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Proposal: Kiwi Observation System

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Abstract

This proposal outlines a device designed to be used for research of little spotted kiwi populations. The client requires a device with the capabilities of weight measurement and image capturing with an emphasis on minimal misidentification. The concept design featured in this proposal accomplishes the constraints as well as introduces further specifications that will be beneficial to accurate photographic data acquisition of the research subject. A focus on a field-ready, cost-effective design is accomplished through the use of open source hardware such as Arduino, and software featuring object recognition. Team 6's goal is to demonstrate a functional prototype for the client, with the ultimate goal in delivering this device for researchers to trial on their research population.

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Introduction

a) Background

With an estimated population of 2000 individuals, the little spotted kiwi (*apteryx owenii)* is the smallest and second rarest of the flightless kiwi species native to New Zealand [1]. The range of little spotted kiwi populations markedly decreased with the arrival of human settlers within their habitat regions. Recent conservation measures have reversed the population decline of the little spotted kiwi. The International Union for Conservation of Nature and Natural Resources has the species currently classified as Near Threatened as of 2008 [2]. Conservation actions proposed by the IUCN calls for regular monitoring of all little spotted kiwi [3].

b) Project

As of 2013, methods for acoustic identification [4] exist for research of little spotted kiwi populations, however no suitable device has been designed capable of photography-based monitoring. A research laboratory studying the population of the little spotted kiwi has identified this deficit, and requires such a device for the purposes of analyzing the health of the subject populations. The constraints of this device, as determined by the client, include the ability to determine if a bird weighs in excess of 1.75lbs and to capture a photograph if the bird meets the weight criteria. A secondary requirement requested asks for the design of a method to distinguish a little spotted kiwi from other species, and to capture a photograph if the bird meets these identification criteria.

c) Specifications

- Client-identified Specifications

    1. Ability to identify an object's weight and determine if the object weighs in excess of 1.75lbs.
    2. Ability to photograph the object and store the data for research.
    3. Minimization of unrelated data acquisition due to faulty object identification.

- A secondary feature narrows the selection criteria of the device:

    4. Design a method to properly distinguish a little spotted kiwi from other birds prior to capturing a photograph.

These client-identified specifications must be met in order for the researchers to gather accurate data related to their study. A device that identifies and obtains photographs of little spotted kiwis above the weight of 1.75lbs will prevent an accumulation of unnecessary images from distracting the researchers from their target data.

- Team 6-identified Specifications

Through research of the target species, Team 6 has identified further constraints that raise the usability of our proposed design:

1. Design a method to implement client-identified specifications in low-light to nighttime conditions.
2. The device must be resistant to wet, forested climates.
3. The device must maintain portability for ease of transporting to the field study area.

The little spotted kiwi is a predominantly nocturnal species [5] that populates a range restricted to seven offshore islands featuring minimal predators. The little spotted kiwi is also noted to maintain a preference towards wet environments. The design must take these traits into consideration, or else the device would be severely handicapped for fieldwork. Maintaining portability is a constraint that will allow the device to be brought into field study areas with little to no disturbance to the sites. The constraint means that an independent power supply would be necessary in the final design.

Proposed Design - Concepts to Selection

a) Initial Concepts

During the early stages each team member conducted their own research in order to maximize the conceptual choices. The ideas were then shared and the concepts were compared, defended, and modified along with the identification of additional constraints. Two designs passed the newly defined specifications:

I Concept 1:

Utilization of OpenCV or MATLAB, an Android camera phone with a waterproof case, and a weight sensor, a device can be constructed to perform all outlined specifications. (Fig.1)

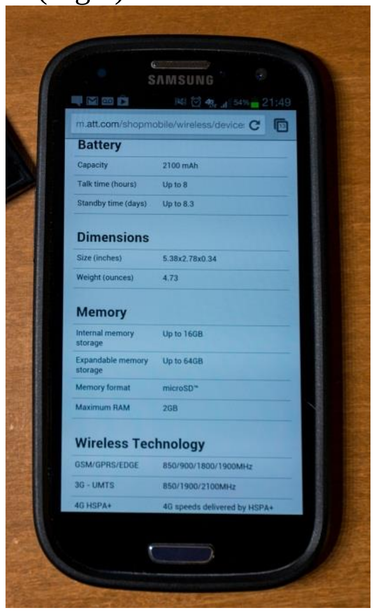


Figure 1: Android-based Samsung Galaxy SIII camera phone

II Concept 2:

Utilization of OpenCV or MATLAB, Arduino microcontrollers, a waterproof camera, and a weight sensor; a device can be constructed at low cost which passes our specification checks (Fig. 2).

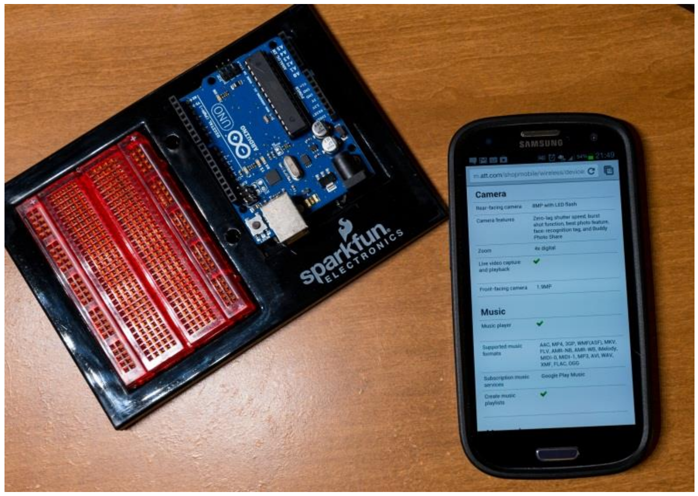


Figure 2: Arduino Uno next to Samsung camera phone

The inclusion of an Android camera phone in Concept 1 was a potential option due to its 8.3 days of standby battery time, camera with face recognition technology (Fig. 1-2), and ease of communication between the platform and either OpenCV or MATLAB. Ultimately the concept was withdrawn once the cost associated with incorporating an Android device was factored in.

Team 6 decided that Concept 2 would better meet the client's specifications. The highlight of this concept is keeping open-source choices for the material and software required. This significantly reduces the overall cost of the design while still maintaining a high level of communication between the design and either the utilization of OpenCV or MATLAB. Further testing on both software will take place in order to determine the optimal visual identification software. The two share similar qualities, and will require experimentation before a final choice is made.

The final choice of which type of weight sensor will also need to be determined through research and experimentation. Team 6 strives to keep the material cost low without negative impact to the design. This will require time spent on identifying the best options for our scale.

b) Flowchart Overview

The flowchart below (Fig. 3) shows the proposed hardware layout of our design:

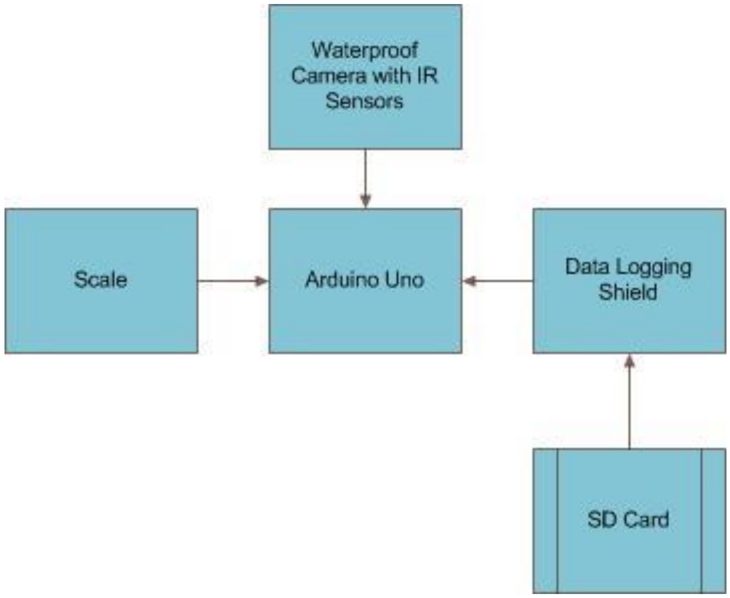


Figure 3: Hardware flowchart

The flowchart below (Fig. 4) shows the sequence of code of our design:

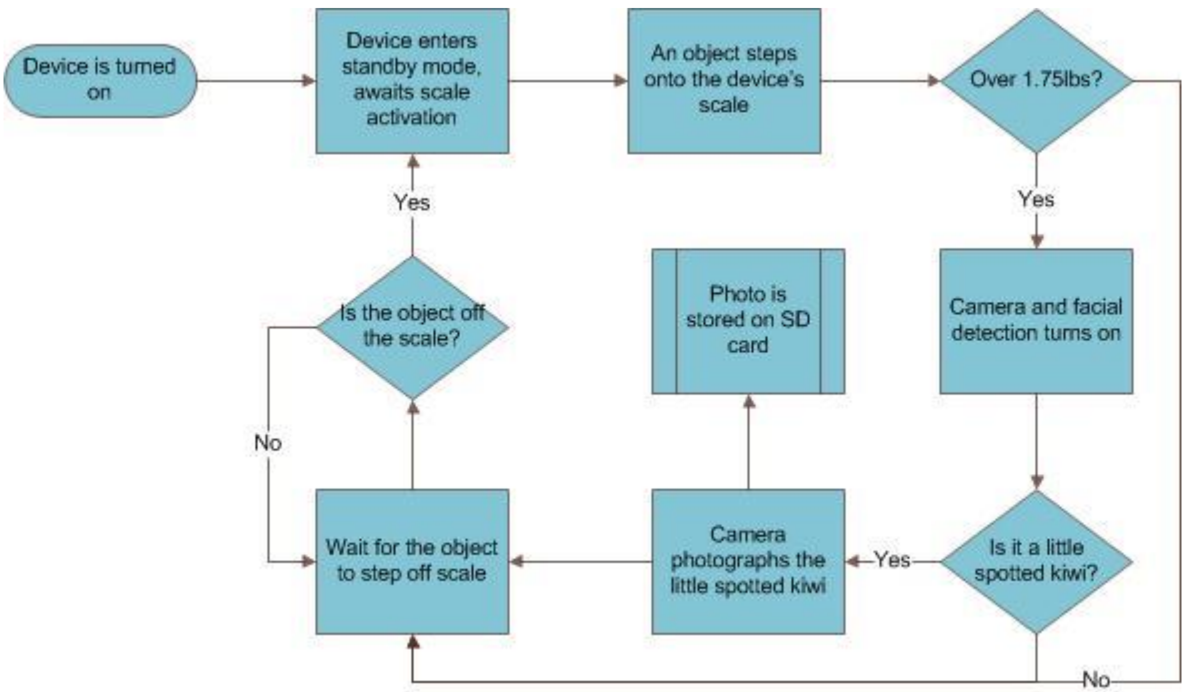


Figure 4: From Kiwi to photograph flowchart

c) Limitation to Investigate

Team 6 recognizes that the device will be used in a field environment for the research of little spotted kiwi populations. The client-specified requirements do not state any intended method in the deployment of the device. Being that the little spotted kiwi is under conservation monitoring, Team 6 wants to ensure that the design process accounts for methods in which subject behavior modification is kept to a minimum. In order to maintain low external pollution to the research populations, Team 6 has forgone baiting and luring methods in the design. If the client identifies that this is a positive specification, one of our resources will travel to the study area and work with researchers in determining a minimal-impact addition to the device.

Methods

At the selection of our proposed concept, Team 6 will immediately assign tasks to each group member. There are two primary branches of tasks that converge into one cohesive unit: hardware and software. As Team 6 has a concrete direction for the design, the majority of our resources will be focused on the software aspect. Research and experimentation of Arduino, MATLAB, and OpenCV code will be divided amongst the team, with one resource focused on hardware configuration. The resource assigned to hardware will keep communication open with the software team. At least once a week, Team 6 will meet to share resources and to discuss progress of their respective tasks. These scheduled meetings will allow Team 6 to assess the design, and to maintain an overall priority of hardware and software integration.

The sequence of design is broken down into 3 main stages (Entire timeline on Table 1.):

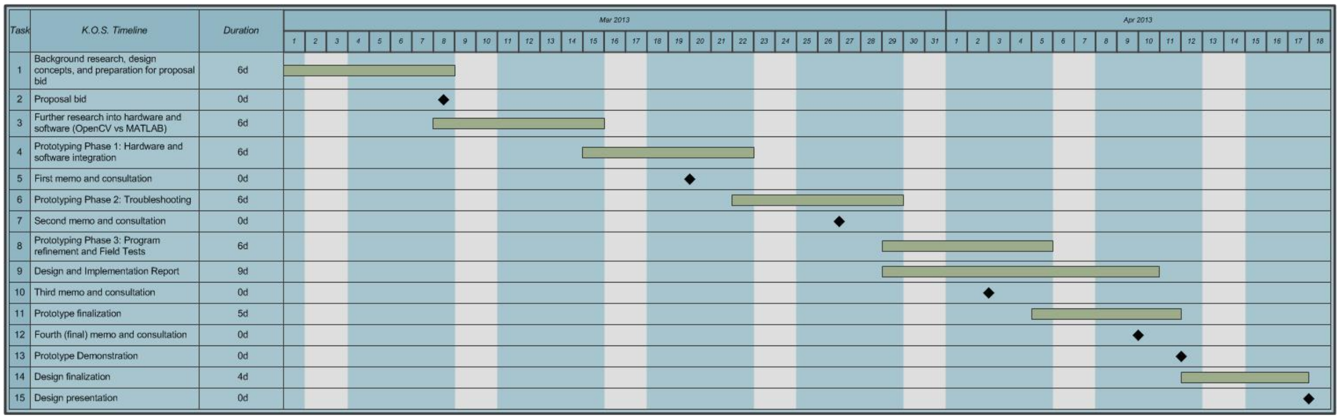
- Research on optimum software choice
- Prototyping phases
    1. Hardware and software integration, construction of a functional prototype
    2. Troubleshooting and debugging
    3. Refinement and Field Tests
- Finalization of prototype

The continuation of research in OpenCV and MATLAB will continue with resources assigned to trial the usability of the software, and potential for integration into our design. Once the software is identified, the prototyping phases will begin, starting with Phase 1 in which a rudimentary but functional prototype will be built. The aim is to successfully incorporate every specification into the prototype by the end of this phase. In Phase 2 the team will enter a troubleshooting stage in where the focus is in QA. Discovery of faulty programming will be repaired, and the overall operation is to be streamlined. Optimizing battery usage will also be a factor in Phase 2. Phase 3 is where Team 6 will bring the experiment into field operations and ensure the prototype will function as intended when it's left outdoors. Data gathered from these experiments will be implemented in a similar fashion to Phase 2. Repeated field trials will be conducted to guarantee non-faulty operation.

As the demonstration and presentation deadlines approach, the device will enter the finalization stages. Minor adjustments in programming and hardware configuration will be conducted along with any enhancements in housing material and deployment methods.

Timeline

Table 1: Timeline Chart



Cost Analysis

Table 2: Cost Analysis

	Type	Unit Price	Quantity	Total
Compensation	Labor	30.00/hr pp.	4 @ 200hrs/pp.	24,000.00
Travel and Accomadations	Research	3,000.00	1	3,000.00
Arduino Uno	Hardware	29.95	2	59.90
Camera	Hardware	54.95	1	54.95
Data Logging Shield	Hardware	19.95	1	19.95
Flexiforce Pressure Sensor	Hardware	24.95	1	24.95
Electronic components	Hardware	50.00	-	50.00
MATLAB	Licensing*	1,900.00	2	3,800.00
TOTAL w/ MATLAB	31,009.75 USD			
TOTAL w/o MATLAB	27,209.75 USD			

Team 6 Qualifications

Team 6 is a group of Computer Engineering Technology and Electronic Engineering Technology students based in Boston, MA's Wentworth Institute of Technology. Each member of the design team brings a core set of problem-solving skills to the client. The background of each of the members form a design team capable of delivering viable, cost-efficient solutions to companies that demand quality results. The resources available to Team 6 mean that each situation will be approached with no limit in experimentation methods, resulting in designs that will meet and exceed the expectations of our clients.

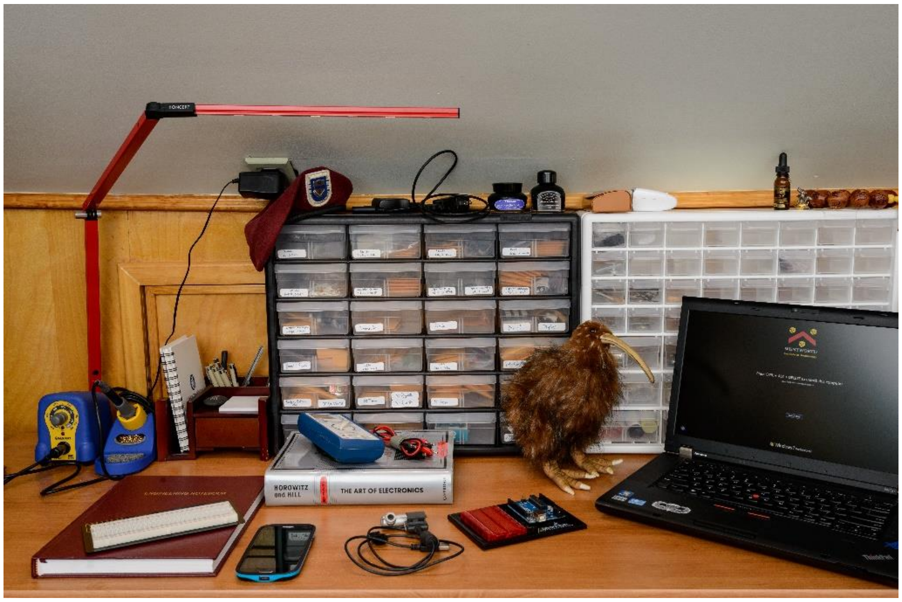


Figure 5: Team 6's state of the art facility

The Design Team:

- Sze "Ron" Chau: Ron majors in Electronic Engineering Technology at WIT. A member of IEEE, Ron keeps an interest in every aspect of the design. He has spent months in the field between Tracker School and his Army enlistment while assigned to JFK Special Warfare Center as field personnel at SERE school, Camp Mackall. This gives Ron a unique perspective in approaching the design dealing with functionality in environments the little spotted kiwi inhabits.

- Benjamin Li: Majoring in Computer Engineering Technology at WIT, Ben has high school experience in CAD and Solidworks software. He was introduced to programming in high school, and continues enhancing these skills.

- Sam Mei: Sam, a Computer Engineering Technology major at WIT, maintains his knowledge in video editing using Adobe software and continues to grow his already impressive command of Solidworks. He spends time disassembling and soldering personal projects. Sam maintains a deep interest in programming.

- Alex Young: An Electronic Engineering Technology major at WIT, Alex expressed interest in the engineering field during high school, and subsequently completed engineering courses. He was the captain of his high school robotics team, and a member of IEEE. His robotics experience brings a critical eye to the development of the device.

Conclusion

The design outlined in this proposal will allow for the deployment of a field expedient and energy efficient device capable of performing the constraints set forth by the client. Careful research analysis and planning in design implementation will be maintained through the entire process in an effort to minimize disturbances to the research subject populations. Overall cost is reduced by a preference towards open sourced hardware and software. Features that increase portability and usability in the field are also balanced into the product.

This design can evolve from the initial concepts through meetings with the researchers and visits to the field study locations. Team 6's Kiwi Observation System will be able to accomplish data-gathering of the little spotted kiwi with strict identification abilities, allowing the researchers to focus on their research of this near threatened flightless bird.

Reference

[1] Jolly, J., 1989, “A Field Study of the Breeding Biology of the Little Spotted Kiwi (*Apteryx Owenii)* with Emphasis on the Causes of Nest Failures,” Journal of the Royal Society of New Zealand, 19(4), pp. 433-434.

[2] BirdLife International 2012, 2012, “Apteryx Owenii,” IUCN 2012, 2012(2).

[3] Holzapfel, S., Robertson, H., McLennan, W., Hackwell, K., Imprey, M., 2008, “Kiwi (*Apteryx spp.)* Recovery Plan 2008-2018”, Threatened Species Recovery Plan 60, NZ Department of Conservation.

[4] Robertson, H., 2004, “Research and Monitoring Plan for the Kiwi Sanctuaries,” Science for Conservation, 241, pp. 18-20.

[5] Martin, G., Wilson, K., Wild, M., Parsons, S., Kubke, F., Corfield, J., 2007, “Kiwi Forego Vision in the Guidance of Their Nocturnal Activities,” PLoS ONE, 2(2).

Appendix

A. Figures

Figure 1. Photograph of Samsung Galaxy SIII (displaying Battery, Dimensions, Memory, and Wireless Technology specifications) by Chau, S., 2013

Figure 2. Photograph of Arduino Uno and Samsung Galaxy SIII (Displaying Camera and Music specifications) by Chau, S., 2013

Figure 3. Design Layout: Hardware

Figure 4. Program Flowchart

Figure 5. Team 6 headquarters contain state of the art facilities

B. Tables

Table 1. Timeline of the entire design process

Table 2. Cost Analysis