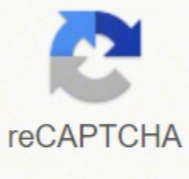




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Additional conditions enable the user to repeat the sequence process indefinitely or up until a specific time. For convenience, maximize that window. If your field of view is large, or if your mosaic is located close to a celestial pole, you may observe that rendered panes start rotating visibly due their horizontal position or high declination. If a FITS file was specified, it first solves the files and slew to the file coordinates. The default selection is to simply mark the observation job as complete once the sequence process is complete. Since the complete process is automated, including focus, guiding, and meridian flip, all equipment should be thoroughly used with Ekos and all their parameters and settings adjusted to achieve the best result. Ekos shall create an observation job and a corresponding customized sequence file for each panel. The following video demonstrates an earlier version of the scheduler, but the basic principles still apply today: Another critical feature of any remotely operated robotic observatory is weather monitoring. The coordinates of each pane are rendered in their center as degrees, minutes and seconds. The sky chart will update automatically after a short time, with target FOV calculated given the number of grid panes and your camera's FOV. Ekos Scheduler enables truly simple robotic operation without the need of any human intervention in any step of the process. button, so that you may load it on any suitable observing night and, with the Remember Job Progress option, it will pick off where you left. Perform plate solving, sync mount, and slew to target coordinates. The user may plan to image one or more targets during the night and expects data to be ready by morning. In simple setups, the user is expected to focus the CCD, align the mount, frame the target, and start guiding before initiating the capture process. Sequence file: The sequence file is constructed in the Ekos Capture Module. For more complex observatory environments, there are usually predefined custom procedures to be executed to prepare the observatory for imaging, and another set of procedures on shutdown. However, if you already know the minimal amount of sub-frames your rejection algorithm will use during post-processing, you may want to increase the overlap to attain that amount on the areas covered by multiple panes. Priority is applied in calculating the weight used to select the next target to image. The Sequence File contains all the information necessary to capture an image including exposure time, filters, temperature setting, etc., and that information will be used for each pane of the mosaic. In KStars, tools such as the Observation Planner and What's up Tonight help the user in selecting candidates for imaging. Priority: Set job priority in the range of 1 to 20 where 1 designates the highest priority and 20 the lowest priority. Nevertheless, many amateurs can obtain stellar wide-field images by combining smaller images into a single grand mosaic. However, if the camera rotation angle is unknown at that step, you will first need to use the Align module to solve a field, preferentially close to the celestial equator, in order to determine it precisely. Observation job conditions and constraints shall be assigned too, so check that they are as per your requirements. The first step can be accomplished in Ekos Scheduler where it creates a mosaic suitable for your equipment and in accordance with the desired field of view. Auto-focus target. If Ekos is already started, you may retrieve optical information by clicking the Fetch to fill those fields automatically. Each observation job is composed of the following: Target name and coordinates: Select target from the Find Dialog or Add it from Observation Planner. Perform post-alignment focusing since the frame might have moved during the plate solving process. Hubble-like super wide field images of galaxies and nebulae are truly awe-inspiring, and while it takes great skills to obtain such images and process them, many notable names in the field of astrophotography employ gear that is not vastly different from yours or mine. You may simply prepare a new job without adding it, or pick an existing job, as long as both target and sequence file fields are valid in the Scheduler form. At the same time, many attractive wide-field targets span multiple FOVs across the sky. Uncheck Minimum mount move to revert to west-east/high-low movement only. Without any changes to your astrophotography gear, it is possible to create a super mosaic image stitched together from several smaller images. For simplicity sake, the weather conditions can be summed in three states: Ok: Weather conditions are clear and optimal for imaging. Changing the overlap will adjust the mosaic grid to cover the same area, while changing the mosaic grid will extend or shrink the mosaic area. The description above only tackles the Data Acquisition stage of the observatory workflow. Use the overlap to ensure panes cover the desired frame extents properly. By increasing FOV by means of a focal reducer or a shorter tube, we gain a larger sky coverage at the expense of spatial resolution. Finally, the angle each pane rotates from the center of the mosaic is displayed at the bottom. Perform calibration and start auto-guiding: The calibration process automatically selects the best guide star, performs calibration, and starts the autoguide process. With Ekos Scheduler, multi-night imaging is greatly facilitated and creating super mosaics has never been so easy. To reset the extents of the mosaic field of view to the area expectedly covered by the grid, click Cover FOV. The scripts take care of any necessary procedures that must take place on startup and shutdown stages. You can also enter a custom name. Load the sequence file in the Capture module and start the imaging process. If the next target scheduled time is not due yet, the mount is parked until the target is ready. Alert: Weather conditions are detrimental to the observatory safety and shutdown must be initiated as soon as possible. Warning weather status does not pose any danger to the observatory equipment so the observatory is kept operational. You also need to enter the rotation of the camera with respect to the celestial pole your mount is pointing to. If Ekos & INDI are already started and online, this selection is ignored. We are often limited by our camera+telescope Field of View (FOV). These include minimum target altitude, minimum moon separation, twilight observation, artificial horizon altitude constraints, and weather monitoring. Using Plasma™ notifications, the user can configure audible alarms and email notifications for the various events in the scheduler. Once the observation job is completed successfully, the scheduler selects the next target. If two targets have identical conditions and constraints, usually the higher priority target followed by higher altitude target is selected for execution. Ekos Scheduler only initiates the startup procedure once the startup time for the first observation job is close (default lead time is 5 minutes before startup time). The Mosaic Job Creator in the Ekos Scheduler will create multiple Scheduler jobs based on a central target. When your target and conditions are ready, start the Mosaic Job Creator by clicking on the icon next to the Find button in Ekos Module. The following is an sample demo startup script in Python: `#!/usr/bin/env python # -*- coding: utf-8 -*- import os import time import sys print "Turning on observatory equipment..." sys.stdout.flush() time.sleep(5) print "Checking safety switches..." sys.stdout.flush() time.sleep(5) print "All systems are GO" sys.stdout.flush() exit(0)` The startup and shutdown scripts must be executable in order for Ekos to invoke them (e.g. use `chmod +x startup_script.py` to mark the script as executable). This greatly facilitates the logistics of capturing many images with different filters and calibration frames across a wide area of the sky. Depending on the on the user selection, the typical workflow proceeds as follows: Slew mount to target. For instance, a 4x4 mosaic grid with 75% overlap has 16 sub-frames covering the central intersection, which is enough for Winsorized Sigma rejection. If you need to adjust the position of the mosaic, click on the view and drag the chart to recenter your target. Profile: Select which equipment profile to utilize when starting Ekos. Selection of the job depends on a simple heuristic algorithm that scores each job given the conditions and constraints, each of which is weighted accordingly. The large number drawn in the corner of each grid pane represents the order in which panes will be captured. The rotation angle is an important parameter of your mosaic, as the Tool will create a grid using this orientation. The script's standard output is also directed to Ekos logger window. However, the scheduler should only be used after you mastered Ekos and knows all the quirks of your equipment. It is the only Ekos module that does not require Ekos to be started as it is utilized to start and stop Ekos. With Ekos, the user can utilize the powerful sequence queue to image batches of images for a particular target. It contains the number of images to capture, filters, temperature settings, prefixes, download directory, etc. A large overlap will make frame stitching easier during post-processing, but it requires more panes to cover the desired extent. Once the startup procedure is completed successfully, the scheduler picks the observation job target and starts the sequence process. There are two major steps to accomplish a super mosaic image: Capture multiple images spanning the target with some overlap between images. Ekos Scheduler is an indispensable arsenal in building your robotic observatory. Process the images and stitch them into a super mosaic image. Completion Conditions: Conditions that trigger completion of the observation job. Startup and shutdown scripts can be written any language that can be executed on the local machine. It must return 0 to report success, any other exist value is considered an error indicator. Currently, the user may select to start as soon as possible, , or when the target is near or past culmination, or at a specific time. Conversely, the shutdown procedure begins with parking the mount & dome before executing the shutdown script as the final procedure. Not only Ekos creates the mosaic panels for your target, but it also constructs the corresponding observatory jobs required to capture all the images. If an unrecoverable error occurs, the observatory initiates shutdown procedure. It requires that you select first one target and one sequence file. Warning: Weather conditions are not clear, seeing is subpar, or partially obstructed and not suitable for imaging. The default S-shaped choice (west-east then alternating high/low/high moves), ensures minimal movement of the mount during observation. On first use, you need to enter your equipment settings including your telescope focal length in addition to camera's width, height, and pixel dimensions. Optional FITS File: If a FITS file is specified, the astrometry solver shall solve the file and use the central RA/DEC as the target coordinates. There is a help icon on the top left part of the sky chart. Without human presence, it becomes increasingly critical to gracefully recover from failures in any stage of the observation run. Next, enter the desired overlap and number of horizontal and vertical mosaic grid panels (e.g. 2x2, 3x3, etc.). The autofocus process automatically selects the best star in the frame and runs the autofocus algorithm against it. If a startup script is specified, it shall be executed first. Steps: The user selects which Ekos modules should be utilized in the observation job execution workflow. You must select the Target and Sequence before you can add a job to the Scheduler. Move your mouse over it to display the latest documentation of the tool. Although the resulting stack does not have the same height on all parts of the final frame, this method gives you control on signal-to-noise ratio and allows you to provide context to your target while exposing a relatively low number of captures. It is designed to be straightforward and intuitive. When the scheduler starts, it evaluates all jobs in accord to the conditions and constraints specified and attempts to select the best job to execute. I emphasize vastly because some do indeed have impressive equipment and dedicated observatories worth tens of the thousands of dollars. On startup, Ekos executes the startup scripts and only proceeds to the remainder of the startup procedure (unpark dome/unpark mount) if the script completes successfully. Any further imaging process is suspended until the weather improves. Ekos Scheduler provides a simple interface to aid the user in setting the conditions and constraints required for an observation job. A Robotic observatory is an observatory composed of several subsystems that are orchestrated together to achieve a set of scientific objectives without human intervention. Furthermore, if the next scheduled target is not due for a user-configurable time limit, the scheduler performs a preemptive shutdown to preserve resources and performs the startup procedure again when the target is due. Save the plan to an Ekos Scheduler List (.esl) file with the Save as... Startup Conditions: Conditions that must be met before the observation job is started. After selecting the desired candidates, the user can add them to the Ekos Scheduler list for evaluation. If you added jobs to the observation list previously, Ekos will ask you if you would want to keep or remove them before inserting the mosaic jobs in the list. The overlap is necessary to enable the processing software from aligning and joining the sub-images. By default, the percentage of the overlap among images is 5%, but you can change this value to your desired value. The user may also add the targets directly in Ekos scheduler or select a FITS file of a previous image. For weather updates, Ekos relies on the selected INDI weather driver to continuously monitor the weather conditions. If there is a shutdown script, it will be executed last. If no candidates are available at the current time, the scheduler goes into sleep mode and wakes up when the next job is ready for execution. A new window will open with a left-side form and your target centered in a sky chart. Each gadget also has its own tooltip. The 2nd step is handled by image processing applications such as PixInsight, among others, and will not be the topic of discussion here. Constraints: Constraints are conditions that must be met at all times during the observation job execution process. The overall procedure typically utilized in an observatory can be summarized in three primary stages: Startup Data Acquisition (including preprocessing and storage) Shutdown Startup procedure is unique to each observatory but may include: Turning on power to equipment Running safety/sanity checks Checking weather conditions Turning off light Fan/Light control Unparking mount etc. The exact behavior to take under Warning status can be configured. When satisfied, set the frequency of alignment and focus steps during the mosaic execution and choose an output folder and accept the dialog. Startup & Shutdown Scripts Due to the uniqueness of each observatory, Ekos enables the user to select startup and shutdown scripts.

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