Fall 2014

Searcue – Quadcopters

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Introduction

When it comes to a person's life a moment's time could be the change between life and death. Ambulances are always on the rush to respond to distress calls as quick as possible because every second counts; a quicker response could lead to a saved life. Similarly for search and rescue operatives, the longer it takes to find the person in need the more danger is posed on their life. In British Columbia, the amount of search and rescue teams and members we have is almost more than double than any other province in Canada (BCSARA, 2011). The amount of search and rescue operations in 2011 in British Columbia was 1 304, this is almost nine times more than the next Canadian province of Nunavut which had 163 (BCSARA, 2011). This is greatly because of British Columbia's large population and geographic terrain as we have many mountains and rivers in which danger is always a factor. British Columbia's Search and Rescue members have been trained in different search and rescue techniques because of this terrain such as mountain rescue, avalanche operations, swift water rescue, etc. Judging from just the volume of searches required in British Columbia it is evident that search and rescue in British Columbia is an issue that can't be ignored.

This is where our company Searcue comes in by introducing a quadcopter that will minimize the time required to search for the patient. The company Searcue comes from the combination of the words Search and Rescue, combining them to give us our company name Searcue. Searcue's goal is to save more lives by attending to those that need to be rescued as quickly as possible, which can be done through our quadcopters. Our quadcopters can not only speed up the process of search and rescue, but can also get to areas where our search and rescue members would have difficulty to reach. For example, due to British Columbia's geographic terrain many areas are dangerous to venture to due to mountains and rivers and this is where the quadcopters would come into action. The quadcopters could fly to these hard to reach places to see if the individual is there, thus giving search and rescue members enough notice to get well equipped for such dangerous areas. By obtaining the notice from the quadcopter the search and rescue members are able to prepare for the type of rescue involved.

The quadcopters also come equipped with thermal cameras allowing the quadcopters to find human heat signatures, thus finding the patient in need as swiftly as possible. There are two modes of flight operation, automatic and manual, as this allows for maximum versatility. The automatic flight mode would scan an area for human heat signatures with the thermal camera and then continue to fly and keep searching. This would be done through digital image processing; if no heat signature is found then the quadcopter would continue to fly however if a heat signature is found the quadcopter would stop to

notify search and rescue members. The heat signatures could then further be investigated through manual flight operation, where you can move closer to the heat signature to pinpoint an exact location for the patient and see the terrain. This then goes back to the search and rescue members being able to be properly equipped for the terrain involved.

Overview of the System - Quadcopter

The Quadcopter is a multi-rotor system usually arranged symmetrically with four motors and propellers. It can be used in different applications but we are concentrating on search and rescue operation. The level of technical knowledge needed for this project is high and involves research into parts and checking compatibility of Arduino board, IMU (sensors) and GPS.

The brain of the system is the flight controller, which would be implemented on Arduino board. It is a circuit board that functions to direct the revolutions per minute (RPM) of each motor in response to input. Commands from the pilot for the multi-rotor to move forward are fed into the flight controller, which determines how to manipulate the motors accordingly. The majority of flight controllers also use sensors like gyroscopes for orientation; barometers for automatically holding altitudes and GPS can also be used for auto-pilot or fail-safe purposes (Tom's Hardware, 2014). The frame should be light enough so as to reduce the effect of gravity and allow high flights.

After much research on the different platforms and components needed for our design, we decided to go with light frames to take in to account the weight of other parts like motor, battery, camera and flight controller which would determine if the Quadcopter can lift. We also went with the Arduino board, which is the microcontroller board and Razor IMU which contains gyroscope, accelerometer and magnetometer to allow for 9 degrees of freedom and provides stability during flight.

It is a small-scale Quadcopter that can be used for search and rescue. It is a low cost prototype of a more advanced technology and it is designed with video streaming. The Quadcopter would be capable of autonomous flight with pre-determined locations. We would be working with open source software, AeroQuad, to configure the Quadcopter for autonomous flight.

The quadcopter would be able to lift off the ground, travel a particular distance and record objects in its location and land. Therefore we need sensors as well as gyroscope, accelerometer, GPS, batteries and a good camera. As compared with military use of unmanned aerial vehicles (UAVs), smaller UAVs like

Quadcopter should be able to handle military operations as well as for commercial and industrial purposes and our project is aimed at validating this assumption. Considering the amount of time and cost of the project, we have narrowed the tasks to achieve the goal at the end of the semester. More development can continue after the project is finalized.

Task 1: To get the Quadcopter to fly

It requires ArduPilot flight controller, motors and propeller to enable it to fly. The weight of the Quadcopter as a whole is an important factor because it affects the flight and lift.

Task 2: Communication system

The Quadcopter would need to receive information from the camera mounted on the frame. The receiver and transmitter would communicate through network and we would be able to change the location and searching area using GPS. The processed information is sent to a computer indicating that an object has been found. The transmitter requires minimum of four channels to control yaw, pitch, throttle and roll and equal number of receivers.

Task 3: Image Processing

With the use of GoPro cameras and night vision and a filter, we would be able to capture images at a particular distance from the ground and process the image.

Risks:

There are lots of risks involved. We have to anticipate problems and plan before the risk occurs by having back up plans for every task. Firstly, the probability of breaking the frame is high depending on motor failures and battery capacity. We planned ahead by buying carbon fiber frame that is more aerodynamically efficient, light and durable and not discharging more than 80% of the battery's capacity. Vibration is one of the biggest problem of Quadcopters and can cause a number of problems, especially ruin footages so proper attention is paid in choosing frames and propellers. There has to be a balance between hard and flexible frames. We also have to pay attention to environmental and weather conditions to prevent destructive results. We can avoid that by designing the copter to auto respond to different conditions by landing safely to the ground. Most importantly, the challenge would be the communication between transmitter and receiver when capturing images form a particular distance

above the ground. Considering the flight time of the controllers and GPS interruption, communication can be delayed. We would mitigate this risk by buying good sensors and performing tests.

Benefits:

It can be used for search and rescue operations in areas that may be dangerous for humans. It also saves time and money. The search and rescue Quadcopter can also be extended to various applications for example, in-house search and rescue. Depending on the material used, it can be used in different environments like water and land. Additionally the base technology can be further developed for a multitude of additional applications, such as security, land surveys, etc.

Cost

Search and rescue quadcopters can be used in many different situations by law enforcement or an individual. One advantage that these quadcopters have over humans is that they can search a wide area over a short period of time and in most search and rescue missions time is a very important factor. Another advantage is that quadcopters can reach areas that ground forces don't have any access to or the areas that are too dangerous for a human rescuer to enter. Also Quadcopters can carry infrared, thermal imaging devices, and night vision cameras to make the search more efficient and increase the probability of success. For example in a case of flood quadcopters can find the location of the survivors or those whose life is in danger and this way the search and rescue team can be directly send to the specified location without any delay. In addition quadcopters can carry water, food and other essentials for those, who are not in an immediate danger, but cannot be reached right away. Quadcopters not only save lives, but also save money! Before their introduction to the search and rescue applications many more human rescuers were used together with real helicopters. The cost of operating helicopters is too high compare to the cost of using a quadcopters and also there are always dangers associated with operating helicopters especially, when the weather condition is bad. Therefore it is apparent that quadcopters are safer and save more lives at a lower cost.

Currently there are models out there such as DJI Phantom, and Parrot AR, that can be used for a search and rescue purposes. Since the good quality cameras are very expensive it's very important for the quadcopter to be as reliable as possible. The Parrot AR crash more frequently than its competitors and therefore the probability of damaging the camera is high. On the other hand the DJI Phantom does not fly well in tight areas and its footage lack a bit of quality due to the vibration of the base of the

Quadcopter. The two mentioned brands have models with cameras and GPS system that are priced at around $1200 to $1500. The purpose of this project is to create a more stable quadcopter, which is much cheaper and can be utilized with minimal human intervention.

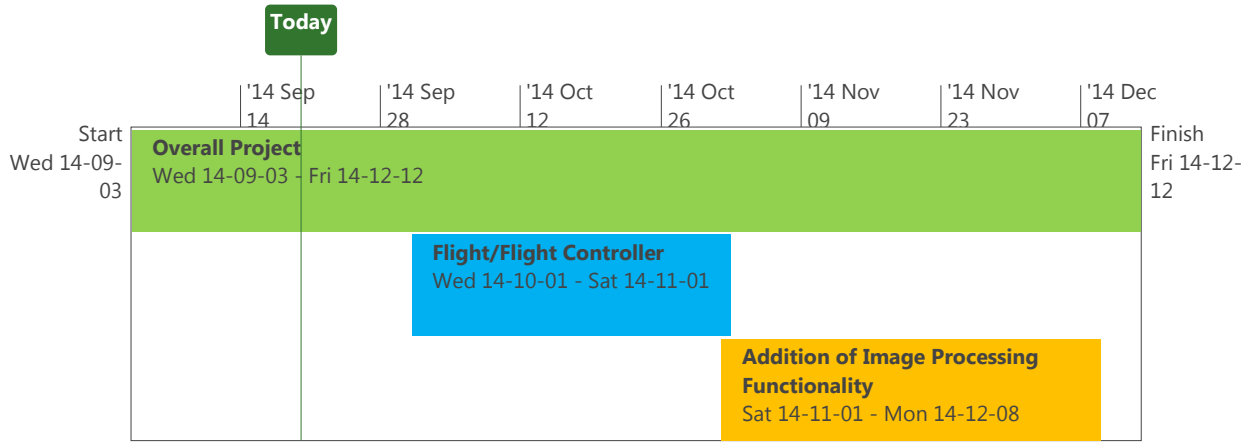
The cost of this project could vary based on the size of the quadcopter and the quality of the motors, cameras, GPS, and other components. Our team has decided that given the limited budget at our disposal it is not realistic to use the highest quality components for our prototype. We will however try to build the best quadcopter that is within our budget and make sure that it is reliable enough to be used for search and rescue missions. There are two ways to improve the quality of our device: one would be to raise our budget by finding more sources of funding and the other would be to reduce the cost of development by making alternations in the design or through other methods. For example we have decided to buy the Arduino board and the IMU unit separately and then solder them together in order to lower the cost of production. The potential funding sources are The Engineering Science Student Endowment Fund (ESSEF) at SFU, the organizations that are involved in search and rescue missions such as RCMP, Fire department, coast guard, and also interested individuals and investors, who have noticed the boost in market demand for drones and quadcopters. It must be mentioned that every group member has accepted that to achieve our goal we may need to spend more than our original capital and that he/she may have to aid the team financially as well.

Equipment	Estimated cost($)
Razor IMU(9Degrees of freedom)	90
Arduino Mega 2560 R3	80
4×Motors	80
GPS unit	80
4×Electonic speed controllers(ESCs)	50
Cable connectors and spacers and wires	50
Battery	40
charger	30
Power supply	10
Power distribution board	5
TOTAL ESTIMATED COST	515

Table of Estimated Costs

Project Organization

The implementation of this project is done in two separate stages. Stage one would be to ensure that the Flight and Flight controller are working, and have been adequately tested and can reliably performs for our applications. Then the second phase is to add the components of image processing to ultimately achieve our final prototype. The following chart summarizes these facts.

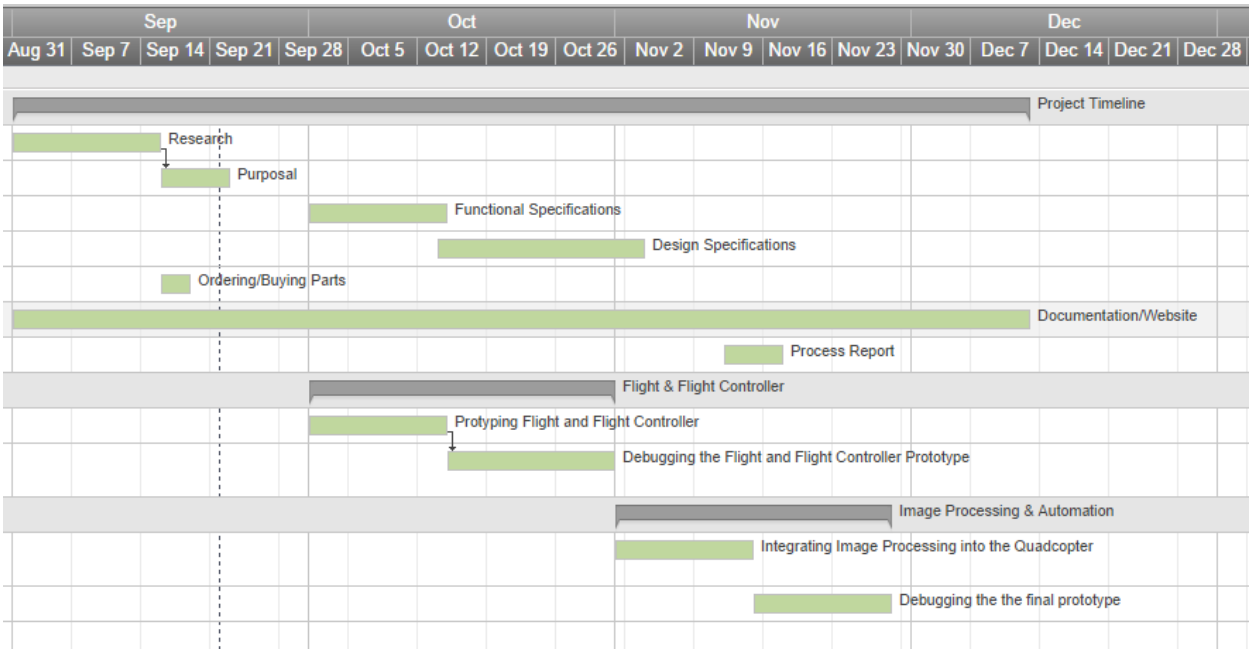


Outside of the main phases of our project it is important to note the time and other important dates and milestones of our project.

Task Name	Start	Finish	Milestone
Overall Project	**Wed 14-09-03**	**Fri 14-12-12**	
Research	Wed 14-09-03	Mon 14-09-15	
Proposal	Tue 14-09-16	Tue 14-09-23	
Ordering/Buying Parts	Tue 14-09-16	Fri 14-09-19	
Proposal Completed	Mon 14-09-22	Mon 14-09-22	MILESTONE
Functional Specifications	Wed 14-10-01	Tue 14-10-14	
Functional Specifications completed	Tue 14-10-14	Tue 14-10-14	MILESTONE
Design Specifications	Wed 14-10-15	Mon 14-11-03	
Design Specifications Completed	Mon 14-11-03	Mon 14-11-03	MILESTONE
Flight/Flight Controller	**Wed 14-10-01**	**Sat 14-11-01**	
Prototyping Flight & Flight Controller	Wed 14-10-01	Tue 14-10-14	
Debugging Flight & Flight Controller	Thu 14-10-16	Sat 14-11-01	
Flight/Flight Controller Completed	Sat 14-11-01	Sat 14-11-01	MILESTONE
Addition of Image Processing Functionality	**Sat 14-11-01**	**Sun 14-11-30**	
Prototyping Camera and Image Processing Software	Sat 14-11-01	Fri 14-11-14	
Debugging the Final Prototype	Tue 14-11-18	Sun 14-11-30	

Table of Important Dates and Milestones

Additionally the following Gantt Chart showcases the overall Project timeline.



Gantt Table – Showcasing the Project Timeline

Conclusion

The quadcopter has the capability of conducting search and rescue missions in areas that are inaccessible or dangerous to human beings in a quick span of time. The machine is of great importance with regards to British Columbia because of the volume of search and rescue operations, which is due to the province's geographical terrain and large population. In order to build the small-scale quadcopter, the group analyzed three step-by-step tasks: quadcopter flight, communication and finally image processing. The first task would be getting the quadcopter to fly and this would require a flight controller, specifically the Ardupilot. The second task involves setting up the communication system, which enables the quadcopter to receive information using the camera by installing a receiver and a transmitter. Furthermore, the changing area and location of the quadcopter will be updated constantly by installing a GPS. The final task requires the quadcopter to have an image capturing and processing system.

The group ordered and bought the following components for building the quadcopter: Razor IMU (9 degrees of freedom), Arduino Mega 2560 R3, 4×Motors, GPS unit, 4×Electonic speed controllers (ESCs), cable connectors and spacers and wires, battery, charger, power supply, and power distribution board. The amount estimated for the project and all the components bought would be approximately $515. The Engineering Science Student Endowment Fund (ESSEF) of SFU, RCMP, fire department, coast guard have accepted to financially help our group, which will further help us in achieving the our goals.

This project poses significant risks, such as a failure in the transmitter and receiver when capturing and processing images taken as well as vibrations within the system. These vibrations can lead to that changes in the hard and flexible frames and environmental issues such as heavy rain or hail could disrupt the quadcopter. The group hopes to prevent such risks from happening by buying good sensors, conducting multiple tests, and utilizing the machine's system efficiently.

The quadcopter system with the digital imaging implementation allows for a unique solution to a search and rescue. The benefit of an aerial view and the added maneuverability in hard to reach areas allows a quadcopter to be a good aid for search and rescue. The implementation of this quadcopter can be achieved numerous ways, and our implementation allows for a cost effective and efficient approach. The main component, the flight controller, is being developed with an

Arduino unit and adding on sensors for a closed-loop control. Furthermore, our base technology can be further utilized for additional applications and allow for expansion. The greatest benefit would be the possible time that a quadcopter can save during a search and rescue effort, ultimately saving lives.

References

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