Combining signal transformation to learning models for human activity recognition

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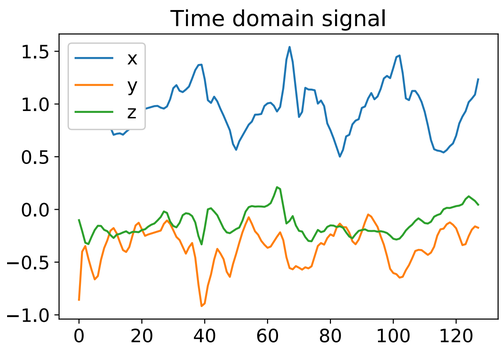
Introduction

- Combine signal processing techniques with machine learning models in order to create simpler models with higher accuracy
- Signal processing techniques: high-pass filtering, discrete Fourier transform (DFT), discrete cosine transform (DCT), wavelet transform (WT)
- Machine learning models: k-NN, SVM, gradient boosting tree, LDA, PCA
- We found that DFT and WT significantly improves the performance of machine learning models.

Dataset

- Accelerometer signals collected by smart phones
- 6 recorded activities: walking, walking upstairs, walking downstairs, sitting, standing, laying
- Each data point contains x, y, z axis accelerometer data for 2.56 second with sampling rate 50Hz of a volunteer doing one of the activities
- We use a 70/30 split for our training and test set.
- Training data shape: 1442 x 128 x 3



Transforms

	K-NN	SVM	XGB
Raw	0.7233	0.8025	0.8188
DCT	0.7152	0.7896	0.7848
DFT	**0.8285**	0.8592	**0.8657**
DFT filtered	0.8123	0.8463	0.8641
WT	**0.8285**	**0.8673**	0.8350

- DFT and WT significantly improve the performance of models, especially the performance of simpler models.
- By applying DFT, the time shift in the signal is ignored, helps the classifiers to focus on more useful information.
- Though WT improves the performance, it also increase the complexity of the model a lot. Way longer training time.

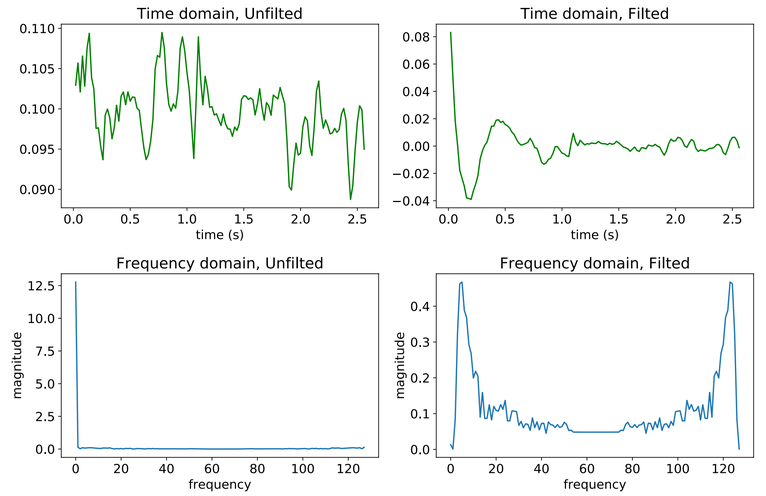
Dimension Reduction

		K-NN	SVM	XGB
LDA	Raw	0.6359	0.6375	0.6117
	DFT	0.7961	0.7702	0.8204
	WT	N/A	N/A	N/A
PCA	Raw	0.7702	0.8317	0.7945
	DFT	0.8269	0.8722	**0.8883**
	WT	**0.8333**	**0.8851**	0.8171

- LDA and PCA are applied to reduce the high-dimension data to 20-dimension.
- PCA performs better than LDA in two senses:
  I. Compared to the original data, PCA does not lose much predictability.
  II. PCA works much faster so has broader availability.

High-pass Filtering

- Gravity has a significant component along z-axis.
- Apply high-pass filter on z-axis to remove gravitational components



	K-NN	SVM	XGB
Unfiltered	0.7233	0.8025	0.8188
Filtered	0.7816	0.8188	0.7961

Filtering slightly increases the accuracy for simple models, while hurts the performance of complex model (XGB) due to reduction of information.

Discussion

- Signal transformations (espacailly DFT and WT) improve the performance of machine learning models significantly.
- Such transformations can be paired with dimension reduction techniques to create simpler models with higher performance.