

Design Issues Paper

Team 8: RC Car Drone

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Introduction

Companies design new products to meet given specifications of their customers. The main goal is to create a product that has the best design, runs better than any competitor's products and meets the customer requirements. There are various design issues that the team will address before the product could possibly go into prototype.

Our team has been tasked with designing an RC car drone that can be controlled through a phone using Bluetooth or online through a website connected via Wi-Fi. There are many factors that go into making decisions when designing our RC car for the ECE 480 project. The issues considered in this paper include lifecycle management, intellectual property protection and universal design principles.

Lifecycle Management

It is important to consider the project lifecycle management (PLM) of a product before you can begin production. The lifecycle of a product spans from its production to its retirement and everything in between. Every stage in a product's development must be analyzed in order to determine the safety and performance characteristics. By finding a potential pitfall early in the product's lifecycle you will save work, money and time. It becomes much more difficult to fix a problem after the product has been produced and distributed. A typical project management lifecycle will involve multiple stages and the ones discussed are design, production, distribution, consumption, maintenance and the retirement stage.

Project Design

The project initiation stage will define a project's objectives, purpose and deliverables. The customer of the RC car drone is Texas Instruments. Design issues include evaluating customer standards, needs, cost, upgradability, testability and delivery time. Conducting a voice of customer interview allowed the team to discover the objectives, specifications and budget for the proposed project. The proposed design is a RC car drone that can receive various commands to reach a destination and then report back data on its location. The customer holds particular standards in mind in regards to the functionality of the drone. The RC drone is expected to steer, stop/go, control speed and switch control algorithms. An Android phone is expected to receive commands from a website via Wi-Fi and relay information on location back to the website.

The purpose for this project is to create a functional demo for Texas Instruments and lay the groundwork for more advanced flying drone projects in the future. The vehicle is easily upgradable since a large, robust platform was selected. This leaves plenty of room for additional sensors, servos and other power options. The product will endure tests over various terrains to prove reliability and multiple power saving options will be explored in the programming. The options include a charger for the vehicle's phone and shutting off supply to the servo/motor when not moving.

A budget of \$500 was allocated to the team with a potential increase based on whether the customer or team decides to add other sensors to the vehicle. The project was broken up into various deliverables with the goal of displaying a functional product on design day.

Project Production

Once the product objective and design is established, it is important to address the production stage of the life cycle. This involves manufacturing cost, safety, materials logistics, production time and environmental considerations. Manufacturing costs depend largely on materials used as well as demand for the product. The RC car drone is composed of a platform, control board, motor, servo, Android phone and Bluetooth module. The components of the vehicle are not designed in-house, so the product will rely on multiple suppliers. An example of this is our platform, the SWorkz S350 BX1e 1/8 Sport ARTR Buggy Roller. It is readily available from www.amainhobbies.com and it is available for \$260 coming equipped with shocks, wheels and a clear body shell which eliminates certain costs on components that would otherwise drive the cost of the vehicle up. Not all of the components, however, will be included. An example of this is in the Android phone on the RC car. The final product will likely not be sold with the phone included. Therefore, there should be a process to make the manufacturing simpler.

It should be easy to integrate the motor, batteries and servos to provide a final product. The process would involve several people physically integrating the parts in the order of creating a phone mount, placing the batteries and servo onto the vehicle and attaching the control board with the Bluetooth module attached. The final process would involve creating a protective case. Eventually the plan would be to create an automated system that would look like an assembly line. This would expedite the process and only a few of people would be needed to monitor the

flow in the manufacturing plant. Although this would shorten the production time, there still exists a need for quality inspection. As previously mentioned, the monitoring of the manufacturing equipment would ensure the product is functional and investing in top quality equipment would create a reliable product in steady supply. The team would aim for a product that doesn't deviate much from the other drones produced and be in the 5 sigma range. 6 sigma would require very expensive manufacturing equipment and this is a product whose main hazard are the batteries and a 97 percent success rate for the product would be deemed satisfactory.

In selecting the type of materials to use, environmental factors must be considered. Substances that are highly toxic such as mercury, lead oxide, or flame retardants should be avoided at all costs. This is especially a concern when looking for newer components to add to the existing design. As mentioned, a large emphasis should be placed on a safe battery pack so as to supply sufficient power and not fail or become a fire hazard.

Project Distribution

Another factor in a product's lifetime is the project distribution. Distribution begins after the product has been mass produced and is the process of transporting it to the customer. This includes both the cost and time it takes to transport the product. In addition, the product's sales network and inventory must be considered. If the RC drone was to be distributed around the globe there could be several changes that may improve the shipping process. One main factor that may help reduce the transportation cost would be to make the entire product lighter. This could be done in several ways. One method could be to choose a lightweight motor. A more effective method, however, may be to reduce the size of the entire platform. The platform still has to be large enough to hold the DRV kit as well as the other components, so a compromise would have to be made. Another way to improve the transportation would be to package all components in one box. The RC drone is comprised of products from several different suppliers. By combining all parts into one main product the packaging is more succinct. During the design process this should be considered so that when all parts are interfaced it will be easy to package. Finally, it may be beneficial to label all products with a bar code so that it will become easier to count inventory and record sales. It is clear that these issues are important to consider during the design stage rather than after the product is completed.

Project Consumption

The next step in the project's lifecycle is the consumption stage. Once a product is delivered to the consumer it begins to perform its main functionality. This stage is arguably the most important phase of the lifecycle. A few factors to consider during the product's consumption are safety, customer training, repair/maintenance, spare parts, upgrades and energy consumption.

During regular use the product should not pose any appreciable threat or endanger a user or the environment. The drone should not have sharp edges or components that heat up to the point that they would burn skin when touched. In order to ensure proper use of the product, a user's manual should be provided with the package. The manual should explain the correct way to operate the product and how to avoid causing damage. With the RC drone it may be necessary to provide some sort of customer training that describes how to control the drone over the internet, i.e. what codes to use, how to send the commands, etc. Some factors to consider during the design are to make the car easy to fix if any problems occur. There may be parts that are subject to lower performance over time. It may be necessary to provide spares of any of these types of components. The RC drone platform that was selected for this project is capable of being upgraded. If the consumer wishes, they may add other features/components to the platform such as a servo for the phone or a different type of phone mount. Finally, the design should minimize power consumption during manufacturing. It is important that the components are selected properly, so that for example, the batteries do not become completely drained after one run.

Retirement

The retirement portion of the PLM involves ensuring a product has a useful lifetime, can be upgraded and be disposed of properly. An RC car platform can last for decades depending on what terrains it is used on and how much physical damage has been accrued. The same can be said for rechargeable batteries. To ensure the product will have a sufficient lifespan, high quality rechargeable batteries will allow the drone to remain functional for up to a decade.

The vehicle will be designed to be easily upgradeable, as mentioned, whether it is the battery pack, motor or servo. This makes the vehicle reusable for years to come and offers a cheaper alternative to buying a new car. The product will, however, require proper disposing of the batteries and control board, both of which are easily recyclable. A high level of technical support is not required for the product and would not be much of a factor in the drone's life

cycle. As long as the product is being sold, there will always be a support team member available to assist a customer.

Intellectual Property

For software development, the source code is the intellectual property and the entirety of the project. Our project will contain all of the source code interfacing the phone, computer and control card. In addition, the control card will have the InstaSPIN motor control algorithms which are owned and trademarked by Texas Instruments. If a competitor were to obtain the source code, then the project could be easily duplicated and resold at a much lower rate since they would not have to offset the cost of development. This would be an obvious detriment to profits and should be avoided. Protection of source code, however, is no easy task.

Reverse engineering is the process of disassembling a product to analyze its structure and operation. After application code compiles, it is stored in machine language. This machine language is what is obtainable by a hacker who may be interested in reverse engineering the source code. Normally, machine code would be incoherent and useless to a normal individual; unfortunately, techniques exist to disassemble the machine code into a more readable form. Once the hacker has a readable form of the code, copying the methods and algorithms becomes trivial. As of right now, there is no way to completely protect an application's source code, but certain techniques can slow down the reverse engineering process.

Obfuscation is a common method for protecting software and algorithms. The basic principle of this technique is changing the code's representation. Typically programmers use intuitive naming conventions in order to make code more readable and therefore easier to troubleshoot. A direct consequence of these good programming habits is the ease for others to interpret the meaning of the code. The process of obfuscation converts the descriptive names of the identifiers into shorter meaningless strings. An example of this would be to change the steering function to a function named "abc". This ambiguity inhibits a person's ability to understand the purpose of the function and will make reverse engineering more difficult. Another way of extracting meaning from the code is looking at the strings that are passed onto the user. Since the user needs to understand the content of the strings that are displayed, simply replacing them with nonsense is self-defeating for the software. In order to mask the meaning, the strings need to be encrypted. A decryptor needs to be present with the source code in order to revert the

string back to its original form. As with the case in muddling the identifiers, encrypting the string information will only slow down the reverse engineering process.

For this project, the risks of reverse engineering are low. The bulk of the source code will contain communication protocols rather than trade secret algorithms. Undoubtedly, Texas Instruments has already implemented some of the previously described techniques as well as more advanced measures. Projects such as this are often open source, or freely available for duplication or modification. This choice will ultimately be made by the client since they will own the rights to the source code. Since they do not intend to market our source code, it is unlikely that they will go through the efforts to hinder reverse engineering and the code will more likely be open source.

Universal Design Principles

To reach a broader market and to better accommodate the existing market, universal design principles must be considered. This aspect covers everything from development to the final product for the consumer, so making the product easy to use, user-friendly, fast and efficient creates more profit. Universal design principles are established to improve accessibility, which in turn, broadens the product's market. A product's ease of use is essential for making it a marketable success.

The first aspect of design to discuss is data interpretation. It is unnecessary for a drone operator to know any programming language, so the data from the program must be translated into an intuitive format. The program will make the appropriate calculations, such as GPS position, and relay the coordinates to the user in a clearly defined space. Ideally, all of the tracking data will be displayed on a hub super-positioned on the video feed from the drone. This will create a centralized location for all of the data, making an aesthetically dynamic stream of data for the user. This approach is heavily reliant on a profound understanding of programming beyond the scope for initial market launch, so it would be a future deliverable.

Since there is no right way to program a function, coding can be done a plethora of ways while achieving the same goal. To code effectively, however, the program must be fast, reliable and easy to operate. This consists of understanding the difference in what is essential to control the drone, and what is superfluous. Since the user will only operate through the GUI (graphical user interface), the interface must only contain the controls in a large and easy to read format. This can be easily implemented by formatting the website's control page to scale the windows to

a manageable size. The commands will be plainly labeled and will feature control schemes appropriate for the function, such as a slider for easy speed control. Beyond direct controls from the website, an improvement would be implementing an analog input.

Using an analog controller for the drone is practical because it is widely used in real life applications. Such a device should have a low learning curve and should be ergonomically comfortable for a range of users. To improve on the website control scheme, a video game controller, compatible and linked with the drone remotely, is a viable future enhancement. Video game console controllers are designed to be held comfortably for long periods of time, and they give a programmer a variety of options to map functionality. The speed and steering will be controlled by an analog stick with a dynamic response. If the user turns the stick all the way, the drone will fully turn that direction, but if the user wants to turn slightly, the controller allows flexibility using variable turning angles. This tactile controller solution caters to many of the principles of universal design and aims to be virtually barrier-free.