.

Student Satellite Project
Indian Institute of Technology, Bombay
Powai, Mumbai - 400076, INDIA

Website: www.aero.iitb.ac.in/satlab

README - Star Catalogue Pre-Processing

Guidance, Navigation and Controls Subsystem

---

ca_preprocessing.m

Code Type: MATLAB - Script
Code author: KT Prajwal Prathiksh
Created on: 25/04/2020
Last modified: 12/05/2020
Reviewed by: NOT YET REVIEWED!
Description:
This script converts the SKY2000 Catalogue, into the Master-Star Catalogue, and the SSP-Star Catalogue.
The following data fields of the SKY2000 Catalogue are used:

1. SKY2000 - *Identifier based on J2000 position*
2. RAJ2000 - *Right ascension (J2000) hours - ("h:m:s")*
3. DEJ2000 - *Declination degrees (J2000) - ("d:m:s")*
4. pmRA - *Proper motion in RA (J2000) - second per year*
5. pmDE - *Proper motion in Dec (J2000) - second of arc per year*
6. Vmag - *Photometric magnitude - (Optical V band between 500 and 600 nm)*

The catalogues, which are classified as follows, is created by this script.

1. **SKY2000.csv** : Comprises of all the aforementioned data fields (unaltered), downloaded from VizieR.
2. **Master_Star_Catalogue.csv** : Same as *SKY2000.csv* except for the following changes:
   (a) **RAJ2000** is split into **RA_h**, **RA_m**, and **RA_s**
   (b) **DEJ2000** is split into **DE_d**, **DE_m** and **DE_s**
3. **SSP_Star_Catalogue.csv :** Same as *Master_Star_Catalogue.csv*, which has been sorted based on *'Vmag'* field, in addition to the following changes:
   (a) **RA_h**, **RA_m**, and **RA_s** is merged to create **RA** field - degrees
   (b) **DE_d**, **DE_m**, and **DE_s** is merged to create **DE** field - degrees

(c) **SSP_ID** - Fictitious identifier created for stars, which is essentially the position of the stars after being sorted according to *'Vmag'*

(d) **[X, Y, Z]** - The Cartesian unit vector representation of each star generated from its Right-Ascension and Declination coordinate. The (X, Y, Z) coordinate system definition corresponds to the projection of the Earth' North Pole onto the celestial sphere as the Z-axis, and the vernal equinox as the X-axis,at epoch ICRS2000, with the Y-axis completing the right-handed orthonormal coordinate system: $Z = X \times Y$

Formula & References:
References:

1. SKY2000 Catalogue - http://tdc-www.harvard.edu/software/catalogs/sky2k.html
2. SKY2000.csv, obtained from - http://vizier.u-strasbg.fr/viz-bin/VizieR-3?-source=V/145
3. Detailed README of SKY200 - http://data.bao.ac.cn/ftp/cats/5/109/sky2kv4.pdf

Input parameters:

1. **skip** : (Integer) Skips the first *n* rows of SKY2000 Catalogue, to avoid header rows.

Output:
Writes Master_Star_Catalogue.csv, and SSP_Star_Catalogue.csv in ./Catalogue/SKY2000/Catalogues directory

ca_guide_star_catalogue.m

Code Type: MATLAB - Script
Code author: KT Prajwal Prathiksh
Created on: 25/04/2020
Last modified: 12/05/2020
Reviewed by: NOT YET REVIEWED!
Description:
This script converts the SSP Star Catalogue, into the Guide Catalogue.
Guide_Star_Catalogue.csv : This Catalogue has been generated specifically for the purpose of Star Matching. It contains the following data fields:

1. **SSP_ID** - The fictitious identifier of all those stars which satisfy the condition, that their **Vmag** is $\leq$ the Limiting Magnitude $(= 6)$
2. **[X, Y, Z]** - The Cartesian unit vector representation of each star generated from its Right-Ascension and Declination coordinate. The (X, Y, Z) coordinate system definition corresponds to the projection of the Earth' North Pole onto the celestial sphere as the Z-axis, and the vernal equinox as the X-axis,at epoch ICRS2000, with the Y-axis completing the right-handed orthonormal coordinate system: $Z = X \times Y$

Formula & References:
References:

1. Guide Star Catalogue, Section 1.1 - Dong, Ying Xing, Fei You, Zheng. (2006). *Brightness Independent 4-Star Matching Algorithm for Lost-in-Space 3-Axis Attitude Acquisition.* Tsinghua Science Technology. 11. 543-548. 10.1016/S1007-0214(06)70232-2.

Input parameters:

1. **Magnitude_limit** : (Float) A system parameter, that ascertains the magnitude of the dimmest star we are capable of detecting by our system

Output:
Writes Guide_Star_Catalogue.csv in `./Catalogue/SKY2000/Catalogues/Star_Matching` directory

ca_sm_preprocessing.m

Code Type: MATLAB - Script
Code author: KT Prajwal Prathiksh
Created on: 25/04/2020
Last modified: 12/05/2020
Reviewed by: NOT YET REVIEWED!
Description:
This script uses the Guide Star Catalogue, to generate the Preprocessed Star Catalogue.
Preprocessed_Star_Catalogue.csv : This Catalogue has been generated specifically for the purpose of Star Matching. It contains the following data fields:

1. **SSP_ID_1** - The SSP-ID of i^{th} star
2. **SSP_ID_2** - The SSP-ID of j^{th} star
3. **AngDst_cos** - The dot product of the Cartesian unit vector corresponding to the i^{th} and j^{th} star $(i \neq j, \forall\, i, j)$
4. **AngDst_deg** - The cos inverse of the corresponding dot product value in degrees

This catalogue has only those pairs of stars whose **AngDst_deg** is $\leq$ the circular Field-of-View $(= 16°)$
Formula & References:
–
Input parameters:

1. **FOV_Circular** : (Float) A system parameter, that ascertains the circular Field-of-View of the optic system

Output:
Writes Preprocessed_Star_Catalogue.csv in `./Catalogue/SKY2000/Catalogues/Star_Matching` directory

ca_DMS2degrees.m

Code Type: MATLAB - Function
Code author: KT Prajwal Prathiksh
Created on: 25/04/2020
Last modified: –/–/—-
Reviewed by: NOT YET REVIEWED!
Description:
This function converts the angle from D:M:S to degrees format
Formula & References:
Conversion Formula - https://in.mathworks.com/help/map/ref/dms2degrees.html
Formula: For input $[DMS]$, output is:

$$deg = SGN \times \left(|D| + \frac{|M|}{60} + \frac{|S|}{3600} \right),$$

where SGN is 1 if $D \geq 0$,and -1 if $D < 0$
Input parameters:

1. **D** : (Float) - Degree component
2. **M** : (Float) - Minute component
3. **S** : (Float) - Second component

Output:

1. **deg** : (Float) - Angle in degrees

ca_HMS2degrees.m

Code Type: MATLAB - Function
Code author: KT Prajwal Prathiksh
Created on: 25/04/2020
Last modified: –/–/—-
Reviewed by: NOT YET REVIEWED!
Description:
This function converts the angle from H:M:S to degrees format
Formula & References:
Formula: For input $[HMS]$, output is:

$$T = H \times 3600 + M \times 60 + S$$

$$360^\circ = 24hr = 24 \times 3600s$$

$$deg = \frac{T \times 360^\circ}{24 \times 3600s}$$

Input parameters:

1. **H** : (Float) - Hour component
2. **M** : (Float) - Minute component

3. **S** : (Float) - Second component

Output:

1. **deg** : (Float) - Angle in degrees

ca_RA_DE_2_CartVect.m

Code Type: MATLAB - Function
Code author: KT Prajwal Prathiksh
Created on: 25/04/2020
Last modified: –/–/—-
Reviewed by: NOT YET REVIEWED!
Description:
This function converts a given Right-Ascension and Declination coordinate to a unit vector in a rectilinear coordinate system - (X, Y, Z). The (X, Y, Z) coordinate system definition corresponds to the projection of the Earth' North Pole onto the celestial sphere as the Z-axis, and the vernal equinox as the X-axis,at epoch ICRS2000, with the Y-axis completing the right-handed orthonormal coordinate system:

$$Z = X \times Y$$

Formula & References:
Formula: For input $[RA, DE]$, output is:

$$X = \cos(RA)\cos(DE)$$

$$Y = \sin(RA)\cos(DE)$$

$$Z = \sin(DE)$$

Reference:

1. Refer 4.1.1 - Computer Science Corporation, *"SKYMAP Requirements, Functional, and Mathematical Specifications, Volume 3, Revision 3"*. (1999).

Input parameters:

1. **RA** : (Float) - Right-Ascension component - in degrees
2. **DE** : (Float) - Declination component - in degrees

Output:

1. **X** : (Float) - X-component of the unit vector
2. **Y** : (Float) - Y-component of the unit vector
3. **Z** : (Float) - Z-component of the unit vector