AstroTortilla User Guide

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1. Introduction

AstroTortilla automates repetitive tasks in astrophotography by plate solving acquired images and making it possible for the necessary software to communicate with each other. By blind plate solving it is possible to snap a picture from anywhere on the sky, identify the direction and sync the GoTo mount to that position.

When doing GoTo-slewing over large distances on the sky the target normally ends up somewhere else than the center of the camera view, if not completely out of the frame. AstroTortilla is capable of applying iterative corrections for the initial slew and getting the target object spot on the center of the frame, often with one or two slews - no matter how bad the GoTo-calibration.

Plate solving combined with goto control also provides a very fast and convenient way of polar aligning the mount. Just let AstroTortilla look around and take a few images and then apply the alignment corrections on your mount’s alignment knobs as suggested by AstroTortilla. In addition, with the ability of controlling the mount and camera, AstroTortilla includes a clever photographic aid for traditional drift alignment with no need for plate solving.

Mexican tortillas are commonly prepared with meat to make dishes such as tacos, burritos, and enchiladas. *AstroTortilla* wraps itself around a bunch of useful software for a tasty nocturnal snack under the starry night sky.

2. Compatibility with other software and equipment

2.1. Camera control

AstroTortilla is able to control any astronomical camera (CCD, DSLR etc.) through the remote interface of ***Nebulosity2*** by Stark Labs or ***Maxim DL*** by Diffraction Limited. Additionally, though not very useful on the field, AstroTortilla can directly control any compatible camera with the ***ASCOM interface***.

PHD Guiding by Stark Labs or any other imaging software can be used via a ***screenshot plugin***. In case your camera can't be supported in any of the above ways, AstroTortilla can read your image files ***from the hard drive***. In future versions directory monitoring will be available to automate the loading of new images.

For users wishing to add support for other camera control software, encouragement and advice are available.

2.2. GoTo mount control

AstroTortilla currently supports any computerized tracking mount with an ***ASCOM interface***. The field testing of AstroTortilla functions under the night sky is carried out with EQMOD software controlling Sky-Watcher HEQ5 and EQ6 mounts.

The ASCOM interface currently limits the usage of AstroTortilla to a Microsoft Windows platform. Supporting the *INDI* interface standard will hopefully be possible in the future and enable AstroTortilla to run under Linux/Unix environments too.

2.3. Plate solver software

AstroTortilla currently uses the ***Astrometry.net*** plate solver engine. The engine can either be run locally trough the linux-like CygWin environment for Windows or through the Astrometry.net online plate solve service. In the future support for using your own local area solver server might be available.

Another possible engine for plate solving the images is *PinPoint Astrometric Engine* by DC-3 Dreams, but support for this is not yet implemented. Unfortunately AstroTortilla is unable to support the free *PinPoint LE* since it can not be controlled trough a remote interface.

3. Plate solving

Plate solving is the sport of identifying the shapes drawn by the locations of stars in an astronomical image. Once the stars are identified, this astrometric solution can be used to work out the coordinates of the center of the frame, the width an height of the field of view, the rotational angle of the image with respect to celestial coordinate axes, the angular resolution of one pixel in the imaging setup and, by knowing the pixel size of the sensor, the exact focal length of the imaging objective used.

Normally, a stellar catalog, that is, a database of star locations and a rough estimate of where the telescope was pointed at during exposure are needed to successfully plate solve an image.

3.1. Astrometry.net

The Astrometry.net project is a revolutionary effort of developing means of working out the astrometric solution of any astronomical image *with no initial knowledge* of the imaging parameters *whatsoever*. The project will make its engine, algorithms and code freely avaible to the public. The key to blindfolded fast plate solving is reducing the calculation time by pre-building huge catalogs of four-star patterns of the whole sky.

At the time of writing Astrometry.net is in *beta testing* phase. An online user interface for plate solving your images is at http://nova.astrometry.net. Astrometry.net can also be run locally in a Linux, Unix, Mac box or Cygwin for Windows environment.

AstroTortilla is compatible with both of these two ways of using Astrometry.net. (not true yet) For using the online solver with AstroTortilla you need to get yourself an API key by signing in. You don't need to sign up in order to sign in, you can use any OpenID account (Google etc.) instead.

Using the online solver plugin requires your imaging PC to be connected to the internet and will be slower than local solving. However, it saves you the trouble from installing Cygwin and keeping a few gigabytes of indices on your hard drive. The online solver plugin might be especially useful for trying out AstroTortilla.

3.1.1. Installing Cygwin and Astrometry.net

For running the linux based Astrometry.net engine locally on a Windows platform, installation of the Cygwin emulator environment is needed. In case your not very computer inclined, installing Cygwin might be a bit unpleasant. However at this point we've managed to streamline the installation quite a bit by including Astrometry.net in the Cygwin software repository.

The Cygwin installation will take up almost a gigabyte of hard disk space and it will contain loads of less useful stuff.

The indices (databases) needed for plate solving however will use up even more space. Solving fields shot with camera optics, short refractors etc. fortunately only require a few small sets of indices, about 1 GB in total. Indices for solving fields smaller than this grow exponentially in size with the rest indices taking up about 24 GB in total.

The instructions below assume that Cygwin will be installed under it's default location, `C:\cygwin`. If you wish to install elsewhere, please adjust the path accordingly (ie. `C:\cygwin` -> `X:\util\cygwin`) when installing the indices.

1) Getting the installer

The installer is available at http://cygwin.com/install.html. Download and run setup.exe. After running choose "Install from the Internet". The installer prompts you for install locations, mirrors to use (usually any one nearby you should work) and after that you'll get to select which packets to install.

2) Choosing the packets (Astrometry.net)
As of now, it is finally easy to install Astrometry.net in Cygwin via the package repository.

First click the View button on your upper right until you see the “Full” viewing mode. Type the name of the package (“astrometry”) to the Search box to filter out matching results.

To select the package click the Skip text once and it changes to a version number. If you accidentally click twice, you can cycle back to the first version number after “Skip”. This is normally the latest version (0.38.1 at the time of writing).

After selecting Astrometry.net, click Next. The installer will now start a long work with three stages: Downloading, Installing and Running. After these you'll probably have a big pile of useless Cygwin stuff on your hard disk, together with a working Astrometry.net installation.

3) Downloading indices
Currently obtaining the indices for local plate solving involves accepting the conditions for using them and sending an email to the Astrometry.net staff as described in http://trac.astrometry.net/browser/trunk/src/GETTING-INDICES. Note that for now redistributing the indices to anyone is forbidden and in the meantime this is the only way to get them. For “stating clearly your intended use of the indices” in the request email, it's fine to explain you like to try out AstroTortilla. The staff will then shortly contact you with a download link.

4) Extracting indices
After downloading the indices you want, place them in `C:\cygwin\usr\share\astrometry\data\` or wherever your Cygwin directory is. Now open your Cygwin shell (a shortcut on your desktop), enter the command `cd /usr/share/astrometry/data` and then the command `tar xjf *.bz2`. Now the FITS-files inside the bz2-files should be extracted in the data-directory. You can make sure this is done, and then remove the bz2-files to save space by commanding `rm *.bz2`. You can also delete them by hand in Windows. Make sure not to delete the FITS-files!

5) Using AstroTortilla to solve images
If everything went fine, you should now be able to solve images with the `solve-field` command in the Cygwin shell. For info on how to modify the shell PATH variable to use the command anywhere and other usage, refer to the Astrometry.net documentation.

Now it's just a matter of choosing `AstrometryNetSolver` as the solver engine in AstroTortilla. Be sure to modify the Cygwin path in the settings table (see below).

4. AstroTortilla usage

4.1. Main screen

The main screen consists of four panels: Telescope, Camera, Solver and Actions.

The Telescope panel lets you select a telescope/mount. Currently, only `ASCOMTelescope` is available. You can connect to all ASCOM-compliant telescopes and mounts.

For useful operation, the ASCOM driver of your mount should work as a hub, i.e., allow several programs to connect to the mount driver simultaneously. This is the normal operation of, for instance, EQMOD and Astro-Physics ASCOM-drivers. In case your driver only supports one software at a time, consider trying out Plain Old Telescope Handset (POTH) at the ASCOM Standards website, or try some other ASCOM hub.

The Camera panel is used to connect to the camera you use. Depending on your camera control application, select `MaximDLCamera` or `NebulosityCamera`.

For trying out some other software through a live view on the screen, select `CaptureCamera`. Working settings for PHD Guiding are provided. For other software, configure the capture area yourself.

For manual GoTo-correction, or other testing purposes, `FileOpenCamera` lets you select an image file from the hard drive once you hit *Capture and Solve* at the Actions panel.

The Solver panel is where you choose the plate solver software to use. If you have Cygwin and Astrometry.net installed locally, use `AstrometryNetSolver`.

If you plan to use the online-version of Astrometry.net, select `AstrometryNetWebSolver`. Be sure to enter your personal API-key in the settings table below.

The Actions panel lets you decide what actions to take after exposing the image and getting a successful plate solution. You can choose only to Sync the scope (tell it where it's pointing), Re-slew the scope (turn the scope where it thought it was pointing before) and even Repeat the cycle until your within a tolerance of your choice from the desired coordinates.

In the ***Tools menu*** you can select Goto image or use AstroTortilla to polar align your mount (see below).

4.2. Normal workflow

When you've got the telescope, camera and solver selected, slew to your target with your favourite planetarium software. Now "Target" shows the coordinates of the object you selected, and "Current" shows the same coordinates since this is where the mount thinks it pointing at at this stage. This might however be more or less incorrect.

Select the actions of your choice in the Actions panel (e.g. all three to be safe), a suitable exposure time in the Camera panel and hit *Capture and Solve* in the Actions panel. AstroTortilla now uses the camera to expose a frame and delivers it to the solver engine. Once the engine has solved the field, AstroTortilla is aware of the *true* pointing direction of the scope and indicates the coordinates in the Camera panel.

If the *Sync Scope* option was checked, the true coordinates are indicated in "Current" at the Telescope panel, too, and the GoTo of your telescope is now properly calibrated.

If the *Re-slew to target* option was checked, AstroTortilla applies a new slew command to the mount, to the coordinates your mount assumed it was pointing at earlier. Usually your object will now be very close to the center of your frame.

In case your mount calibration was way off to start with or the object still isn't quite centered yet, you can choose to have AstroTortilla repeat the previous actions automatically until the target is centered. Check the *Repeat until within* box and enter your desired tolerance in arc minutes in the numeric box.

4.2.1. Future workflow

In the future the workflow described above will be greatly simplified when AstroTortilla will act as an ASCOM-compatible telescope. This means you can choose AstroTortilla as the telescope driver in your planetarium software. You can then choose to slew to an object in the planetarium software and AstroTortilla will automatically apply its plate solving GoTo corrections and get your object in the center of the frame with one click.

You can also choose not to apply the iterative corrections for slews shorter than a treshold of your choice, say five degrees. This makes AstroTortilla pass the slew commands from your planetarium software directly to the ASCOM driver of your mount to ensure small slews for, e.g., object framing purposes are executed without delay.

4.3. Goto image tool

The Goto image tool solves an image from your hard drive and slews the telescope to its central coordinates. You can use it to return to the exact framing of a previous night's exposing session, or mimic the framing of your favourite Hubble Space Telescope shot, for example.

To use it, select *Tools -> Goto image* and select the image to solve in the appearing dialog. AstroTortilla then solves it and slew the telescope to the coordinates of its center. The image has to be in FITS, JPEG, TIFF or PNM format.

When using the Goto image tool, AstroTortilla ignores any check marks you've entered in the Actions panel and always does iterative centering with the treshold you entered in the bottom of the panel. The search radius parameter in your Solver panel is also ignored - the Goto image is always a blind solve.

4.4. Polar aligning your mount with AstroTortilla

AstroTortilla provides two ways to help your polar alignment task. You can access the tools via the *Tools* menu at the top.

The plate solver based **Polar Alignment** tool invites you to point the telescope first in the south and then in the east/west direction. After pointing, it moves your telescope around a bit and plate solves the directions. After this, it tells you the amount of your polar alignment error in degrees, which you then can adjust for.

The **Drift shot** tool will automate a clever technique for traditional drift aligning, described below. For this you don't even need to install a plate solver, only a camera and a mount supported by AstroTortilla is enough.

In the future, AstroTortilla will employ a fully automatic plate solver algorithm which takes three images around the sky and leaves you nothing but the job of turning the alignment knobs. Stay tuned.

4.4.1. Polar Alignment tool

The Polar Alignment tool exposes two pairs of frames with a half a degree offset in right ascension between the the images of the pair. Their plate solved coordinates are then used to calculate the polar alignment errors by detecting the amount of declination error when the mount was only moved along the RA axis.

A pair of frames shot at the east/west meridian is used to determine the altitude error of the polar axis, and a pair shot at the southern meridian (assuming northern hemisphere observation) gets you the azimuthal error.

To use the tool, select *Tools -> Polar Alignment*. Choose the correct hemisphere and point your mount roughly at the meridian to measure azimuth error or to the east or west to measure altitude error (also select which way you're pointing in the drop down menu).

Then press the according button to let AstroTortilla shoot and solve the pair of frames. When done, your polar alignment error in degrees is shown on the screen. Use this to correct your alignment by turning the alignment knobs on your mount.

When measuring azimuthal error, be sure not to point within a half a degree or closer to the meridian to avoid meridian flips! Pointing on the west (right) side of the southern meridian is the safest bet.

4.4.2. Drift shot tool

Drift alignment is an accurate but tedious way to adjust the polar alignment of your tracking mount, and it's easiest to accomplish by using a CCD camera. The fundamental idea of drift alignment is that polar alignment error will show up with stars drifting in the declination direction.

When imaging a star close to the **southern meridian** (assuming northern hemisphere observation), the error of the polar axis elevation adjustment contributes is zero and all observed drift is because of **azimuthal** misalignment. Similarly when imaging at the **eastern/western direction**, only **elevation** misalignment is responsible for the drift. These observations are then used to correct the alignment.

AstroTortilla makes it easier to observe the amount and direction of drift by employing a technique introduced by Robert Vice in the September 2005 issue of AstroPhoto Insight magazine. It involves slewing the mount eastward for a specified amount of time, after which an equally long westward slew is done.

If there's any declination drift present, the star will trace a horizontal V pattern. The image is exposed for a few seconds before starting the slews in order to create a small blob to the other arm of the V to distinguish the direction of drift.

When the alignment is correct, the V will converge into just a horizontal line. For more information about the V-drift method, see http://www.astrophotoinsight.com/node/568.

To use the tool, point your telescope at a reasonably bright star and select *Tools -> Drift shot*. AstroTortilla then starts a 30 second exposure and moves the mount around during it. You can then examine the resulting image to see if your alignment causes any declination drift.