Celestial Tracking and Imaging

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1 Abstract

The Celestial Tracking and Imaging project will focus on creating a device to improve photographers' abilities to perform high quality astro-photography easily and at a low cost. The device will consist of three parts. The first part will be a physical tracking device able to connect to a DSLR camera and tripod. The device will be able to easily move the weight of a camera and lens, with mobility to point to any location in the sky. The second part will be an automatic finder in the form of a phone application. Not only will this app be able to control the entire device's tracking, it will also allow users to input coordinates or the name of a celestial object. The last part will include special features on the app, purely for fun and aesthetic purposes.

2 Fundamental Problem

Astro-photography is becoming more and more accessible for photographers without a physics or math background. As camera lenses and sensors grow in power and low light capability, it is even easier to create these images. However, there are limits that need to be overcome in order to take these photos.

The first issue is cost of equipment. Long exposure photography of the night sky needs a tracking device to eliminate star trails. Tracking devices are historically made for telescopes. Most are unable to adapt to a DSLR camera. This adds to the total cost, as a tracking device, mount, and telescope are needed. In the few cases where a tracking device and mount are adapted for a DSLR camera, the price increases exponentially based on quality.

The second issue is ease of use. Most tracking devices themselves are difficult to set up and use without help. The main difficulty is trying to find the objects to photograph. This step normally requires help from an outside source (a star chart). Moving and centering the telescope and making sure the tracking device is aligned correctly can prove difficult.

3 Past and Future Approaches

Tracking devices are used in modern day telescope set-ups, both professional and amateur. The devices are aligned with the North Star (Polaris) and track using the direction of motion and speed of Earth's rotation. For objects with different speeds (planets and asteroids) a tracking device allows a user to change the speed.

When speaking about tracking devices, the current approaches for amateur set-ups are very common. In general, a tracking device will attach onto a telescope mount. The telescope is aligned with the North Star to begin accurate tracking. Some tracking devices and mounts are adapted to DSLR camera. These will track much in the same way as the former.

Automatic finders historically were in the form of star charts. Archaeologists have found ancient versions of star charts that date back 30,000 years. These star charts are very crude; and are usually used to predict the position of large celestial objects such as the Sun, Moon, and planets. More modern interpretations of star charts date back to 1500 BC in ancient Egypt. Physical paper star charts are still used today, although digital versions are becoming more common.

Current versions of automatic finders vary greatly, but still use star charts. There are apps created to transpose a star chart on the night sky. This augmented reality allows users to move their phones across the sky to find objects. More advanced apps allow users to input an object and show basic directions to find it.

This specific project will connect these two devices, there are only a few products on the market. These products are considered "GoTo" telescopes. These have a telescope permanently attached to a tracking device and mount. There is a handheld control allowing the user to choose from a bank of celestial objects to find and track. Then the telescope will point towards the object. Some of these telescopes have the option of attaching a sensor for imaging; most are adaptable for a DSLR camera.

4 Project Goals

This project will consist of many steps. Each step will have specific goals which must be met before it can be considered complete. The following list outlines each step in detail, including goals.

4.1 The Tracking Device

The tracking device must be able to hold and move a DSLR camera and lens freely. This will be started by creating a simple prototype for testing and then 3-D printing a final product. It is important for the tracking device to be able to combine easily with software, therefore an Arduino or Raspberry Pi will be used for control. Both of these devices will be able to easily work with servos and motors. The device must be able to rotate fully in two directions to include all positions to cover the night sky.

4.2 The Software

The software will be used to control the back-end processes of the tracking device. These functions include moving the device, orienting the device to the North Star, reading the time and input location of the user, and calculating the positioning of astronomical objects in the sky using a stored bank of objects' right ascention and declination. This software will include additional functions to test the accuracy of the device.

4.3 The App

The app for this device will encompass the entire software and create an easy-to-use system for the user. This will help solve one of the fundamental problems of the current technology: difficulty of use. The app will allow the user to start and calibrate the tracking device through Bluetooth. This will allow the user to fully adjust the positioning of the device through small controls as well as choose from a bank of celestial objects to find.

5 Production Schedule

The project schedule will be created to start at the beginning of the spring semester at RIT. The production of this project has already begun with cooperation between myself and students in the Computer Engineering department at RIT. The schedule is currently subject to change, but will become finalized when the spring semester begins:

December 2016: Before the end of the fall semester, a final prototype of the tracking device will be created out of laser cut wood. This device will be very rough, still unable to hold a camera. The goals are to calibrate the device to the north star and find and track a single object in the night sky within a large degree of inaccuracy. This inaccuracy will be determined through mathematical calculations and shown through a graph, plotting the distance from object over time spent tracking.

January 2017: At the beginning of the spring semester the prototype will be improved. By the end of the month the accuracy should be significantly corrected. A design for a strong device, able to hold a DSLR camera, will be in production.

February 2017: The prototype should be fully accurate for this project by the end of this month. The larger scale tracking device should begin to be built and tested with a DSLR camera. A log of right ascention and declination should be created for the automatic finder at this time. This bank can easily be added to, but should begin with a large amount of stars.

March 2017: The new tracking device should be finalized with the ability to track and hold a DSLR camera. Field testing should begin at the end of the month. The software should be edited to include celestial objects other than stars (i.e. Moon, Sun, comets, galaxies) to the search bank.

April 2017: More field testing should be conducted during this month. Fine-tuning on the device should be completed. At this point, the final images and data should be taken (see Section 8). To gain input, the device should be tested with a variety of users.

May 2017: For the last few weeks, the schedule will be subject to change. The projects for the last month are reach goals, only to be completed if the previous goals have been met. These goals include, but are not limited to: creating photographic filters for images, allowing manipulations of fabricated star trails for aesthetic value, attach a cheap camera to the device for a basic live stream of the camera, app branding and design and user experience, and adding additional images (see Section 8).

6 Budget

Item	Cost
Hourly Wage	$30/per hour
Arduino 101	$30
Servo Pan Tilt Robotic Arm	$25
Laser Cut Wood Prototype	$50
3-D Printing	$30
Canon EOS 60D DSLR Camera	$450
Canon EF 400mm f/5.6L USM Lens	$1,200
Samsung Galaxy Note 4	$250
Total	$3835

The values taken for the camera, lens, and phone are taken using the specific products that will be used for this project. The final total is including the hourly wage for 4 hours a week for 15 weeks.

7 Deliverables

Deliverables of this project will include the following:

1. Paper detailing the methods used to create the project;
2. Time lapse video to show tracking accuracy;
3. Still images of the Moon and stars.

Reach Goals of this project (discussed in Section 4) include, but are not limited to the following:

1. Designed app;
2. Section in paper focusing on marketing this product, including user reviews;
3. Still images of constellations, fabricated star trails, and Moon phases;
4. Gif of Moon phases.

8 Appendix

8.1 Resume

Resume available at charlotteguthery.com/images/Resume/Resume.png

8.2 Biography

8.2.1 First Person

My name is Charlotte Guthery. I am in my senior year as a student at Rochester Institute of Technology, majoring in Imaging and Photographic Technology with a minor in Mathematics and Imaging Science. Math and science always interested me as much as photography, which was a reason I chose this major. Imaging and Photographic Technology combines the sciences with photography by focusing on the scientic applications. My interest in optics began after I participated in a summer REU in Tucson, Arizona. There I learned how to program, creating an image processing system for an astronomer. The system included image alignment, high dynamic range processing, and ltering. In addition, I worked on calibrating the sensor that would be used in the project. Although this summer project focused on programming and astronomy, I was introduced to optical systems in the observatories on Kitt Peak and found my specific area of interest. While I have worked on astronomy research in the past, I would like to expand my knowledge in an engineering direction, and therefore will be applying to graduate school for optical engineering. To prepare for this, I have been taking classes in math, physics, optics, and programming. I hope to eventually work on optical engineering for telescopes.

8.2.2 Third Person

Charlotte Guthery is in her senior year as a student at Rochester Institute of Technology, majoring in Imaging and Photographic Technology with a minor in Mathematics and Imaging Science. Math and science always interested her as much as photography, which was a reason she chose this major. Imaging and Photographic Technology combines the sciences with photography by focusing on the scientic applications. Ms. Guthery's interest in optics began after she participated in a summer REU in Tucson Arizona. There she learned how to program, creating an image processing system for an astronomer. The system included image alignment, high dynamic range processing, and ltering. In addition, Ms. Guthery worked on calibrating the sensor that would be used in the project. Although this summer project focused on programming and astronomy, she was introduced to optical systems in the observatories on Kitt Peak and found her specific area of interest. While she has worked on astronomy research in the past, she would like to expand her knowledge in an engineering direction, and therefore will be applying to graduate school for optical engineering. To prepare for this, Ms. Guthery has been taking classes in math, physics, optics, and programming. She hopes to eventually work on optical engineering for telescopes.

8.3 Electronic Presence

This section focuses on the changes and improvements made to my own personal electronic presence. The purpose of this is to keep a professional face when applying for jobs and schools. My own presence includes the following sites: Facebook, Instagram, LinkedIn, and my personal website.Each of these were updated and improved in the following ways.

Facebook:All future posts will be changed to private (only friends and view). All posts prior to 2013 will be deleted. All photos will be reviewed and deleted if needed.

Instagram: Account set to private.

LinkedIn: Updated Work experience, skills, profile picture, education, and summary.

Personal Website: Bugs in the website were fixed. Updated resume was posted. Images in the portfolio were updated. Biography and profile picture updated. Skills, software abilities, and classes updated.