Crystal Lake Observatory - ATrack (v0.9.5.41)

Config | Adaptive Tracking | Model | Mount | Pinpoint

ADAPTIVE TRACKING

Watch Folder

Number of new images 0
Number of images processed 0
Number of Plate Solve fails 0
Number of images used 0
Delay counter 0
Image Time
Elapsed Time 00.00.09
dT 00.00.00

Image Coordinates RA 00 00 00.00
DEC +00 00 00.0

Image Shift

	Prev Image	Reference	
RA	000.0	000.0	arc-sec
DEC	000.0	000.0	arc-sec

HA 00 59 52

Drive Tracking Rates

RA 00.00000 arc-sec/sec
DEC 00.00000 arc-sec/sec

Corrections

Base RA ☑ 0.00000 arc-sec/sec
DEC ☑ 0.00000 arc-sec/sec

Model RA ☐ 0.00000 arc-sec/sec
DEC ☐ 0.00000 arc-sec/sec

Drift RA ☐ 0.00000 arc-sec/sec
DEC ☐ 0.00000 arc-sec/sec

Centering RA ☐ 0.00000 0
DEC ☐ 0.00000 0

STOP | Drift correction | Centering | Model correction

SEQ #	FNAME	JDATE	UTC DATE	UTC TIME	LST	HA	ETIME	NCATSTA
Use faint stars	False							
Use SExtractor	NO							
Convolve gaussian	NO (FWHM = 0.0)							
Convolve log	NO (FWHM = 0.0)							
Remove hot pixels	YES							
Max solve time	020							
Max solve stars	050							
Minimum star size	02							
Minimum match stars	000							
Sigma above mean	05.0							
Catalog	USNO UCAC4							
Catalog path	E:\UCAC4							
Catalog maximum magnitude	15							
Catalog minimum magnitude	010							
Catalog expansion	00.1							
Horizontal plate scale	00.57							
Vertical plate scale	00.57							
Inner aperture	00.0							
Outer aperture	00.0							
Image exclusion border	000							
Background tile size	000							
Centroid algorithm	PSF							
Projection type	TAN							

SEQ #	FNAME	JDATE	UTC DATE	UTC TIME	LST	HA	ETIME	NCATSTA

ATrack User Guide

Crystal Lake Observatory
v0.9.0
November, 2019

Table of contents

1. Introduction

ATrack (AT) is a free Windows 10 software program that adaptively adjusts the tracking rates of both the RA and DEC motors to maintain telescope pointing accuracy. The software operates in the background to existing image acquisition and control software and requires no change to existing imaging methodologies. AT will work with both ASCOM telescope mounts and Software Bisque mounts controlled through SkyX.

AT has one input; the plate solve data from an image. It has two outputs: a) tracking corrections sent to the RA and DEC motors, b) image and correction data recorded to a log file which can be loaded into a spreadsheet for later analysis.

AT is basically a telescope software auto guider. A conventional hardware auto guider uses a secondary camera to track the movement of a guide star and uses pulse guiding to maintain pointing accuracy. Because the telescope drift is not corrected, the auto guider will continually need to re-centre the telescope. If the guide star is lost, then drifting will move the telescope away from the centre of the image.

AT uses a different approach to auto guiding. Science images captured with the primary camera are plate solved to determine telescope drift.   Corrections to the RA and DEC tracking rates are then used to counter the drift, reducing the need for re-centring. No secondary camera is required.

The total RA and DEC drift correction is comprised of four components:

1.   **Base correction** – a fixed value applied during the entire observing run. Usually this is set to 0.

2.   **Model correction** – used to correct for a change in the tracking error over a declination arc. For example, the RA tracking rate correction at the beginning of the observing run may be different then at the end of the run. This correction is calculated periodically during the observing run and used to update the total tracking correction rate. Normally this is done using a 3rd party telescope pointing model like APCC or TPoint. But both a telescope pointing model and the AT Model correction can be used together.

3.   **Drift correction** – consecutive images are plate solved and used to determine the telescope drift. The tracking correction is then calculated and used to update the total tracking correction.

4.   **Centring correction** – each image is compared to a reference and used to determine the centring error. A fixed re-centring rate is then added to the tracking correction long enough for the telescope to re-centre. After that the re-centring rate is removed.

Total correction = Base correction + Model correction + Drift correction + Centring correction

Any or all the four components can be enabled or disabled during the observing run. For example, if using a 400-point TPoint model the centring component would be enabled and the other three components disabled. AT would then correct for any cumulative drift error from the pointing model.

ATrack can be used in 'passive' mode where all four correction components are disabled during an observing run. In this case AT calculates the correction rates but does not apply them to the telescope. This can later be analysed to review the telescope performance. This is useful if the telescope mount does not support RA and DEC corrections or it is desired to test the software during an observing run but not change the telescope tracking rates.

ATrack can also be run in 'simulation' mode where the ASCOM telescope mount simulator is used instead of a real mount.   Previously captured images can be dropped into a folder monitored by AT to simulate a camera recording the image and saving it to disk. AT will then process these images and calculate correction rates. This is a great way to learn how AT works before trying it on the actual mount.

1.1. Theory of Operation

When the image acquisition software (e.g., ACP, SkyX, SGPro) captures a new image, it is written to a user specified folder on the PC hard drive. In the background (i.e., running parallel to the other software), AT watches this folder and when a new image is added to the folder it plate solves the image using Pinpoint. The plate solve solution is then used to calculate image drift and image shift which is then used to update the mount tracking rates in both RA and DEC.

Image drift is the difference in the plate solution between consecutive images.
    iDrift = current plate solution – previous plate solution

Image shift is the difference between the current image plate solution and a reference position.
    iShift = current plate solution – reference position

The reference position can be either a user specified RA and DEC or the plate solution of the first image.
Four components are used to calculate the tracking correction:
\#   Base correction
\#   Model correction
\#   Drift correction
\#   Centring correction

        Correction rate = Base correction + Model correction + Drift correction + Centring correction

Any or all the correction components can be enabled or disabled. With all components disabled ATrack can be used to log the drifting and image shift during an observing run. No change is made to the mount tracking rates.

Base correction
When an observing run is started, and Adaptive Tracking enabled AT will immediately set the correction rate to the Base rate with all other components reset to 0.

                    Initial Tracking rate = Base Rate + 0 + 0 + 0

During the observing run the Base rate will remain constant but the other components will be updated and added to the Base rate.

Model correction
Normally the image acquisition and telescope control software use a sky model to determine the tracking rate given the pointing of the telescope (e.g., ProTrack). In this case the model correction component in ATrack is not used.
For those telescopes not using a sky model ATrack provides a simple internal tracking correction model based on the hour angle of a declination arc. It is assumed the tracking rate changes linearly over a declination arc and given the hour angle the tracking correction can be calculated:

            Model correction = tracking coefficient x hour angle + base correction rate

ATrack uses two equations one for the East side of the pier and one for the West side of the pier. ATrack will automatically select the equation based on the pier side as reported by the telescope mount.

The model correction is calculated each n seconds (user configured) and added to the other components. This has the advantage of updating the tracking rates even if clouds intervene and AT is not able to plate solve one or more images.

Drift correction

ATrack uses consecutive plate solved images to determine telescope drift in both RA and DEC. The calculation is simple:

Drift = (centre of current image – centre of previous image) / (time of current image – time of previous image) or,

$$raDrift = dRA / dt$$
$$decDrift = dDEC / dt$$

If dt is too small, then the tracking corrections may be chasing seeing conditions. If dt is too large, then the change in the tracking rate may be larger than the measured drift and AT may begin to fall behind.

AT uses drift integrators to smooth variations in drifting due to seeing. The integrators save each drift measurement and then take the mean of the current and previous measurements to determine the current drift rate. The integrators also help to remove the effect of an outlier which could cause over correction of the drift rate.

Centring correction

Centring correction involves comparing the plate solution of the current image with a reference position and calculating a correction distance in both RA and DEC.

Centring correction = current plate solution – reference position

The reference positions can be either:

a)   A fixed RA and DEC (e.g., a variable star)
b)   The plate solution of the first image

If a fixed position, then AT will centre each image to that RA and DEC. This is used when it is important that the target always be centred on the same pixel each night and across meridian flip.

If referencing to the first image, then AT will centre each image to the RA and DEC centre of the first image. This is likely to be different each observing night and across a meridian flip.

1.2. Program requirements

Requirements:

1. ATrack has been developed on the Windows 10 operating system so any PC running Windows 10 will work. Because ATrack processes images taken by the Image acquisition and control software (e.g., SkyX), ATrack should be running on the same PC as those programs.

2. Atrack uses the DC-3 Dreams full Pinpoint plate solve engine. This must be installed on the same PC with ATrack and tested using Visual Pinpoint. The catalog used should successfully plate solve the science images used by ATrack. Recommended catalog is UCAC 4.0 but others may work okay also.

3. SkyX or ASCOM mount that supports custom tracking rates for RA and DEC. This can be tested by using the Base tracking correction rate to move the telescope in RA and DEC and checking the RA and DEC position to verify they are indeed changing.
NOTE: if ATrack is being used only to monitor the tracking performance of the mount then custom tracking rate control is not required.

1.3. Program Installation

Installing ATrack on a Windows PC is very simple.

1. Create a folder on the same PC as the image acquisition and control software is running on. Name the folder "ATrack".

2. Copy the ATrack.exe file and config.ini file to the new folder.

3. Create a desktop (or taskbar) link to the ATrack.exe file.

ATrack does not use the Windows registry, which means the ATrack folder can be moved at any time to a new location without having to reinstall it.

1.4. Program Setup

After ATrack has been installed there are several settings that need to be set before running the program.

1. From the Pinpoint tab, enter in all of the Pinpoint settings that were found to successfully plate solve your images. Most important are the catalog, catalog path and plate scales. These settings should have been verified using the visual Pinpoint application and several of your images.

2. From the Mount tab, if using an ASCOM mount then use the chooser to select the correct mount. If using SkyX then make sure the correct mount is selected in SkyX. It is recommended that the simulator be used first.

3. From the Config tab enter the following:
a. Images folder (this is where the science images will be saved). Initially you might want to setup a test folder (e.g., C:\Temp\).
b. Centering rate in arcsec/minute.
c. Limiters, initally 0.5000 or smaller.
d. Mount polling rate, in seconds (usually 1 second)

It is recommended that the first testing be done using a mount simulator (SkyX or ASCOM). This way you can test all of the ATrack settings without causing any harm to your telescope and a good way to change settings to see how they work.

If using a simulator then when tracking correction is running, simply drop images into the watch folder manually (simulates the image acquisition software saving images to the folder). As each image is added to the folder, ATrack will call pinpoint to plate solve the image and then calculate image drift and shift. The log file can then be analyzed to view the results in a spreadsheet.

Save the settings to a profile with a name like "Testing". Then it can be loaded after making changes to a default set. Or, after a optimal set has been found then save the profile as "Optimal settings" or "Default".

1.5. Operating Procedure

1.5.1. Simulation

<TODO>: Insert description text here... And don't forget to add keyword for this topic

1.5.2. Passive Mode

1.5.3. Using a Sky Model

<TODO>: Insert description text here... And don't forget to add keyword for this topic

2. Program Functions

ATrack uses Tabs to display the user interface indicators and controls. Each tab is a major function of the program. The major functions are:

• Config - enter program configuration data.

• Adaptive Tracking - start/stop tracking correction and display current status.

• Model - define the operating parameters for a simple tracking model.

• Mount - select mount type, connect/disconnect from the mount and display current status.

• Pinpoint - define the operating parameters for Pinpont plate solving engine.

There are two types of indicators: a) status, b) configuration. Status indicators display the status of an ATrack operational parameter, e.g., telescope RA. If the status is red it means the status is not available, e.g., mount not connected. If the parameter is green it means the status is available and is updated automatically by the program to display current status.

A configuration indicator displays the current value of ATrack configuration parameters, e.g., a centering rate in arcsec per minute. If the indicator is red it means the value is not being used. A green indicator means the parameter value is valid and is being used by ATrack.

The control types are: a) buttons, b) check boxes, c) spin up down buttons. A red button means that function is not active, e.g., tracking correction is not running. A green button means the function is active. These buttons are toggle buttons which mean clicking them repeatedly will change the state active or inactive (green or red).
  Some buttons may always remain green meaning their function is executed when the button is pressed, e.g., SET for setting the mount base tracking rate to a new value.

Check boxes operate as normal check boxes. A tick in the box means the function is enabled, no tick means the function is disabled.

Spin up down buttons are used to incrementally change the value of a configuration parameter, e.g., a delay counter. Each button has a lower minimum value and an upper maximum value. The parameter can be changed directly by clicking on the value and entering the desired value.

The next sections describe in detail each major function (Tab).

Config Tab

The config tab is used for setting program configuration parameters. The values are saved in the "config.ini" file located in the ATrack folder. The config.ini file is updated when the program is closed, not when a parameter is changed. The config parameters are loaded from the config.ini file when the program is started. If a config.ini file is not found then default values for each parameter are used.

Many of the configuration parameters can be changed while tracking correction is running and will be used the next time the program uses the parameter. For example, the centering rate can be changed at any time and when the next centering function is performed the new value is used. Those parameters that do not affect the currently running tracking correction when changed are noted in their descriptions below.

It is recommended that the configuration parameters be reviewed before turning on tracking correction.

Indicators and buttons

Center on Target Coordinates   Profiles   Base Tracking rate   Centering rate   Tracking rate limiter   Delay counter   Image Mask   New images folder

⑤   **①**   **⑦**   **⑥**   **⑧**   **④**   **③**   **②**

CONFIG

Profile   E:\ATrack\GCVS SS For.prf   [Load Profile]   Images Folder   C:\Images

                                          [Save Profile]   Image Mask

☑ Center on Target Coordinates   RA   02 07 52.00   DEC   -26 51 58.0   (J2000)   Delay counter   0   Images

Base Tracking rate   Centering rate   01.00   arc-sec/min

[SET]   RA   +0.00000   arc-sec/sec

[RESET]   DEC   +0.00000   arc-sec/sec   Limiter   RA   0.50000   arc-sec/sec

                                                         DEC   0.50000   arc-sec/sec

Drift correction

Integrator   RA   5   Images   Mount polling rate   001   sec

              DEC   5   Images

Limiter   RA   0.10000   arc-sec/sec   Tracking model update period   015   sec

         DEC   0.10000   arc-sec/sec

                                         ☐ Invert RA Corrections

                                         ☐ Invert DEC Corrections

⑨   **⑫**   **⑬**   **⑩**   **⑪**

Drift correction integrators   Drift correction rate limiter   Tracking rate inverters   Mount status polling rate   Tracking correction frequency

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① Profiles

Profile   E:\ATrack\GCVS SS For.prf   **Load Profile**

                                                Save Profile

Profiles are used to save program user defined parameters in different files. For example, a profile can be used to save specific parameters for each target star. Refer to section Profiles for a more detailed description.

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② New images folder

Images Folder   C:\Images

ATrack uses science images from the main imaging camera to determine drift and centering corrections. This parameter specifies the folder the new images are saved in by the image acquisition software. This is also referred to as the "Watch Folder".

As each new image is saved in the watch folder, ATrack will open the image, pass it to Pinpoint to calculate the plate solution and then the corrections calculated.

A dialog for selecting the watch folder is provided at the far right of the edit field.

This parameter must be defined before starting tracking correction. Tracking correction must be turned off before changing this field.

3 Image Mask

Image Mask [   ]

This mask can be used to select (filter) specific images for processing. For example, if a narrowband image is known to not plate solve reliably then a "Clear" filter image can be added to the imaging sequence and this mask used to select only those images (mask = Clear). The narrowband images might be 120 second integrations while the plate solve image (Clear) might be 15 seconds.

If left blank then all images added to the watch folder are processed.

4 Delay counter

Delay counter [0] **Images**

This can be used to process a subset of new images. The counter specifies how many images are ignored before processing the next image. For example, a value of 1 would be used to process every other image (half of the images). A value of 5 would be used to process every 6th image.

The first image is always processed. The counter begins after the first image.

A value of 0 means all new images are processed.

5 Center on Target Coordinates

☑ **Center on Target Coordinates**   RA [02 07 52.00]   DEC [-26 51 58.0] (J2000)

This is only used if the centering function is enabled.

If the centering function is enabled then the program must know what RA and DEC to center each image to. There are two options: a) a user specified coordinate, b) the first image. The checkbox is used to select which option.

If centering on a specific coordinate then the RA and DEC coordinates must be entered manually using a "hh mm ss.ss" for RA and "+-dd mm ss.s" for DEC. Coordinates must be J2000 coordinates. The value can be saved in a profile. Each image processed by ATrack will compare the current plate solution with the reference coordinates and attempt to center the telescope if centering is enabled.

If not centering on a specific coordinate then the plate solution of the first image is used as the reference coordinate for the observing run. Subsequent images will then attempt to matching the centering to the first image.

6 Centering rate

Centering rate [01.00] **arc-sec/min**

This is only used if the centering function is enabled.

The centering rate specifies how fast the telescope will attempt to recenter and also defines the maximum distance the telescope will move when centering each minute.

For example, if the plate solution shows the telescope is off center by 5 arcseconds in RA, then the RA motor tracking rate will be increased this amount for a period of time long enough to recenter the telescope. In this case if using 1 arcsecond/minute centring rate and a 5 arcsecond movement is required, it will take 5 minutes to recenter the telescope.

If the centering rate is too fast then the stars will be distorted on the next image. If the centering rate is too slow it will take longer to recenter the telescope and may not be able to keep up with an accumulated tracking error in the mount.

When calculating this number, consider the image plate scale and the exposure time of the images. The total drift of the star in the image in pixels will be:

centering drift (px) = centering rate (arc-sec/min) x exposure time (seconds) / 60 seconds/minute / plate scale (arcsec/px)

Example:

centering rate = 1.0 arcseconds / minute
exposure time = 60 seconds
plate scale = 1.5 arcseconds / pixel

centering drift = 1.0 x 120 / 60 / 1.5 = 0.66 pixels (would not cause any noticeable elongation of the stars)

but if the exposure time = 10 minutes and the recentering distance is 10 arc-seconds then

centering drift = 1.0 x 600 / 60 / 1.5 = 6.7 pixels (this would cause the stars to be elongated)

In general, if taking short exposure images then increase the centering rate. If taking long exposure images then decrease the centering rate.

7 Base Tracking rate

The base tracking rate is a constant tracking correction rate that is fixed during the observing run. If the mount has a known 'bias' in its tracking error then the base tracking rate correction can be used to offset that. Normally this value is set to 0.

This can also be used to test the system. Using a simulator, the base tracking rate for each motor can be set to a large value, e.g., 5 arc-sec/sec and then the change in the RA and DEC positions can be examined to check both rate and direction.

It can also be used to create very precise star trails in an image. For example, if the the image exposure time is 300 seconds and the base tracking rate is set to 0.10000 arcseconds / second then the star trails will be 300 x 0.100 = 30 arcseconds. This might be useful when studying changes in luminosity due to a rotating object such as an asteroid.

8 **Tracking rate limiter**

Limiter	RA	0.50000	arc-sec/sec
	DEC	0.50000	arc-sec/sec

Used to limit the maximum value of the tracking rate correction to the RA and DEC motors. The correction rate is the sum of four components (base tracking rate, drift correction, centering correction and model correction). If the sum is greater than this number then it will be limited to the max value.

This is very useful if a typing error is made or an invalid model used that results in incorrect tracking correction rates.

9 **Drift correction integrators**

Integrator	RA	5	Images
	DEC	5	Images

This is only used if the Drift correction function is enabled.

NOTE: a value of 0 or 1 effectively disables the integrator. Values of 2 or more are normally used.

An integrator is used to smooth the drift correction values by taking the average tracking rate of the current and last n-1 images. For example, if the integrator is 5 images then the tracking correction rate of the current image and the previous four images are averaged and used as the drift correction rate.

NOTE, when the observing run is started, the integrators are reset to 0. This means the tracking correction rate of the second image (which generates the first tracking correction rate) will be the average of the tracking correction rate and the previous n rates which are 0. This has the effect of slowly ramping up the actual tracking correction rate used.

This value is dynamic and takes effect on the next image. For example, the value could be set to 0 for the first tracking correction and then set to 3 for the next five images and then 7 for remainder of the run. This would provide a more responsive correction but may be more erratic.

If the integrator is too small then the telescope drift correction may end up chasing the seeing conditions.   If the integrator is too large it may not be able to keep up with the change in correction rates over a declination arc.

10 **Mount status polling rate**

Mount polling rate	001	sec

Specifies how often the mount is requested to send status. Normally a value of 1 second is used, but if this causes problems with the other software then this can reduced. Too large a value may affect the tracking correction performance due to old values being used in the calculations.

11 **Tracking correction frequency**

Tracking model update period	015	sec

This is only used if the Model correction function is enabled.

Specifies how often the tracking correction is updated using the model. If the change in tracking is large then shortening this period will result in faster corrections. If the change in tracking is slow then a larger update period can be used.

12 Drift correction rate limiter

Limiter	RA	0.10000	arc-sec/sec
	DEC	0.10000	arc-sec/sec

This is only used if the Drift correction function is enabled.

Used to limit the maximum drift correction rate. This number should be less than the overall tracking correction limit defined above. The limiter insures an erratic drift correction number caused by a bad plate solve does not cause a large jump in the overall tracking correction.

13 Tracking rate inverters

☐ Invert RA Corrections
☐ Invert DEC Corrections

These are used to invert the tracking rate correction being sent to the mount. A good way to test this is to use the base tracking rate to move the simulator (or mount) in a given direction. If the direction is wrong then invert the correction and check again.

For example, if the RA base rate is set to 1.0 arcsec/sec then after 60 seconds the RA of the mount should have decreased by 1 arc minute (speeding up the RA motor causes it to track faster westward). If the RA increases then the mount actually slowed down and needs to be inverted.

Adaptive Tracking Tab

The Adaptive Tracking tab is where the tracking correction function is enabled/disabled. It is also used to select which tracking corrections are used and the tracking status. A spreadsheet is used to display the observing run log, which is also saved to disk after each image is processed.

It is important that the program configuration be completed and reviewed before starting tracking correction.
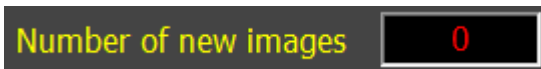
Indicators and buttons
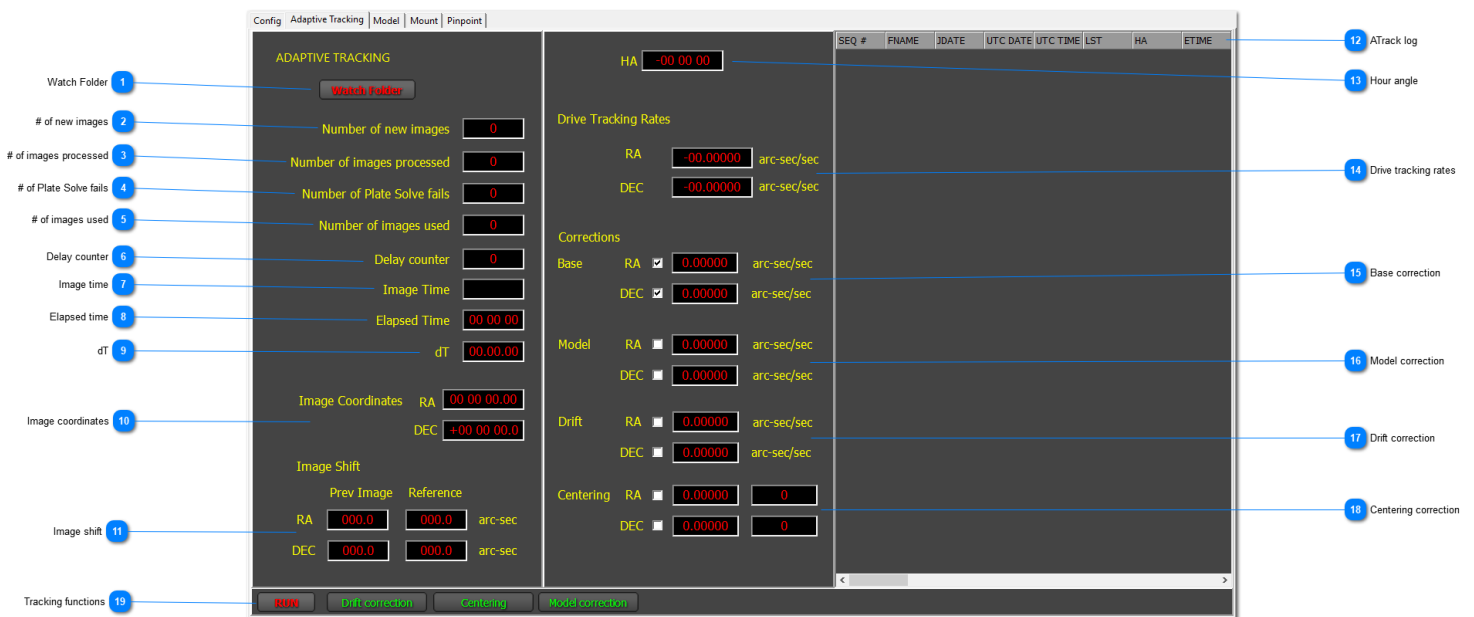
Watch Folder

Watch Folder

This button is used to temporarily suspend processing of new images. When the button is green it means any new image added to the watch folder is ignored. When the indicator is red it means all new images added to the watch folder are processed by ATrack.

of new images

Number of new images   0

This is the number of new images added to the watch folder. This number will be greater than or equal to the number of images processed by ATrack. It includes the number of new images added to the watch folder that were not processed by ATrack. This counter is very useful for determining if ATrack is watching the correct image folder. If an image is saved to disk and does not increment this counter then ATrack may be watching the wrong folder.

of images processed

Number of images processed   0
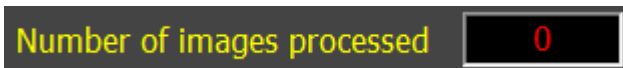
This is the number of images processed by ATrack. It should be equal to or less than the number of new images added to the watch folder. If an image is added to the watch folder and this number does not increment then:

• if the number of new images did not increase then it is likely ATrack is watching the wrong image folder,
• the delay counter may not be zero and some images will not be processed by ATrack,
• the image mask is set and the images do not include the mask

There is a difference between an image processed and an image used. An image processed means ATrack has passed the image to Pinpoint to plate solve. If the plate solve fails then the image is not used.

4 **# of Plate Solve fails**

Number of Plate Solve fails   0

A count showing the number of images that were processed by ATrack, but failed to plate solve. If an image(s) fails to plate solve use the Pinpoint visual program to see if changing any of the pinpoint solve parameters need to be changed to get a successful solve. If successful then change the corresponding pinpoint settings in ATrack.

5 **# of images used**

Number of images used   0
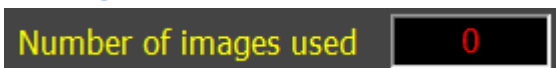
A count showing the actual number of images used in this observing run. This number should be equal to or less than the number of images processed. An image is used if it has a successful plate solve.

6 **Delay counter**

Delay counter   0

This counter is only used when the delay counter is non-zero.

This countdown counter shows the number of images that are added to the watch folder but not processed by ATrack. When the counter reaches 0 the next image will be processed.

7 **Image time**

Image Time

Shows the UT time of the image. It is taken from the image FITS header using the keyword: DATE-OBS.

8 **Elapsed time**

Elapsed Time   00 00 00
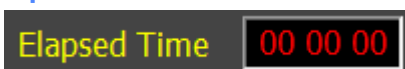
This is a simple counter that shows the elapsed time of the current observing session.

9 **dT**

dT   00.00.00

This is the elapsed time from the previous solved image to the current solved image. It is calculated by subtracting the UT time of the previous image from the UT time of the current image:

$$dT = UT \text{ current image} - UT \text{ previous image}$$

dT is used to calculate the telescope drift. dT is normally the exposure time of the images but can be longer if other tasks such as focusing or slewing are performed or one or more images did not plate solve.

10 **Image coordinates**

Image Coordinates RA `00 00 00.00`

DEC `+00 00 00.0`

This is the plate solution reported by Pinpoint of the current image.

11 **Image shift**

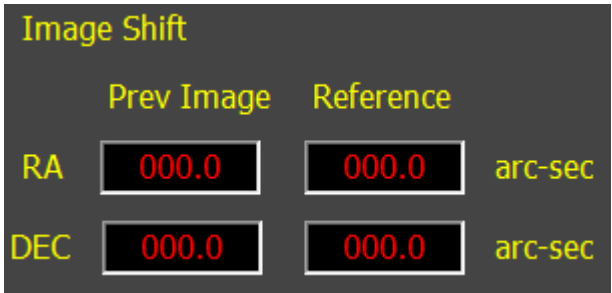| Image Shift	Prev Image	Reference	
RA	000.0	000.0	arc-sec
DEC	000.0	000.0	arc-sec

Image shift is the difference between the current image plate solution and a reference coordinate. The reference coordinate can be either a fixed RA and DEC entered by the user or the plate solution of the first image in the observing run. If a reference coordinate is used then the first image is used to calculate the image drift. If the first image is used as the reference then the image shift for the first image is 0 and the second image will show a drift away from the reference.

This image shift is displayed in the "Reference" column.

The image shift values are used to calculate the centering distance if the centering function is enabled. Ideally the image shift should be 0.

The image drift is shown in the "Prev Image" column.

Image drift is the difference between the current image plate solution and the previous image plate solution. The first image will have a drift of 0. Subsequent images will show the drifting of the telescope. NOTE: telescope drift can include any centering action if enabled. For example, if the telescope recentered two arcsec and the drift is one arcsec then the drift displayed would be three arcsec:

drift = telescope drift + centering move

If centering is disabled then the drift is the telescope drift.

12 **ATrack log**

SEQ #	FNAME	JDATE	UTC DATE	UTC TIME	LST	HA	ETIME

ATrack displays a log using a spreadsheet. Each row in the log is either a new image or a status message. See the ATrack Log file for a detailed description of the log fields.

In addition, a log file is saved in the watch folder. Each new entry to the log updates the disk file so no data is lost if the program is terminated due to an error. The log filename includes the date and time the log was created. The log file is tab delimited and can be imported into a spreadsheet for further analysis.

NOTE: each time an observing run is started, a new log file is created. Examining the size of the file indicates how many images were processed.

Hour angle

HA -00 00 00

This clock is used to display the time before crossing the meridian or the time past the meridian. This is useful for knowing when a pier flip may be coming up.

Drive tracking rates

Drive Tracking Rates

RA -00.00000 arc-sec/sec

DEC -00.00000 arc-sec/sec
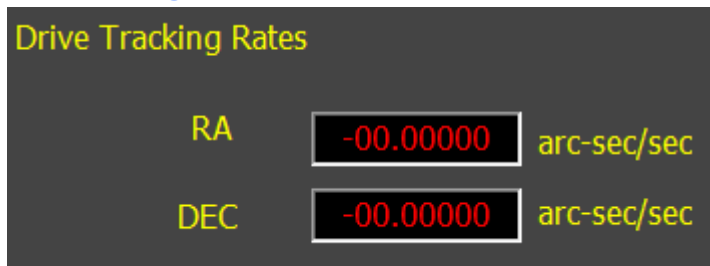
These are the current tracking rates received from the mount. It should include the sum of all the ATrack correction rates:

Tracking Rate = Base + Model + Drift + Centering

If all of the correction rates are disabled then the Tracking rate should show 0.

NOTE: this value is added to the telescope sidereal rate, which is not included in the RA tracking rate. For DEC it is the actual tracking rate.

Also, the tracking rate does not include any tracking corrections provided by ProTrack or APCC when using models as these are done independently of ATrack.

Base correction

Corrections

Base   RA ☑ 0.00000   arc-sec/sec

        DEC ☑ 0.00000   arc-sec/sec
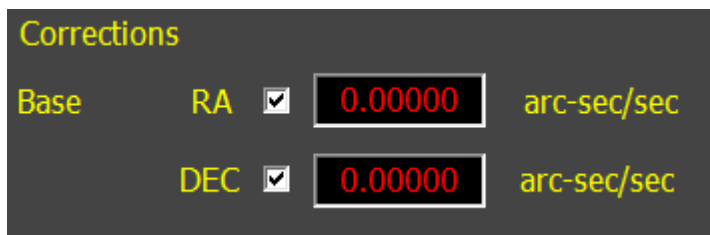
This is the base correction rate applied to the RA and DEC motors. It is a fixed value that is only changed by the user. To set or reset the base rate use the Base Tracking Rate on the config tab.

Red indicators mean the function is disabled. For the Base correction it means tracking correction is not enabled. A green indicator means tracking correction is enabled and the base correction values are being added to the overall tracking correction rate sent to the mount.

The checkboxes are used to individually enable/disable the correction for a given motor. This is normally used if the telescope mount supports tracking corrections in only one motor.
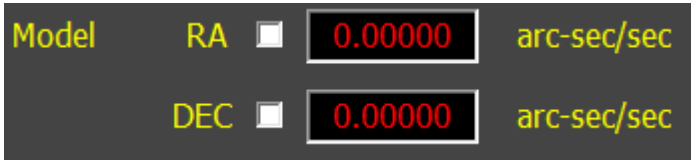
Model correction

The model correction is calculated from the hour angle (see Theory of Operation for more detail).

The model correction values are updated periodically using the Model Update user specified value in the config tab.

A red indicator means the values are not added to the total tracking correction due to either tracking correction not running or model correction disabled. A green indicator means the value is added to the overall tracking correction rate.

The checkboxes are used to individually enable/disable the correction for a given motor. This is normally used if the telescope mount supports tracking corrections in only one motor.

Drift correction
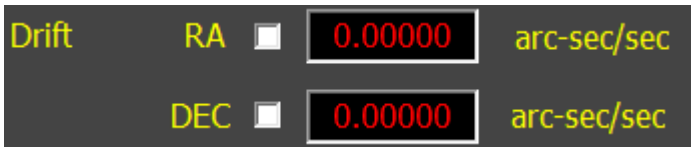
The drift rate is calculated by subtracting the plate solution from the previously solved image and the current solved image (see Theory of Operation for more detail).

A red indicator means the values are not added to the total tracking correction due to either tracking correction not running or drift correction disabled. A green indicator means the value is added to the overall tracking correction rate.

The checkboxes are used to individually enable/disable the correction for a given motor. This is normally used if the telescope mount supports tracking corrections in only one motor.

Centering correction
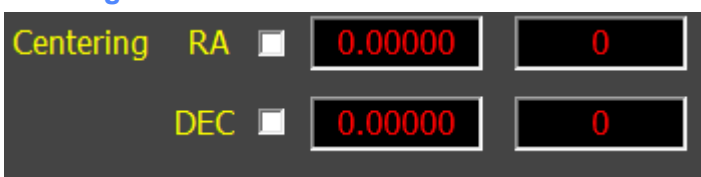

The centering correction (distance in arcsec) is calculated by subtracting the plate solution from a reference coordinate and the current solved image (see Theory of Operation for more detail).

The centering rate is a fixed value specified by the user.

The timer to the right of the correction rate indicates the number of seconds remaining in the centering correction. For example, if the centering rate is 1 arcsec/minute and the centering offset is 1 arcsec then this counter will begin with a value of 60 (seconds) and decrement each second. The centering rate will be added to the overall tracking correction rate. When the count down timer reaches 0 the centering correction rate is removed from the overall tracking correction rate.

NOTE: the centering for the RA and DEC motors operate independently of each other.

A red indicator means the values are not added to the total tracking correction due to either tracking correction not running or drift correction disabled. A green indicator means the value is added to the overall tracking correction rate.

The checkboxes are used to individually enable/disable the correction for a given motor. This is normally used if the telescope mount supports tracking corrections in only one motor.

19 **Tracking functions**

These buttons are used to enable/disable tracking correction, and each correction function.

At the start of an observing run the configuration parameters are checked, ATrack is connected to the mount and then the "RUN" button is clicked. The button will turn green indicating tracking correction is now running. To turn off tracking correction, normally at the end of an observing run, click the "RUN" button again and it will turn red to indicate tracking correction is now disabled.

The correction buttons are toggle buttons. Green indicates the function is enabled, red indicates the function is disabled. Any or all of the functions can be enabled or disabled. The functions can be enabled/disabled while tracking correction is enabled and take immediate effect.

NOTE: even though a function is enabled/disabled, tracking correction values are still calculated and displayed in the status indicators, but they will show as red values meaning they are not added to the overall tracking correction rate.

Model Tab
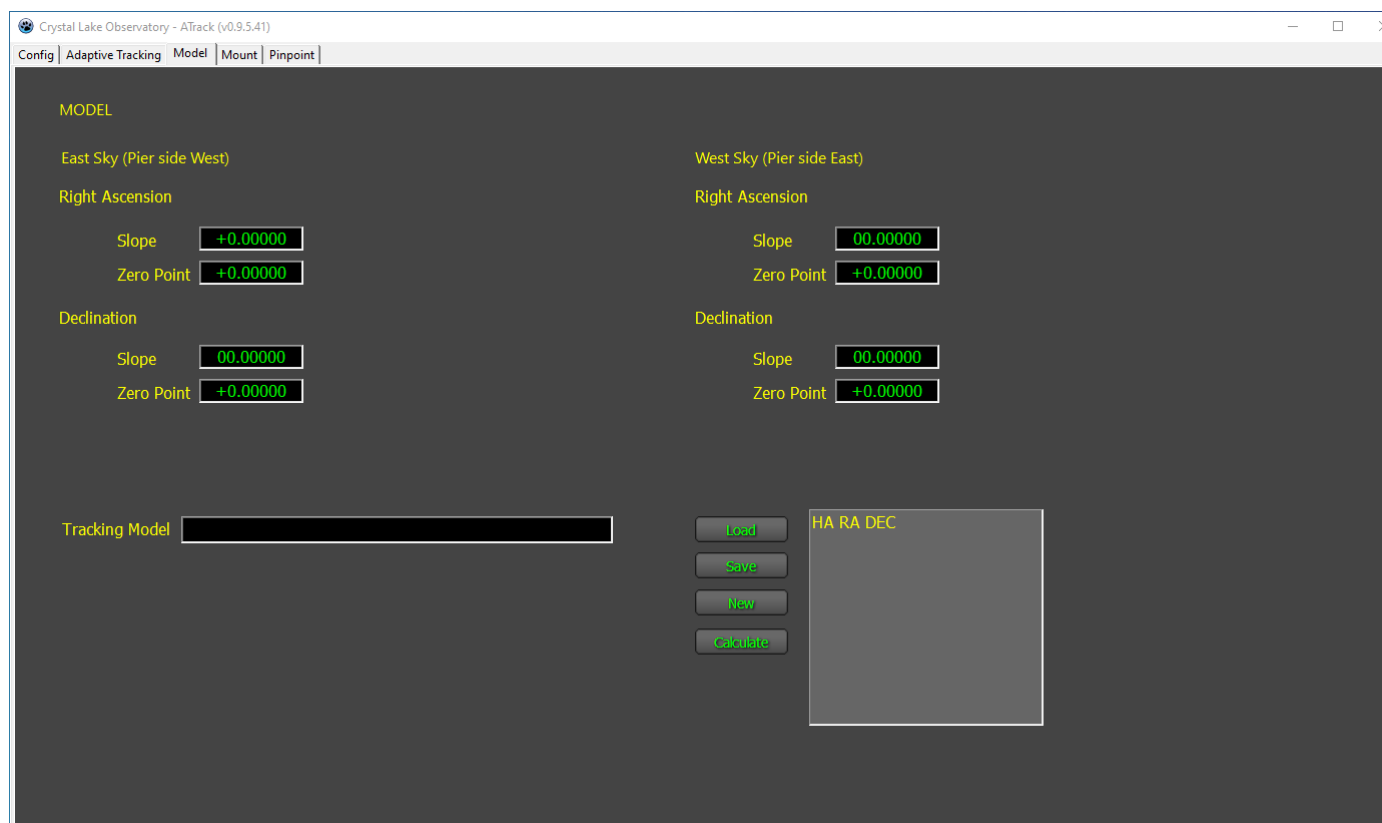
This tab is not needed if the telescope is already being controlled by a sky model such as ProTrack.

The model tab is used to define the parameters used to calculate the model tracking corrections (see Theory of Operation for more details).

There are two sets of parameters, one for the East sky and one for the West sky. For each set there are two parameters, Slope and Zero Point for both RA and DEC. These are simply the slope and intercept of a straight line along a declination arc.

The East sky is defined as negative hour angles along the declination arc of the observing run. The West sky is defined as the positive hour angles along the declination arc. ATrack will select the set based on which side of the pier the telescope reports. The reason for this is a telescope may track past the meridian for a period of time and ATrack will use the parameter based on this and not the sign of the hour angle.

Normally the parameters are derived from a spreadsheet using ATrack data, but there is a calculator on this tab which can be used to derive the slope and intercept from ATrack data.

All of the settings on this tab are saved in both a profile and the config file and restored when ATrack is restarted.

Indicators and buttons
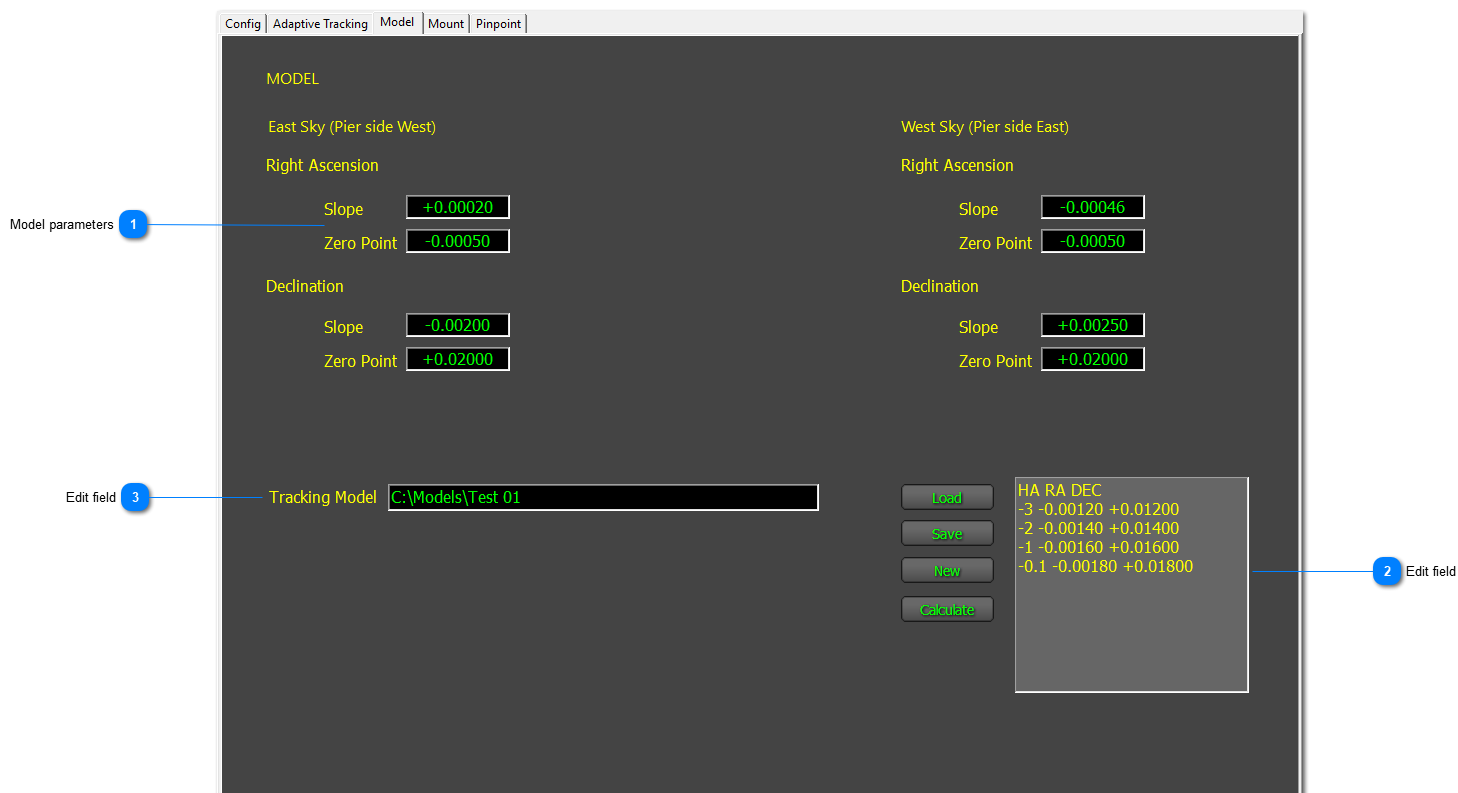
1 Model parameters

This is the slope and intercept of a straight line representing the tracking rate for a given hour angle along a declination arc. There is one set for the RA motor and another set for the DEC motor in each sky (East or West). These values are normally calculated by plotting the tracking correction rates from an ATrack log over a declination arc and then fitting a straight line to it. The intercept is the tracking rate at the meridian and the slope is the change in tracking rate by hour angle.

2 Edit field
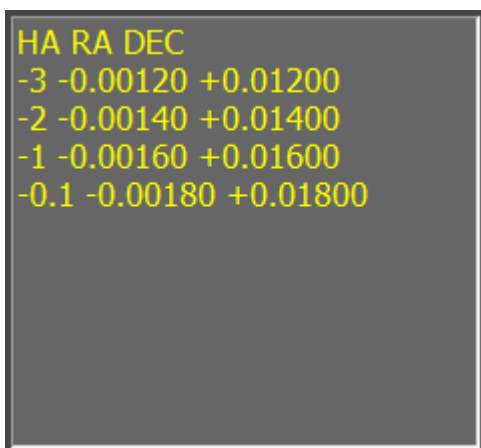
The slope and intercept used above can be calculated using a spreadsheet or using the ATrack linear regression fit calculator. Simply record the tracking correction rates at two or more hour angles along the

declination arc for each sky (East or West). The example shown shows 4 measurements made at hour angles of -3, -2, -1 and close to the meridian in the East sky (pier side West). The values are the RA and DEC tracking correction rates. Use the Calculate button to then determine the slope and intercept of the linear regression. These values are then automatically placed in the fields above. Use the Load and Save buttons to save the data and New to enter a new set.

NOTE: these data are not saved in a profile or config file so be sure to save them in a separate file if needed later.

3 **Edit field**

Tracking Model   C:\Models\Test 01

Specifies the name of the file to save the model data.

Mount Tab
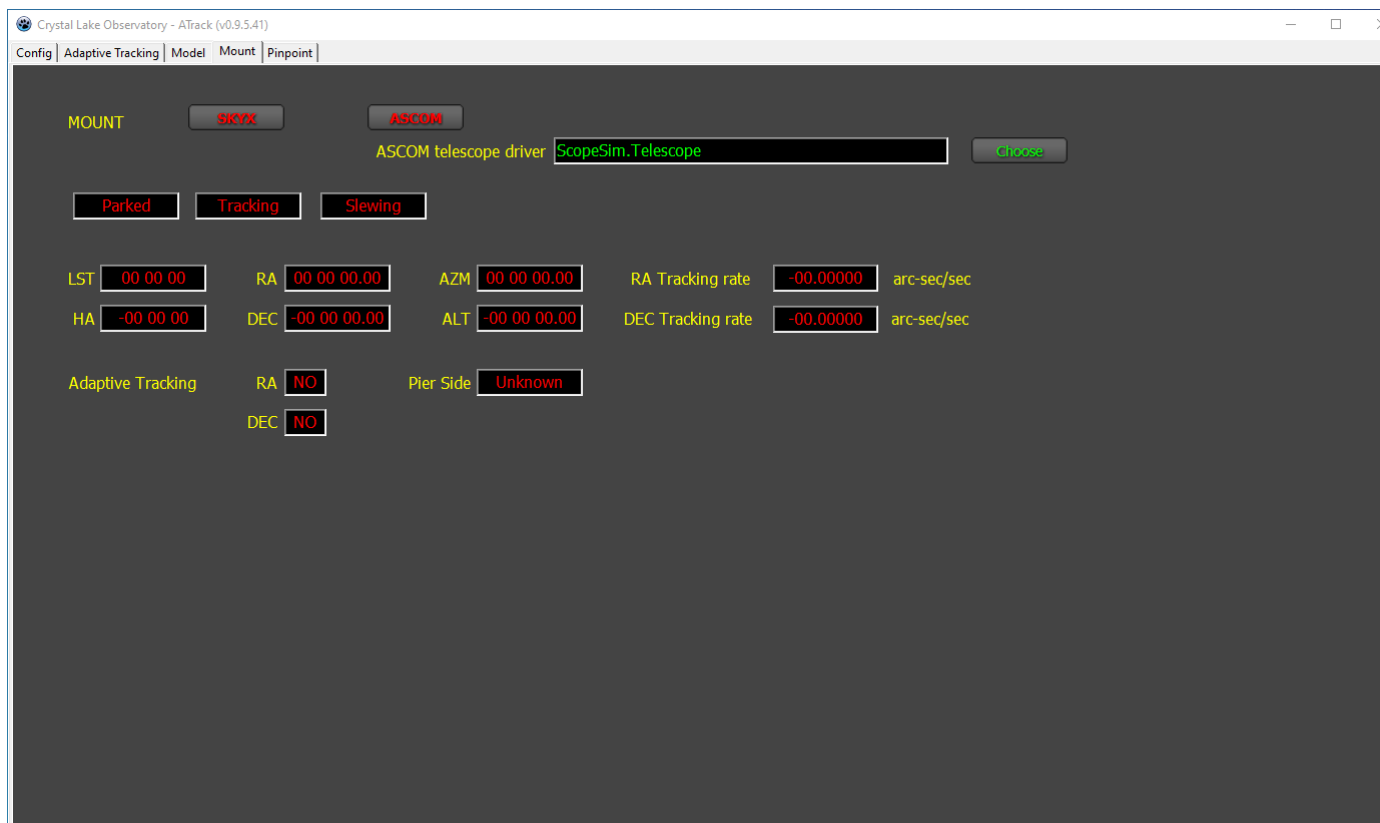
This tab is used to select the mount and view status information.

NOTE: the mount must be connected before running tracking correction.

At present there are two types of mounts that ATrack can work with: a) ASCOM mounts, and b) SkyX mounts. If using an ASCOM mount then the specific mount is selected using the ASCOM chooser tool. If using a SkyX mount then SkyX is used to select the specific mount and ATrack simply connects to SkyX, not really knowing which mount has been selected.

In addition, both SkyX and ASCOM support mount simulators which means you can test ATrack using a simulator before actually trying it on a real mount.

The indicators are all red until a mount is connected then they turn green. Status information is updated periodically based on the mount status polling rate specified in the config tab.

Indicators and buttons
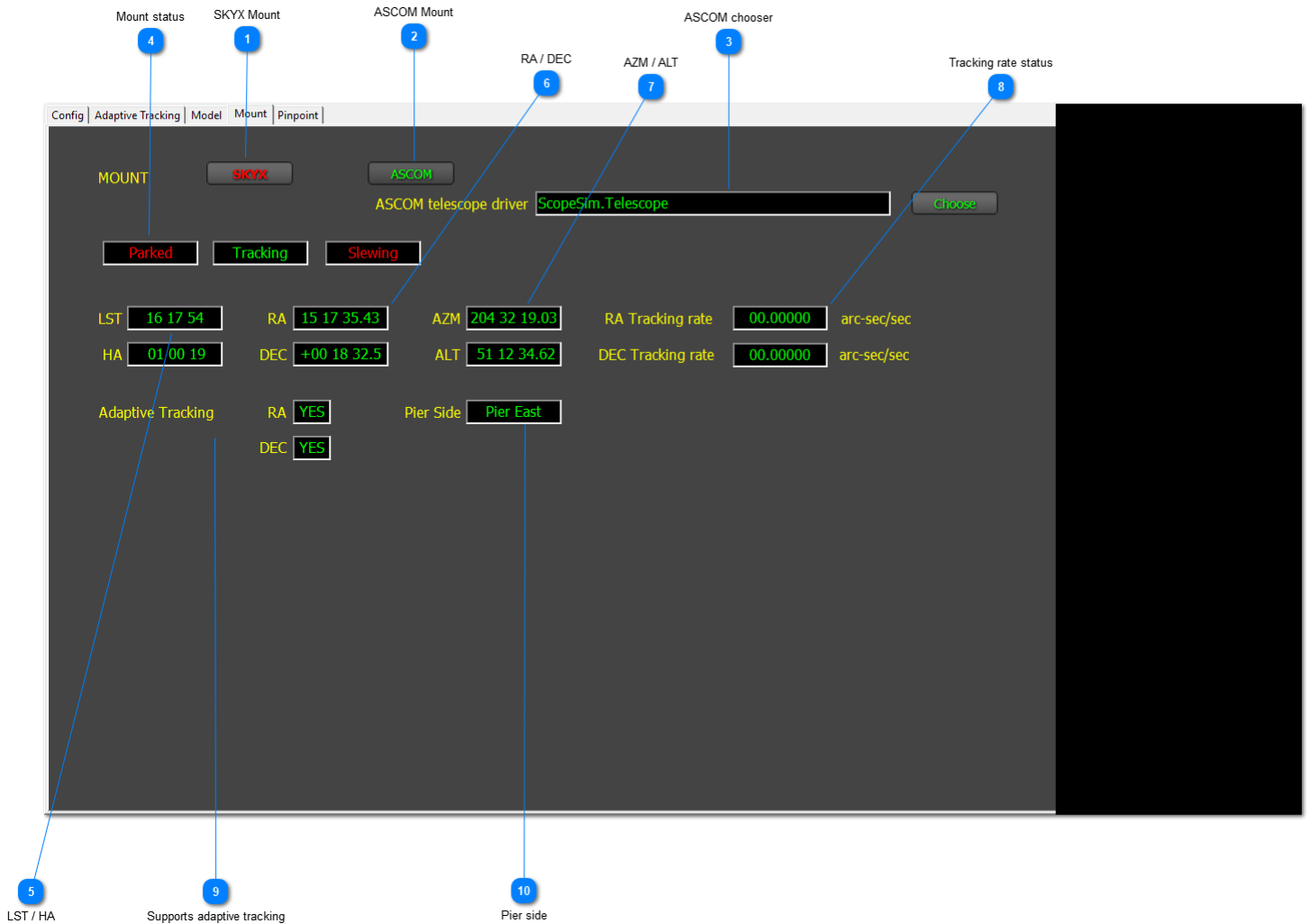
SKYX Mount

Click this button to connect to a SkyX mount.
When connected, the button will change from red to green.
To disconnect, click button again and it will change back to red when disconnected.
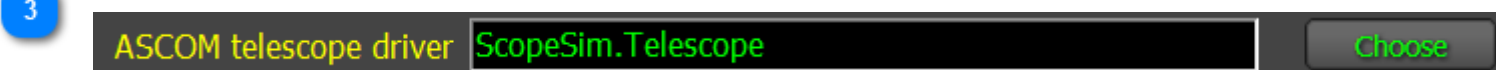
ASCOM Mount

Click this button to connect to a ASCOM mount.
When connected, the button will change from red to green.
To disconnect, click button again and it will change back to red when disconnected.

NOTE: be sure to use the chooser (below) to select the ASCOM mount before trying to connect to it.

ASCOM chooser

Use this to select the specific ASCOM mount. It will open ASCOM on the PC to select and setup the mount.
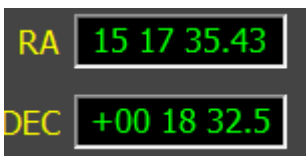
4 **Mount status**

Displays the mount status.
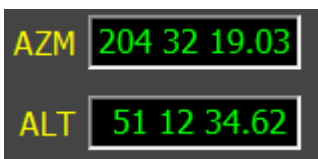
5 **LST / HA**
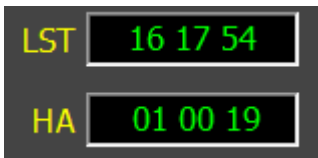
The Local Sidereal Time (LST) and Hour Angle (HA) as reported by the mount.
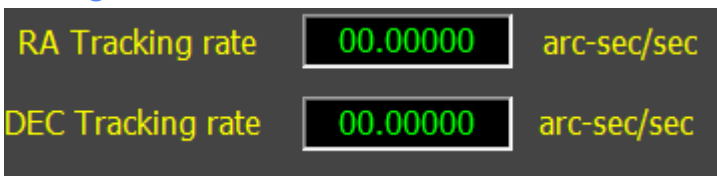
6 **RA / DEC**

The RA and DEC (J2000) of the telescope as reported by the mount.

7 **AZM / ALT**

The Azimuth (AZM) and Altitude (ALT) of the telescope as reported by the mount.
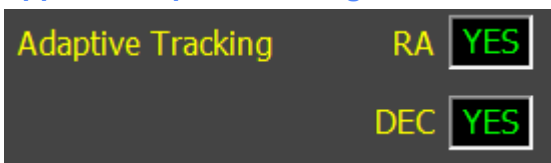
8 **Tracking rate status**

Current tracking rate as reported by the mount.

NOTE: this will not include the sidereal tracking rate of the telescope and will not include any sky model corrections provided by an external program like ProTrack.

9 **Supports adaptive tracking**

The result of asking the mount if it supports setting custom rates for RA and DEC.

NOTE: SkyX mounts report NO but they do actually wok okay with ATrack. This is being investigated.

10 Pier side

Pier Side **Pier East**

Which side of the pier the telescope is on, as reported by the mount. Pier side east means the telescope is on the East side of the pier looking at the West sky. Pier side West means the telescope is on the west side of the pier looking at the East sky.

Pier side
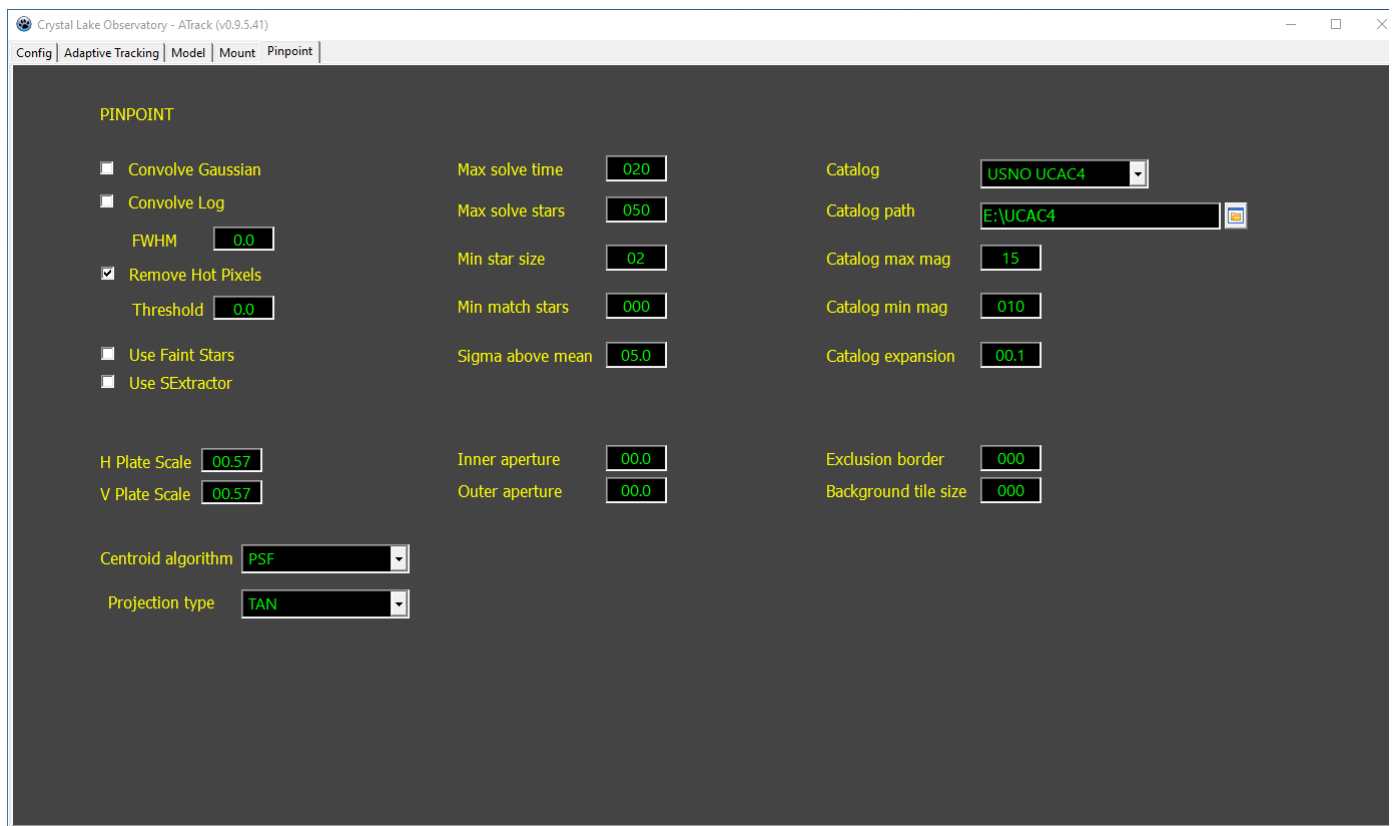
Pinpoint Tab

This tab is used to set the Pinpoint parameters for plate solving.

One method for determining the best set is to use Visual pinpoint and solve typical images recorded previously. By changing the various settings the plate solve can be "tuned" for maximum performance. Images that previously failed a plate solve can sometimes be solved by carefully tuning the engine parameters. Once an optimum set has been determined, they can then be entered on this tab.

NOTE: the parameters are saved within a profile and so each profile can have its own set of Pinpoint settings.

The definition of each of these parameters is fully described in the Pinpoint documentation and not included in this document.

3. ATrack Log file

4. Building an ATrack Model

5. Profiles