ECE445 Senior Design

Solar Drone

Proposal

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Introduction

Statement of Interest & Objectives

With the advantage of agility and stability, quadrotor helicopter (quadcopter) has become a good choice for applications that requires unmanned aerial vehicle. However, most of the quadcopters in market at present are still at entry level and sold as hobbyist toys, due to the limit of onboard power supply and onboard computation power. In this project, we are designing and building a quadcopter that utilize solar energy to prolong flight time and incorporate iOS platform to provide vast computing power.

Benefits:

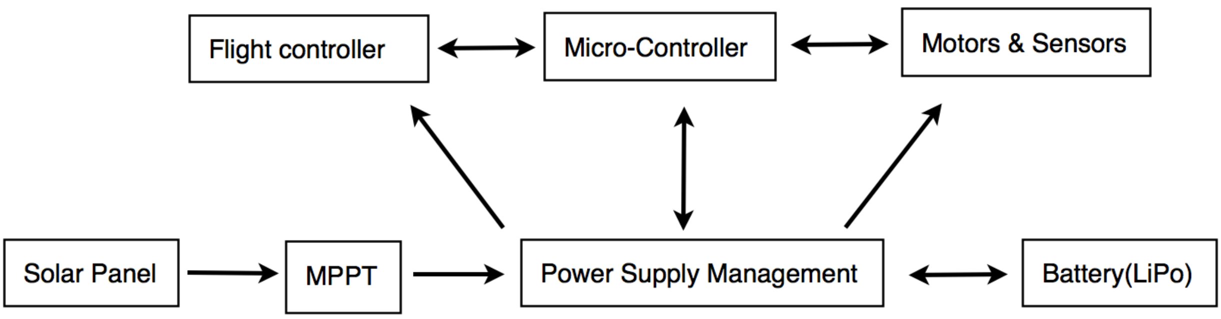
- Able to reach areas that are difficult for human to reach.
- Can be used in applications that require long lasting hover, provided with sufficient sunlight.
- Smart and provide APIs for extensible application.

Features:

- Self-navigation using GPS integrated in phone.
- Self-balancing using gyroscope integrated in phone.
- Long lasting power supply using Lithium-polymer battery can be charged during flight by using solar cells.
- Automatic landing mechanism with low power supply
- Able to return to base in case of emergency

Design

Block Diagram:



Block Descriptions:

Flight Controller: This is the brain of the quadrotor helicopter. It controls the motion, stabilization, flight routine and is the interface between human and the quadcopter. This flight controller is based on iOS platform and can take advantage of such platform by utilizing existing APIs for Bluetooth, 3G network, gyroscope, camera, GPS and etc.
This module interface with microcontroller using serial cable and self developed protocol. The power is provided by power supply management module using micro USB.

Main Microcontroller: This is the interface between the flight controller and the basic hardware. This module talks to the brain using serial cable and translates various commands into control signal for motors or translate sensor signals into data usable by the flight controller.

Motors and Sensors: This block consists of four DC outrunner motors and various sensors sensing temperature, proximity, current, voltage and possibly barometric pressure. Motors are controlled by existing motor drive unit in the market, which talks to microcontroller for control signals. Sensors are directly connected to microcontroller.

Power Supply Manager: This is a power electronic circuit that convert power input from solar panel to usable power by DC motors and onboard controllers. It also includes a backup LiPo battery in case the solar energy falls short. The circuit is controlled by its own microcontroller, which monitors the live status of both solar panel and battery, and makes adjustments accordingly. This module would also communicate with main microcontroller in case of power shortage so that the quadcopter could prepare for landing.

Solar Panel: This module provides extra energy to the vehicle. It interfaces with MPPT that converts voltage from solar cells to the rated voltage of motors.

MPPT: The max power point tracker (MPPT) is used to trace the max power point of solar cells to make sure the cells always output power at maximum capacity. It interfaces with power management Block.

Requirements and Verification

Requirements:

1. The flight controller should update motion information (roll, pitch and yaw) and calculate feedback control signal values at 100Hz frequency at least to maintain stability of the quadcopter. Accordingly, the flight controller should also be able to communicate such

information with fundament hardware via microcontroller at the same frequency.

2. The microcontroller should be able to handle all the information comes from flight controller without encountering buffer overflow and should be able to communicate the translated sensor signals with flight controller. The microcontroller is supposed to provide four sets of 50Hz 1ms-2ms pulses for four motor drives and accept at least 5 sensor signal inputs.

3. The four motors should be able to lift 2kg payload off the ground and have extra power to maintain stability. The throttles at hover should not exceed 50% to ensure good maneuverability.

4. The power supply manager should be able to handle large current (10A~50A) and include a backup battery in case the solar energy falls short. It should monitor live status of both solar panels and battery and charge the backup battery when there is extra power from the solar panels. The battery should always maintain minimum power that is sufficient for 3 minutes landing procedure.

5. Solar Panel: The solar panel should consist of a total of 48 to 60 pieces of solar cells that can provide a maximum of 220W to 240W power output. The power output level should be adjusted by max power point tracker to guarantee max power output at all time.

6. MPPT: According to the details of solar cell, it should decrease current by a factor of 5, increase voltage by a factor of 5. The voltage output for a single module:11 V+-0.4V. Current Output for a single module: 4.72 A +-1A

Verifications:

1. Tests code will be inserted into the program and tests will be performed to measure average loop time and package delivery time and they must be less than 10ms to guarantee the 100Hz update frequency.

2. Benchmark tests will be performed to measure the performance of the microcontroller and try to record the conditions for max performances, under which it should never fail or recover automatically within one second. Flooding test will also be performed to ensure zero failure rate.

3. Measure the performance of motors in Power Lab and measure the lift force of a single motor with 15/4 propeller on at max throttle, half throttle and a quarter throttle.

4. The power supply manger circuit should handle 50A max current at 20V max voltage without overheating and output usable power, which will be specified later in the design.

5. Solar Cell: Power, Voltage and Current can be verified through multimeters in Everrit 50. Results will be presented in a table.

6. MPPT: Compare results before and after the use of MPPT. Results will be presented in graph along with solar cells IV curve.

Tolerance Analysis:
The data transfer rate among modules is the critical limitation on the motion update frequency, which would affect the stability of the quadcopter greatly. The detailed requirements will be specified in design report.

Cost and Schedule

Parts Cost

Name	Quantity	Price per Unit	Total Price
Turnigy Talon Carbon Fiber Quadcopter Frame	1	US$28.78	US$28.78
Turnigy Smart6 80w 7A Balance Charger with Graph Screen	1	US$46.80	US$46.80
HobbyKing Programming card for BlueSeries Brushless Speed Controller	1	US$3.32	US$3.32
Slow Fly Electric Prop 12x4.5R SF (4 pc Right Hand Rotation)	1	US$4.26	US$4.26
NTM Prop Drive 28-36 750KV / 265W	4	US$15.99	US$63.96
CNC Alloy Prop Balancer for Propeller, EDF & Heli Shaft/Blade	1	US$15.86	US$15.86
Hobby King Quadcopter Power Distribution Board	1	US$3.99	US$3.99
Male XT60 connectors (5pcs/bag) GENUINE	1	US$2.44	US$2.44
Female XT60 connectors (5pcs/bag) GENUINE	1	US$2.35	US$2.35
Extra Size Cardboard Box and Packing 183g	1	US$0.00	US$0.00
Turnigy nano-tech 4000mah 3S 35~70C Lipo Pack (USA Warehouse)	1	US$33.70	US$33.70
HobbyKing 30A BlueSeries Brushless Speed Controller (USA Warehouse)	4	US$10.59	US$42.30

Labor Cost

Name	Salary($/hr)	Hours	Total	Total * 2.5
Jie Wang	40	180	7200	18,000
Jinming Zhang	40	180	7200	18,000
Yingkan Ni	40	180	7200	18,000
Total	54,000			

Weekly Schedule

Week	Task Type	Assigned To	Task Description
1	Independent	Jinming Zhang	finish arduino-ios interface [iOS][Arduino]
	Collaborate	Jinming Zhang & Jie Wang	finish power supply management module top level design
	Independent	Jie Wang	finish solar mppt circuit design [Circuit]
	Independent	Yingkan Ni	finish P2P debug module [iOS]
	Collaborate	All	finish proposal
2	Independent	Jinming Zhang	finish Motion Control module [iOS]
	Collaborate	Jinming Zhang & Jie Wang	work on power supply management module - circuit design [Circuit]
	Independent	Jie Wang	finish solar mppt controller design [Arduino]
	Collaborate	Yingkan Ni & Jinming Zhang	assemble iOS flight controller [iOS]
3	Independent	Yingkan Ni	assemble quadcopter scaled model [Hardware]
	Collaborate	Jie Wang & Jinming Zhang	finish feedback tuning [iOS]
	Collaborate	Jie Wang & Jinming Zhang	verify the design of power supply management module [Circuit]
	Collaborate	All	finalize design details of final quadcopter
	Collaborate	All	design review report
4	Independent	Yingkan Ni	generate parts list for the final quadcopter and make purchases
	Independent	Jie Wang	fabricate and test power supply management module (prototype)
	Independent	Yingkan Ni	look for funding
	Independent	Jinming Zhang	work on Sensor Control module and take-off procedure [iOS]
5 & 6	Collaborate	All	assemble final quadcopter as parts come in
	Independent	Jinming Zhang	work on Communication module and communication protocol
	Independent	Yingkan Ni	design server side database
	Independent	Jie Wang	fabricate and test power supply management module (prototype)
7~9	Collaborate	All	debug and test
	Collaborate	Jie Wang & Jinming Zhang	PCB design and fabrication
10			Thanksgiving
11	Collaborate	All	work on demo, presentation and final report