Needs Assessment

Underground Robotic Gopher Tortoise Scope

Team 21 (E19)

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Abstract

Tall Timbers Research Station and Land Conservancy has provided Team 21 the task of the creation of a more affordable burrow scope for the purpose of studying gopher tortoises. Although there is already a scope on the market manufactured by Sandpiper Technologies, INC. it is out of the budget of most research stations, not only Tall Timbers. The final product should include an infrared camera that is able to traverse a burrow up to 15 meters in length and connected to a screen that can not only display the image but also capture and record the footage, and the entire system should be waterproof and cost less than 1000 dollars.

It is still early in the timeline of producing this product. However, steps have already been taken towards the completion of the system. A Code of Conduct for the team has been established, outlining the appropriate meeting times, dress code, and interpersonal relations between the members. The sponsor, Tall Timbers, has been contacted and an onsite field assessment has been completed in order to observe the environment that the final system will be operating in. The current technology Tall Timbers possesses for the scoping of gopher tortoise burrows has also been studied, the downfalls of the system observed, and improvements for the future system noted. Along with meeting the sponsor, the team has also met with both the mechanical and electrical engineering faculty advisors, Dr. Jonathan Clark and Dr. Bruce Harvey respectively, the head of the electrical engineering course, Dr. Michael Frank, and the heads of the mechanical engineering course, Dr. Nikhil Gupta, Dr. Scott Helzer and Dr. Chiang Shih, in order to discuss the projects current progress and plans for future steps. An initial brainstorming session has also been completed.

Prototyping is scheduled to begin in the next week in order to start the initial design of the underground tortoise scope, and to have the first functioning prototype by mid to late October. Testing of the prototype will begin in early December, at which time a mock burrow will be built in order to simulate the real world conditions the scope will be facing at Tall Timbers.

Introduction

Tall Timbers Research Station and Land Conservancy's primary research focus is the ecology and management of fire-dependent ecosystems and wildlife. One resident of these ecosystems is the gopher tortoise, which is a candidate species for federal listing [1]. Because of this, it is imperative that conservation groups such as Tall Timbers study these reptiles in order to have some chance of increasing their population numbers. Conservation and research groups use a standard method to survey gopher tortoise borrows in order to achieve accurate populate estimates. This requires scoping all burrows in the vicinity in entirety to obtain precise occupancy data. Because the market scopes are very expensive, Tall Timbers was driven to create their own scope which is heavy, very cumbersome to use, and mud often clumps in front of the camera lens limiting visibility. This senior design team has been given the task to design a more economical scope that is lightweight, easy to use, and reproducible for other conservation groups studying gopher tortoises and other burrowing species.

Project Definition

A. Background Research

Many species find refuge in the burrow of a gopher tortoise. Due to the large effect this tortoise has on its surrounding ecosystem it is considered a keystone species [2]. This fact makes the study of the animal so imperative, especially for a research station such as Tall Timbers which specializes in fire ecology studies. Gopher tortoises however are not the only burrowing animals that require a scope in order to be studied; there are also burrowing owls, foxes, prairie dogs and many other small mammals.

Figure 1. Sandpiper Technologies INC. Peeper 2000

To meet this need for research equipment, Sandpiper Technologies, INC. introduced the Peeper 2000, which can be seen in Fig. 1. This system consists of a head mounted display video, a video probe, a battery charger and a case. The system has the positive attributes of being lightweight as well as waterproof. As far as the probes are concerned there is the Peep-A-Roo, which is 1 inch in diameter and 4 meters long, and the Peeper Video Probe, which is 2.3 inches in diameter and long enough to reach the end of tortoise burrows. These systems however have the major drawback of costing 6,000 dollars apiece, as of their most recent catalogue [3]. This is generally out of the budget of research centers such as Tall Timbers, leaving them still without a scope. In order to meet this need, Tall Timbers built their own scope for a total of about 500 dollars. It however is outdated and slightly crude in design. It consists of an infrared camera connected via long detachable wires to a portable DVD player. The wires are protected by thick rubber hosing. This hosing has proven to be heavy as well as not easily navigated through the burrow, and the DVD player is not waterproof.

The creation of a scope that is on the technological level of Sandpiper's Peeper 2000 while also costing less than 1000 dollars would be pivotal for research centers such as Tall Timbers, and could do a great deal of good for the advancement of the study of many burrowing keystone species, not only the gopher tortoise.

B. Needs Statement

As stated, the current scope consists of a basic infrared camera that is connected to a tube and wired to a DVD player. The design is cumbersome for several reasons. In order to use the camera, the user must physically push the camera down the tortoise burrow. Thus, the camera can easily dig into the ground and get blocked by dirt. It is difficult to navigate the camera, as there is nothing to help the camera move forward/backwards or navigate turns. Because of this lack of maneuverability, many parts of the burrows are unreachable for

decent research. Often, the camera will be flipped over or rotated in an attempt to go around obstacles. Consequently, the user may no longer be able to determine which side is up or down.

The scope, which involves three large components, is heavy and bulky. By the end of the day, the sponsor related that her hands would be covered in blisters from having to physically handle the heavy equipment for eight or more hours. Furthermore, after a burdensome day of work, any results the user does find will have to be handwritten, since there are no video/picture-capturing capabilities with the current model.

When the weather is inclement problems are amplified. If it is raining, the device is at risk due to the fact that it is not waterproof, and there are open wired connections. Further, water could ruin the infrared camera itself, leading to costly repairs or replacements. Also, the scope could run into obstacles, and is not shock-proof enough to handle unexpected impacts. Finally, in the common case that the lens fogs up or is covered with dirt or mud, the user must pull out the scope, clean it, and start the process over from the beginning.

Buying a manufactured scope is typically not an option for research centers such as Tall Timbers. It is a non-profit organization, and does not have the budget for a system that can cost up to $6000. Thus, research stations like these are stuck in a financial trap, and are unable to get adequate tools for underground research.

Final Needs Statement:

In all, there is a need for gopher scopes to have improved weather and impact durability, greater mobility, data-acquisition capability, and reduced weight and space.

C. Goal Statement

Design a mechanism to have testing sensors, better durability, and more advanced video capabilities than the current system in order to enhance the surveying process of gopher tortoises.

Objectives:

- Mechanism needs to be water and dirt resistant
- No more than 6 inches wide
- Weigh less than 50lbs
- Shock resistant
- Have a battery life for at least 8 hours
- Operate in temperatures from 0°F and 100°F
- Infrared camera that can take pictures and record live video
- Gather temperature and humidity readings of the burrow
- Move quickly with good traction down the burrow
- Be relatively quiet in order to not disturb the gopher tortoises or other animals

D. Constraints

The planned usage and environment of the Gopher Tortoise scope means that a great deal of constraints must be considered when designing the product. Firstly, the average size of the Gopher Tortoise burrow must be taken into consideration. The underground rover portion of the design should be no more than six inches in diameter, and ideally only four inches in diameter. The rover will also need to be attached to a tether which extends to a length of at least 10 meters.

The portability of the design must also be considered. The design of the product must allow for a single researcher to easily carry it through several miles of dense forest. To accommodate this, the design will have to fit into a standard backpack and must not weigh more than 50 pounds. The design should also be durable and shock resistant in order to withstand the stresses associated with being kept in a backpack and being loaded and unloaded from the back of a truck.

Additionally, the product will be required to operate in the field for a full work day under a variety of weather conditions. To allow for this, the batteries will need to provide enough power for eight hours of continuous operation. The design will need to be able to operate in temperatures ranging from 0^0F to 100^0F. The design will also need to be dirt and water resistant so that the electronics are not compromised while operating underground or in adverse weather.

Finally, the product should be able to be purchased and built by researchers across the country who may have limited funds and/or technical experience. To accommodate this, the product will have to be designed using only readily available (off-the-shelf???) parts. The assembly process will need to be carefully documented to allow other teams to duplicate the results. The final product should cost no more than $800, and ideally be only $500.

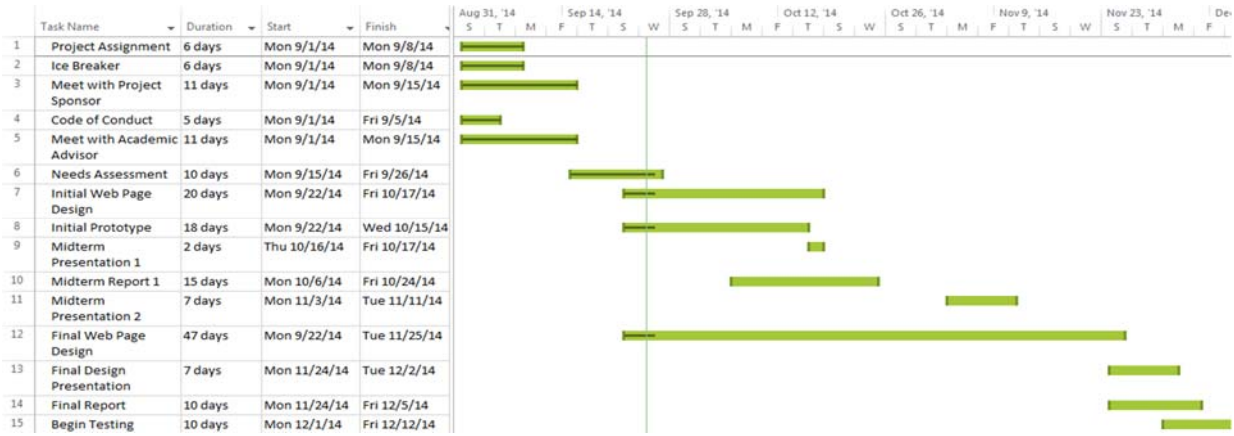
E. Methodology

- Identify key systems and functionalities
- Discuss various design ideas/methods
- Factor in constraints, limitations, possibilities, feasibility, and ergonomics
- Choose design
- Determine sectional components to design and prototype
- Outline initial CAD drawings and calculations
- Construct initial prototype and test
- Analyze need modifications and budget
- Order parts for final design
- Field testing
- Final design construction
- Final design testing
- Presentation of final product

Table 1. Summary of Desired Subsystem Features

Subsystem	**Features**
Power	8 hours of operation
Camera	Infrared
	Tilt/Pan
	Screen
Maneuverability	Cornering
	Anti-flipping
Data Acquisition	Temperature
	Humidity
	GPS
	Depth
	Recorded video
User Interface	Control Switches and Display
Tether	Durable
	Flexible
	10-15 meters in length

F. Schedule



	Task Name	Duration	Start	Finish
1	Project Assignment	6 days	Mon 9/1/14	Mon 9/8/14
2	Ice Breaker	6 days	Mon 9/1/14	Mon 9/8/14
3	Meet with Project Sponsor	11 days	Mon 9/1/14	Mon 9/15/14
4	Code of Conduct	5 days	Mon 9/1/14	Fri 9/5/14
5	Meet with Academic Advisor	11 days	Mon 9/1/14	Mon 9/15/14
6	Needs Assessment	10 days	Mon 9/15/14	Fri 9/26/14
7	Initial Web Page Design	20 days	Mon 9/22/14	Fri 10/17/14
8	Initial Prototype	18 days	Mon 9/22/14	Wed 10/15/14
9	Midterm Presentation 1	2 days	Thu 10/16/14	Fri 10/17/14
10	Midterm Report 1	15 days	Mon 10/6/14	Fri 10/24/14
11	Midterm Presentation 2	7 days	Mon 11/3/14	Tue 11/11/14
12	Final Web Page Design	47 days	Mon 9/22/14	Tue 11/25/14
13	Final Design Presentation	7 days	Mon 11/24/14	Tue 12/2/14
14	Final Report	10 days	Mon 11/24/14	Fri 12/5/14
15	Begin Testing	10 days	Mon 12/1/14	Fri 12/12/14

Figure 2. Gantt Chart for Team 21

Conclusion

It is evident that the underground robotic gopher tortoise scope is a device that both has a significant role in biological and ecological research, and has major obstacles that are preventing it from being used more prominently. Current models may range from expensive automated rovers to distinct rudimentary devices used in conjunction with each other. Major problems that researchers often face with the latter model type include a lack of durability, no video/picture capturing capability, no mobility, and poor ergonomics. High-end rovers may mitigate many of these problems, but the price itself makes it inaccessible for many non-profit research institutes, such as Tall Timbers.

Thus, Team 21 is assigned with devising a means to scope these underground burrows. The team will try to set the needs outlined by the sponsor as the main priority, while considering the budget for production, and the cost of the final product. As a result, a layout of steps to reach the end goal is tentatively proposed, but may change based on resources, time and availability, and unexpected circumstances. This process will start with design proposals, further research into feasibility, and deeper exploration of designs. From there, calculations, product assembly and design, and specifications will be produced. Finally, building the product, including prototype testing and final product fabrication, will occur.

Regarding future work, the team will propose designs, analyze each one with respect to the sponsor's needs and wishes, and choose the most agreed upon designs. Also, more clarity on current obstacles faced by the sponsor can be determined by continued contact with Tall Timbers. Similarly, the group will meet with the Mechanical Engineering and Electrical Engineering sponsors to gain more insight into design possibilities and critique of designs. With regular contact with advisors and with the sponsor, this project's ultimate goal of a gopher tortoise scope should be within reach.

References

[1] Service, U.s. Fish & Wildlife. "Section 4 of the Endangered Species Act." Candidate Species (n.d.): n. pag. Http://www.fws.gov/. U. S. Fish and Wildlife Service Endangered Species Program, 2011. Web. 25 Sept. 2014. <http://www.fws.gov/endangered/esa-library/pdf/candidate_species.pdf>.

[2] "Examples of Keystone Species." YourDictionary, n.d. Web. 25 September 2014. <http://examples.yourdictionary.com/examples-of-keystone-species.html>.

[3] Sandpiper Technologies, Inc. "2006-7 Catalog." Metal Finishing 104.6 (2006): 67. Sandpipertech.com. Sandpiper Technologies, Inc, 2006. Web. 25 Sept. 2014. <http://sandpipertech.com/Sandpiper_Tech_Web_2006_Catalog.pdf>.