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Auto-Stellar

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Abstract - *Astronomy is becoming a new booming field of science. With the end of exploration on Earth, scientists have begun to take a keen interest in what is not in this world. Just by being able to observe the countless stars in our galaxy and discover new horizons in the universe. Telescopes have become one of the basic tools used by every aspiring scientist. Now that it is quite easy to point a telescope at the sky, doing so is equally busy. After many research and technological advances we. The first was able to mount a GoTo that would tell you exactly what you were aiming at in the sky. Now while these mounts are useful, they are also expensive. The purpose of this project is to build a low-cost equatorial telescope mount using an Arduino DUE board. The project uses a variety of basic electronic equipment and some 3D printing. The idea is to create a commercially available cheaper and build-to-build alternative to the GOTO/Star Tracker products produced by Skywatcher, Orion, Vixen, and others. At the heart of the system is an Arduino DUE board, loaded with software that is constantly being developed to add functionality. The project tends to solve tracking issues for adult astronomers to capture and research space objects with a cheap and customizable setup.*

Keywords: Astronomy, Telescope, GOTO, Arduino, 3D printing, Equatorial.

1.INTRODUCTION

GOTO refers to a type of telescope mount and associated software that can automatically point the telescope at a user-selected astronomical object. Both GoTo base axles have a motor and computer control. GoTo mounts are calibrated before use. When enabled, the user's latitude, longitude, time, and date can be queried. You can also get this data from a GPS receiver attached to your telescope or built into the telescope mount itself. Also, the mount controller can have its own real-time clock.

1.1 History of AUTO/GOTO telescopes:

The first computerized telescopes were developed in the 1970s and were mainly used by professional astronomers. However, with the advent of more advanced technology and the reduction of electronics costs, automatic telescopes have become more affordable and accessible to amateur astronomers in recent years. Today's most popular automatic telescope manufacturers include Celestron, Meade Instruments, Orion Telescopes & Binoculars

1.2 Functionality

Automated telescopes are equipped with electronic motors that control the movement of the telescope mounts, allowing for precise movement and tracking of celestial objects. It also has a computerized system that can store a database of famous celestial objects, so users can easily find and track these objects without manually entering coordinates. Some advanced automated telescopes can also be remotely controlled, allowing remote observation.

2. OBJECTIVE

The Auto-Stellar is an inexpensive and build-to-build alternative to commercially available GOTO (computerized telescopes) for equatorial mounts. That armature helps astronomers capture and explore space objects with an inexpensive and customizable setup. A cost efficient, customizable, and alternative solution for readily available GoTo mounts (star trackers). It will solve the tracking issue which is a common problem faced by rookie astronomers.

3. SCOPE

This project can find and track a database of 250 stellar masses in the northern and southern hemispheres. Observation logs are kept for each observation, including temperature, location, etc. This is independent operation and/or computer/tablet assisted operation. Provides an accurate and fast alignment method for an "always-at-a-glance" experience. Auto-Stellar is an idea to make GOTO telescopes more affordable. It is a good way to learn a lot of new things, such as elevation and elevation coordinates, local sidereal time, earth motion, Arduino coding, and much more. Telescopes are customized based on your needs. Auto-Stellar has the potential to change the market. Inexpensive for amateur astronomers and Astro photographers with a budget of up to Rs 23,000.

4. PROJECT DESIGN

Auto-Stellar is an open source (GOTO) Arduino Due based telescope control system. Built as a stand-alone system,

Auto-Stellar does not require a computer, tablet, mobile phone or internet connection to operate and deliver stunning views. Basically, we have a database containing the best 250 stellar masses (the messier catalog and Hidden Treasure) and 200 stars to calculate their position in the sky and show the telescope. The implemented alignment procedure allows for an "always-on-eye" experience when rotating to a selected object, and when an object enters the eye, the system tracks it. However, if you want to take advantage of electronic devices, Auto-Stellar uses Bluetooth communication (wireless setup) to connect to all electronic devices and accept commands based on the MEADE LX200 communication protocol. The system works with a variety of stepper motors and can be connected to both DIY mounts and commercial products such as Skywatcher, MEADE, Orion, and Vixen. The project aims to solve the issue of tracking heavenly objects in the sky for photographic and research purposes.

4.1. Components:

- Arduino Due Original
- Nextion Enhanced 5.0" HMI Touch Display
- RTC DS3231 Real Time Clock
- GPS uBlox Neo 6M
- PS2 joystick for Arduino
- DHT22 Temperature Sensor
- HC-05 Bluetooth Module
- DRV8825 Motor Driver 2x
- Stepper Motors NEMA 17 x2
- Prototype Electronic board (PCB)
- 20 Tooth & 36 Tooth Pulleys
- Timing Belt
- Buck Converter
- Memory Card Reader
- 12V 1A DC Adapter
- 3D Printed Case & Motor Mount

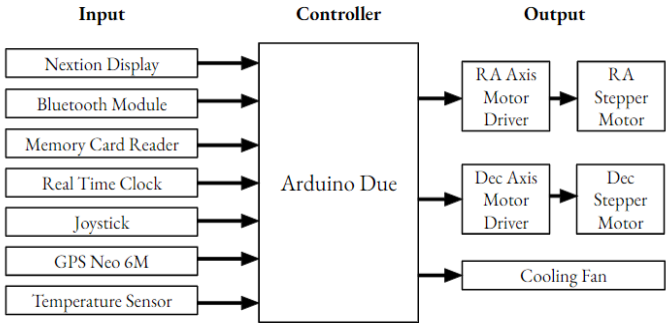

Fig -1: Connection setup for Auto-Stellar

The block diagram consists of three blocks:

1. Input
2. Controller
3. Output

4.2. Input Block:

The input block has all the sensors and input peripheral devices given in the block diagram. All these inputs are given to the Arduino DUE microcontroller. It has a touch screen display with a GUI program loaded in it.

4.3. Controller Block:

The controller block has an Arduino Due with the main program loaded in it. It performs all the calculations and gives the output to the motor driver of Right Ascension and Declination axes. It has the information about the equatorial mount and the GPS data collected from the GPS.

4.4. Output Block:

The output block consisting of motor drivers give the pulses to stepper motors according to the Arduino DUE's calculation that is the equatorial coordinates of the object in the sky. The right ascension and declination axis are the coordinates of the equatorial coordinates system.

5. OBSERVATIONS

Object: Moon:
Period: 20th April to 26th April
Coordinates: Right Ascension

Table -1: Right Ascension Coordinates

	Right Accension Coordinates	
Date	Calculated	Stellarium
20/04/2023	01h 49m 05.07s	01h 50m 14.89s
21/04/2023	02h 40m 15.75s	02h 41m 39.75s
22/04/2023	03h 33m 17.09s	03h 34m 25.91s
23/04/2023	04h 27m 25.39s	04h 28m 36.84s
24/04/2023	05h 22m 11.13s	05h 23m 44.29s
25/04/2023	06h 17m 11.28s	06h 18m 53.81s
26/04/2023	07h 12m 14.89s	07h 13m 01.04s

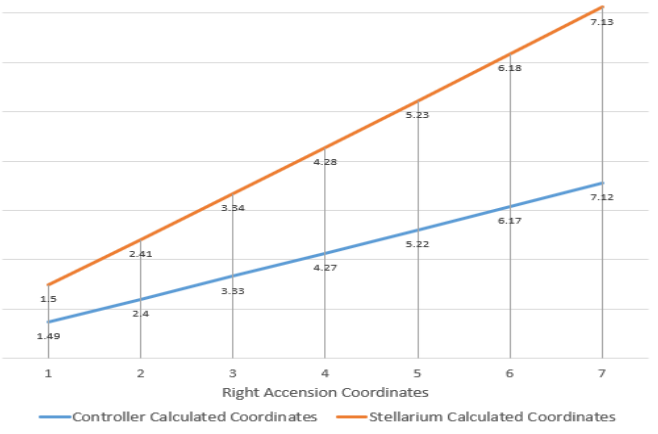

Chart-1: Calculated Coordinates of Stellarium and Controllers

Above chart represents the error of handheld controller in comparison with Stellarium for Moon's right accension coordinates over a period of 20th April to 26th April. This error can be minimized by aligning and calibrating the setup in real time, to get the maximum positioning and tracking accuracy.

GoTo telescopes are useful tools for both amateur and professional astronomers. They simplify the process of locating and tracking celestial objects, allowing users to spend more time observing and less time adjusting telescope mounts. They may be more expensive than hand-held telescopes and require more technical expertise, but the advantages they offer make them a worthwhile investment for those serious about astronomy.

Table -2: Observations for other celestial objects

Objects	Time	Calculated Right Ascension Coordinates	Stellarium Right Ascension Coordinates
Sun	11:43	02h 12m 51.6s	02h 13m 51.8s
M31(Andromeda Galaxy)	11:44	00h 42.7m 25.5s	00h 43m 42.8s
Jupiter	11:46	01h 34m 51s	01h 35m 00.4s
M45(Pleiades)	11:47	03h 47m 16s	03h 46m 45.5s
M42(Orion Nebula)	11:48	05h 35.4m 13s	05h 35m 16.4s

Objects	Time	Calculated Declination Coordinates	Stellarium Declination Coordinates
Sun	11:43	+13° 19′ 00″	+13° 26′ 41.8″
M31(Andromeda Galaxy)	11:44	+41° 0′ 00″	+41° 15′ 57.0″
Jupiter	11:46	+8.41° 0′ 00″	+08° 45′ 57.6″
M45(Pleiades)	11:47	+24° 0.2′ 00″	+24° 06′ 56.7″
M42(Orion Nebula)	11:48	-05° 0.1′ 00″	-05° 23′ 35.9″

Objects	Time	Calculated Hour Angle Coordinates	Stellarium Hour Angle Coordinates
Sun	11:43	22h 38.3m 12.5s	23h 07m 14.5s
M31(Andromeda Galaxy)	11:44	00h 08m 17s	00h 38m 07.7s
Jupiter	11:46	23h 17.6m 2.5s	23h 49m 06.1s
M45(Pleiades)	11:47	21h 6.3m 12s	21h 36m 45.5s
M42(Orion Nebula)	11:48	19h 19.8m 15s	19h 48m 42.1s

6. CONCLUSIONS

Auto-Stellar must be accurately aligned with the celestial pole in order to track objects smoothly. Polar alignment is a critical step that must be performed carefully, as any misalignment can cause objects to drift out of view.

Equatorial mounts are designed to work at a specific latitude, and adjustment may be necessary if you plan to use the mount in a location with a different latitude. This adjustment ensures that the mount remains accurately aligned with the celestial pole.

Another important aspect is the **Meridian flip**. Due to the rotation of the Earth, objects observed with an equatorial mount will eventually cross the meridian and begin to move in the opposite direction. This requires a "meridian flip" in which the telescope is moved to the other side of the mount and re-aligned with the celestial pole.

So, to counter this problem Auto-Stellar is fit with motorized tracking systems that allows the project to follow celestial objects as they move across the sky. This is important for observing objects that move relatively quickly, such as planets and comets.

Fig -2: Auto-Stellar Motor Drive & Controller Setup with Motor Cords

Fig -3: Equatorial Mount with Motors.

Fig -4: Mount Tripod.

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