## **Purdue ECE Senior Design Semester Report**

## **(Team Section)**

|  |  |
| --- | --- |
| **Course Number and Title** | ECE 477 *Digital Systems Senior Design Project* |
| **Semester / Year** | Spring 2019 |
| **Advisors** | Prof. Thottethodi, Todd Wild |
| **Team Number** | 17 |
| **Project Title** | Facing Tracking Drone |

|  |  |  |  |
| --- | --- | --- | --- |
| Senior Design Students – Team Composition | | | |
| **Name** | **Major** | **Area(s) of Expertise Utilized in Project** | **Expected Graduation Date** |
| Xufei Gao | Comp E | software | May 2019 |
| Xingchen Wang | Comp E | system and packaging | Dec 2019 |
| Yi Qiao | Comp E | software | Dec 2019 |
| Haobo Chen | Comp E | PCB layout, PCB soldering | May 2019 |

**Project Description:** Provide a brief (2-3 page) technical description of the design project, as outlined below:

1. Provide a general description of the product to be delivered by this design project.

## The Face-Tracking Drone is a device used to allow people like journalist and musicians shoot short videos easily by themself. The drone will control most of the motions by itself, and track the user’s face while shooting video. The drone will send back video stream to user’s laptop. The sent live video stream will be processed by our control software, generating drone control data and sent back to the drone for movement control and face tracking. The control unit on the drone can read datastream via RF communication form the ground, parse the data and use them to control the motion of the drone by communicating with the flight control and gimbal controller. For safety reason, the drone is capable to fallback to manual control mode when the control unit is malfunctioning, by select another source of control by the choice of user. (For example, a regular RF transmitter/receiver) Beyond controlling the drone, the device also feature a user-friendly firmware update interface. Using a switch, the device can switch into the bootloader mode and allow user to flash firmware using USB.

1. What is the purpose of this product? For whom is it intended?

## The Face-tracking drone is designed for individuals who would like to film short videos for which the camera is not fixed at one position. Right now the need of filming videos is increasing quickly. The product we design is able to provide people who want to film videos from various perspective a low-budget yet reliable filming device.

1. Describe how the engineering design process used to create your product was utilized in this project. Include how you were able to develop and conduct appropriate experiments, analyze and interpret data, and use engineering judgment to draw conclusions related to the development of your product.

## At the beginning of this project, we analyzed our objectives and criteria in detail and set up several criteria to determine the requirements of our device in desired use case. In the analysis and synthesis stage, we first make our choices on all the parts we are going to use. After interfacing and testing each of them with the discovery board, we carefully designed the PCB. In synthesis and construction, all parts were put together on the PCB. Also, after PCB finished, each part on the PCB was tested with software to verify the functionality of each component. Then, all firmware pieces were put together and refined into our final firmware. On the Software side, different open-source packages was tested for our use case, After verified the software is functional, the GUI was designed and the backend code was integrated with the GUI. In the final packaging stage, after all software parts and hardware part was carefully tested, the device was tested in lab without propellers. After evaluating, we began the iterative process of making changes and testing.

1. Describe the design constraints, and resulting specifications, incorporated into your product (list a minimum of 3).

## RF transmitting distance: Since our project will be flying, a reliable middle range RF connection is needed. As a result of that, our RF module contains built-in power-amplifier and low noise amplifier.The Filming needs: Since we are shooting videos, a relatively high-quality camera is needed, and this fact makes that it is impossible to have a very small drone. As a result, we choose the F450 frame, which is relatively small among all drone frame support a full-fat gimbal. Computational power limit: The video stream that is sent back from the drone is processed by the user’s laptop. Generally, we do not expect a laptop to have a desktop level processor or even a GPU, so, we make choose the Haar-cascade classifier that is relatively cheap computational wise while still reaching a acceptable performance.

1. Describe how each of the following factors influenced your design specifications and constraints.

## **Health, Safety, Safety, and Welfare:** Operating a drone is harder than one would expect. If the user doesn’t have the skill to fly a drone correctly, the drone may cut or hit the user and other people. Because of that, the user must have a detailed training on how to operate the drone and he/she must be fully aware of the danger that may be caused by the drone. To minimize such danger, we installed drone stand and propeller protectors to make sure that the user won’t get hurt as easy as if those parts are not installed. Those components can also protect the product itself from being damaged.

## 

## **Global:** It is a trend that people are using drones for filming and photography. We would like to understand how hard it is to design a product like this and put it into reality. The drones in the market really influenced our design and people are mounting their own sports cameras on the drone as well. So we really considered how people are using the drones and what add-ons are popular right now. We specifically designed the drone so that it can mount a GoPro on it. Instead of a camera that comes with the package, we give users the freedom to choose their own filming equipments.

## **Social:** Since there are laws against drones that it is forbidden to fly in certain areas. We designed the drone such that a user could see its current location in the Ground Station. If we had more time developing this we certainly will add the feature that user could see the restricted areas in the ground station application.

## **Environmental:** This drone is designed so that it can function with its own power source, which is a Lipo battery. Environmental impacts caused by waste batteries are minimal because Lipo batteries can be recharged for a large number of times. Other than that, all the materials that build the packaging part of the drone are not biodegradable, which will cause a problem if they are not treated correctly. The motors are built from metals which can be reused with acceptable cost.

## **Economic:** Our design considered to use low-cost material and cheaper modules integrated in our project, which considered the affordability of the targeted users.

1. Describe the appropriate engineering standards incorporated into the creation of your product.

Our project required two important certifications. Firstly, the most important license that our face tracking drone needed to pass was that the one that was released by Federal Aviation Administration (FAA). Since our drone were designed for recreational purposes, there were three steps when it came to registering the unmanned aircraft systems: register the drone, review the rules, and know legal flight area. Secondly, the FCC regulates radio frequency (RF) devices contained in electronic-electrical products that are capable of emitting radio frequency energy by radiation, conduction, or other means. These products have the potential to cause interference to radio services operating in the radio frequency range of 9 kHz to 3000 GHz, and our device has the RF frequency of 2.4 GHz.

1. Describe the final status of your product.

The final integrated project with packaging achieved all the desired functions. The GUI in our ground station showed that it could track a face in the video and reach a reasonable framerate, which was above 30 fps. And our software could detect and choose one face precisely in any given image frame. Using two RF in our project, it realized the communications between ground station and the components on the drone. With the interface between ground station and gimbal, the software could control the gimbal to point to a specific human face. Finally, flight control could be controlled to perform desired movement.

1. Describe the makeup of your project team and how you were organized to establish goals, plan tasks, and meet the objectives of this project.

## Each teammates played different roles in our team. As a software engineer in our project team, he worked on the software for our ground station including the design of our GUI and the interface between video transmitter and ground station. Yi was another software engineer in our team. He was mainly focus on the software for our embedded system and also helped Xufei design the main algorithm of data processing in ground station. As the system engineer in our team, Xingchen primarily worked on the integration of the whole project and the packaging for done and ground station. Haobo was a hardware engineer in our team, he was in charge of PCB design and soldered components relative to PCB.

1. Did your project require the production of any written documentation other than this document (i.e., manuals, educational materials, etc.)? If so, describe the types, composition, and nature of the audiences for whom these materials were intended.

## Besides this document, our project also required User Manual. It consisted of product illustrations, setup instructions, usage instructions, and troubleshooting instructions. For a user who was first time to play with a drone, it was helpful to have a detailed instruction to setup the product and use it legally and appropriately.

1. Describe the types, composition, and nature of the audiences in attendance for the final oral design review. Discuss how you prepared for this audience.

## The audience of our final presentation are students and faculties from ECE, so we expect them to have some background knowledge of circuit design, embedded system and software engineering. We will prepare a short video to show how the device functions. After that we will give a presentation about the how those functions are realized and the dataflow we used for them. The presentation will be delivered with a couple of slides with more detailed information about different parts of our project. Finally there will be a Q&A session i case that there are anything that are not explained clearly in our presentation.

## **Purdue ECE Senior Design Semester Report**

## **(Individual Section)**

|  |  |
| --- | --- |
| **Course Number and Title** | ECE 477 *Digital Systems Senior Design Project* |
| **Semester / Year** | Spring 2019 |
| **Advisors** | Prof. Thottethodi, Todd Wild |
| **Team Number** | 17 |
| **Project Title** | Face-Tracking Drone |

|  |  |  |  |
| --- | --- | --- | --- |
| Senior Design Students – Team Composition | | | |
| **Name** | **Major** | **Area(s) of Expertise Utilized in Project** | **Expected Graduation Date** |
| Haobo Chen | CompE | Circuit Design | May 2019 |

**Individual Reflection:** Provide a brief (1-2 page) individual reflection of the design project, as outlined below:

1. Describe your personal contributions to the project.

## I did research in all the hardware components that we needed, read datasheet of all the chips and module that are utilized in this project. With the knowledge collected, I designed the circuit and made the PCB layout. After our PCB arrived, I manufactured and tested the circuit, made corrections and redid the manufacture process for a couple of times.

1. Describe how your contributions to this project built on the knowledge and skills you acquired in earlier course work.

## When doing works described above, I utilized the experience of collecting specification of devices that I learnt from both ECE 270 and ECE 362. In addition, the circuit knowledge that I learnt during my sophomore year helped me to design more reliable circuits.

1. Describe how you acquired and applied new knowledge as needed to contribute to this project. What learning strategies did you employ to do so?

## Whenever there are things that I don’t know, I tend to ask faculties because I learn faster as a listener rather than as a reader. For the same reason, if the faculties are not available, I searched for videos that do similar things as what I would like to do.

1. Discuss your ethical and professional responsibilities as they relate to this engineering design experience.

## When designing and manufacturing the circuits, I tried my best to make sure the power is not shorted with anywhere it’s not suppose to be shorted with, for the reason that I am aware that it may cause electric shock or even fire with the high current produced.

1. Consider what the impact of the product of this engineering design experience could have in economic, environmental, societal, and global contexts. Discuss how you would make (or did make) an informed judgement as to your product’s impact in each of these four contexts?

## Economically, although we bought components that are relatively expensive to make sure of the functionality, this is still designed to be a affordable product. More people would be able to make good videos by using our product. In terms of social and global impact,because the low cost of our product, people will be able to use device and have more opportunities to record and present their ideas to other people. Beside the minimized impact caused by the battery carried on this product, the materials that we used to build the packaging of this product are not biodegradable and need to be treated correctly to minimize the negative impact result from the waste of our product.

## **Purdue ECE Senior Design Semester Report**

## **(Individual Section)**

|  |  |
| --- | --- |
| **Course Number and Title** | ECE 477 *Digital Systems Senior Design Project* |
| **Semester / Year** | Spring 2019 |
| **Advisors** | Prof. Thottethodi, Todd Wild |
| **Team Number** | 17 |
| **Project Title** | Face tracking drone |

|  |  |  |  |
| --- | --- | --- | --- |
| Senior Design Students – Team Composition | | | |
| **Name** | **Major** | **Area(s) of Expertise Utilized in Project** | **Expected Graduation Date** |
| Xingchen Wang | Comp E | system and packaging | Dec 2019 |

**Individual Reflection:** Provide a brief (1-2 page) individual reflection of the design project, as outlined below:

1. Describe your personal contributions to the project.

## As the system engineer in our team, I participated in the design the interfaces among all components in the whole system. And I were in charge of the integration of the product and the packaging of the drone and the ground station. I made the timeline of the whole project and organized teammates to make progress according to the timeline. I also devoted my time in helping hardware engineer and software engineer when they needed help.

1. Describe how your contributions to this project built on the knowledge and skills you acquired in earlier course work.

## When I took ECE362, I learned some knowledge of embedded system. PWM could be used for controlling gimbal. SPI could be used for communication with UART. And I was familiar with the usage of discovery board by taking ECE362. In last module of ECE 362, it introduced the basic knowledge of PCB which also helped a lot in this semester. Both for the schematic and PCB layout, I had some experience when I designed my project for ECE362.

1. Describe how you acquired and applied new knowledge as needed to contribute to this project. What learning strategies did you employ to do so?

## Since our project was related to drone, I tried to contact to the drone club and some friend who had experience in flying their drone to learn tips of setting up drone and keeping it balance. When I designed the packaging of the project, I used Fusion 360 to draw the STL file for 3D printing. I watched a lot of youtube video related to Fusion 360 to get familiar with it. And I contacted the robot club to asking how to choose material of 3D printing and how to design it to make it fit our design well.

1. Discuss your ethical and professional responsibilities as they relate to this engineering design experience.

## To design a face tracking drone, I realized the safety issues were the most important thing. I needed to provide a detailed user manual for user to use the product in safe way. And it is necessary to design the fail-safe mode in our product which made the usage more reliable.

1. Consider what the impact of the product of this engineering design experience could have in economic, environmental, societal, and global contexts. Discuss how you would make (or did make) an informed judgement as to your product’s impact in each of these four contexts?

## For economic context, I tried to reduce the cost our product. Firstly, I chose PLA Filament as the material of 3D printing, which was much cheaper compared to the product in the market. By considering the affordability of the targeted users, cheaper modules was chosen to be integrated in our project. For environmental context, our rechargeable batteries needed to be processed carefully when it out of use. The instruction of dealing with discarded batteries would be included in the user manual. For social and global context, there were three steps for the unmanned aircraft systems: register the drone, review the rules, and know legal flight areas. It would be done before promoting this product into markets.

## **Purdue ECE Senior Design Semester Report**

## **(Individual Section)**

|  |  |
| --- | --- |
| **Course Number and Title** | ECE 477 *Digital Systems Senior Design Project* |
| **Semester / Year** | Spring 2019 |
| **Advisors** | Prof. Thottethodi, Todd Wild |
| **Team Number** | 17 |
| **Project Title** | Face tracking drone |

|  |  |  |  |
| --- | --- | --- | --- |
| Senior Design Students – Team Composition | | | |
| **Name** | **Major** | **Area(s) of Expertise Utilized in Project** | **Expected Graduation Date** |
| Yi Qiao | Comp E | software | Dec 2019 |

**Individual Reflection:** Provide a brief (1-2 page) individual reflection of the design project, as outlined below:

1. Describe your personal contributions to the project.

## I interfaced and tested all peripheral with discovery board, including nrf24l01(via SPI), ftdi232(UART), Gimbal(DAC, PWM), Flight control(PPM, Timer). On the software side, I tested different face-tracking and pose estimation libraries and hacked into open-source projects and integrate them with our use case. And I also did my research about how to communicate to com ports using C++. In the process of manufacturing PCB, I helped with testing by flash firmware with single function into the micro and observe the behaviour of the board. After the PCB was finished, I developed firmwares for both the on-drone controller and ground-station controller.

1. Describe how your contributions to this project built on the knowledge and skills you acquired in earlier course work.

## The interfacing and firmware development heavily depends on my experience in ECE 362, especially for the UART and SPI part. Moreover, when trying modulate PPM signals, the experience of configuring timer interrupt in ECE 362 really helps. On the software end, ECE 30862 really helps when developing the backend with OOP design and multi-threading. And, obviously, basic circuit knowledge helps a lot. (ECE 201, ECE 202, ECE 270).

1. Describe how you acquired and applied new knowledge as needed to contribute to this project. What learning strategies did you employ to do so?

## In order to achieve our goal, a lot of new skills were learnt. I personally learnt a lot about drone. How to set up the parameters, how to tune it, and how to fly. Also, I have dig into the protocol that RC transmitter/receivers used a lot, which is the PPM protocol. It has the capability to compress up to 9 PWM channels in a single channel. On the microcontroller side, I learnt how to use the bootloader of a STM microcontroller and how it works. Also, I have learnt how to implement serial port communication in C/C++. On the hardware side, I learnt a lot more about PCBs. More specifically, how should a PCB be designed, what rule should we follow and how can we test it.

1. Discuss your ethical and professional responsibilities as they relate to this engineering design experience.

## As a computer engineer I strongly feel the responsibility to build reliable computer systems with sufficient safety redundancy. In our use case, I cannot even imagine what will happen if the system crashes when the drone is flying without any failsafe. And that’s exactly why we have the option to fall back to manual control when such failure happens.

1. Consider what the impact of the product of this engineering design experience could have in economic, environmental, societal, and global contexts. Discuss how you would make (or did make) an informed judgement as to your product’s impact in each of these four contexts?

## Economically, it is not cheap at all to build a drone. However, compare to a dedicate cameraman or even a team with all the expensive filming equipments, shoot videos with a drone might be cheaper. Even though it might not deliver videos that has as high quality as the former way, with the improving technology, such gap will become smaller and smaller. Even phones today deliver amazing photo and videos! Environmentally, the most hazardous part of on the drone is the Lipo battery. However, It should be fine if we dispose it properly after its life-cycle. Globally and Societally, the reliability of drones is always a controversial topic. However, I believe, with the improvement of control theories, our drones will become more and more reliable and in the near future, it will be able to provide all kind of services for us.

## **Purdue ECE Senior Design Semester Report**

## **(Individual Section)**

|  |  |
| --- | --- |
| **Course Number and Title** | ECE 477 *Digital Systems Senior Design Project* |
| **Semester / Year** | Spring 2019 |
| **Advisors** | Prof. Thottethodi, Todd Wild |
| **Team Number** | 17 |
| **Project Title** | Face tracking drone |

|  |  |  |  |
| --- | --- | --- | --- |
| Senior Design Students – Team Composition | | | |
| **Name** | **Major** | **Area(s) of Expertise Utilized in Project** | **Expected Graduation Date** |
| Xufei Gao | Comp E | software | May 2019 |

**Individual Reflection:** Provide a brief (1-2 page) individual reflection of the design project, as outlined below:

1. Describe your personal contributions to the project.

## I was responsible for purchasing the components and I assembled the prototype of this drone. I am the software engineer in this project and I am responsible for programming the GUI application and embedded programming. I also helped with testing and outfield flying.

1. Describe how your contributions to this project built on the knowledge and skills you acquired in earlier course work.

## For programming I was glad that I took ECE 30862 since I was using C++ mainly for this project, and I learned a lot about C++ in ECE 30862. Also ECE 368 taught me a lot about C programming which really helped me on this embedded programming part. While it is early in this semester, we prototyped this drone together and I was glad that I have learned a lot about microcontroller in ECE 362 so I could easily come up with feasible solutions. And ECE 362 taught me about how to use PWM.

1. Describe how you acquired and applied new knowledge as needed to contribute to this project. What learning strategies did you employ to do so?

## I have encountered many difficulties while playing with the OpenFace library since it is using cmake and the Qt is using qmake as its own build tool. I learned cmake by myself and the learning process is quite a headache since the official documents are poorly organized. I studied from youtube and I have to go through a whole series of cmake tutorials to figure out how to build my own CmakeList.txt. I think the best way to learn a thing is by implementing it. I am now able to understand how cmake works.

## Qt itself requires some time to master as well. And thankfully I have learned PyQt in ECE 364 and it gives me lots of intuition of how the GUI application works even though there is a huge difference between C++ syntax and Python syntax. I learned Qt by looking at official examples and Youtube videos. Thank to those people who are willing to contribute on Youtube and they are my best teachers on this.

## Before building the drone I knew nothing about it. I was able to understand the basic components and and how flight controllers, motors and ESCs are connected by looking up online. There are so many different sources online and they basically cover everything that I want to know about drones.

1. Discuss your ethical and professional responsibilities as they relate to this engineering design experience.

## As a Software Engineer I am responsible for writing codes that are robust and understandable. I should always stick with the design documents and discuss before start writing any code. I should always use comments to make my code more organized. The code block should be reusable with clear defined APIs.

1. Consider what the impact of the product of this engineering design experience could have in economic, environmental, societal, and global contexts. Discuss how you would make (or did make) an informed judgement as to your product’s impact in each of these four contexts?

## Economically this product could be a new popular product in Photography markets, since it has all the features that a photographer wants. Comparing to other filming equipments, this product has a relatively low price. Environmentally this product should not be a problem as long as the user knows about recycling. This product is just another electronic device and today’s technology can properly recycle those components. Societally and Globally there are laws and indeed, there are some incidents that are caused by flying drones. But since drones are getting more and more popular these days, the market will drive the laws to reinforce, and people will be more educated on drone flying. The only negative, Socitally and Globally influence can be caused only by improper usage of this product. As long as people are following the rules, there will not be a time that drone flying is prohibited.