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DEVELOPMENT OF A QUADCOPTER BASED ON THE RASPBERRY PI PLATFORM

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Abstract: *The usage of drones in the industry, research and hobby has increased during the last years. In the world of academia (that includes this project) quadcopters present a perfect test bench for a research. Many fields like robotics and automatics use them to solve some specific problems. The research area of quadrotors is toward the implementation of new control techniques, new control and machine learning algorithms. Autonomous drones are the main trend in modern research area. To be able to implement this sophisticated algoritms, a more computation intensive hardware is nesesery with as small as possible form-factor. This project sets its objectives on the construction of a quadcopter using development board Rasberry pi 3B used as a companion computer and a flight controller (FC) at the same time. The implementation of a FC is on the basis of a sensor board Emlid Navio 2. The FC is implemented as a software process started in a real-time OS provided by the manufacturer of sensor board. At first a general look is taken to the parts that form the quadcopter, the construction of the system, the software components that are used to implement the flight controller and a free, open-source control ground station that is used to monitor the system. The configuration and testing of the proposed system capabilities is investigated in a real environment. In a conclusion it could be said that the system is stable, has smaller form-factor and has the ability to perform more complex tasks.*

Keywords: *Quadcopters, Raspberry Pi, Emlid, companion computers, Mission Planner*

INTRODUCTION

With the advancement of technology and reduced electronic device prices, it is becoming more and more common the use of these devices both for hobbyists and for professionals, often replacing the need of human labor (Azevedo, 2014). Between these devices, a group called quadcopters is increasingly being the subject of studies and being used for many different kinds of tasks (Mapping & Surveying, Real estate photography, Disaster zone mapping, Crop spraying). They are a specific type of multirotor helicopters aircrafts with four rotors which generates lift with moving wings as opposed to fixed-wing aircrafts. In general, hobbyists use quadcopters for leisure purposes (e.g. aeromodelling) or simple experiments, like First-Person-View while flying through real-time video transmission (Iqbal, 2014). There are many commercial quadcopters on the market (DJI Phantom, Freefly Alta 8, Flyabilty Elios 2) with different sizes and capabilities but not all of them have a development features. In the world of academia quadcopters present a perfect test bench for a research and for study. To extend the capabilities of drone application in different areas some manufacturers of hardware and software components developed platforms which give the researchers possibilities to experiment with there algorithms. These kinds of platforms for example
are the following: KIT-HGDRONEK66 (NXP Semiconductor, 2021), Qualcom Flight Pro (Qualcomm Developer Network, 2021), STMicroelectronics development kit (Digi Key Electronics, 2021), Humming-bird quadrotor helicopter (Researchgate, 2021) andothers. Some of the platforms not only include controllers but integrate more sophisticated computers inside them. As for researchers, quadcopters might be used in many different kinds of tasks like autonomous

product delivering or reaching special places to perform specific tasks (delivers consumer goods and foods, fly over forest paths to look for fallen trees or lost hikers, fly in areas where a GPS signal is restricted such as inside and between buildings, mapping and photogrammetry). The ‘heart’ is a device that is capable of handling both flight stability and data exchange between it and a host, responsible for giving the flight guidelines or retrieving flight data. This thing is called flight controller (FC) and is the means by which a pilot controls the direction and altitude of an aircraft in flight. Primary flight controls are required to safely control an aircraft during flight. The controllers that are used with quadcopters are just as important as the quality and capabilities as the quadcopters themselves. Without a fly controller the quadcopter is practically useless. Lets give some examples of flight controllers: HOBBYPOWERKK 2.15 (Hobby King Online, 2021), DJINAZA-MV2 (DJI-Official Website, 2021), TauLabs Sparky 2.0 32bit Flight Controller (Hobby King Online, 2021) and more. The possibilities of using some advanced features in quadcopters is restricted to only stabilize the system in the environment and give possibilities to the flight pilot to operate it. If we want some kind of more sophisticated features, like autonomity, or the quadcopter to perform more complex tasks, the usage of flight controller only is not enough. Flight controlers are a special kind of controllers that are dedicated to specific task – impement the stability of the quadrotor. Types of computers named “companion” computers are used in a combination with FC to perform more complex tasks. These computers can be in addition to the flight controller hardware or can be implemented in a single platform (if the FC is implemented by software). As a rule of thumb “companion” computes are development platforms with hardware enhancements and with a small form-factor appropriate for solving more complex tasks (ODroid, Arduino family, NVidia TX1, Raspberry Pi). They have in most cases operation system (OS) that is Linux based, so the advanced algorithms can run in an appropriate environment. Vision and navigation algorithms are the most popular once used in this area. On the other hand there are many ready to use vision and navigation algorithm implementations for the Linux platforms. A kind of system like those mentioned above is a Raspberry Pi development board. This platform, combined with the sensor board Navio2 implements a flight controller. The flight controller is a software proess that runs in a multitask operating system. It occupies less space then the standard flight controllers with companion computers and the communication between companion computer and FC is quicker because they reside on the same operating system and share the same memory.

EXPOSITION

Development of a quadcopter system - Hardware

This article will be focused on the construction of a quadcopter using Rasberry pi (Fig.1) and Emlid Navio 2 (Fig.2). The company called Emlid creates an autopilot board (similar to more common boards like Pixhawk or APM) with all its features (IMU, preasure sensors, pwm input and output ports, etc.) but with the flexibility of software implemented autopilot started on a computer with a Linux like OS. The software is started on a Linux like OS called “Raspbian” that is modified by the manufacturer of sensor board “Navio2” with the addition of real-time capability. The paper focuses on the construction of a quadcopter with the two boards.

The Raspberry Pi is a low cost, small sized computer and is a little device that enables people explores computing capabilities. It’s like a computer and has more intensive computation capabilities than a standard microcontroller. As a rule of thumb the FC are made by the microcontrollers with the reduced capabilities and inability to start parallel proesses.

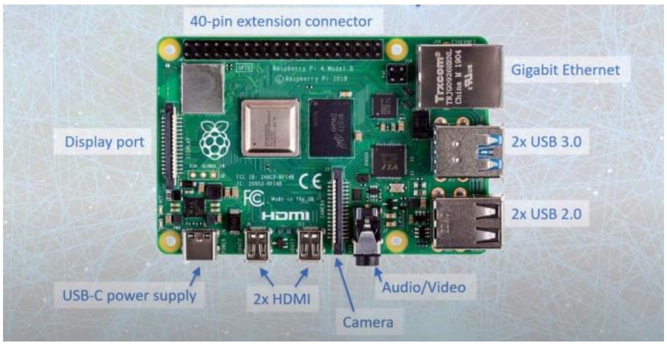

Fig.1 Image of Rasberry Pi 3

The Navio2 Autopilot Kit for Rasberry Pi 2/3 is designed both to your own custom robotic projects and as a platform for Linux version of APM (Ardupilot) Navio2 eliminates the need in multiple controllers onboard making development easier and increasing robustness. It provides all sensors for creating a powerfull flight controller with a Raserry Pi running PX4 software: dual IMU (inertial measurement unit) for orientation and motion sensing, a barometer for precise altitude control, GNSS (Global Navigation Satellite System) receiver for GPS positioning and extension ports (UART) for telemetry radio.

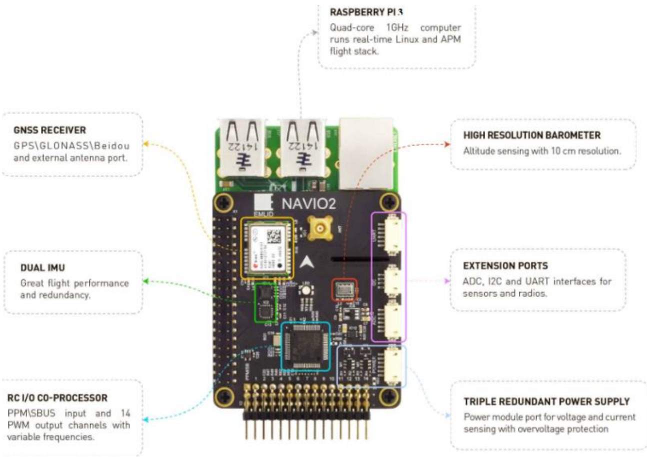

Fig.2 Image of Emlid Navio 2

Furthermore, this combination provides compatibility for Robot Operating System (ROS). This hardware is the lightest and most compact stack for our application. This combination Navio2 mounted on a Rasberry Pi is not only used as a FC but is also used as a Companion Computer capable of completing more complex tasks.

Fig.4 Readytosky S500 Quadcopter Frame Stretch

Fig.5 Racerstar BR2212 1000KV 2-4S Brushless Motor For RC Models

Fig.6 2/4/6pcs RC ESC 30A Brushless Speed Control 2S

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Fig.7 ZIPPY Compact 2200mAh 3S 35C Lipo Pack

Fig.8 Turnigy iA6C PPM/SBUS 8CH 2.5G AFHDS 2A Telemetry Receiver

Other hardware components that are used in the project include: Drone frame by Readytosky S500 Quadcopter Frame shown on fig. 3, 4 brushless motors by Racerstar BR2212 1000KV 2-4S fig. 5, 4 speed controllers RC ESC 30A Brushless Speed Control 2S shown on fig. 6, a battery pack by ZIPPY Compact 2200mAh 3S 35C Lipo Pack shown on fig.7 and a telemetry receiver - Turnigy iA6C PPM/SBUS 8CH 2.5G AFHDS 2A shown on fig.8.

On Fig.10 all the components are mounted to the quadcopter frame. The arrows indicate the direction of rotation and the motors. The connection between Navio 2 board, battery and speed controllers and telemetry module is shown on fig.9.

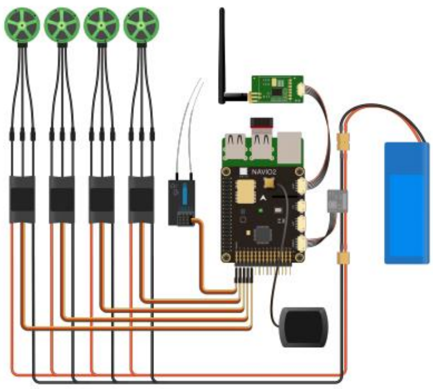

Fig.9 The connection between components

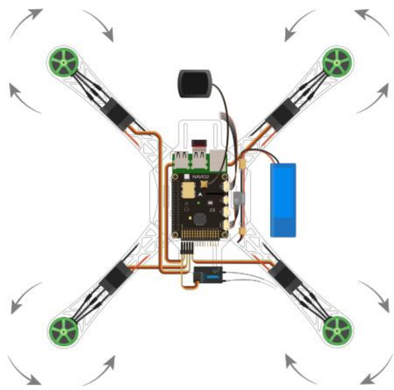

Fig.10 Quadcopter components mounted on the frame

Development of a quadcopter system - Software

As it is said in the paper the software installed on the raspberry pi is a modified version of "Rasbian" preinstalled with ArduPilot and ROS and also comes with DroneKit and GStreamer. These features made the preconfigured OS image a perfect development platform. Another point that must be noted is that the OS image provided by Emlid has a real-time kernel (PREEMPT_RT). The most important characteristic here is the max latency which indicates the longest time it might take your Raspberry Pi to respond to an event. It can be said that the kernel provides much lower latency using this kind of kernel and make it more suitable for usage in time-sensitive embedded systems like this. In the paper the program that acts as a FC is the open source autopilot software system called ArduPilot. The ArduPilot Project (Ardupilot developer guide) provides an advanced, full-featured and reliable autopilot capable of controlling autonomously different kinds of vehicles like airplanes, gliders, multirotor drones, helicopters, sailboats, powered boats, submarines, ground vehicles and even Balance-Bots. Here the autopilot is started as a program in a raspberry pi OS environment. Another thing that must be done before we can use the quadrotor is the possibility to connect to it. The emlid board has a build-in functionality to use standard RC radio modules. The raspberry pi has an embedded wifi module thath shoud be used to communicate with the quadrotor and to get the telemetry. There are two types of possible communications between the quadrotor and the user: the first is by using a standard WiFi router and another is to use the raspberry pi as an access point. In the field it is better to use the second option because of the limited infrastructure. In the project the rapberry pi is made to be a WiFi access point and the telemtry can be obtained through it. The drawback of this kind of communication is high power consumption of the quadcopter which shortens the fly time of the drone but the main idea of the platform is for research purposes and the fly time is not of great importance.

After the communication with the raspberry pi is insured the next step is to configure it to work like a quadcopter. This is done by using a ssh interface to the raspberry pi and after some provided by manufacturer commands that are given on the fig.11 the quadrotor is configured. It is important to make ardupilot to boot on start. The next important thing for quadcopter monitoring is to get the fly parameters by telemetry. All the information concerned to the fling vechicle is stored in the controller and can be obtained by the telemetry in real time or by history of the flight. The Ground Control Station (GCS) is a type of software that collects this kind of information and helps with the real time monitoring of the system. In this paper "Mission Planner" software is used to monitor the quadrotor fig.12.

Fig.11 Steps to configure the copter

To be able to connect the quadcopter and the "Mission Planner" the configurations in the text file "arducopter" must be done. Here the telemetry IP and port must be provisioned.

Fig.12 Image of Mission Planner

When the configuration is finished, the quadcopter is started with the following command "sudo systemctl start arducopter". The beauty of Mission Planner is a huge amount of data you can extract from the flight history, so some graphs from the test flight are given in the fig. 13.

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Fig.13 Image of Mission Planner

CONCLUSION

This paper sets its objectives on the construction of a quadcopter using development board Rasberry pi 3B used as a companion computer and a flight controller (FC) based on a sensor board Navio 2. The FC is implemented as a software process started in a real-time OS with a preempted kernel. The hardware and software components are presented. At first a general look is taken to the parts that form the quadcopter, the construction of the system, the software components that are used to implement the flight controller and software components used for monitoring and configuration called ground control station (GCS). The configuration and testing of the proposed system and its capabilities is investigated in a real environment. In the paper only FC capabilities are tested and the possibilities to implement some more advanced fetures. In a conclusion it could be said that the system is stable, has small form-factor and has the ability to perform more complex tasks.

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