Component Analysis

Year: \_2019\_ Semester: \_Spring\_ Team: \_\_17\_\_ Project: \_Face Tracking Drone\_\_\_\_\_\_

Creation Date: \_\_\_\_Jan 23, 2019\_\_\_\_\_\_\_\_\_\_ Last Modified: September 8, 2016

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Assignment Evaluation:

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| --- | --- | --- | --- | --- |
| **Item** | **Score (0-5)** | **Weight** | **Points** | **Notes** |
| **Assignment-Specific Items** | | | | |
| **Analysis of Component 1** |  | x2 |  |  |
| **Analysis of Component 2** |  | x2 |  |  |
| **Analysis of Component 3** |  | x2 |  |  |
| **Bill of Materials** |  | x6 |  |  |
| **Writing-Specific Items** | | | | |
| **Spelling and Grammar** |  | x2 |  |  |
| **Formatting and Citations** |  | x1 |  |  |
| **Figures and Graphs** |  | x2 |  |  |
| **Technical Writing Style** |  | x3 |  |  |
| **Total Score** |  | | |  |

5: Excellent 4: Good 3: Acceptable 2: Poor 1: Very Poor 0: Not attempted

General Comments:

*Relevant overall comments about the paper will be included here*

IMPORTANT NOTE: The Bill of Materials is a separate document and should be downloaded and filled out for another assignment. The Bill of Materials is to be submitted separately, per the course calendar (possibly on a different week), and will graded collectively with this assignment.

1.0 Component Analysis:

The most important component of this project is the Pixhawk flight controller since it will talk to the microcontroller and control all the ESCs. ESCs are used for supplying power to the motors and it will respond to the input signals. Video receivers and transmitters will pair together. The video captured from GoPro will be sent to the video receiver that is connected with the PC. A microcontroller is used to talk with local computer since local computer will send control commands to the microcontroller after analyzing the video information received from VTX. Meanwhile, the microcontroller with control the gimbal according to the control signal sent from local computer. A radio frequency transceiver is also needed since there will be face-tracking mode and manual mode for our drone. When the mode is switched to manual mode, users are able to control the drone through the pedal controller.

1.1 Analysis of Microcontroller:

The microcontroller is the core part of the project. In this project, the main function of the microcontroller is interfacing with multiple peripherals. Since it is necessary for the drone to respond quickly to control signals from multiple sources, A microcontroller with moderate computation power is desired. A/D converters are another concern of the project because part of this project is the pedal control. The signals from the two pedal controls need to be converted to digital signals. In addition, the number of I/O pins is also a major concern because this project requires the microcontroller to communicate with multiple devices either directly or remotely.

|  |  |  |  |
| --- | --- | --- | --- |
|  | STM32F0 | STM32F4 (chosen) | STM32F7 |
| Operating Frequency (MHz) | 48 | 84 | 216 |
| RAM Size (kB) | 4 | 64 | 256 |
| Number of A/D Converter Channels | 10 | 16 | 16 |
| I/Os | 27 | 50 | 140 |
| SPI | 1 | 3 | 5 |

Table 1.1 Information of different microcontrollers

From the microcontrollers above, we finally chose STM32F4 Series[1] because it has enough power to perform the desired task. It also has 50 I/O pins, which should be enough for talking with other devices analyzed below. STM32F7[2] is more powerful for sure, however, we have decided to perform the image processing algorithm on a local computer. So STM32F7 is redundant for this project. The size of STM32F7 is also too large to be carried on a drone, while STM32F4 is a better fit. On the other hand, STM32F0[3] is not chosen because it may not be fast enough to perform quick reaction corresponding to the control signals.

1.2 Analysis of Electronic Speed Control Module:

The ESC module we chose to use is ‘4x SIMONK 30A ESC For DJI Phantom’[4] which supports lipo batteries. There are two more options which are ‘iFlight 4pcs iPeaka 45A V2 32bit BLHeli\_32 ESC’[5] and ‘Makerfire 4pcs BLHeli\_S 30A ESC’[6].

When choosing ESCs the first thing that needs to be considered is their current rating. A higher current rating means that motors can draw more current from ESC. If the ESC’s current rating is incompatible with the whole design, it may cause ESC to burn. Higher motor KV, larger motor size, and heavier propellers always require a higher current rating.

Since motors with low KV will produce larger torque which is better for heavy load lifting. For this project, a GoPro and a large capacity heavy battery are needed. Thus, a low KV motor is needed. As a result, a ESC with a lower current rating is preferred.

Also, different ESC applies different firmware. But it is unnecessary to consider firmware differences since we do not need to flash ESCs.

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| --- | --- | --- | --- |
| Feature | 4x SIMONK 30A ESC For DJI Phantom (chosen) | Makerfire 4pcs BLHeli\_S 30A ESC | iFlight 4pcs iPeaka 45A V2 32bit BLHeli\_32 ESC |
| Current Rating | 30A | 30A | 45A |
| Price | $56.99(Comes with 4 compatible motors) | $46.99(ESCs only) | $59.99(ESCs only) |
| Battery cells | 2-3s | 3-6s | 2-6s |

Table 1.2 Information of different electronic speed control modules

Ultimately, we have chosen the ‘4x SIMONK 30A ESC For DJI Phantom’ since it has appropriate current ratings and the price is very attractive considering that it comes with four compatible motor, which saves money and time by avoiding accidentally buying inappropriate motors.

1.3 Analysis of Radio Frequency Receiver:

The radio frequency receiver will be in charge of receiving control signals from the local computer. The local computer will be responsible to send control signals accordingly after finishing processing the image data received from the drone. This is an important module because the autonomous mode is the most important mode of the face tracking drone. In this mode, the drone is expected to make movements so that it can keep tracking of the face of its target.

nRF24L01[7] has a higher frequency than FS1000A[8]. This ensures that it can have a higher data rate. This would be a good fit for the drone because control signals need to be received quickly so that the drone can have quick movements corresponding to the control signals. nRF24L01 also support SPI interface, which is our desired interface. Moreover, nRF24L01 has a detailed while FS1000A doesn’t.

The only disadvantage of nRF24L01 is that the operating range is smaller because of supporting high frequency. However, the range is not a major concern of this product for the following reasons. First, a short distance is required to make sure the face tracking algorithm works properly. Second, the drone is designed for individual musicians who make a small-scale performance. An operating range of 800 meters should be enough to record the video for those people.

|  |  |  |
| --- | --- | --- |
|  | MakerFocus nRF24L01 (chosen) | Wolfwhoop FS1000A |
| Frequency | 2.4GHz | 433MHz |
| Range | 800m | 20-200m |
| Data Rate | 2Mbps | 10kbps |
| I/O Voltage Tolerance | 1.9-3.6V | 5V |
| Interface | SPI | - |
| Weight | 6.64g | 4.53g |
| Price | 2 for $10.99 | 10 for $12.99 + $12.74 shipping |

Table 1.3 Information of different radio frequency receivers

Because of the higher frequency and data transfer rate, nRF24L01 will be chosen as the final RF receiver for the drone. Although FS1000A provides a larger operating range, this won’t affect the final decision because nRF24L01 provides an operating range that is large enough for the product.

1.4 Analysis of Video Receiver:

The video receiver will be connected to a PC and receive data from the video transmitter that is installed on the drone. “FPV 5.8GHz Receiver, 150CH UVC Video Downlink OTG Receiver ONLY for OTG and UVC Android Mobile”[9] from Amazon is the top choice since it supports micro USB connection, which is easy for the PC to recognize it. The other two options are “Wolfwhoop WR832 5.8GHz 40CH Wireless FPV Receiver”[10] and “Lumenier RX5GDR V2 48CH 5.8G AV Diversity Receiver”[11]. By comparing them, it is not hard to find that the first option has more channels to choose which makes it more adaptable for different receivers.

Output power impacts the range and signal quality, but as the drone has no long-range application, the output power is not a serious factor to be considered about.

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| --- | --- | --- | --- |
| Features | FPV 5.8GHz Receiver, 150CH UVC Video Downlink OTG Receiver (chosen) | Wolfwhoop WR832 5.8GHz 40CH Wireless FPV Receiver | Lumenier RX5GDR V2 48CH 5.8G AV Diversity Receiver |
| Output Connector | USB | AV Out | Av Out |
| Channel | 150CH | 40CH | 48CH |
| Working Current | 200mA/5V | 200mA/12V | <130mA/12V DC |
| Resolution | 640\*480 30fps | N/A(Not found) | N/A(Not found) |
| Price | $20.90 | $15.66 | $39.99 |

Table 1.4 Information of different video receivers

Ultimately, we have selected the ‘FPV 5.8GHz, 150CH UVC Video Downlink OTG Receiver’ since it supports USB, which saves us time and money to turn the analog video signals into digital signals. And this receiver covers more channels than the others, which makes it much easier to pick a transmitter.

1.5 Analysis of Flight Controller:

The only problem we care about is whether the flight controller is open-source since the flight controller needs to talk to the microcontroller. We have discovered several powerful flight controllers but the only one that supports interfacing with the microcontroller is Pixhawk[12]. The other two options are Naza[13] and Lumenier LUX F7[14]. Based on the reason above, we will choose Pixhawk. It supports MAVLink which can be used to communicate with the microcontroller, and there are nicely written documents for developers which can be found online.

|  |  |  |  |
| --- | --- | --- | --- |
| Features | Pixhawk (chosen) | Naza | Lumenier LUX F7 |
| Processor | Advanced 32 bits CortexM4 ARM high-performance processor,32 bits STM32STMF100 failsafe co-processor | N/A (Not found) | 216MHz STM32F722RET6 |
| SPI Interface with Microcontroller | YES | NO | NO |
| Compass | YES | YES | NO |
| Gyros | YES | YES | YES |
| Open Source | YES | NO | NO |
| Price | $127.99 | $158.99 | $44.90 |

Table 1.5 Information of different flight controllers

1.6 Analysis of Gimbal:

The Gimbal is one of the three hardware that the microcontroller will directly interface with. It will be carrying and stabilizing the camera. In addition, the microcontroller will control its movements to aid the face tracking function of the drone.

The STorM32 gimbal controller[15] support 3-axis control over brushless motors. Which provides more space for customization over USAQ BGC 3.1[16] which only supports 2-axis control. Moreover, STorM32 is the only open-source gimbal controller that we can find with extremely detailed documentation. Besides, STorM32 is integrated with motors and frames. This saves the work to look for compatible devices.

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| --- | --- | --- |
|  | STorM 32 (chosen) | USAQ BGC 3.1 |
| Open-source | Yes | - |
| Support for Gopro | Gopro3, Gopro4 | - |
| Document | Detailed document presented | No document |
| Support for multi-axis | 3 axis | 2 axis |
| Price | $50.99 | $18.95(not including motors and frames) |

Table 1.6 Information of different gimbals

Since STorM 32 has a detailed document and is a fully open-source device, it meets the requirement of being able to interact with the microcontroller directly and is selected as the final gimbal controller.

1.7 Analysis of Battery:

It is essential to choose an appropriate battery for our project. By watching a lot of YouTube videos and searching on the Internet, the choices are narrowed down to HRB 11.1V 5000mAh 3S 50C-100C LiPo Battery with Traxxas TRX Plug[17], 11.1V 6500mAh 3S Cell 75C-150C HardCase LiPo Battery[18] and Tattu R-Line 14.8V 1300mAh 4S 75C LiPo Battery Pack with XT60 Plug[19]. To ensure enough fight time, relatively high capacity is required. Thus, Tattu R-Line 14.8V 1300mAh 4S 75C LiPo Battery Pack with XT60 Plug is given up. Due to the limited budget, it is impossible to choose a too expensive one, and the great weight may lead an overload to the flying drone. Therefore, 11.1V 6500mAh 3S Cell 75C-150C HardCase LiPo Battery is also abandoned. Meanwhile, HRB 11.1V 5000mAh 3S 50C-100C LiPo Battery with Traxxas TRX Plug has a suitable size for the drone and the maximum discharging current ensures that circuit will not burn when this face tracking drone is working. In sum, HRB 11.1V 5000mAh 3S 50C-100C LiPo Battery with Traxxas TRX Plug becomes the best choice for this project.

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| --- | --- | --- | --- | --- | --- | --- |
|  | Cells | Discharge Rate | Capacity | Dimension | Weight | Price |
| HRB 11.1V 5000mAh 3S 50C-100C LiPo Battery with Traxxas TRX Plug (chosen) | 3s | 50-100C | 5000mAh | 155\*48\*24mm | 381g | $39.99 |
| 11.1V 6500mAh 3S Cell 75C-150C HardCase LiPo Battery | 3S | 75C | 6500mAh | 138.0\*46.6\*36.5 mm | 454.44g | $64.99 |
| Tattu R-Line 14.8V 1300mAh 4S 75C LiPo Battery Pack with XT60 Plug | 4s | 75C | 1300mAh | 72mm\*35mm\*29mm | 153g | $23.99 |

Table 1.7 Information of different batteries

1.8 Analysis of Camera:

To record a piece of video, the camera is indispensable. After collecting information and analyzing similar projects, there are three competitive options which are suitable for this project. They are GoPro HERO4[20], DJI OcuSync Camera for Goggles Racing Edition[21] and BLADE FPV Camera for Inductrix 200 Quadcopter[22]. GoPro HERO4 costs most but has formal datasheet while the datasheets for other two cannot be found. Since this face tracking drone is designed for individual musicians to record their musical works, it is really helpful for the camera to support SD card. Besides that, it is also necessary to consider the recorded video quality. Another point is that one of the teammates has his own GoPro HERO4 already. Thus, GoPro HERO4 is the best option for this project.

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|  | Cost | Size | Weight | Datasheet | Storage |
| GoPro HERO4 (chosen) | Free (already have one) | 9.95\*4.1\*4.1" | 0.92 lb | Formal datasheet | Support SD card |
| DJI OcuSync Camera for Goggles Racing Edition | $49.00 | 9.0\*4.5\*2.0" | 0.4 lb | Cannot be found | Does not support SD card |
| BLADE FPV Camera for Inductrix 200 Quadcopter | $79.99 | 3.7\*3.2\*0.5" | 0.05 lb | Cannot be found | Does not support SD card |

Table 1.8 Information of different cameras

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