PAPER • OPEN ACCESS

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To cite this article: S A Sanchez *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **519** 012011

View the article online for updates and enhancements.

Development of a prototype of an electronic module that allows to calculate the frequency of spawning in laying hens

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Abstract. Poultry farming is an industry recognized worldwide, being one of the main activities in different countries. From the national level, poultry farming is a source of income dedicated to the production of eggs and poultry meat, which has had a constant growth since the mid-twentieth century. This market in Colombia is one of the few economic sectors with permanent growth, this is evidenced by the increase in the per capita figures for this type of product. Nowadays in the market there is no evidence of a low cost system that allows to measure the hens' position in real time, this necessity being the main objective to develop an electronic module that allows to calculate the frequency of spawning in laying hens, with the purpose that this information can be used by poultry farmers in order to determine what food treatments and environmental conditions improve egg productivity. The materials used for the prototype were; a module cell (independent cage for each bird), an Arduino UNO card, infrared proximity sensor, 12x2 LCD display, MicroSD card module and an SD memory. This investigation is framed in a technological development of experimental type, for the construction of the prototype 3 stages were taken into account; prototype design and its characteristics, final assembly of the prototype and tests and results. In the results found there is evidence of a versatile tool that allows to inform in real time in a graphic way the postures. The tests carried out demonstrate the potential of a low- cost, lightweight and state-of-the-art prototype.

1. Introduction

The development of technologies is advancing rapidly in the world, due to factors that are changing their leading role, this is how we can appreciate the change that has been generated in different sectors and the great progress that the sector has made in recent years. Poultry In the poultry farms technified egg producers, different techniques are implemented to improve the productivity of these. Therefore, the breeders carry out tests with manual and inaccurate data on the laying time of the birds; to determine which treatment works best.

Currently in some municipalities of the department of Sucre, poultry farmers carry out this activity from the empiricism, there are no certified processes that allow improving the quality of the products and achieve a positioning in the national and international market. For this reason, the national government from different programs has been encouraging and financing the public and private sector (companies, universities, industries, among others) to generate projects that help position and generate competitiveness in these markets [1]. It should be noted that poultry farming is one of the economic activities that take place in this area.

According to the National Service of Learning, SENA, "poultry farming worldwide and nationally, thanks to advances in genetics, nutrition and animal management, currently presents a rapid growth, improving the supply and facilitating the access to egg consumption as one of the most complete foods in human nutrition" [2].

According to the National Federation of Poultry Farmers of Colombia, Fenavi; Nowadays, most laying hens are raised in intensive systems with a controlled environment, where parameters such as light intensity and duration are monitored by man, in order to improve the egg position, modify the behavior or simply save on energy costs. Birds are characterized by having a greater number of cones than rods in the retina, so they have better daytime vision than nighttime. As for laying hens, they are bred with light intensities ranging between 5-10 lux, enough to maintain the physiological behavior of the laying, through the stimulation of the optic nerve. In this context, electric light plays an important role, since it is used to keep the laying birds active and influence the production of eggs. Initially, the work of regulating the lighting period was done manually by a manager, who turned on and / or turned off the light according to the convention held in the house [3].

With the advancement of technology, electronic devices were designed, which must be programmed to perform this function. However, to prevent the light from being turned on and off abruptly, the agricultural research company, Embrapa Suínos e Aves, linked to the Ministry of Agriculture, Livestock, and Supply of Brazil, developed a new adjustable device. An automatic luminosity controller, with an approximate dimension of 25x25 cm, which promises to simulate gradually the beginning of the day or the arrival of the night. In addition, the regulator also stores in memory everything that happens during the batch process. Another interesting aspect is the light compensation work that this system implements in relation to external light.

According to Saatkamp, M. analyst in the area of technology transfer of Embrapa. "This automatic controller optimizes the light inside the house. The light is turned on at the programmed time gradually, simulating the start of the day" [4].

By the time the end of the light period is programmed, it decreases until it is turned off, simulating the end of the day. "He had already announced that the management of light / dark / light illumination should be a gradual change, to avoid a greater stress in the birds. These researchers analyzed the behavior of the hens in both cage and ground, subjected to two different lighting management practices: in the first, turning on and off the lights was instantaneous, while in the second, the passage from light to dark or vice versa was gradual, simulating a sunrise or natural sunset. In both situations, an increase in food intake was observed before the darkness, to later go to the resting areas, when the light was suddenly extinguished, some s hens, especially in the system of accommodation in soil, did not have enough time to look for the slats, having it done in the dark, experienced stress. This did not happen when simulating a sunset with a gradual reduction of light. Regarding the ignition, when it was sudden, it caused in the hens a situation of alarm and disorientation, reaching, even, to cause some stereotyping (they revolved around themselves). These authors concluded that a gradual ignition and / or shutdown would increase the comfort of the hens. However, they pointed out that chickens must be accustomed to sudden changes of light / darkness or vice versa, as this way, in case of any failure in the electrical system, a situation of generalized panic in the house would not be triggered. The first precaution that should be considered with this brightness regulating device is the installation, which must be carried out by technicians. Another important aspect is the regulation, where it must be assigned to a professional for the operation of the device, since the lighting program introduced should not be altered. In addition, you should have the normal basic care of the equipment in bird plants such as protect the electric discharges and prevent water from falling into the equipment.

It highlights the research conducted by San Lucas et al. where they implement an automatic system with sensors to measure some variables within the house, the data taken are sent to a website to be observed via the internet [5]. Focusing on a chicken farm for meat production, where variables such as humidity and temperature are controlled by means of combustion heaters and curtains that rise or descend automatically allowing the air to flow inside the house depending on the alteration in the variables before mentioned, in addition, depending on the age of the chickens their food and water consumption varies, for this they carry out an automatic system that supplies a precise quantity.

Coturniculture is a branch of the poultry sector, whose objective is the production of quails for obtaining eggs, meat and other derivatives. For Vásquez et al. in the exploitation of the quail, several processes are implicit, such as egg harvesting, food irrigation and cleaning the house [6]. The main cause of dirt is the codornaza. (manure produced by the quail), this produces gases such as ammonia and increases humidity, raising the temperature inside the house and affecting production.

The quail is a bird very sensitive to the environment, this can get sick because of the poor conditions of this. To carry out the cleaning in the house, the codornaza must be extracted from the deposit sheets, this process requires between two and three hours per man for each thousand quails, as it requires physical contact and exposure to toxic gases. Which the coturnicultor is susceptible to diseases and infections. They address the problem of codornaza extraction by developing a prototype on a fully automated scale, which will comply with the process at a frequency determined by the coturniculturist through an HMI (Human Machine Interface) interface or when the ammonia gas level exceeds the maximum allowed value. With the objective of guaranteeing which environment is the most suitable for the exploitation of the quail, measuring and controlling the temperature variable [7].

These new technological tools that are offered in the poultry industry, specifically for the posture sector, provide favorable measures to reduce bird stress and therefore improve the welfare of the birds. This type of products help to increase egg productivity as well as allow energy savings, consequently improving the final profitability. The electronic devices used for the development of the remote monitoring prototype are specified below:

1.1 Arduino programmable card

According to the information consulted, the Arduino development board is a free hardware and software microcontroller, designed to favor the indispensable operation of the electronics in different projections. One of the peculiarities of this, is that the hardware resides on a board with a small controller. Which allows the interconnection with other shields or modules. Nowadays it is very used in the digital world, since the electronic circuit assemblies are made easier. Its applications can be found in biomedical equipment, unmanned aircraft, 3D printers, among others [8].
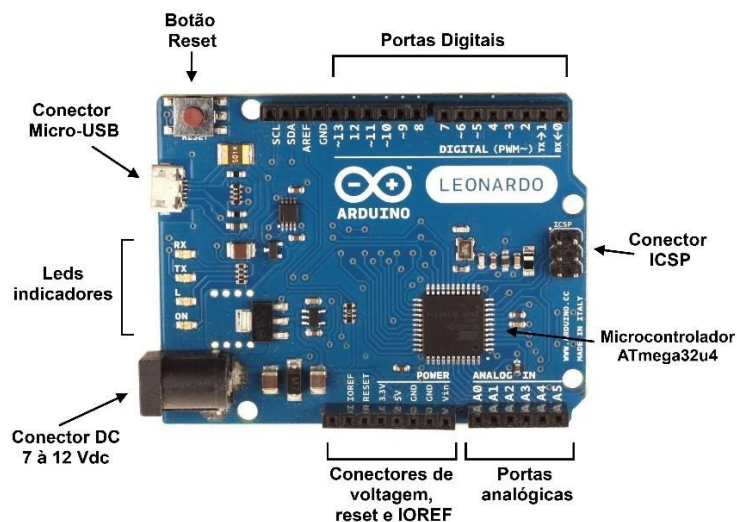

Figure 1. Programable Arduino Card Uno

1.2 Lithium-ion battery

It is a device designed for storage of electrical energy that uses a lithium salt as electrolyte that obtains the necessary ions for the reversible electrochemical reaction that takes place between the cathode and the anode.

Figure 2. Lithium-ion battery

1.3 Display LCD (Liquid Crystal Display)

It is a passive display of low consumption, based on a substance trapped between two plates of glass. This electronic component serves to display messages by means of characters such as letters, numbers or symbols.

Figure 3. Display LCD

1.4 Micro SD card interface module

This device allows an SD memory card to be connected to a microcontroller, so that information can be stored. This is ideal for carrying out different types of projects.

Figure 4. Module interface Micro SD Card

1.5 Infrared proximity sensor

It is a distance measurement sensor, which is based on a system of emission / reception of light radiation in the infrared spectrum [9].

Figure 5. Infrared proximity sensor

The terms presented below are concepts collected from the project, these describe important aspects within the research process:

- *Poultry Farms:* A poultry farm is an agricultural establishment for the breeding of poultry such as chickens, turkeys, ducks, and geese, with the purpose of using them as a food base either by killing them for meat or by collecting their eggs.
- *Egg Posture:* Action of the birds, to lay eggs in the nest.
- *Module Cells:* Individual plastic or metal cages for laying hens.
- *Oviduct:* Conduit of the female reproductive system of the mammals that communicates each ovary with the uterus. In the reproduction of the birds, the ovule, when mature, penetrates inside the oviduct and after being fertilized by a spermatozoon it is surrounded by the clear and the shell, to finally form the egg.
- *Lighting pattern:* are the different characteristics of the lighting (type of light, intensity, exposure time, etc.), to adapt to specific needs [10].

1.6 Reasons why chickens stop laying eggs

a) *Shorter days.* Chickens are sensitive to the length of daylight, and particularly to the direction in which the length of the day is changing, when it comes to laying eggs.

b) *Inadequate nutrition.* Chickens need a balanced and adequate diet to maintain egg production. Each egg contains large amounts of protein and energy, which the hen must first consume as part of its daily food intake.

c) *Age.* A hen can live for many years. It is not unusual for a backyard flock owner to have several generations of birds and loses the notion of the age of some chickens. As in other species, an old chicken will eventually lose its ability to be active for reproduction and stop producing eggs.

d) *Illness.* Many bird diseases will affect the production of eggs. Often birds will show symptoms of disease, but sometimes they will not.

2. Methodological framework of the investigation.

2.1 Kind of investigation.
This investigation is framed in a technological development, of EXPERIMENTAL type, where it is tried to develop a practical prototype and of low cost that will be put under different types of tests to find the most optimal operation.

2.2 Research method.
The focus of this research is quantitative, according to Sampieri this type of approach is based on analyzing an objective reality from numerical measurements and statistical analysis to determine predictions or patterns of behavior of the phenomenon or problem posed, also employing experimentations and cause-effect analysis.

2.3 Technological resources.
The technological means with which the objectives of the project will be achieved are:

- Computer.
- Internet connection.
- Printer.
- Digital camera.
- Academic database.
- Office automation applications.
- CAD software for electronic design.

- Programming software.
- Procedures of the investigation.

2.4 Procedures of the investigation.
In order to successfully carry out the present project, it will be carried out in chronological fulfillment of the specific objectives and three stages were defined:

2.4.1 Design of the prototype and its characteristics.
In this stage the functional and non-functional requirements of the prototype will be defined, be they technical, mechanical, electronic, among others.

2.4.2 Final assembly of the prototype.
For the development of this stage it is necessary to validate all the requirements to proceed to the construction of the prototype, using the elements and suitable devices to achieve efficient and effective operation of the module.

2.4.3 Tests and results.
For this stage, the module undergoes different types of tests in order to meet the basic characteristics of a prototype, whatever it may be; complete, reachable and verifiable.

3. Results

For the development of the prototype, the productive chain of commercial poultry farming was validated, which has six production processes; interdependent, technified and demanding in aspects of genetics, nutrition, health, biosecurity and environment.

Specifically, the process taken into account for the development of the electronic module is carried out in the production farms of laying hens, where the birds arrive a day after birth and are vaccinated according to the risk factors of the area. The birds are generally housed in modules, floor, rice husk bed, chip, among others. The complete cycle in the laying hens lasts approximately 72 weeks, divided in turn in the breeding, raising and laying phases.

For the development of the prototype, a scaled module cells were designed, to which a proximity sensor module (consisting of an infrared LED and a phototransistor) was adapted. This module fulfills the function of detecting the passage of the eggs deposited by the hen laying The module cells are inclined at an angle of 30 degrees, making the eggs go down a ramp made of wood, passing through an area where the sensor is located, in which a beam of light is emitted and, if interrupted, a signal is sent. electrical signal to a microcontroller (Arduino Card), this system processes the information, then goes through a micro SD card module, which stores the data in a flat file of .txt format, later this information displayed on an LCD display, so that the Farmer poultryman can observe in real time the frequency of posture of the hen at any instant of time. In the figures 9 the final prototype is observed.

Figure 6. Electronic Module allows to measure the pawning frequency of laying hens.

In the figure 10 and 11, the tests and validations that were carried out with several angles of inclination of the module to achieve the suitable location for the postures of the hens are evidenced, it was validated that the system made count of postures and showed them in a LCD screen. It was found that it is necessary that poultry farms are divided into lots, to determine what factors can increase or decrease production. All the information collected and stored, the poultry farmer can take advantage of it to perform a thorough analysis in order to optimize the processes. The size and comfort of the module were also evaluated, important factors to avoid chicken stress and to reduce egg production.

For the feeding stage of the prototype it was determined that the consumption per hour is 1W, for this case 5 rechargeable batteries of 3.7 volts were placed at 1 ampere, in order to achieve a time of autonomy of the module of approximately 18 hours in case of failure of the electrical supply.

This tool can be of great importance for poultry farms, since all these processes are carried out by many poultry farmers through the observation method, which can generate a lot of uncertainty. With this device you can make projections and draw conclusions about the behavior of the hens.

Figure 7. Final Prototype to measure the pawning frequency of laying hens.
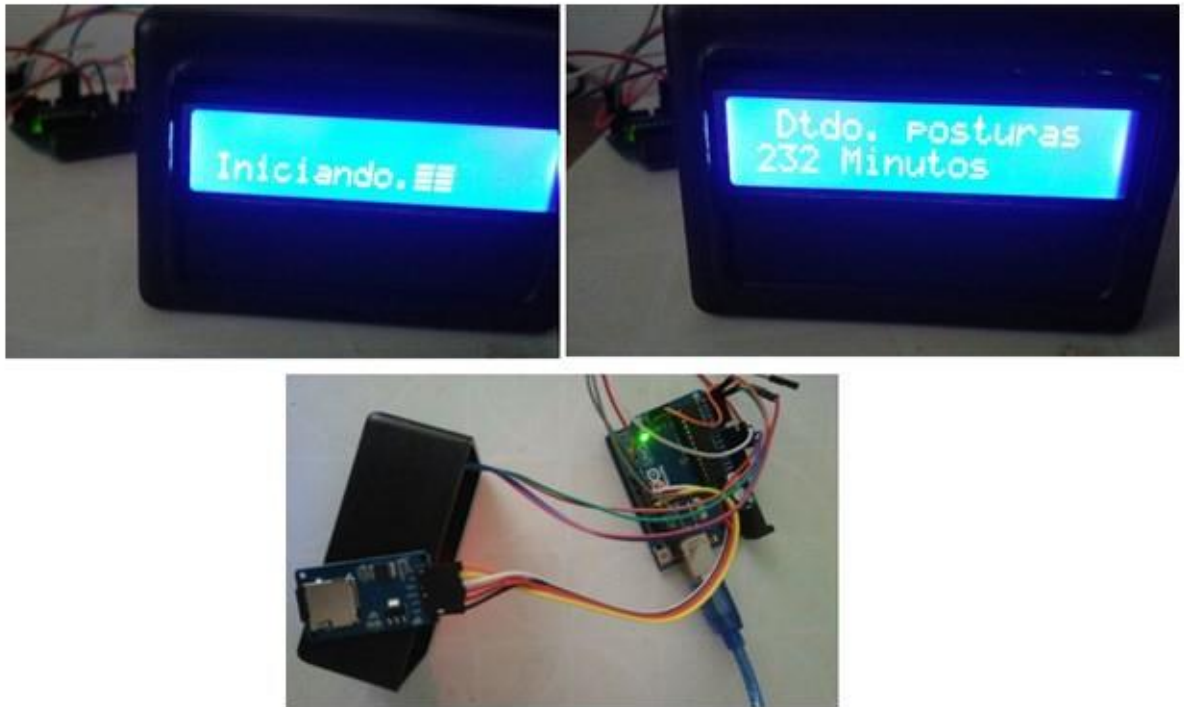
Figure 8. Technology used for final prototype

In the pilot tests of the prototype, the following technical characteristics were found, which are evidenced in Tables 1, 2 and 3. As future work, the investigation should be conducted in tests on poultry farms of the Department of Sucre.

Table 1. Technical tests of the Prototype.

Test	Average
Security	100%
Functionality of the Prototype	100%
Interaction with the user	95 %
Easy to use	95 %
Response time	99 %

Table 2. Characteristics of the final prototype vs. market prototypes

| Device	Sensors	Size	Weight	Warning mode	Market price (Approx)
Module to measure egg frequency (created)	Infrared	Adjustable	[200-550 gr]	Tone and warning by light	20,2 €
Module to measure egg frequency (In the market)	Without sensors	Adjustable	[300-1000] gr	By observation	[25,00 - 100] €

Table 3. Characteristics of the final prototype

Elements	Infrared proximity sensor	LCD display	Battery	Arduino card
Working range	0.1 – 3 V	0.5 –5 V	0.5 –12 V	0-5V
Immunity external factors	No	Si	Si	Si
Energy consumption	0.03 W	0,15 W	0.21 W	0.25 W

For this first phase of the investigation, it only focuses on the design of the module. For phase 2, it is intended to test poultry farms in the department of Sucre to perform these processes manually and by the technique of observation to ensure that these are optimized.

The important aspects that must be had in the poultry industry are the following:

- The birds must be in well-designed module, clean, disinfected and with high levels of biosecurity.
- Birds must have good ventilation, air quality, temperature and space.
- The spread of diseases should be controlled by housing birds of one age and one origin.
- The homogeneity of the birds should be controlled.
- Prevent, detect and treat diseases.
- Cover nutritional needs, make good management of food and water supply.
- Waste collection system (excreta, corpses, etc.).
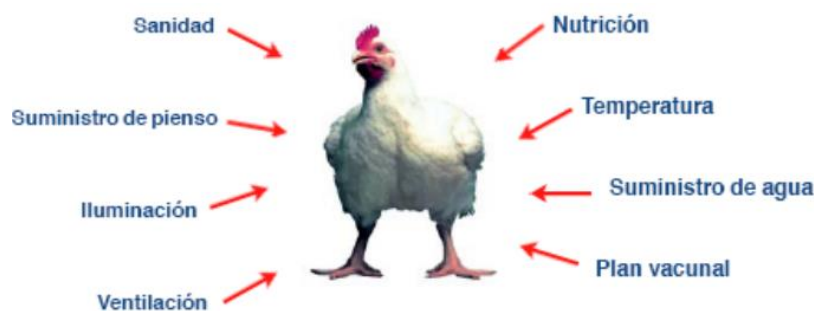
Figure 9. Important factors in poultry farming.
Source: Ross, 2010 Handbook.

4. Conclusion.

After carrying out this research work, it was concluded that it is possible to develop an electronic device that is economical, functional and versatile. A module was generated that allows to collect egg position data in real time to achieve the optimization of the productive processes of the poultry farmers; and with good results. This project aims to generate greater profitability and encourage quality processes that improve the competitiveness of the poultry sector in the department of Sucre, also providing the opportunity to use technology and human talent. The prototype was subjected to technical tests of operation, response time, use and safety where successful results were found and

demonstrate the versatility of the tool. Finally, the aim is to encourage poultry farmers to invest in more competitive technologies in national and international markets. As future work, it is intended to generate a mobile application that allows to visualize in a graphic way the pawning of the chickens and generate historical records.

5. Recommendations

- The module cells must be properly inclined so that the egg has a free movement towards sensor detection.

- It is very important to check that the position detector sensors are not obstructed by foreign bodies, in order to avoid erroneous captures of the data.

- In the event that the electrical supply to the house fails, it is essential to restore it within 18 hours, in order to prevent the device from shutting down and the continuity of the process to be lost.

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