PanLapse: A Time Lapse Panoramic Imaging Device

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Research Summary

Panoramic and time-lapse imaging cameras are used in ecological settings to provide information regarding species activity patterns and other monitoring information. In the past, panoramic and time-lapse cameras have been expensive and relied on moving components and numerous image captures. The PanLapse project has aimed to develop a low-cost device that is effective for capturing high-resolution, panoramic, time-lapse images. PanLapse will accomplish this through its use of an inexpensive, high resolution camera, a Raspberry Pi, a Witty Pi, an array of stationary mirrors, and a battery. The device is programmed using Python to automate image acquisition, and to shut down between image captures to preserve battery life. The PanLapse device is capable of capturing near 360 degree, high-quality images within one camera shot by capturing reflections as they appear on the mirror array. As a result, the device can be suitable for use in ecological settings and provide an inexpensive, effective method of image procurement.

Introduction

In the past, attempts to create panoramic, or 360 degree view, imaging cameras have been successful with the use of moving parts, expensive equipment, and intrusive, distracting components. Similarly, ecological time-lapse imaging cameras are often expensive and complex. In 2009, a method of acquiring panoramic images for ecological purposes that relied on a robotic arm and a number of 8 mp images stitched together was proposed by Carnegie Mellon (Nichols, 2009). Similarly, in 2020 a camera was proposed for ecological time-lapse imaging that relied on a DSLR camera and had an overall cost of 956.56 euros, or over 1000 US dollars (Winterl, 2020).

The PanLapse project aims to create a device that is effective for capturing high-resolution, panoramic, time-lapse images, while remaining inexpensive, customizable, and non-intrusive. PanLapse will accomplish this through its use of inexpensive, high resolution cameras, a Raspberry Pi, a Witty Pi, and an array of mirrors.

The Raspberry Pi is a single board computer that is used frequently in projects due to its low price point and high customizability (DevicePlus Editorial, 2021). The Pi can be used in numerous applications and is able to be combined with other products, such as cameras, to allow the creation of complex projects while requiring very few components.

The Pi has commonly been used by biologists to create devices that are specified to research needs, while remaining low cost and effective (Jolles, 2021). Further, the Pi is able to be programmed to capture images of wildlife using Python code and relatively few additional components (Hattersley, 2020).

Within the PanLapse device, the Raspberry Pi will function to control the camera and facilitate the storage of images on a micro-SD card. The Raspberry Pi will remain powered off in between each image acquisition and will be powered on by a Witty Pi. The addition of the Witty Pi will allow the device to keep track of time, boot up the device, and allow the Raspberry Pi access to a clock (UUGear). The RAspberry Pi will be able to use the clock on the Witty Pi to time and date stamp images as they are acquired.

The camera used within the PanLapse device is a 64 mp camera manufactured by Arducam. The camera will face the mirror array, allowing very high resolution images to be captured. The mirror array component of the device will allow the device to capture a nearly 360 degree field of view in a single image. The mirror array will consist of multiple vertically stacked mirrors at varying angles (See Figure 1 & 2). In the future, a 3D printed structure can be used to stabilize the device.

The creation of the PanLapse device will allow the acquisition of high-resolution, panoramic time-lapse images. The device will not be disruptive to wildlife, and will provide imaging capabilities for use in ecological settings, without necessitating bulky or expensive components. (See Figure 3)

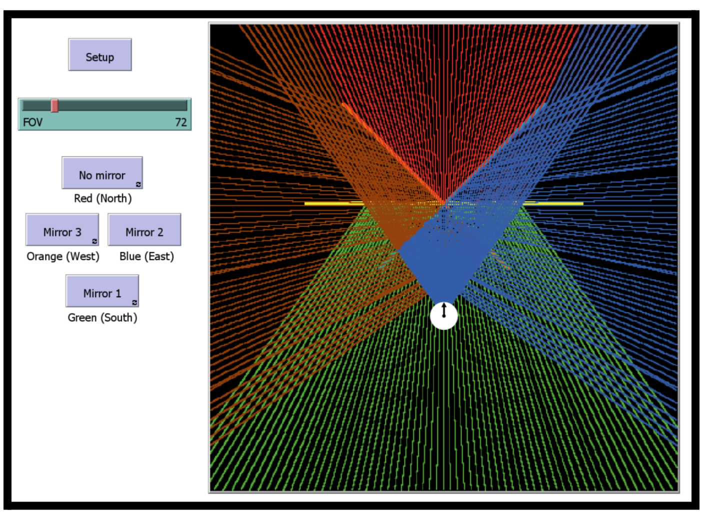

Figure 1. The PanLapse device will use three mirrors, which will reflect surroundings to create a 360 degree field of view. (Photo Credit: R. Boone)

Figure 2. The mirror array utilized within the PanLapse device, prior to vertical angle changes. (Photo Credit: N. Heronema)

Figure 3. The PanLapse device, set up for testing. (Photo Credit: N. Heronema)

Research Questions and Hypothesis

Research *Outcome*: To leverage inexpensive single board computers and newly available high resolution cameras, combined with mirrors, to create an inexpensive device capable of acquiring panoramic time-lapse images of wildlife and livestock.

We will determine the efficacy of the PanLapse device by testing the device by arranging a number of individuals in a circle around the device, and evaluating how many individuals are captured at varying radiuses.

Hypothesis: We expect that the PanLapse device will be effective in capturing quality images of wildlife and livestock due to its static positioning, quiet components, and high-resolution image capture ability. This will be an improvement from other available models that often rely on multiple cameras; movement; large, obtrusive devices; and noisy components.

Methods

To develop the PanLapse device, many steps were taken prior to construction to better understand the applications of camera traps and the functionality of the components that would go into the device.

To begin, I familiarized myself with a commercial camera trap and then set it up to be able to capture time lapse and motion activated images within 8 feet of the camera. I then attached the camera to a tree on the Lower Dadd Gulch Trail in the Poudre Canyon with strapping and set it to acquire the images. I returned to change out the batteries and exchange the SD card after multiple months, and then repeated this process again. The second time I exchanged the SD card, I changed the location and flash brightness of the camera trap, as the SD card had been taken out of it, and the previous images had turned out too dim throughout the night.

In addition to using the commercial camera trap, prior to construction I read the Raspberry Pi and Witty Pi manuals, read tutorials, and watched videos about how to safely cut glass. I then began cutting glass experimentally to determine the best method for acquiring the pieces needed for the mirror array. This process involved a large amount of trial and error, and resulted in a significant amount of broken glass, however I became competent with glass cutting equipment after numerous attempts.

In the same period of time that I was initially cutting glass during, I also began familiarizing myself with the Raspberry Pi and a smaller MP Pi camera. I learned how to code for simple image captures with help from Dr. Boone, and became more familiar with the Raspberry Pi’s settings and terminals.

After becoming more comfortable with simple image acquisition, I attached the 64 MP arducam camera. This presented an issue, as the Raspberry Pi did not register that the camera was attached how it had the previous camera. Through a significant amount of troubleshooting, I was able to determine that I was attempting to use a ribbon strip with the wrong number of pins for the camera. This did not resolve the issue however, and I had to request further assistance from Dr. Boone. He was able to determine that there was an issue with the model of the camera’s compatibility, and was able to get a 64 MP camera that was supported by the Raspberry PI.

Once the camera was functional, we moved on to attaching the Witty Pi to the Raspberry Pi, which would allow a clock function and would be able to boot the Raspberry Pi. There was an issue with the pinhead connectors, which required further exploration. A pin head extender was ordered, which will allow the Pi’s to connect. While ordering the extender, we explored potential power source options that would allow the PanLapse device to not require external power.

By reviewing Dr. Boone’s initial conceptual design for the PanLapse device, I began constructing the mirror array. I continued through the construction of the array with a large amount of experimentation and trial and error, using both modeling clay and hot glue to secure the mirror segments. I used a laser pointer to determine the areas the mirrors had the capacity to capture. During this time I also created a stand for the camera to allow it more security and adjustability to allow it to be pointed at the mirror array.

Dr. Boone and I determined a manner to test the device once it was largely constructed and had displayed a decent level of functionality in my experiments with the laser pointer. We determined that, by arranging individuals with colored and numbered sheets of paper in a circle, we could determine what areas the device was capturing, and that by having the individuals progressively back away from the device we could determine the radius with which the device was effective for capturing. At this time I was also given access to soldering equipment, and I began researching soldering techniques.

I then determined how to code the Raspberry Pi to acquire images while allowing for a delay between when the code was run and when the image was taken with help from Dr. Boone. This allowed us to complete the testing and acquire images.

Dr. Boone then used projection software to project one of the images that was captured during testing into a panoramic image to display the capabilities of the PanLapse device. After acquiring this panoramic image, we discussed changes and additions to the device that could be made in order to create a more complete 360 panoramic image and to eliminate some of the vertical space choppiness.

From this point, there are a number of ways that the PanLapse device can be further developed to utilize the full potential of the components.

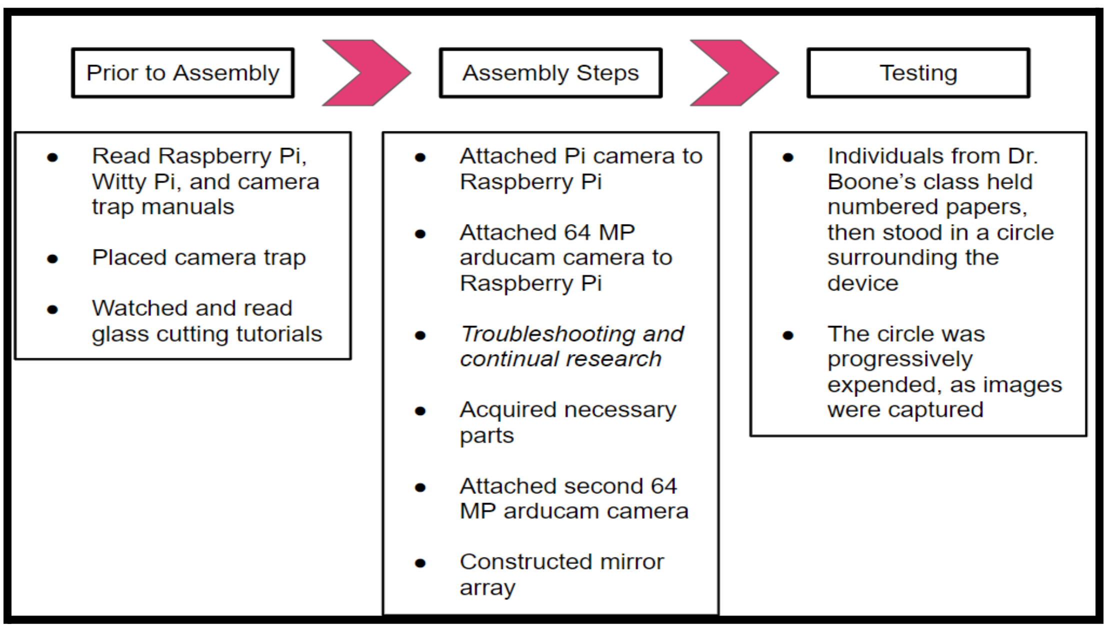

Figure 4. A flow diagram of simplified steps taken within the development of the PanLapse Device. (Photo Credit: N. Heronema)

Results

- We determined that the PanLapse device, at this time, is capable of capturing 16 mp images.
- The device captures near 360 degrees, with few uncaptured segments.
- The device adequately captures images up to a radius of ~3 meters from the device.
- The mirror array component achieves these capabilities while requiring an area of 929 square cm (1 sq foot).

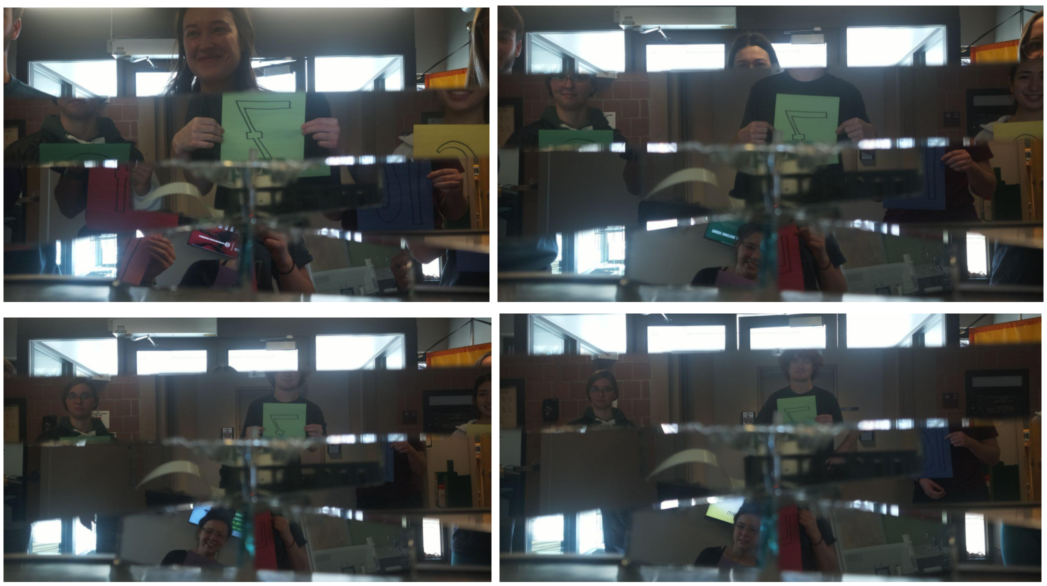

Figure 5. The unprojected images acquired during the testing of the PanLapse Device, with the smallest radius from the device in the top left corner and the largest radius in the bottom right. (Photo Credit: N. Heronema)

Figure 6. The projected panoramic image produced by projecting one of the images captured in the testing of the device. This panoramic image was produced from the top left image within figure 5. (Photo Credit: R. Boone)

Discussion

- The PanLapse Device's field of view imaging capacity is similar to the imaging field of view made possible by previous, more complicated, imaging devices
- The device's small size and lack of moving components will allow it to be non-obtrusive in environments to allow more accurate representations
- The PanLapse Device captures images accurately up to a radius of ~3 meters which will allow it to capture a total area of ~28 square meters
- The device offers a low cost option to procure high-quality images for a variety of ecological needs
- Further consideration regarding battery and storage may allow the device to require less maintenance
- Due to the utilization of a Raspberry Pi, the device offers a significant amount of customization, which will allow the device to be applicable in a wide variety of contexts
- The device would be improved by miniaturizing the mirror array to a greater extent and being encased within a 3D printed container, however this was not possible due to present time constraints
- To acquire a more uniform cross section image, more calibration of the mirror's vertical angles is necessary. At present, the height from the ground that is captured is not uniform, so once the image is projected into a panorama it does not create one smooth continuous image.
- Further testing with greater precision in radius and angular measurements would be a beneficial next step

Conclusions

The PanLapse device will allow ecological researchers to obtain panoramic time-lapse images for a variety of applications without necessitating the use of complex mechanical imaging devices. The device will make obtaining quality imaging more accessible due to its low component cost and simple maintenance. While the device currently obtains 16 mp images, in the future, the current camera can be exchanged for ones with higher resolution capacities. Additionally, alternative components, such as more recent generation Raspberry and Witty Pi's and/or wider field of view cameras could be exchanged to provide additional customization capacity in order to fit a larger variety of imaging needs. Further, there is potential to further decrease the price of the device by switching to older, more simplified, versions of the Raspberry Pi computer board while still maintaining the current capabilities of the current PanLapse device.

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Appendix 1: Methods Outline (w/ future goals)

- Read commercial camera trap users manual to learn how to program the camera trap
- Read Raspberry Pi user manual to prepare for Raspberry Pi use
- Read Witty Pi user manual
- Placed commercial camera trap with collection set for time-lapse and motion-activated capture up to 8 feet
- Prepared for mirror cutting by reading tutorials and watching a variety of videos
- Began experimenting with mirror-cutting equipment to prepare for assembling mirror array
- Assembled and configured Raspberry Pi single board computer and small MP Pi camera
- Began image acquisition with Raspberry Pi and attached camera (w/ Dr. Boone)
- Attached larger MP arducam camera
- Attempted to troubleshoot camera connection, reconnected camera
- Dr. Boone contacted arducam's support for assistance
- Attempted to connect Witty Pi to Raspberry Pi
- Troubleshot Witty Pi connection failure and discussed with Dr. Boone
- Researched Raspberry Pi and Witty Pi components to purchase needed connector part on Adafruit website
- Researched appropriate power supply options (w/ Dr. Boone)
- Constructed PanLapse mirror array through modeling and experimentation
- Learned to solder by watching a variety of circuit board soldering videos
- Programed Raspberry Pi for image acquisition with preview time delay
- Experimented with laser pointer to determine vague initial field of view
- Acquired test images of ~15 individuals at various radiuses from the device (w/ Dr. Boone and Dr. Boone's class)
- Dr. Boone constructed projected panoramic image from one selected test image (See Figure 5)
- Discussed potential methods to remedy gaps in capture and to allow more smooth transition between image sections with Dr. Boone
- Solder Witty Pi (future)
- Attach Witty Pi to Raspberry Pi and program to allow power management (future)
- Program Raspberry Pi and Witty Pi for automatic image acquisition and image stamping using python (future)
- Determine appropriate power supply and attach power supply to device (future)
- Construct PanLapse device case using 3D printing materials and software (future)
- Assemble PanLapse mirror array, camera, computer, and battery within 3D printed case (future)

Appendix 2: Development Photos (Photo Credits: N. Heronema)

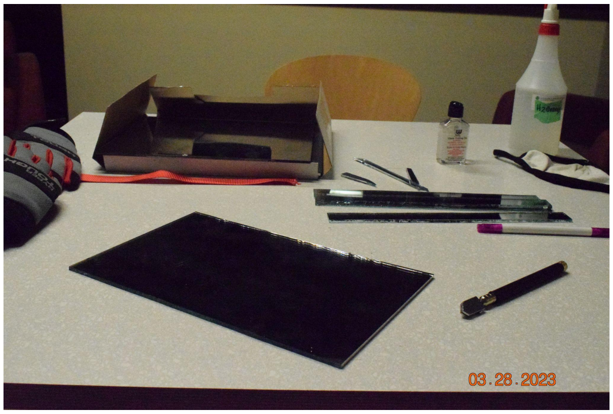

Figure 7. Development Photo 1

Figure 8. Development Photo 2

Figure 9. Development Photo 3

Figure 10. Development Photo 4

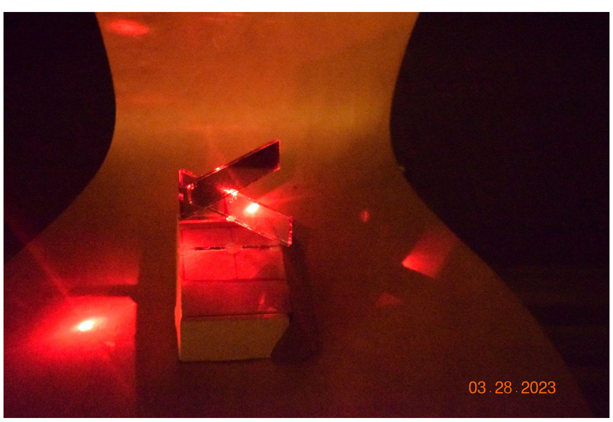

Figure 11. Development Photo 5

Figure 12. Development Photo 6

Figure 13. Development Photo 7

Figure 14. Development Photo 8

Figure 15. Development Photo 9