A Satellite-Based Monitoring System for the Harpy Eagle

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***Abstract*—This paper presents the status of an on-going work that aims at implementing an embedded system for monitoring the Harpy Eagle (Harpy harpyja), which is an animal found in the Amazon, Cerrado and Atlantic Forest. The monitoring system is structured in three parts: data collection, data storage and transmission. At first, there is a collection of various data: from sensors (temperature and humidity), location via GPS, the presence of birds in the nest, especially at the feeding of the babies and also a camera which will be responsible for capturing pictures. The second part aims at storing and preprocessing all the collected information. The third part is responsible for transmitting sensible information via satellite using the Brazilian System for Environmental Data Collection (SBCDA), especially the alarm that the parents have prematurely abandoned the nest.**

Keywords: Embedded Systems, Monitoring, Harpy, Sensors, Image Capture, Satellite Transmitter.

1. Introduction

With the increasing rates of endangered species, it is necessary to intervene in the natural environment to better analyze the livelihood of these animals [1], obtaining information such as habits, practices of survival, food types, among others. Thus, we could help preserve those species. With this goal, this paper proposes a system for monitoring the natural habitat of certain species of bird, or more specifically the Harpy Eagle (*Harpia harpyja*).

The Harpy Eagle is considered the biggest bird of prey in the world. In Brazil, the bird inhabits sites like Amazon, Paraná and Rio Grande do Sul and some forests of the Atlantic Forest. Currently, this bird is endangered due to human predation, which has practiced the indiscriminate hunting of this bird species [2], motivated by its high commercial value. Moreover, there is increasing deforestation of forests, which are the natural habitat of this bird.

This proposed system consists of a recording equipment and sensors for environmental data collection, in order to record and/or photograph the exact moment of the babies' feeding, as well as the kind of food, and temperature and humidity data. Moreover, the system uses satellite-based communication [3], through the Brazilian System for Environmental Data Collection (SBCDA).

This work shows the potential integration between the fields of biological research and the extensive range of opportunities provided by technologies such as telemetry [4] and satellite-based communication [5]. This work is part of the Master thesis of the first author, and it is within a project in which the other authors participate. This project started in January 2010 and is a cooperation between the Federal University of Para (UFPA) and the National Institute for Space Research (INPE).

The rest of this paper is organized as follows: Section II presents the requirements for the Harpy monitoring system. Section III presents the modeling of the system. Section IV shows some of the preliminary results obtained and Section V discusses the conclusions.

2. Requirements for Monitoring the Harpy

To carry out the Harpy monitoring, the team faced the difficulty of access to the nests, due to its eventual location in the forest. On average, the nest is placed in trees up to 21 meters [6]. The Figure 1 shows researchers measuring the wingspan of the bird.

Fig. 1. Researchers measuring the wingspan of the Harpy, which can reach 2.5 meters.

In addition, a number of requirements must be considered when designing the system, such as:

- The power consumption of the system must be reduced to a greater longevity of observation;

- The recognition of the bird should be differentiated between parents and offspring, so that some sensors are triggered only when the parents arrive or leave the nest.
- The system should be camouflaged so as to prevent it from being damaged or lost.

3. Harpy Monitoring System

The system consists of three complementary parts: a sensors' system, a video and data storing unit and data transmission, which interact according to the Figure 2.

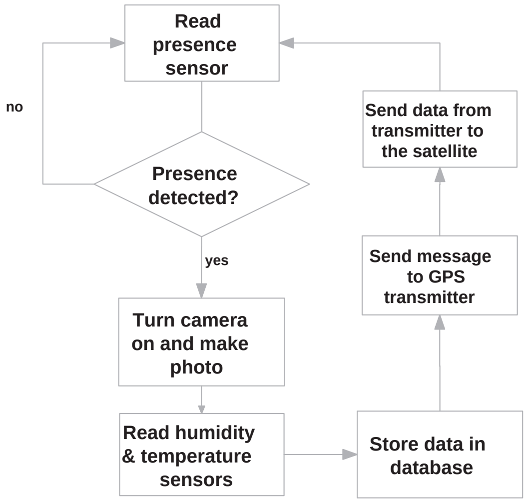

Fig. 2. Flowchart of the designed system.

The System of Sensors and Data Collection (SSDC) (1) consists of a camera to photograph the bird when it arrives or leaves the nest. The goal is to register the Harpy baby's diet and to detect the abandonment of the nest by the mother Harpy. The camera is activated by a motion sensor, pre-configured to detect animals with a wingspan of up to 2.5 meters, this is done by configuring the sensor to operate in a range of angles of 45 degrees. Thus, the system can differentiate the mother from its baby bird. In addition, there are also temperature and humidity sensors to monitor the climatic characteristics of the nest. This set of sensors is controlled by a microcontroller [7], which is responsible for activating the camera and perform the A/D conversion of signals from the sensors.

The Video and Data Storing Unit (VDSU) (2) receives data from the SSDC (via USB communication) and stores them in a MySQL database [8], [9] through a capturing and storing system, called the Data Storage System (DSS). The VDSU is located at an accesible height to researchers.

The data transmitter (3) sends a message to the satellite, which is connected to the SBCDA (5), reporting in real time [10] when the bird leaves the nest.

The system is powered by a solar panel (4) and a battery (4), in order to extend the autonomy of the system, so that it carries out the planned period of monitoring (1 month). The Figure 3 illustrates the proposed system.

Sections 3-1 e 3-2 describe the developed hardware and software:

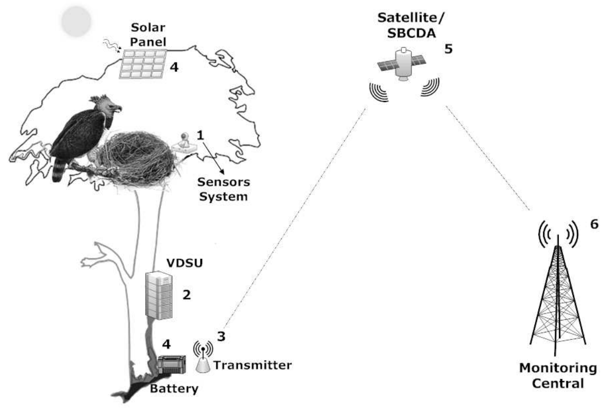

Fig. 3. Illustration System

3.1. Hardware

1) SSDC: The SSDC hardware is composed of the LM 35 temperature sensors(measure from -55 degrees to 150 degrees), humidity 600 UPS, PIR(InfraRed sensor) presence sensor, a camera, a 18F4550 PIC microcontroller and a data acquisition and control board, whose circuit is shown in Figure 4. The 18F4550 PIC has 2 kB of flash memory, an analog/digital converter of 10 bits, an internal oscillator of 8 MHz, and USB 2.0 communication [11], with operating frequency of 48 MHz. Importantly, this system is located near the nest, so that the capture will be accurate.

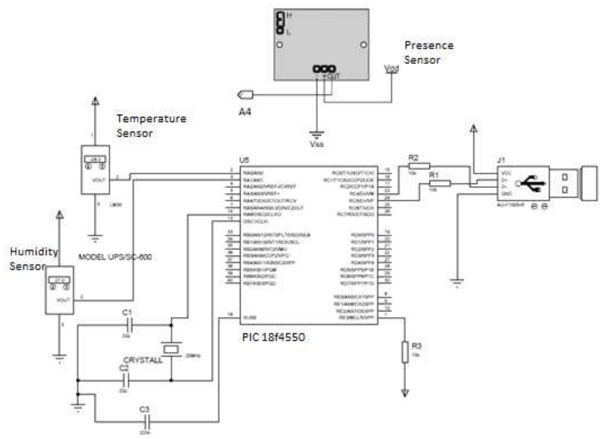

Fig. 4. Scheme of the developed circuit.

2) VDSU: The hardware of the VDSU is a common PC composed of motherboard, processor, hard drive and peripheral ports. It stores the data captured by the camera and the sensors and makes them accessible via USB communication to which a user has access, thus allowing the data analysis. The USB communication is a high speed bus and the most currently used by peripherals on personal computers due to its easy handling and traffic information.

3) Satellite: The system consists of the communication to satellites from the Brazilian System for Environmental

Data Collection, CBERS-1, CBERS-2 e CBERS-2B, where the signals can be obtained within a system or platform of data collection, spread all over the Brazilian territory by data receiving stations, one in Cuiabá and the other in Alcântara. These satellites have one inclination of the orbital plane around 90 degrees in relation to the Equator. They lob up to a speed of 27.000 km/h, completing one orbit in around 100 minutes, total 14 orbits per day. Only 14 orbits are visible in sequential orbits by the station of Cuiabá, with a range of approximately 10 hours (6 orbits). The orbits of the satellites were designed so that one covers the absence of the other [12]. The satellites work in the UHF for receiving messages transmitted by the transmitter (around 401.62 MHz and 401.65 MHz - which are the same as the transmitter ones) [13].

4) HAL2 ELTA Transmitter: The transmitter HAL2 manufactured by Elta communicates with the satellite, sending data of 32 Bytes, 24 hours a day and frequency of 401 MHz, with power consumption 7-14 (seven the forten)Volts [14]. The HAL2 transmitter is connected directly to VDSU using the serial port, so that data (strings with information about temperature and humidity, as well as the bird's absence or presence in the nest) can be sent via software and then to the satellite. Figure 5 shows the transitter HAL2 measuring 45 millimeter of largure by 55 millimeter of compriment and 15 millimeter of thickness and weight 50g.

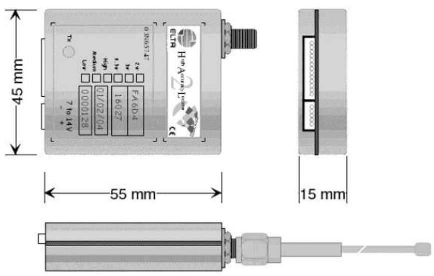

Fig. 5. HAL2 Satellite Transmitter: with and without antenna.

5) Battery and Solar Panel: The supply system is composed of a battery and a solar panel, which should provide enough power for a prolonged system's autonomy, even at night. The solar panel must be installed at the top of the tree, so that the contact with the sunrays is more effective. The battery should be installed at the base of the whole system in order to supply all components.

3.2. Software

1) Programming of the PIC 18F4550: The microcontroller performs the control of sensors and camera according to the instructions of a specific software programmed in C language, so that the ports are properly directed to send signals to the camera and to receive signals from the presence sensor.

2) Data Storage System (DSS): It is a software that runs on VDSU that allows the storage of the collected data. This software is based on JAVA programming language, developed from a framework called JMF (Java Media Framework) and a software called JMStudio [15], which allow the audio and video processing. The DSS will consist of a login screen with username and password for the user to access the system safely, as shown in Figure 6.

Fig. 6. Screenshot of the developed DSS access.

The DSS uses MD5 encryption [16], widely used in communication systems [17].

3) HAL2 the of Software V4.03: The HAL2 transmitter was configured according to the instructions generated by your softwate [18], a software that allows the user to program the transmitter code and make their own tests before sending the data via satellite. This software is provided by the transmitter's manufacturer, ELTA.

4. Conclusions

This work described an embedded system for monitoring the Harpya. The paper performed a survey of the requirements, specification of components, described the circuit already implemented and the hardware simulation. The circuit was implemented using hardware techniques and tools specifically targeting embedded systems. The prototype attended the system's requirements. The next step is to conduct signal transmitting tests via satellite, which depend on the acquisition of the transmitter.

It should be remarked the importance that the SBCDA has demonstrated within the research on endangered species, which have been used for studies of rehabilitation and subsequent release of species, as well as behavioral and environmental data. This paper is part of that context and seeks to strengthen the use of innovative technological solutions in biological research. There are other solutions to monitor animals, but this work is innovative because it includes the intelligent processing of information, such as triggering an alarm that the parents have prematurely abandoned the nest.

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