

# Autonomous Remote Erosion Monitoring Using Computer Vision

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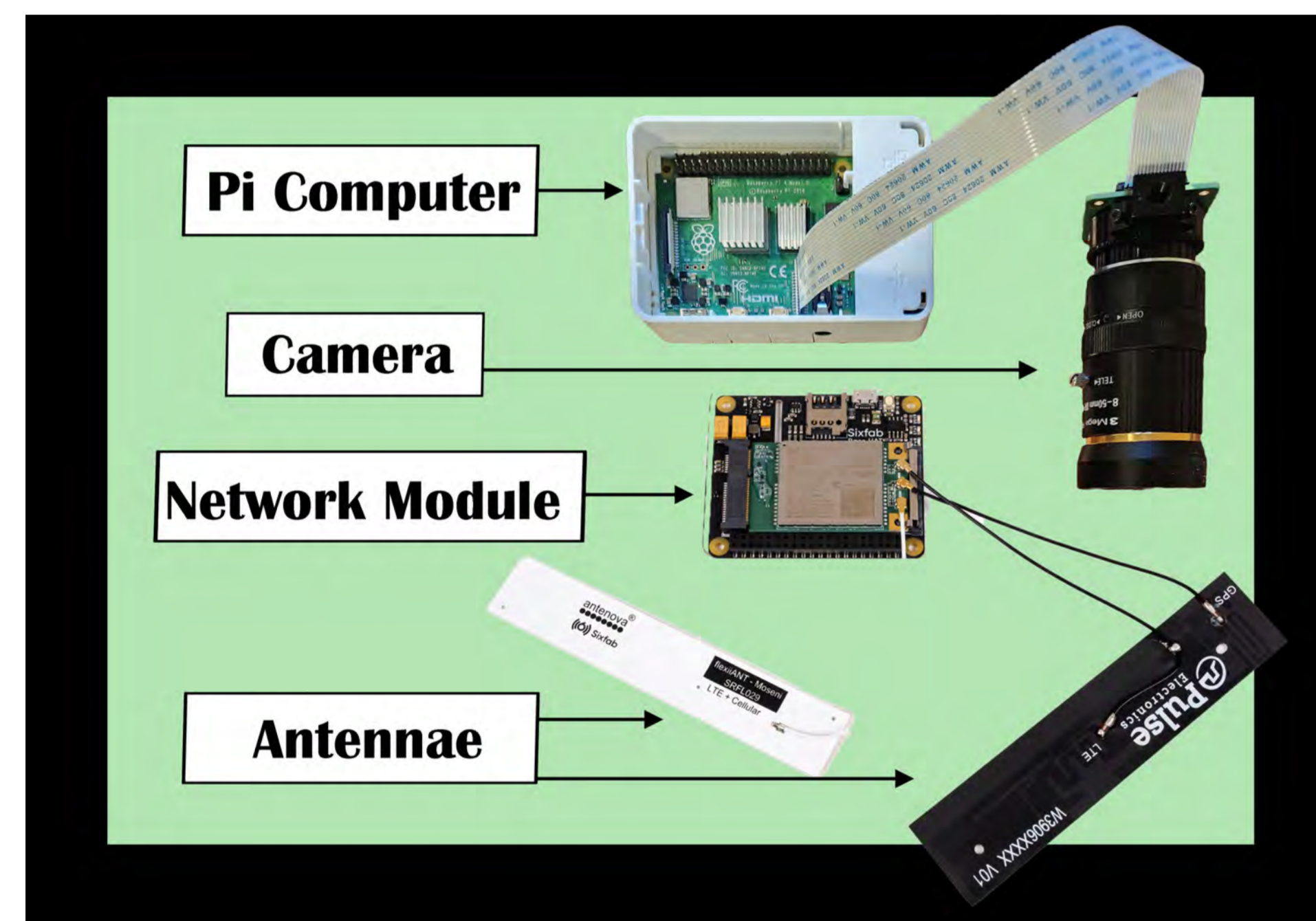


## Introduction

This project aims to collect data from the coastlines in Narragansett Bay using cameras and then analyze the images using AI models. This semester focused on learning what steps we needed to take to image the subject properly. Our team wanted to have a way to get the images we needed so that we could then explore models that would help detect changes in the coastline. The expectations included as follows:

1. Setting up a camera that properly communicated with the pi
2. Taking clear images and adjusting focus for specific weather patterns/lens disturbances
3. Taking images on certain intervals
4. Communicating with a server via cellular networks and transmitting the images
5. Sustaining power on its own

## Raspberry Pi



The Raspberry Pi is a compact, affordable computer that can be equipped with a camera module, making it ideal for creating custom image-capturing projects. To set up a Raspberry Pi, first, connect it to a monitor, keyboard, and mouse and insert a microSD card containing the operating system into its slot. Next, power up the Raspberry Pi by connecting it to a power source using a micro USB or USB-C charger, depending on the model. Finally, follow the on-screen instructions to complete the setup, which includes configuring settings such as language, time zone, and wifi connection. Once placed outside, the box we will use to contain the Raspberry Pi contains a MightyMax rechargeable battery that will act as a power source. There is also a wanderer solar power charger to sustain the battery and power the Raspberry Pi

## The Code Explained

1. **Communicates with Camera:** The Raspberry Pi camera is connected to the Raspberry Pi computer via the dedicated Camera Serial Interface (CSI). This high-speed connector enables direct communication between the camera module and the processing unit. This hardware connection allows efficient data transfer, directly supporting high-resolution image capture and processing on the Raspberry Pi.
2. **Cronjob:** A cron job has been configured on the Raspberry Pi to execute the Python script hourly, on the hour, ensuring a systematic and automated collection of image data. This scheduling allows for consistent image acquisition without manual intervention, capturing environmental changes accurately over time. After capture, the images are immediately transferred to a secure server, enabling researchers to access real-time data.
3. **Image Quality Upgrade:** We utilize the 'rpicinfo' command to allow optimal image capture by adjusting image quality to the highest setting and automatically adapting to varying lighting conditions. This approach ensures that the camera settings, such as exposure, white balance, and dynamic range compression, are finely tuned to capture the best possible images in diverse environmental conditions.
4. **Taking Images and Sending Them to a Server on the Network:** This Python script automates capturing high-quality images using a Raspberry Pi camera and transferring them securely to a remote server via SFTP (Secure File Transfer Protocol). The script begins by establishing a connection to the server using the 'pysftp', then uses the command to capture an image from the Raspberry Pi's camera.
5. **Naming Images:** Each image file is saved locally under a name based on a timestamp to ensure uniqueness. After capturing and storing the image, the script synchronizes the file system to ensure all data is written to disk. It then lists all image files in the specified directory and one by one, attempts to upload each to the remote server under a designated directory.

## Process

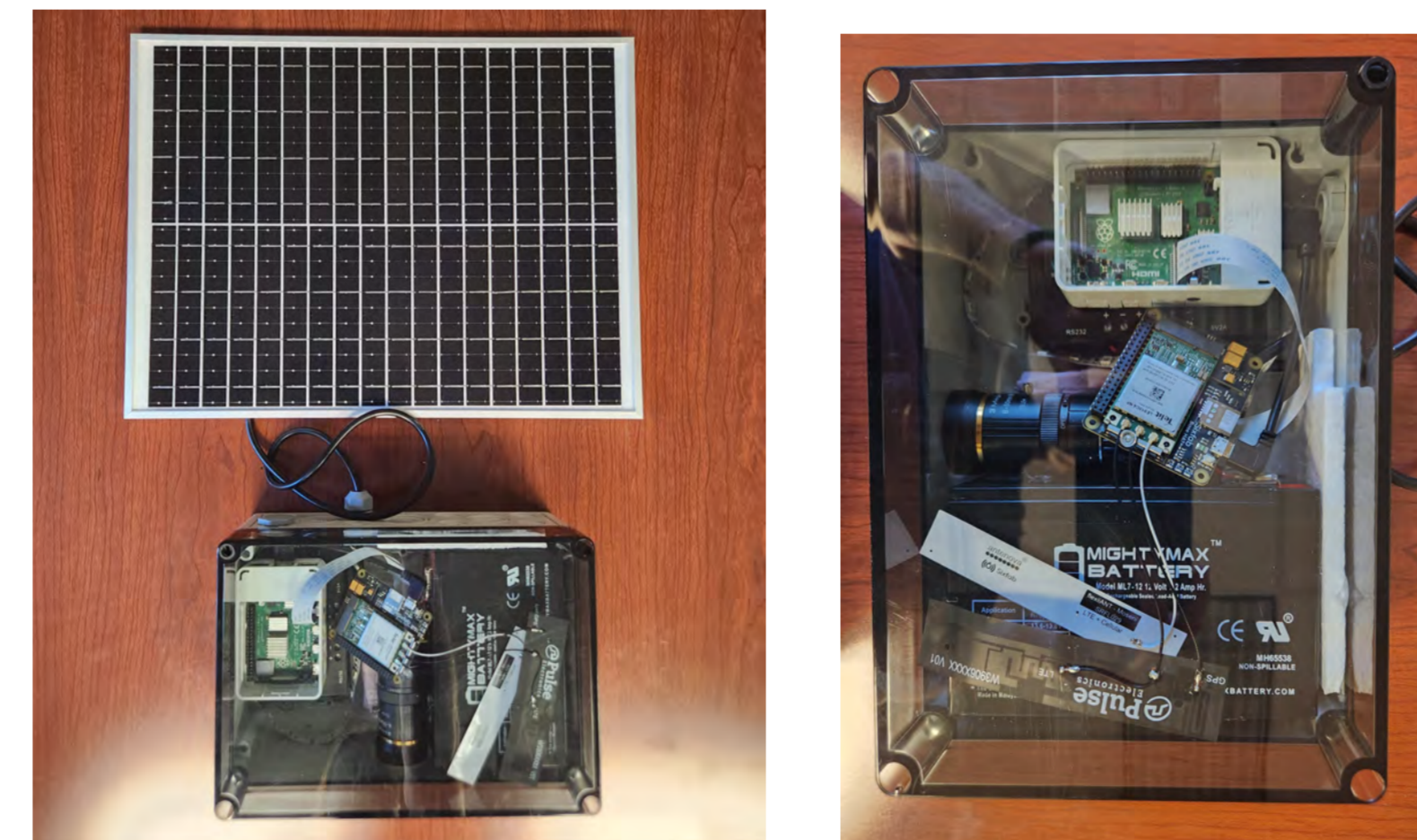


Figure 1. Left: Box with Solar, Right: Close Up on Box

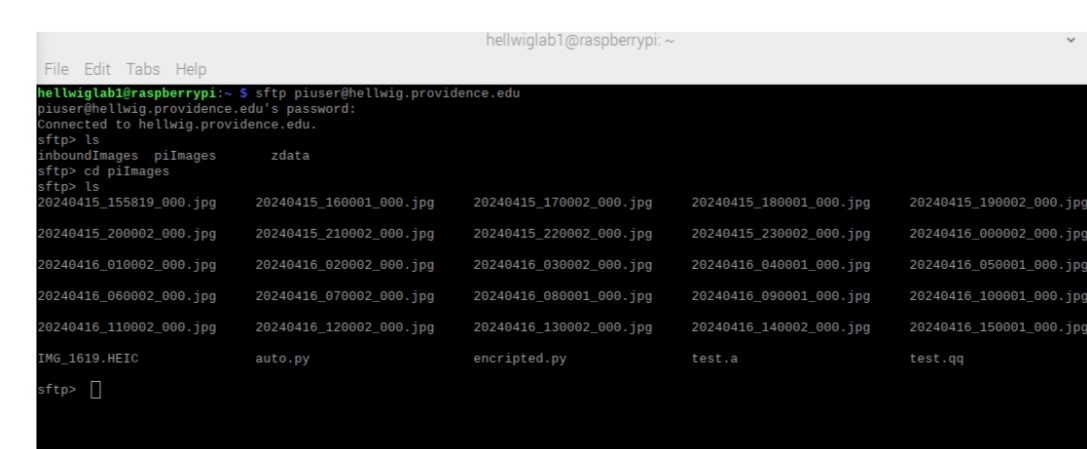


Figure 2. Example of Connection to Server with Image Files

## Where We are At Now

Timelapse:



The images displayed above the top were taken over one full day. This is merely an example of the image quality that will be received once the camera is moved to the shoreline. You can notice the automatic adjustments made by the camera at times of increased brightness/shadow.

## Future Goals - Off Campus

Improve setup:

1. **Pizero:** Less power consumption, simple commands. Transitioning to the Raspberry Pi Zero in future project phases could significantly enhance efficiency and sustainability due to its low power consumption and ability to execute simple commands. This shift aims to minimize environmental impact and operational costs, maintaining high data collection standards in a more cost-effective and ecologically responsible setup. The Pi Zero's substantially lower power requirements also allow it to run through much longer times with little or no sun exposure.
2. **Cellular network:** Ability to connect to the server off wifi connection, allows box placement anywhere. In future developments, we plan to transition from using wifi to a cellular network for our Raspberry Pi camera setup. This change will enable us to deploy our cameras in virtually any location, regardless of wifi availability, greatly expanding our data collection capabilities. The ultimate goal is to enhance energy conservation and efficiency by programming the Raspberry Pi to power on only at the top of each hour. During these brief operational windows, the device will capture images, upload them to the server via the cellular network, and then power down itself and the cellular module. This method ensures minimal energy usage while maintaining consistent data flow, making our system more versatile and environmentally friendly.
3. **Computer Vision to Analyze Images:** After collecting enough data, we plan to use Computer Vision software to train a machine learning model to detect the information we need from the images. A machine learning model is a system of neural networks that is given data and, through this data, learns how to derive certain patterns/obscurities. Through this, we can teach a model to see the specific patterns in the shoreline that point to erosion and see, through all the images given, how erosion is affecting Narragansett Bay.