**Intro & Problem Statement:**

INTERESTING INTRO LINE

Good afternoon Dr. Paine, Dr. Schonken and the rest of the audience. Monitoring animals by hand is a long and tedious process. It often involves setting up camp in one spot with a hand-held camera and a notebook for several hours at a time. While nothing quite beats the thrill of capturing good data, a researcher’s presence in an animal’s habitat could disturb them or drive them away. Some animals, like birds, also build their nests in trees or on top of high buildings. This poses problems for the observer. An easy solution is obviously using a camera trap.

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The inspiration for this project comes from Dr Celiwe Ngcamphalala who studies red-winged starlings on UCT Upper Campus. Her research forms a part of the global change and urban birds research project at the FitzPatrick Institute. Red-Winged Starlings are known for thriving on UCTs campus, and the behaviour of these birds is studied by several ornithologists. Dr Ngcamphalala needs a low-cost solution for tracking the activity of red-winged starlings in their nests. This includes, among other things, how long it takes for their eggs to hatch and the birds’ feeding behavior.

In response, we have developed a low-cost network-enabled camera trap to be used by ornithologists at the FitzPatrick Institute. The final system is triggered by body heat and takes photos which are uploaded to Google Drive with environmental sensor data. These images are processed at a later stage.

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**Housing:**

Following the project taking a life of its own, resulting in a shift in focus, this system had to be adapted from a wild, remote outdoor area to a more urban and furnished environment. The assembly is made of two parts; one to house the camera and transmission circuitry, and one to house the power supplying system. The housing opens only to expose the sensors to the environment during operation, otherwise it is built enclosed.

Due to the narrow nature of the setting environment, the circuit boards and the housing were optimized to be compact in terms of size, but to also leave some space for mounting. It is recommended that the system be mounted with a variation of a chair angle bracket where it should rest on its longest side (resulting in a setting whereby it is longer horizontally). Because of its lightweight nature and simplicity, there is a lot of flexibility around how this may be achieved. This is ideal given that these birds build their nests in the most random places on campus. For ease of use, cable ties may be used to keep the system in place with respect to the bracket or alternatively, they may be joined using bolts, nuts and washers.

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**Power:**

The power subsystem has

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**Camera:**

The camera subsystem has both hardware and software components. Put together, it is able to capture a photo of an animal as it passes by. Not only does it do this, but it also captures environmental data such as temperature and humidity. The picture taken is then stored on an SD card, along with the environmental data, which is embedded in the image name.

To achieve this functionality, the ESP32-CAM was used. It is a low-cost microcontroller which features an on-board 2MP camera. It also consumes little power, especially in deep-sleep mode, making it ideal for longer deployments. An external trigger was used to wake the camera up and let it know that an animal is passing by. This trigger took the form of a Passive Infra-Red (PIR) sensor circuit, which registers a difference between the ambient temperature and the body heat of an animal.

The prototype circuit was built and tested. Overall, the picture quality is satisfactory, but the camera does sometimes take photos that have a greenish hue. This usually happens during the initialization of the camera and therefore only affects the first couple of photos. It could be prevented by increasing the shutter delay, but this comes at the risk of missed images. Otherwise, the PIR sensor works well up to 7m away from a target. Naturally, some false triggering still occurs but future iterations of the camera subsystem could include on-board image processing to remove these false triggers from the picture batch. As of right now, however, this is left to a separate submodule.

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**Image Transmission and Processing:**

The Image Transmission and Processing subsystem has two main functions. It uploads the images taken by the camera subsystem to a Google Drive folder and processes the files to extract relevant data. The purpose of this is to allow for real-time access to data and reduce demand on researchers to manually sort through captured data thus saving time and effort that could be better spent elsewhere.

The transmission part of this subsystem is executed using the ESP-32 microcontroller and 2 main software components. The onboard code connects the camera to the internet and uploads images to Google Drive. Currently the board connects to a mobile hotspot. Further development would include connecting to eduroam (as research is on campus) or adding an additional wifi access point so that a mobile hotspot is not needed.

The image processing part of the subsystem does 2 main things:

* It checks if there is a bird in each image and stores a list of the images that do contain birds; and
* It processes this list of file names which contain temperature, humidity, and heat index data from the camera subsystem.

The images and graphs shown on the slide above are generated by the image processing subsystem which circles what it recognizes as a bird and plots the relevant data. Due to time constraints, the images were not taken with the system but rather with a cell phone.

This is all done in a Google Colab notebook allowing for easy access to the Google Drive. This also means that no images need to be downloaded before processing. Only images containing birds are processed and the data retrieved is plotted. Future development would include a dashboard with access to the images that do have birds in them as well as plots and further analysis of the data. A better object detection model would also be developed to ensure that no photos are incorrectly excluded from processing and to identify whether a bird is a starling.

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**Conclusion:**

This project was driven by the need for better low-cost equipment in the field of ornithology and we hope that the system we have designed makes the data gathering process both easier and more effective. Together, the above-discussed submodules form a network-enabled camera trap that will allow an ornithologist to monitor birds activity in and around their nests at a low cost. The camera and transmission subsystem specifically, cost approximately R300 in components. This specific solution has been optimized and tailored to suit the needs of the red-wing starling project. However, it can be modified to fit into several contexts. While there is room for our system to grow, we are proud to say that the solution we have built is able to successfully capture, save and transmit both images and sensor data as shown in the following demonstration.

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SHOW VIDEO

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Monitoring birds in the hustle of activity surrounding the UCT campuses is no easy task. In completing this project, we hope to have made the process at least somewhat easier. Thank you!