西はりま天文台６０cm望遠鏡の全自動化

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アブストラクト

我々は、2mなゆた望遠鏡に対して補助的な測光観測を自動で実行するよう、西はりま天文台の60cm望遠鏡を改修している。これまでに、機器の異常、気象、観測条件を判断するための機械学習アルゴリズムや、オンザフライでの天文検出と組み合わせたポインティング補正プログラムを開発した。こうしたGPUベースのソフトウェアはすべてオープンソースであり、一般に公開される予定である。

Challenges:

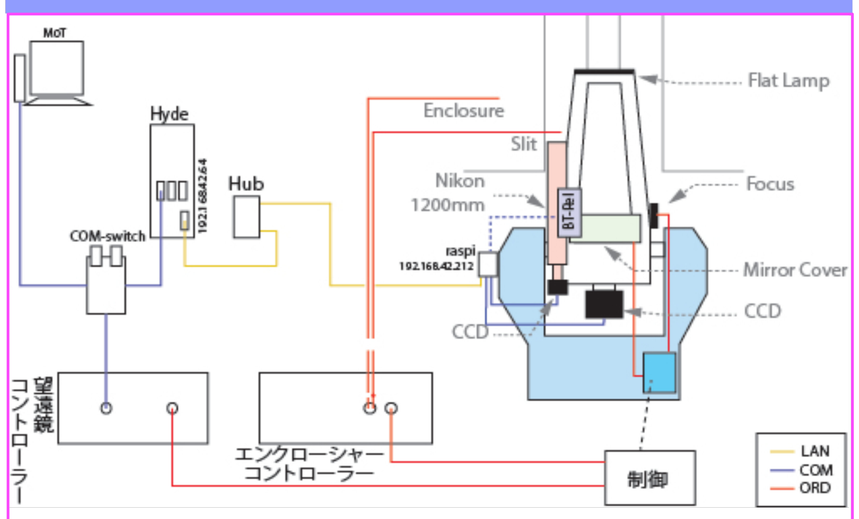
Telescope and Components

- no encoder for focus, enclosure and slit
- limited pointing accuracy, precision and stability
- analogue components (slit, mirror cover)

Automatic Observation

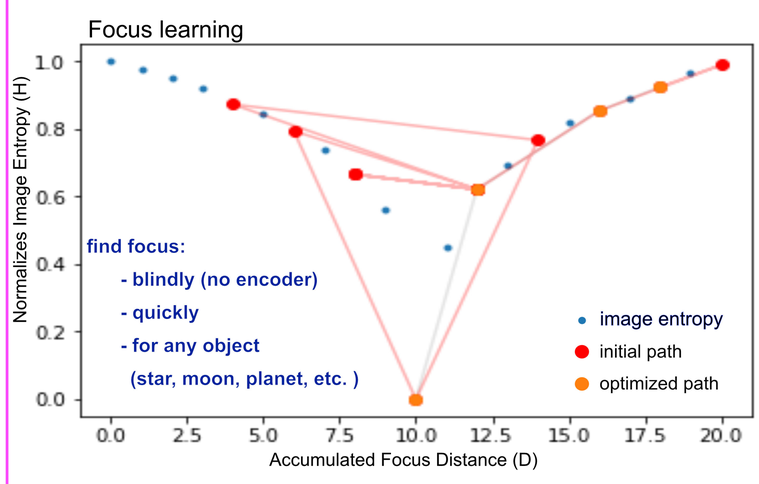
- FOV confirmation and tracking
- observability evaluation
- exposure estimation

Overview



Focusing

We have created a python script to find the focus under any condition (except for zero seeing). The differential focus is estimated by comparing the image entropy of two relative focus position. Due to the lack of an encoder, the absolute focus position is always unknown.



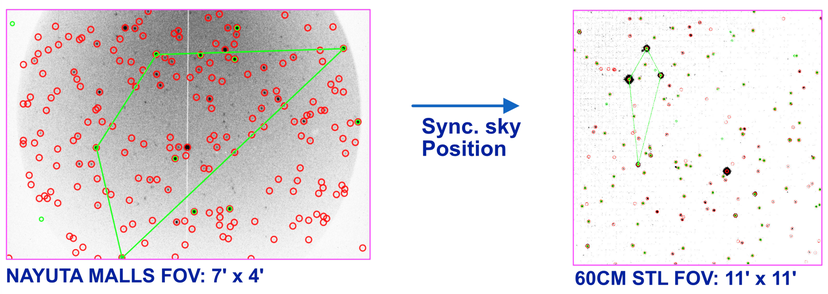
$$H = -\sum_{xy} p_{xy} log_2(p_{xy})$$

The focus between the The figure shows the estimated shortest path to lowest entropy focus from any position. dH/dD is used to anticipate the stepping distance for each point

NAYUTA – 60CM –Synchronization

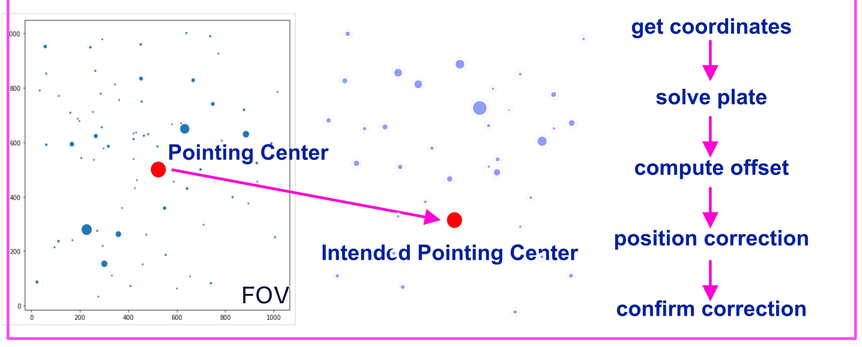
The telescope pointing can be synchronized to that of the Nayuta telescope by evaluating the MALLS FOV and determining position and and brightness of the currently observed object.

We evaluate the FOV of both malls and the 60cm CCD camera by computing a brightness level function, extracting sources and solving the source positions through pyplate and astrometry-net

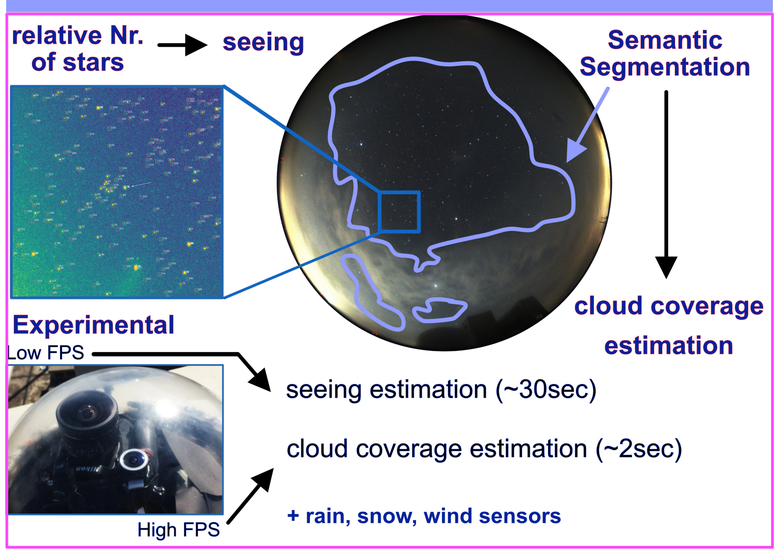


On-the-Fly Offset Correction and Tracking

We use on the fly plate solving to ensure correct pointing of the telescope and correct the pointing when needed.



Weather and Observation Conditions



Summary

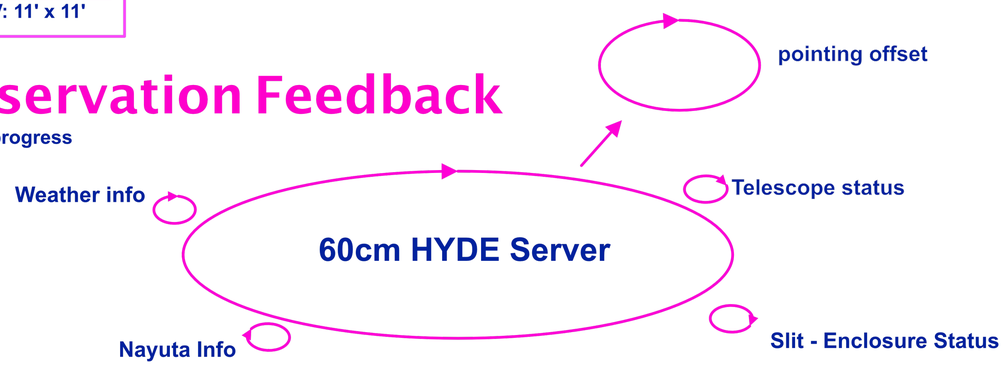
The development for the individual components has been largely finished but not yet fully tested.

Especially the telescope to telescope synchronization as well as the observation feedback still require initial and long term testing.

The automatic observation routine for the 60cm telescope of the Nishi Harima Observatory is currently estimated to be able to perform automated observation by the end of the year.

Observation Feedback

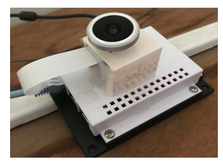
work in progress



Enclosure / Slit Encoder

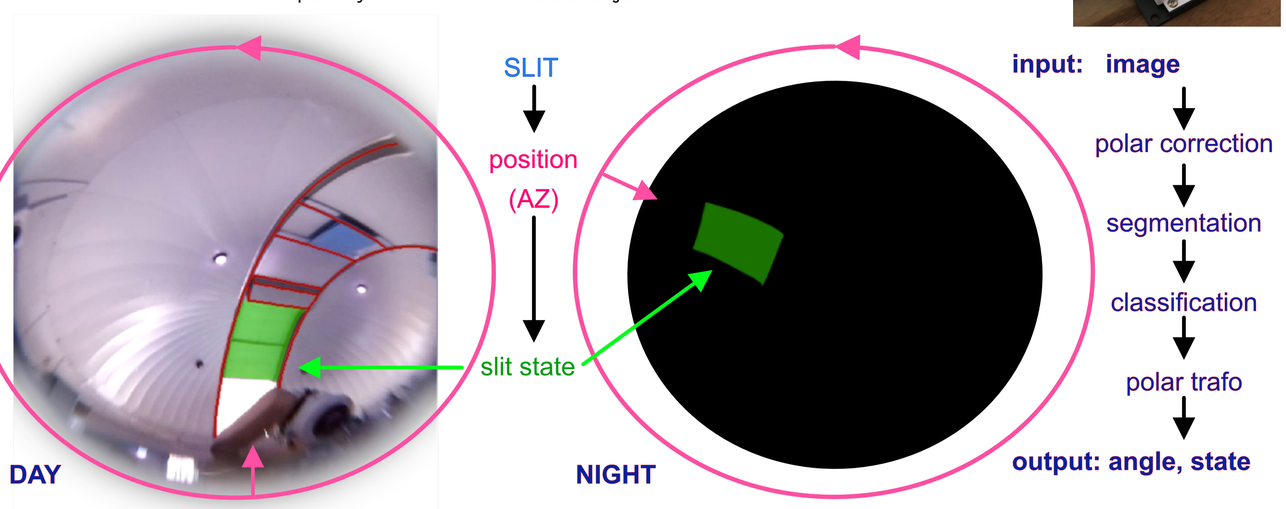
Since the motors driving the enclosure and slit have no readable encoders, we employ active object detection to locate the Az component of the slit position and whether it is open, closed or moving into either state.

source: https://github.com/shissler1987/60cm/enclosure



motion tracking without encoder → optical encoder

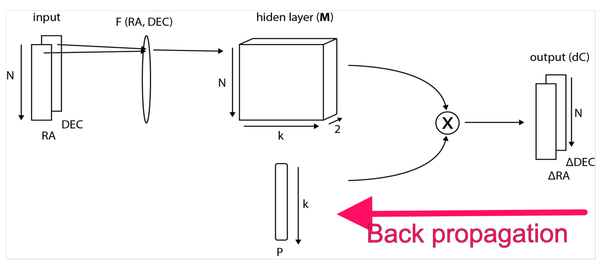
Raspberry Pi + IRcam + YOLO object detection

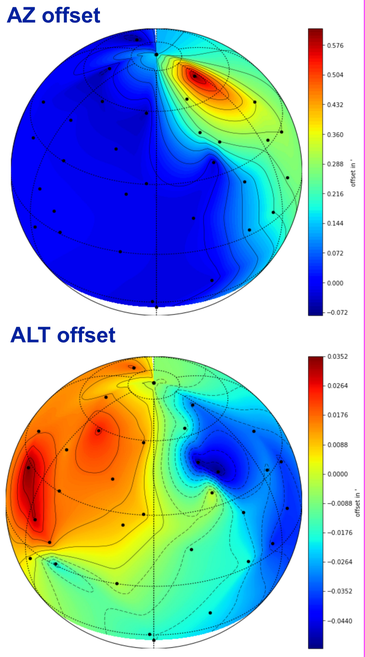


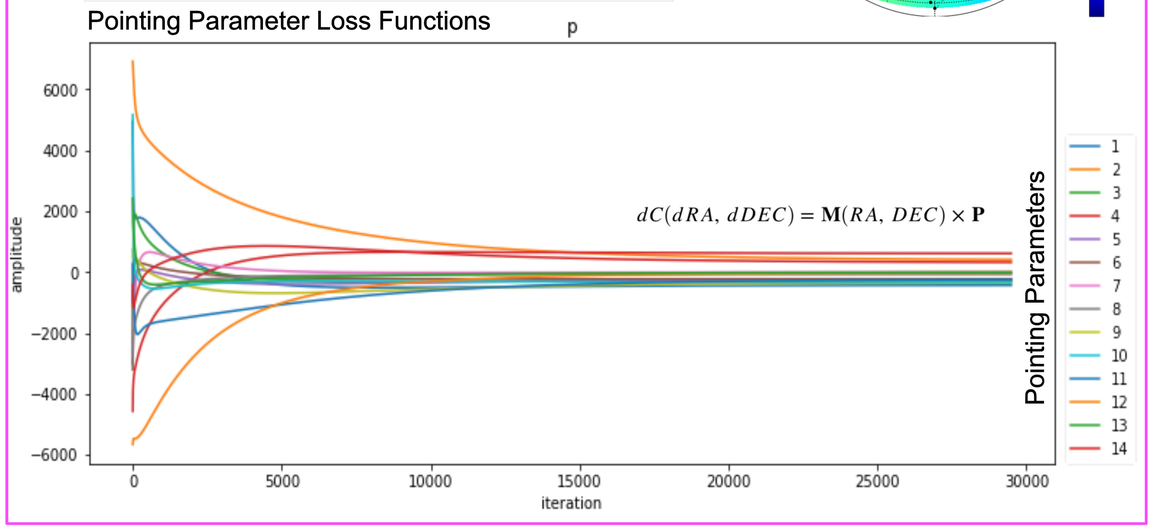
Pointing Correction

Depending on mount, mechanics and the overall telescope construction, the pointing accuracy and precision varies for each position (Alt Az). For older telescopes, the pointing can vary quite strongly (>10'). We can create a set of pointing parameters to roughly model the geometric misalignments from a set of coordinates and their offset. Since most software approaches for correcting telescope pointing are hidden behind relatively expensive paywalls, I have started a github repo for analyzing and applying pointing corrections. The code is written in python using numpy, matplotlib, pytoch etc. and contains functions for solving and applying correction equations. For more information see the jupyter notebook on github

source: https://github.com/shissler1987/TPC-Telescope-Pointing-Correction







Digitalization of Analog Telescope Components

The slit and and mirror cover had no prior control interfaces. Therefore, we installed digital relays parallel to the manual switches, to operate the switches remotely. USB and Bluetooth relays are installed for either slit and mirror cover. Schematics and images of the installation procedure are presented below.