STELLARDUINO

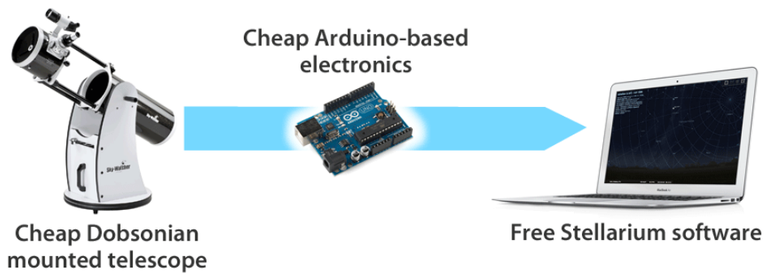
The Problem

Consumer telescopes are becoming very affordable, but they lack the convenience of digital tracking and alignment.

Although this is available on high-end telescope mounts, it's still prohibitively expensive.

The Solution: Stellarduino

A freely available digital telescope tracking system that amateur astronomers can download and assemble themselves from cheap and ubiquitous components.



Project Aims

Open source

Stellarduino utilises open source libraries, and is published on Github under the MIT license. Any future custom hardware will also be published under the Open Hardware guidelines.

Cheap to build

The components required to build Stellarduino are both cheap and ubiquitous. Total cost is under $100.

Simple to use

Free doesn't have to mean bad. Stellarduino is a plug and play device that abstracts away the complexity of celestial coordinate systems.

Technical Features

- ★ Two star alignment, using (possibly magic) matrix transformations to convert telescope coordinates to celestial.
- ★ PushTo navigation – you push the telescope, Stellarduino shows you where its pointing.
- ★ Implements the Meade Autostar protocol for serial output to other devices, such as the free planetarium software Stellarium.

Unimplemented Features

- ★ Automatic selection of alignment stars from internal memory.
- ★ Various screen display modes: celestial and horizontal coordinates, time, location, etc.

Project Milestones

1. Proof of concept

A float math test on the Arduino using fixed inputs for alignment, to see if it can keep up with input from the rotary encoders.

2. Alignment using preselected stars

Obtain useful output from alignment using preselected stars.

3. Implement Meade serial protocol

Get the output of Stellarduino to be visible as a "reticle" in Stellarium (free planetarium software).

4. Automatic selection of alignment stars

Stellarduino picks the best alignment stars to use from an internal catalogue of 50 bright stars.

5. LCD display mode selection

Allow the user to cycle between different display modes – RA/Dec, Alt/Az, time, long/lat, etc.

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How it works

Hardware

Stellarduino's hardware consists of:

- ⋆ Two high-resolution rotary encoders attached to each axis of the telescope, which read the rotational movement.
- ⋆ A 16 x 2 character display to show the current orientation of the telescope, status messages, etc.
- ⋆ Push buttons for user input.
- ⋆ A real time clock to avoid having to enter the time each time you power up.
- ⋆ An Arduino Uno or Nano to do all the math.

The Arduino barely scrapes in as powerful enough to do the job – the ATmega 328 chip provides **only two hardware interrupt pins**, which are split between the encoders, and the 8-bit microcontroller barely manages **single-precision floating point** operations, and with the real time clock, display and buttons installed, there's **not many pins left over**.

Math

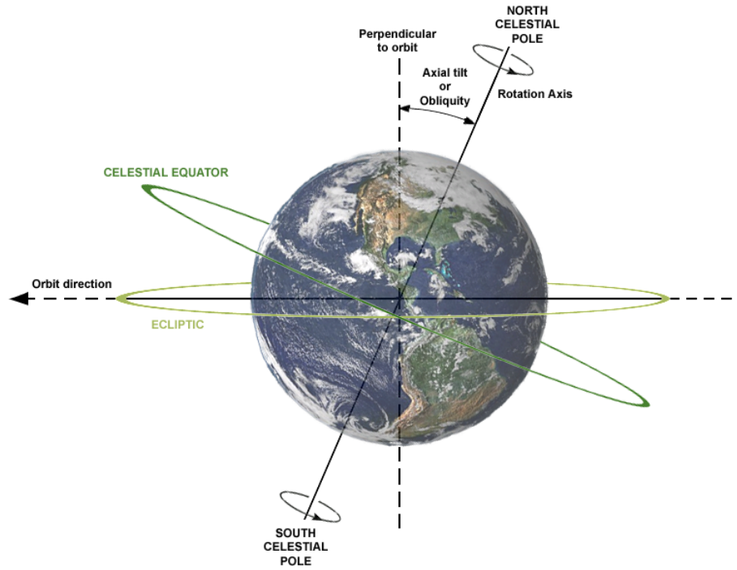
Until the advent of computers, coordinate translation was performed using horribly complex trigonometric functions

Stellarduino uses matrix transformation to convert the telescope's orientation to celestial coordinates.

The transform matrix is generated by conducting an alignment process, where the user orients the telescope at known bright stars, effectively linking corresponding points in each coordinate system.

This transform matrix is then applied to successive telescope coordinates to obtain their celestial equivalents.

$$\begin{pmatrix} \cos\theta\cos\varphi \\ \cos\theta\sin\varphi \\ \sin\theta \end{pmatrix} = \begin{pmatrix} \cos 1.09083078\cos 0.93375115\cos(-0.0013962634) \\ \quad -\sin(-0.0013962634)\cos 0.0026179939\sin 0.93375115 \\ \quad\quad +\sin 1.09083078\sin 0.93375115\sin 0.0026179939\cos(-0.0013962634) \\ \\ \cos 1.09083078\sin 0.93375115\cos(-0.0013962634) \\ \quad +\sin(-0.0013962634)\cos 0.0026179939\cos 0.93375115 \\ \quad\quad -\sin 1.09083078\cos 0.93375115\sin 0.0026179939\cos(-0.0013962634) \\ \\ \sin 1.09083078\cos 0.0026179939\cos(-0.0013962634) \\ \quad\quad +\sin 0.0026197739\sin(-0.0013962634) \end{pmatrix}$$



Coordinate Systems

Much like earth's geographic coordinates, the night sky is similarly partitioned by it's own celestial coordinate system.

It has a north and south pole that align with earth's, and a meridian at the Vernal Equinox, in the same way Greenwich is the earth's arbitrary meridian.

If you go outside and look straight up, directly above you, you're looking at a point astronomers call your local zenith, which is sort of "north pole" of another set called horizontal, or telescope coordinates.