Basic Principles of Design of an Autonomous System

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Abstract— **This article describes the basic steps to create autopilot. States what action should follow, what inputs and outputs will contain. It describes the basic proposals for the regulator. It also describes the disturbances, that may arise in different situations and how to avoid, or that it should be able to react on these disturbances. As the future we will also regulate the amount - the location, it can select the appropriate device. The article describes the basic of GPS.**

Keywords - autopilot, GPS, regulator, intup, output, pitch, roll and yaw axis

I. Introduction

History [1] of the first RC (radio controlled) model dates back in 1893. RC model was invented by Nikola Tesla. His first model was not an aircraft but a submarine. He controlled it with radio waves. The first successful radio-controlled model was invented in 1917. And during the World War II, Germans controled weapons using radios. Since the first flight in 1917, the radio controlled model aircraft have been developing and few years later were developed some improvements. Aviation, in its early days, required flying pilot`s permanent concentration to flying safely. Long flying required permanent concentration, which leaded to fatigue. Therefore they tried to develop an autopilot to perform certain tasks instead of the pilot.

The first ship, which used the autopilot, was Standard Oil tanker JA Moffet in 1920. The first aircraft with autopilot was invented by Sperry Corporation, managed by Elmer Sperry in 1912. About two years later, his son Lawrence Sperry, convinced the audience so that he flew over them, without the hands controlled the aircraft.

Nowadays, autopilot is mainly used for long lines, when the aircrafts are set to direct flight in a horizontal course, if the situation do not requires close attention of the pilot, and thereby it is reducing pilot`s workload.

II. DESCRIPTION OF THE AUTONOMOUS SYSTEM

The concept of autonomy [2], in the case of robot, is defined as a system, which for a longer period can independently carry out tasks and where no human intervention is necessary. To characterize the robot as autonomous, it should satisfy certain properties:

- collecting and processing information about their surroundings in real time,
- prolonged work without human intervention,
- shifting ability in space,
- also avoid situations, objects, which could lead to human injury, and damage of buildings or the robot itself.

As we already know, the concept of autonomous pilot - an autopilot can be characterized as a process that responds to certain changes in the environment. Application of autopilot can be used for different devices. Devices are divided into two categories: stable and unstable. How the stable passive devices, we could characterize the robots, which are firmly on the ground. They are such a small ground mobile robots. Unstable category includes aircraft, helicopters and all devices that do not have a stable base. Autopilots are used in the case of flight, when it is set the exact route and position.

III. TRENDS IN THE USE OF AUTONOMOUS SYSTEMS

This process begins to be use increasingly in more sectors. Not only in industrial (robots, aircraft), but also in other institutions. They are used for example in economics, households, health care and in others. It is used primarily to facilitate and speed up work in industry and households. The main reason is that autonomous systems are used in environments, which are unhealthy for human bodies or in places, where human access is not possible.

IV. THE USE OF AUTONOMOUS SYSTEM

They are mostly used in the military sphere, where the equipment is programmed with an autonomous system for small mobile robots. In the military, we observe the greatest long-term progress of autonomous systems development and subsequent use in various military systems. These robots are used for retrieval, disposal, information gathering, transfer and delivery of materials and so on. Furthermore, it is used in the aircraft as autopilot. Currently, we are experimenting with the autopilot in the RC (Radio Controlled) models. Autopilot can control parameters such as height, speed, direction, location and more.

V. BASIC PRINCIPLES OF FLIGHT

The most fundamental principle is the principle of flight method [3]. Principle of flight includes two main concepts, and those are the aerodynamics and flight mechanics. Aerodynamics deals with the movement of gases, their effects on the bodies when they are floating through. A flight mechanics of aircraft includes the laws of motion. It is very important because there are many types of flight, where the various flying forces effect on devices.

For example:

- aerodynamic forces,
- physical strength,
- inertia and centrifugal forces,
- tensile strength.

This is all we should know and deliberate, when we are going to design the autopilot.

VI. DISORDERS OF INPUTS

In our paper we will now pay attention on the autonomous system of aircraft. In respect of fault inputs operating on our system, as we mentioned in the introduction, fault input can be weather conditions, especially wind flow as an impact on the system, but it may also be other objects which have to be identify by the system and if it is necessary they should change and pre-programmed the route. The deflection of route is the result of bad weather conditions or failure of communication between devices. Failure of communication evocates information dropout. These information plane uses to identify and monitor all the information necessary for safe flight. To prevent from hazards, we are trying to design quality autopilots. For example an autopilot, which is specifies on the high compensation. Furthermore, the system must be designed in the way to be able to self-control the aircraft without an accident also in the case, when is the communication lost.

VII. IDENTIFICATION SYSTEMS

To enable us to design an autopilot [3] for the aircraft we should consider all the details of aircraft. It means, we should record inputs and outputs, whic are needed to obtain the model. Seeing that it flies in the three dimensional environment, identification is difficult. Thus, there appear to us the x, y and z-axis. So the movement of aircraft in the space we are describing by 3 - ch axes, acting on the side upright. The centre of these axes is the centre of aircraft centroid. Through them we can examine each movement. Axes:

- x is the longitudinal axis of aircraft – it is located in the symmetry plane and it has suitably chosen direction
- y is the lateral axis of aircraft - is perpendicular to the symmetry plane
- z axis is perpendicular axis of plane – it lies in the symmetry plane perpendicular to the x axis

X-axis (longitudinal) identifies the flight speed, namely:

- longitudinal vx,
- lateral vy,
- perpendicular vz.

Y axis defines lateral breakaway and z axis defines ascending and descending. Rotating motion around the longitudinal x axis is called the pitching x, around the side of the y-axis, it is called luffing and around the perpendicular axis, it is called cornering.

Each of these axes has its specific properties. The best would be to design their own controller for each of them, so we can control their properties.

Quality regulator can be design using various methods. We can choose any method according to parameters that we know. At first, we should identify the model. Identification is a process by which we can initiate the experiment on the basis of the input-output information or and we get a dynamic process. Processes can be controlled by the control signal.

Kind of Methods:

Analytical methods or Experimetal methods

Analytical: Naslin`s Method
Method of Placing Poles

Experimental: Ziegler-Nichols`s Method
Strejc`s Method
Method of Direct Synthesis
Cohen-Coon`s Method
Method IMC
Haalman`s Method
Chien-n-Hrones
Reswicka`s Method
Smith-Murrill`s Method

For example: if we want to determine a PID regulator by an experimental method for example for measuring the height, we can use the method of Ziegler-Nichols. We can do this, when we activate in the system the greatest instability.

VIII. PRACTICAL DESIGN OF EQUIPMENT (SYSTEM)

The aircraft consists from the forequarters of aircraft [3], where the cabin is located, the centre of aircraft - fuselage and from the end of aircraft. Further are the wings, propeller, and landing gear. In the front of aircraft is located cabin as we mentioned before, where is located AC motor. Then there are servos (actuators) to control the elevator, rudder and flaps. The chassis is fully given. The apparatus from which we obtain data and which contains the aircraft are: accelerometer, gyro, altimeter, planimeter, speedometer, processor, camera controller, receiver, transmitter. All of these devices include avionics.

The accelerometer is a device that measures the non-gravitational acceleration. Further to this are used inertial properties of material objects. For the overall acceleration we need at least three accelerometers, because accelerometer measures acceleration only in one direction. We can recall that in the Space are accelerometer used to measure the pressure of solar radiation, environmental resistance, thrust engines.

By the gyroscope we keep the momentum conservation law. This means, if we are using it we measure and maintain the same orientation and direction. Flywheel is a major part of gyroscope. The outer frame is created by the flywheel attached on the axle and the axle is attached on the swivel joints. The flywheel body can move in all directions around its axis.

Altimeter may be use in air transport as a device for measuring the height of total Earth's surface (usually is used barometric altimeter based on pressure measurements in atmosphere). We can also use GPS for measuring the height. The best for for measuring height is probably a combination of both methods.

Control is performed by 2.4 GHz transmission of RC (Radio Controlled) station. This includes sending and receiving part. The receiver provides the reception of signal from transmitter and then instructs servomotor. On the transmitter there will be defined by all the channels necessary for the flight. Gradually we will replace it by small radio autonomous computer. At this time, the aircraft will obtain control by microprocessor, where will be the program to regulate the height.

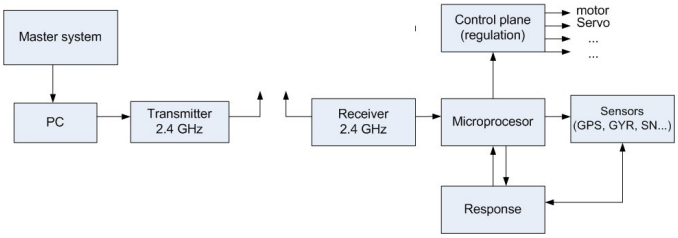

Figure 1. – the schem of the automatic autonomous system

IX. GPS – Global position system

To enable us to measure and then control the high in real-time, we need to choose a device that will be convenient for sending data to the PC. The PC will be recorded the high values and on the basis of these values it will prevent from the inclination from route. There are several devices that are provided these measurements. Of course it also depends on what high we want to measure. We can measure the water table, temperature, pressure, humidity and other amounts. But we need to measure the high somewhere in the Space. These measurements allows us to measure the GPS [4], altimeter, vario, pressure gauge and others.

We should describe GPS that we use to determine the exact location by three dimensions. To determine it, we need at least three satellites, one for each dimension. GPS is built on three basic segments. They are the space, control and user segments. What does it mean?

Space segment includes 21 active satellites and three backup satellites. Each satellite circle arount the Earth every 12 hours. Satellites circle around the orbits. Satellites circle around the orbits in 22.200 km. Orbit contains four satellites. It means, when we want to determine the correct position, four satellites are enough. Signals from the satellites can be received at all locations on the Earth in the frequencies 1575.42 MHz and 1227.6 MHz.

Management segment updates information contained in the satellite data messages. Five monitoring stations that create the management segment are placed around the earth along the equator. Using these stations are calculated ephemeris - orbits.

User segment mainly consists from users and GPS tools. GPS calculates preliminary route determination by received signals: position, velocity and time.

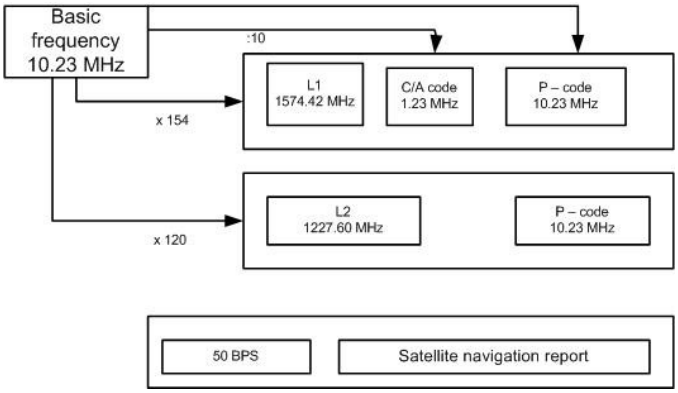

Figure 2. – frequency of satellite signals

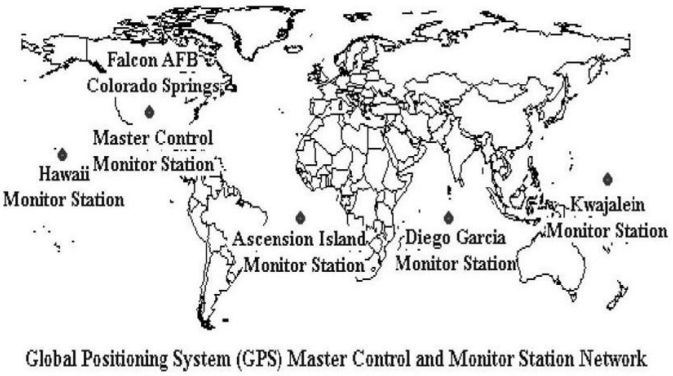

Figure 3. – location of the satellites in the world

X. Assessment

The paper is aimed on the independent control systems. Following a brief introduction we went directly to the centre of our research and that is the independent management and design process management system for aircraft. Nowadays, we have well defined the structure of system and partial system proposals (for example plane construction) are done. We will continue in our research with the proposals of optimum control system with microprocessor.

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