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Noise Reduction in Unmanned Air Vehicles Using Hamming Code

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Abstract: Micro Air Vehicles (MAVs), which have been popular in the military context, have recently attracted attention of many researchers because of their potential civilian applications. However, before UAVs can fly in civilian airspace, they need to be able to navigate safely to its goal while maintaining separation with other manned and unmanned aircraft during the transit. In this paper, different method of Unmanned Arial Vehicles (UAVs) controlling and noise truncating was presented applicable for MAVs. Implementing autopilot and hamming code in order to have a stabilized UAV control system in a more enhanced performance was exposed to several tests.

Keywords: Noise Reduction, UAV, Coding, Dynamical Systems.

I. INTRODUCTION

Unmanned airplanes smaller than 500mm and weighing less than 500g are considered to be Micro Air Vehicle (MAV). They could be designed in four types, that is, fixed wing, VTOL, flapping wing, and rotary wing. Depending on the mission type and dimension of the equipment this may vary. The salient features of using MAVs have resulted in the establishment of some researches toward the optimization and enhancement of such planes [1, 2]. Their remote control capability has made their application possible to those conditions where the presence of human beings is impossible or dangerous. Also, their small size regarding the size of UAVs has paved the way for their extensive application [3, 4].

Although their small size helps in reducing their structure, costs for the small electrical equipment are very high. Of course, technological advances have helped to reduce their prices and promote their capabilities. Regarding the aforementioned features, MAVs have the potential of recognition, cruising and protection, spying, and carrying small-sized payloads with theweight of less than 10 grams, as sensors for marking special places. Likewise, such unmanned planes could be employed for meteorological purpose which is more economical in comparison with other methods. The first comprehensive researches on MAV were conducted in 1993 by RAND institution [5, 6]. Nowadays, in different parts of the world moreextensive researches on micro-planes are being conducted. Restriction on weight and dimension, and low velocity in these types of planes has changed the sizing to an overriding part of designing. These aircrafts are usually controlled in three ways: Manually (by radio control), through video system (video base) and Autopilot. Nowadays the usage of autopilot in these MAVs is considered as modern technology. Some of these micro-planes are displayed in Figure 1.

Fig. 1 Types of MAVs

II. NAVIGATION OF MAV AIRCRAFTS

Communication with MAVs should be safe, and as many hazards as possible should be avoided [7]. Controlling and sending the instructions to MAVs is usually done using three methods: radio control, video base, and autopilot. Nowadays the usage of autopilot in these MAVs is considered as modern technology.

III. DIRECTING THROUGH RADIO-CONTROL

One of the most common ways to control and direct these drones is using radio-control system. In this method, radio-control aircrafts will be controlled by a radio-system

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that includes a transmitter, with a receiver. In this system, sending instructions will be transmitted to plane's servos by sending electromagnetic waves. Basically RC equipment consists of a radio transmitter which includes several radio channels that can be used by the pilot to transmit instructions to the aircraft. Each radiochannel causes the movement of the aircraft control surfaces by sending radio-waves. The transmitter range is different, but in typical type will cover a range of about five kilometres. A radio transmitter for model aircraft must consist of at least 4 to 6 channels to control different flight levels of aircraft. Additional channels can have usages like camera control. The transmitter uses other channels to control other instructions. In this system receiver is used for transmitting instructions to the servos and speed controller. An example of this system is shown in Figure (2) [8].

Fig. 2 Radio controller and receiver

IV. DIRECTING THROUGH VIDEO-BASE

In directing system, using video-base a camera is installed that allows the aircraft to take films and photos from passing regions and send them to the ground station by video transmitter. Low weight and small size are the essential features of video system. Other features of the video system are high visibility and clarity. In ground station, the images sent from video-transmitter received by antenna will be displayed on the screen. Antennas can be evaluated by analysis of the output waves. In some cases an Amplifier is used with the antenna, which makes it much easier to receive pictures. Usually video transmitter will signal a certain distance, but in many flights signals will be removed after certain distances. The commercial types of transmitters work in a special radius and, when the aircraft is out of this range, show one dead zone forcing the aircraft to fly in a small range to ensure no loss of communication. An example of this system is in Figure (2) [9, 10].

V. DIRECTING THROUGH AUTOPILOT

Among the mentioned methods, the best way for directing and controlling MAV aircraft is to use an autopilot system. Autopilot is a set of software and hardware which enables flight missions to be performed automatically. For example, by defining flight plans, direction and speed can be specified in different parts of flight and aircraft obeys this flight plan automatically and tries to perform its mission with minimal errors.

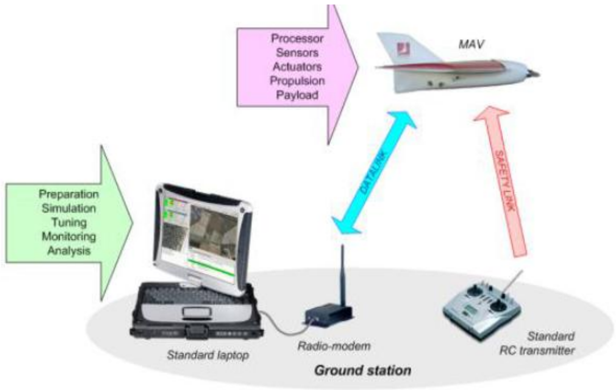

Fig. 3 Directing through autopilot

VI. AUTOPILOT INVESTIGATION

At present, several types of autopilot exist in the market, Micro-pilot, Piccolo, and Paparazzi to name but a few. For example, Micro-pilot autopilots have some unique capabilities such as weight of 28 grams, dimensions of 4cm/10cm; ability to control 24 servos simultaneously, maintaining altitude up to 12 km and the capability to keep a radius of 50 kilometres away from the ground station [11].

The procedure of autopilot system is such that the flight plan should be uploaded on the system board before the flight and the aircraft is in constant contact with the ground station and data such as altitude, velocity, etc. are transmitted. From the ground station, different instructions can be sent through RF modem to aircraft. After sending instructions, autopilot will apply them to the servo and the aircraft will perform the desired reaction. Components of autopilot include both software and hardware.

VII. AUTOPILOT HARDWARE

1- The board is equipped with micro controller to process received and transmitted data.

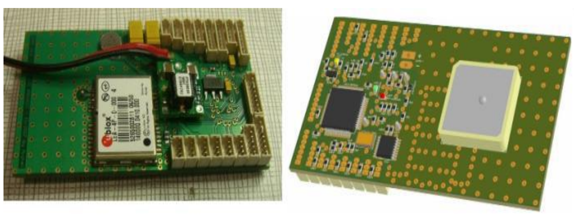

Fig. 4 Example of autopilot board [12]

2- Sensors: such sensors installed on the autopilot system are infrared sensors that can recognize their direction by the temperature difference. Another type of more advanced sensors named IMU are composed of 3 Gyro and 3 digital accelerometers, and provide accurate information for board. These sensors have a higher recognition rate which increases the performance of self-stabilizer system. Some examples of infrared sensors are shown in Figure (5) [12].

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Fig. 5 Examples of IR sensor [12]

3- GPS: to detect the position, velocity and altitude, GPS system should be used in autopilot. So GPS will be in contact with at least 4 satellites simultaneously to provide the board an accurate position of the aircraft. The board will process the information and determine MAVs direction and motion. GPS is divided into two types: External and Internal.

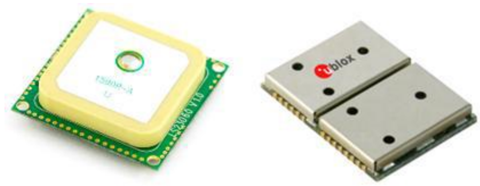

Fig. 6 Examples of GPS sensor

4- Modem: for connecting aircraft and ground station RF modem which has a range of about 2 kilometers will be used. In case aircraft moves out of the pilot's vision, by visualizing the GPS coordinates sent via Modem, pilot can apply the instruction of return to aircraft. Furthermore, sensors information can be sent to the ground station via this.

Fig. 7 Examples of Modem

VIII. AUTOPILOT SOFTWARE

Correct usage of this system requires special software. Data can be sent to the aircraft or received through ground station. In addition, flight planning should be programmed for the entire mission with software.

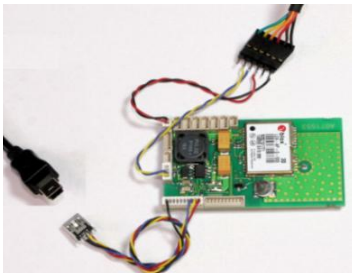

Fig. 8 Examples of programmed board

Connection of the MAVs equipment and sensors to autopilot system is shown in Figure (9).

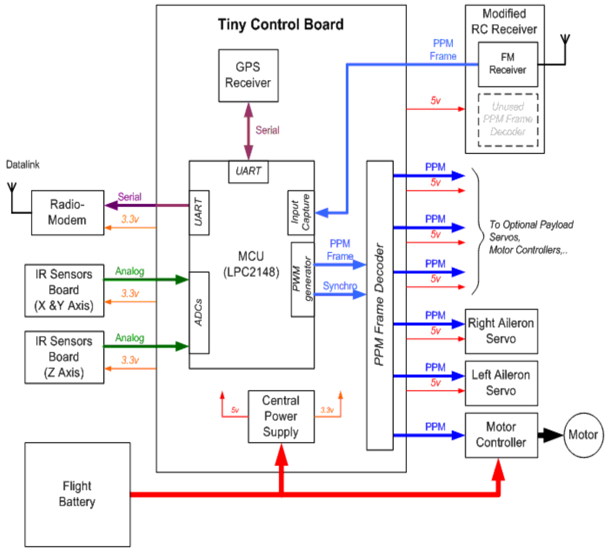

Fig. 9 Examples of connection of sensors to autopilot

IX. THE NECESSITY OF RESEARCH

Range restriction of other methods for controlling and directing this type of aircraft has prompted the telecommunication network to provide a new method for sending instructions to MAVs, thereby increasing the efficiency and range of these aircrafts [13, 14, and 15].

X. NOISE IN SENDING DATA

Send instructions and receive data via telemetry systems and wireless communication, error and noise problems. The performance of wireless communication systems is highly determined by noise. The effect of noise on the output data minimizes the use of channel coding. Channel Coding method which is called data transmission in telecommunications includes adding redundant bits for data transmission and prevention of disorders and is intended to be conveyed by the code, is faster and contains a lot of code with the right to correct errors or to detect them Hamming code method for identifying and correcting unwanted changes in the channel is noisy. The coding of the three parity bits is to detect and correct the error. Hamming code is a binary linear code that can detect and correct any single error within each block.

A hypothetical data set is used in channel coding to reduce errors and obtain the desired data on the client side MAVs considering the constant BER (Bit Error Rate), as instance 0.1, and obtain SNR (Signal Noise Rate) in the different ways can reduce SNR for each of the methods of non-coding techniques, the coding gain is achieved. The procedures and results of some tests are described in the following:

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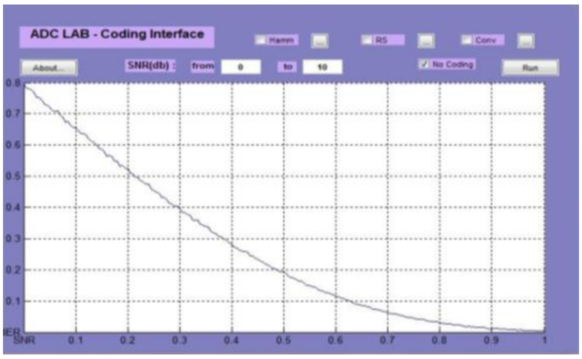

Fig. 10 Non-coding BER (Bit error rate) to SNR (signal noise rate)

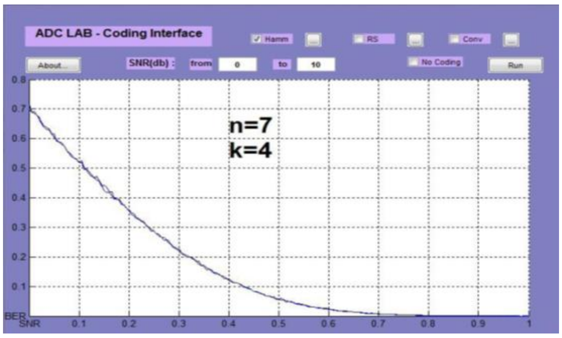

Fig. 11 Coding Ham (7-4), BER (Bit error rate) to SNR (signal noise rate) n-k =3 redundancy of bit

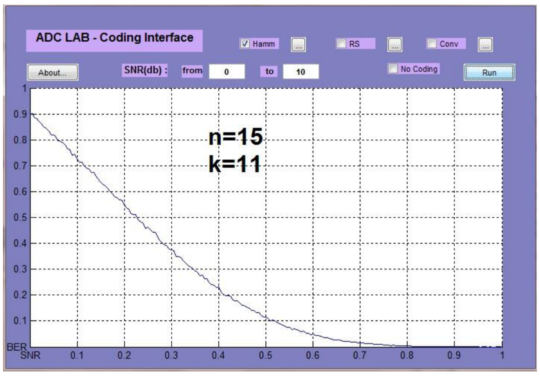

Fig. 12 Coding Ham (15-11), BER (Bit error rate) to SNR (signal noise rate) n-k=4 redundancy of bit

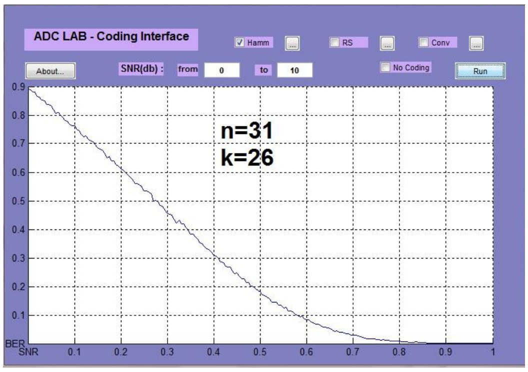

Fig. 13 Coding Ham (31-26) BER (Bit error rate) to SNR (signal noise rate) n-k=5 redundancy of bit

Comparing the figures 10-13, it is clear that the constant BER encoded at lower SNR compared to a post code is required. Furthermore, it can be inferred that despite redundancy increasing, the probability of error at the receiver is reduced, and then more bandwidth is required. Thus, the comparison of the above cases can be optimized by using a grap coding Ham (7-4). To post and receive information from the sender to the receiver with the least changes, the modulation of the carrier signal is used to modulate the signal message on the receiver demodulation. ASK modulation is a branch of digital modulation in which simulations have been used to advantage is high bit rate.

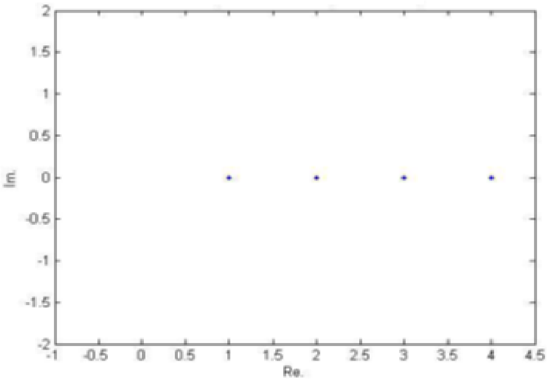

Fig. 14 ASK signal constellation (without noise) (SNR=-20 dB, M=4)

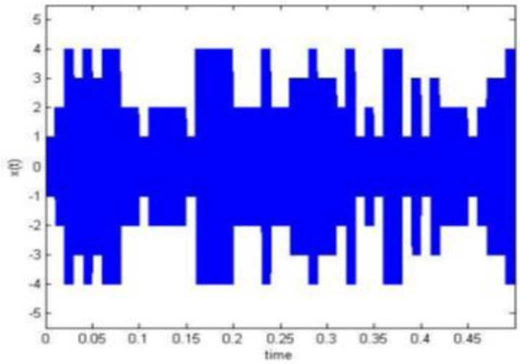

Fig. 15 Mask modulated signal before channel

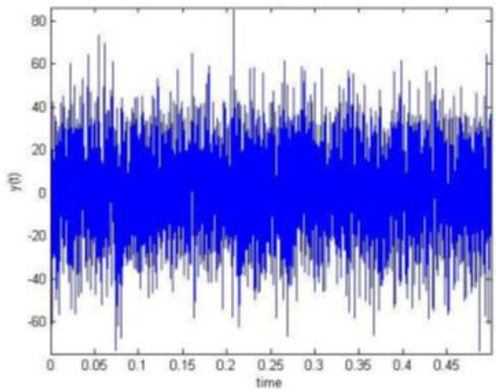

Fig. 16 Mask modulated signal after channel

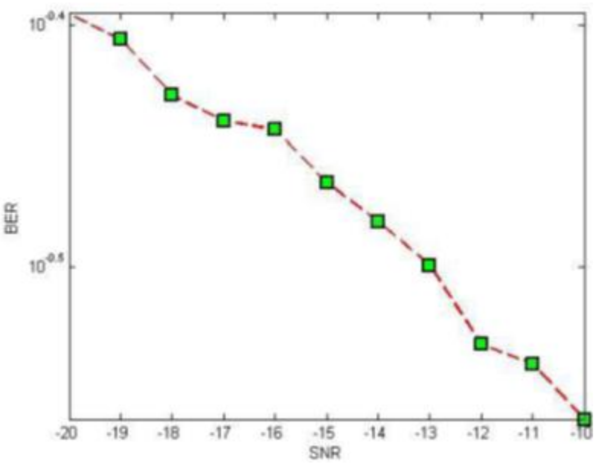

Fig. 17 BER (Bit error rate) to SNR (signal noise rate) for MASK modulation

The simple structure of the signal envelope detector displays an important point, however, because demodulator noise power is the sum of the signals, by reducing the SNR, the BER increases attributably.

XI. CONCLUSION

In this work, the process of noise reduction for communications between a Micro Air Vehicle (MAV) and ground station has been introduced and analysed.The process is imposed toward the analytical tests and showed to be effective for test case scenarios.

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