math178_project_imu

July 8, 2019

[38]:
```
"""
% John Kath
% Math 178 - Nonlinear Data Analytics
% Summer 2019
% Final Project Code - 7/7/19

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"""
# This import registers the 3D projection, but is otherwise unused.
from mpl_toolkits.mplot3d import Axes3D  # noqa: F401 unused import
from pathlib import Path
from typing import List
import pandas as pd
from pandas import DataFrame
import numpy as np
import matplotlib.pyplot as plt
import os

from numpy import sin, cos, array, r_, vstack, abs, tile, pi
from numpy.linalg import norm

import skinematics as skin
from skinematics import imus, quat, vector, rotmat, view
from skinematics.sensors.manual import MyOwnSensor
```

[2]:
```
# data pre processing
file_name_to_colume_names = {
    'Activity.csv': ['ID', 'SubjectID', 'Start_time', 'End_time',␣
 ↪'Relative_Start_time', 'Relative_End_time','Gesture_scenario', 'TaskID',␣
 ↪'ContentID'],
    'Accelerometer.csv': ['Systime', 'EventTime', 'ActivityID', 'X', 'Y', 'Z',␣
 ↪'Phone_orientation'],
    'Gyroscope.csv': ['Systime', 'EventTime', 'ActivityID', 'X', 'Y', 'Z',␣
 ↪'Phone_orientation'],
    'Magnetometer.csv': ['Systime', 'EventTime', 'ActivityID', 'X', 'Y', 'Z',␣
 ↪'Phone_orientation'],
}
```

[3]:
```
def read_file(user_id: str, user_session_id: str, file_name: str, colume_names:␣
↪List[str]) -> DataFrame:
    """
    Read one of the csv files for a user
    :param user_id: user id
    :param user_session_id: user session id
    :param file_name: csv file name (key of file_name_to_colume_names)
    :param colume_names: a list of column names of the csv file (value of␣
↪file_name_to_colume_names)
    :return: content of the csv file as pandas DataFrame
    """
    # read data from csv
    filename = user_id + '_session_' + user_session_id + '_' + file_name
    csv_data = pd.read_csv(filename, names=colume_names)
    return pd.DataFrame(data=csv_data)
```

[49]:
```
# pick the user as well as activities and extract features
userId = '151985';
session = '2';
data_act = read_file(userId, session, 'Activity.csv',␣
↪file_name_to_colume_names['Activity.csv'])
data_acc = read_file(userId, session, 'Accelerometer.csv',␣
↪file_name_to_colume_names['Accelerometer.csv'])
data_gyr = read_file(userId, session, 'Gyroscope.csv',␣
↪file_name_to_colume_names['Gyroscope.csv'])
data_mag = read_file(userId, session, 'Magnetometer.csv',␣
↪file_name_to_colume_names['Magnetometer.csv'])
# print(data_acc.dtypes)
# print(data_gyr.dtypes)
```

[40]:
```
# To plot pretty figures
%matplotlib inline
import matplotlib as mpl
import matplotlib.pyplot as plt
mpl.rc('axes', labelsize=14)
mpl.rc('xtick', labelsize=12)
mpl.rc('ytick', labelsize=12)

# Where to save the figures
PROJECT_ROOT_DIR = "."
CHAPTER_ID = ""

def save_fig(fig_id, tight_layout=True):
    path = os.path.join(PROJECT_ROOT_DIR, "", CHAPTER_ID, fig_id + ".png")
    print("Saving figure", fig_id)
    if tight_layout:
        plt.tight_layout()
```

```
    plt.savefig(path, format='png', dpi=300)
```

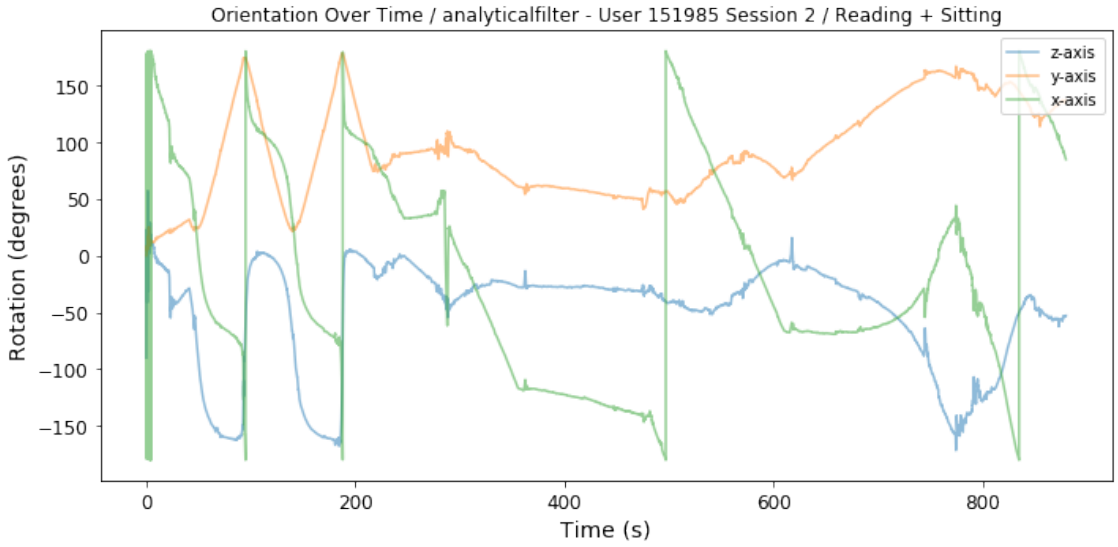
[59]:
```
def plot_orientation(x, y, title_name, y_label_name, file_name):
    # plot of feature
    plt.figure(figsize=(10, 5))
    plt.plot(x, y[:,0], alpha=0.5)
    plt.plot(x, y[:,1], alpha=0.5)
    plt.plot(x, y[:,2], alpha=0.5)
    plt.title(title_name)
    plt.xlabel('Time (s)')
    plt.ylabel(y_label_name)
    plt.legend(['z-axis', 'y-axis', 'x-axis'],loc='upper right')
    save_fig(file_name)
    plt.show()
```

[7]:
```
rate = 100.0
acc = np.column_stack((data_acc['X'], data_acc['Y'], data_acc['Z']))
omega = np.column_stack((data_gyr['X'], data_gyr['Y'], data_gyr['Z']))
mag = np.column_stack((data_mag['X'], data_mag['Y'], data_mag['Z']))
```

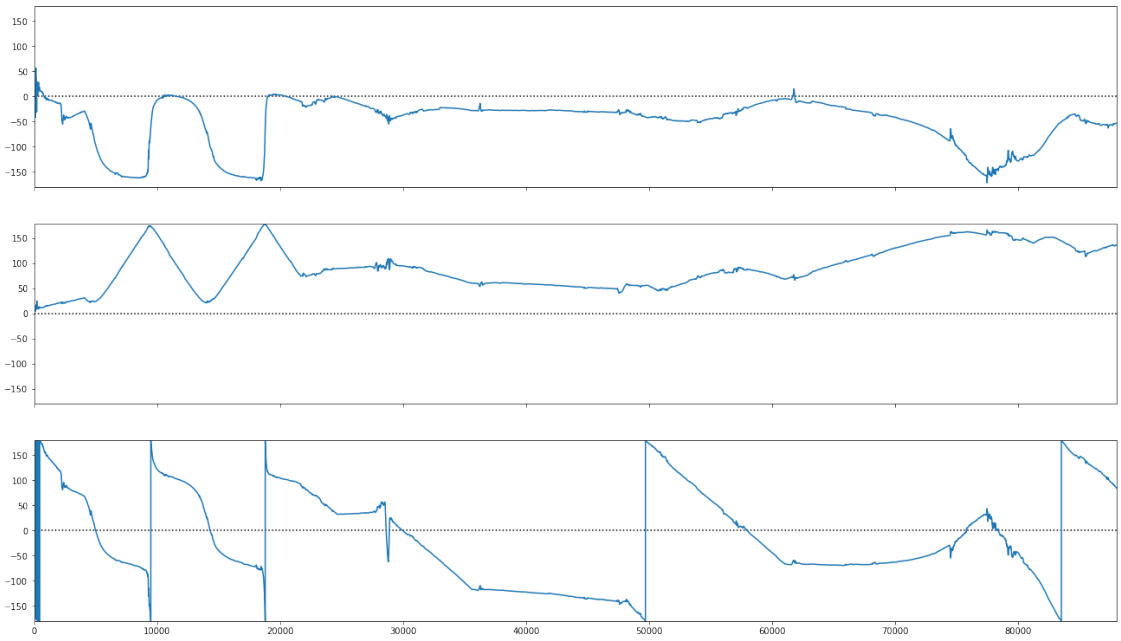
[8]:
```
R_initialOrientation = np.eye(3)
initialPosition = np.zeros(3)

# q1, pos1 = analytical(R_initialOrientation, omega, initialPosition, acc,␣
 ↪rate)
q_analytical, pos_analytical, vel_analytical = imus.
 ↪analytical(R_initialOrientation, omega[:88000], initialPosition, acc[:
 ↪88000], rate)
# express quat as Euler angles
e_analytical = quat.quat2seq(q_analytical, seq='Euler')
```

[61]:
```
# time axis
time_i = [x / rate for x in list(range(0, len(e_analytical)))];
# plot_orientation(time_i, euler_angles, 'Orientation Over Time', 'Rotation␣
 ↪(degrees)', file_name)
plot_orientation(time_i, e_analytical,
                 'Orientation Over Time / analyticalfilter - User ' + userId +␣
 ↪' Session ' + session + ' / Reading + Sitting',
                 'Rotation (degrees)',
                 userId + '_' + session + '_analyticalfilter')
```

```
Saving figure 151985_2_analyticalfilter
```

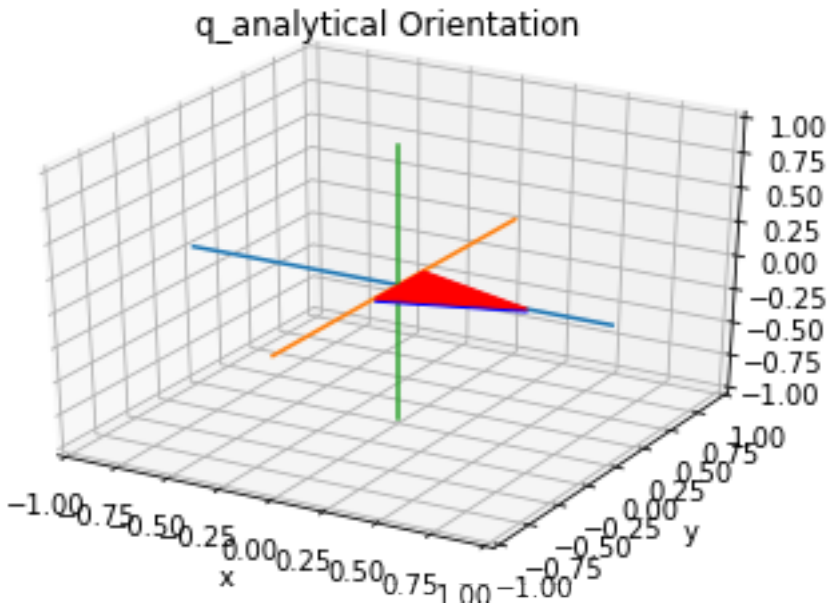


[51]:
```
view.ts(e_analytical)
```



[54]:
```
out_file = 'q_analytical.mp4'
view.orientation(q_analytical[:600], out_file, 'q_analytical Orientation',␣
 ↪deltaT=1000./rate)
```

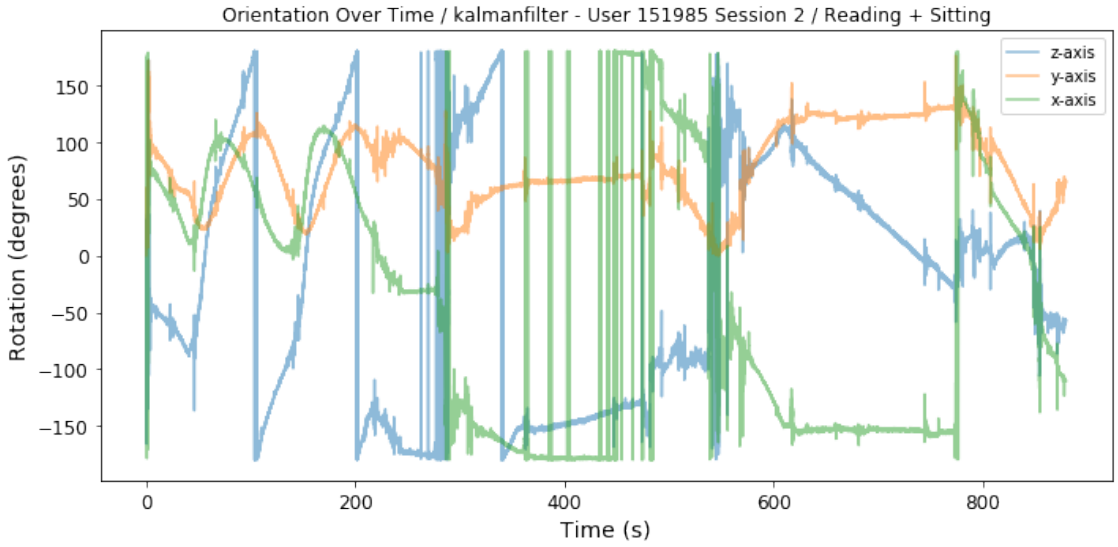
```
Animation saved to q_analytical.mp4
```



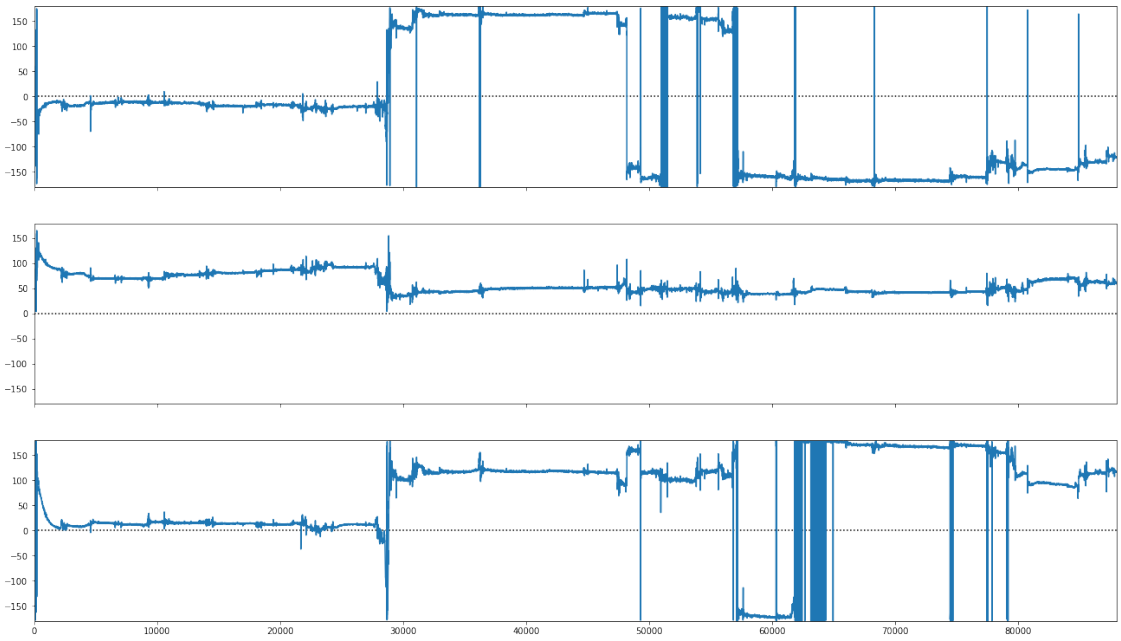
[64]:
```
# imus.kalman(rate, acc, omega, mag)
q_Kalman = imus.kalman(rate, acc[:88000], omega[:88000], mag[:88000])
# r_Kalman = quat.convert(q_Kalman, to='rotmat')
# r_Kalman.reshape((-1,3))
# express quat as Euler angles
e_Kalman = quat.quat2seq(q_Kalman, seq='Euler')
```

[65]:
```
# time axis
time_i = [x / rate for x in list(range(0, len(e_Kalman)))];
# plot_orientation(time_i, euler_angles, 'Orientation Over Time', 'Rotation␣
 ↪(degrees)', file_name)
plot_orientation(time_i, e_Kalman,
                 'Orientation Over Time / kalmanfilter - User ' + userId + '␣
 ↪Session ' + session + ' / Reading + Sitting',
                 'Rotation (degrees)',
                 userId + '_' + session + '_' + 'kalmanfilter')
```

```
Saving figure 151985_2kalmanfilter
```

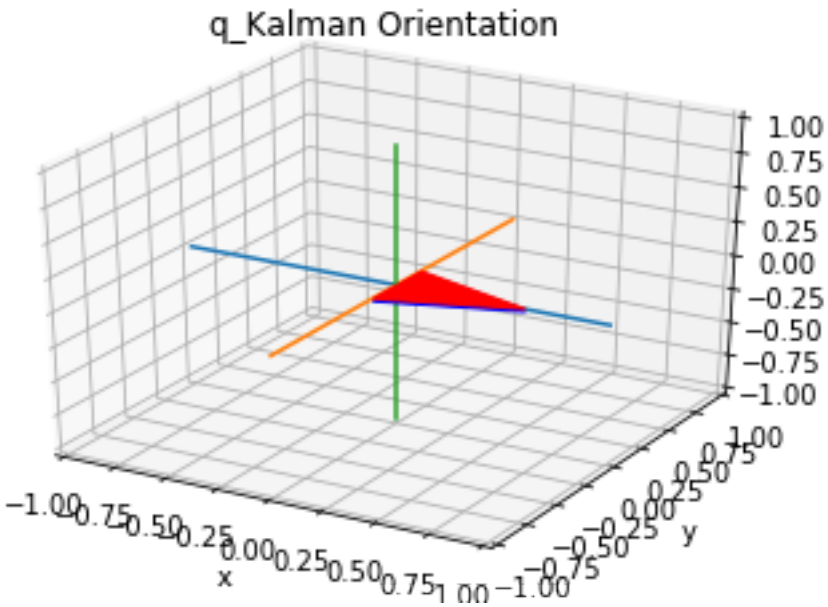


[52]:
```
view.ts(e_Kalman)
```



[22]:
```
out_file = 'q_Kalman.mp4'
view.orientation(q_Kalman[:600], out_file, 'q_Kalman Orientation', deltaT=1000./
 ↪rate)
```

```
Animation saved to q_Kalman.mp4
```

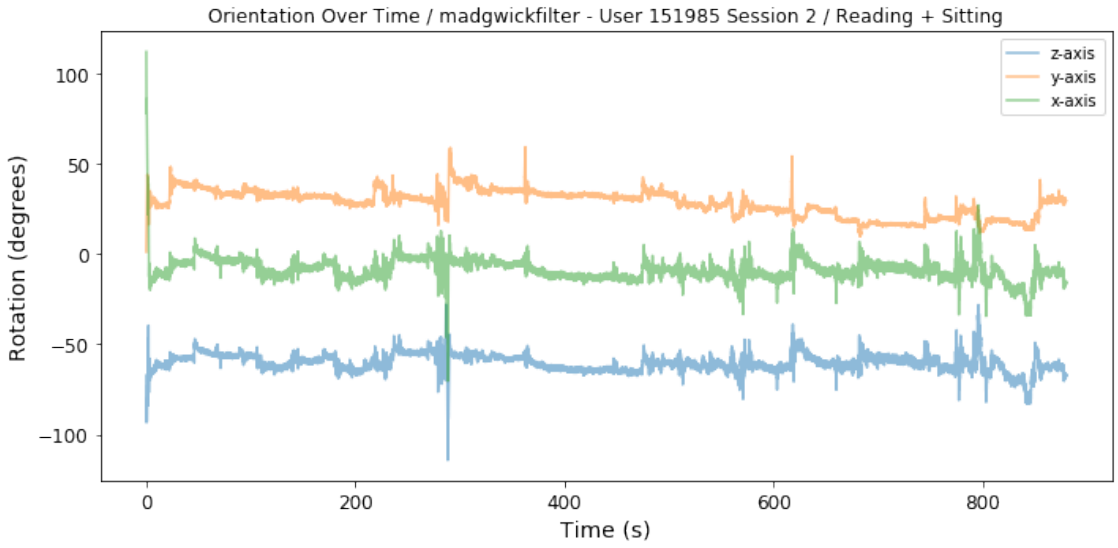


[66]:
```
initialPosition = array([0,0,0])
R_initialOrientation = rotmat.R(0,90)

# get data
in_data = {'rate' : rate, 'acc' : acc[:88000], 'omega' : omega[:88000], 'mag' :␣
 ↪mag[:88000]}

my_sensor = MyOwnSensor(in_file=None, in_data=in_data,
                        R_init=R_initialOrientation,
                        pos_init=initialPosition,
                        q_type='madgwick')

# and then check, if the quat_vector = [0, sin(45), 0]
q_madgwick = my_sensor.quat
# express quat as rotation matrix
# r_madgwick = quat.convert(q_madgwick, to='rotmat')
# r_madgwick.reshape((-1,3))
# express quat as Euler angles
e_madgwick = quat.quat2seq(q_madgwick, seq='Euler')

result = quat.q_vector(q_madgwick[-1])
correct = array([ 0.,  np.sin(np.deg2rad(45)),  0.])
error = norm(result-correct)
```

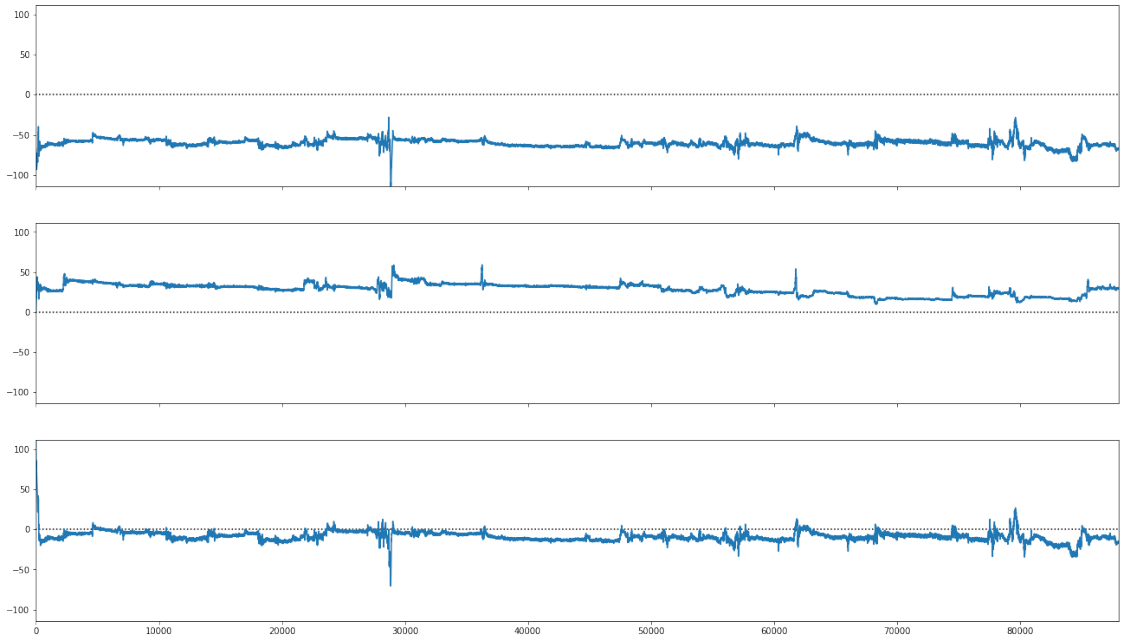
```
Calculating the Quaternions [#########################] 88000/88000
```

[67]:
```
# time axis
time_i = [x / rate for x in list(range(0, len(e_madgwick)))];
# plot_orientation(time_i, euler_angles, 'Orientation Over Time', 'Rotation␣
 ↪(degrees)', file_name)
plot_orientation(time_i, e_madgwick,
                 'Orientation Over Time / madgwickfilter - User ' + userId + '␣
 ↪Session ' + session + ' / Reading + Sitting',
                 'Rotation (degrees)',
                 userId + '_' + session + '_' + 'madgwickfilter')
```

```
Saving figure 151985_2madgwickfilter
```

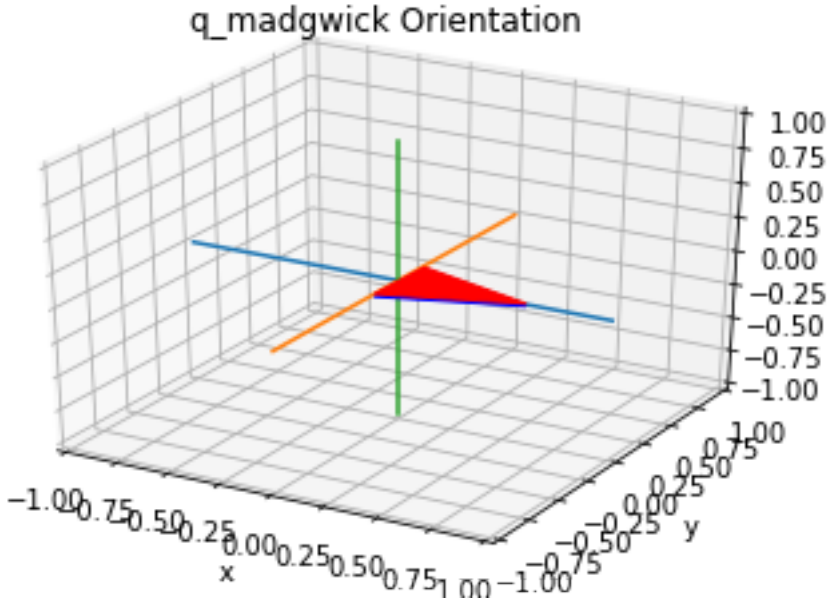


[35]:
```
view.ts(e_madgwick)
```



[31]:
```
out_file = 'q_madgwick.mp4'
view.orientation(q_madgwick[:600], out_file, 'q_madgwick Orientation',␣
 ↪deltaT=1000./rate)
```

```
Animation saved to q_madgwick.mp4
```

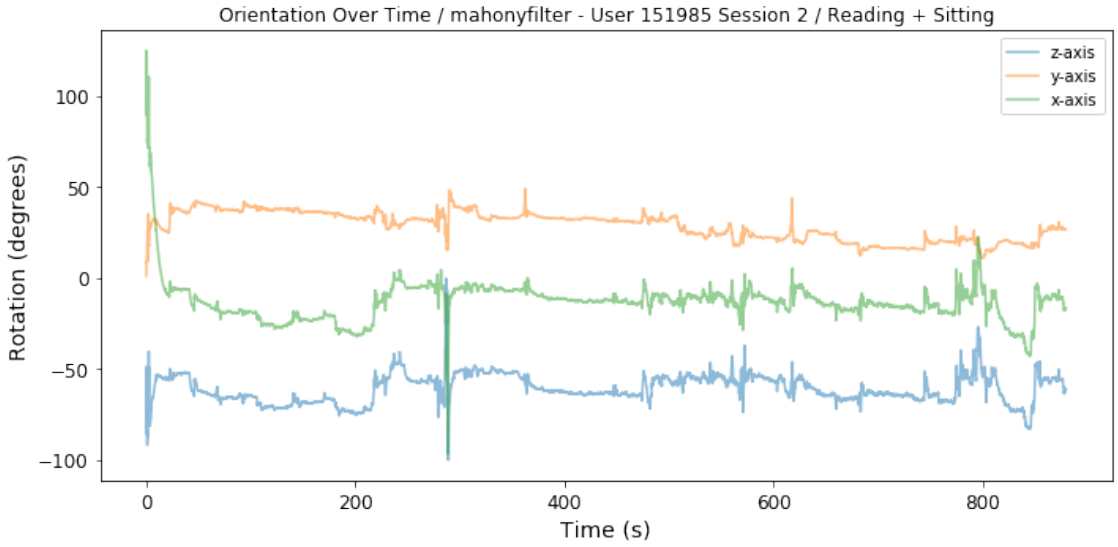


[68]:
```
initialPosition = array([0,0,0])
R_initialOrientation = rotmat.R(0,90)

# get data
in_data = {'rate' : rate, 'acc' : acc[:88000], 'omega' : omega[:88000], 'mag' :␣
 ↪mag[:88000]}

my_sensor = MyOwnSensor(in_file=None, in_data=in_data,
                        R_init=R_initialOrientation,
                        pos_init=initialPosition,
                        q_type='mahony')

# and then check, if the quat_vector = [0, sin(45), 0]
q_mahony = my_sensor.quat
# express quat as rotation matrix
# r_mahony = quat.convert(q_mahony, to='rotmat')
# r_mahony.reshape((-1,3))
# express quat as Euler angles
e_mahony = quat.quat2seq(q_mahony, seq='Euler')

result = quat.q_vector(q_mahony[-1])
correct = array([ 0.,  np.sin(np.deg2rad(45)),  0.])
error = norm(result-correct)
```

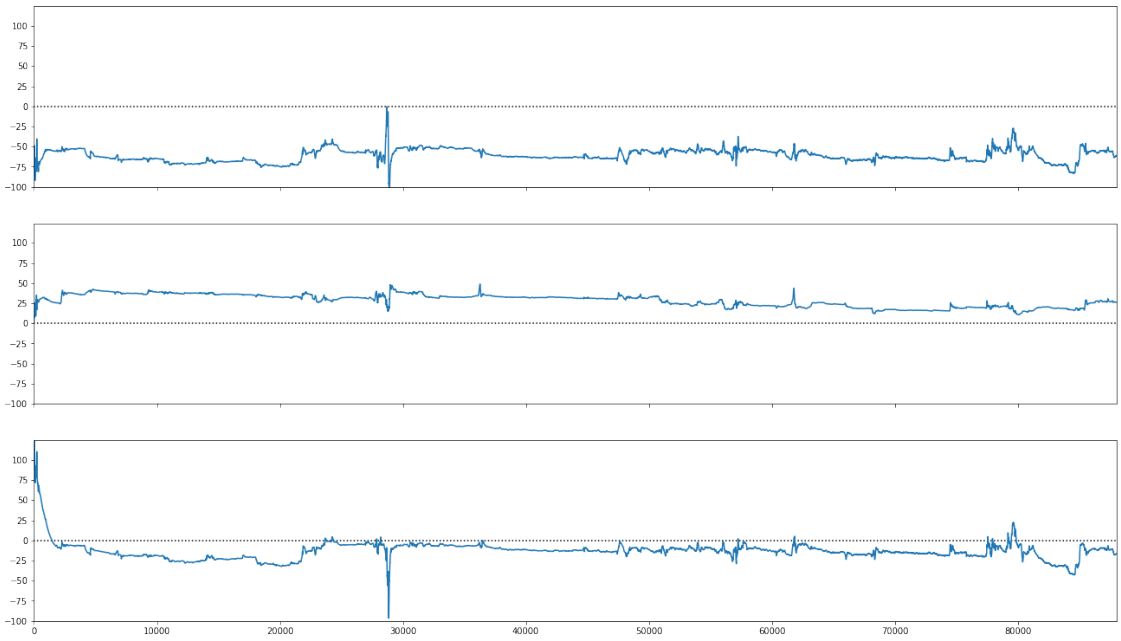
```
Calculating the Quaternions [#########################] 88000/88000
```

[69]:
```
# time axis
time_i = [x / rate for x in list(range(0, len(e_mahony)))];
# plot_orientation(time_i, euler_angles, 'Orientation Over Time', 'Rotation␣
 ↪(degrees)', file_name)
plot_orientation(time_i, e_mahony,
                 'Orientation Over Time / mahonyfilter - User ' + userId + '␣
 ↪Session ' + session + ' / Reading + Sitting',
                 'Rotation (degrees)',
                 userId + '_' + session + '_' +  'mahonyfilter')
```

```
Saving figure 151985_2_mahonyfilter
```

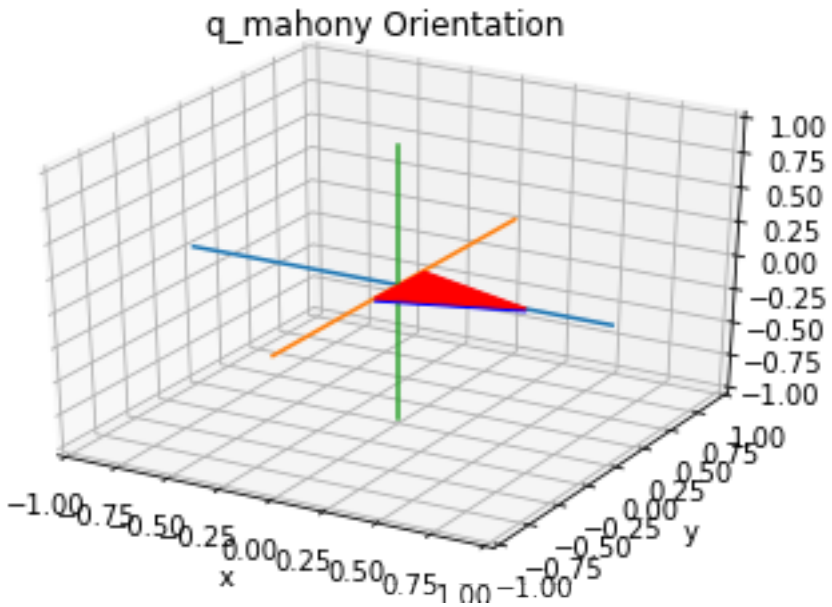


[38]:
```
view.ts(e_mahony)
```



[32]:
```
out_file = 'q_mahony.mp4'
view.orientation(q_mahony[:600], out_file, 'q_mahony Orientation', deltaT=1000./
 ↪rate)
```

```
Animation saved to q_mahony.mp4
```


q_mahony Orientation
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00
x
y

[ ]: