CONTRIBUTIONS TO DATA POSTPROCESSING IN SENDING SAMPLED PARAMETERS AT CRITICAL MOMENTS ON UNMANNED AERIAL

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Abstract. In this paper we investigate the different stages that allow us to create a model that would provide a better understanding of what happens on certain parameters that measure physical quantities related to the behavior of both, burst and reaction, unmanned aircraft as well as unmanned helicopters based on a data transmission to land via radio modem.

Keywords: Information retrieval, unmanned aircraft, data processing, sensors, radio modem

1 Introduction

INTA is the Institute for Aerospace Technologies in Spain and flight tests has been part of INTA’s activity since it was created, with the objective of upgrading such activities and modernizing its facilities. INTA created the Flight Test Area, (AEV is the Spanish acronym). The AEV is responsible for providing flight test support for all current and future programs including RPV (Remotely Piloted Vehicle) Test, Rocket Launches, Ballons and Missile Test

There are UAV's that have a data acquisition system, other have an embedded computer system with data transmission via radio modem, and others have the two systems working simultaneously. In some UAV's, and at critical moments of the flight, there is a need to send the value of certain parameters, sampled more frequently than others, to analyze the behavior of the aircraft and to be able to make decisions on time real, depending on the results received. Our aim is to bring a model to collect more information in those critical moments

2 State of the Art and previous research

With the increasing requirement for flight test at several locations throughout Spain, a program was launched to acquire a mobile capability which could support these test ranges in current flight test requirements as well as anticipate future requirements.

INTA, has a mobile telemetry acquisition system (Fig. 1) that have the following configuration.

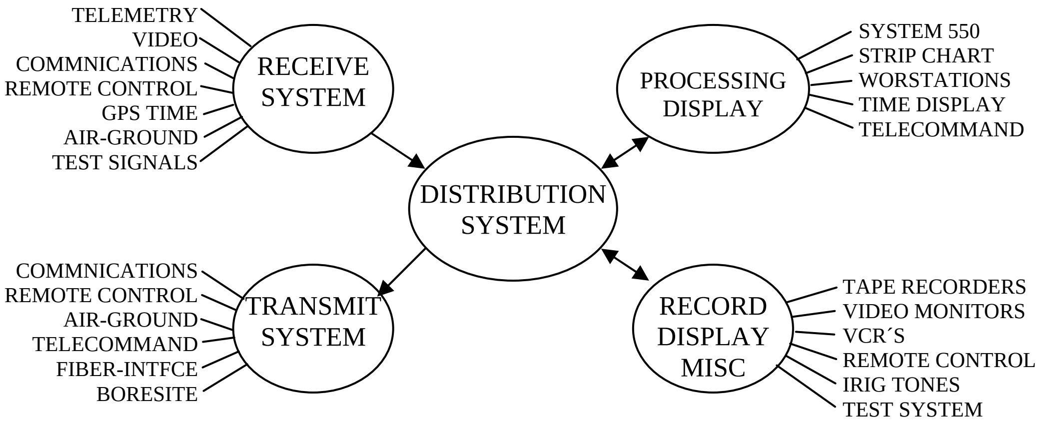

Fig. 1 Mobile system set-up and configuration for operation

The concluded capabilities of the system are as follows:

- Telemetry Acquisition Short and Long range.
- Telemetry Data Reception Distribution / Display / Recording and Processing.
- Digitized and Analog Video Reception / Distribution / Display / Recording and Processing.
- Air to Ground and Ground Communications.
- 400 Mhz. Up-link Command and Control.
- High End Data Proccessing and Distribution to Workstations.

- Test and System Calibration.
- Local and Remote Control Software.
- Microwave Transmission of TM Data / Remote Control and Communications.
- Trailer Enclosure equipped with generator power and environment.

Currently, the AEV is working on various unmanned aircraft developed at INTA as SIVA (Integrated System for Aerial Surveillance), ALO (Light Aircraft Monitoring) MILANO (*Longer range and ceiling UAV platform*),and HADA (VTOL Aircraft morphological, ALONDRA (*Tactical VTOL morphological UAV*), SHARK (*Tactical VTOL UAV*).

On the other hand, there are defined the so-called critical moments. The critical moments of flight are selected from the various stages of flight: preflight, initial stage of the mission to initialize the navigation system guidance and control of the flight station (NGFCS), taxi, where NGFCS is started and the pilot may take control of the aircraft, takeoff run; when the plane started its takeoff run either independently or through the RC pilot, takeoff; where the plane takes off and reaches a certain height above the ground, flight; when the UAV is flying in any case, landing; either vertical drop (activation of a parachute from the station) or horizontal (with landing gear), and end of flight; when the plane is parked on the ground.

In the same way, the parameters that the Navigation, Guidance and Control System sends using radio modem are perfectly defined in floating point according to ANSI / IEEE Std 754 (short) 32-bit (4-bytes) or in 16-bit integer format (2-bytes). The parameters provide different information through sensors installed on the aircraft that provide the capability to measure different accelerations, angular velocities, magnetic fields, positioning, pressure, angle of incidence ... etc.

In previous studies, it was determined that the software for digital acquisition via serial port on the onboard computer system (MEC Estimation and Control, see fig. 2), the type of communication used, is based on the generation of interrupts for the UART on the microprocessor, each time you fill the input buffer or output port. The input data for each sensor, regardless of the frequency at which, is being written into a memory buffer which is sent to land with a frequency of ten times per second.

Among the parameters there is no hierarchy, some send the measured values to the onboard computer with frequencies above the ground shipping (up to 450 samples per second), and others are below this value (even to one sample per second in old GPS). There is also no distinction in the different stages of flight, the selection parameter types and frequency of delivery, so the ground data reception is made linear and uniformly, both in types and in time.

As for the storage of data in the aircraft, beyond the memory unit available in the control computer, the infeasibility of storage lies in the management of interruptions by the operating system used, where an increment of these would involve an additional burden to the system, and therefore a possible loss of data in real time. The final storage of every data generated is finally performed on land.

Figure 2 shows a block diagram representative of the several elements that act on the aircraft. The central part is based on the control computer, along with their actions and chains for measurements and demand as well as communications.

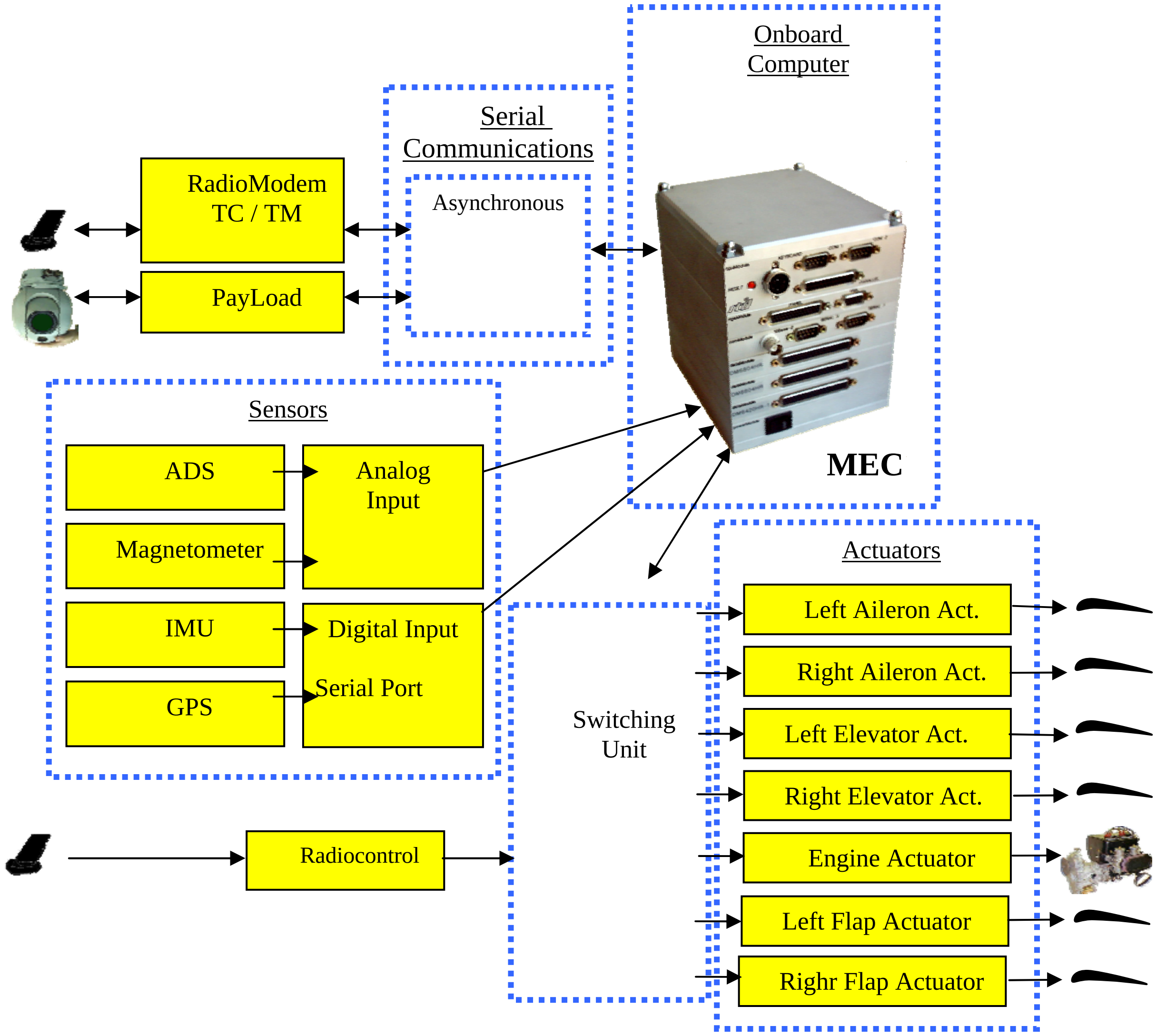

Fig. 2 System onboard

3 Methodology to follow

The objective is to investigate the ability of different propose models which will provide knowledge about what happened on certain aircraft sensors that suffer substantial alterations in its physical quantities at critical moments. This process can be broken down into the following operational objectives:

1.- Based on prior knowledge, the current model, examines the initial conditions, amount of parameters, frequency of transmission, limited communications, data storage and display ... etc.

2.- Identify the variables concerned, establishing a proposal for grouping them based on objective criteria. Also identify the critical moments for which we want to make the depth of the analysis to be performed.

3.- Define and join consistent strategies to define optimal mechanisms for approaching the desired goal: to obtain more information about certain parameters at critical moments.

For the first objective, the initial conditions and frequency of shipments were detailed on the previous section of this document. As for the limitation of communication through the serial port, information is sent between 240 and 280 bytes in parameters of 32 and 16 bits (this value varies according to certain optional parameters) plus 19 bytes of parameters payload (camera) as the focus, zoom or angle of the payload on a gyro-stabilized platform, making it worth about sending 300 bytes, ten times per second, speed. This is fully guaranteed by RS-232 , although for reasons of data loss in communications (distance, weather conditions etc ....), it is advisable to overcome. Regarding the storage and presentation of data, both being held on arrival, on land, in the first case, files from which you proceed to post-process data for analyzing the behavior of the aircraft and the display values decimal places for making decisions in real time if necessary.

The second objective is related with the identification of the affected variables and the establishment of proposals for grouping them based on objective criteria. It was decided to group the parameters into three categories, the first and most important contain those parameters with a very high sampling rate capacity, and a very high capacity in changing their values per unit of time. In this category are found, among others, accelerations and angular velocities in the x - y - z. These parameters suffer substantial alterations and perhaps the sampling frequency of ten times per second, could not be stored. Within the second largest group are, among others, the different angles measured; of attack, slipping, balance, trim, yaw ... etc. The remaining parameters would be part of the group with less importance. As for the critical moments in which an exhaustive analysis is desired, they are clearly described in the preceding paragraph.

Section three is the most important in terms of the definition of optimal strategies to approach the desired objective. Quantitative and experimental methods will be used. A toolkit will be designed to tackle the stated problem getting different aproximations. This raises the necessary step of the analysis of alternatives and selection of appropriate methods. The algorithms will be tested through the implementation of prototypes in a specific programming language. For all this, more than one alternative will be designed and implemented in order to perform a comparative analysis of the different designs and techniques.
The techniques used for this proposal lie in the combination of the following fields or areas:

1.- Standards of measurement processes and data acquisition which provide application solutions to improve the compatibility and quality of the telemetry system (IRIG 119, 2007), and the definition of the standard features of communication such as broadcasting frequencies, bandwidth, etc (IRIG 106, 2007). Both must be taken into consideration as a preliminary study of existing standards.

2.- The transmission of information via radio modem, necessary to study the standard series of binary data exchange between devices such as RS-232 (EIA RS-232C, 1969), (V.24, ITU-T, 2000).

3.- Mechanisms for data compression based on standards, which will be used for extracting bits of some of the less conclusive information, to add more decisive information as the *Moving Picture Expert Group* MPEG-2 (ISO 13818-1. 2007)) and at a more advanced stage MPEG-4 (ISO / IEC 14496-13. 2008).

Currently, each sensor stores the sampled value on a cell, overwriting the previous value, and each sensor has a different sampling frequency. A process is activated and runs all the cells, making an image of the value found at that time. Using pointers, and knowing the order of the

parameters visited (32-bit floats or 16-bit integers), the pointer moves through all the parameters to capture in one-dimensional array, the set of all values that are sent to land via radio modem, a transmission format of 8, n, 1 (8 data bits, no parity and one stop bit). This process is repeated ten times per second, and when it reaches land, knowing the order in which the parameters and the size of these, the decoding is done in a simple way. Our approach entails to change the concept of a one-way matrix for at two-dimensional matrix array with a variable number of rows and columns, depending on the different types of techniques. You can add as a value to send to land a time stamp indicating the time at which it was gathered that value, a concept so far lacking, given the linearity of the consignment to land of the resulting matrix per unit time. The variability of the two-dimensional array can be done in real time, either automatically, to be integrated into the onboard computer programming done by flight to the aircraft, or manually by sending signals from the ground through the radio modem. Independently of the format of the cell in rows and columns, land shipping will be done in the same way as a PCM stream, traversing the array and sending the values byte by byte via RS-232.
From a basic phase will go through increasing levels of complexity, reaching the best solutions for specific needs. You can think of an early stage based on sending only the value of the parameters of the most important category as well as sending the average between time units using functions specifically designed for this purpose (with optional insertion of time labels). You can then proceed to the definition of different matrices mixing several values of the three categories, adding more values of the first and those of the last category, each of them with its time label (with a choice of measured values or average between times), arriving finally at more complex stages based compression techniques for sending data values (eg using differential values, similar to sending data using differential PCM).

4 Conclusions and preliminary results

The main contribution to knowledge lies in the definition and design of new methods, based on the various existing mechanisms and techniques that permit a real approach to what happened in the behavior of an unmanned aircraft at certain critical moments. The knowledge about these ratios happened in a short space of time, will provide more information about the behavior of the aircraft and thus improve the flight control system that enables command. As preliminary results, we present a graph obtained in initial tests performed on a simulation with data matrix generation which corresponds to the parameters listed first class or category that shows a parameter over an entire flight (Fig . 3), an extension of the parameter data (Fig. 4), and the detailed values obtained, showing that with increased transmission of sampled data, we obtain a graph with more detail (Fig. 5)

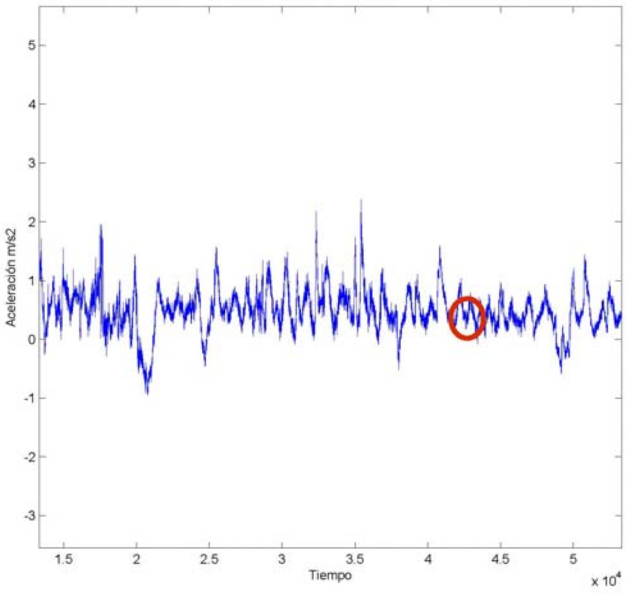

Fig. 3: Acceleration in the x-axis (full flight)

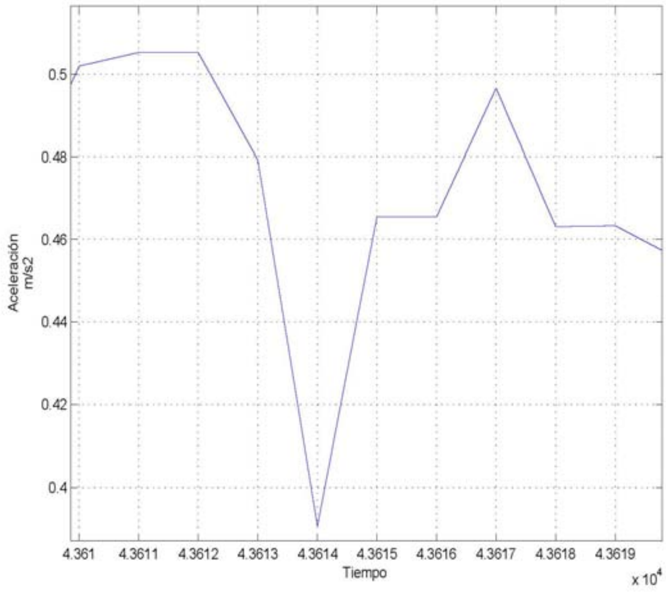

Fig. 4: Extension of section marked in Fig.3

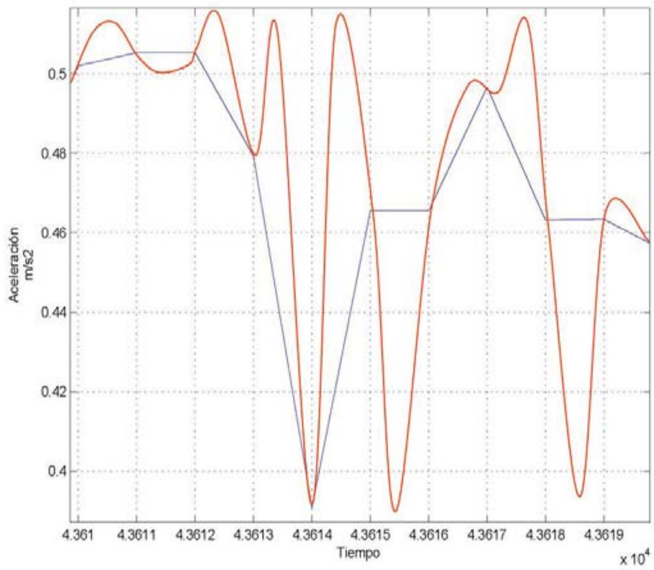

Fig. 5: values obtained

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