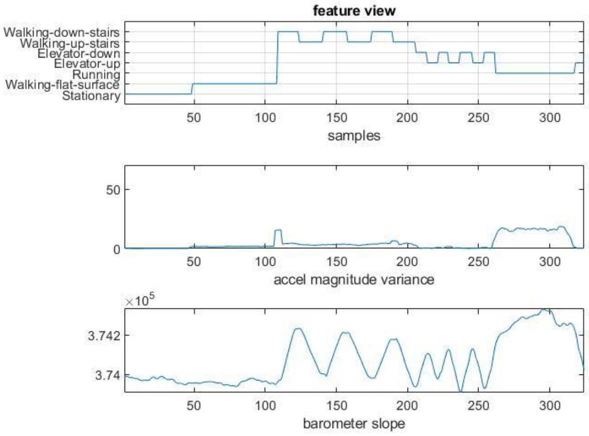
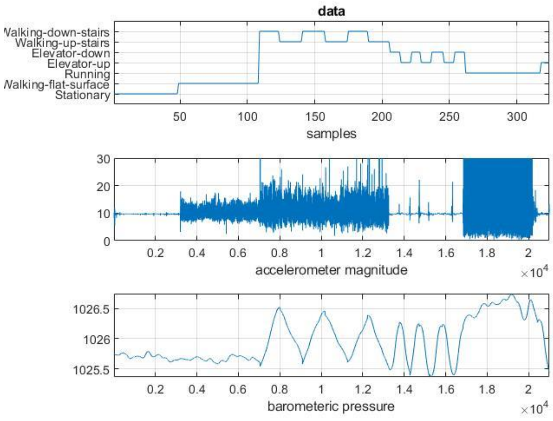
A2 | Disha Singh

P.S. : Since my data “Disha_Singh” folder did not capture pressure.txt data, I had to use the folder “Cody” as test data.

Step 1: Plot figures





Stationary: The **accelerometer magnitude is least**(~10) with **almost no peaks** among all activities. **Variance for accelerometer is 0** as the person is stationary. **Barometer slope is almost constant**.

Walking flat surface: There are **more peaks** in accelerometer magnitude than stationary. All other plotted metrics are **very similar to stationary except** that the accelerometer magnitude **amplitude is not consistent** and is very small too – it **oscillates up and down** centering at the stationary level amplitude. The accelerometer **variance** even though not very considerable, is **not 0** like stationary. The **mean peak value** for accelerometer magnitude will be definitely lesser than other movement activities (<20).

Running: All windows taken during running had similar variance and this was the **highest accelerometer variance** among all activities (~20). Accelerometer magnitude peaks crossing 80(varied from 0 to 80). The highest amplitudes were witnessed for running which were very high than the other magnitudes (<20). **Barometric pressure is consistently high** with **most peaks > 1026.5**

Elevator up: **Pressure keeps falling** while going up the elevator with a **constant accelerometer magnitude ~10. Barometer slope keeps falling linearly.** Accelerometer magnitude variance close to 0.

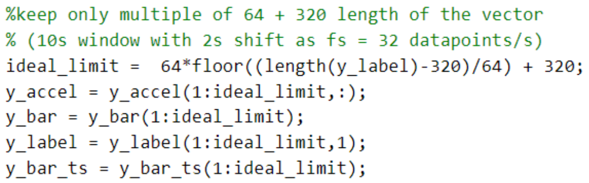
Elevator down: **Pressure keeps rising** while going up the elevator with a **constant accelerometer magnitude ~10. Barometer slope keeps rising linearly.** Accelerometer magnitude variance close to 0.

Walking stairs up: A slight **accelerometer magnitude variance <5. Pressure keeps decreasing** with a linearly **decreasing slope**. The **accelerometer magnitude signal oscillates between 0 and 20** with about 10% of the peaks crossing 20. Lowest **barometer slope** value achieved is usually lesser than that achieved during elevator up. Same is true for pressure.

Walking stairs down: A slight **accelerometer magnitude variance <5. Pressure keeps increasin**g with a linearly **increasing slope**. The **accelerometer magnitude signal oscillates between 0 and 20** with about 10% of the peaks crossing 20. Highest **barometer slope** value achieved is usually lesser than that achieved during elevator down. Same is true for pressure.

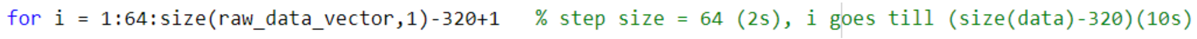
Step 2: Windowing and feature extraction

I have computed sampling rate in the file computeSamplingRate.m . It approximately yielded in fs = 203Hz =>203 samples/s. But since we were asked to use default sampling frequency of 32Hz. I have taken sampling rate to be 32 samples/s.
Therefore, the shift for 2s => 64 samples/s and the window length of 10s => 32*10 = 320 samples/s. To modify the data length according to this, I have made changes in computeRawData.m: Line 76-82.



```
%keep only multiple of 64 + 320 length of the vector
% (10s window with 2s shift as fs = 32 datapoints/s)
ideal_limit =  64*floor((length(y_label)-320)/64) + 320;
y_accel = y_accel(1:ideal_limit,:);
y_bar = y_bar(1:ideal_limit);
y_label = y_label(1:ideal_limit,1);
y_bar_ts = y_bar_ts(1:ideal_limit);
```

This clipping of some data from the end is done to enable proper windowing and shifting of data in extractFeatures.m: Line 12 :



```
for i = 1:64:size(raw_data_vector,1)-320+1   % step size = 64 (2s), i goes till (size(data)-320)(10s)
```

Please see extractFeatures.m: Line 17-85 to see all extracted features. The implementation of frequency domain features along with conversion from time domain to frequency domain(FFT) is in class FREQUENCYDOMAIN.m

Continued…

Step 3: KNN and Random Forest on all features

I have implemented the KNN classifier in knn.m and randomForest classifer in RandomForest.m separately. Please run these scripts separately to see performance results.
Within randomForest.m change *domain* variable in Line:6 to *'all'* in order to run the classifier on both time domain and frequency features.

KNN Performance with all 30 features:

testAccuracy: 0.19

Predicted	Actual (same order)						
'Stationary'	1	46	0	0	1	0	0
'Walking-flat-surface'	0	58	0	2	0	0	0
'Running'	0	56	0	0	0	0	0
'Elevator-up'	0	27	0	0	4	0	0
'Elevator-down'	0	29	0	0	3	0	0
'Walking-up-stairs'	0	50	0	0	0	0	0
'Walking-down-stairs'	0	47	0	0	0	0	0

Activity wise Performance Metrics:

Activity	Precision	Recall	F-1 Score
Stationary	1.00	0.02	0.04
Walking-flat-surface	0.19	0.97	0.31
Running	NaN	0.00	NaN
Elevator-up	0.00	0.00	NaN
Elevator-down	0.38	0.09	0.15
Walking-up-stairs	NaN	0.00	NaN
Walking-down-stairs	NaN	0.00	NaN

RandomForest Performance with all 30 features:

testAccuracy:0.94

Predicted	Actual (same order)						
'Stationary'	48	0	0	0	0	0	0
'Walking-flat-surface'	1	59	0	0	0	0	0
'Running'	0	0	51	2	0	2	1
'Elevator-up'	4	0	0	27	0	0	0
'Elevator-down'	2	0	0	2	28	0	0
'Walking-up-stairs'	0	0	0	0	0	50	0
'Walking-down-stairs'	0	6	0	0	0	1	40

Activity wise Performance Metrics:

Activity	Precision	Recall	F-1 Score
Stationary	0.87	1.00	0.93
Walking-flat-surface	0.91	0.98	0.94
Running	1.00	0.91	0.95
Elevator-up	0.87	0.87	0.87
Elevator-down	1.00	0.88	0.93
Walking-up-stairs	0.94	1.00	0.97
Walking-down-stairs	0.98	0.85	0.91

Comments:

1. On the test data, Random Forest(94% accuracy) performs way better than KNN (19% accuracy).
2. Places where Random Forest makes a mistake is that it classifies a very few number of elevator up and down instances as Stationary. For random forest all metrics are >=85% showing that it is an overall a good classifier.
3. KNN on the contrary classifies almost everything as walking-flat-surface and therefore, the recall for walking flat surface is very high. Even the precision for stationary is very high. But all other metrics ~0.

Step 4: Random Forest on time domain and frequency features separately

In order to switch between the feature domain, change the *domain* variable: Line 6 in randomForest.m to ‘time’ or ‘freq’.

RandomForest Performance with only time domain features:

testAccuracy:0.92

Actual (same order)

Predicted

'Stationary’	48	0	0	0	0	0	0
'Walking-flat-surface’	1	59	0	0	0	0	0
'Running’	0	0	47	2	0	2	5
'Elevator-up’	5	0	0	26	0	0	0
'Elevator-down’	5	0	0	1	26	0	0
'Walking-up-stairs’	0	0	0	0	0	50	0
'Walking-down-stairs’	0	6	0	0	0	0	41

Activity wise Performance Metrics:

Activity	Precision	Recall	F-1 Score
Stationary	0.81	1.00	0.90
Walking-flat-surface	0.91	0.98	0.94
Running	1.00	0.84	0.91
Elevator-up	0.90	0.84	0.87
Elevator-down	1.00	0.81	0.90
Walking-up-stairs	0.96	1.00	0.98
Walking-down-stairs	0.89	0.87	0.88

Performance with only frequency domain features RF:

testAccuracy:0.54

Actual (same order)

Predicted

'Stationary’	47	0	0	1	0	0	0
'Walking-flat-surface’	50	0	2	4	0	4	0
'Running’	0	0	53	1	0	2	0
'Elevator-up’	13	0	0	15	3	0	0
'Elevator-down’	9	0	0	14	6	2	1
'Walking-up-stairs’	1	0	0	0	0	38	11
'Walking-down-stairs’	1	0	3	0	0	26	17

Activity wise Performance Metrics:

Activity	Precision	Recall	F-1 Score
Stationary	0.39	0.98	0.56
Walking-flat-surface	NaN	0.00	NaN
Running	0.91	0.95	0.93
Elevator-up	0.43	0.48	0.45
Elevator-down	0.67	0.19	0.29
Walking-up-stairs	0.53	0.76	0.62
Walking-down-stairs	0.59	0.36	0.45

Comments:

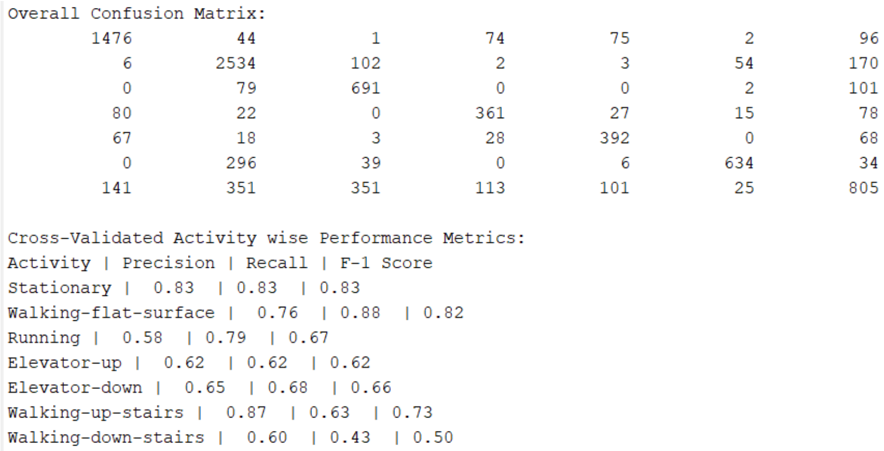
1. Overall test accuracy of time domain features (92%) is more than frequency domain features (54%).
2. Frequency domain fails to find any walking-flat-surface and elevator-down instances efficiently.
3. On the contrary, time domain features successfully classify all activities.
4. That means, **time domain features are the main features** that are essential for activity recognition, even though **frequency domain features assist them** to **differentiate between few confusing activity instances**, thereby increasing precision and recall when we classify using all features.

Step 5: Cross Validation on Random Forest

I have implemented cross validation with Random Forest Classifier in a separate file: crossValidation.m

RandomForest Performance with Cross Validation:

Overall Confusion Matrix:



```
Overall Confusion Matrix:
        1476          44           1          74          75           2          96
           6        2534         102           2           3          54         170
           0          79         691           0           0           2         101
          80          22           0         361          27          15          78
          67          18           3          28         392           0          68
           0         296          39           0           6         634          34
         141         351         351         113         101          25         805

Cross-Validated Activity wise Performance Metrics:
Activity | Precision | Recall | F-1 Score
Stationary |  0.83  | 0.83  | 0.83
Walking-flat-surface |  0.76  | 0.88  | 0.82
Running |  0.58  | 0.79  | 0.67
Elevator-up |  0.62  | 0.62  | 0.62
Elevator-down |  0.65  | 0.68  | 0.66
Walking-up-stairs |  0.87  | 0.63  | 0.73
Walking-down-stairs |  0.60  | 0.43  | 0.50
```

Cross-Validated Activity wise Performance Metrics:

Activity	Precision	Recall	F-1 Score
Stationary	0.83	0.83	0.83
Walking-flat-surface	0.76	0.88	0.82
Running	0.58	0.79	0.67
Elevator-up	0.62	0.62	0.62
Elevator-down	0.65	0.68	0.66
Walking-up-stairs	0.87	0.63	0.73
Walking-down-stairs	0.60	0.43	0.50

-x-x-x-