Component Analysis

Year: 2020 Semester: Fall Team: 4 Project: Pollination Drone

Creation Date: 9/10/2020 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** | 5 | x2 |  |  |
| **Analysis of Component 2** | 5 | x2 |  |  |
| **Analysis of Component 3** | 5 | x2 |  |  |
| **Bill of Materials** | 4.5 | x6 |  |  |
| **Writing-Specific Items** | | | | |
| **Spelling and Grammar** | 5 | x2 |  |  |
| **Formatting and Citations** | 5 | x1 |  |  |
| **Figures and Graphs** | 5 | x2 |  |  |
| **Technical Writing Style** | 5 | x3 |  |  |
| **Total Score** | 97 | | |  |

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

General Comments:

*Excellent work! Every chosen component well analyzed and compared. Please check my comments. A few of the mentioned components missing in the BoM though.*

*Also make sure, you order extra components to avoid delays, in case any component fails.*

1.0 Component Analysis:

The image processor is the chip that will do the DSP and image processing operations in flower detection.

The microcontroller is the chip that will control communications between all devices and perform flight decisions based on the coordinates relayed by the jetson nano.

The battery and motors will be used to supply an appropriate amount of power to the system to ensure stable flight and maintain flight operations for at least 10 minutes

The flight controller will handle computing motor outputs based off of roll, pitch, and yaw set points and readings from the accelerometer and gyroscope.

The appendage will be used to pollinate flowers and detect contact with flowers for the stm32

potato

1.1 Analysis of Component 1: Image Processor

We wanted to offboard the image processing from the embedded system. We looked at the Jetson Nano versus a Blackfin DSP chip.

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|  | **Jetson Nano** | Black Fin ADSP-BF607 |
| Power Consumption | 5V/2A | 3.3V/357 mA (typ) |
| DSP Capabilities | Yes, made for DSP and AI | Yes, made for demanding DSP computations |
| Documentation | Tons, including Nvidia’s developer zone. | not much, if any. |
| Price | Developer kit is $99 | Chip itself is ~$20 |
| Developer Kit? | yes | not for this chip |
| CPU | Quad Core ARM A57 @ 1.43 GHz | 2 Blackfin Cores |
| Interfaces | 3x UART, 2xSPI, 4xI2C, 2xI2S, GPIOs, Ethernet | USB 2.0 OTG, Removable storage interface, CAN interface, 2 Ethernat MACs, 2 SPI ports, 2 UART |
| Packaging | only available as module or dev kit | BGA |
| CSI camera interface | yes | no |
| Source: | [jetson nano info](https://www.nvidia.com/en-us/autonomous-machines/embedded-systems/jetson-nano/) | [blackfin info](https://www.analog.com/en/products/adsp-bf607.html#product-overview) [4] |

We chose the Jetson Nano to do the job. On one hand, the nano draws much more power than the Blackfin which negatively affects flight time; however, the nano has much better documentation and a developer kit to allow us to prototype more easily. Even past prototyping, the nano will be more easy to mount. Additionally, we must have a camera for image processing, and we planned on using the CSI interface. The blackfin does not have this capability.

1.2 Analysis of Component 2: The microcontroller

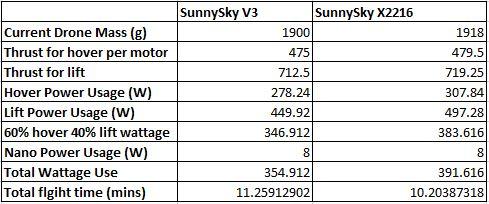
To select a microcontroller, we compared STM products. We knew we wanted to stick with STM because that was what we are all familiar with from ECE 36200. Below is a comparison between the STM32F411E and the STM32H745ZIT6.

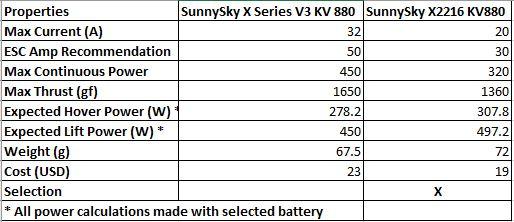
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|  | **STM32H745ZIT6** | STM32F411E |
| Communication Peripherals | 4xI2C, 4xUSART/UART, 1xLPUART, 6x SPIs, 4xSAI (not really necessary), SPDIFRX (not necessary), SWPMI, MDIO slave, 2x SD/SDO/MMC interfaces, 2x CAN controllers, 2x USB OTG interfaces, Ethernet MAC interface with DMA controller, HDMI-CEC, 8 to 14 bit camera interface | 3xI2C, 3xUSART, 5xSPI, I2S, 1xSDIO,1x USB OTG |
| Analog Peripherals | 3x ADCs (16 bit res), 1x temp sensor, 2 12 bit DACs, 2 ultra low power comparators, 2 op amps, digital filter for sigma delta modulator | ADC (12 bit), temp sensor |
| DMA | 4: 1x high speed master memory access controller (MDMA), 2x dual-port DMAs with FIFO, 1x basic DMA | 2 general purpose DMAs |
| GPIO | 186 GPIO ports with interrupt capability | 81 GPIO ports |
| Cores | Dual Core: 32-bit Arm Cortex M7 (16 kbytes of data, 16 kbytes instruction cache, freq up to 480 MHz, MPU, DSP instructions), 32-bit cortex M4 core (frequency up to 240 MHz, MPU, DSP instructions) | ARM Cortex M4 core |
| Memory | 2 Mbytes flash memory | 512 kbytes Flash memory |
| Documentation | yes (also course staff familiar with stm) | yes (also course staff familiar with stm) |
| ARM based? | yes | yes |
| Datasheet | [H7 datasheet](https://www.st.com/resource/en/datasheet/stm32h745ii.pdf) [1] | [M4 datasheet](https://www.st.com/content/ccc/resource/technical/document/datasheet/b3/a5/46/3b/b4/e5/4c/85/DM00115249.pdf/files/DM00115249.pdf/jcr:content/translations/en.DM00115249.pdf#page=32&zoom=100,89,117) [2] |

We selected the STM32H745ZIT6. Because this microcontroller is dual core, it would allow parallelization of computation of flight decisions and communication with peripherals to achieve faster performance. Additionally, the STM32H745ZIT6 has additional features beyond the M4 alone, including more memory and a camera interface, which gives us some wiggle room in case we need to have the micro perform some additional functions than we originally anticipated. In general, we thought this board would give us more freedom in prototyping.

1.3 Analysis of Component 3: Battery and Motors

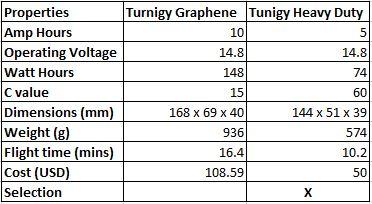
The selection of our motors and battery were heavily dependent on each other and our anticipated use case. Due to the prototype nature of our drone we decided upon an anticipated flight time of 10 minutes for proof of concept of our algorithm. In addition to this another consideration was the overall cost of our drone in order to avoid our product becoming cost prohibitive. With these constraints in mind we found a supplier SunnySky USA that offered high power and efficient motors for an adorable cost at a size that is able to fit our drone frame. After evaluating two motors from SunnySkyUSA we decided upon the SunnySky X2216 KV880 because of its lower continuous power draw allowing us to use more affordable ESC when compared to its arguably more power efficient cousin. When evaluating the two motors expected flight times the more efficient motor only allowed our drone an extra minute of flight which when compared to an additional thirty dollars per motor in ESCs was simply not worth it.





Source for motors: [13] , [14]

Once we decided upon the use of this motor we moved onto evaluating various battery capacities and their impact on flight time. Since we knew that we were aiming for a flight time of 10 minutes this became the baseline for our battery performance. However, we also wanted to determine if increasing our flight time was reasonable so that we could limit the amount of time charging batteries between flights. We found that the density of LiPo batteries is rather fixed and unable to be improved with larger capacity batteries. Due to this when we evaluated a 10Ah battery we found that this only gave us a sixty percent increase in flight time when compared to our original 5Ah battery used to achieve 10 minutes of flight time. When this is compared again with the cost of the two batteries being evaluated we decided upon the 5Ah battery to maximize cost effectiveness and minimize the overall weight on our drone.



Source for batteries: [11] , [12]

1.4 Analysis of Component 4: Flight Controller

The selection of the flight controller is dependent on which firmware we used. There are two main players in open source drone firmware, PX4 and ArduPilot. ArduPilot is actually a fork off of PX4 when some of the developers disagreed with what license the project should fall under. Our constraints were that the software be open source (so that we may edit it if need be), be easy to configure, and be able to take commands and queries from a companion computer.

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|  | **PX4** | ArduPilot |
| Open source | yes | yes |
| License | BSD | GPLv3 |
| Open hardware standard | yes | no |
| Ground control | yse | yes |
| Companion Computer communication | MAVLink | MAVLink |
| Ease of use (1-5; easy-hard) | 3 | 5 |

We decided to go with the PX4 flight stack since it is officially part of the dronecode project, the organization that develops the MAVLink protocol, Pixhawk hardware, and QGroundControl application. ArduPilot also works with these things since they are all an open standard, but we believe PX4 will have better compatibility with the other parts of the software/hardware suite. Our decision was also influenced by the license type. We do not foresee any need to change the source code of the firmware, but PX4 offers more flexibility of redistribution of IP under the BSD license.

We then move to the decision of the actual flight controller. The flight controller must obviously be supported by the PX4 firmware, but we decided that one that could run both ArduPilot and PX4 would give us more wiggle room and be better in the long run. Another serious constraint was sizing and weight. As there is a lot to be mounted on the drone, we need to save as much space and weight as we can. Ultimately, we decided between two flight controllers: the Pixhawk 4 mini and the mRo Pixracer.

We settled on the Pixhawk 4 mini mostly because of its polish and ease of use. The size and weight differences between the two components is negligible. Though it may seem like the mRo PixRacer excels in those two categories, its numbers do not include the associated GPS and power distribution board (PDB) required. The difference in cost, once the GPS and PDB are taken into account, was another reason for our decision.

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|  | **Pixhawk 4 mini [6]** | mRo Pixracer [5] |
| Included GPS and external Compass | yes | no |
| Ease of wiring | clearly labeled ports with standard connectors | little on board descriptions but uses standard connectors |
| Case | yes | no |
| weight | 37g (including GPS and PDB) | 10.45g |
| Case | yes | no |
| Dimensions | 38x55 mm | 36 x 36mm |
| Cost (including associated GPS andPDB) | $ 180.00 | $ 226.80 |

1.5 Analysis of Component 5: appendage

When evaluating what type of material to use on our drones appendage to conduct the pollination we first wanted to evaluate what is currently used in hand pollination methods. Throughout this evaluation we found the most common type of material used for hand pollination are small artist brushes as they are cheap to produce, abundant, and gentle when interacting with the flower's stigma. This is important because the pollen can be easily collected and transferred from flower to flower however too much pressure can damage or even kill the flower. For this reason we decided to use a brush to collect and deposit the pollen from flower to flower, however we still needed to solve the problem of ensuring contact with the flower. To accomplish this task we are planning on using a capacitive touch switch mounted to the base of our pollinator. Once the bristles make contact with the flower the switch will inform the STM32 that contact has been achieved and the drone will cease to move forward. Finally when conducting hand pollination it is recommended that the brush is moved around the stigma of the flower to increase likelihood of proper pollen distribution upon the flower. To accomplish this task we are going to be mounting our entire pollinator to a servo motor. Initially we had two options for servos that can be seen in the table below. However, since we are unsure yet how heavy our pollinator will be we decided to go with the servo that had a higher torque. We decided upon this servo because it can be controlled over a PWM signal from our STM32 which can be controlled at low power and easily limited in its range of motion to avoid damage to the flowers. Once we have achieved contact with our flower the STM will oscillate the pollinator back and forth over the flower before moving away from the flower and onto the next.



Sources for servos: [9] , [10]

2.0 Sources Cited:

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