Star Tracker

An attempt to create an Arduino powered device that can point at a particular star at any given instant of time.

DEPARTMENT OF ENGINEERING PHYSICS
IIT Hyderabad - 2018

Dhruv Gupta
EP17BTECH11006

Gautham Gururajan
EP17BTECH11008

Raghav Girgaonkar
EP17BTECH11016

Contents

1 Introduction **2**

2 Celestial Coordinate System **3**
2.1 Horizontal System 3
2.2 Equatorial System 3
2.3 Ecliptic System 3
2.4 Galactic System 4
2.5 Supergalactic System 4

3 Principle **5**
3.1 Right Ascension 5
3.2 Sidereal Time 5
3.3 Declination 5

4 Implementation **6**

5 Our Model **7**

6 Conclusion **9**

7 References **10**

1 Introduction

This project is an Arduino Powered Star Tracker and Pointer which uses the help of the Celestial Coordinate System. Celestial coordinates define positions of objects in the sky. It is based on the observations of ancient astronomers. They believed that the earth was motionless and was at the center of the universe.
There are different ways to specify the position of an object in the celestial sphere, the difference being the choice of the fundamental plane. The different types of coordinate systems are:

- Horizontal System
- Equatorial System
- Ecliptic System
- Galactic System
- Supergalactic System

2 Celestial Coordinate System

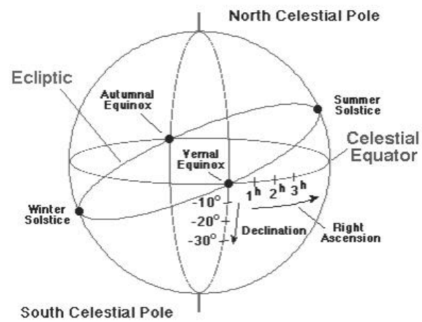

Fig.1: *Visualizing the Celestial Coordinate System.*

2.1 Horizontal System

The horizontal(or altitude-azimuth) system is based on the position of the observer on Earth, which revolves around its own axis once per sidereal day (23 hours, 56 minutes and 4.091 seconds) in relation to the star background. The positioning of a celestial object by the horizontal system varies with time, but is a useful coordinate system for locating and tracking objects for observers on Earth.

2.2 Equatorial System

The equatorial coordinate system is centered at the Earth's center, but is fixed relative to the celestial poles and the *vernal equinox*. The coordinates are based on the location of stars relative to Earth's equator if it were projected out to an infinite distance. The equatorial system describes the sky as seen from the solar system, and modern star maps almost exclusively use equatorial coordinates.

2.3 Ecliptic System

The fundamental plane is the plane of the Earth's orbit, called the ecliptic plane. There are two principal variants of the ecliptic coordinate system: geocentric ecliptic coordinates, centered on the Earth and heliocentric ecliptic coordinates, centered on the center of mass of the solar system.

2.4 Galactic System

The galactic coordinate system uses the approximate plane of our galaxy as its fundamental plane. The solar system is still the center of the coordinate system, and the zero point is defined as the direction towards the galactic center.

2.5 Supergalactic System

Supergalactic coordinates are coordinates in a spherical coordinate system which was designed to have its equator aligned with the supergalactic plane, a major structure in the local universe formed by the preferential distribution of nearby galaxy clusters (for example the Virgo cluster, the Great Attractor and the Pisces-Perseus supercluster) towards a (two-dimensional) plane.

3 Principle

In this project the Equatorial System of coordinates is used, this is because the altitude and the azimuth of a star are contantly changing making it difficult to use the horizontal coordinate system. In this system, the position of an object is defined by the *declination* and *right ascension.* Also, the coordinates of an object in the sky do not change relative to your position.

3.1 Right Ascension

Right ascension is the angular distance of a particular point measured eastward along the celestial equator from the Sun at the March equinox to the point above the earth in question.
It is the celestial equivalent of a longitude. Both the longitude and the right ascension measure an angle from a primary direction (a zero point) on an equator. Right ascension is measured from the sun at the March equinox i.e. the First Point of Aries, which is the place on the celestial sphere where the Sun crosses the celestial equator from south to north at the March equinox and is currently located in the constellation Pisces. Right ascension is measured continuously in a full circle from that alignment of earth and sun in space, that equinox, the measurement increasing towards the east.
Right ascensions are measured in hours(and minutes and seconds) of the Earth's rotation.For example, if a star with RA = 1h 30m 00s is at its meridian, then a star with RA = 20h 00m 00s will be on the/at its meridian (at its apparent highest point) 18.5 sidereal hours later.

3.2 Sidereal Time

Sidereal time is different from solar time. Because of the Earth's rotation about the sun, the sidereal time is 4 minutes lesser than a solar day. An object in the sky observed from some observational point at a particular solar time, may not be at the exact location at the same solar time the next day. However sidereal time is the time measuring unit where the object is observed at the same location at the same sidereal time.

3.3 Declination

Two component angles are required to specify the the location of an object in the equatorial system. The first one being the hour angle specified by the right ascension. The second being the declination, which specifies the angle north or south of the *celestial equator*.

4 Implementation

In our implementation of the same, we have used 2 motors, one for the base rotation, and one that takes care of the rotation in the perpendicular plane. A Gyro-senser has been attached to our star pointer, which monitors and controls the angle of rotation by sending feedback to our arduino and consequently actuating it with the help of the motor. We have configured it to point to the north star. With the help of Sky Maps it is possible in theory to integrate it onto our project and make it point at a specific star, using the known location of the North Star.

We also designed and 3D-printed the body of our device, to meet the size requirements of our components.

Components:

- 2 Step Motors
- 2 Arduino UNO
- Jumper Wires
- L293D IC
- Thrust Bearings

5 Our Model

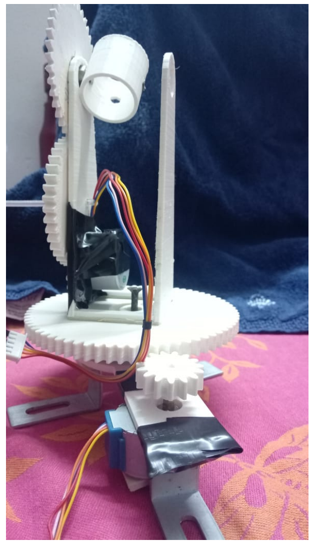

Fig.1: *The 3-D printed body.*

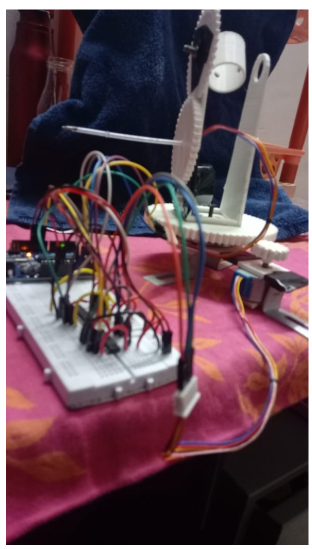

Fig.2: *Some Circuit-work beside the body.*

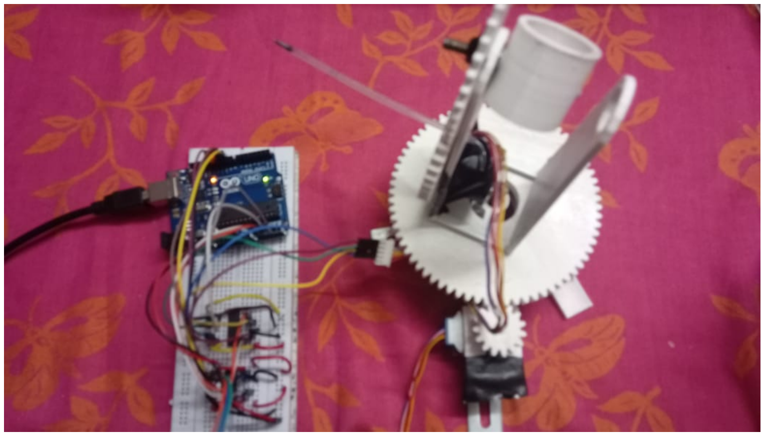

Fig.3: *The complete model.*

6 Conclusion

From this project, we can conclude that the Equatorial System of coordinates is a convenient reference to plot and track celestial objects. This can be seen as the coordinates of an object in the sky do not change relative to the observer's position.

What we had hoped to achieve was a device that could be of use to Physicists studying particular stars, by making the critical process of configuring a particular telescope, and focussing it at that particular star easier, with optimal reduction of manual error.

Future plans may include integrating SkyMaps to our arduino code, adding different sensors, based on specific requirements and also including remote control access with the help of a Bluetooth IC.

7 References

Following are the links of the references used for our project :

- https://en.wikipedia.org/wiki/Sidereal_time
- https://en.wikipedia.org/wiki/Right_ascension
- https://en.wikipedia.org/wiki/Declination