Package ‘RAHRS’

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Type Package

Title Data Fusion Filters for Attitude Heading Reference System (AHRS) with Several Variants of the Kalman Filter and the Mahoney and Madgwick Filters

Version 1.0.2

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Description Data fusion filters for Attitude Heading Reference System (AHRS) based on Vlad Maximov's GyroLib AHRS library (quaternion based linearized/extended/unscented Kalman filter,
Euler based LKF, gyro-free with vector matching, SVD calibration and EKF calibration),
Sebastian O.H. Madgwick AHRS algorithms and Sebastian O.H. Madgwick implementation of Mayhony et al AHRS algorithm.

License GPL (>= 3)

LazyLoad yes

LazyData yes

Depends R (>= 2.10), pracma, RSpincalc (>= 1.0.1)

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R topics documented:

`accl.coefs` *accelerometer coefficients*

Description

`accl.coefs` contains accelerometer coefficients for an example created by Vladimir Maximov for the project GyroLib.

Usage

```
accl.coefs
```

Format

This data frame contains 12 columns of data (accelerometer coefficients).

Author(s)

Jose Gama

Source

Vlad Maximov, 2012 Scalar Calibration of Vector accelerometers and magnetometers, GyroLib documentation

References

Vlad Maximov, 2012 Scalar Calibration of Vector accelerometers and magnetometers, GyroLib documentation

Examples

```
data(accl.coefs)
accl.coefs
```

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ahrs.EKF.QUATERNION *EKF-based AHRS algorithm*

Description

Implementation of the EKF-based AHRS algorithm based on measurements from three-component accelerometer with orthogonal axes, vector magnetometer and three-axis gyroscope. Estimates the current quaternion attitude.

Usage

```
ahrs.EKF.QUATERNION(Filter, Sensors, Parameters)
```

Arguments

`Filter`	data structure for Extended Kalman Filter
`Sensors`	calibrated gyroscope, accelerometer and magnetometer measurements Sensors.w current calibrated gyroscope measurement [3x1], rad/sec Sensors.a current calibrated accelerometer measurement [3x1], g Sensors.m current calibrated magnetometer measurement [3x1], |m| = 1
`Parameters`	AHRS Parameters Parameters.mn Magnetic Field Vector In Navigation Frame [3x1], |m|= 1 Parameters.an Acceleration vector In Navigation Frame [3x1], g Parameters.dt Sampling period, 1/Hz

Value

Q estimated attitude quaternion [1x4] Filter data structure for an Extended Kalman Filter dw estimated gyroscopes bias [1x3]

Author(s)

Jose Gama

References

Vlad Maximov, 2012 Scalar Calibration of Vector accelerometers and magnetometers, GyroLib documentation

ahrs.LKF.EULER *Euler angles estimation with vector matching and Kalman filter*

Description

Attitude Euler angles estimation by means of complementary Kalman filter.

Usage

```
ahrs.LKF.EULER(Sensors, State, Parameters)
```

Arguments

Sensors	calibrated gyroscope, accelerometer and magnetometer measurements Sensors.w current calibrated gyroscope measurement [3x1], rad/sec Sensors.a current calibrated accelerometer measurement [3x1], g Sensors.m current calibrated magnetometer measurement [3x1], |m| = 1
State	previous state State.q State.dB State.dG State.dw State.P
Parameters	AHRS Parameters Parameters.mn Magnetic Field Vector In Navigation Frame [3x1], |m|= 1 Parameters.an Acceleration vector In Navigation Frame [3x1], g Parameters.dt Sampling period, 1/Hz

Value

Attitude estimated attitude Euler angles [1x4] State estimated current state

Author(s)

Jose Gama

References

Vlad Maximov, 2012 Scalar Calibration of Vector accelerometers and magnetometers, GyroLib documentation

ahrs.LKF.QUATERNION *LKF-based AHRS algorithm*

Description

Implementation of the LKF-based AHRS algorithm based on measurements from three-component accelerometer with orthogonal axes, vector magnetometer and three-axis gyroscope. Estimates the current quaternion attitude.

Usage

```
ahrs.LKF.QUATERNION(Filter, Sensors, q, Parameters, dw)
```

Arguments

`Filter`	data structure for Linear Kalman Filter Filter.x State vector [3x1] Filter.P Covariance matrix [3x3] Filter.Q System noise matrix [3x3] Filter.R Measurement noise matrix [6x6]
`Sensors`	sensors data structure Sensors.w current calibrated gyroscope measurement [3x1], rad/sec Sensors.a current calibrated accelerometer measurement [3x1], g Sensors.m current calibrated magnetometer measurement [3x1], |m| = 1
`q`	quaternion
`Parameters`	AHRS Parameters Parameters.mn Magnetic Field Vector In Navigation Frame [3x1], |m| = 1 Parameters.an Acceleration vector In Navigation Frame [3x1], g Parameters.dt Sampling period, 1/Hz
`dw`	angular rate

Value

`Filter`	Data structure for Linear Kalman Filter
`Q`	Correct quaternion
`dw`	Correct angular rate

Author(s)

Jose Gama

References

Vlad Maximov, 2012 Scalar Calibration of Vector accelerometers and magnetometers, GyroLib documentation

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`ahrs.LKF.VMATCH` *Quaternion estimation with vector matching and Kalman filter*

Description

Attitude quaternion estimation by means of complementary Kalman filter.

Usage

```
ahrs.LKF.VMATCH(Filter, Sensors, q, Parameters)
```

Arguments

`Filter`	data structure for Linear Kalman Filter Filter.x State vector [3x1] Filter.P Covariance matrix [3x3] Filter.Q System noise matrix [3x3] Filter.R Measurement noise matrix [6x6]
`Sensors`	sensors data structure Sensors.w current calibrated gyroscope measurement [3x1], rad/sec Sensors.a current calibrated accelerometer measurement [3x1], g Sensors.m current calibrated magnetometer measurement [3x1], |m| = 1
`q`	quaternion
`Parameters`	AHRS Parameters Parameters.mn Magnetic Field Vector In Navigation Frame [3x1], |m| = 1 Parameters.an Acceleration vector In Navigation Frame [3x1], g Parameters.dt Sampling period, 1/Hz

Value

`Filter`	data structure for Linear Kalman Filter
`Q`	Correct quaternion

Author(s)

Jose Gama

References

Vlad Maximov, 2012 Scalar Calibration of Vector accelerometers and magnetometers, GyroLib documentation

---

`ahrs.UKF.QUATERNION` *Estimate the current quaternion attitude by UKF-based AHRS algorithm*

Description

Estimates the current quaternion attitude with an implementation of the UKF-based AHRS algorithm based on measurements from three-component accelerometer with orthogonal axes, vector magnetometer and three-axis gyroscope.

Usage

```
ahrs.UKF.QUATERNION(Filter, Sensors, Parameters)
```

Arguments

`Filter`	data structure for Unscented Kalman Filter Filter.x State vector [3x1] Filter.P Covariance matrix [3x3] Filter.Q System noise matrix [3x3] Filter.R Measurement noise matrix [6x6]
`Sensors`	sensors data structure Sensors.w current calibrated gyroscope measurement [3x1], rad/sec Sensors.a current calibrated accelerometer measurement [3x1], g Sensors.m current calibrated magnetometer measurement [3x1], |m| = 1
`Parameters`	AHRS Parameters Parameters.mn Magnetic Field Vector In Navigation Frame [3x1], |m| = 1 Parameters.an Acceleration vector In Navigation Frame [3x1], g Parameters.dt Sampling period, 1/Hz

Value

data structure for Unscented Kalman Filter

Author(s)

Jose Gama

References

Vlad Maximov, 2012 Scalar Calibration of Vector accelerometers and magnetometers, GyroLib documentation

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`anglesGyroLib` *Test recording and calibration recording data*

Description

`anglesGyroLib` and `calibrationGyroLib` contain test recording and calibration recording data read by Vladimir Maximov for the project GyroLib. Data W, A and M should be divided by 3000 to get the actual values.

Usage

```
anglesGyroLib
```

Format

This data frame contains the following columns:

sincIMU IMU synch value

Wx x-value of gyroscope data, angular rate in rad/sec

Wy y-value of gyroscope data, angular rate in rad/sec

Wz z-value of gyroscope data, angular rate in rad/sec

Ax x-value of accelerometer data, acceleration in g

Ay y-value of accelerometer data, acceleration in g

Az z-value of accelerometer data, acceleration in g

Mx x-value of magnetometer data, magnetic field, uncalibrated, anti-clockwise positive

My y-value of magnetometer data, magnetic field, uncalibrated, anti-clockwise positive

Mz z-value of magnetometer data, magnetic field, uncalibrated, anti-clockwise positive

temperature temperature

Author(s)

Jose Gama

Source

Vlad Maximov, 2012 Scalar Calibration of Vector accelerometers and magnetometers, GyroLib documentation.

References

Vlad Maximov, 2012 Scalar Calibration of Vector accelerometers and magnetometers, GyroLib documentation.

Examples

```
data(anglesGyroLib)
anglesGyroLib
```

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ekf.calibration.indirect *Calibration coefs by complementary EKF*

Description

Estimation of the calibration coefs by complementary EKF

Usage

```
ekf.calibration.indirect(m, initMean = NA)
```

Arguments

`m`	Calibration data, recorded while rotating corresponding sensor in 3D
`initMean`	Initial guess for coefs

Value

coefs[1x12] vector of sensor's calibration coeffs m_ calibrated data tr_ Covariance matrix trace

Author(s)

Jose Gama

References

Vlad Maximov, 2012 Scalar Calibration of Vector accelerometers and magnetometers, GyroLib documentation

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MadgwickAHRS *Madgwick's AHRS algorithm*

Description

Implementation of Madgwick's AHRS algorithm.

Usage

```
MadgwickAHRS(MSamplePeriod, MBeta, q, Gyroscope, Accelerometer, Magnetometer)
```

Arguments

`MSamplePeriod`	Sample Period.
`MBeta`	Algorithm gain beta.
`q`	Quaternion.
`Gyroscope`	Gyroscope measurement.
`Accelerometer`	Accelerometer measurement.
`Magnetometer`	Magnetometer measurement.

Value

Quaternion describing the Earth relative to the sensor.

Author(s)

Jose Gama

References

S. O. H. Madgwick, An efficient orientation filter for inertial and inertial/magnetic sensor arrays, Technical report, University of. Bristol University, UK, 2010.

MadgwickAHRSupdate *Madgwick's AHRS update method*

Description

Madgwick's algorithm for AHRS update method.

Usage

```
MadgwickAHRSupdate(gxi, gyi, gzi, axi, ayi, azi, mxi, myi, mzi, sampleFreqi,
betai, q0i, q1i, q2i, gz)
```

Arguments

gxi	Gyroscope x axis measurement in radians/s.
gyi	Gyroscope y axis measurement in radians/s.
gzi	Gyroscope z axis measurement in radians/s.
axi	Accelerometer x axis measurement in any calibrated units.
ayi	Accelerometer y axis measurement in any calibrated units.
azi	Accelerometer z axis measurement in any calibrated units.
mxi	Magnetometer x axis measurement in any calibrated units.
myi	Magnetometer y axis measurement in any calibrated units.
mzi	Magnetometer z axis measurement in any calibrated units.
sampleFreqi	Sample frequency.
betai	Algorithm gain beta.
q0i	Quaternion[0]
q1i	Quaternion[1]
q2i	Quaternion[2]
gz	Quaternion[3]

Value

output quaternion describing the Earth relative to the sensor.

Author(s)

Jose Gama

References

S. O. H. Madgwick, An efficient orientation filter for inertial and inertial/magnetic sensor arrays, Technical report, University of. Bristol University, UK, 2010.

MadgwickAHRSupdateIMU *Madgwick's IMU update method*

Description

Madgwick's algorithm for IMU update method.

Usage

```
MadgwickAHRSupdateIMU(gxi, gyi, gzi, axi, ayi, azi, sampleFreqi, betai,
q0i, q1i, q2i, sampleFreq)
```

Arguments

gxi	Gyroscope x axis measurement in radians/s.
gyi	Gyroscope y axis measurement in radians/s.
gzi	Gyroscope z axis measurement in radians/s.
axi	Accelerometer x axis measurement in any calibrated units.
ayi	Accelerometer y axis measurement in any calibrated units.
azi	Accelerometer z axis measurement in any calibrated units.
sampleFreqi	Sample frequency.
betai	Algorithm gain beta.
q0i	Quaternion[0]
q1i	Quaternion[1]
q2i	Quaternion[2]
sampleFreq	Sample frequency.

Value

output quaternion describing the Earth relative to the sensor.

Author(s)

Jose Gama

References

S. O. H. Madgwick, An efficient orientation filter for inertial and inertial/magnetic sensor arrays, Technical report, University of. Bristol University, UK, 2010.

`MadgwickData` *Test data for Sebastian Madgwick's IMU and AHRS sensor fusion algorithms*

Description

`MadgwickData` contains test data created by Sebastian Madgwick for his IMU and AHRS sensor fusion algorithms.

Usage

```
MadgwickData
```

Format

This data frame contains the following columns:

Time Time of reading

Gx x-value of gyroscope data

Gy y-value of gyroscope data

Gz z-value of gyroscope data

Ax x-value of accelerometer data

Ay y-value of accelerometer data

Az z-value of accelerometer data

Mx x-value of magnetometer data

My y-value of magnetometer data

Mz z-value of magnetometer data

Author(s)

Jose Gama

Source

S. O. H. Madgwick, An efficient orientation filter for inertial and inertial/magnetic sensor arrays, Technical report, University of. Bristol University, UK, 2010.

References

S. O. H. Madgwick, An efficient orientation filter for inertial and inertial/magnetic sensor arrays, Technical report, University of. Bristol University, UK, 2010.

Examples

```
data(MadgwickData)
MadgwickData
```

MadgwickIMU *Madgwick's IMU algorithm*

Description

Implementation of Madgwick's IMU algorithm.

Usage

```
MadgwickIMU(MSamplePeriod, MBeta, q, Gyroscope, Accelerometer)
```

Arguments

`MSamplePeriod`	Sample Period.
`MBeta`	Algorithm gain beta.
`q`	Quaternion.
`Gyroscope`	Gyroscope measurement.
`Accelerometer`	Accelerometer measurement.

Value

Quaternion describing the Earth relative to the sensor.

Author(s)

Jose Gama

References

S. O. H. Madgwick, An efficient orientation filter for inertial and inertial/magnetic sensor arrays, Technical report, University of. Bristol University, UK, 2010.

magn.coefs *magnetometer coefficients*

Description

`magn.coefs` contains magnetometer coefficients for an example created by Vladimir Maximov for the project GyroLib.

Usage

```
magn.coefs
```

Format

This data frame contains 12 columns of data (magnetometer coefficients).

Author(s)

Jose Gama

Source

Vlad Maximov, 2012 Scalar Calibration of Vector accelerometers and magnetometers, GyroLib documentation

References

Vlad Maximov, 2012 Scalar Calibration of Vector accelerometers and magnetometers, GyroLib documentation

Examples

```
data(magn.coefs)
magn.coefs
```

MahonyAHRSupdate *Mahony's AHRS update method*

Description

Mahony's algorithm for AHRS update method.

Usage

```
MahonyAHRSupdate(gxi, gyi, gzi, axi, ayi, azi, mxi, myi, mzi, sampleFreqi,
twoKpi, twoKii, integralFBxi, integralFByi, integralFBzi, q0i, q1i, q2i, halfex)
```

Arguments

gxi	Gyroscope x axis measurement in radians/s.
gyi	Gyroscope y axis measurement in radians/s.
gzi	Gyroscope z axis measurement in radians/s.
axi	Accelerometer x axis measurement in any calibrated units.
ayi	Accelerometer y axis measurement in any calibrated units.
azi	Accelerometer z axis measurement in any calibrated units.
mxi	Magnetometer x axis measurement in any calibrated units.
myi	Magnetometer y axis measurement in any calibrated units.
mzi	Magnetometer z axis measurement in any calibrated units.

`sampleFreqi`	Sample frequency.
`twoKpi`	Kp constant passed as a parameter
`twoKii`	Ki constant passed as a parameter
`integralFBxi`	Integral FB[0]
`integralFByi`	Integral FB[1]
`integralFBzi`	Integral FB[2]
`q0i`	Quaternion[0]
`q1i`	Quaternion[1]
`q2i`	Quaternion[2]
`halfex`	Half

Value

output quaternion describing the Earth relative to the sensor.

Author(s)

Jose Gama

References

S. O. H. Madgwick, An efficient orientation filter for inertial and inertial/magnetic sensor arrays, Technical report, University of. Bristol University, UK, 2010.

R. Mahony, T. Hamel, and J.-M. Pflimlin. Nonlinear complementary filters on the special orthogonal group. Automatic Control, IEEE Transactions on, 53(5):1203 –1218, june 2008.

`MahonyAHRSupdateIMU` *Mahony's IMU update method*

Description

Mahony's algorithm for IMU update method.

Usage

```
MahonyAHRSupdateIMU(gxi, gyi, gzi, axi, ayi, azi, sampleFreqi, twoKpi,
twoKii, integralFBxi, integralFByi, integralFBzi, q0i, q1i, q2i, halfex)
```

Arguments

`gxi`	Gyroscope x axis measurement in radians/s.
`gyi`	Gyroscope y axis measurement in radians/s.
`gzi`	Gyroscope z axis measurement in radians/s.
`axi`	Accelerometer x axis measurement in any calibrated units.
`ayi`	Accelerometer y axis measurement in any calibrated units.
`azi`	Accelerometer z axis measurement in any calibrated units.
`sampleFreqi`	Sample frequency.
`twoKpi`	Kp constant passed as a parameter
`twoKii`	Ki constant passed as a parameter
`integralFBxi`	Integral FB[0]
`integralFByi`	Integral FB[1]
`integralFBzi`	Integral FB[2]
`q0i`	Quaternion[0]
`q1i`	Quaternion[1]
`q2i`	Quaternion[2]
`halfex`	Half

Value

output quaternion describing the Earth relative to the sensor.

Author(s)

Jose Gama

References

S. O. H. Madgwick, An efficient orientation filter for inertial and inertial/magnetic sensor arrays, Technical report, University of. Bristol University, UK, 2010.

R. Mahony, T. Hamel, and J.-M. Pflimlin. Nonlinear complementary filters on the special orthogonal group. Automatic Control, IEEE Transactions on, 53(5):1203 –1218, june 2008.

MahonykAHRS *Mahony's AHRS algorithm*

Description

Implementation of Mahony's AHRS algorithm.

Usage

```
MahonykAHRS(MSamplePeriod, Kp = 2, Ki = 0.005, q, Gyroscope, Accelerometer, Magnetometer)
```

Arguments

MSamplePeriod	Sample Period.
Kp	Constant Kp.
Ki	Constant Ki.
q	Quaternion.
Gyroscope	Gyroscope measurement.
Accelerometer	Accelerometer measurement.
Magnetometer	Magnetometer measurement.

Value

Quaternion describing the Earth relative to the sensor.

Author(s)

Jose Gama

References

S. O. H. Madgwick, An efficient orientation filter for inertial and inertial/magnetic sensor arrays, Technical report, University of. Bristol University, UK, 2010.

R. Mahony, T. Hamel, and J.-M. Pflimlin. Nonlinear complementary filters on the special orthogonal group. Automatic Control, IEEE Transactions on, 53(5):1203 –1218, june 2008.

MahonykIMU — *Mahony's IMU algorithm*

Description

Implementation of IMU's AHRS algorithm.

Usage

```
MahonykIMU(MSamplePeriod, Kp = 2, Ki = 0.005, q, Gyroscope, Accelerometer)
```

Arguments

`MSamplePeriod`	Sample Period.
`Kp`	Constant Kp.
`Ki`	Constant Ki.
`q`	Quaternion.
`Gyroscope`	Gyroscope measurement.
`Accelerometer`	Accelerometer measurement.

Value

Quaternion describing the Earth relative to the sensor.

Author(s)

Jose Gama

References

S. O. H. Madgwick, An efficient orientation filter for inertial and inertial/magnetic sensor arrays, Technical report, University of. Bristol University, UK, 2010.

R. Mahony, T. Hamel, and J.-M. Pflimlin. Nonlinear complementary filters on the special orthogonal group. Automatic Control, IEEE Transactions on, 53(5):1203 –1218, june 2008.

svd.calibration	*calibration coefs by Merayo's technique*

Description

Performs the estimation of the calibration coefs by complementary EKF using Merayo technique with a non iterative algoritm

Usage

```
svd.calibration(X)
```

Arguments

X	Calibration data, recorded while rotating corresponding sensor in 3D

Value

coefs[1x12] - vector of sensor's calibration coeffs X_ - calibrated data

Author(s)

Jose Gama

References

using Merayo technique with a non iterative algoritm J.Merayo et al. "Scalar calibration of vector magnemoters" Meas. Sci. Technol. 11 (2000) 120-132.

Alain Barraud, Suzanne Lesecq 2008 MgnCalibration - magnetometer calibration from a measurements data set. http://www.mathworks.com/matlabcentral/fileexchange/23398-magnetometers-calibration/content/MgnCalibration.m

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