linear_sideways

June 16, 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("..//straight_line_sideways.csv")
```

[ ]:
```
cart_df
```

[ ]:

	sys_time	e_fr	e_fl	e_rr	e_rl
0	2022-06-15 12:13:22.489984	13	-5	7	3
1	2022-06-15 12:13:37.124103	20	1	14	10
2	2022-06-15 12:13:37.124103	20	1	14	10
3	2022-06-15 12:13:37.124604	20	1	14	10
4	2022-06-15 12:13:37.124604	20	1	14	10
…	…	…	…	…	…
3529	2022-06-15 12:14:09.344631	-7439	8332	8437	-8135
3530	2022-06-15 12:14:09.345196	-7439	8332	8437	-8135
3531	2022-06-15 12:14:09.345196	-7439	8332	8437	-8135
3532	2022-06-15 12:14:09.345196	-7439	8332	8437	-8135
3533	2022-06-15 12:14:09.345671	-7439	8332	8437	-8135

[3534 rows x 5 columns]

[ ]:
```
mc, mc_dt = read_df_csv("..//cart_linear_sideways_mc.csv")
mc_dt
```

[ ]:
```
datetime.datetime(2022, 6, 15, 12, 13, 29, 772000)
```

[ ]:
```
type(mc["center_y"][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  center_x  center_y  center_z     org_x     org_y  \
0         0     0.00  0.376711  0.061965  0.048003  0.336798  0.061981
1         1     0.01  0.376718  0.061963  0.048005  0.336790  0.061988
2         2     0.02  0.376716  0.061963  0.048015  0.336800  0.062010
3         3     0.03  0.376717  0.061982  0.048010  0.336802  0.061984
4         4     0.04  0.376725  0.061983  0.048010  0.336806  0.062019
…       …       …         …         …         …         …         …
3771   3771    37.71 -0.259718  0.074456  0.032517 -0.295468  0.075046
3772   3772    37.72 -0.259718  0.074461  0.032516 -0.295468  0.075018
3773   3773    37.73 -0.259725  0.074467  0.032514 -0.295458  0.075047
3774   3774    37.74 -0.259725  0.074449  0.032517 -0.295471  0.075023
3775   3775    37.75 -0.259726  0.074454  0.032511 -0.295475  0.075036

         org_z    xdir_x    xdir_y    xdir_z    zdir_x    zdir_y    zdir_z  \
0    -0.017959  0.416365  0.060203 -0.015434  0.334189  0.063507  0.109515
1    -0.017958  0.416369  0.060193 -0.015421  0.334194  0.063522  0.109507
2    -0.017967  0.416390  0.060189 -0.015428  0.334197  0.063521  0.109513
3    -0.017958  0.416364  0.060215 -0.015432  0.334195  0.063524  0.109503
4    -0.017969  0.416386  0.060197 -0.015427  0.334199  0.063509  0.109510
…          …         …         …         …         …         …         …
3771 -0.035858 -0.216485  0.072623 -0.028880 -0.305695  0.075331  0.091150
3772 -0.035852 -0.216473  0.072621 -0.028879 -0.305703  0.075329  0.091161
3773 -0.035849 -0.216485  0.072634 -0.028877 -0.305710  0.075306  0.091175
3774 -0.035861 -0.216482  0.072616 -0.028889 -0.305722  0.075303  0.091165
3775 -0.035838 -0.216481  0.072625 -0.028884 -0.305703  0.075339  0.091154

                        time
0    2022-06-15 12:13:29.772
1    2022-06-15 12:13:29.782
2    2022-06-15 12:13:29.792
3    2022-06-15 12:13:29.802
4    2022-06-15 12:13:29.812
…                        …
3771 2022-06-15 12:14:07.482
3772 2022-06-15 12:14:07.492
3773 2022-06-15 12:14:07.502
3774 2022-06-15 12:14:07.512
3775 2022-06-15 12:14:07.522
```

```
[3776 rows x 15 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]
```

[ ]:
```
0.336798
```

[ ]:
```
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
```

[ ]:
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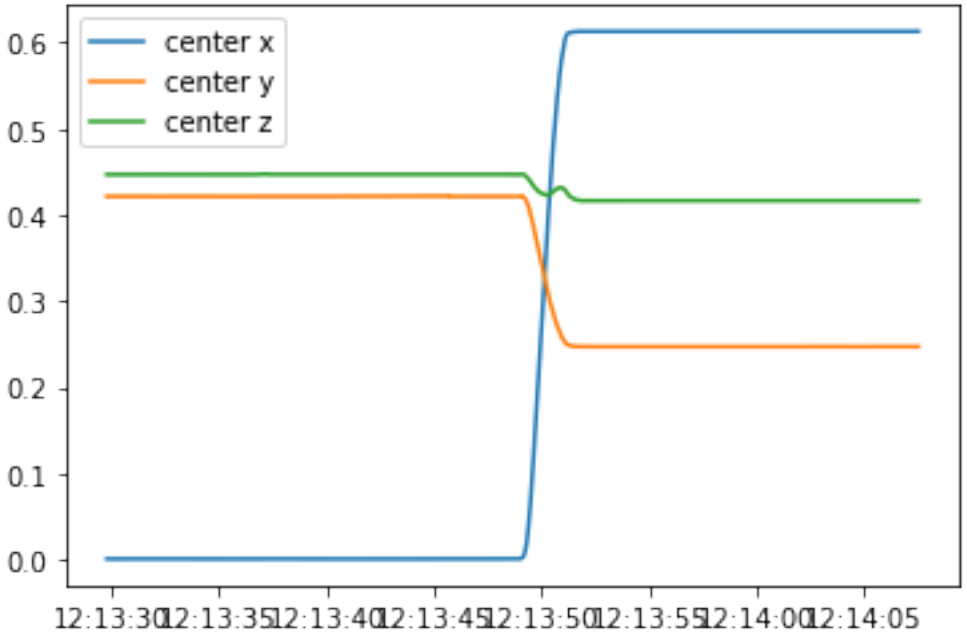
array([[-0.96774126,  0.25042626,  0.02763225],
       [-0.23987084, -0.94934797,  0.20297885],
       [ 0.07706385,  0.18980284,  0.97879316]])
```

[ ]:
```
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 = center_val.reshape(3,1)
    transformed_center = rot_mat.T @ center_val + marker_cen
    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 0x1e7e49a7688>
```



[ ]:
```
"""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 12:13:22.489984	0	0	0	0
1	2022-06-15 12:13:37.124103	7	6	7	7
2	2022-06-15 12:13:37.124103	7	6	7	7
3	2022-06-15 12:13:37.124604	7	6	7	7
4	2022-06-15 12:13:37.124604	7	6	7	7
…	…	…	…	…	…
3529	2022-06-15 12:14:09.344631	-7452	8337	8430	-8138
3530	2022-06-15 12:14:09.345196	-7452	8337	8430	-8138
3531	2022-06-15 12:14:09.345196	-7452	8337	8430	-8138
3532	2022-06-15 12:14:09.345196	-7452	8337	8430	-8138
3533	2022-06-15 12:14:09.345671	-7452	8337	8430	-8138

[3534 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 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       0.000000
1       0.942478
2       0.000000
3       0.000000
4       0.000000
          …
3529    0.000000
3530    0.000000
3531    0.000000
3532    0.000000
3533    0.000000
Name: av_fl, Length: 3534, 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
```

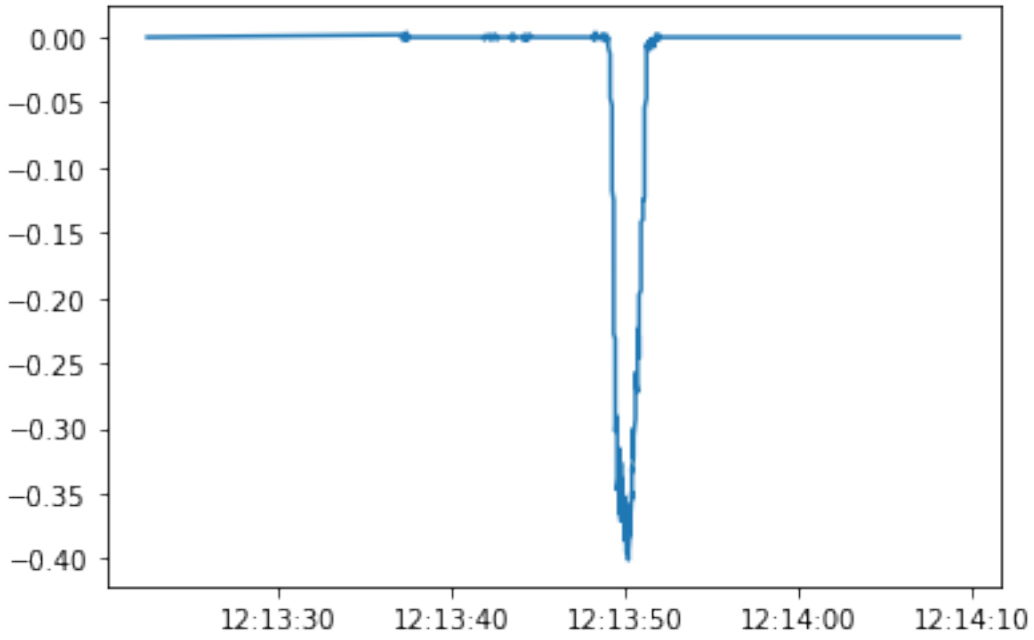
[ ]:
```
"""finding vx, vy, w"""

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 0x1e7e1741b08>]
```



[ ]:
```
"""calculating displacement
s=(1/2)* (v+u)t
v = current velocityn
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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9.326603190344698e-06
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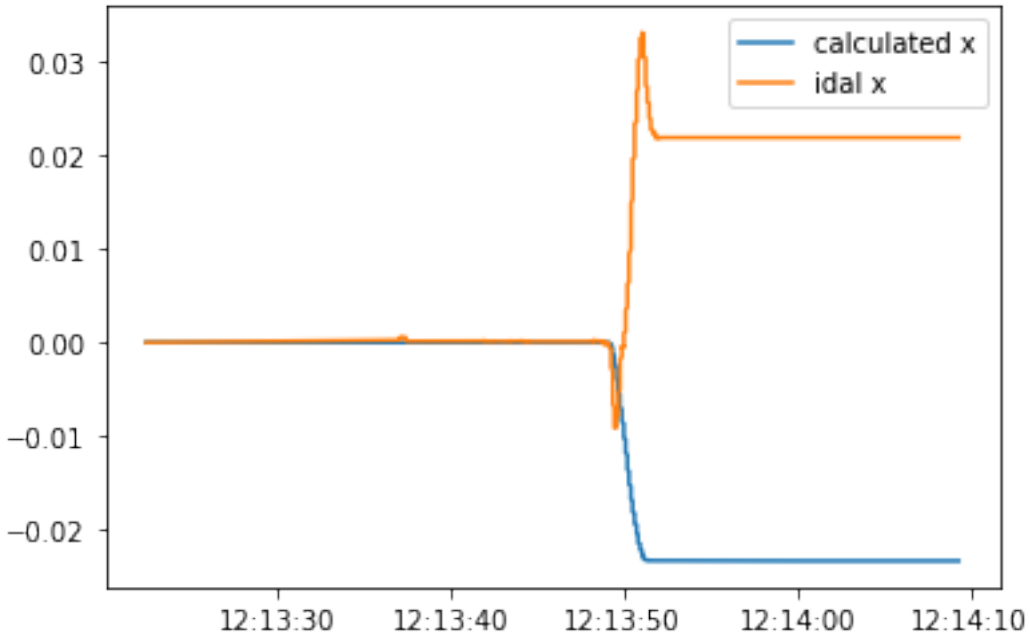
[ ]:
```
"""calculating displacement for calculated coordinates
```

```
"""
_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
```

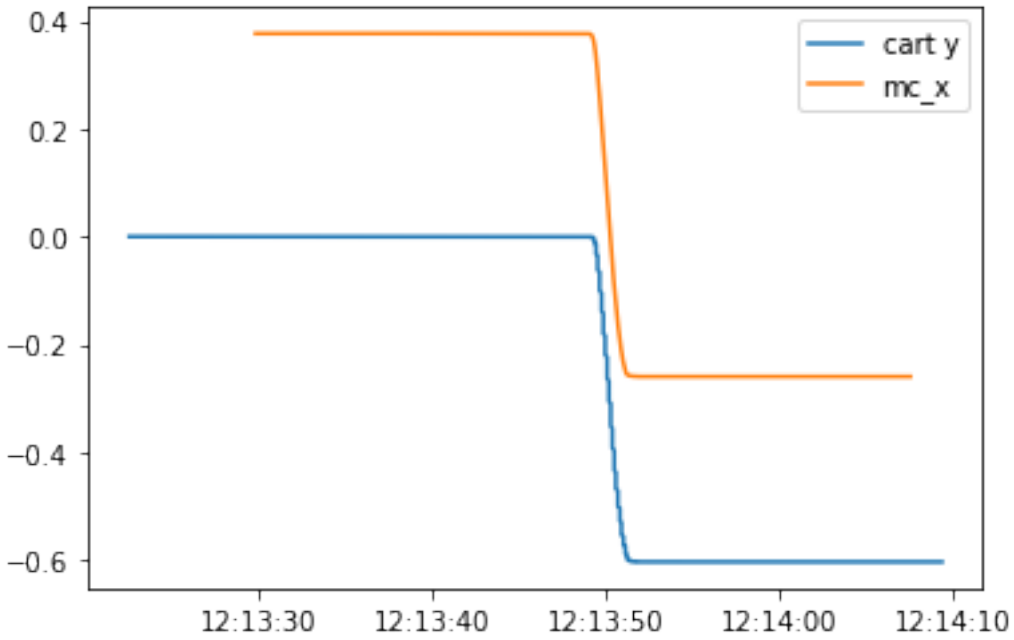
[ ]:
```
# plt.plot(cart_df["sys_time"], cart_df["x_val"], label = "ideal x")
plt.plot(cart_df["sys_time"],cart_df["cal_x"], label = "calculated x")
plt.plot(cart_df["sys_time"], cart_df["x_val"], label = "idal x")
plt.legend()
```

[ ]:
```
<matplotlib.legend.Legend at 0x1e7e14f0a88>
```



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

[ ]: <matplotlib.legend.Legend at 0x1e7e58ebb88>



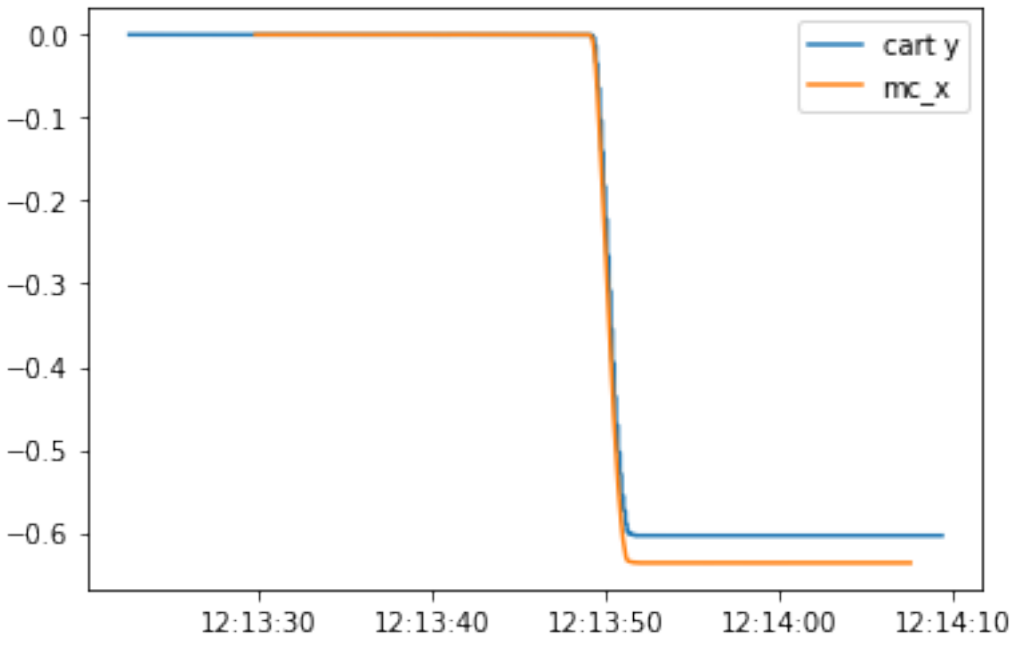
[ ]:
```
_t2 = []
for i in cart_df["sys_time"]:
    _tt = mc["time"][0]-i
    # print(_tt)
    _t2.append(_tt.total_seconds())
```

[ ]:
```
0      2022-06-15 12:13:22.489984
1      2022-06-15 12:13:37.124103
2      2022-06-15 12:13:37.124103
3      2022-06-15 12:13:37.124604
4      2022-06-15 12:13:37.124604
                  …
3529   2022-06-15 12:14:09.344631
3530   2022-06-15 12:14:09.345196
3531   2022-06-15 12:14:09.345196
3532   2022-06-15 12:14:09.345196
3533   2022-06-15 12:14:09.345671
Name: sys_time, Length: 3534, dtype: datetime64[ns]
```

[ ]:
```
offset = cart_df["y_val"].iloc[0] - mc["center_x"].iloc[0]
plt.plot(cart_df["sys_time"], cart_df["y_val"], label = "cart y")
plt.plot(mc["time"], mc["center_x"] +offset, label  = "mc_x")

plt.legend()
print(offset)
```

```
-0.376711
```



[ ]:
```
# 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 12:13:22.489984
2022-06-15 12:13:29.772000
```

[ ]:
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[ ]:
```
f = interp1d(mc["time"], mc["center_x"])
a = f(cart_df["sys_time"])
mc["time"]
```

```
---------------------------------------------------------------------------
UFuncTypeError                            Traceback (most recent call last)
~\AppData\Local\Temp/ipykernel_6956/269749632.py in <module>
      1 f = interp1d(mc["time"], mc["center_x"])
----> 2 a = f(cart_df["sys_time"])
      3 mc["time"]

~\anaconda3\envs\py37t2\lib\site-packages\scipy\interpolate\polyint.py in␣
↪__call__(self, x)
     76         """
     77         x, x_shape = self._prepare_x(x)
---> 78         y = self._evaluate(x)
     79         return self._finish_y(y, x_shape)
     80

~\anaconda3\envs\py37t2\lib\site-packages\scipy\interpolate\interpolate.py in␣
↪_evaluate(self, x_new)
    680         #    The behavior is set by the bounds_error variable.
    681         x_new = asarray(x_new)
--> 682         y_new = self._call(self, x_new)
    683         if not self._extrapolate:
    684             below_bounds, above_bounds = self._check_bounds(x_new)

~\anaconda3\envs\py37t2\lib\site-packages\scipy\interpolate\interpolate.py in␣
↪_call_linear(self, x_new)
```

```
    628         # Note that the following two expressions rely on the specifics
 ↪of the
    629         # broadcasting semantics.
--> 630         slope = (y_hi - y_lo) / (x_hi - x_lo)[:, None]
    631
    632         # 5. Calculate the actual value for each entry in x_new.

UFuncTypeError: ufunc 'true_divide' cannot use operands with types␣
 ↪dtype('float64') and dtype('<m8[ns]')
```

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

[ ]:
```
rw = []
vr = []
for i in range(len(cart_df["av_rl"])):
    _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"]
```

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

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