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An Approach to Measure the Aerodynamic Parameters Using Unmanned Aerial Vehicle Implementing Nanosensors

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Abstract : A novel aerodynamic parameters monitoring model for unmanned aerial vehicle using nanosensors is presented. This new monitoring method takes into account the real time monitoring of accurate unmanned aircraft parameters. The use of nanosensors as the vital part of this system makes it to differentiate from all the existing systems. By replacing the conventional sensors with nanosensors makes a huge difference since low weight and high accuracy, which is the main advantage of nanosensors, are exploited by flight monitors. Inadequate fabrication of low flying aircraft community reminds to generate a complete monitoring system. We still progress very slowly to the complete monitoring of aircraft parameters being flown at extreme flight conditions in complex flow fields. Since the estimation is not accurate, we are forced to think about an alternate method, which is more accurate and easy way to measure the aerodynamic parameters. The search for the alternate method can be end by exploiting the new trends of nanosensors, hence the big evolution will be from the tinyencapsulations. Experimentally, monitored aircraft parameters using conventional sensors are Humidity, Temperature, light intensity and Position co-ordinates. Synchronization with Google Earth were also implemented as an add-on. The system uses Zigbee[1] support for wireless communication which is also interfaced to the ARM Microcontroller[2]. This paper discusses ways in which analysis of unmanned aerial vehicle data can contribute to the formulation and aerodynamic design using nanosensing technology.

Introduction

Currently, an important thrust in the aerodynamic community is it specifies completely aerodynamic mathematical model for an aircraft. The ultimate goal of this thrust is to obtain a complete understanding of the physical laws (phenomenology) governing all aspects affecting the behavior of the aircraft. Presently we fall short of this goal in all unmanned aerial vehicles. But even with this wealth of experience, we still progress very slowly to the complete understanding of aircraft being flown at extreme weather conditions in complex flow fields. Since the estimation is not accurate, we are forced to think about an alternate method, which is more accurate and easy way to measure the aerodynamic parameters. The search for the alternate method can be end by exploiting the advantages and the user friendly encryption technique of any Data Acquisition Boards, which is compatible with Nano Technology. This paper discusses ways in which analysis of unmanned aerial vehicle data can contribute to the formulation and aerodynamic design using Nanosensing Technology. To date, no comprehensive flight results are available for extreme flight weather conditions. This paper is intended to inform no flight specialists of the current state of flight data coefficients estimation despite first pointing out some of the Nanosensors which are compatible with the flight conditions. Later their application in the monitoring field is discussed. A nanosensor is not just a tiny sensor, but a device that makes use of the novel properties of nanomaterial to detect and measure new types of events in the Nanoscale. For example, nanosensors can detect and measure physical characteristics of nanostructures just a few nanometers in size, chemical compounds in concentrations as low as one part per billion, or the variation of environmental factors such as temperature, humidity and light intensity. Nanosensors are sensing devices with at least one of their sensing dimensions being not greater than 100 nm, which will nullify the main concern of aircraft parameter sensing. In the field of nanotechnology, nanosensors are instrumental for monitoring physical and chemical phenomena in regions difficult to reach, detecting biochemical in cellular organelles, and measuring nanoscopic particles in the industry and environment. A search on the terms ―nanosensor(s) and ―nano-sensor(s) appearing in titles of journal papers shows a growing trend in nanosensor research, as evident from the resulting publication records. Needless to say, a far greater number can be expected if a complete keyword search is performed to include all nanosensor publications. The advance in scientific understanding is naturally followed by technological development. Although sensors have a long and illustrious history, the realm of nanosensors is relatively new[2-8].

Significance of project[2-8]

Existing Technology of aircraft monitoring systems use sensors hard wired to their electronic acquisition unit. It precludes acquisition of major parameters where wires cannot be installed which results in complex installation. It results very often in increasing weight. Current Wireless technologies enable an easy and flexible installation, but their current technology design does not match aircraft monitoring needs as:

a) Autonomy is limited and power re-loading is requested and
b) Compatibility with harsh aircraft environment is not reached.
c) Matching aircraft constraints and power autonomy is targeted for wireless monitoring[3] as they request operating at low data rate.

To enhance aircraft system monitoring by developing concepts based on new wireless technologies and integrated nanosensing solutions. Monitoring part is for autonomous nanosensor powering low consumption and compatible for the harsh environment of unmanned aircraft vehicle systems. This development system can used for monitoring of new parameters, or replace, or simplify complex existing solutions with physical links (wire, fluid). This also allows continuing monitoring or improves redundancy when with the physical solutions the link would be stopped, to improve information segregation. Main focus is on improved aircraft design, maintainability, availability and the associated costs which save weight, reducing fuel consumption and avoiding contributions to the environmental emissions.

Hardware

The three main hardware developments were 1) packaging individual sensors into one sensor unit, 2) packaging the wireless transmitter unit along with the sensing unit, and 3) implantation of GPS module along with the carrier package. An example of a nanosensor that could be applied in the field of national security is something called the SnifferSTAR, which is a lightweight, portable chemical detection device that works with a micro electromechanical system and can be integrated into an unmanned aerial vehicle. The packaging process was very challenging, and involved determining the layout of the sensor position, the efficiency of the circuit design, and the optimum coating with field material since temperature and pressure nanosensors is being used. The sensor position was designed to decrease the distortion of signals, which will decrease the chance of false readings by individual sensors. The efficient circuit was designed to decrease the usage of power and the size of the sensor unit. Size reduction is the most important aspect and requirement of development, as this has been designed to be used in unmanned aircrafts.

Software

The two main software developments were 1) communication between the sensor unit and a PC, and 2) a command center console. Each sensor needed to translate the physical property that it measured (e.g., temperature, pressure, and humidity) to electrical voltage and current to start the data stream. The efficient circuit design in packaging was critical to reduce the noise that can interfere with the electrical properties. The Data Acquisition Boards (DAQ), commercially available interfaces between the signal and a PC, were applied to transform the electrical properties to a digital signal that can be recognized by the command center console on a PC. The customizable command center console was programmed using MICROSOFT VISUAL BASIC software, which is the emerging standard in visual programming-based instrumentation control systems [4]. Figure-2 shows snapshot of the command center console.

Experimental[2-8]

In the experimental point of view Nanosensors, Nano transceivers and Nano GPShas been replaced by conventional sensors wireless transceivers along with GPS module. Three major experiments are tested: 1) a sensor unit strength test, 2) the proof of concept on aircraft monitoring algorithm, and 3) a live demonstration with sensor package with unmanned aerial vehicle. Figure 3 shows a test aircraft with an experimental version of the sensor unit attached inside. Datas from the sensor end transferred the signal to DPU. The objective was to ensure that the sensor unit had the strength for normal outdoor RF line-of-sight performance Up to 1 mile (1500m). The proof of concept on monitoring algorithm was conducted to confirm the hypothesis that unmanned aerial vehicle can be monitored by the algorithm that computes the fluctuation of the sensor reading. The experiment used a commercial a Humidity sensor module (SY-HS-220), and a Temperature sensor module (LM35 Precision Centigrade Temperature Sensor) instead of the experimental nanosensor in order to confirm the feasibility of the algorithm. All the analog values from sensors are flood into a DAU (Data Acquisition Unit) where storing and calculations are made possible.The DAU that has been used in the experiment is ARM-7 microcontroller. This experiment successfully confirmed the concept of the monitoring algorithm under the most extreme weather condition (small scale with a less sensitive sensor) in the laboratory.It can be used to analyze, monitor, store and verify the measurements from a real-time system.(Fig-1) shows the design diagram of live demonstration with Monitoring System named as “CURIOUS”.Based on the circuit design theory (Fig-2), an earlier version of simulation software for the algorithm of aircraft parameter monitoring was developed using MS-Visual Basic. The software is capable of simulating a network with various conditions such as immobile, mobile, and extreme weather condition regimes.

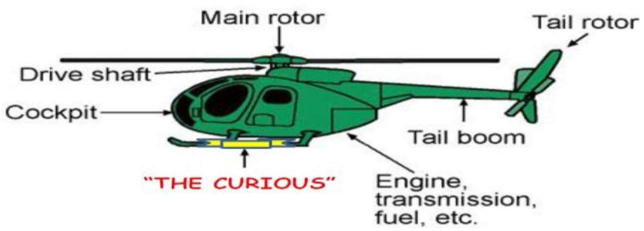

Fig-1.The design diagram of live demonstration with CURIOUS implemented with unmanned vehicle.

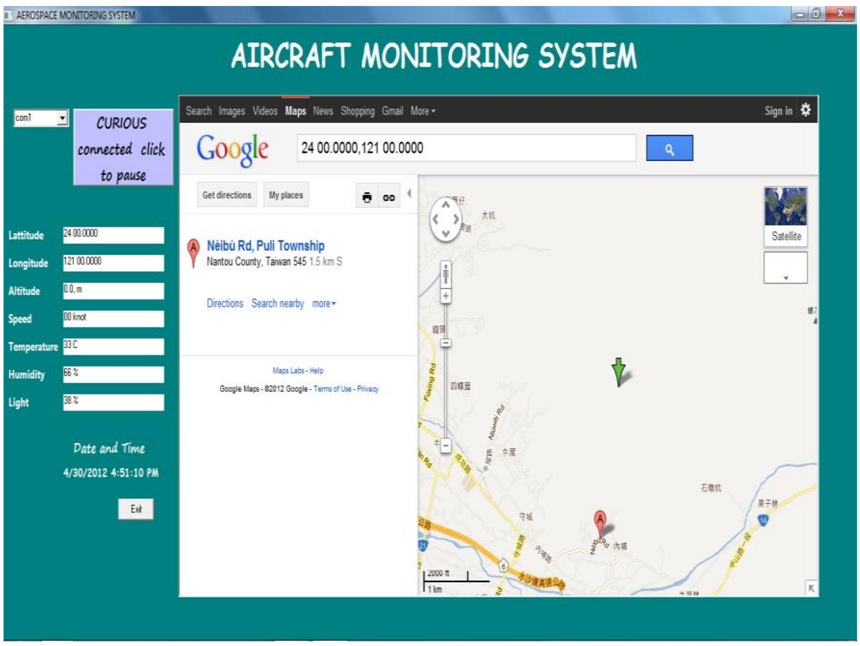

Fig-2.Shows one of the examples from this experiment, which is the test data taken from the sensor package mounted on the Aircraft Carriage.

Working

Transmitter Module

The sensing part is a package of nanosensors, which are created on the atomic scale that obtains information about nanoparticles[5] and translates it to a scale we can easily analyze.The first transmitter package consists of aircraft parameter monitoring sensors. This unit will transmitthe data to the amplifier. The data may be analog or digital depending upon the nature of sensors being used. Since the sensors are of Nanoscale, their output will also be of the same kind so amplification is a confined process.Nanoparticles are nanometer-size materilas with unique physical and chemical properties and have been widely used for many years. The terms "actuator", "sensor", and "transducer" are used in the description of measurement system, sometimes interchangably. In the broadest sense, a transducer receives energy from one system and transmits this energy to another system, often in a different form. A sensor monitors a system it responds to physical stimuli,such as heat, light, humidity[6], temperature generates an electronic impulse for detection. An actuator, on the other hand, imposes a state upon a system

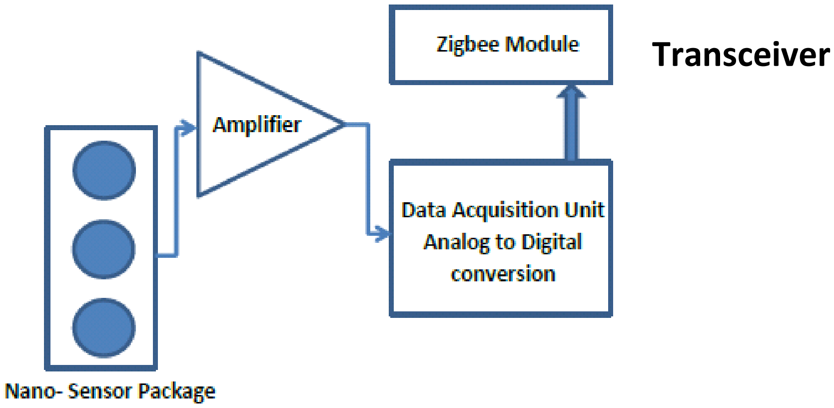

Fig-3 Sensor Transmitter Unit End

The amplified signal is transmitted to the DAU (Data Acquisition Unit), which consist of required number of ADCs and DACs for the conversion of incoming signal from Nanosensor[7] package after amplification to a form which is compatible for the DAU to process on the sensed Data. Along with this, a GPS module also can be associated to know the position co-ordinates. These co-ordinates also get processed by DAU. It is the responsibility of DAU to shape the signal which can be accessed by the wireless transmitting unit.Wireless unit is the combination of a transmitter part and a receiver part. DAU will flood the data to transmitter. Depending upon the range, different transmitting modules can be used.

Receiver Module

The first stage of the receiver is the wireless receiver unit along with the antenna. The received Datas are digital in nature, inorder to accomplish the wireless protocols confidentiality, integrity and accuracy. The signal is then feed to a Filter and Conditioning unit. The output of filter unit will be processed in parallel form, so it has to be converted in to serial to feed it into the command center console on a PC. This parallel output is suitable for Local Data Storage. Stored or recorded data can be processed after the real time working of the Sensor Unit, which enables the 'Curious', work as a reference Module.

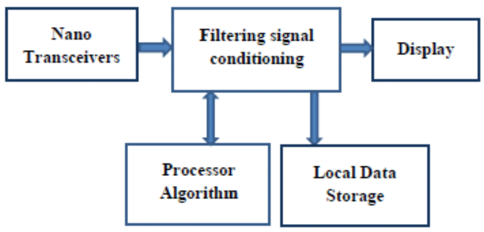

Fig-4 Module Receiver Unit End

Results and Discussions

The experiment was successfully completed using conventional sensors with low flying RC copters. This type of copters flies around a range of 20-30 meters indoors in moderate weather conditions. (Fig-5) shows copter with the sensor and transceiver carriage along with GPS. But hindrances were mainly weight balancing during aerial lift and calculation of speed, because speed calculations were carried out in knots.By considering high lift aircrafts, these problems got bypassed. For that the experiments carried out with an aircraft- “SKYSTAR”, which come under the category of high fly unmanned aircrafts. The main advantages are without the presence of human aid, we are able to monitor an aircraft. This is considered as a great advantage in weather broadcasting and surveillance. This can also made useable in military applications to get the information of the places about to camp. Since GPS is included it is very easy to locate and navigate.

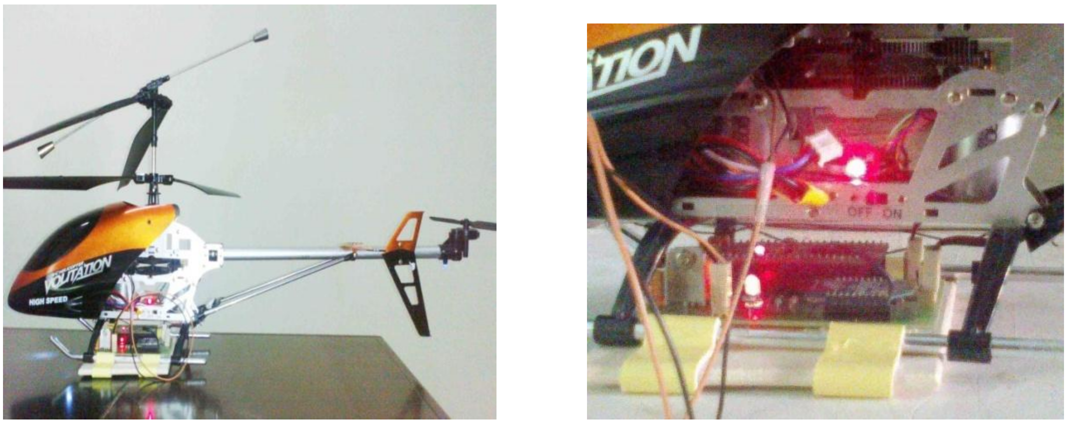

Fig-5 Sensor Package “CURIOUS”, along with GPS installed in an RC copter.

Hence the same experiment was conducted using comparatively high flying range aircraft- ‘SKYSTAR’. Fig-6 gives the combined view. ‘SKYSTAR’ is a type of aircraft, which is having a flying range of 1500-2000 meters even in extreme weather conditions.

Fig-6 “CURIOUS” installed in high range flying unmanned aircraft

Table.1 Experimental values with low flying RC copters

Position co-ordinates	12 54.6809, 07451.5789	12 54.6812 , 07451.5801	12 54.6855, 07451.5832
Altitude	84.1 m	88.5 m	89.2 m
Speed	00 knot	01 knot	00 knot
Temperature	34 C	34 C	33 C
Humidity	03%	03%	02%
Light intensity	60%	56%	62%

Table.2 Experimental values with high flying unmanned aircraft

Position co-ordinates	12 54.5644, 074 51.6190	12 54.5851, 074 51.6335	12 54.5425, 074 51.6609
Altitude	131 m	122m	123 m
Speed	04 knots	04 knots	03 knots
Temperature	33 C	32 C	32 C
Humidity	57%	60%	60%
Light intensity	53%	52%	56%

The above tabulated tables (Table-1 and Table-2) give the experimental output monitored values carried out using low and high flights. These values are observed to be 95-98% accurate. In the near future, technology will advance in the path of nanotechnology[8]. As an up-gradation to the experiment, here by, propose the replacement of conventional sensors and wireless modules by nanosensors and transceivers.

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