

Asteroids Detection Pipeline

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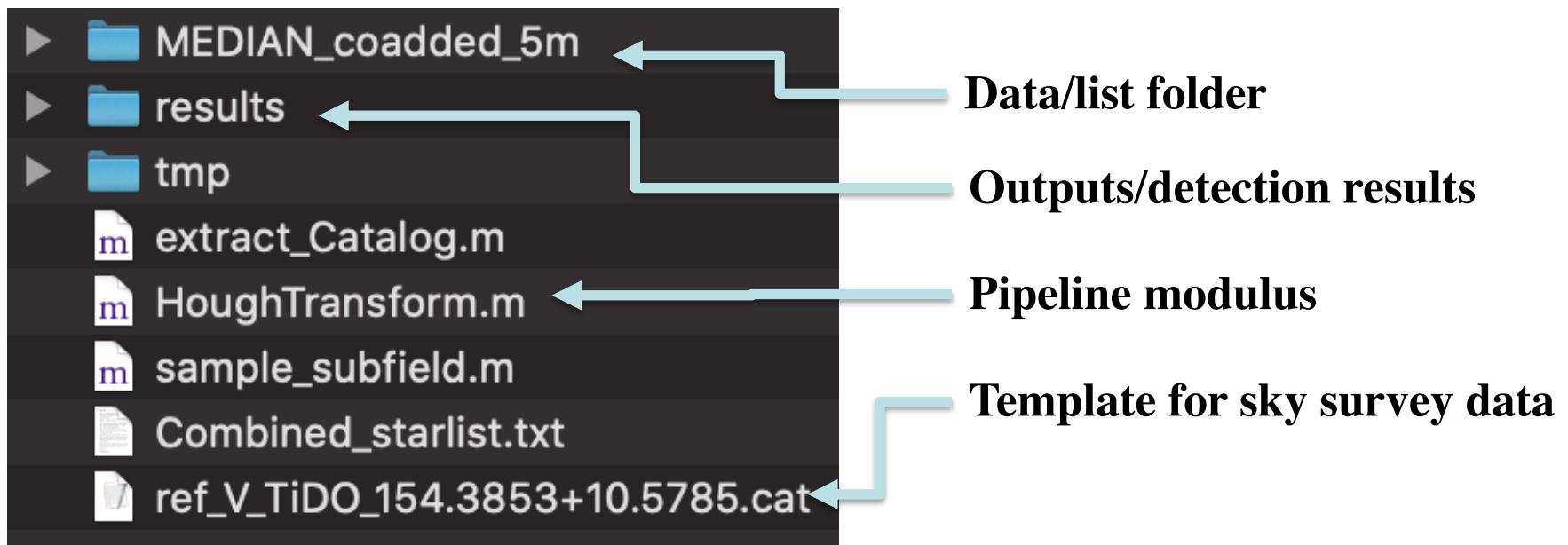
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Asteroid Detection Pipeline

Function: A pipeline based on MATLAB that can detect fast-moving asteroids in sky survey data from TiDO.





Modulus Illustrations

MATLAB toolboxes: Image Processing Toolbox, Mapping Toolbox

List Stacking

- Coordinate info calibration, overall subtractions (template needed).
- Static sources (field stars, artifacts) removal.

Subsampling

- Divide the image by parts to employ the HT.

Hough Transform

- Detect line segments (Comets, tracklets of asteroids).

Identification/ Compare with MPC database

- Outputs. Generate summary report.



Inputs/Outputs/Running

Example:

- sky survey data from Time Domain Observatory (TiDO).
- Two days' data
 - UTC 2018.03.08 13:00-22:00
 - UTC 2018.03.09 13:00-22:00
- 180 star lists in total

- Instrument: 18cm Telescope from TiDO.
- Field of view: 144 (100) deg^2
- Pixel scale: $10 \text{ arcsec} \cdot \text{pixel}^{-1}$
- Field centers: all around the ecliptic





Inputs

```
%=====Input=====
%Specify the name of the folder that contains the data/list
%Specify the name of file that contains the reference stars
%Specify the center of FoV
%For now, only the RA Dec info will be used, so specify locations of RA Dec
%in the data/list

Folder      = 'MEDIAN_coadded_5m';
FITS        = 'TiDO*';
filename    = dir(fullfile(Folder,FITS));
ref_file    = 'ref_V_TiDO_154.3853+10.5785.cat';
center      = [154.3853,10.5785];
X_posi     = 1;
Y_posi     = 2;
RA          = 12;
DEC         = 13;
Mag         = 17;
delimiterIn = ' ';
headerlinesIn = 37;
```

- Basic info of data (to get the coordinates info properly).
- Only the RA Dec Mag info will be used.
- Reference data/template data (optional but recommended)



Running

```
>> extract_Catalog  
180 lists to be combined, 1.3688 minutes expected.  
Lists calibration and combination finished, running time 1.7306 minutes in total.  
Start searching tracklets now...
```

• • •

```
Tracklets found around(157.3853,+6.0937)  
Elapsed time is 47.912028 seconds.  
2479 out of 3283 subfields have been done!
```

```
Tracklets found around(157.6353,+6.0937)  
Elapsed time is 47.779671 seconds.  
2546 out of 3283 subfields have been done!
```

```
Tracklets found around(157.8853,+14.124)  
Elapsed time is 47.642233 seconds.  
2613 out of 3283 subfields have been done!
```

```
Tracklets found around(158.1353,+13.9724)  
Tracklets found around(158.1353,+14.124)  
Elapsed time is 48.475770 seconds.
```

```
2680 out of 3283 subfields have been done!
```

• • •

```
Elapsed time is 50.866156 seconds.  
3283 out of 3283 subfields have been done!
```



1st part: List stacking and calibration. (a few minutes)



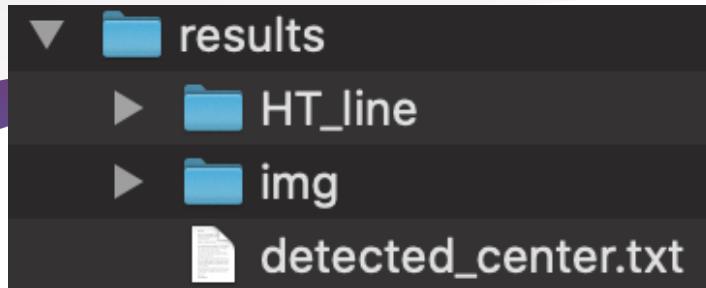
2nd part: Subsampling and HT

- Pre-report detections
- Progress feedback
- Takes 0.5~1 hr

Ending



Outputs

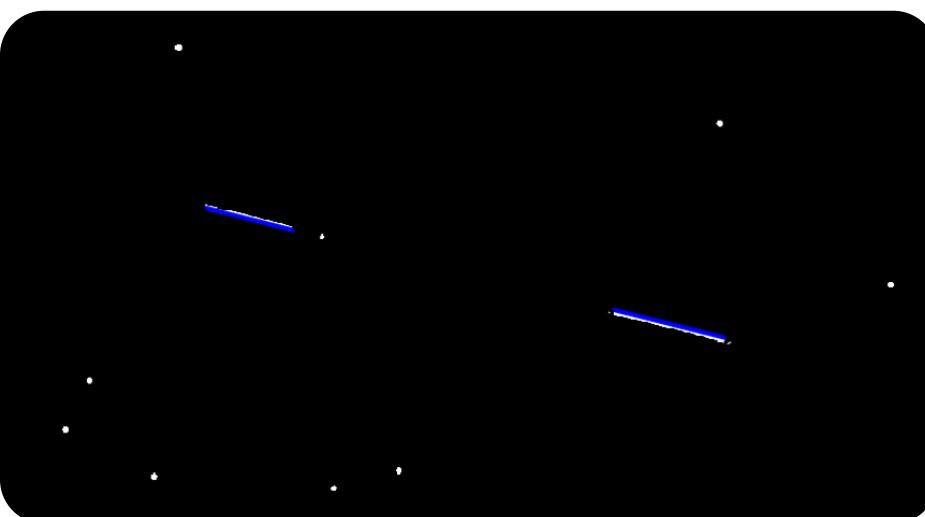


The *results* folder contains:

- Raw HT-identified images, *img* folder.
- HT-marker images, *HT_line* folder.
- Summary of detection "designation", *detected_center.txt*, could be uploaded to MPCcheck.

Example: 154.1353_12.0027.png

HT_line folder

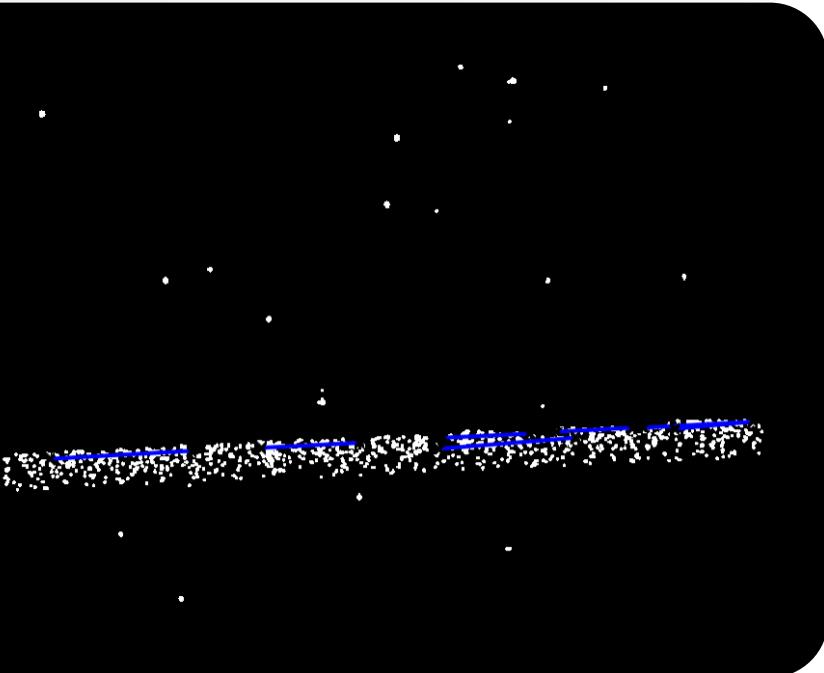


Img folder

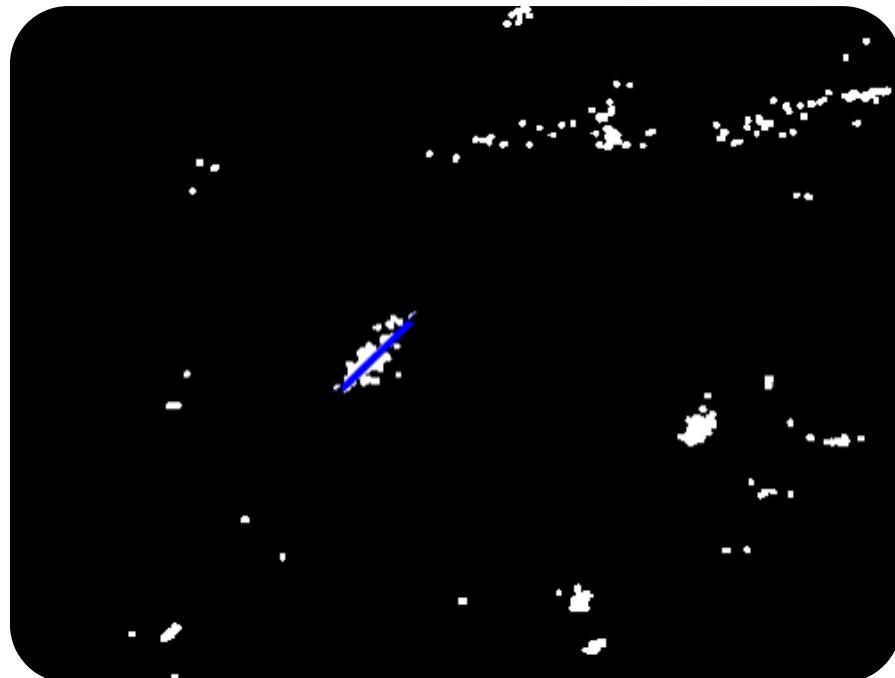




False Positives



CCD Artifacts



***Uncorrected
Field Stars***

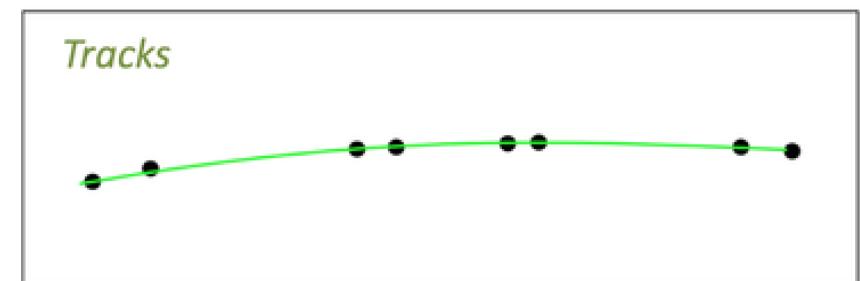
- False Positives Rate depends on the quality of Input data.
- Visual Inspection is enough.



Improvements

- Integrate time information into identification.
- Upgrade to Randomized Hough Transform for diverse structure detection.

- Reportable discovery: tracks can fit a Keplerian orbit.





Thank you