

Overview

This project contains MATLAB files created to visualize and verify quaternion calculations, specifically those employed in Madgwick 2010 [1]. This document was made to show which code matches with which equations in Madgwick 2010 [1] and to discuss some results. To quickly view a rotation of a vector by defined by a given quaternion, run **driver.m**.

Selected Code

$$\begin{aligned} \mathbf{a} \otimes \mathbf{b} &= [a_1 \ a_2 \ a_3 \ a_4] \otimes [b_1 \ b_2 \ b_3 \ b_4] \\ &= \begin{bmatrix} a_1 b_1 - a_2 b_2 - a_3 b_3 - a_4 b_4 \\ a_1 b_2 + a_2 b_1 + a_3 b_4 - a_4 b_3 \\ a_1 b_3 - a_2 b_4 + a_3 b_1 + a_4 b_2 \\ a_1 b_4 + a_2 b_3 - a_3 b_2 + a_4 b_1 \end{bmatrix}^T \end{aligned} \quad (4, \text{Madgwick})$$

quatMult.m

```
28 a1 = q_a(1); b1= q_b(1);
29 a2 = q_a(2); b2= q_b(2);
30 a3 = q_a(3); b3= q_b(3);
31 a4 = q_a(4); b4= q_b(4);
32
33 q_out = [a1*b1 - a2*b2 - a3*b3 - a4*b4...
34          a1*b2 + a2*b1 + a3*b4 - a4*b3...
35          a1*b3 - a2*b4 + a3*b1 + a4*b2...
36          a1*b4 + a2*b3 - a3*b2 + a4*b1];
```

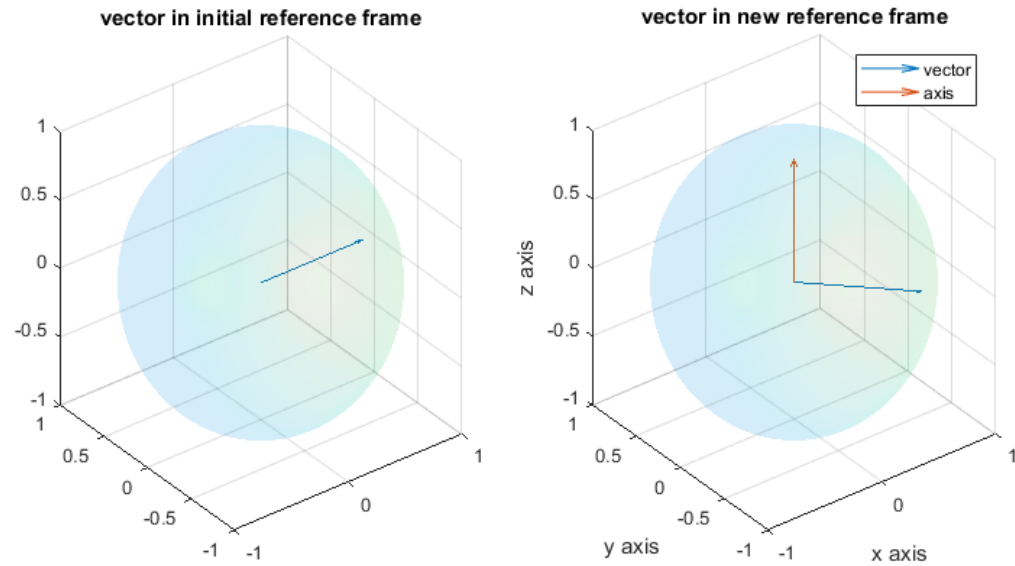
$${}^B \mathbf{v} = {}^A_B \hat{\mathbf{q}} \otimes {}^A \mathbf{v} \otimes {}^A_B \hat{\mathbf{q}}^* \quad (5, \text{Madgwick})$$

quatRotateDup.m

```
9 qconj = [q(1) -q(2) -q(3) -q(4)];
10
11 first = quatMult(q,[0 vect_a]);
12 vect_b = quatMult(first, qconj);
13 vect_b = vect_b(2:4);
```

Example

The below figure demonstrates the result of **driver.m** for a $\pi/4$ angle rotation about the z axis. The initial vector $[1\ 0\ 0]$, a unit vector in the x axis, was hardcoded in **quatTest.m**.



Directory Tree

```
./
├── README.md
├── driver.m
├── quatRotateDup.m
├── quatMult.m
└── quatTest.m
```

README.md

```
1 # Quaternion Testing
2 # Michael Sikora
3 # 2018.1.14
4
5 for quick visualization run driver.m and change the ax (axis of
   rotation) and angle given in quatTest call.
6
7 quatRotateDup.m is a function that rotates a vector given a
   quaternion representing a 3D rotation.
8   It was intended as a duplicate of the quatrotate function
   available in the Aerospace Toolbox.
9
10 quatMult.m is the quaternion multiply operation.
11
12 quatTest.m was originally not a function, just a test script for
   rotating a vector in 3D using the
13   quaternion calculation. The function was added to quickly see
   the effect of various angles and axis.
14
15 THEORY
16
17 A rotation in three dimensional space can be mathematically
   represented using quaternion algebra. Quaternion
18 algebra is often preferred for heavy calculations, because only 4
   rational numbers are needed. A quaternion
19 represents a change in coordinate reference frame.
```

References

- [1] S. O. Madgwick, "An efficient orientation filter for inertial and inertial/magnetic sensor arrays," April 2010. [Online]. Available: http://x-io.co.uk/res/doc/madgwick_internal_report.pdf