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README - Star Catalogue Pre-Processing

Guidance, Navigation and Controls Subsystem

cat_preprocessing.m

Code Type: MATLAB - Script

Code author: KT Prajwal Prathiksh

Created on: 25/04/2020

Last modified: -/-/-

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)
7. B-V - Color index or magnitude difference - (Optical V band between 500 and 600 nm; Optical B band between 400 and 500 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*'

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

cat_guide_star_catalogue.m

Code Type: MATLAB - Script

Code author: KT Prajwal Prathiksh

Created on: 25/04/2020

Last modified: -/-/—

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` directory

cat_sm_preprocessing.m

Code Type: MATLAB - Script

Code author: KT Prajwal Prathiksh

Created on: 25/04/2020

Last modified: -/-/—

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 ($= 16^\circ$)

Formula & References:

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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` directory

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

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

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, Y, Z]**: ((3,1) - Matrix) - Cartesian unit vector