Machine Learning Control (With all data)

December 2, 2021

1 Define the libraries

[33]:

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from matplotlib.backends.backend_pdf import PdfPages
from datetime import timedelta
```

2 Define Function

[34]:

```
def␣
↪PlotData(Start,Duration,Mistake,Time,Data1,Data2,Figuur,player,arraystartsprint,arraystopsp
↪

    #Define starting en stopping positions for the CSV data
    Start = (Start-Mistake)*100
    Stop = int(Start + Duration*100)

    WheelRotationspeed = Data1[Start:Stop]
    FrameRotationspeed = Data2[Start:Stop]
    Timestamp = Time[Start:Stop]

    #Lowpass filter design for rotation and wheelspeed to improve accuracy of␣
↪code (Butterworth filter)
    Order = 5
    cutoff_freq = 1.5
    sampling_freq = 100
    sampling_duration = Duration

    normalized_cutoff_freq = 2 * cutoff_freq / sampling_freq
    numerator_coeffs, denominator_coeffs = signal.butter(Order,␣
↪normalized_cutoff_freq)
    filtered_WheelRotationspeed = signal.lfilter(numerator_coeffs,␣
↪denominator_coeffs, WheelRotationspeed)
```

```
    filtered_FrameRotationspeed = signal.lfilter(numerator_coeffs,␣
↪denominator_coeffs, FrameRotationspeed)


    #Play with different operations to see clearer patterns
    Sub = filtered_WheelRotationspeed + filtered_FrameRotationspeed
    Conv1 = filtered_FrameRotationspeed / filtered_WheelRotationspeed
    Conv2 = (abs(filtered_FrameRotationspeed)+abs(filtered_WheelRotationspeed))/
↪filtered_WheelRotationspeed

    DiffFrame = np.diff(filtered_FrameRotationspeed,n=1)
    DiffFrame = np.insert(DiffFrame,0,0)

    DiffWheel = np.diff(filtered_WheelRotationspeed,n=1)
    DiffWheel = np.insert(DiffWheel,0,0)

    Multi = filtered_WheelRotationspeed + filtered_FrameRotationspeed

    #Set all data into a datafram
    Data = pd.DataFrame({'Time':Timestamp,'WheelRotationspeed':
↪filtered_WheelRotationspeed,
                         'FrameRotationspeed':filtered_FrameRotationspeed,
                         'Sub':Sub ,'Conv':Conv1, 'DiffFrame':DiffFrame,␣
↪'DiffWheel':DiffWheel},
                        columns=['Time',␣
↪'WheelRotationspeed','FrameRotationspeed','Sub','Conv','DiffFrame','DiffWheel'])

    #Convert data into chunks of n/100 of a second
    n = 50  #chunk row size
    Data_chunks = [Data[i:i+n] for i in range(0,Data.shape[0],n)]

    #Search for the sprints
    Startsprint = []
    Stopsprint = []
    Sprinting = False
    Stop = True

    #Use Sub en Conv to detect sprints
    for chunks in Data_chunks:
        if abs(chunks['Conv'].max()) < 3 and chunks['Sub'].mean() > 300 and␣
↪Sprinting == False:
            Startsprint.append(chunks['Time'].min())
            Sprinting = True
            Stop = False
        elif abs(chunks['Conv'].max() < 3) and chunks['Sub'].mean() > 300:
            Sprinting = True
            Stop = False
        elif Stop == False:
            Stopsprint.append(chunks['Time'].min())
            Sprinting = False
            Stop = True

    #Use wheelrotation, framerotation and conv to detect rotations
    Startrotate = []
    Stoprotate = []
    Rotate = False
    Stop = True

    for chunks in Data_chunks:
        if abs(chunks['FrameRotationspeed'].max()) > 75 and␣
 ↪abs(chunks['DiffFrame'].max()) > 4 and Rotate == False:
            Startrotate.append(chunks['Time'].min())
            Rotate = True
            Stop = False
        elif abs(chunks['FrameRotationspeed'].max()) > 75 and␣
 ↪abs(chunks['DiffFrame'].max()) > 4:
            Rotate = True
            Stop = False
        elif Stop == False:
            Stoprotate.append(chunks['Time'].min())
            Rotate = False
            Stop = True

    #Filter Sprints by lenght, if length is below 2 delete sprint
    Deleted = 0

    if len(Startsprint) > len(Stopsprint):
        Startsprint.pop(-1)

    if len(Startsprint) == len(Stopsprint):
        for i in range(0,len(Startsprint),1):
            if (Stopsprint[i-Deleted] - Startsprint[i-Deleted]) < 3:
                Startsprint.pop(i-Deleted)
                Stopsprint.pop(i-Deleted)
                Deleted = Deleted + 1

    if str(StartError) == 'NaN':
        Startsprint = []
        Stopsprint = []
    elif len(Startsprint) == 0 and float(StartError) > 0:
        Startsprint = [StartError]
        Stopsprint = [StopError]
    elif float(StartError) > 0:
        for i in range(len(Startsprint)):
            Startsprint[i] = StartError
            Stopsprint[i] = StopError


    #Plot graph
    fig, ax = plt.subplots(1,1)
    ax.plot(Timestamp,WheelRotationspeed,'r',Timestamp,FrameRotationspeed,'b')

    #Plot the vertical lines in plot 1
    for Start in Startsprint:
        ax.axvline(x=Start, color = 'g')
    for Stop in Stopsprint:
        ax.axvline(x=Stop, color = 'm')
    ax.legend(['Wheel Rotation Speed','Frame Rotation Speed'])
    ax.set_xlabel('Time (sec)')
    ax.set_title("Fast Defence " + str(Figuur) + ", " + str(player) + ", Video␣
 ↪Time = "
                      + str(Start))

    ArrayStartSprint.append(Startsprint)
    ArrayStopSprint.append(Stopsprint)
```

3 Visualize Data

3.1 Define player and match

[35]:

```
Player = 15
Game = 2
```

3.2 Insert Data player

[36]:

```
df_Player = pd.read_csv('matrix_Player_' + str(Player) + '_game_' + str(Game) +␣
 ↪'.csv')
df_Player.columns =␣
 ↪['frAcc','frRoAcc','frDispl','frRoAng','frSpeed','timeLine','frameRotationalSpeedX','frameR
df_Player
```

[36]:

```
            frAcc  frRoAcc  frDispl  frRoAng   frSpeed  timeLine  \
0        0.000000      0.0      0.0  0.00000  0.000000      0.01
1        0.000000      0.0      0.0  0.00000  0.000000      0.02
2        0.000000      0.0      0.0  0.00000  0.000000      0.03
3        0.000000      0.0      0.0  0.00000  0.000000      0.04
```

```
4       0.000000      0.0      0.0  0.00000  0.000000      0.05
…          …      …      …      …       …       …
860405 -0.002098   6556.8  -1946.6 -0.18538 -0.000787   8604.10
860406 -0.026347   6556.8  -1946.6 -0.18939 -0.000808   8604.10
860407  0.012933   6556.8  -1946.6 -0.23979 -0.001071   8604.10
860408       NaN      NaN      NaN      NaN       NaN       NaN
860409       NaN      NaN      NaN      NaN       NaN       NaN

        frameRotationalSpeedX  frameRotationalSpeedY  frameRotationalSpeedZ  \
0                         NaN                    NaN                    NaN
1                         NaN                    NaN                    NaN
2                         NaN                    NaN                    NaN
3                         NaN                    NaN                    NaN
4                         NaN                    NaN                    NaN
…                        …                    …                    …
860405                 1.0500                0.85556                -1.0500
860406                 1.0920                0.93100                -1.0710
860407                 1.1690                0.95900                -1.1200
860408                 1.1433                0.93333                -1.0967
860409                 1.1900                0.94500                -1.0850

        wheelRotationalSpeedX  wheelRotationalSpeedY  wheelRotationalSpeedZ  \
0                         NaN                    NaN                    NaN
1                         NaN                    NaN                    NaN
2                         NaN                    NaN                    NaN
3                         NaN                    NaN                    NaN
4                         NaN                    NaN                    NaN
…                        …                    …                    …
860405                 1.4000                1.16670                -1.5867
860406                 1.4000                1.09200                -1.6240
860407                 1.4000                1.08110                -1.5089
860408                 1.4000                1.08500                -1.4700
860409                 1.4389                0.97222                -1.5089

        frRoSpeed
0         0.00000
1         0.00000
2         0.00000
3         0.00000
4         0.00000
…            …
860405   -0.40135
860406   -5.03910
860407        NaN
860408        NaN
860409        NaN
```

```
[860410 rows x 13 columns]
```

3.3 Define boundaries

3.3.1 Get Timestamps from CSV

[37]:

```
df_Timestamps = pd.read_csv('matrix_Player_' + str(Player) + '_game_' +␣
 ↪str(Game) + '_FoundSprints.csv')
Timestamps = df_Timestamps['Time'].to_numpy()
len(Timestamps)
```

[37]:

```
156
```

4 Fix Error things

[38]:

```
StartError = [
              343.8,736,2114.2,2125.5,2137.2,0,2198,'NaN',2234,2266.
 ↪5,'NaN',2310.8,2351,2374.9,2395.5,2620,2645.3,2672.2,2687,2697.
 ↪5,2752,2773,2808.5,2823,2841,2866.5,2899.5,2956.7,3001,3119.
 ↪5,3208,3317,3398,3407,3600.5,3623.5,0,3654,0,3728.5,3767.8,3798,3836.
 ↪6,3850,3956.3,0,0,3969,4013.5,'NaN',4032,4053,
              4108,4120,'NaN',0,4168.5,'NaN',4216.5,4223.5,'NaN',4285.
 ↪5,0,4326,'NaN',4933,'NaN','NaN',4955,'NaN','NaN',4997.5,'NaN',5057,'NaN',0,
              5121,5146,5181,5184,5195,5217,5239,5256.5,5374.5,0,5439.
 ↪5,5451,'NaN',5474.5,5522,0,6208,'NaN',6237,'NaN',6264.5,'NaN',6282,6308
              ,'NaN',6352.5,6372,6383,'NaN',6490,6512,0,6536.5,6547,6575.5,6600.
 ↪5,'NaN',6627.5,0,6677,0,6872,6887,6914,'NaN',7008.5,0,7065,7065,'NaN',7084.
 ↪5,7144,7199,7229,7244,7375.5,7469,'NaN',0,0,7520.
 ↪5,'NaN','NaN',7729,7766,7772.5,7782.5,0,7803,7811,7841,7899.5,7925.
 ↪5,0,7948,0,7974.5,7986,8010.5,0,
             ]

StopError =  [
              347,738,2121.5,2128.
 ↪8,2143,0,2203,'NaN',2236,2270,'NaN',2314,2354,2377,2399,2621.5,2649,2674.
 ↪5,2691,2700.5,2755,2779,2812,2828,2845,2869.5,2902.5,2962,3006.8,3123.3,3211.
 ↪8,3321,3401,3411,3604,3626,0,3659,0,3735,3774.8,3804,3842.
 ↪4,3854,3962,0,0,3974,4019,'NaN',4042,4058.5,
              4113,4124,'NaN',0,4172,'NaN',4220.5,4226.4,'NaN',4288,0,4328.
 ↪5,'NaN',4935.5,'NaN','NaN',4960,'NaN','NaN',5006,'NaN',5061,'NaN',0,
              5124,5151.5,5183,5188,5200,5220.5,5241.5,5258,5379,0,5443,5457.
 ↪5,'NaN',5477,5526,0,6212,'NaN',6240,'NaN',6268,'NaN',6285.5,6310.5
```

```
                ␣
 ↪,'NaN',6357,6378,6390,'NaN',6494,6517,0,6543,6551,6578,6604,'NaN',6633,0,6682,0,6877,6890.
 ↪5,6918,'NaN',7012,0,7068.5,7068.
 ↪5,'NaN',7087,7146,7202,7232,7248,7380,7471,'NaN',0,0,7522.
 ↪5,'NaN','NaN',7731,7770,7774.5,7787,0,7808,7813,7837.
 ↪5,7904,7930,0,7951,0,7980,7991,8016.5,0
             ]
len(StartError)
```

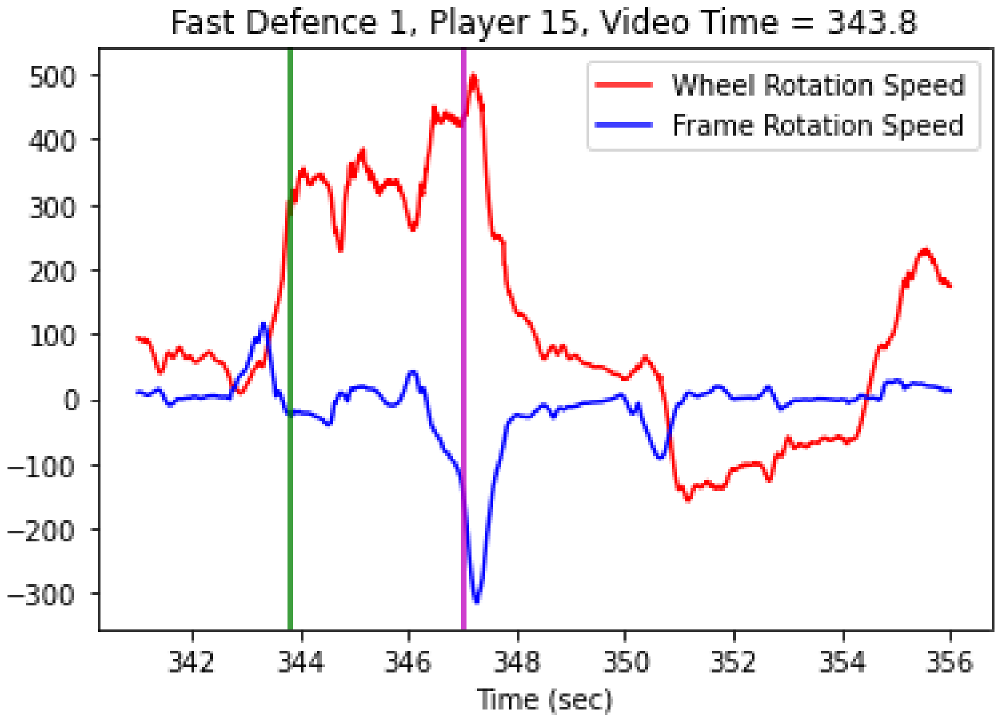
[38]: 156

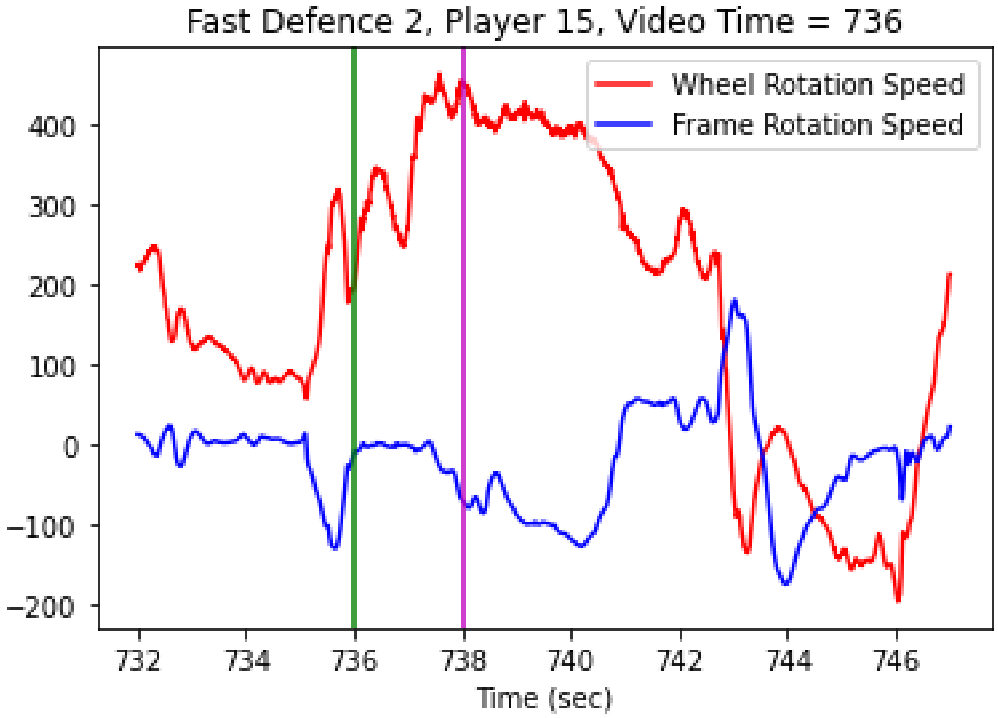
4.0.1 Visualize

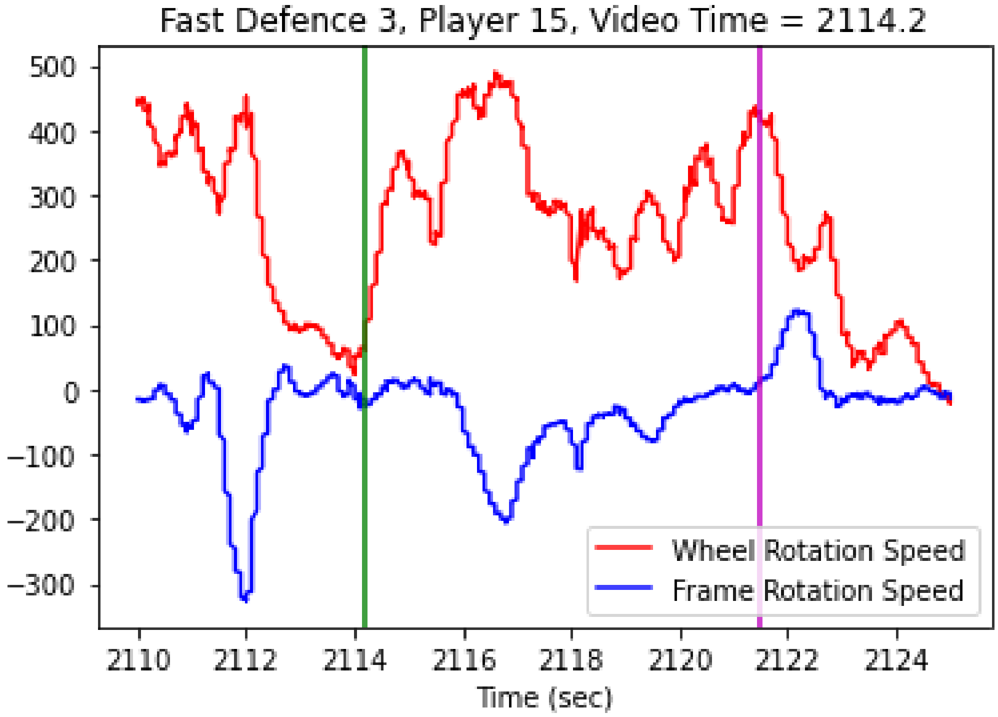
[39]:

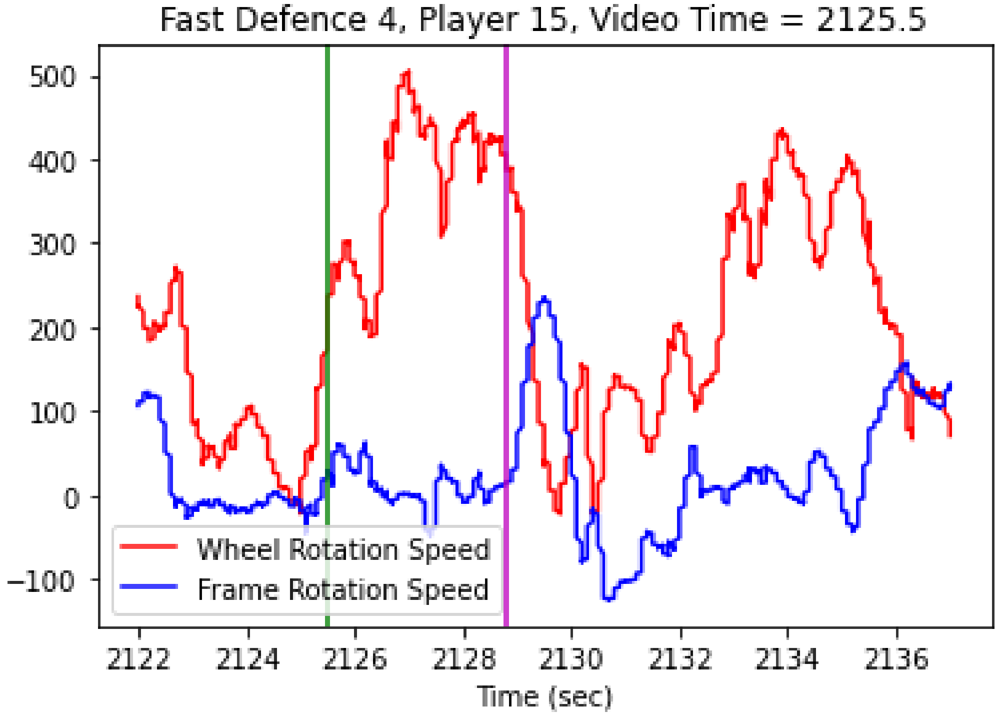
```
ArrayStartSprint = []
ArrayStopSprint = []
for i in range(0,len(Timestamps),1):
     PlotData(Timestamps[i], 15,5, df_Player.timeLine.to_numpy(),
             df_Player.wheelRotationalSpeedX.to_numpy(),
             df_Player.frameRotationalSpeedZ.to_numpy(),
             i+1,('Player ' + str(Player)),ArrayStartSprint,␣
 ↪ArrayStopSprint,StartError[i],StopError[i])
```

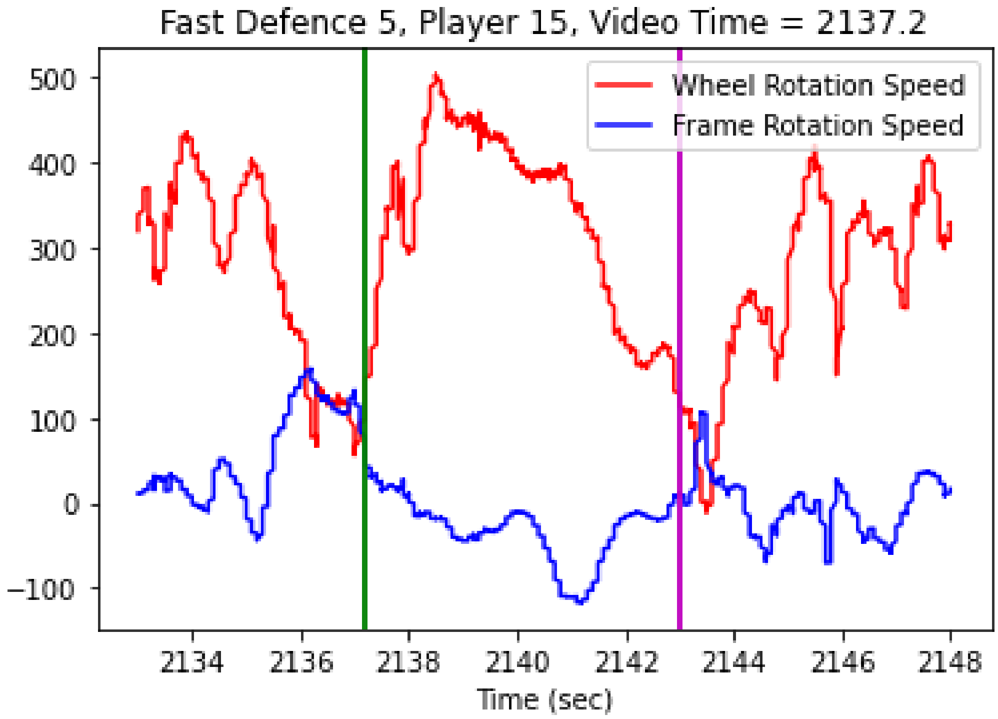
```
<ipython-input-34-69a0fbf6054f>:111: RuntimeWarning: More than 20 figures have
been opened. Figures created through the pyplot interface
(`matplotlib.pyplot.figure`) are retained until explicitly closed and may
consume too much memory. (To control this warning, see the rcParam
`figure.max_open_warning`).
  fig, ax = plt.subplots(1,1)
```

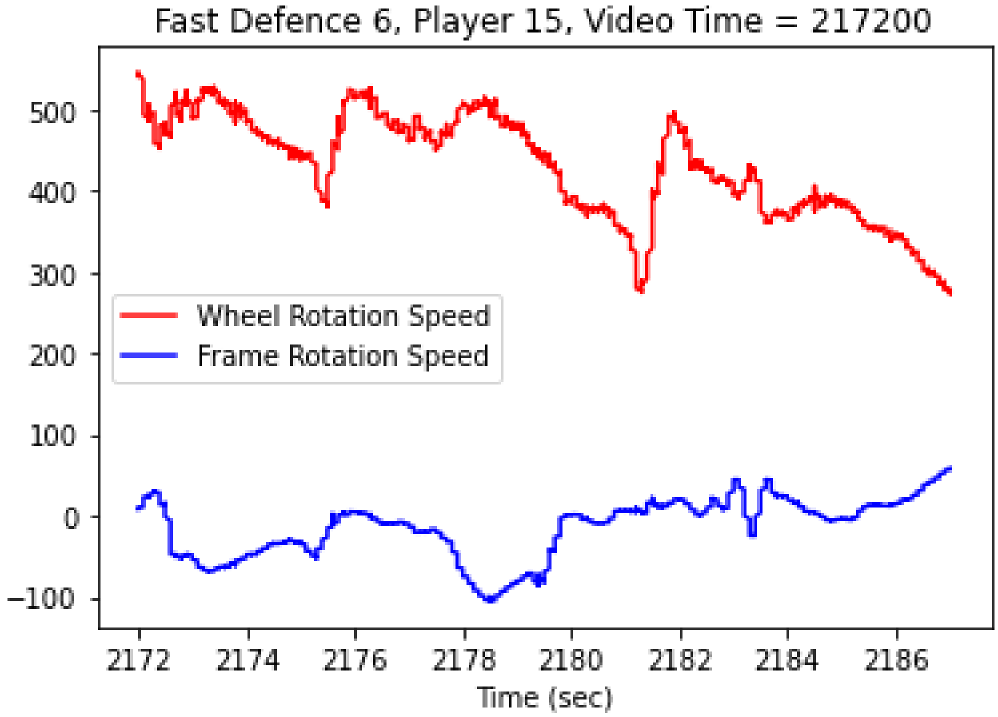

Fast Defence 1, Player 15, Video Time = 343.8
Wheel Rotation Speed
Frame Rotation Speed
500
400
300
200
100
0
−100
−200
−300
342
344
346
348
350
352
354
356
Time (sec)

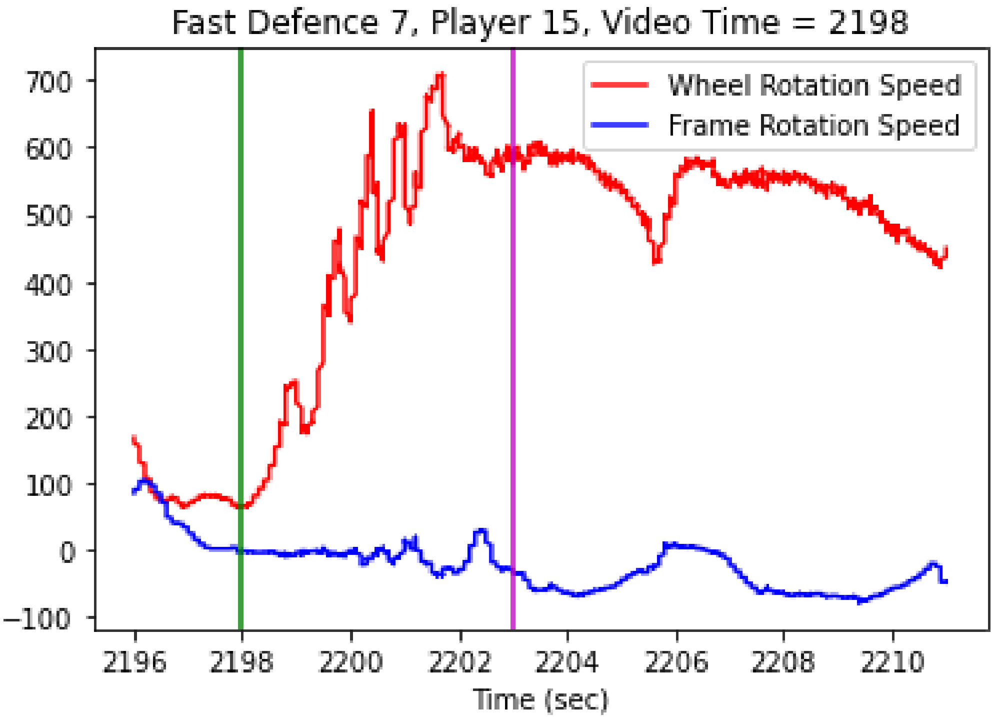

Fast Defence 2, Player 15, Video Time = 736
Wheel Rotation Speed
Frame Rotation Speed
400
300
200
100
0
−100
−200
732
734
736
738
740
742
744
746
Time (sec)

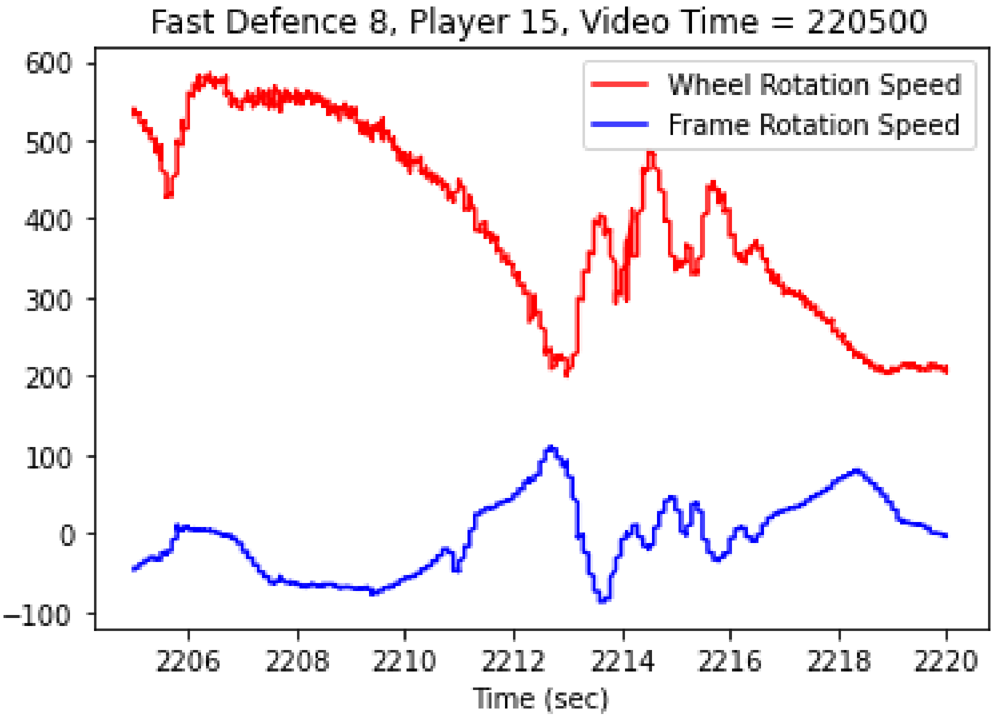

Fast Defence 3, Player 15, Video Time = 2114.2
500
400
300
200
100
0
−100
−200
−300
Wheel Rotation Speed
Frame Rotation Speed
2110
2112
2114
2116
2118
2120
2122
2124
Time (sec)

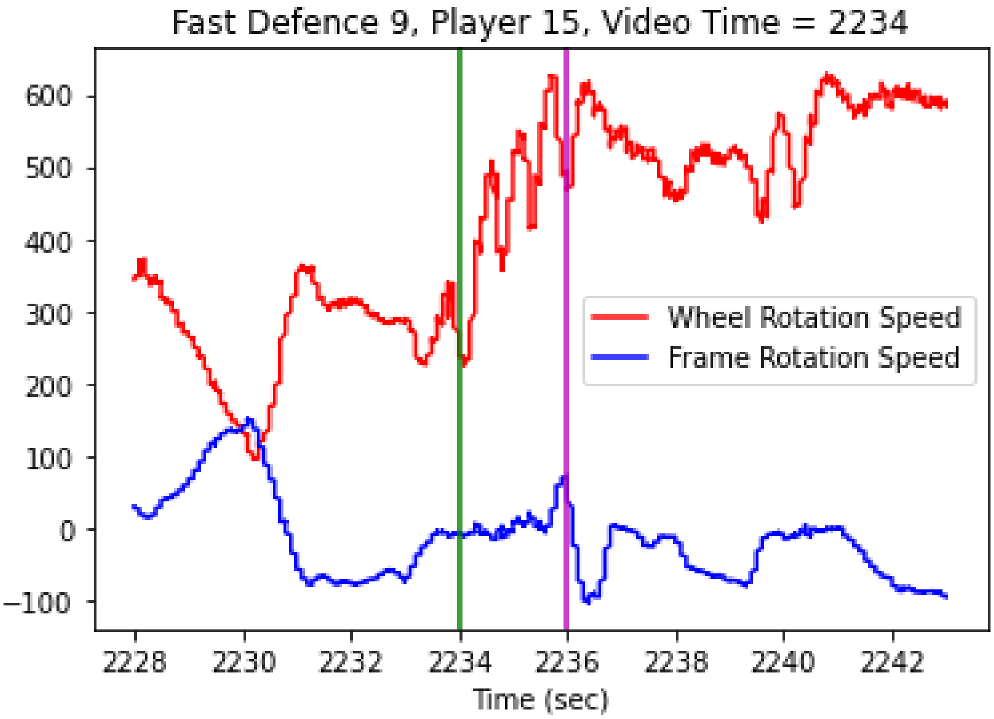

Fast Defence 4, Player 15, Video Time = 2125.5
500
400
300
200
100
0
−100
Wheel Rotation Speed
Frame Rotation Speed
2122
2124
2126
2128
2130
2132
2134
2136
Time (sec)

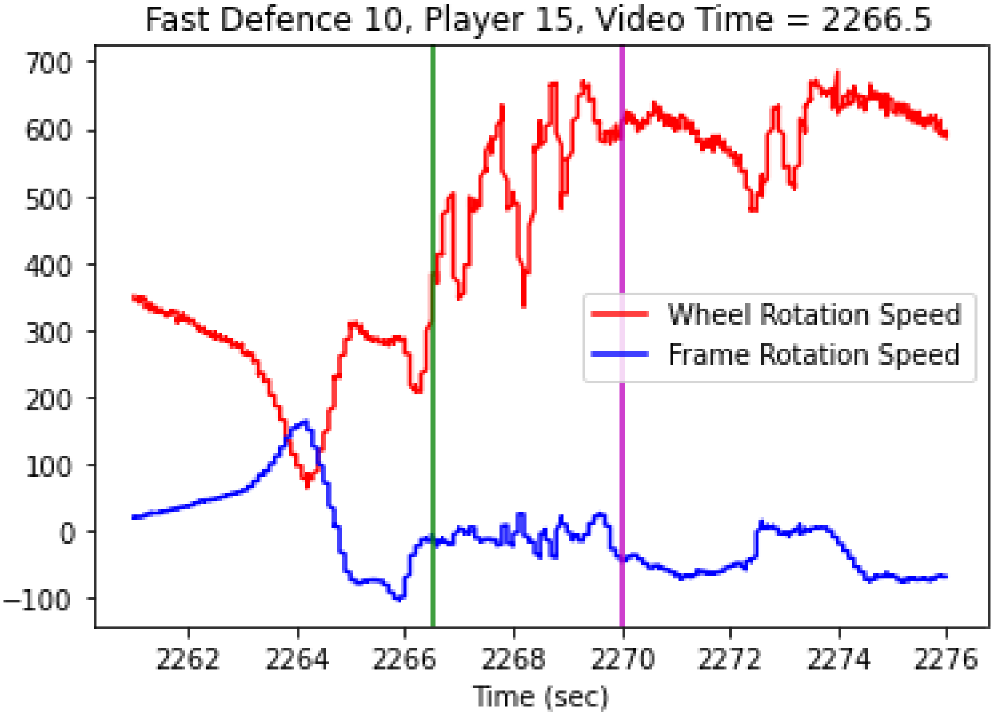

Fast Defence 5, Player 15, Video Time = 2137.2

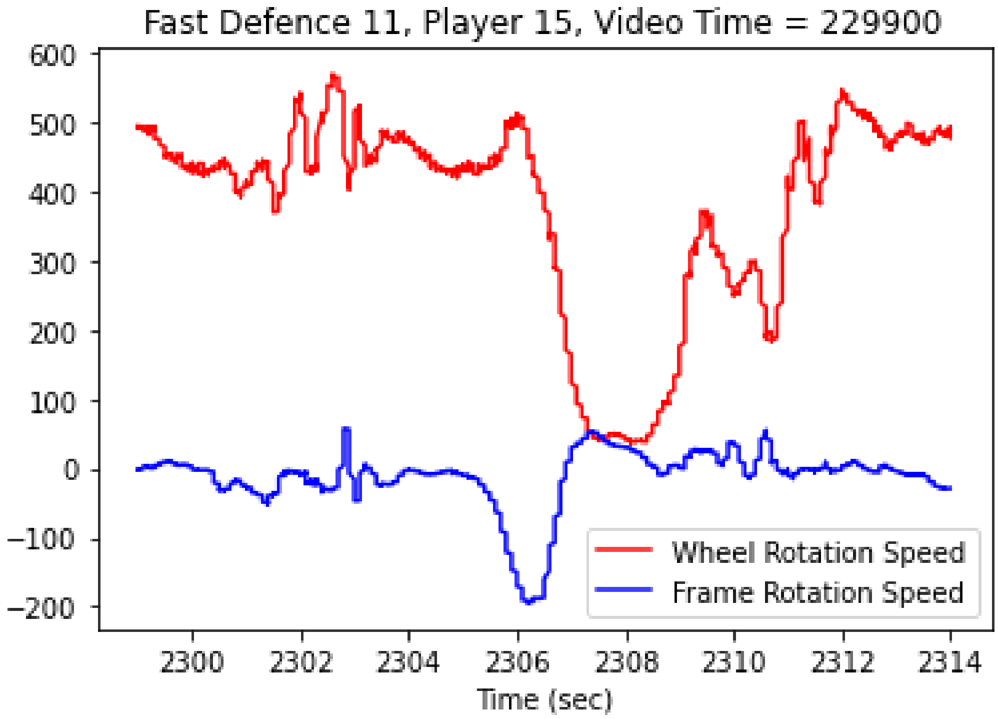

Fast Defence 6, Player 15, Video Time = 217200

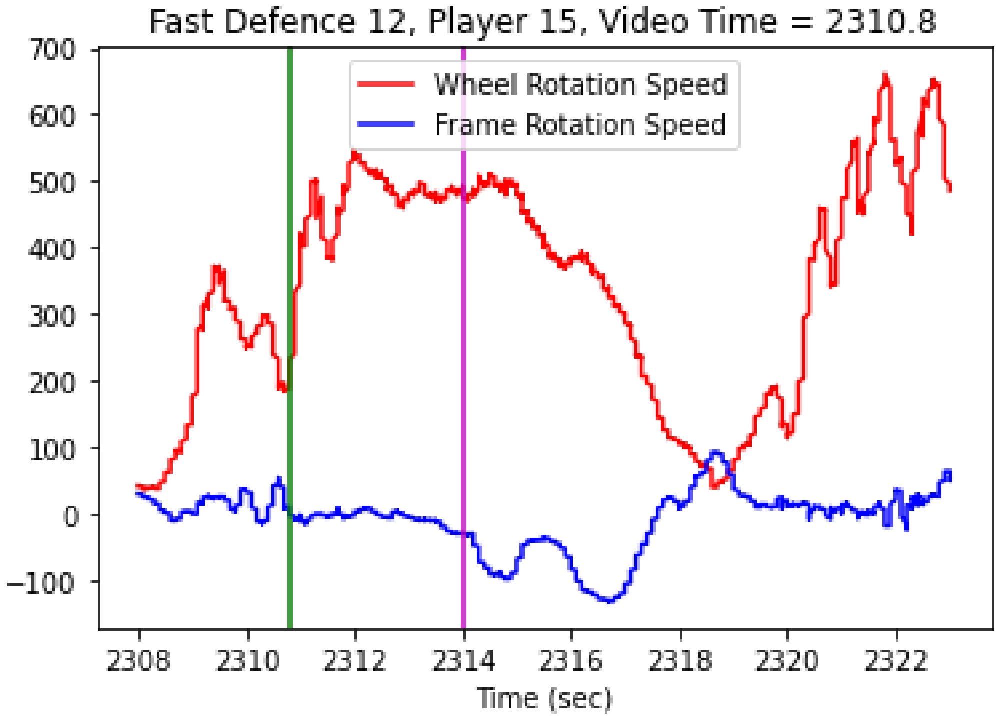

Fast Defence 7, Player 15, Video Time = 2198
Wheel Rotation Speed
Frame Rotation Speed
700
600
500
400
300
200
100
0
−100
2196
2198
2200
2202
2204
2206
2208
2210
Time (sec)

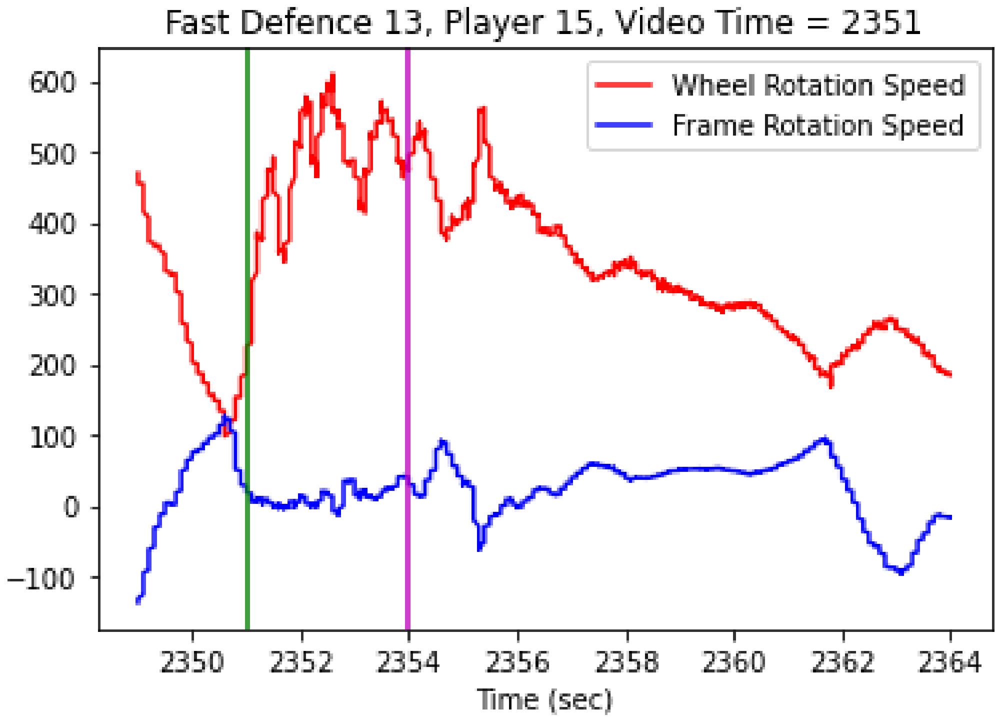

Fast Defence 8, Player 15, Video Time = 220500
Wheel Rotation Speed
Frame Rotation Speed
600
500
400
300
200
100
0
−100
2206
2208
2210
2212
2214
2216
2218
2220
Time (sec)

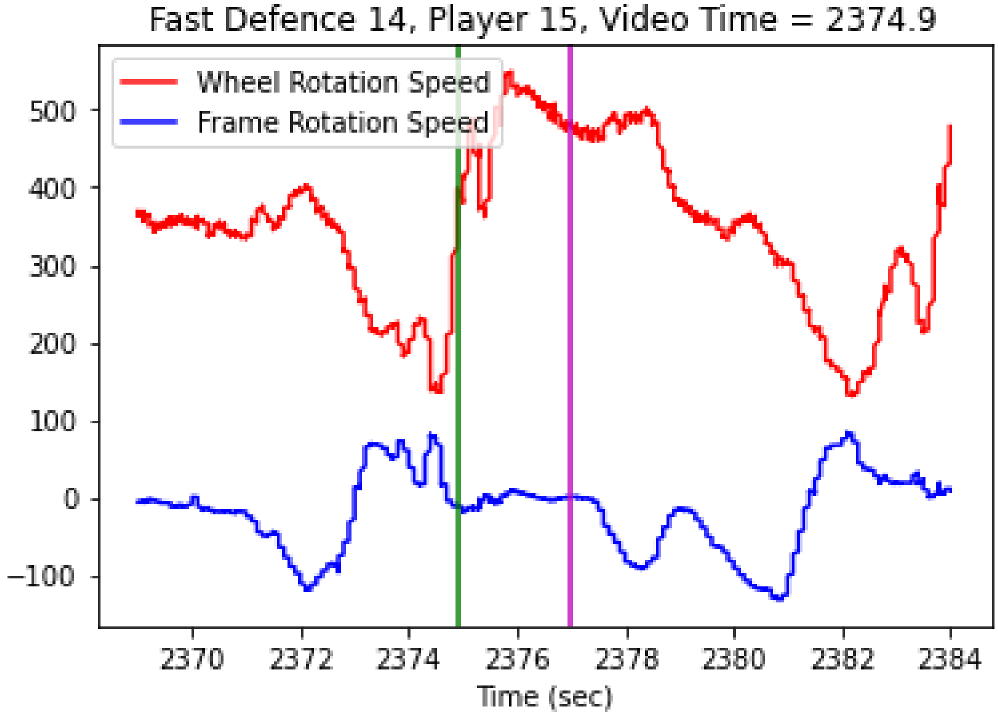

Fast Defence 9, Player 15, Video Time = 2234
600
500
400
300
200
100
0
−100
2228
2230
2232
2234
2236
2238
2240
2242
Time (sec)
Wheel Rotation Speed
Frame Rotation Speed

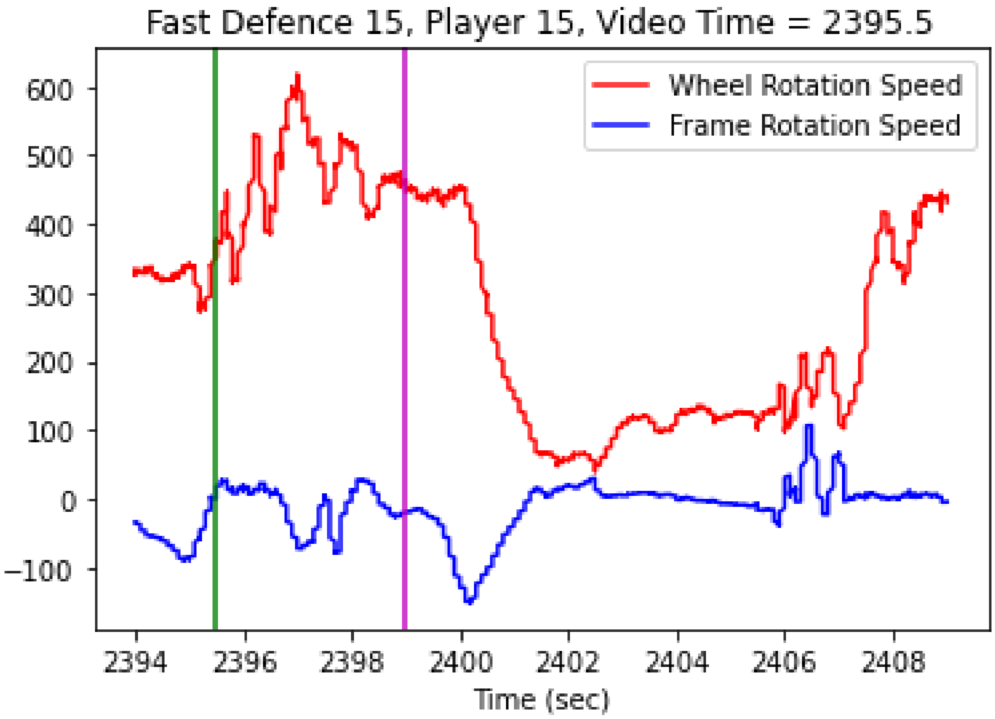

Fast Defence 10, Player 15, Video Time = 2266.5
700
600
500
400
300
200
100
0
−100
2262
2264
2266
2268
2270
2272
2274
2276
Time (sec)
Wheel Rotation Speed
Frame Rotation Speed

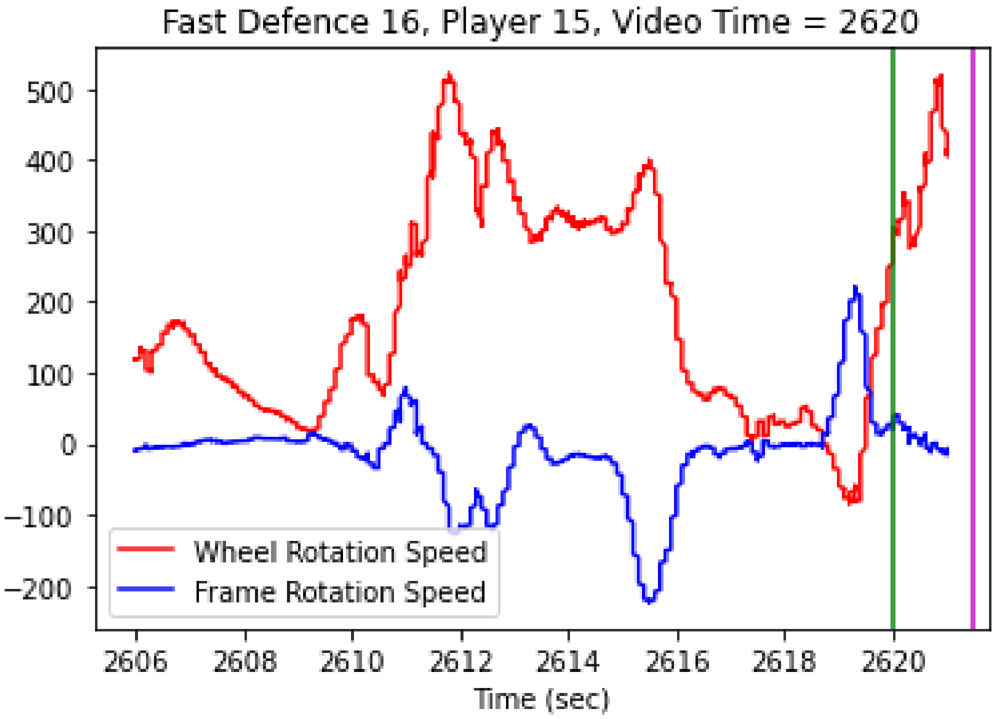

Fast Defence 11, Player 15, Video Time = 229900
600
500
400
300
200
100
0
−100
−200
Wheel Rotation Speed
Frame Rotation Speed
2300
2302
2304
2306
2308
2310
2312
2314
Time (sec)

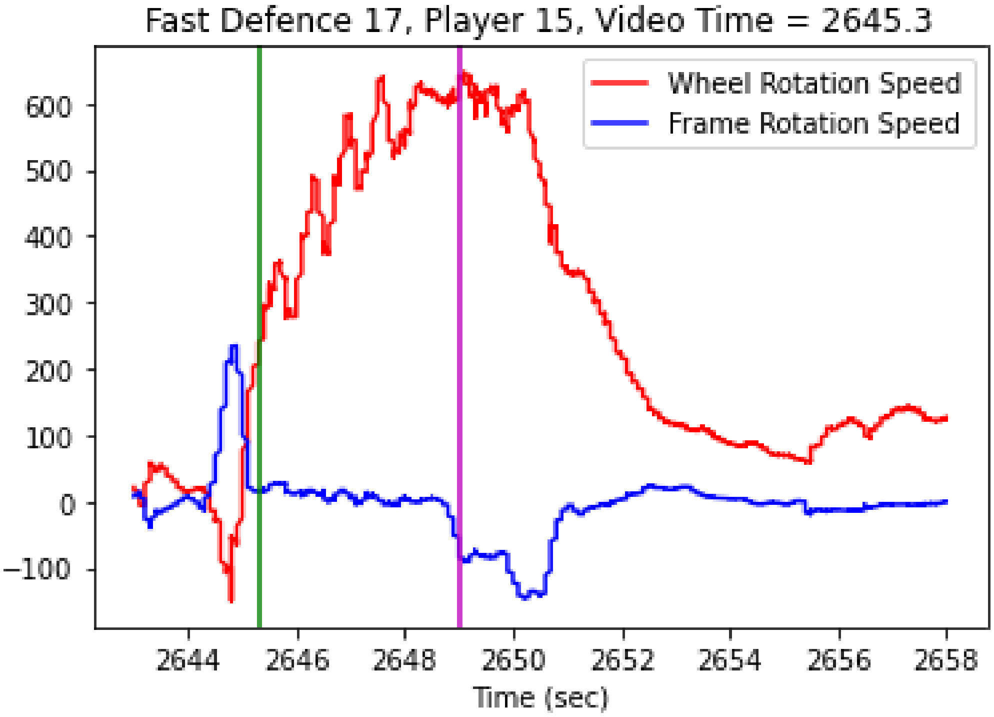

Fast Defence 12, Player 15, Video Time = 2310.8
700
600
500
400
300
200
100
0
−100
Wheel Rotation Speed
Frame Rotation Speed
2308
2310
2312
2314
2316
2318
2320
2322
Time (sec)

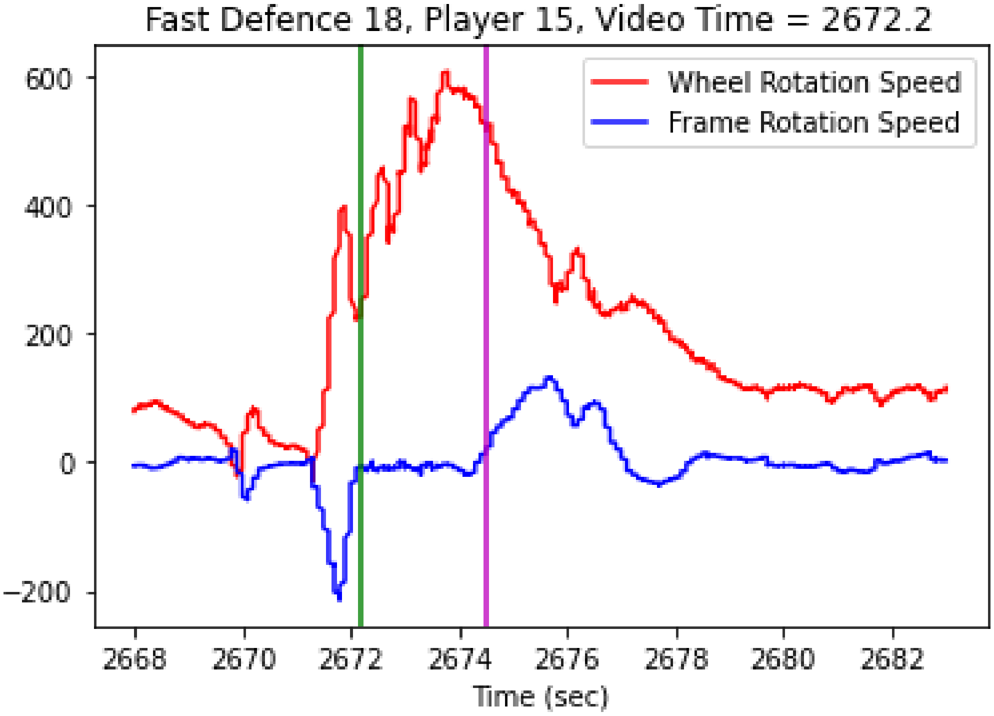

Fast Defence 13, Player 15, Video Time = 2351
Wheel Rotation Speed
Frame Rotation Speed
600
500
400
300
200
100
0
−100
2350
2352
2354
2356
2358
2360
2362
2364
Time (sec)


Fast Defence 14, Player 15, Video Time = 2374.9
Wheel Rotation Speed
Frame Rotation Speed
500
400
300
200
100
0
−100
2370
2372
2374
2376
2378
2380
2382
2384
Time (sec)


Fast Defence 15, Player 15, Video Time = 2395.5
Wheel Rotation Speed
Frame Rotation Speed
600
500
400
300
200
100
0
−100
2394
2396
2398
2400
2402
2404
2406
2408
Time (sec)


Fast Defence 16, Player 15, Video Time = 2620
Wheel Rotation Speed
Frame Rotation Speed
500
400
300
200
100
0
−100
−200
2606
2608
2610
2612
2614
2616
2618
2620
Time (sec)


Fast Defence 17, Player 15, Video Time = 2645.3
Wheel Rotation Speed
Frame Rotation Speed
600
500
400
300
200
100
0
−100
2644
2646
2648
2650
2652
2654
2656
2658
Time (sec)


Fast Defence 18, Player 15, Video Time = 2672.2
Wheel Rotation Speed
Frame Rotation Speed
600
400
200
0
−200
2668
2670
2672
2674
2676
2678
2680
2682
Time (sec)