Project Decomposition and Block Diagrams- Deadline: 10/5/2022

EE/CpE 4812 – ECE Capstone Design I

Fall 2022

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Team name: D2R

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Description: Breaks down the project into smaller blocks and goes into detail on how the final solution can be achieved.

Level 0 Block Diagram Description

The goal is to add multiple modules to an existing drone framework model with the intention to expand and improve the functionality. In level 0, it is shortly described how we will achieve these goals. The main goal is to add a rover functionality to the drone.

To do this, there will be an input driven from the controls to toggle between the two modes of the drone, a driving mode and a flying mode. Ideally, the input should only be accepted when the drone is landed and stationary. When the button is pressed, the drone should either fold up or unfold the wings with the fly motors attached. The main purpose of this is so when in driving mode, collisions will deal as little possible damage to the structure. The small motors in control of this will be powered off of the battery and allow a smooth and quick transition between modes of operation.

In addition to adding functionality for the wings to fold up out of the way, wheels will be needed to be added to these new modules. The standard modules for the flight motors include feet for the drone to land on. Our proposed solution is to create a new arm module that instead of feet, has a wheel for the drone to land on. The specifics of how we plan to implement the wheels to achieve a clean driving experience are unsure.

Another functionality that may be implemented is creating a way for flight/drive data to be preserved through mode switches. This will most likely increase complexity significantly, because the firmware will not remain the same through the different modes, however methods of dealing with this issue are currently being discussed.

There is also a requested functionality of creating a new module for the drone that improves the flight capabilities while keeping the ability to have a vertical take off and landing, using fixed-wing VTOL mode. This will be done in two parts, a physical component where wings are 3D printed and snap into existing slots for add-on modules. As far as physical considerations go, a rear tail that adds stability as well as an extra propeller in the rear to increase the thrust will also be added.The second part will need to add to or modify the firmware of the drone to accommodate the new weight and shape of the drone with the modules attached. This may include using a separate flight controller for the drone, although this is a consideration that will have to be tested through extensive experimentation.

Modifying the firmware is needed as the shape and weight of the drone are different, which means the balancing of the motors need to be modified. This extends to the purpose of adding wings; allowing the drone to glide with minimal output on the motors. This can increase the possible flight distance and maximum speed while also increasing the battery life, as the motors don't need to work as hard when moving in a forward direction. Keeping the quadcopter arms on the drone will allow for faster take-off and landing procedures than would be possible with only the fixed-wings.

Level 1 Block Diagram Description

There are two major roadblocks in achieving the functionality of swapping between a driving and a flying mode. The first one is the software and firmware considerations. The drone uses an existing firmware meant entirely for quadcopter drone flight, and will need to be heavily modified or swapped out entirely when driving mode is enabled. One proposed solution is to have a dedicated controller that swaps between the two modes' respective firmwares. The drones firmware would be completely incompatible with a driving mode, as its purpose is to balance the output of the four motors while accommodating the shape and weight of the drone. It would be incredibly difficult to pilot a drone while controlling all 4 motors individually as opposed to just pressing forward. If the firmware is not properly tuned and adjusted for the size, weight, and power of the motors, then attempting to move the drone forward would result in a collision. This is why different firmware is possibly needed for driving mode. The wheels need to be the same speed and be controlled in pairs, not individually. Another solution is to have an additional flight controller, either as a part of the module or added as a main part of the drone. However, this will add both significant cost and weight to the drone.

The second major roadblock will be how to design the wheels being attached, as well as how to keep them on the same axle. This part of the design has nothing to do with the wings folding. One of the proposed solutions is having a front and rear axle with functionality similar to a toy remote controlled car, and having the driving mode behaving similarly. A 4-wheel drive mode could also work here, however the additional motors would increase battery drain, as well as cost and weight.

The drone will be able to sense if it is landed through LiDAR, as well as its current mode. This will allow it to safely switch between driving and flying mode, as the motors for flight being disengaged while flying would almost certainly assure a collision of some kind. After the drone is landed and not moving at all, when a button is pushed by the user, the drone will automatically change modes. The wings will either fold or unfold, and the firmware and controls will be swapped appropriately to the new mode.

Folding of the wings should each be handled by their own small, individual motor, which moves an arm up or down, with the flight motor attached to the end. The motors will be controlled by the same controller that determines whether flight or driving firmware should be used. Testing will determine whether a single motor could be used instead here, for folding all of the arms simultaneously.

For the Fixed-Wing VTOL mode, there are several considerations to be looked at. The first is the positioning of the wings when added to the drone. For ideal functionality, the wings should be positioned below the quadcopter and to the side of the drone. A proposed solution for this problem is to create an L-shaped connector for the top and bottom of the drone where modules sit, and attach the wings in this manner. This module will also have a tail wing, as well as a propeller for the rear of the drone.

Software considerations for the Fixed-Wing VTOL mode are generally limited to the firmware and/or flight controller. Whether a new flight controller is necessary remains to be seen, however a secondary firmware option will be required. If an additional flight controller is not used, the Fixed-Wing VTOL firmware will either need to be stored on the flight controller, or stored externally. Because it won't be feasible to switch modes during drone operation, an external storage for the firmware is a reasonable option.

A final consideration for the Fixed-Wing VTOL mode will be size and weight considerations. In order to work with the existing quadcopter arms, extensive testing will need to be done in order to ensure take-off and sustained flight can be attained. This may require adding additional batteries, quadcopter arms, or removing components to fit weight requirements.

Terminating Sheet

Role	First and Last Name	Contribution (%)
Engineering Manager	Conrad Obeng	25%
Secretary	Ehab Afsoonko	25%
Systems/Software Engineer	Lexi McMinn	25%
Financial Officer	Mark James Jr	25%

Date: 5 October 2022

Assignment: Project Decomposition