

wheels_vs_mc_realvalues_3

October 4, 2022

```
[ ]: import matplotlib.pyplot as plt
import numpy as np
import pandas as pd
from datetime import datetime, timedelta
from pd_support import read_df_csv
from scipy.interpolate import interp1d

[ ]: cart_df = pd.read_csv("../data_csv/test.csv")

[ ]: # plt.plot(np.arange(len(cart_df["mils"])), cart_df["mils"].diff())
# plt.plot(np.arange(len(cart_df["mils"])), cart_df["mils"].diff())
cart_df["mils"].diff()

[ ]: mc, mc_dt = read_df_csv("../data_csv/cart_random_mc.csv")
mc_dt

[ ]: type(mc["org_x"][0])

[ ]: numpy.float64

[ ]: mc = mc.rename(columns={"time": "seconds"})

[ ]: _t = []
for i in list(mc["seconds"]):
    _t.append(mc_dt + timedelta(0, float(i)))

mc["time"] = _t

[ ]: mc

[ ]:
    frame  seconds    org_x    org_y    org_z    xdir_x    xdir_y  \
0         0      0.00  0.372066  0.062682 -0.089318  0.412840  0.061187
1         1      0.01  0.372051  0.062662 -0.089333  0.412849  0.061191
2         2      0.02  0.372070  0.062637 -0.089315  0.412834  0.061140
3         3      0.03  0.372069  0.062652 -0.089324  0.412833  0.061156
4         4      0.04  0.372066  0.062658 -0.089321  0.412827  0.061154
...     ...     ...     ...     ...     ...     ...
6314    6314     63.14  0.037280  0.068873 -0.085428  0.077838  0.067106
```

6315	6315	63.15	0.037297	0.068825	-0.085467	0.077832	0.067124
6316	6316	63.16	0.037267	0.068837	-0.085447	0.077830	0.067113
6317	6317	63.17	0.037304	0.068842	-0.085422	0.077817	0.067092
6318	6318	63.18	0.037282	0.068836	-0.085427	0.077835	0.067098

	xdir_z	zdir_x	zdir_y	zdir_z	time
0	-0.088165	0.368545	0.062648	-0.025666	2022-06-15 17:41:53.371
1	-0.088166	0.368510	0.062674	-0.025655	2022-06-15 17:41:53.381
2	-0.088163	0.368532	0.062695	-0.025672	2022-06-15 17:41:53.391
3	-0.088165	0.368524	0.062681	-0.025673	2022-06-15 17:41:53.401
4	-0.088159	0.368526	0.062646	-0.025689	2022-06-15 17:41:53.411
...
6314	-0.087170	0.038145	0.068804	-0.021561	2022-06-15 17:42:56.511
6315	-0.087163	0.038147	0.068819	-0.021562	2022-06-15 17:42:56.521
6316	-0.087170	0.038138	0.068835	-0.021552	2022-06-15 17:42:56.531
6317	-0.087173	0.038125	0.068796	-0.021542	2022-06-15 17:42:56.541
6318	-0.087162	0.038133	0.068766	-0.021551	2022-06-15 17:42:56.551

[6319 rows x 12 columns]

```
[ ]: mc["time"] = pd.to_datetime(mc["time"])
```

```
[ ]: """getting initial values of motion capture data"""

# marker_cen = np.array(mc[["center_x", "center_y", "center_z"]].iloc[0]).T
marker_xvec = np.array(mc[["xdir_x", "xdir_y", "xdir_z"]].iloc[0]).T
marker_zvec = np.array(mc[["zdir_x", "zdir_y", "zdir_z"]].iloc[0]).T
marker_org = np.array(mc[["org_x", "org_y", "org_z"]].iloc[0]).T
marker_org[0]
```

```
[ ]: 0.372066
```

```
[ ]: v1 = marker_xvec - marker_org #v1
v2 = marker_zvec - marker_org #v2

v1 = v1.reshape(3,1)
v2 = v2.reshape(3,1)
v3 = marker_org.reshape(3,1)
```

```
[ ]: def calculate_rotmat(xdir,zdir,org):
    """
    this function calculates rotation matrix
    """

    v1 = xdir - org #v1
    v2 = zdir - org #v2

    vxnorm = v1/np.linalg.norm(v1)
```

```

vzcap = v2 - (vxnorm.T @ v2) * vxnorm
vznorm = vzcap/ np.linalg.norm(vzcap)

vynorm = np.cross(vznorm.T[0], vxnorm.T[0]).reshape(3,1)
rotMat = np.hstack((vxnorm, vynorm, vznorm))
return rotMat

```

```
[ ]: """getting initial rot mat in mc data"""
```

```

rot_mat = calculate_rotmat(v1, v2, v3)
rot_mat

```

```
[ ]: array([[ -0.94826055,  0.23644182,  0.21188957],
          [-0.1836945 , -0.95291786,  0.24125483],
          [ 0.25895609,  0.18984949,  0.94704747]])
```

```

[ ]: temp_list = []
for i in range(len(mc["xdir_x"])):
    # center_val = np.array(mc[["center_x", "center_y", "center_z"]].iloc[i])
    center_val = np.array(mc[["org_x", "org_y", "org_z"]].iloc[i])

    center_val = center_val.reshape(3,1)
    transformed_center = rot_mat.T @ (center_val - v3)
    # if i == 0:
    #     print(center_val - v3)
    transformed_center = transformed_center.T[0]
    temp_list.append(transformed_center)
mc[["cen_x", "cen_y", "cen_z"]] = temp_list

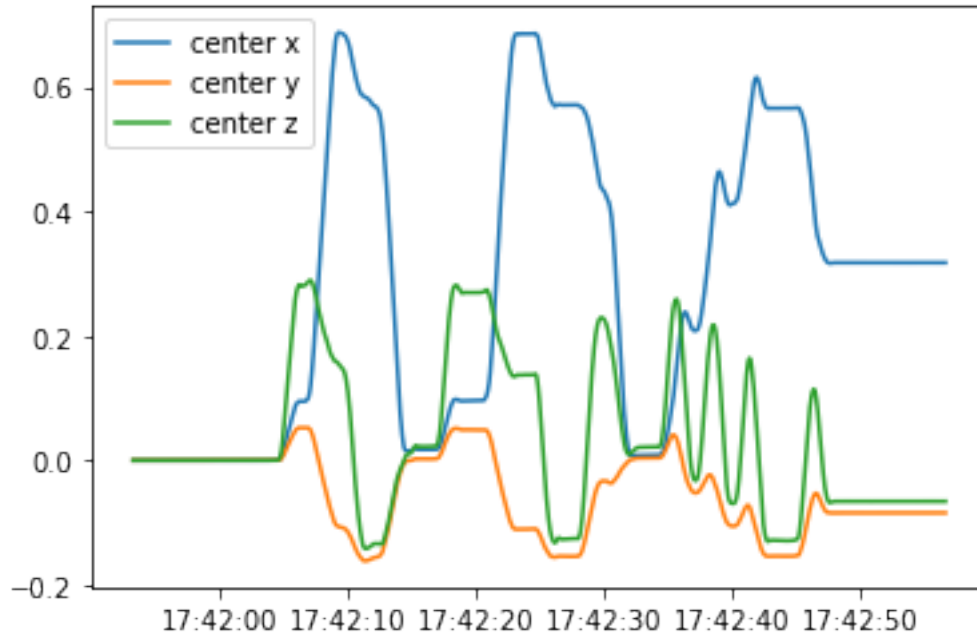
```

```

[ ]: plt.plot(mc["time"], mc["cen_x"], label="center x")
plt.plot(mc["time"], mc["cen_y"], label="center y")
plt.plot(mc["time"], mc["cen_z"], label="center z")
plt.legend()

```

```
[ ]: <matplotlib.legend.Legend at 0x129b1cf1888>
```



```
[ ]: """resetting cart values to zero"""
cart_df["e_fr"] = cart_df["e_fr"]- cart_df["e_fr"].iloc[0]
cart_df["e_fl"] = cart_df["e_fl"]- cart_df["e_fl"].iloc[0]
cart_df["e_rr"] = cart_df["e_rr"]- cart_df["e_rr"].iloc[0]
cart_df["e_rl"] = cart_df["e_rl"]- cart_df["e_rl"].iloc[0]

cart_df
```

```
[ ]:
      sys_time  e_fr  e_fl  e_rr  e_rl
0   2022-06-15 17:41:42.658968    0    0    0    0
1   2022-06-15 17:41:42.851436    0    0    0    0
2   2022-06-15 17:41:42.851436    0    0    0    0
3   2022-06-15 17:41:42.851936    0    0    0    0
4   2022-06-15 17:41:42.851936    0    0    0    0
...
8508 2022-06-15 17:42:59.441218 -4576  4122  2725 -5178
8509 2022-06-15 17:42:59.441218 -4576  4122  2725 -5178
8510 2022-06-15 17:42:59.441675 -4576  4122  2725 -5178
8511 2022-06-15 17:42:59.441675 -4576  4122  2725 -5178
8512 2022-06-15 17:42:59.441675 -4576  4122  2725 -5178

[8513 rows x 5 columns]
```

```
[ ]: mils = np.arange(0, len(cart_df["e_fr"])*10, 10)
cart_df["mils"] = mils
cart_df["sys_time"] = pd.to_datetime(cart_df["sys_time"])
```

These are the parameters of the cart

Diameter = 95 mm radius = 47.5 mm wheel thickness = 45 mm gap between wheel and chassis = 6.5 mm angle between center of chassis and z-dir vector = 51.21 degrees distance between the wheel = 158 mm distance between the wheel and the center of the robot = 101.36 (li)

```
[ ]: """circumfrence of the wheel"""

cir_wheel = np.degrees(2*np.pi*(47.5/1000))
cir_wheel
radius = 47.5/1000

lx = 79 #half of the distance between the wheels
ly = 122.5/2

lx = lx/1000
ly = ly/1000
```

The encoder values will give 4000 values per revolution $360/4000 = 0.09$ degrees per encoder rotation value

```
[ ]: """ angular velocity"""
cart_df["av_fr"] = (cart_df["e_fr"]*0.09).diff()/0.01
cart_df["av_fl"] = (cart_df["e_fl"]*0.09).diff()/0.01
cart_df["av_rr"] = (cart_df["e_rr"]*0.09).diff()/0.01
cart_df["av_rl"] = (cart_df["e_rl"]*0.09).diff()/0.01
cart_df['av_fr'] = cart_df["av_fr"].fillna(0)
cart_df['av_fl'] = cart_df["av_fl"].fillna(0)
cart_df['av_rr'] = cart_df["av_rr"].fillna(0)
cart_df['av_rl'] = cart_df["av_rl"].fillna(0)

#converting them to radians
cart_df['av_fr'] = cart_df["av_fr"]* np.pi/180
cart_df['av_fl'] = cart_df["av_fl"]* np.pi/180
cart_df['av_rr'] = cart_df["av_rr"]* np.pi/180
cart_df['av_rl'] = cart_df["av_rl"]* np.pi/180

cart_df["av_fl"]
```

```
[ ]: 0      0.0
      1      0.0
      2      0.0
      3      0.0
      4      0.0
      ...
      8508   0.0
      8509   0.0
      8510   0.0
```

```

8511    0.0
8512    0.0
Name: av_fl, Length: 8513, dtype: float64

```

```

[ ]: # g1 = np.radians(-51.21)
      # g2 = np.radians(51.21)

```

```

g1 = np.radians(-np.pi/2)
g2 = np.radians(np.pi/2)

```

```

g3 = g2
g4 = g1

```

```

b1 = np.pi/4
b2 = -np.pi/4
b3 = b1
b4 = b2

```

```

a1 = np.pi/4
a2 = -np.pi/4
a3 = 3*np.pi/4
a4 = -3*np.pi/4

```

```

li = 101.36/1000

```

```

[ ]: t = (-1/radius)*np.array([[np.cos(b1 - g1)/ np.sin(g1), np.sin(b1 - g1)/np.
    ↪sin(g1), li * np.sin(b1 - g1 - a1)/np.sin(g1)],
    [np.cos(b2 - g2)/ np.sin(g2), np.sin(b2 - g2)/np.
    ↪sin(g2), li * np.sin(b2 - g2 - a2)/np.sin(g2)],
    [np.cos(b3 - g3)/ np.sin(g3), np.sin(b3 - g3)/np.
    ↪sin(g3), li * np.sin(b3 - g3 - a3)/np.sin(g3)],
    [np.cos(b4 - g4)/ np.sin(g4), np.sin(b4 - g4)/np.
    ↪sin(g4), li * np.sin(b4 - g4 - a4)/np.sin(g4)]]
    )
t
pseudo_t = np.linalg.pinv(t)
pseudo_t

```

```

[ ]: array([[ 4.47561242e-04, -4.47561242e-04, -4.72799786e-04,
    4.72799786e-04],
    [ 8.73787444e-04,  8.73787444e-04, -2.39613824e-05,
    -2.39613824e-05],
    [ 5.92854944e-03,  5.92854944e-03,  6.26286783e-03,
    6.26286783e-03]])

```

```
[ ]: val = pseudo_t @ np.array([[cart_df["av_fr"][0]], [cart_df["av_fl"][0]],  
    ↪ [cart_df["av_rr"][0]], [cart_df["av_rl"][0]]])  
val.T
```

```
[ ]: array([[0., 0., 0.]])
```

```
[ ]: np.array([[cart_df["av_fr"][0]], [cart_df["av_fl"][0]], [cart_df["av_rr"][0]],  
    ↪ [cart_df["av_rl"][0]]])
```

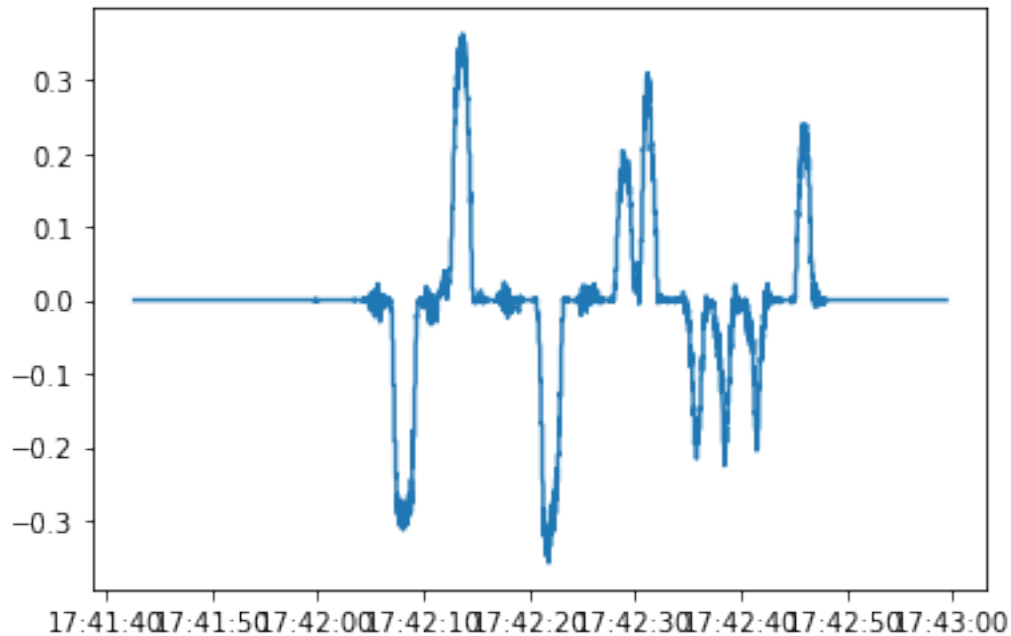
```
[ ]: array([[0.,  
            [0.,  
            [0.,  
            [0.]])
```

```
[ ]: _val = []  
for i in range(len(cart_df["e_fl"])):  
    _v = pseudo_t @ np.array([[cart_df["av_fr"][i]], [cart_df["av_fl"][i]],  
    ↪ [cart_df["av_rr"][i]], [cart_df["av_rl"][i]]])  
    _val.append(_v.T[0])  
  
cart_df[["cal_vx", "cal_vy", "cal_w"]] = _val  
# _val
```

```
[ ]: """finding vx, vy, w"""  
  
cart_df["vx"] = (cart_df["av_fl"] + cart_df["av_fr"] + cart_df["av_rl"] +  
    ↪ cart_df["av_rr"])*(radius/4)  
cart_df["vy"] = (- cart_df["av_fl"] + cart_df["av_fr"] + cart_df["av_rl"] -  
    ↪ cart_df["av_rr"])*(radius/4)  
cart_df["w"] = (- cart_df["av_fl"] + cart_df["av_fr"] - cart_df["av_rl"] +  
    ↪ cart_df["av_rr"])*(radius/(4*(lx + ly)))
```

```
[ ]: plt.plot(cart_df["sys_time"], cart_df["vy"])  
# plt.plot(cart_df["vx"])
```

```
[ ]: [ <matplotlib.lines.Line2D at 0x129b20574c8>]
```



```
[ ]: """calculating displacement
s=(1/2)* (v+u)t
v = current velocity
u = initial velocity
t = time
s = displacement
"""

_xval = []
_yval = []
xf_disp = 0
yf_disp = 0
for i in range(len(cart_df["vx"])):
    if i == 0:
        _xval.append(0)
        _yval.append(0)
    else:
        x_disp = 0.5*(cart_df["vx"].iloc[i] + cart_df["vx"].iloc[i-1])*0.01
        y_disp = 0.5*(cart_df["vy"].iloc[i] + cart_df["vy"].iloc[i-1])*0.01
        print(y_disp)
        xf_disp = xf_disp+x_disp
        yf_disp = yf_disp+y_disp
        _xval.append(xf_disp)
        _yval.append(yf_disp)
```



```
cart_df["x_val"] = _xval
cart_df["y_val"] = _yval
# cart_df["y_val"]
```

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1.8653206380689027e-05
3.730641276137911e-05
2.7979809571034438e-05
-3.6971294081755703e-19
-3.730641276137911e-05
-2.7979809571034438e-05
4.663301595172447e-05
8.393942871310292e-05
3.7306412761378006e-05
-9.32660319034433e-06
-2.797980957103441e-05
-5.5959619142068144e-05
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-0.00011191923828413618
7.37257477290143e-19
7.461282552275828e-05
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-9.326603190343538e-06
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9.326603190346492e-06
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-9.326603190342115e-06
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6.528622233241532e-05
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4.663301595172239e-05
9.326603190342115e-06
-5.595961914207036e-05
-4.663301595172228e-05
-2.797980957102919e-05
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0.00014922565104551487
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-1.8653206380690135e-05
-7.46128255227604e-05
-0.00010259263509378972
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-5.595961914207326e-05
-3.730641276137727e-05
6.528622233241538e-05
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0.00010259263509378973
5.204170427930421e-20
2.9522825156780286e-18
9.32660319034206e-06
1.8653206380687075e-05
5.853650897336138e-18
3.730641276138022e-05
2.79798095710322e-05

-5.595961914206149e-05
-0.00016787885742620802
-0.00022383847656827545
-0.00018653206380688932
-0.00012124584147448861
-0.00012124584147448277
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-4.663301595172239e-05
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-3.730641276138316e-05
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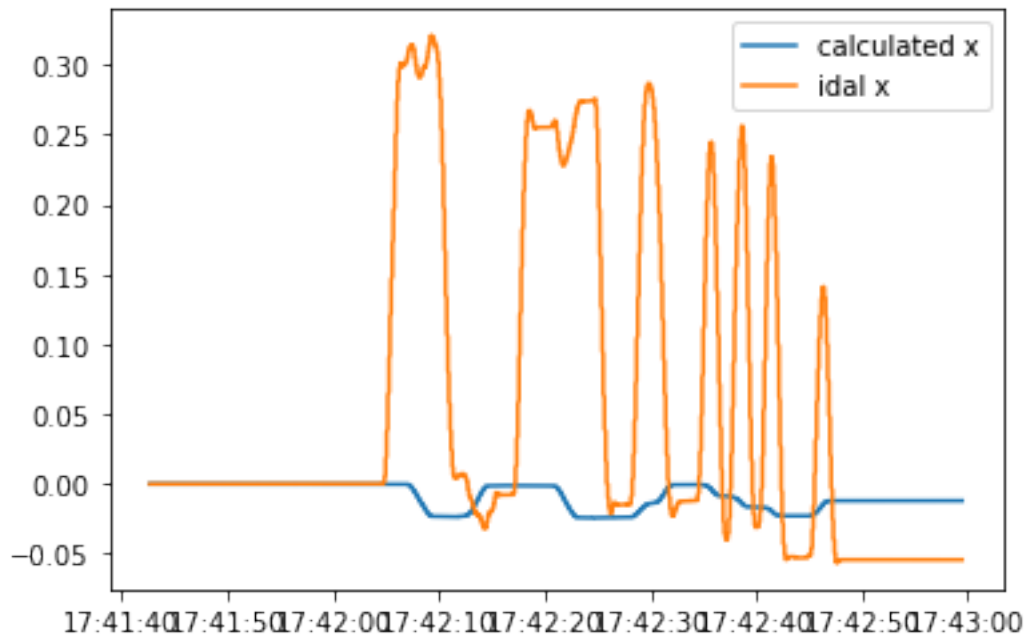
```
[ ]: """calculating displacement for calculated coordinates

"""
_xval = []
_yval = []
xf_disp = 0
yf_disp = 0
for i in range(len(cart_df["vx"])):
    if i == 0:
        _xval.append(0)
        _yval.append(0)
    else:
        x_disp = 0.5*(cart_df["cal_vx"].iloc[i] + cart_df["cal_vx"].
↪iloc[i-1])*0.01
        y_disp = 0.5*(cart_df["cal_vy"].iloc[i] + cart_df["cal_vy"].
↪iloc[i-1])*0.01
        # print(x_disp)
        xf_disp = xf_disp+x_disp
        yf_disp = yf_disp+y_disp
        _xval.append(xf_disp)
        _yval.append(yf_disp)

cart_df["cal_x"] = _xval
cart_df["cal_y"] = _yval
```

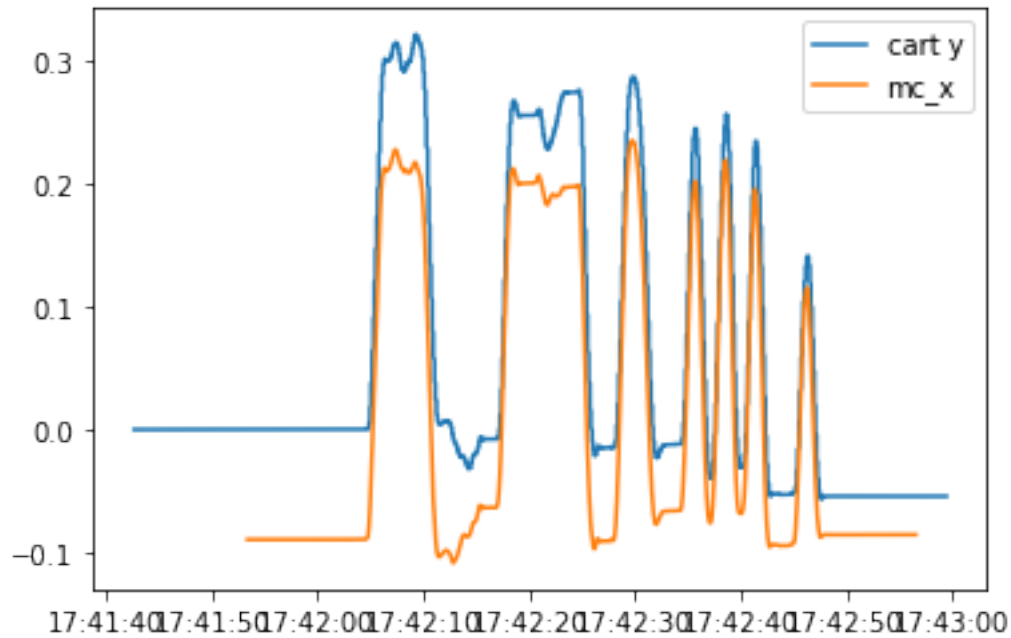
```
[ ]: # plt.plot(cart_df["sys_time"], cart_df["x_val"], label = "ideal x")
plt.plot(cart_df["sys_time"], cart_df["cal_x"], label = "calculated x")
plt.plot(cart_df["sys_time"], cart_df["x_val"], label = "ideal x")
plt.legend()
```

```
[ ]: <matplotlib.legend.Legend at 0x129b1fada08>
```



```
[ ]: plt.plot(cart_df["sys_time"], cart_df["x_val"], label = "cart y")
plt.plot(mc["time"], mc["org_z"], label = "mc_x")
plt.legend()
```

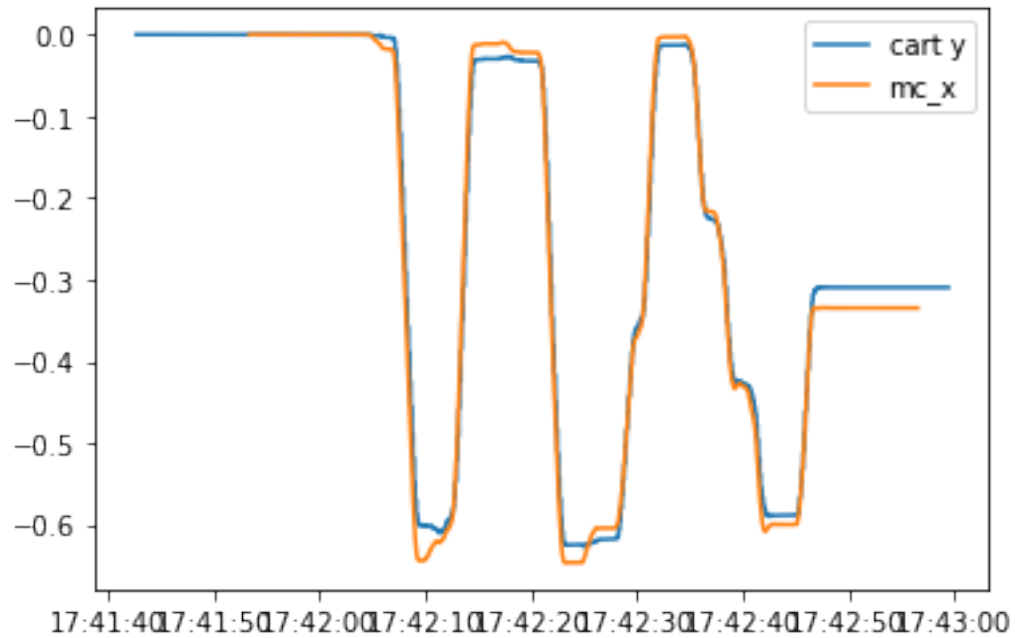
```
[ ]: <matplotlib.legend.Legend at 0x129b214d3c8>
```



```
[ ]: _t2 = []
      for i in cart_df["sys_time"]:
          _tt = mc["time"][0]-i
          # print(_tt)
          _t2.append(_tt.total_seconds())
```

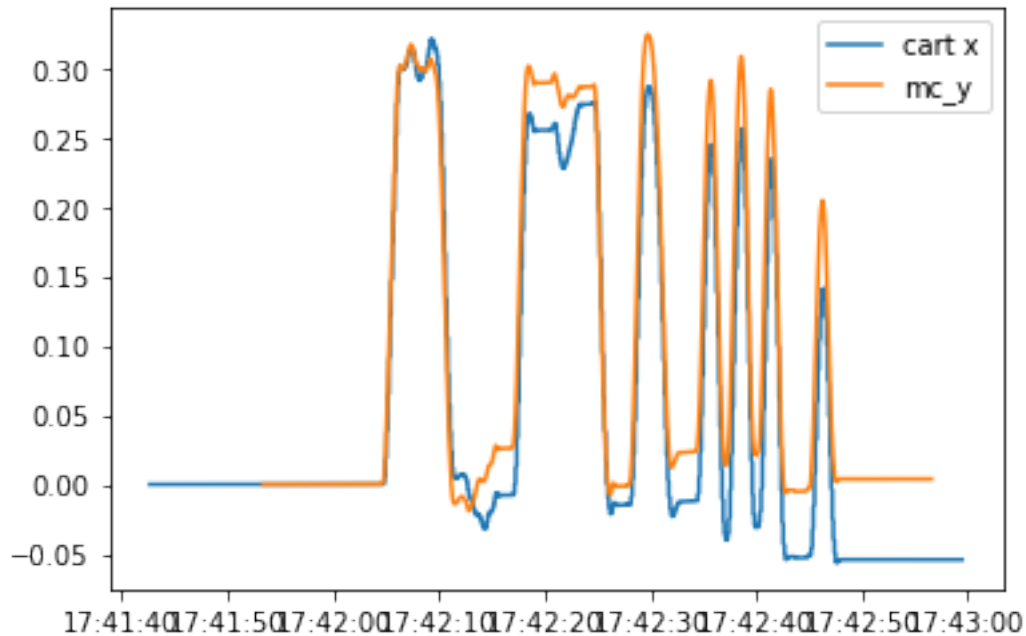
```
[ ]: offset = cart_df["y_val"].iloc[0] - mc["org_x"].iloc[0]
      plt.plot(cart_df["sys_time"], cart_df["y_val"], label = "cart y")
      plt.plot(mc["time"], mc["org_x"] +offset, label = "mc_x")
      plt.savefig("lateral.png")
      plt.legend()
      print(offset)
```

-0.372066



```
[ ]: offset = cart_df["x_val"].iloc[0] - mc["org_z"].iloc[0]
plt.plot(cart_df["sys_time"], cart_df["x_val"], label = "cart x")
plt.plot(mc["time"], mc["org_z"] + offset, label = "mc_y")

plt.legend()
plt.savefig("transversal.png")
```



```
[ ]: # print (cart_df["sys_time"].get_loc(mc["time"][0], method='nearest'))
print(cart_df["sys_time"][0])
print(mc["time"][0])

result_index = cart_df['sys_time'].sub(mc["time"][0]).abs().idxmin()

cart_df.iloc[(cart_df['sys_time'] - mc["time"][0]).abs().argsort()[0],:]
# (cart_df['sys_time'] - mc["time"][0]).abs()
result_index
```

2022-06-15 17:41:42.658968

2022-06-15 17:41:53.371000

[]: 1274

```
[ ]: # cart_df["diff"] = cart_df["y_val"] - cart_df["center_x"] - 0.34
```

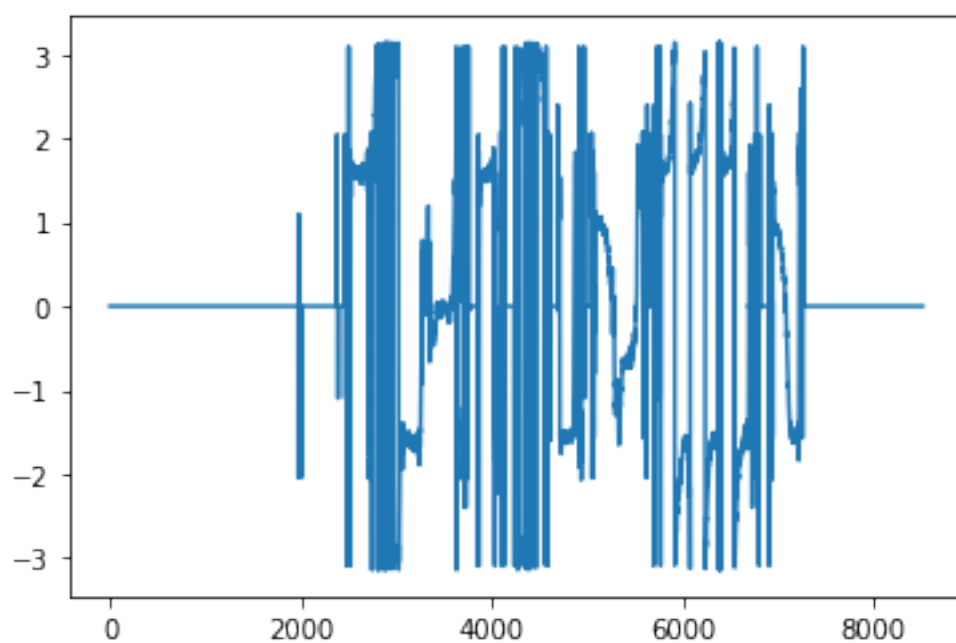
```
[ ]: rw = []
vr = []
for i in range(len(cart_df["av_r1"])):
    _vy = cart_df["cal_vy"][i]
    _vx = cart_df["cal_vx"][i]
    rw.append(np.arctan2(_vy, _vx))
    vr.append(np.linalg.norm((_vx, _vy)))
cart_df["rw"] = rw
cart_df["vr"] = vr
```

```
[ ]: cart_df["rw"]
```

```
[ ]: 0      0.0
      1      0.0
      2      0.0
      3      0.0
      4      0.0
      ...
      8508    0.0
      8509    0.0
      8510    0.0
      8511    0.0
      8512    0.0
      Name: rw, Length: 8513, dtype: float64
```

```
[ ]: plt.plot(cart_df["rw"])
```

```
[ ]: [<matplotlib.lines.Line2D at 0x129b23e4448>]
```



```
[ ]: cart_df["rw"]
```

```
[ ]: 0      0.0
      1      0.0
      2      0.0
      3      0.0
      4      0.0
```

```
...
8508    0.0
8509    0.0
8510    0.0
8511    0.0
8512    0.0
Name: rw, Length: 8513, dtype: float64
```