Needs Assessment

Team 10

Tree Trimming Snake Robot

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Table of Contents

Table of Figures

Table of Tables

ABSTRACT

The removal of trees is a hazardous task for those involved. Human interaction can be reduced by using a remotely-operated tree-cutting robot. A snake inspired model was chosen since it has high mobility and required little interaction when setting up. Research has shown the existence of other snake robots that can be used for inspiration, also demonstrating the feasibility of this project. The research includes other types of robots to be able to compare and examine them with the snake model. After deciding for the snake robot, research was done about the different types of movement that can be achieved with this model, to allow for grounded and climbing movement. Research was done as well on the design to successfully build the robot. Some things to keep in mind during development will be the distance of communication, as well as how much power it will consume, and how the snake will be aware of its environment. This report contains the analysis of the needs of the customer, and research on: other climbing robots, some snake robots and the types of movements that can be achieved with such robots.

1. Introduction

Currently it is very dangerous and expensive to remove trees that are on the verge of falling. If these trees are not taken care of, they can cause a great deal of damage to their surroundings, especially to residential and commercial property. This ends up being more expensive than removing the tree initially. These trees need to be professionally removed in order to minimize their potential hazards to their environments. However, the tree removal profession is still considered a very dangerous occupation. This can be fixed by removing people from the equation and replacing them with robots.

After researching tree climbing robots, it was concluded that a snake-like robot will be the most effective. The main reason was because snake robots can climb trees and crawl on the ground without direct human interaction. Many problems could be solved if a remote control tree removing snake robot was created.

2. Project Definition

2.1 Need Statement

The removal of trees is too technical and dangerous for the average person.

2.2 Background and Literature Review

The main objective is to develop a snake robot that can climb and cut down trees. The use of a snake robot is mostly due to customer desire. There are many types of climbing robots and some robots have been developed to prune trees. These robots were investigated as well as snake robots to see if a snake robot is really the right tool for the objective. It is important to analyze if the different robots that have been developed for the task being asked may be a better option and if some redesign or an alteration of the project scope may be needed.

2.2.1 Types of Climbing Robots

There are many methods and types of wall climbing robots. A popular way to navigate trees is using a wheeled robot [1]. These kinds of robots use two platforms each having two wheels that clamp around the trunk of the tree. The wheels can have spikes known as spines which increase the traction for climbing up the tree [1]. With the added spines the robot is able to climb trees and rough surfaces unlike some type of climbers that are more suitable for smooth surfaces. Other climbing robots consist of legged robots, such as bipedal and hexapod robots [1][2]. The ‘mini bipedal climber’ uses small claws to adhere to a surface [2]. Another robot, ‘Rise’, utilizes suction as a means of adherence to a surface [1]. Another method that was developed to climb walls was using a swarm type crawling, or anchor climbing [3]. It enables large payloads to be transported up and down walls. This is done so using parent and child units. The parent climber is attached to multiple child units that pull and assist the parent unit, all of which stay on a surface using magnetic adhesion [3]. This method is similar to a group of ants carrying large items. Other types of robots can climb up rounded surfaces using an inch worm technique of climbing [4]. The top and bottom of the device are clamps. As the bottom is clamped down on the surface the top can reach out and clamp down. This method of locomotion is extremely slow [4]. Many of the robots mentioned above typically climb on straight, even walls, aside from the

wheeled robots and the pole-like climber mentioned. Some of these types of climbing are not practical for climbing trees. For instance, magnetic adhesion or suction are not useful when climbing trees. The speed at which the robot needs to traverse the tree needs to at least be moderate, meaning the inch-worm technique is not a useful climbing method for the purpose of the objective. An important aspect of the design is that it needs to be able to climb and move on flat ground. The wheeled robots need to be attached to the tree directly by the user, as it is unable to move from the ground to the tree on its own. A snake robot has the ability to shift from crawling on the ground to climbing up a tree at a reasonable speed. For these reasons, a snake like robot is a viable option for becoming a tree cutting robot.

2.2.2 Snake Robots

Gaits

A main focus for the project is for the robot to be able to climb trees and crawl on the ground. This is because the customer desires a remote controlled robot. This can be more easily done using the snake robot because different gaits for both of those motions have already been developed [5]. Gaits are the different way the robot can move and typically change based on the type of surface it is traversing. Crawling on a horizontal surface is much different than a climbing motion. Some of the more common type of horizontal gaits include: sidewinding, rolling and slithering [5]. By sending different sine waves to the robot it is able to alter its motions to the aforementioned gaits. For climbing, the rolling gait tends to be used by having the snake wrap its body around the object tightly, clamping itself to the object and using its segments as wheels to roll upward. On the ground the rolling gait makes the body in a c shape and rolls individual links to allow for motion [5].

Designs

The motion of a physical snake is very fluid and smooth, in order to achieve motion similar to this, the snake robot needs many segments or modules that can move independently from one another. A few different designs that use modules are reconfigurable robots such as ‘PolyBots’ [6]. These types of robots can be reconfigured by adding or taking away modules to create new designs. They are not limited to just snake-like designs, but making them attachable and finding ways for the modules to communicate with one another can be difficult [6]. Another type of

modular robot is a string type robot, these are the typical snake robots that are built [6]. They cannot be taken apart. Instead, they are a series of modules connected together. To allow for more variety of motion (allowing the use of multiple gaits), these modules can be oriented offset to each other by 90 degrees. Each module needs to have one degree of freedom, rotation about the z axis, and it has to be powered by motor individually [6]. More research on the different designs of snake and snake like robots need to be done, but it is worth noting that the ones described have proven to be successful.

2.3 Goal Statements and Objectives

The goal is to build a remotely operated snake-like-robot that will aid in the safe removal of trees.

2.3.1 Objectives

The objectives for this project are detailed under Table 1.

Table 1. Objectives for project.

Characteristic	Description	Units Involved
Good Grip	Correspond length of snake relative to the circumference of the tree (about 1.5 times)	Length Units (m, ft, etc.)
Good Range of Communication	How far the remote communication works	Length Units (m, ft, etc.)
Ground Speed	How fast it moves on ground	Velocity Units (m/s)
Climbing Speed	How fast it moves vertically	Velocity Units (m/s)
Durability	Max strength tolerance	Toughness (Pa or psi)

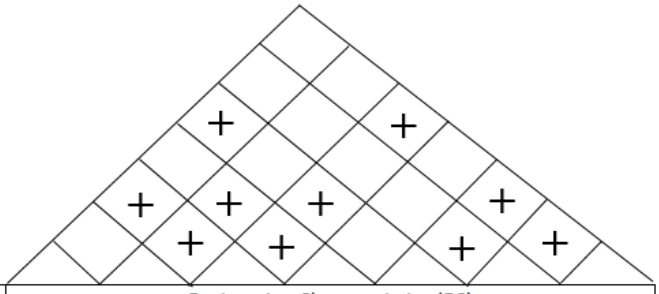
2.4 Constraints

During development, it is important to keep in mind that not everything is feasible. Some constraints have to be developed to keep in mind the realism of the project. For instance, the snake robot must be lightweight enough to overcome dynamic forces and be able to climb the trees. The client's desires must also be included as constraints. These include: the robot must be remotely controlled, have a camera for user feedback and it must operate on rechargeable battery power. Being a snake robot, it must be multimodal. And since it will be operating outdoors, the

robot must also be developed to be weather-resistant. Since this project runs until the end of spring, that deadline is a constraint on the time allowed for development.

3. Methodology

In order to tackle the multi-variable problem set forth by our sponsor the team implemented a House of Quality, see Figure 1. By design, the House of Quality is a methodological tool that consolidates the need of the customer and the need of the product. The customer requirements were obtained through consultations with the sponsor. Engineering characteristics were then developed by the team to provide specifications for the product. From the House of Quality it may be seen that the highest ranking Engineering Characteristics were in order of importance: distance of communication, environmental awareness, and power consumption.



Customer Requirements (CR)	Customer Importance (CI)	Engineering Characteristics (EC)						
		Multiple Gaits	Strength of Material	Weight	Weather resistant	Power Consumption	Distance of Communication	Environmental Awareness
Rechargeable Batteries	5			3		10	5	5
Easy To use	6	9		5	7	3	8	7
Resilient	5	3	10	5	10			1
Visibility	7				5	6	10	10
RC Friendly	7	6		2		6	10	9
Climbing	10	10	7	10		10	8	7
Moving on ground	9	10	7	10		10	2	5
Safe	10		7	6	7	4	10	9
Score		301	253	334	197	382	411	410
Relative Weight		13.2	11.1	14.6	8.6	16.7	18.0	17.9
Rank		5	6	4	7	3	1	2

Figure 1 House of Quality for Project.

4. Conclusion

A tree cutting robot is to be designed, with the goal of improving the safety associated with removing trees. Preliminary research suggests that a snake robot is a good choice to handle the task set forth by the sponsor. For snake robots different gaits have already been developed for both, climbing and crawling. While more research was necessary, it was found that the assembly of the snake may be handled by attaching the joints modularly with multiple segments connected to one another. In this set-up there is inherently a high amount of redundancies. This will provide flexibility, allowing for more fluid motion. From the information gathered, the main concerns during development will be environmental awareness of the robot, the distance of communication, and power consumption.

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