Robinson Observatory Restoration

Description

University of Central Florida
Department of Electrical Engineering and Computer Science

EEL 4914
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Senior Design I

Sponsor(s): *Florida Space Grant Consortium*

Under the direction of Mike Conroy, *FSI Project Manager*

Group A

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Project Narrative

History

Although the groundbreaking for the Robinson Observatory occurred in January of 1994, the story of our current telescope begins in 2007. It was at this point that the existing 26" Tinsley telescope was removed and the existing 20" telescope, manufactured by RC Optical Systems, was installed. Although the installation of the device was led by Nate Lust, students played a significant role in the effort. From the beginning, the telescope was a partnership between the University of Central Florida and its students.

The 20" telescope is far from the largest or most powerful in use, so it has been designated a unique role. The telescope was designed to fill the niche of a rapid response device; that is, it can be deployed at a moment's notice, and is therefore uniquely situated to make time sensitive observations of astronomical phenomena. In addition to its academic and scientific applications, the telescope has also served to arouse an interest in astronomy for countless Scout troops, student groups and people of all ages. In 2015, the Orlando Sentinel recommended the Robinson Observatory as one of the "things you have to do before graduating UCF."

The telescope served faithfully from its installation until approximately three years ago, when its functionality began to degrade. In brief, the various subsystems of the telescope are controlled through a combination of software and dedicated peripheral devices. The focuser is controlled by a dedicated piece of hardware. Control of the dome is accomplished through the PC. Two Pittman 4431E064-R3, 24V DC, 500 CPR motors control the rotation and elevation of the telescope, which are in turn driven by a software package designated as TheSkyX. TheSkyX references a database of coordinates and pushes control signals to the motors. A controller, branded as Bisque TCS, sits between the PC running TheSkyX and the motors driving the telescope. This controller translates the commands of the software into the inputs that allow the motors to track various astronomical objects.

As it is currently understood, the heart of the problem lies in the ability of the telescope to accurately track the coordinates provided by TheSkyX software. Images produced by the telescope are blurry, unfocused and include "streaking" of illuminated objects, suggesting that one of the motors is not correctly compensating for the earth's rotation. At this time, the exact cause of this breakdown is unknown; it could be due to the software itself (as the problems became more pronounced after an update of the software), an issue with the motors or the translation of the commands by the Bisque TCS controller. In addition to the tracking issues, the telescope is no longer correctly reporting its position back to TheSkyX software package.

Until initial investigation and reverse engineering are underway, it is impossible to say whether the Bisque TCS controller is functioning as intended. However, this is a proprietary piece of hardware. There is a single individual who is able to service this equipment, and he must be flown in at great cost to the University any time that service is needed. Therefore, even if the controller is operating, it is the desire of the Robinson Observatory to replace it with an open source design. This is the core goal of our team, and additional functionality may be added as time and budget allow.

Motivation

The 20" telescope serves as the showpiece of the Robinson Observatory. In addition to performing the bulk of the scientific observations for the astronomy team, it is a significant draw to youth groups and has served as a destination for Scout troops, school fieldtrips and the general public. When the telescope is operating as designed, it fills scientific, academic and social needs of the Central Florida community.

It is the desire of our team to engage with a Senior Design project that has a lasting impact. We do not wish to diminish the creativity, technical challenge and opportunities for learning that are inherent in many other Senior Design projects, but the simple fact is that many of them are relegated to a storage closet after the team graduates. It is our belief that the successful execution of this project will restore a resource that will benefit the community for years to come.
In addition, our team is inspired by the close cooperation that has existed between the Robinson Observatory and the UCF student body since the initial installation of this telescope. We all feel that we have benefited greatly by our time at UCF, and are excited to have an opportunity to continue this partnership and give back to the University that has been our home for the last few years.

Challenges

The team envisions a number of challenges associated with this project. First, this project is somewhat outside the scope of a traditional Senior Design effort. Instead of designing and implementing a project from the ground up, we are tasked with designing around a large amount of expensive, existing equipment. The cost of the equipment makes it impractical to replace, therefore, our first order of business is to undertake a reverse engineering project and decompose the communication protocols that drive the telescope.

This first challenge is compounded by the fact that existing documentation for the hardware is sparse or nonexistent. Our team has already reached out to Pittman in an effort to better understand how to drive the motors, and have been told that the motor is proprietary and that they will not be able to offer any support. We are continuing our efforts to obtain some documentation on the equipment, but our expectations are tempered. Moreover, the single individual who services this

controller will very likely not be incentivized to work with a team who is attempting to make his equipment obsolete. These factors point to a significant reverse engineering project that will need to be completed before any design work can begin.

A second challenge lies in finding the root cause of the problem with the telescope. At a very high level, there are three components in play: TheSkyX software, the Bisque TCS controller and the Pittman motors. At this time, it is unknown which of these elements is causing the breakdown, and therefore further analysis will be required before functionality can be restored.

A third challenge can be found in the budget of the project. Our contact at the Florida Space Institute (FSI) will be engaging with the Florida Space Grant Consortium (FSG) to secure funding for the project, but the timeline for funding is still several months out. In addition, an estimated $800 per team is expected to be allotted, meaning that we should expect to have on the order of $1600 - $2400 (dependent on team composition) available to be divided across the project. Specific costs are not yet defined, and budget requirements will need to be addressed across the interdisciplinary teams.

A final challenge is rooted in an unknown composition of our team, and therefore, an as-of-yet undefined scope of the overall project. As it stands currently, a team of three mechanical engineering students have committed to the project in addition to our team. At the time of this writing, there has not been a commitment from a computer science team to undertake the project. We have been in communication with Dr. Heinrich, and it is our understanding that he will effort to promote this project to his students, but it is possible that any required programming will need to be addressed by our team of electrical engineering students.

Goals

The minimum viable product, as defined by our contact at FSI, is a replacement of the proprietary controller that translates TheSkyX commands to the motors that drive the telescope. In a broader sense, our intention is to restore full functionality to the telescope. However, since parts of this goal are dependent upon the efforts of other teams working the project (e.g. if the motors are not restored to full functionality, no amount of effort from the E.E. team will be able to overcome this deficiency), the clearly defined project goal is an open source replacement of the Bisque TCS controller, as requested by the customer.

There are a number of additional goals that have been defined by the Robinson Observatory team (and are enumerated in more detail in the Requirement Specifications section of this document). Key examples are wireless functionality and the ability to tie various telescope subsystems (e.g. focuser, dome control, etc.) into TheSkyX software to afford an all-in-one solution for observatory control.

If time and budget allow, we will effort to incorporate some of these “want tos” into our design. Since much of this project will be defined by the reverse engineering undertaking, this may not fit within the scope of our project. If this is the case, we would like to leave room in the project (e.g. additional ports on our PCB and sufficient documentation) for a team to follow behind us and continue the observatory update.

Requirement Specifications

- Shall accept an input voltage of 120VAC +/- 15%.
- Shall have a sensor response time of less than 2 seconds.
- Shall have a cost of less than $800.
- Shall have a power usage of less than 100W.
- Shall have dimensions less than 20” x 20” x 10”.
- Shall have a weight of less than 5lb.
- Shall interpret control signals from existing TheSkyX software.
- Shall relay motor control signals to existing Pittman 4431E064-R3 motors.
    - This includes both right ascension and declination as well as slew rates from TheSkyX.
- Shall accept secondary input from user operated joystick to move motors manually at variable slew rates.
- Shall support home and park capabilities for the telescope.
- Shall support pointing limits (no declinations below the horizon; no horizontal azimuths that will damage the telescope)
- Shall support the ability to work in multiple modes:
    - Sidereal tracking: in which the declination motor does not move and right ascension motor tracks at sidereal rate
    - Nonsidereal tracking in which both motors move at non-standard tracking rates
        - These targets are delivered from TheSkyX

There are few quantitative design constraints placed upon this project. Rather, the challenge, and the requirement, comes from the fact that the above specifications are to be implemented using existing software (TheSkyX) and hardware (the Pittman motors). Design choices and budget will inform quantitative design choices rather than explicit requirements from the customer (Robinson Observatory).

Block Diagrams

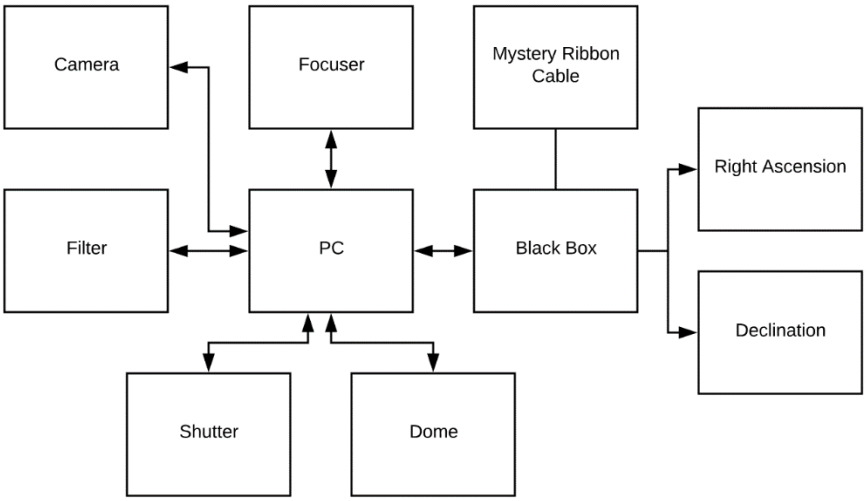

Figure 1: Overall System Block Diagram of Existing System

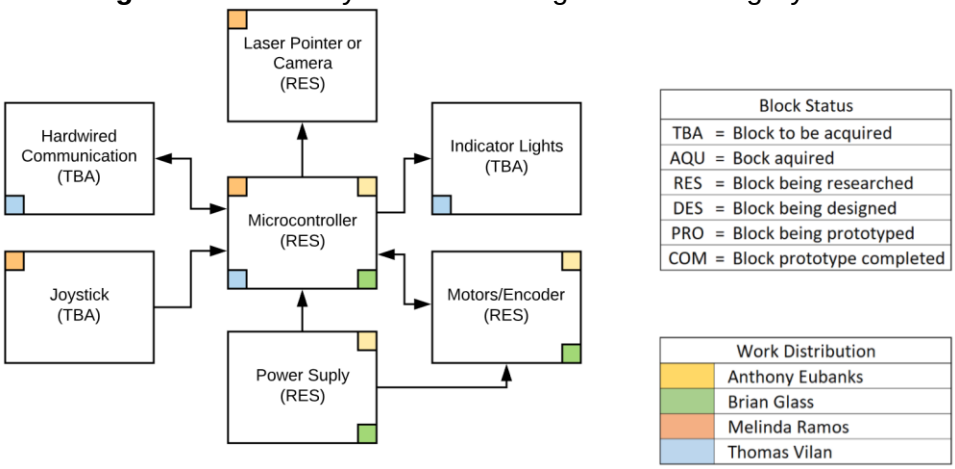

Figure 2: Control Box Block Diagram for EE Design Project Scope

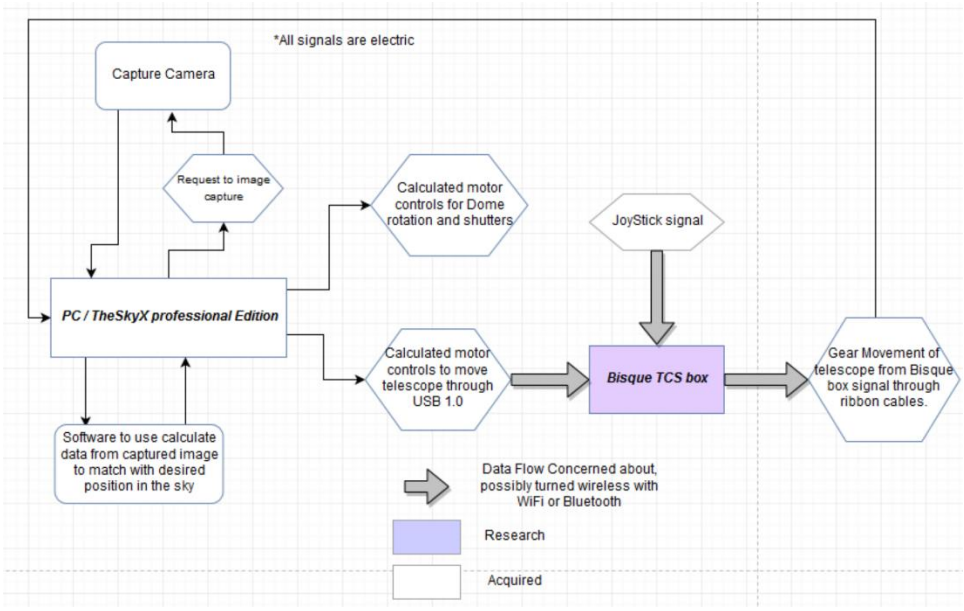

Figure 3: Software Block Diagram

House of Quality

The essential components for a minimum viable product are shown above, with the exception of the wireless communication module. Wireless communication is not a part of the existing design and is not a requirement of the project. However, if time and budget allow, wireless functionality will be investigated.

Distribution of work is tentative and subject to change as the scope of each subsystem becomes clear. An in-depth investigation of the existing system is scheduled to begin on Friday, 2/1 and will be ongoing over the course of the next several weeks. Subsystem assignments may be modified following this investigation.

Project Budget

Description	Quantity	Estimated Cost
Joystick	1	$20
Power Supply	1	$35
Microcontroller	1	$50
Wireless Communication	1	$50
Remaining PCB parts	N/A	$100
PCB	1	$100
Misc cables, connectors, etc	N/A	$100
Housing	1	$75
Total		**$530**

The ultimate source of funding for this project will be through the Florida Space Grant Consortium (FSGC); however, process of obtaining the grant will be facilitated by the Florida Space Institute (FSI).

The preliminary estimate for the budget is $800 per team. If three teams take on the project, that would allocate a total budget of $2400 to cover the project. It is expected that each team will work within their own portion ($800) of the budget, but this has not been formally outlined between teams.

Initial estimates are estimates only. Specific design choices have not yet been made to allow for maximum flexibility, and it is expected that some additional needs will surface as the project progresses. Therefore, some categories here (e.g. cables and PCB parts) are an overestimation of the anticipated cost, but this should serve to mitigate the impact of unforeseen needs.

Milestones

Senior Design I	Tasks	Week
	Divide and assign duties	3
	Divide and Conquer Document	4
	Research	4-6
	Divide and Conquer 2.0	7
	Design	7-10
	Begin writing Documentation	10
	60 page draft due	12
	Order Parts	13
	100 page submission due	14
	Finalize documentation	15
	Final documentation due	16
Senior Design II		
	Build Prototype	35-39
	Hardware/Software Check	40
	Address Prototype Issues	41
	Assemble Final Project	42-46
	Test and Fine Tune	47-49
	Presentation	50