

Autonomous Target Tracking Robot Design Issues Paper

ECE 480 Design Team 7

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When creating any new product design, it is important to consider any possible design issues that could be present. Three of the most common areas to look at are the product lifecycle management, environmental issues, design safety, and universal design principles. When each of these aspects is examined individually, many potential improvements can be found.

Design

The design for our product is an Autonomous Target Tracking Robot that will be able to track any specified target and close within 3 feet of the object. The robot will have collision detection for any obstacles that may be in its path during the tracking of the target. This robot will focus on two different markets, police/military and household applications. The design of the robot is estimated at 4 months.

The design delivery time takes in consideration the mechanical, electrical, and software components of the robot. The mechanical features will optimize the locomotion, kinematics, and dynamics to give the best results for mobility to the specific market that we are focusing on. The electrical and software components will take the majority of the 4 months to allow room for testing of the target tracking and the microprocessor programs. Once the testing of the robot is finished there will be room for optimization of 3 features to reduce production costs.

The robot is marketed to two different types of customers; therefore the need, costs, and profits will vary. The customer needs of the household applications are specifically to track the desired target as well as avoid obstacles that may come in its path. The robot must go at least 5 mph so the target may follow a moving target. The military/police customer has similar needs but additionally it should have a strong body that can withstand dangerous situations.

It must also have strong capabilities of moving around tougher terrain to maneuver in all different types of environments. Currently the cost for the household robot will be approximately \$328.69 to produce separately. Since the military/police robot requires a stronger body and tougher terrain tracks the cost for production is higher and varies for environmental use. Contracting the work to a manufacturing company will allow the robot to be produced from raw materials which will in turn reduce the cost when mass produced. When mass produced the cost for robot is reduced significantly and profit can be made from each product.

In the future the product will have to be adjusted for cost, customer needs, and efficiency. The body will be made from raw materials. Customizing the body will allow to build a more durable vehicle where the hardware will be better reinforced. The software can also be upgraded in the future to track various targets rather than one. The running time may be increased with different types of batteries or from the optimization. The robot could be extended to different body styles rather than restricting it to the tank style. The design could extend to an aerial robot. In the future there may be a more powerful and efficient motor needed for the specific military/police robot.

We will run various tests on the robot prior to release to deliver a strong product for the customers. The product will be tested indoors as well as outdoors. We will test the robots tracking capabilities with various sized and colored objects. We will also test the software's human tracking capabilities as well. The robot will go through an obstacle type course developed by our team to test the robots collision detection capabilities. We will run all electrical and mechanical components for a period of time to measure the runtime. The police/military robot will run through a series of strength tests to measure how much damage it can sustain at any given time. It will be placed on various types of terrain to check the maneuverability and make adjustments if needed. The speed will be measured by the wheel encoders.

The robot is currently using a lithium ion battery because it delivers high energy and is rechargeable. It loses only about 5% of its charge per month which

is compared to 20% loss per month on the NiMH batteries. This type of battery is the most efficient on the market today for powering objects such as our tracking robot. The software and hardware programming can be minimized to reduce the amount of lines of code so that we can reduce energy use. The motor used may be subject to change for energy efficiency as well. The household robot will have a light plastic design to reduce power drawn from the motor when mobile.

Production

The ATTR will be manufactured and assembled inside of a single factory. All of the parts, with the exception of the body, will be shipped in bulk to the factory. These parts include the webcam, the range finders, the Arduino Uno, the motorshield, the Bluetooth mate, and the battery.

The current body used in the prototype is a commercially available RC tank created by Heng Long Plastic Toys. However, when the ATTR goes into mass production, a customized body will be manufactured at the factory. Plastic and molds will be shipped to the factory. Building the body on site allows for a custom design and the integration of the other parts, both of which are not viable when using a commercially available RC tank.

Using only a single factory will help to lower manufacturing costs, decrease energy consumption, and simplify the materials logistics. It will also help to decrease production time. As always, safety and environmental issues are paramount. The factory will meet or exceed all local, state, and federal safety and environmental standards.

Consumption

The product will ship with a manual in order to facilitate easy use by the customer. The manual will explain how to operate the product in detail, as well as warnings and explanations of any hazards that the costumer needs to be aware of. The team website will also include several videos that demonstrate proper use, as well as the code that runs the microcontroller and camera-target detection. The product will also ship with a one-year parts warranty.

In case the product is in need of repair, the current model has parts that are easy to replace. The manual will include a list of components that make up the final product. As such, technically savvy users can order any needed part online and replace accordingly at an affordable price. The most expensive part is the tank body, but this is also the most durable part and least likely to require replacement. The tank will be designed so that it is secure, yet easy to open in order to make it easy for the customer to access the internal parts. The product is also designed so that the parts that are more likely to need replacement (for example, the batteries) are easy to access. However, opening the product will void the warranty. In case the user does not wish to repair the product himself, it can be shipped back to the factory for repairs or replacement, thereby also retaining the warranty.

Since the tank will be designed in a way that allows it to be opened, the user can upgrade the robot by adding new parts or replacing older ones. For example, the consumer could replace the motors for higher speed, replace microcontroller to add further functionality, and so on. Any software upgrades can be done by downloading the Arduino SDK and the code from the team website. The robot will have lithium ion batteries installed, which can be replaced easily. The user could upgrade it by adding a rechargeable battery.

Retirement

The robot will use a Lithium Ion battery, which normally lasts between 2-4 years. The life of the product can be extended by replacing the battery when it dies out. If the manufacturing company upgrades the product, for example by adding functionality such as shooting a target, upgrading the speed or using a newer microcontroller, a trade-in or upgrade plan will be supported by the manufacturing company as long as the trade in happens within the warranty period. As long as the product is under warranty, customer support will be provided for that period. If the customer wishes to extend the warranty period, he may do so at a small fee.

The product can be reused for many different applications, since the parts themselves can be reused. For example, the customer may use the Arduino microcontroller or Bluetooth module for other electronic applications. Some parts of the product may be recycled, such as the plastic Tank for the household version, or the metal casing for the military version of the robot. Other parts, such as the Lithium Ion battery, have to be returned to the manufacturer for proper disposal.

Distribution

It is necessary to be able to distribute the ATTR to market at a low cost and in a timely manner. The distribution network will consist of a single factory, a network of warehouses, and a shipping network. The factory will be located in Dallas, Texas. This location provides many unique advantages over other sites throughout the country. First of all, Texas was ranked “America’s top state for business” by CNBC. Secondly, North Texas provides a relatively central location for distribution in the United States, lowering shipping time and costs. And thirdly, Dallas is only 150 miles away from Fort Hood, the largest military base in the United States.

A network of independently run warehouses will be used to store inventory around the country, allowing for shorter delivery times and lower shipping costs. The network consists of five warehouses located in the following cities and covering the following regions:

- Sacramento, California for the West Coast
- Dallas, Texas for the Southwest
- Atlanta, Georgia for the Southeast
- Indianapolis, Indiana for the Midwest
- Philadelphia, Pennsylvania for New England

These cities were picked because they have large populations, are located near major highways and rail lines, and are spread out enough to effectively cover most of the country. As situated, the warehouse network does not effectively cover Idaho, Montana, Wyoming, North Dakota, South Dakota, and

Nebraska. However, due to the low population density of these states, adding an additional warehouse to cover these locations would not be cost efficient.

To ship the ATTR between the factory, warehouses, and markets, a shipping network is needed. The plan is to contract out the shipping to one or more major shipping companies. Potential companies include UPS, DHL, R&L Carriers, and FedEx.

Universal Design Principles

Improving the universal design principles simply means making the product more user friendly for a broader range of individuals. The first possible improvements could concern blind users. A simple adjustment would be to add a speaker to the system to output a beeping tone to indicate when a target is within range. Additionally, code could be added to the program to vocally tell the user the distance measurements at certain time intervals. For those users with hearing impairments, a simple adjustment to be made is a light indicator on the robot to indicate its position in relation to the target. If the target is within range, the light could be lit.

A difficult aspect of this design is to improve it for people with dexterity issues. Although this design is primarily autonomous, there is the initial aspect of manually driving the robot to the target area. For this, it is recommended that the manual control is done via a joystick controller. This method is most likely the easiest for someone to control, especially for those with conditions such as arthritis and other similar joint or hand issues. A possible design flaw is simply the cosmetics of the design. Currently a tank design is being implemented, but this will appeal to mainly male users. Possible body design changes such as shape and color may help to improve use by female individuals. Getting away from a tank design may also help appeal to parents who don't want their child using a violent toy like a military tank.

Environmental Issues

The main environmental issues with our product are the batteries and the plastic of the body. NiCad batteries are considered hazardous waste and contain 6-18% cadmium, which is a toxic heavy metal. We are using both a NiCad battery, and a Lithium ion battery. In the future, we may want to switch to using only Li-Ion. The plastic that forms the body could potentially be hazardous because plastics are designed to have a very long lifespan. Some of the chemical building blocks in the plastic used to make it so versatile are absorbed by the human body and have been found to alter hormones or produce other negative health effects for humans, poison or injure wildlife if ingested by animals. Additionally, if buried, plastics can leach chemicals into groundwater.

Product Safety

The largest safety concern of our product is the dangers involved with Li-Ion batteries. Overcharging or allowing the batteries to overheat can cause thermal runaway, which may cause the cells to rupture or combust. Over discharging the cells may cause physical short-circuits within the cell which can render it useless and dangerous to attempt to charge. Fortunately laws within the U.S. prevent manufacturers from selling lithium ion cells without protection circuitry, though it is possible to purchase them from outside the US. It is also very cheap and easy to buy protection circuit modules for a wide range of lithium ion batteries.