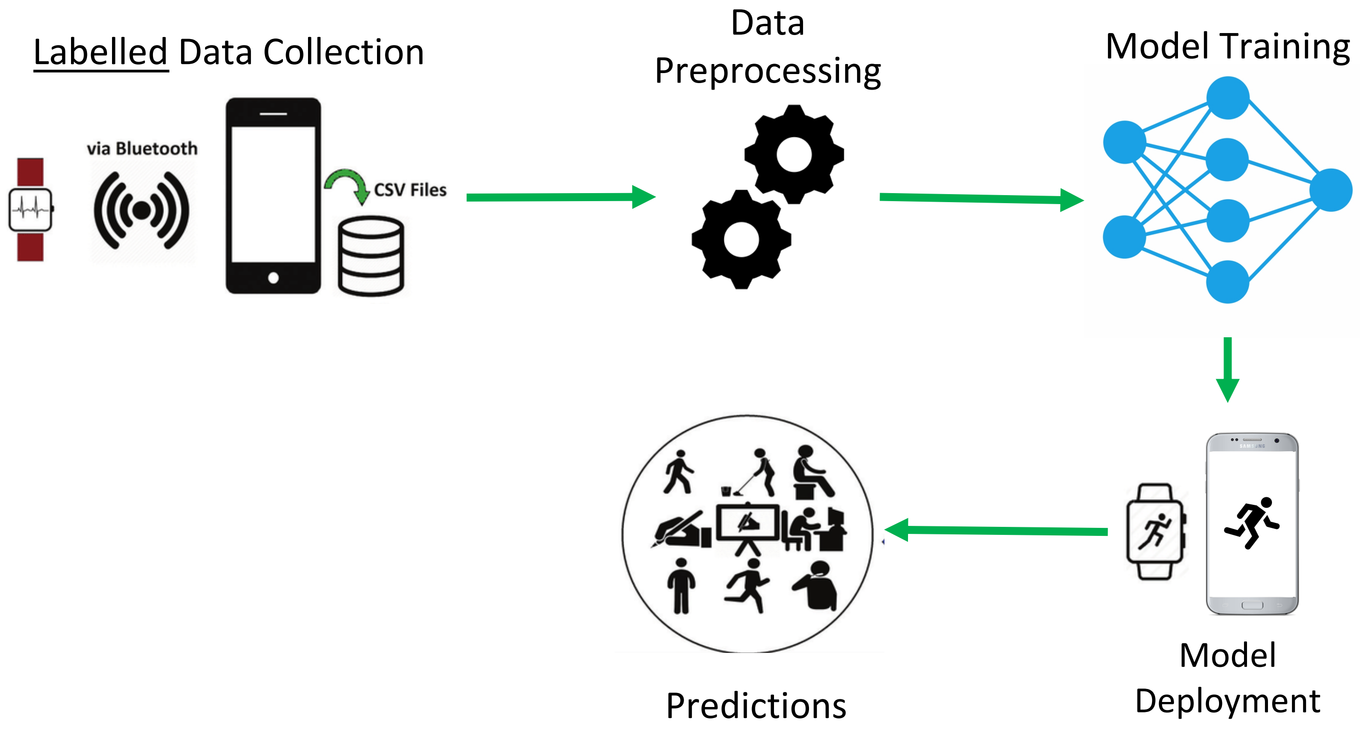




Other Sensor Modalities

- Electromyography (EMG)
- Electrocardiography (ECG)
- Radar
- Wifi

Overview of HAR



Labelled Data Collection

Data Preprocessing

Model Training

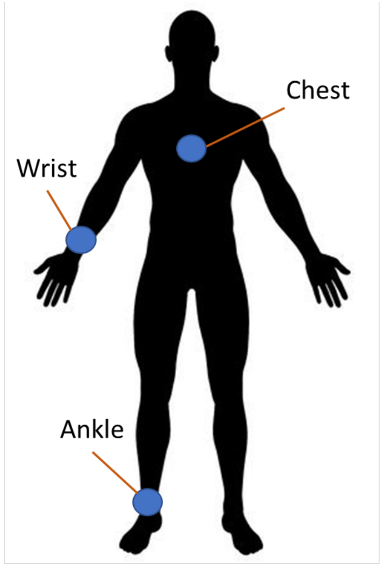
Model Deployment

Predictions

Data Collection

- ▣ Time Series Data
- ▣ Sensors have a sampling frequency
- ▣ Labeled using a video recording or by the participant

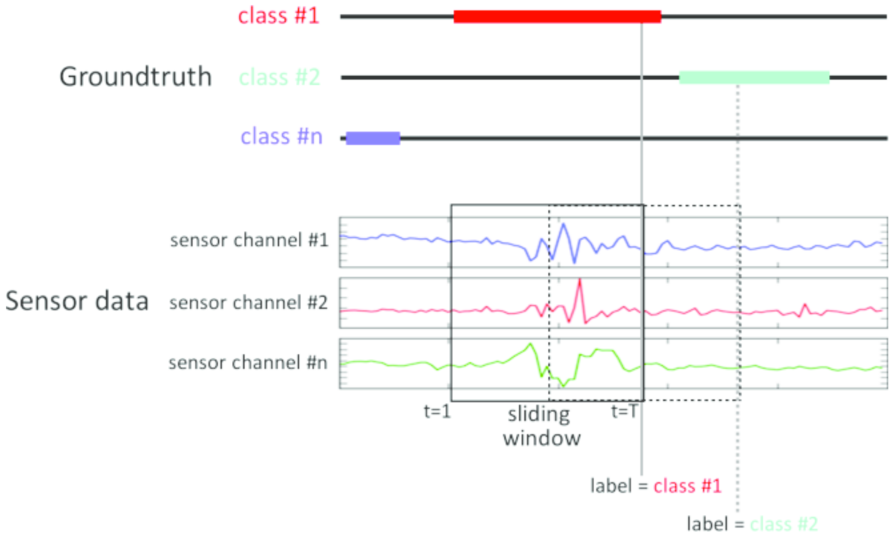
Timestamp(ms)	x,	y,	z,	Activity
100	1.1,	2.1,	0.1,	1
200	1.2,	2.2,	0.2,	1
300	1.3,	2.3,	0.3,	1
…				



PAMAP2

Data Preparation

- Split data into fixed size windows
  - Sliding window approach
- Hyperparameters:
  - Window size
  - Stride
- Final shape of data should be:
  - (n_samples, window length, features)
- Labels - One hot encoded
- Train, Val, Test split



Window Size and Stride

- Optimal window size is an application-dependent task
- Determined in such a way that each window is guaranteed to contain enough samples (at least one cycle of an activity)
- Decreasing the window size allows for a faster activity detection, as well as reduced resources and energy needs.
- On the contrary, large data windows are normally considered for the recognition of complex activities
- 50% overlap, will double the size of the training data, which may aid in modeling smaller datasets
    - Small strides might result in overfitting

Tensorflow Tutorial

Setting Up Tensorflow Environment

- Use Anaconda to install Python
- Identify your machine config (Note AMD Graphic cards don’t work)
- Create a virtual environment with the required python version
- Activate the virtual environment
- Conda install tensorflow-gpu

This eliminates the hassle of installing Cuda!

Easy to update

- If you need the nightly build or the latest version:
  - Conda install cuda toolkit
  - Pip install tensorflow_version

Tensorflow and Keras

- I’m using Tensorflow version 2.x
- Keras API
  - ***Sequential Models***
  - Functional API’s

Neural Network Layers

- Dense
- Convolutional
- LSTM
- Activation
- BatchNorm
- Dropout
- MaxPooling

Model Architectures

- Multi-Layer Perceptron (MLP)
- Convolutional Neural Network (CNN)
- Long Short-Term Memory (LSTM)
- Convolutional LSTM

Tensorboard

- Monitor different runs
- Tune Hyperparameters
- Logs training process
- Plots

Checkpoints

- Can restore training process
- Save models after every epoch
- Save only the best models

Classification vs Regression

Two Key Differences

- Output layer Activation function
  - Softmax - Classification
  - ReLu - Regression
- Loss Function
  - Cross Entropy - Classification
  - MSE, MAE - Regression

Metrics

- Confusion Matrix
- Accuracy
- F1-score
- Precision
- Recall

Tensorflow Lite

For Android apps and Embedded Devices

- Post Training Quantization:
  - https://www.tensorflow.org/lite/performance/post_training_quantization
  - Model size decreases by 4x
- Limited support for LSTM
  - https://github.com/tensorflow/tensorflow/blob/master/tensorflow/lite/experimental/examples/lstm/TensorFlowLite_LSTM_Keras_Tutorial.ipynb
  - https://www.tensorflow.org/lite/convert/rnn

Key Takeaways

- Identify if you are doing a classification or regression task
- Use only CNNs for Real Time processing
- Use Batchnorm and Dropout layers
- Activation : Relu
- Optimizer : Adam

Related Reading

1. Deep Learning for Sensor-based Human Activity Recognition: Overview, Challenges and Opportunities
2. Deep Learning Models for Human Activity Recognition
3. A Comprehensive Analysis on Wearable Acceleration Sensors in Human Activity Recognition

Github Repo:

https://github.com/vikranth94/Activity-Recognition

Thanks!

Any questions?