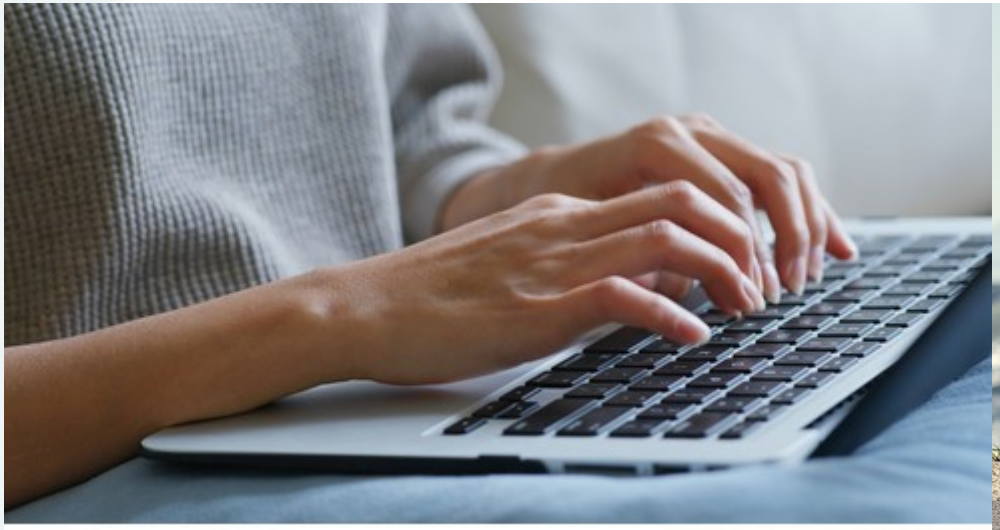
What am I doing?

Activity Classification with smart devices



Objective

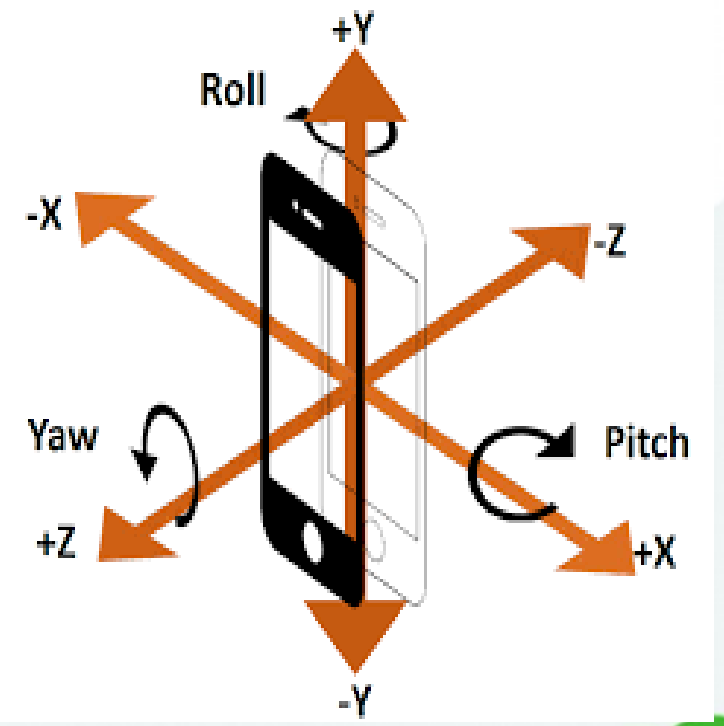
- Classify 18 different activities
- 51 total users in dataset
- Identify minimum sensor data requirements
- Identify useful features

Data

- Eating 5 different type of food, pasta,
- Hand activity, typing, writing, clapping, folding cloth,etc
- Body activity, walking, kicking, jogging
- Activity lasts 3 minutes, sensors from smart phone and smart watches every 50 ms

Accelerometer / Gyroscope

- Readings relative to the device
- Device orientation matter
- Left-handed vs. Right-handed
- Timestamp difference between phone and watch in days



Methodology

- Combine data from 4 different sensors to create sample.
- Convert Spherical coordinates
- Test set has seperate users
- ExtraTree with 150 trees, max_depth 30
- Time domain Statistic and frequency domain
- Varying time window

Result

Features	Time duration	F1 / Accuracy	Activity with Best Results / F1	Activity with worst result / F1
Sensor only	1 reading 50 ms	0.38 / 0.38	Jogging, 0.73	Eating Sandwich, 0.09

Result

Features	Time duration	F1 / Accuracy	Activity with Best Results / F1	Activity with worst result / F1
Sensor only	1 reading, 50 ms	0.38 / 0.38	Jogging, 0.73	Eating Sandwich, 0.09
Mean, std, min, Max	4 readings, 200 ms	0.48 / 0.48	Jogging, 0.93	Eating Sandwich, 0.10

Result

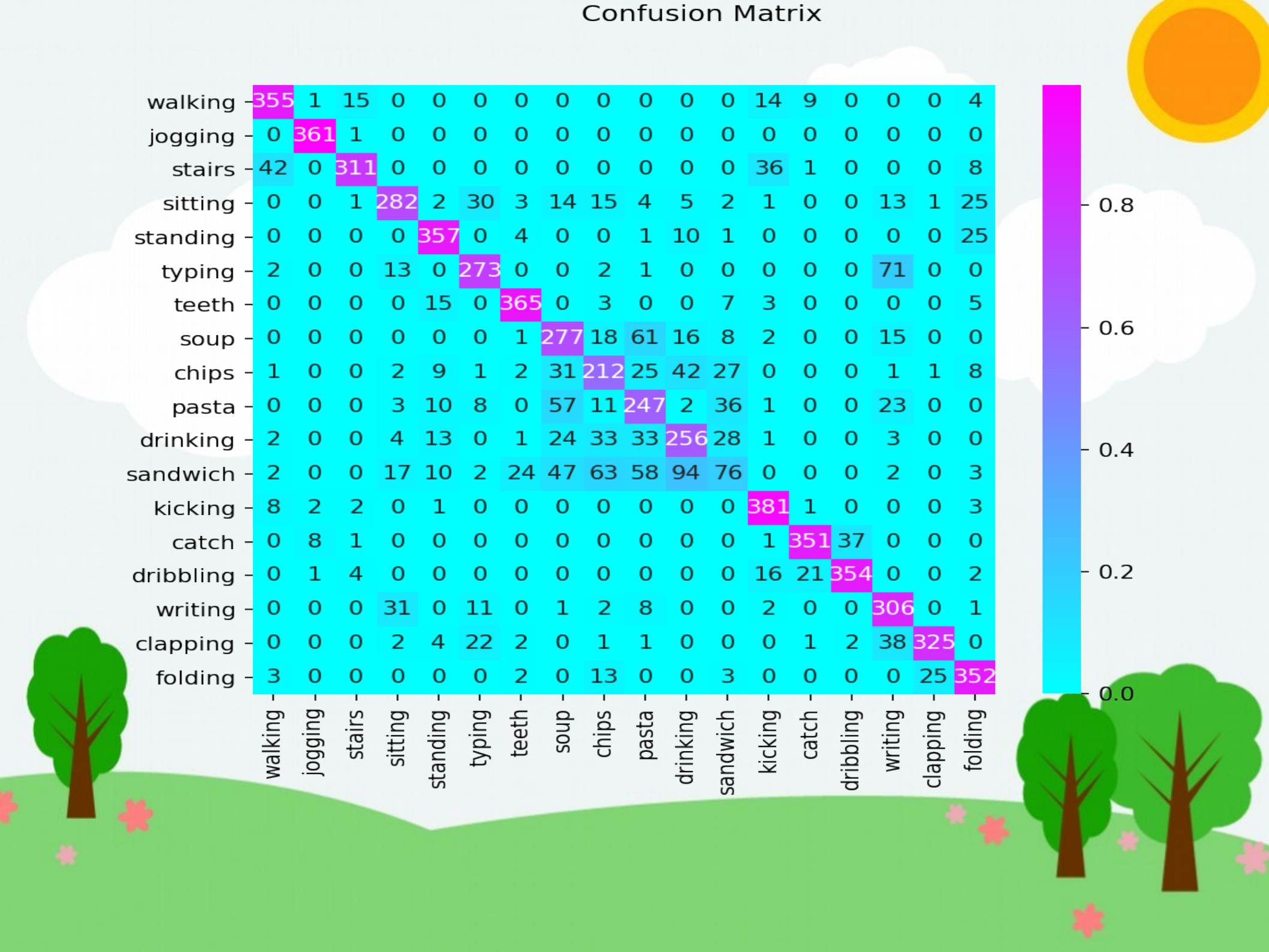
Features	Time duration	F1 / Accuracy	Activity with Best Results / F1	Activity with worst result / F1
Sensor only	1 reading, 50 ms	0.38 / 0.38	Jogging, 0.73	Eating Sandwich, 0.09
Mean, std, min, Max	4 readings, 200 ms	0.48 / 0.48	Jogging, 0.93	Eating Sandwich, 0.10
Mean, std, min, Max, high frequency data	100 readings, 5 seconds	0.78 / 0.77	Jogging, 0.98	Eating Sandwich, 0.26

Result

Features	Time duration	F1 / Accuracy	Activity with Best Results / F1	Activity with worst result / F1
Sensor only	1 reading, 50 ms	0.38 / 0.38	Jogging, 0.73	Eating Sandwich, 0.09
Mean, std, min, Max	4 readings, 200 ms	0.48 / 0.48	Jogging, 0.93	Eating Sandwich, 0.10
Mean, std, min, Max, high frequency	100 readings, 5 seconds	0.78 / 0.77	Jogging, 0.98	Eating Sandwich, 0.26
Mean, std, min, Max, high and low frequency	300 readings, 15 seconds	0.77 / 0.77	Jogging, 0.98	Eating Sandwich, 0.25

Other Models

- ExtraTree F1 = 0.78, 5 sec
- Random Forest F1 = 0.78, 25 sec
- XGB F1 = 0.73, 3 ~ 6 sec


Confusion Matrix
walking 355 1 15 0 0 0 0 0 0 0 0 0 14 9 0 0 0 4
jogging 0 361 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
stairs 42 0 311 0 0 0 0 0 0 0 0 0 36 1 0 0 0 8
sitting 0 0 1 282 2 30 3 14 15 4 5 2 1 0 0 13 1 25
standing 0 0 0 0 357 0 4 0 0 1 10 1 0 0 0 0 0 25
typing 2 0 0 13 0 273 0 0 2 1 0 0 0 0 0 71 0 0
teeth 0 0 0 0 15 0 365 0 3 0 0 7 3 0 0 0 0 5
soup 0 0 0 0 0 0 1 277 18 61 16 8 2 0 0 15 0 0
chips 1 0 0 2 9 1 2 31 212 25 42 27 0 0 0 1 1 8
pasta 0 0 0 3 10 8 0 57 11 247 2 36 1 0 0 23 0 0
drinking 2 0 0 4 13 0 1 24 33 33 256 28 1 0 0 3 0 0
sandwich 2 0 0 17 10 2 24 47 63 58 94 76 0 0 0 2 0 3
kicking 8 2 2 0 1 0 0 0 0 0 0 0 381 1 0 0 0 3
catch 0 8 1 0 0 0 0 0 0 0 0 0 1 351 37 0 0 0
dribbling 0 1 4 0 0 0 0 0 0 0 0 0 16 21 354 0 0 2
writing 0 0 0 31 0 11 0 1 2 8 0 0 2 0 0 306 0 1
clapping 0 0 0 2 4 22 2 0 1 1 0 0 0 1 2 38 325 0
folding 3 0 0 0 0 0 2 0 13 0 0 3 0 0 0 0 25 352
walking jogging stairs sitting standing typing teeth soup chips pasta drinking sandwich kicking catch dribbling writing clapping folding
0.8
0.6
0.4
0.2
0.0

Most Common Mistakes

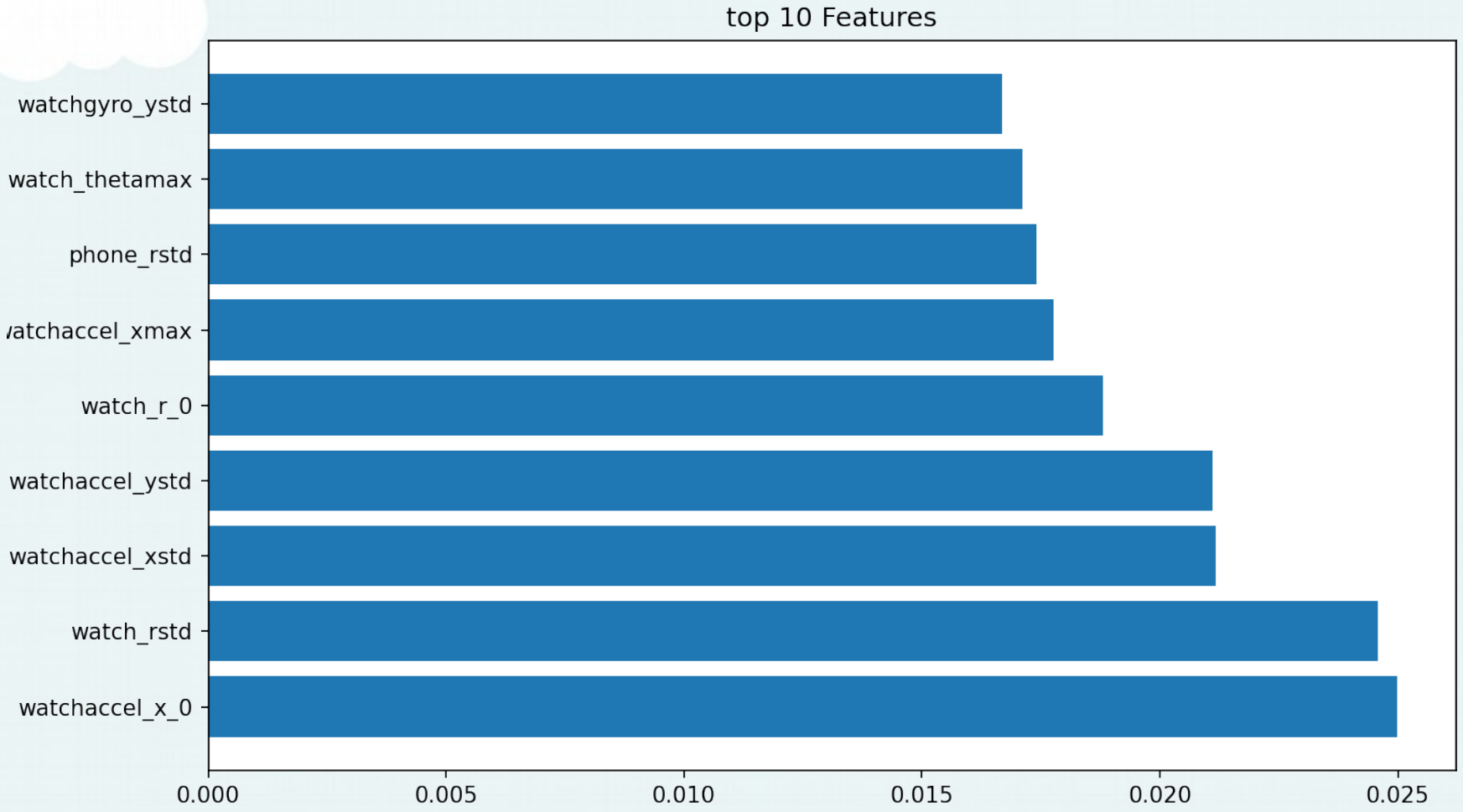
- Eating Food, especially Sandwich
- Writing and Typing
- Walking and go up stairs
- Catch and Dribbling

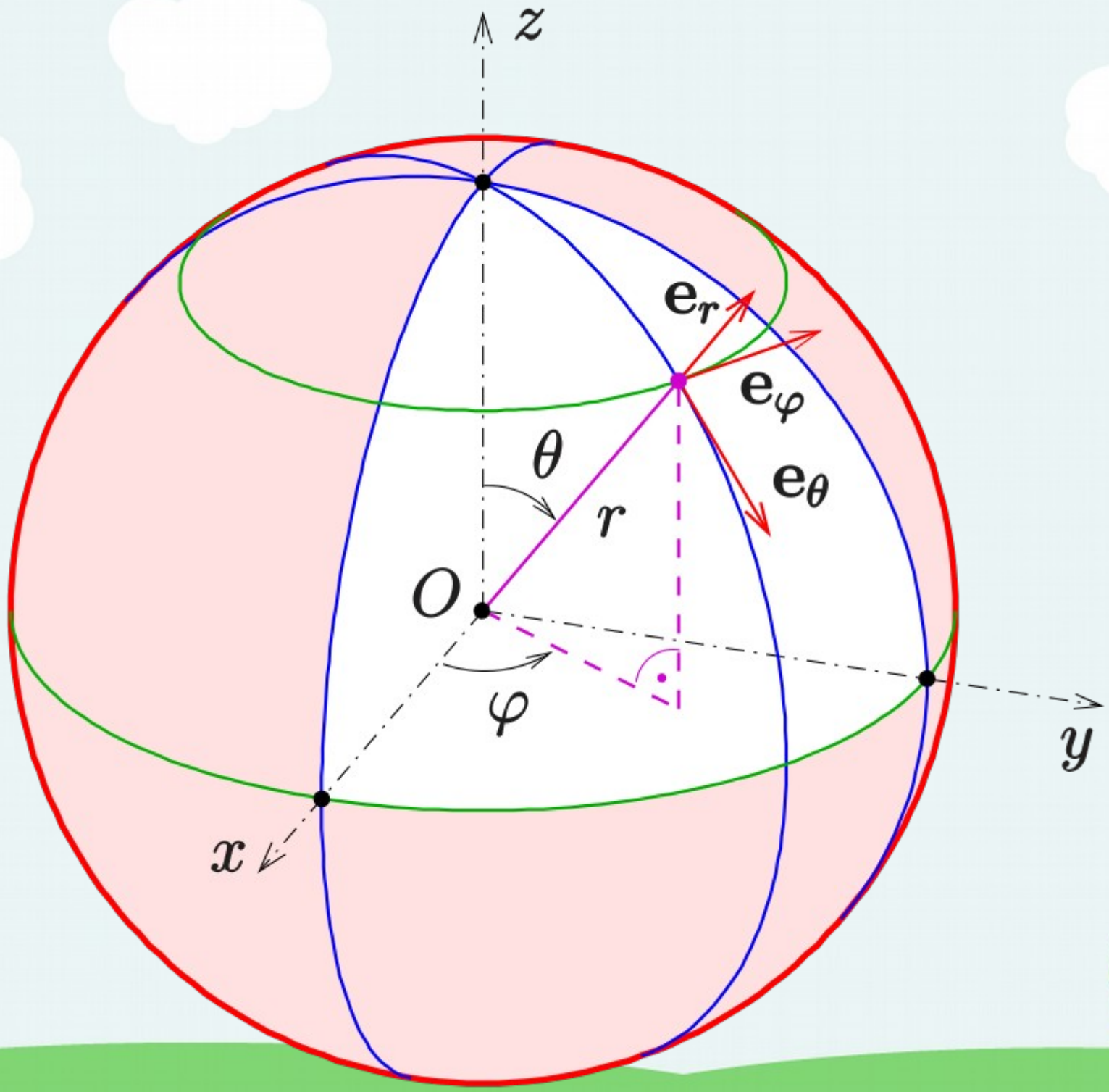
Conclusion

- Minimum time window per activity
- Longer window can dilute instance activity
- Frequency domain data
- Eating activity requires more than Gesture alone
- Determine activity orientation

Future Work

- Identify left-handed user
- Gravity identification
- Movement versus Rotation
- Combine three models


top 10 Features
watchgyro_ystd
watch_thetamax
phone_rstd
watchaccel_xmax
watch_r_0
watchaccel_ystd
watchaccel_xstd
watch_rstd
watchaccel_x_0
0.000
0.005
0.010
0.015
0.020
0.025


z
$\mathbf{e}_r$
$\mathbf{e}_\varphi$
$\mathbf{e}_\theta$
θ
r
O
φ
y
x