Rock Climbing Classification

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Overview

Our project focused trying to differentiate head movements between a beginner climber and a more advanced climber

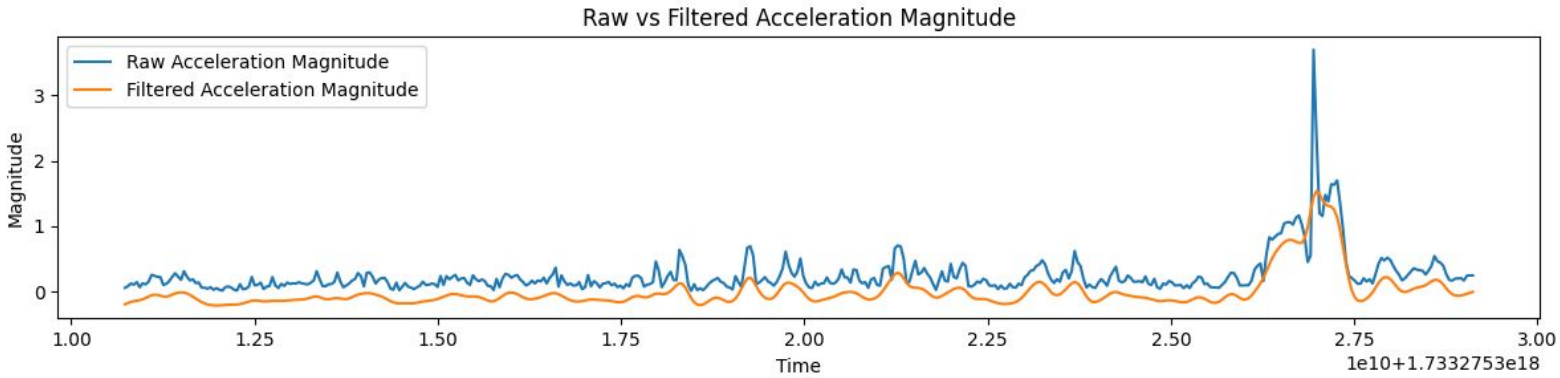
- Classify differences in head movements

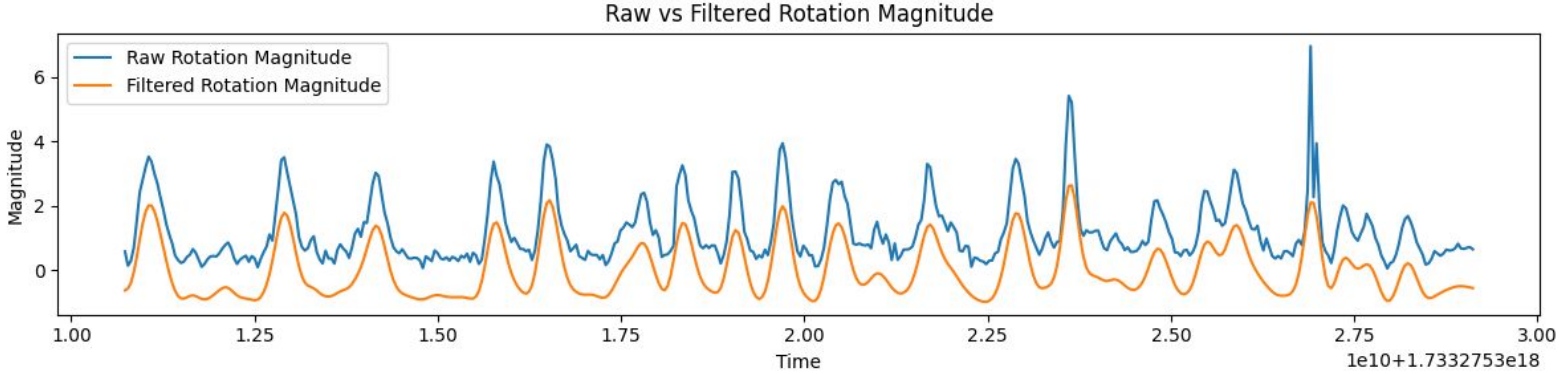
Advancement from previous assignment:

- Multiple sensors - both Accelerometer and Gyroscope

Data Collection and Processing

- Recorded 4 participants doing 5-6 sets of the same set climb
- Sensor Logger app + AirPod Pro
  - Sampled at 25 Hz
  - Utilized both Accelerometer and Gyroscope
- Sliding Window approach


Raw vs Filtered Acceleration Magnitude
Raw Acceleration Magnitude
Filtered Acceleration Magnitude
Magnitude
0
1
2
3
1.00
1.25
1.50
1.75
2.00
2.25
2.50
2.75
3.00
Time
1e10+1.7332753e18


Raw vs Filtered Rotation Magnitude
Raw Rotation Magnitude
Filtered Rotation Magnitude
Magnitude
0
2
4
6
1.00
1.25
1.50
1.75
2.00
2.25
2.50
2.75
3.00
Time
1e10+1.7332753e18

Technical Implementation

Feature Engineering

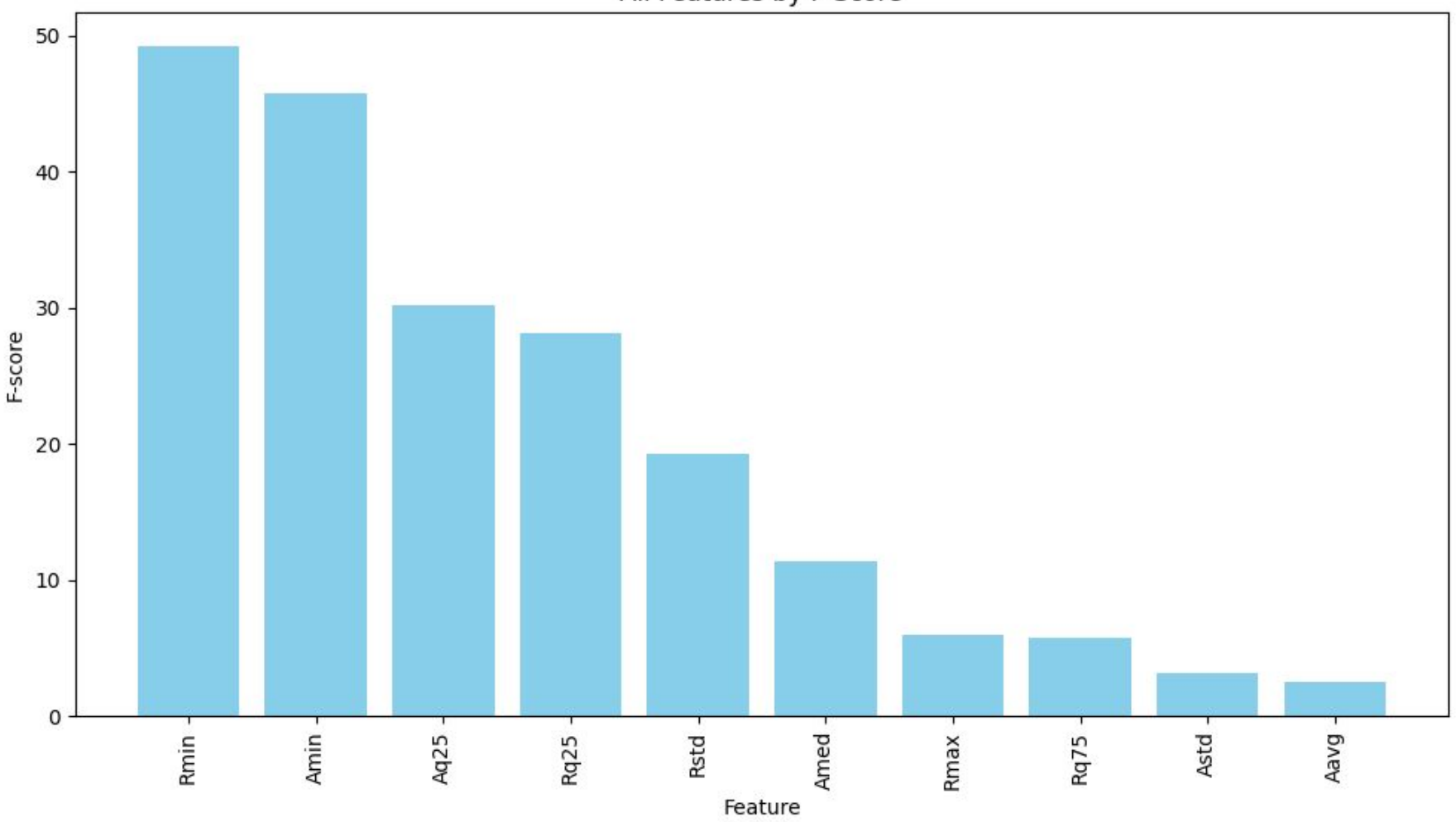
- Used time domain features in x, y, z axis with both acceleration and rotation
    - Mean, Max, Min, Standard Deviation, Q25, Q75

Used a feature importance function to select the **top 4** features

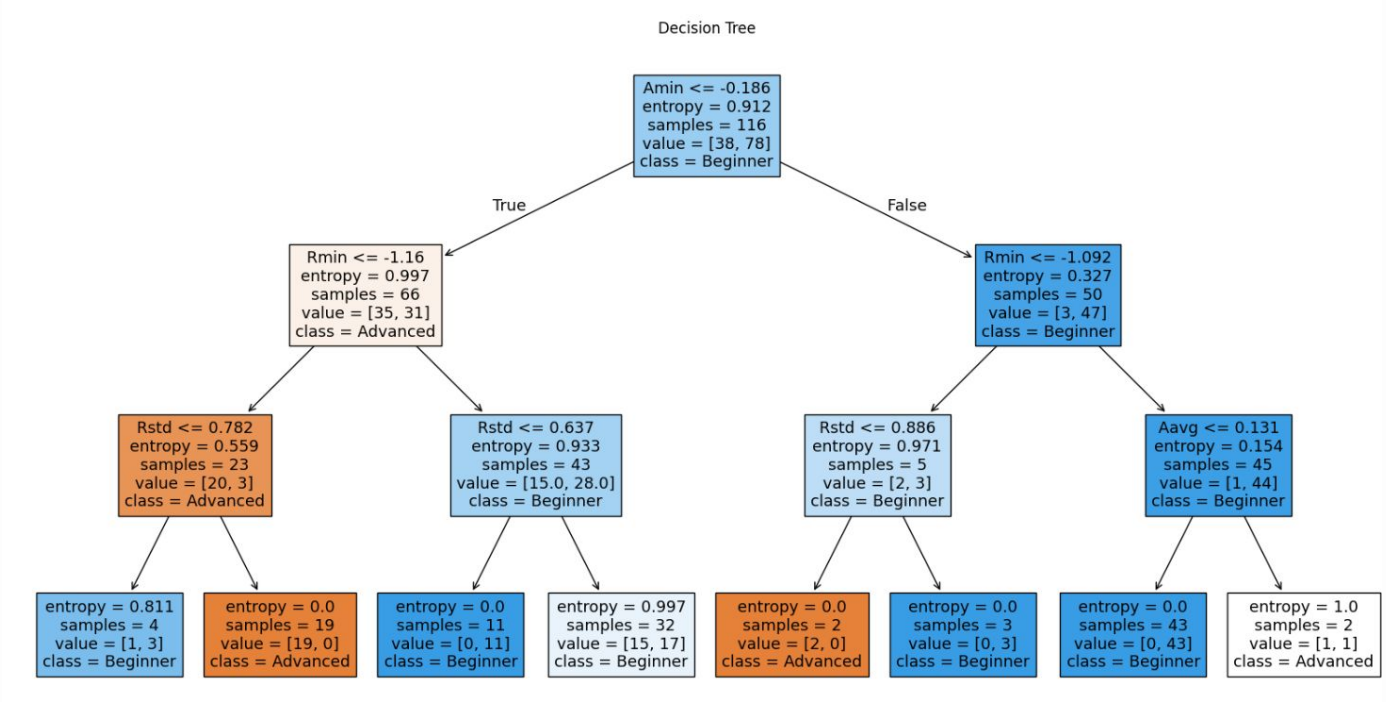
Classification Approach is **70% training and 30%** testing

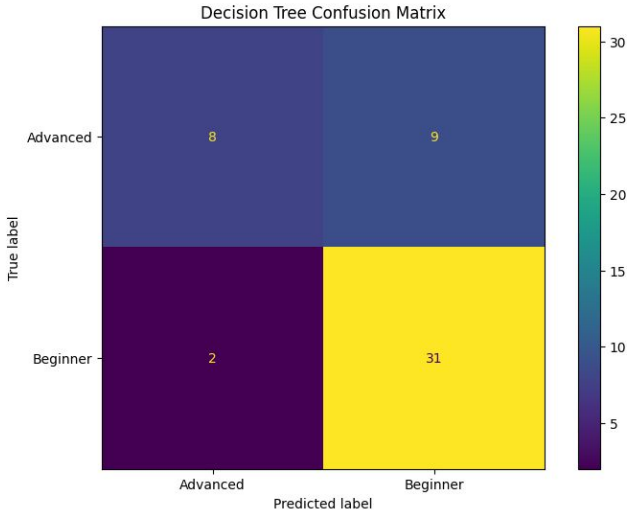
Tested decision tree classification and random forest

Compared acceleration, rotation, and acceleration + rotation confusion matrixes


All Features by F-Score
F-score
0
10
20
30
40
50
Rmin
Amin
Aq25
Rq25
Rstd
Amed
Rmax
Rq75
Astd
Aavg
Feature

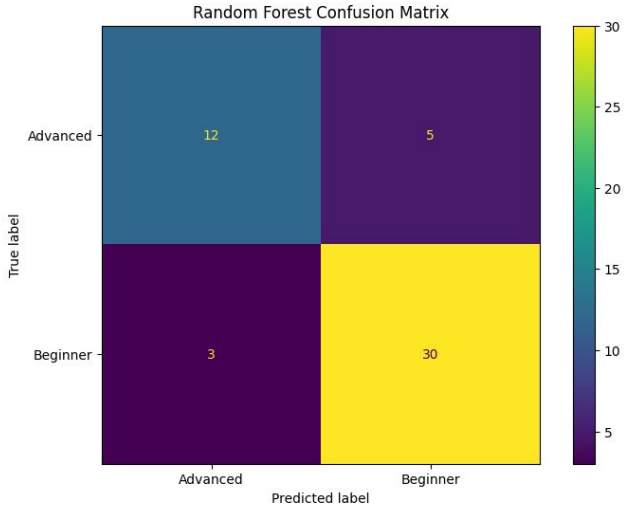
Results


Decision Tree
Amin <= -0.186
entropy = 0.912
samples = 116
value = [38, 78]
class = Beginner
True
False
Rmin <= -1.16
entropy = 0.997
samples = 66
value = [35, 31]
class = Advanced
Rmin <= -1.092
entropy = 0.327
samples = 50
value = [3, 47]
class = Beginner
Rstd <= 0.782
entropy = 0.559
samples = 23
value = [20, 3]
class = Advanced
Rstd <= 0.637
entropy = 0.933
samples = 43
value = [15.0, 28.0]
class = Beginner
Rstd <= 0.886
entropy = 0.971
samples = 5
value = [2, 3]
class = Beginner
Aavg <= 0.131
entropy = 0.154
samples = 45
value = [1, 44]
class = Beginner
entropy = 0.811
samples = 4
value = [1, 3]
class = Beginner
entropy = 0.0
samples = 19
value = [19, 0]
class = Advanced
entropy = 0.0
samples = 11
value = [0, 11]
class = Beginner
entropy = 0.997
samples = 32
value = [15, 17]
class = Beginner
entropy = 0.0
samples = 2
value = [2, 0]
class = Advanced
entropy = 0.0
samples = 3
value = [0, 3]
class = Beginner
entropy = 0.0
samples = 43
value = [0, 43]
class = Beginner
entropy = 1.0
samples = 2
value = [1, 1]
class = Advanced



	precision	recall	f1-score	support
Advanced	0.80	0.47	0.59	17
Beginner	0.78	0.94	0.85	33
accuracy			0.78	50
macro avg	0.79	0.70	0.72	50
weighted avg	0.78	0.78	0.76	50

Accuracy on test set: 0.78

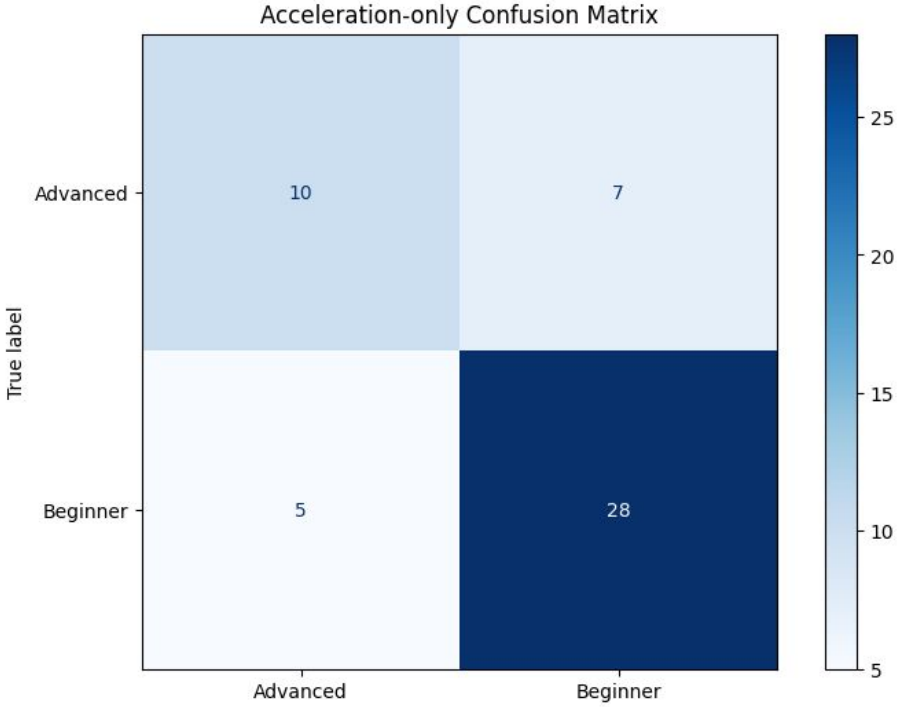


	precision	recall	f1-score	support
Advanced	0.80	0.71	0.75	17
Beginner	0.86	0.91	0.88	33
accuracy			0.84	50
macro avg	0.83	0.81	0.82	50
weighted avg	0.84	0.84	0.84	50

Accuracy on test set: 0.84

Acceleration-only Classification Report:

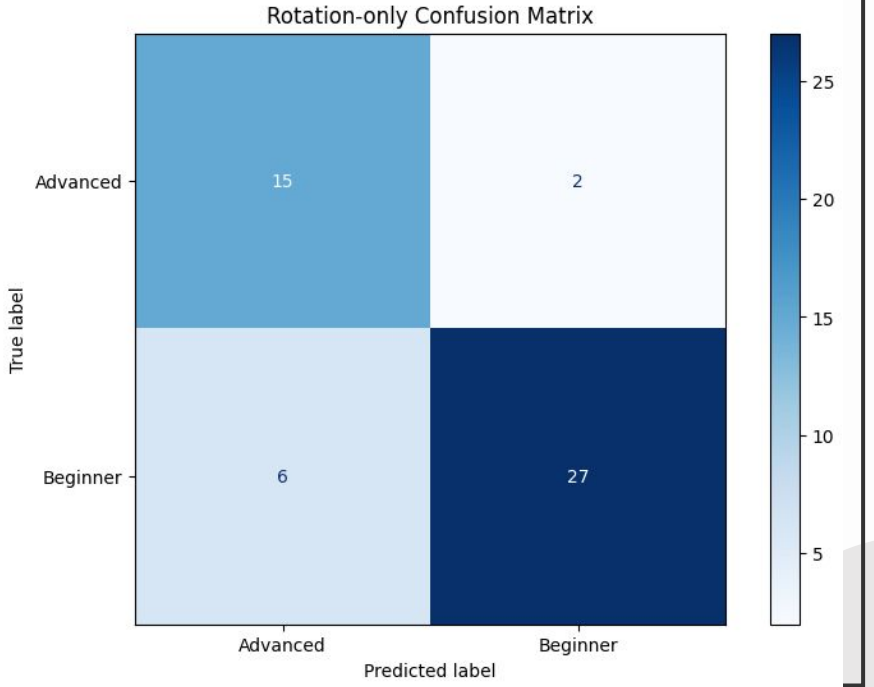
	precision	recall	f1-score	support
Advanced	0.67	0.59	0.62	17
Beginner	0.80	0.85	0.82	33
accuracy			0.76	50
macro avg	0.73	0.72	0.72	50
weighted avg	0.75	0.76	0.76	50



Predicted label

Rotation-only Classification Report:

	precision	recall	f1-score	support
Advanced	0.71	0.88	0.79	17
Beginner	0.93	0.82	0.87	33
accuracy			0.84	50
macro avg	0.82	0.85	0.83	50
weighted avg	0.86	0.84	0.84	50



Conclusion

What did you learn?

- Data collection, pre-processing techniques, feature selection, training and evaluation of models

What were the main challenges

- Designing how to collect the data, finding meaningful differences between groups

Future improvements

- Would want to take measurements of more difficult climbs in a more controlled setting, would like to evaluate more metrics hip and arm