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BLACK SEA SCIENCE 2021

Information Technology, Automation and Robotics

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Odessa National Academy of Food Technologies, 2021

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SIMULATION OF MOTION OF AN UNMANNED AERIAL VEHICLE FOR MEASURING PURPOSES AND PROTOTYPING OF ITS KINEMATIC DIAGRAM

Author: ***Oh Suchan***
Advisor: ***Leshkevich S.V.***
Belarus State University (Belarus)

Abstract. *The work is devoted to the development of an unmanned aerial vehicle, loaded with optical and radio measuring equipment, whose task is to identify and correct manufacturing defects in parts of wide-aperture antennas. The aim of the work is to create a simple, relatively autonomous aircraft with satisfactory aerodynamic qualities, the efficiency of which is ensured through the use of the latest achievements in electronics and radio communications. As the basis of the UAV, the Rogallo wing was used. To control the flight, a robot of the SCARA type was used, which ensured the parallel displacement of the steering trapezoid in the horizontal plane.*

Keywords: *unmanned aerial vehicle, flight control system, SCARA, Rogallo wing, microcontroller.*

I. INTRODUCTION

In areas such as space communications and radio astronomy, the received signals are extremely weak due to the large distances, so large apertures are needed to obtain sufficient signal energy. Typically a large aperture is implemented as a massive direct focus parabolic antenna that rotates mechanically. This somewhat outdated antenna architecture limits the use of parabolic antennas for many other applications. A more efficient antenna system design can improve the performance of all communication systems. With an increase in the aperture dimensions of the mirrors and the transition to higher frequency ranges, the requirements for the accuracy of manufacturing the shape of the mirrors increase significantly, since the effect of wind and temperature deformations on it increases. At the same time, to lighten the weight and reduce the windage of structures, mesh antennas are often used, the mirrors of which have a relatively low rigidity. Ultimately, the deviation of the mirror shape from the theoretical profile reduces the efficiency of the antenna system. Also, external factors that reduce efficiency include random phase errors that occur when radio waves propagate through an inhomogeneous atmosphere. The solution to these problems is possible through the use of adaptive phased antenna arrays, by analogy with optics, where adaptive systems have long and successfully been used to compensate for phase distortions of a signal in the atmosphere and to increase the resolution limit of optical systems. When creating an antenna, it is necessary to quickly carry out antenna measurements, and this is convenient using an unmanned aerial vehicle (UAV). The aim of the work is to create a simple, relatively autonomous aircraft with satisfactory aerodynamic qualities, the efficiency of which is ensured through the use of the latest achievements in electronics and radio communications. When performing the work, it is supposed to solve the following tasks: to simulate and test the device.

Fig. 1. Wide-aperture direct focus parabolic antenna.

II. UNMANNED AERIAL VEHICLE

2.1. Creation of UAV measuring purpose

All unmanned aerial vehicles (UAVs) can be roughly divided into 2 classes - helicopter-like (or copters) and aircraft-like. Each of these classes has its own merits [1,2]:

- the aircraft-like UAV has superiority in speed, duration and flight range, simpler design and control systems;
- helicopter-type vehicles are capable of hovering in the air and do not require much space to perform a maneuver.

For work, a variant of an aircraft-like UAV was chosen (Rogallo wing, balance glider or delta-flying), which will have all the advantages of aircraft-like UAVs. With a sufficiently high rigidity and load capacity, it is easy to manufacture, which allows it to be assembled and tested as quickly as possible. The principle of flight control is based on displacement of the center of mass relative to the suspension point to create a roll in the desired direction and, due to this, turn the aircraft and change the angle of attack to climb or descend. The UAV wing maintains its shape only due to the incoming air flow. In flight, its surface takes the form of two conical surfaces aligned at the top. It is controlled by moving the mass of the load relative to the steering linkage, rigidly connected to the frame (balance control method).

Fig. 2. UAV model.

2.2. UAV design

The prototype of the design is a hang-glider [3] - a motorized aircraft with a flexible delta wing and balance control, equipped with a landing gear. It is a load-bearing frame (usually three duralumin pipes connected at the front point), forming a fan in the horizontal plane with an angle of 90-140 degrees, covered with a light, but dense and durable synthetic fabric. A motor with a propeller and a trolley are suspended from the central tube at a certain place located near the center of mass of the apparatus. The device is controlled by means of a trapezium, the design of which consists of three pipes, in the front view it is a triangle with a horizontal base, fixed in space with guy wires (Fig. 2).

2.3. Flight control system

The flight control system is based on the interaction of a set of aircraft surfaces associated with control devices and mechanisms (electronic computing, electrical, mechanical) that ensure the selection and maintenance of the direction of flight of an aircraft (unmanned aerial vehicle). The block diagram of the system is shown in Figure 3.

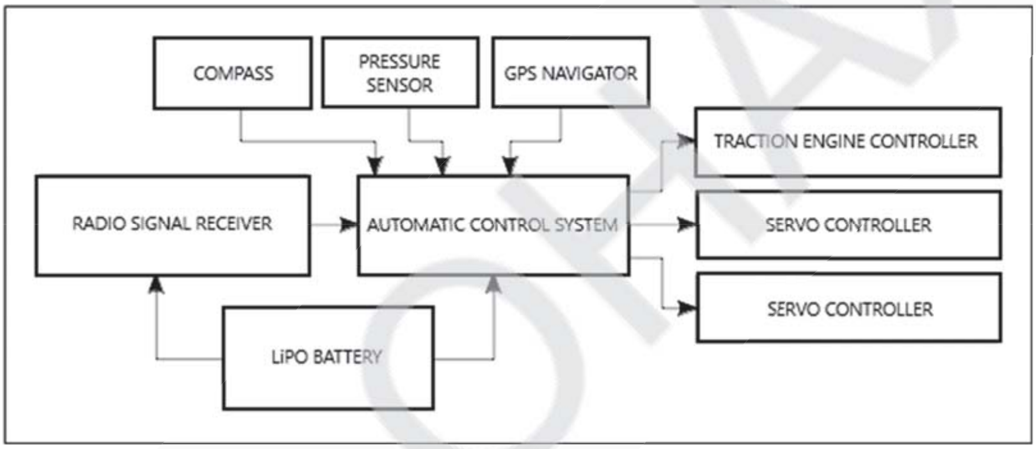

Fig. 3. Block diagram of the flight control system.

The block diagram shows the main components of the UAV complex and their interconnection. Along with the main object of the complex - the automatic control system, which ensures the autonomy of the flight of the aircraft, the on-board system of the aircraft also includes:

- radio signal receiver that receives a transmitter signal for manual control of the apparatus;
- motor and servo controllers that accept a pulse width modulation (PWM) input from the control system and set the target mode for each motor;
- lithium polymer (LIPO) battery for powering motors and DC-DC converters built into the motor controllers, for powering the control system and radio signal receiver.

III. UAV MODELING

3.1. SCARA – type robot

To control the glider, a parallel displacement of the steering linkage in the horizontal plane is required. The two degrees of freedom required for this can be provided by a SCARA robot [4], the kinematic diagram of which is shown in Figure 4.

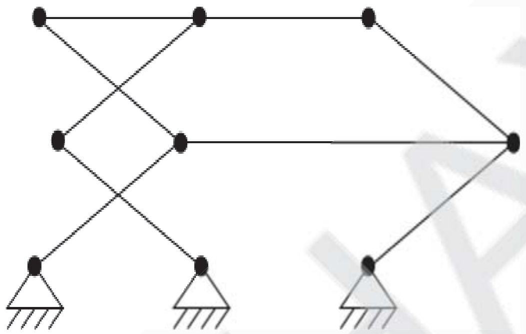

Fig. 4. Kinematic diagram of a SCARA-type robot, which should provide parallel displacement of the steering linkage in the horizontal plane.

The entire mechanism can be flat-mounted. It is lightweight and takes up little space. Modern SCARA robots provide very high travel speeds, which is an undoubted advantage for the aircraft in question. In addition, SCARA mechanics are characterized by high repeatability of movement results without changing accuracy. The load (in our case it will be basically a battery on a trolley) is shown in Figure 4 as a fulcrum. Simultaneous movement of two servos in the same direction allows the load to be deflected from the point of application of the lifting force to the left/right, creating a roll, and movement in opposite directions deflects the load forward / backward, allowing to decrease/gain flight altitude accordingly. This control option involves securing and deflecting the load using a lever arm. At the same time, transferring to the computing device the distance by which the load should deflect in the plane, we actually solve the inverse problem of kinematics, which consists in finding the angles of rotation of the joints of the manipulator for a given kinematic diagram and a given position in space of all elements of the manipulator.

The model of the SCARA robot is shown in Figure 5. The mechanism consists of two 2 independent servo drives that control the system of levers, interconnected so that the structure is rigid in the working plane and the parallel movement of the lever connected to the steering link is maintained. The servos are controlled by a PWM signal from the controller.

Fig. 5. SCARA robot model for flight control system.

3.2. Microcontroller

A microcontroller plays for the automatic control system. This work uses the NanoPi Neo Core2 microcontroller. The mini single board computer NanoPi Neo Core2 is an alternative to the Nano Pi Neo2 that acts like a processor board with pin-headers. In addition, NEO Core2 can have optional on-board eMMC flash and ESD protection for connectors and ports, which is especially preferable for industrial users. NanoPi NEO2 is as small as a cookie but faster than the RaspberryPi. Compared to NanoPi NEO2, NanoPi NEO Core2 performs more reliably with much less overheating. It is a good platform for IoT applications, monitoring systems, intelligent control systems, cluster computing and AI applications [5].

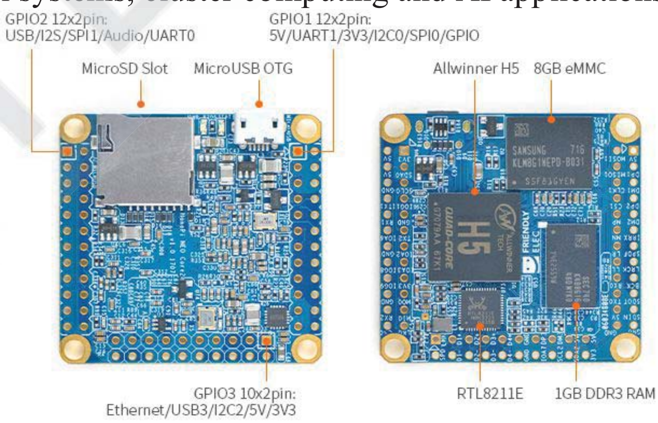

Fig. 6. NanoPi Neo Core2 layout.

Also, the main advantage of the NanoPi Neo Core 2 is its size - 40 x 40 mm, which essentially fits into a UAV.

From Figure 3, we connect the microprocessor to other used devices. Figure 7 shows the connection diagram.

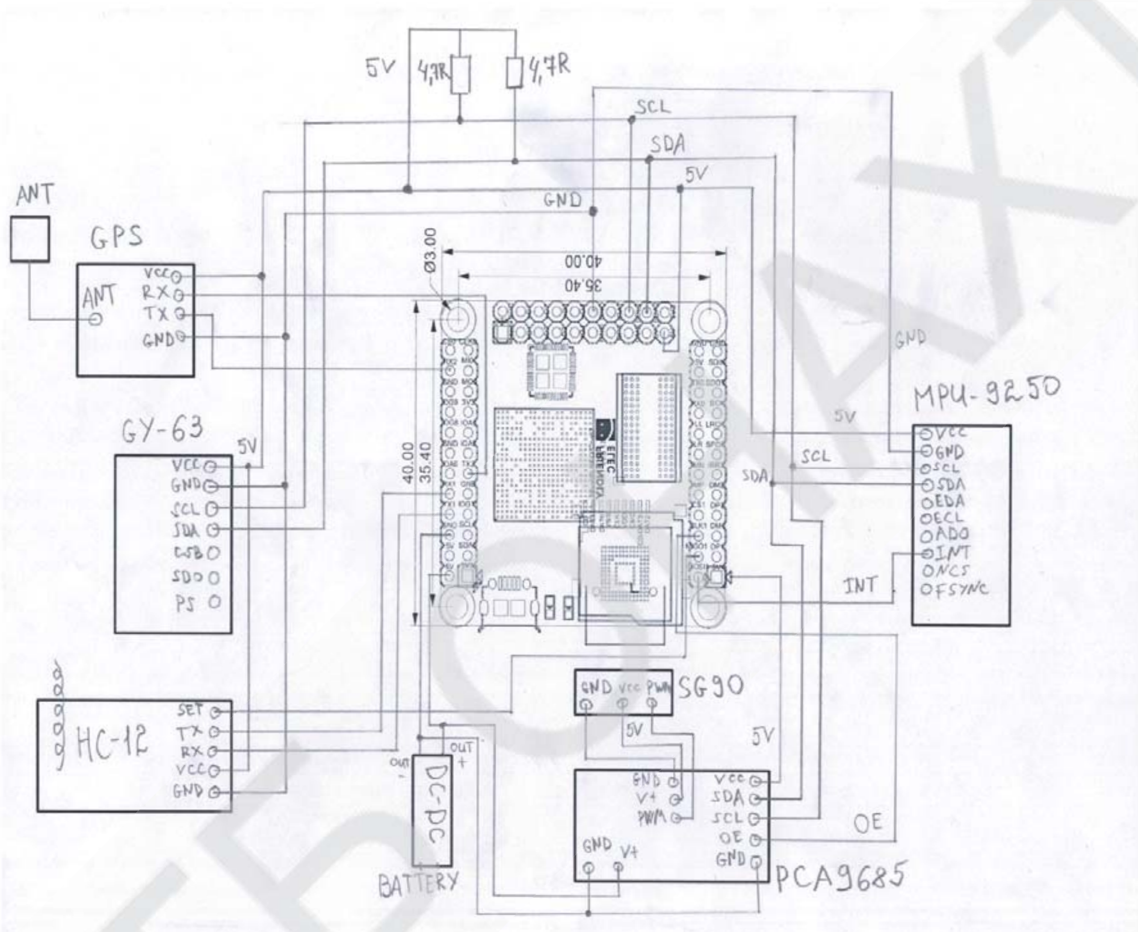

Fig. 7. Wiring diagram of the microcontroller NanoPi Neo Core2 with other used devices.

List of other devices used:

- PCA9685 - 16-Channel 12-bit PWM/Servo Driver. With the help of a PWM controller, you can control the brightness of LEDs, servos, and other devices where a PWM signal is used as a control signal. The PWM/Servo Driver uses I2C-bus;
- MPU9250 – 3-axis accelerometer & gyroscope and magnetometer sensor module, designed to measure the position of the UAV;
- GY-63 – high performance pressure and temperature sensor module with I2C and SPI interface, designed to measure the height of the UAV;

- HC-12 – 100mW multi-channel wireless transceiver, used for communication between two microcontrollers, computers at a distance of up to a 1 kilometer;
- GPS(GY-NEO6MV2) – GPS module with antenna, designed for UAV navigation through a computer;
- SG90 – servo, controlled like a lever, left/right, creating a roll for the UAV;
- DC – DC – converter that steps down 7 V (from batteries) to 5 V to power all devices at the output of the converter.

IV. RESULTS

The result of the connection diagram of the NanoPi Neo Core2 microcontroller with other used devices is shown in Figure 8.

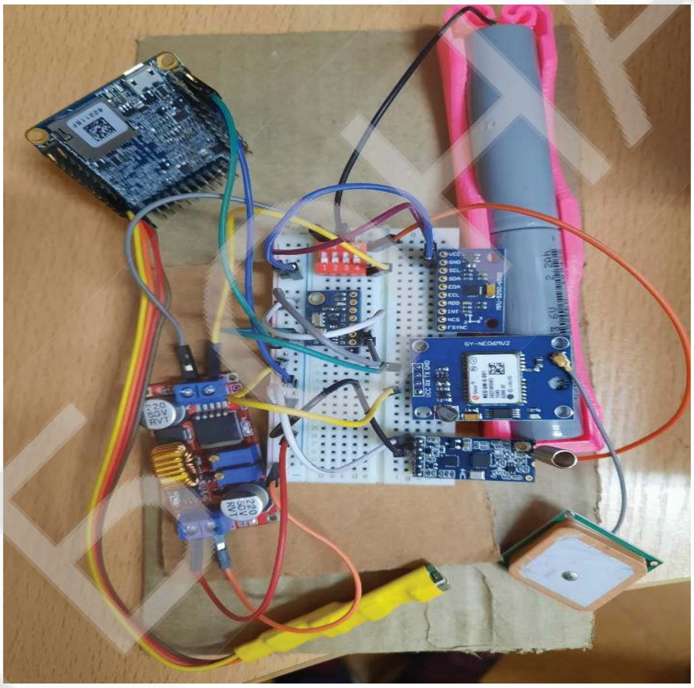

Fig. 8. The result of the connection diagram of the NanoPi Neo Core2 microcontroller with other used devices.

V. CONCLUSIONS

A Rogallo wing was used as the basis for the UAV, and a SCARA-type robot was used for flight control, which provided a parallel displacement of the steering trapezoid in the horizontal plane. This device will be able to automate antenna measurements and will contribute to the creation of more efficient designs of wide-aperture antenna systems that will increase the performance of space communication systems.

This device will be designed to perform rural work related to measuring the parameters of wide-aperture antennas and research work related to their development.

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DEVELOPMENT OF ELECTRONIC APPLICATION FOR RENDERING OF BEZIER CURVES

Author: ***Andrii Kurhanskyi***
Advisor: ***Nadiia Olefirenko***
H. S. Skovoroda Kharkiv National Pedagogic University (Ukraine)

Abstract. *The work is devoted to the development of a program for rendering one of the types of parametric curves - Bezier curves. These curves have already become an important part of computer design. In the course of the work, the author developed an electronic application using the C ++ / CLI programming language. This app helps to demonstrate the process of rendering a Bezier curve. The paper shows the historical and mathematical aspects of the topic, talks about writing code and using Bezier curves.*

Key words. *Bezier curves, de Casteljau algorithm, development, electronic application, C++/CLI, Windows Forms, GUI.*

I. INTODUCTION

Bezier curves have influenced computer graphics a lot. They are in almost every computer graphics processor. But none of them can show us the process of rendering Bezier curves, which is a very interesting process, especially for students of a secondary school.

The purpose of work is to develop electronic application for demonstrating the process of rendering Bezier curves. For this purpose, we offer to use the geometric

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The collection includes student works of the participants of the competition, which were not included in the number of prize-winners. The texts of the competitive works are published in the form in which they were submitted by the authors. The authors of the articles are responsible for the content and form of submission of the material.

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