Showing possibility of near real time creation of an initial WCS with solvefield

Search for a fast parameter set

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Abstract

The detection of fast moving or new objects on sky surveys with small cameras depend largely on the creation of a valid WCS solution for each image. A short time for detecting these objects on images is crucial for subsequent time critical actions to be taken. For comparing found sources with online catalogs a valid WCS is needed. Getting the optimum parameters for solving each field of a survey can't be done manually if n(ear)r(eal)t(ime) processing should be achieved. But an automated process needs a near optimum parameter set to be used for all fields of the survey to minimize overall solving time for all images but not only for some. This work focusses on the possibility of getting duration minimized parameter sets for an (initial) astrometric solving of a sky survey. Several sets are checked on real images of *SODASS (**S**onneberg **O**bservatory **D**igital **A**ll-**S**ky **S**urvey)* and are evaluated for being possible candidates for an automated detection process. In the first part 65 randomly choosen digital images of different sky areas are solved with 36 parameter sets. The second part takes a detailed look on two parametrisations. Possible enhancements are discussed and an outlook for further investigations is given.

Introduction

Carrying out a sky survey can be driven by very different goals and can be done in different ways. Census of any kind of observable parameters or the discovery of new objects can be some goals. For the type of the survey there are many aspects to distinguish them. Used instrumentation, used wavelength, coverage of the sky or frequency with which one field is rescanned are some of them [1]. Sky surveys designed for covering the whole sky possibly at the whole night at a location are often used as a trigger for follow up detailed observations with specialized instrumentation. Often consumer DSLR cameras are used for such surveys.

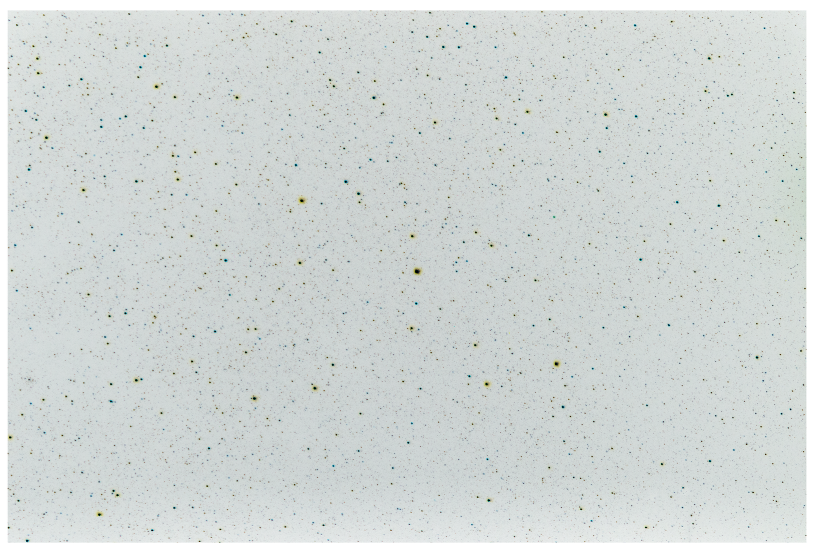

Figure 1: Negative of image taken with consumer DSLR

These surveys can be used for example for detecting fast moving or rapidly varying objects within the limitation of their observational domain. Often surveys are restricted to a certain range of wavelength and magnitudes they can observe but having a large area of coverage. For detecting new objects the images must be compared with catalog data which can be done automatically if there exists an astrometrical solution for the field. This corresponds to the existence of a WCS solution. Retrieving this WCS within a short time is crucial for the overall time until some possible new object alert can took place. In this paper the possible usage of *solvefield* [2], a standard tool of astrometry, for n(ear)r(eal)t(ime) processing is checked.

Materials and Methods

The optical equipment for taking the used images is a Canon EOS 5D Mark I with a Zeiss Tessar 80/360mm. 65 images (each of 180s exposure time) of *SODASS* of the years 2016 - 2018 are taken as the basis for further analysis. At first one of the two green channel of the RGGB images are extracted with *rawtran* which is a wrapper around *dcraw*. From former experiences with digitized plates of the *SOPHIA (**S**onneberg **O**bservatory **PH**otographic **I**mage **A**rchive)* a set of 36 parameters for *solvefield* was defined. At the next step these 65x36 combinations are processed by *solvefield*. The individual results are finally put to three tables representing the success (0/1), the duration of the solution and the number of sources for each combination. Only the first two tables are used for this evaluation.

Automation of getting the single results and constructing the overall tables are done with (bash-)shell scripts and *python* on a laptop running *Ubuntu 16.04 LTS*. Extracting valuable graphs from the two tables is done again by *python* scripts. During the processing of individual images with a single parameter set all logs and semi final files, like annotations and WCS enhanced fit files, are stored on the laptop and are finally transfered to a backup device. These files can be used for detailed analysis if needed. The maximum runtime of one solvefield run is limited to 300s. The solution time for unsolved images is set to 999.9s as this differs enough from the highest solution times at around 400s which occurs occasionally.

Results

Of the 36 parameter sets only four parameter sets (P5 and P11 to P13) didn't solve all 65 images and one had a solution time over 300s (P4). These five parameter sets are excluded from further analysis (see figure 2).

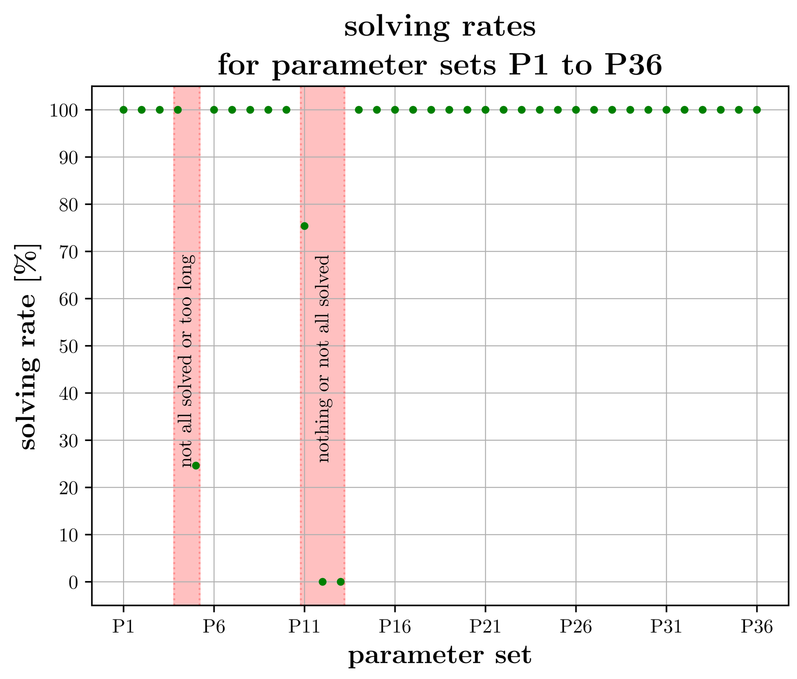

Figure 2: Solving rates

Nearly all parameter sets found exactly the same number of objects within one image. As the images were taken at different sky quality and stray light conditions this shows the stability of the source extracting algorithm of solvefield.

A completly different behaviour can be seen at the time needed for solving the images with the different parameter sets. Plotting the mean solution time (see figure 3) shows a range from $2 \times 10^{-1}s$ to $2 \times 10^{+1}s$ which means a factor of 100. Parameter set P27 and P32 have the minimum and maximum mean solution times. Interestingly these two are also representing the group of parameter sets where only the *(hash-)code* tolerance parameter for *solvefield* is varied from 1×10^{-3} to 5×10^{-2}.

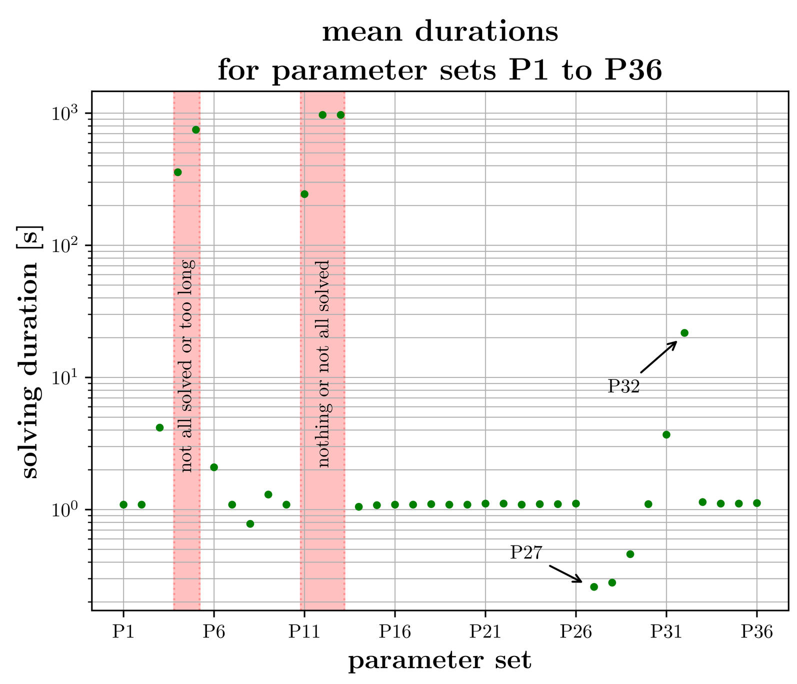

Figure 3: Mean durations

Comparing the histograms for P27 and P32 (see figure 4) shows another reason for choosing P27 and not P32 as the favourite parameter set for a whole sky survey. Beside the smaller mean value which lies nearly a factor of 100 beneath the one of P32 the broadness of both distributions are very different. P27 shows a narrow one where minimum and maximum differ only by a factor of 5. The other parameter set P32 shows differences between $7 \times 10^{-1}s$ and $2 \times 10^{+2}s$ which corresponds to a factor of nearly 290.

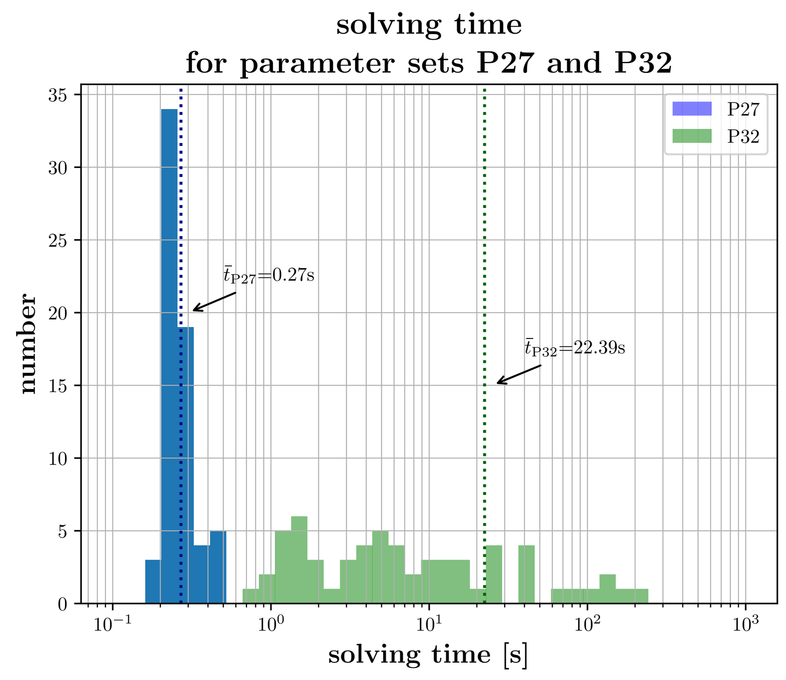

Figure 4: Parameter sets compared

Conclusions

It seems to be possible to get an astrometry solution for 100% of the fields of an all sky survey within less than 1s with the right solvefield parametrisation.

Setting parameters *tweakorder* to 8 and *downsample* to 0 results in unsolving or very slow solution. *Scalelow* seems to be a very critical parameter for getting a solution at all. Setting it to high compared to the size of the image (*scalehigh*) leads to no solution at all.

If the "lost in space" approach is not working properly that means no hint to solvefield is given where your camera is pointing to, just add the center of your image and look if they are solved better (faster or at all).

Therefore solvefield can be used as the first major step within an automated processing chain to get a near real time first WCS solution within the first third of the exposure time.

Forthcoming Tasks

- check the influence of parameter scalelow in more detail
- do the whole with a lot of more images
- define a paramter set which should be used for ongoing Sonneberg sky survey
- develop next steps for setting up near real time processing and alerting

References

[1] S.G.Djorgovski et al. Sky surveys. In H. Bond and T. Oswalt, editors, *Astronomical Techniques, Software, and Data, Vol.2 of Planets, Stars, and Stellar Systems*. Springer Netherlands, 2012.

[2] Dustin Lang et al. Astrometry.net:blind astrometric calibration of arbitrary astronomical images. *The Astronomical Journal*, 139:1782–1800, May 2010.

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