Project Proposal

Project #11: Robo-tick

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Executive Summary

This proposal targets scientists and researchers who specialize in the study of ticks and the various diseases they transmit. The goal is to implement a robot design that automates the collection process by capturing the ticks as the robot drives through the terrain and carefully stores the ticks into a container for easy removal. To achieve this goal, extensive knowledge and tests will be performed such as quality, mechanical, operational, and function control. The robot will operate in areas of high concentration of ticks while being monitored and controlled by a user to map a path for the tick robot. In doing so, this will eliminate the risk of transmitted diseases from venturing into the field.

Problem Statement

Ticks are large contributors to the widespread cases of Babesiosis virus in the areas of Northern Africa amongst the general population of humans and livestock [1]. As a result, more researchers are venturing to specific areas such a Kenya and Mongolia to collect and analyze ticks located in those regions. As a result, tick collection has been widely practiced in foreign regions, for scientists to gain a better understanding of the diseases and how to treat them. The most common way of capturing ticks generally includes these scientists going out into the field and dragging a white cloth along the ground for approximately 2-3 hours at a time. The various problems with this method include: the potential transmission of disease due to ticks attaching to the researcher, heat exhaustion or heat stroke due to the extended time in the very hot and dry climate of Kenya. The possibility of dangerous encounters with wildlife such as lions and elephants are a hazard as well [2]. To address this physical method of tick collection, a robot will be designed in a manner where it eliminates the risk of transmitted diseases in sub-Saharan areas and help reduce the environmental impact of tick pesticide [3].

To address this problem, the robot will be designed with the following specifications. To retain the portability of the robot, the maximum weight of the product will be no more than 30 pounds. Doing so will allow the robot to operate with less power and more efficiency. Lightweight materials such as carbon fiber will aid in keeping the cost and weight down. In addition, the robot will operate on a battery/solar-powered system, which will allow it to travel up to a distance of at least 750 meters and be operational for a minimum of 2-3 hours. Tires of at least 8-inches will also be implemented to address the need of the robot to be operated in grassy terrains and to avoid any obstacles and obstructions in its path. In accordance, during the collection process, the robot will include a container of at least 50 ml to have enough space to store the desired number of ticks. To attract the ticks, the robot will include a holder for either a C02 canister or dry ice [2]. A potential design element for the storage container is to line it with pesticide to either kill or prevent the ticks from escaping. The storage container will also be designed for easy access and extraction from the robot. In addition, since some ticks respond to different environmental senses such as sound and smell, other elements could be included into the tick bot to better attract them. For example, Hyalomma ticks respond to sounds and vibrations, so a stomper could be incorporated to the robot.

In addition, this robot can help reduce areas of high tick concentration in high traffic environments such as schools, malls, and parks. With the incorporation of special design elements and concrete specifications, it will increase our product’s appeal in the tick-research industry by not only serving to aid in the research of ticks, but by also contributing to the welfare of people by reducing tick concentration in public areas.

The market for this robot ranges from people in the field of Entomology to companies that deal with the removal/collection of tick-like insects. While, this robot is specifically designed for the collection of ticks, it can be modified to suit the needs for collecting insects. Currently, tick robots on the market only attempt to collect ticks on to the cloth and then require users to manually remove the ticks by hand. What sets our design apart from market-ready products is that it will automate the process of removing the ticks.

Approach

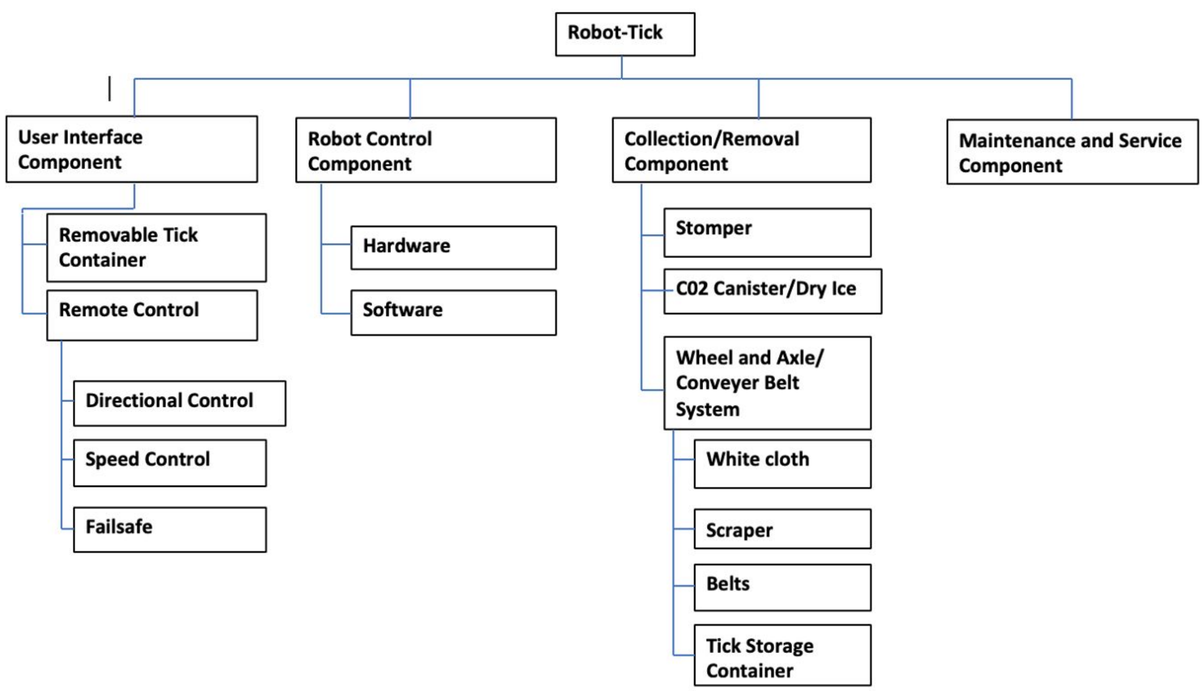

Figure 1: Physical Architecture

As stated before, the main problem being addressed with the robot is the safety of people collecting ticks in the field. The robot also makes the process more efficient and reduces the need for human labor through automation. The main design challenge for the robot is creating a mechanism for the removal of ticks from the cloth. Based on field testing, we noticed there was difficulty when removing a tick from the cloth due to the cotton material of the cloth and the tiny size of the tick. We experimented with various tools such as blades and brushes and were unsuccessful in completely removing the tick off the cloth. The difficulty of this process is also evident in the fact that ticks are normally removed from the cloth using tweezers during a traditional cloth sweep.

In the early stages, we came up with various designs for collecting ticks. One of them included a retractable belt system where the cloth is initially placed onto a wheel. As the wheel rotates it will retract the cloth, and the ticks will be pushed off by a stationary diagonal wall which will guide the ticks to a drop box where the ticks will be collected. After the removal of the ticks, the cloth will then be retracted out of the robot onto the ground and continue its path. Another potential design complication is the size and type of wheels to use for the robot so that it can travel on different types of terrain, specifically in areas with grass height around 8 inches. The approach is either to go with wheels or continuous tracks as both have their advantages and disadvantages. Additional features that the robot could have are GPS tracking for location and a stomper which will attract Hyalomma ticks with its movement.

Another design for capturing ticks is to scrape the ticks off the cloth while it is at a vertical angle. The cloth will begin by dragging against the ground to allow ticks to attach to it. Then the cloth will wrap around a bar from the ground and rise to the top of the robot. As it descends two “blades”, keen-edged metal strips, on either side of the cloth will scrape against it at an angle to prevent the ticks from passing underneath, almost cutting the ticks free from the cloth. The ticks will then fall off into a container where there will be cotton balls with pesticide to kill them and keep the ticks from escaping. After the cloth moves past the containers it will extend back out behind the robot where it finally returns to the ground. This cycle will occur continuously as the robot moves along its path to its destination. The rotation of the cloth will be controlled by a separate motor or by the forward movement of the wheels as they will be moving at a slow speed already.

The robot will have a combination of electric and solar panels to power up the machine and increase efficiency. The solar panel will be mounted to the top cover, so it acts as a backup power supply while the robot is out in the field. The robot will also pause at 15-meter intervals to remove the ticks, and then continue its path. This approach will make it so that no ticks will be lost from the cloth during a long tick sweep. To implement this collection process, there needs to be various testing with different tools to determine the best method for removing the ticks from the cloth.

During the field testing, many experiments involved repeated cloth drags before a single tick could be captured. Therefore, an implementation of dry ice or CO2 canisters is needed to attract the ticks. Bright colors can also attract ticks and can be incorporated into the design to bait and capture the ticks. However, ticks can easily withstand different types of brushes and can hold their position without losing grip which creates a potential issue with our collection system. Knives are potentially a viable solution as the to push ticks off, but ticks can go under the knife or climb on the knife which can cause various problems. One being that the tick can be damaged when under the knife, another being that the ticks can travel around the knife and perhaps into hardware where it poses a potential risk in the future. The field test provided more insight into our design process since we realized that a tick's grip is powerful and must be weakened before it can be collected.

With the knowledge and experience from field testing, we can change our original designs to better suit the experiment. We now know that ticks are very difficult to collect as they stick on to any material and won't let go, but we have a couple of ideas that may help to bypass this issue. The first was mentioned by Dr. Mike where he stated we can use pesticides on ticks and he does not mind if the ticks are dead, only not destroyed. We could implement a metal slit or "knife" at an angle with pesticides attach to it and drag along the cloth trap and push the ticks which should weaken the tick's grip on the cloth and drop down to a container or tray easily, where it will have pesticide inside as well which should be dead without being damaged. The only complication we may have is that too much pesticide can cause various problems for the environment like contaminating water, soil, turf and other vegetation while being toxic to other organisms as well [3].

Another implementation could include an electrical gate or field since it will not introduce toxic substances into the environment. The idea is based off that of an electric fly swatter, the ticks will be shocked and pushed down by a knife or metal edge into a container. The voltage for this tool should be at least 1 to 2 Volts, to prevent damage to the tick and only weaken it. However, a key issue would be if the ticks get their strength back and they escape. The last concept would be to combine the knife and electric field into one tool.

The combined conceptual design can be utilized for collecting the ticks, where the electric knife will help push the ticks to the destination, forcing the ticks to drop down to the container or tray. The electric knife will have wires attached to the blade that provide a shock as it is dragged along the cloth filter. It will use a 1 to 2-volt range previously mentioned and no pesticides would be required in the procedure. These ideas will not be concrete until proper testing is conducted in the future as they still may not entirely work for the process of tick extraction.

A few other potential applications that can be added to the final design in the future are elements such as a camera and a GPS tracker. One of the many concerns researchers encounter when they are traveling, particularly in Africa, is the risk of wildlife that can cause potential dangers. The visual camera attachment will give the user the capability of seeing what possible obstacles are present along the tick collection path. This will better notify the operator when the time comes to collect the robot or if the researcher decides to physically scope out the environment. The GPS feature will be used for recording what path the robot takes during a typical day and can be used in conjunction with the amount of ticks collected to find the tick density of that area. The goal is to have the robot be one of the most efficient and easy to use interfaces for tick collection and make the lives of tick researchers around the world easier.

System Design

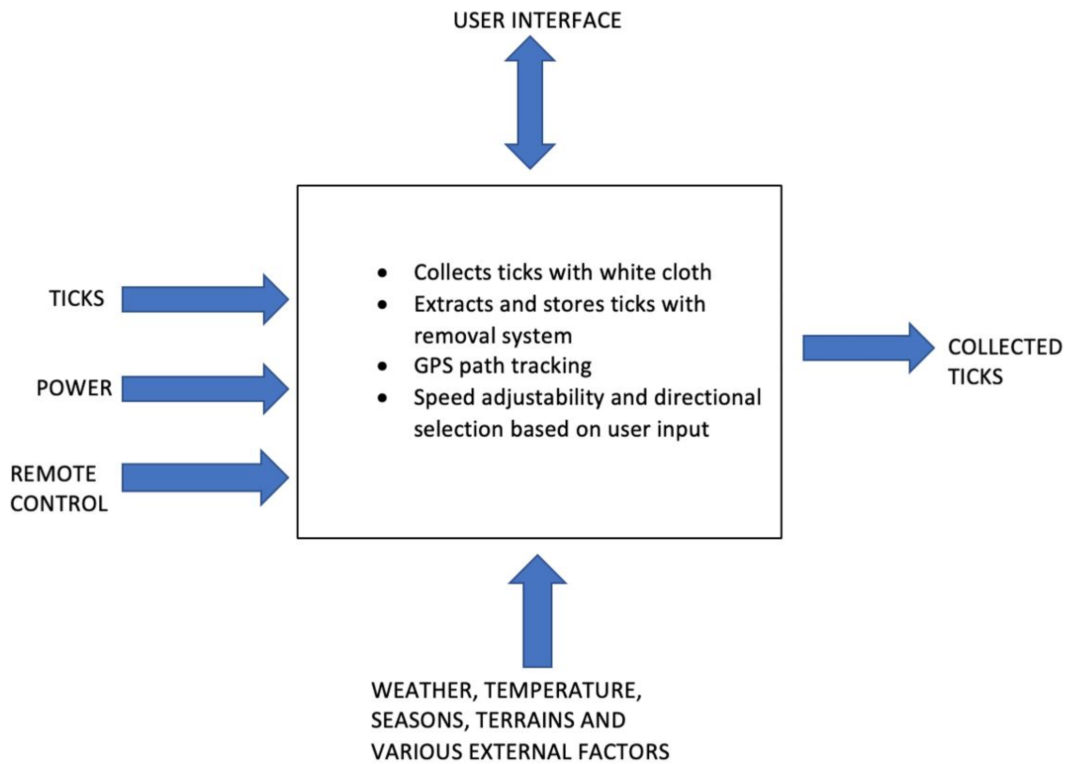

Figure 2: System Architecture

In figure 2, the system architecture, there are six main functions shown interacting with the system. The user interface, ticks, power source, controller, and environmental factors. The main output function of the system is the captured ticks collected in the container of the robot.

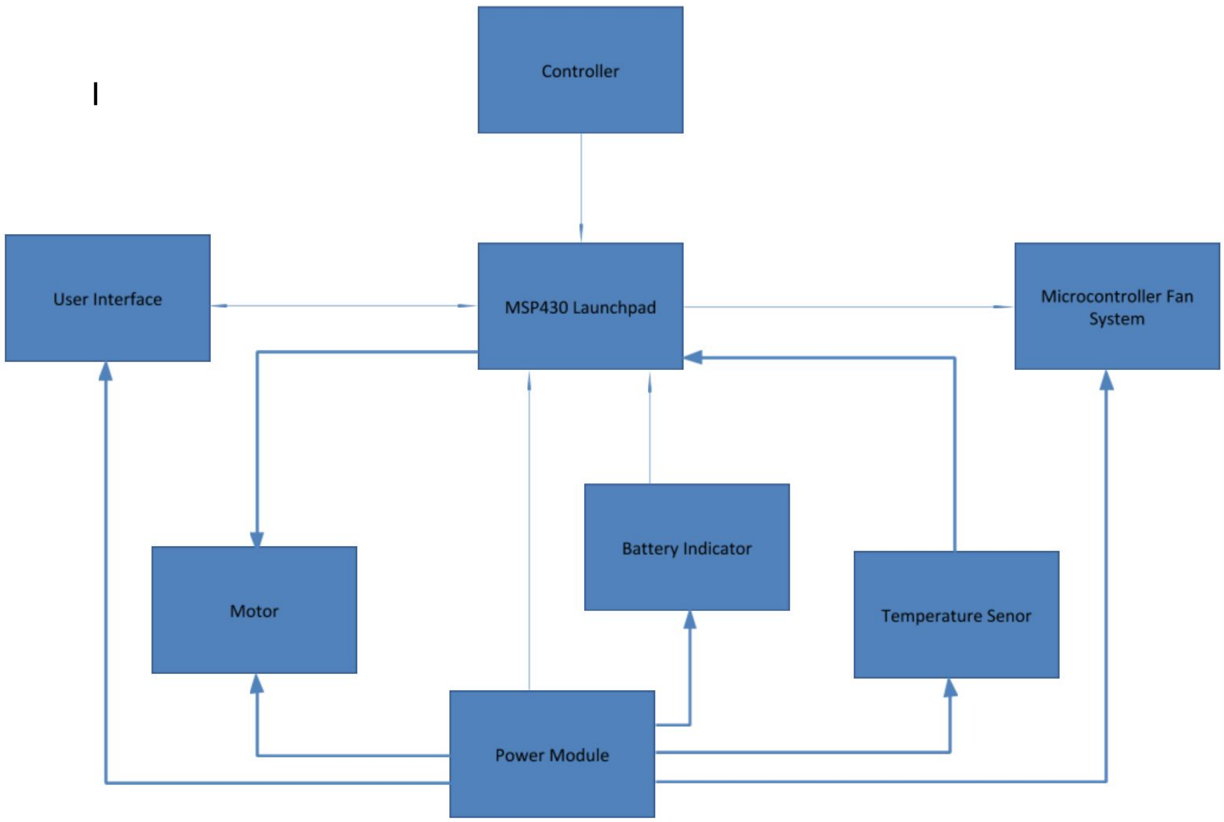

Figure 3: Level 1 Design

The MSP430 Launchpad is going to be the microcontroller that will control the other functions in the system. While using the controller, the user will have control over the motor and direction of the robot

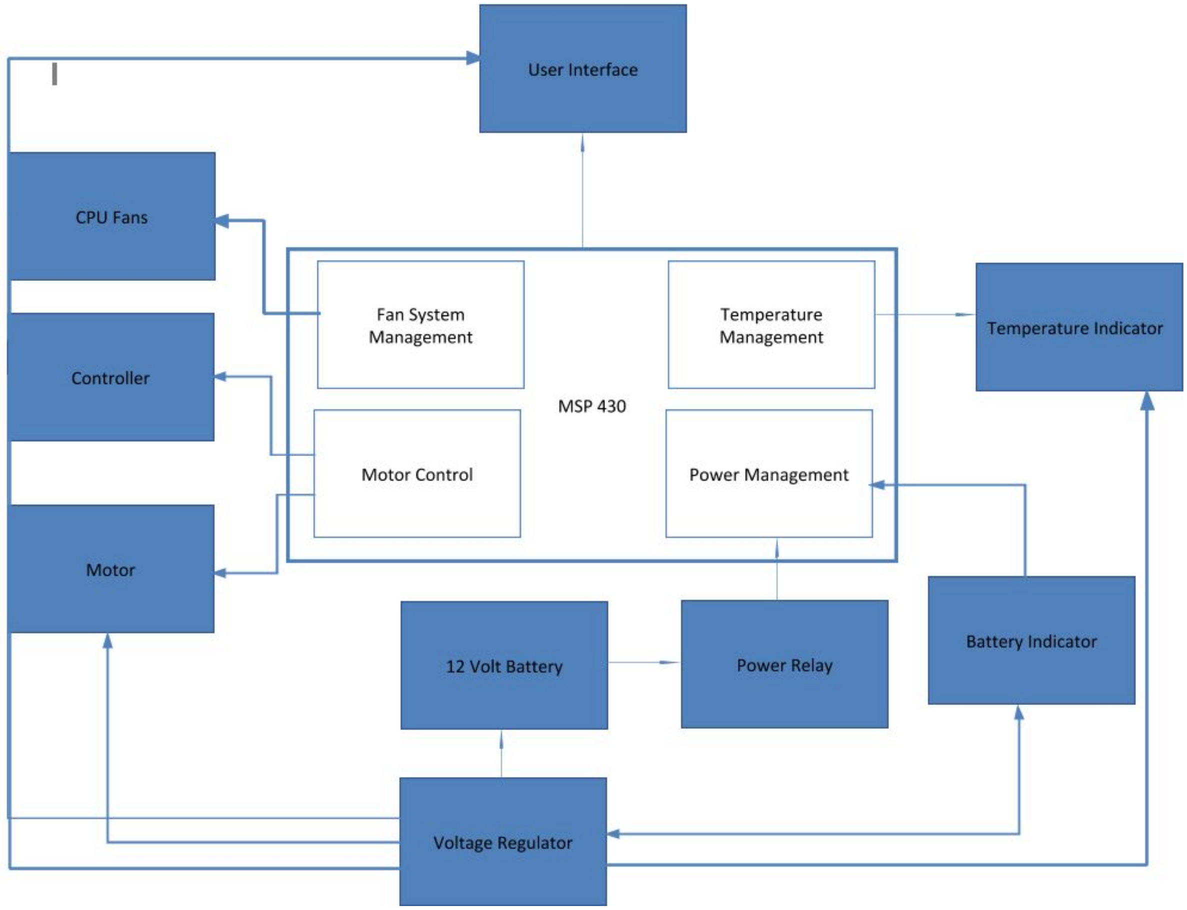

Figure 4: Level 2 Design

The MSP 430 has 4 components that provide specific actions for the robot. The camera and GPS interface processes the signal for the front and rear cameras as well as the GPS to have a secure connection on the display. The display interface provides the video feed for seeing the robot's surroundings and displays the location of the robot using the GPS system. The motor control oversees the movements of the robot and the movement of the retractable wheel used for the collection process. Power Management is the distribution of energy throughout all the systems implemented on the robot. The relay connects to the 12V battery to serve as a failsafe for the robot, immediately putting it into a stationary position in case there is any issues. The voltage regulator supplies power to all the applications in the robot, while the battery indicator provides information about the battery remaining in the voltage regulator before the regulator shuts off.

Preliminary Experimental Plan

1. **Testing Mechanics:**

This experiment will test the overall mechanics of the robot and how they work together cohesively. This will mainly focus on the collection system and its effectiveness in collecting the ticks. This will also include the communication between the microcontroller and parts of the system such as the power module and the motor. During this experimentation, the system mechanics will also test how the robot responds to the environment and other external elements.

2. **Testing of the tick bot and the remote-control system:**

Other experimentation will include testing the robot in different kinds of environment. The robot should be able to traverse 8-inch-tall grass and slightly rocky terrain. This includes the ability to avoid any small impact or debris along the path. In addition, other tests would include the connectivity of the controller to the robot as a response to possible signal blockage due to trees or obstructions. In accordance, the remote-control system needs to work effectively so that the robot can be controlled from at least 20 meters away. An ideal design would also be to include water resistivity in the case of moisture or light rain during its travel.

Preliminary Project Plan

In ECE 493, we will need to finish creating the microcontroller for the robot. The microcontroller is the component used for the overall control of the system such as movement and collection.The implementation of the robot will be divided among team members where the microcontroller will be implemented by those who have taken the course ECE 447. The prototype and the construction of the final product will begin in ECE 493. Each of the functions of the robot will be tested several times to ensure their success. This includes the collection of ticks, the removal of ticks, various sustainable methods for attracting the ticks, the movement of the robot in different terrain, the remote control and waterproofing/sealing of the hardware. Lastly, the final product will be tested when all the different components are assembled together.

Potential Problems

While working on this project we will have to learn many skills to create the robot. This includes learning about each of the components involved in making the robot to ensure that we use the best parts. Designing the robot will require us to learn more about the operations of microcontrollers, power systems, motors and other moving parts. Aside from all the technical knowledge we will need to learn, we will need to figure out how to remove the ticks from the cloth. This will involve intensive testing of different tools and operations. Through our recent research we discovered how researchers in the field collect and remove ticks. We can use this knowledge in designing and developing our robot. Potential problems can include hardware issues in any of the different components of the robot. Another potential problem can be in the collection of ticks where the method of removing the ticks becomes unsuccessful. This can be due to the design problem or any unforeseen error when assembling the final product.

References

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