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Presentation of the content

In the first article we present, *Design and construction of a token vending machine for wireless internet connection*, by SAMPAYO-RODRIGUEZ, Carmen Jeannette, CASTILLO-QUIROZ, Gregorio, HERNANDEZ-LUNA, Aldo and CABRERA-HERNANDEZ, Iberio, with adscription in the Instituto Tecnológico Superior de Huauchinango, in the next article we present, *Solar concentrating and redirecting systems for application in an agricultural construction*, by BETANZOS-CASTILLO, Francisco, DE ANDA-LÓPEZ, Rosa María, FUENTES-CASTAÑEDA, Pilar and CORTEZ-SOLIS, Reynaldo, with adscription in the Tecnológico Nacional de México/TES Valle de Bravo, in the next article we present, *Aligning system for a pick-and-place BGA soldering equipment*, by TALAVERA-VELÁZQUEZ Dimas, GUTIERREZ-VILLALOBOS José Marcelino, RIVAS-ARAIZA Edgar Alejandro and MEJÍA-BELTRÁN Efraín, with adscription in the Universidad de Guanajuato and Universidad Autónoma de Querétaro, in the next article we present, *Two Axis Solar Tracker Monitoring* by SANTANA-CRUZ, Rene Francisco, OLIVO-FLORES, Marco Antonio, OCAMPO-MARTÍNEZ, Rafael and SOTELO-MATÍNEZ, Samuel, with adscription in the Universidad Tecnológica de San Juan del Río.

Content

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Design and construction of a token vending machine for wireless internet connection

Diseño y construcción de máquina expendedora de fichas para conectarse a internet inalámbrico

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Abstract

This paper presents the design and construction of a machine that automates the process of selling access credentials to a wireless network. For its construction, the V methodology for project management was followed. The machine consists of a closed box with two buttons on the outside to indicate the start and end of the transaction, a 16x2 LCD screen with an I2c conversion interface to show transaction, user and password indications, a multi-currency purse and four LED lights that serve as indicators of the amount entered. Internally the machine consists of an ESP-8266-E development board, an Mb102 breadboard source module, a 12V 2.5A eliminator, a 5.0 V universal charger cube and a breadboard. Logically, the web-based spreadsheet (*Google sheets*), *Google apps script* and the Arduino integrated development environment were used. The result is a low-cost prototype, which provides controlled internet access credentials for multiple users.

Prototype, Credentials, User, Automation, Process

Resumen

En este artículo se presenta el diseño y construcción de una máquina que permite automatizar el proceso de la venta de credenciales de acceso a una red inalámbrica. Para su construcción se siguió la metodología en V para la gestión de proyectos. La máquina consta de una caja cerrada de lámina que muestra en su exterior dos botones para indicar inicio y fin de transacción. una pantalla lcd de 16x2 con interfaz de conversión I2c para mostrar indicaciones de transacción, usuario y contraseña, un monedero multimoneda y cuatro luces leds que sirven como indicadores del monto ingresado. De manera interna la máquina consiste en una placa de desarrollo ESP-8266-E, un módulo fuente para *protoboard* Mb102, un eliminador 12V 2.5A, un cubo cargador universal 5.0 V y una *protoboard.* De manera lógica se utilizó la hoja de cálculo basada en web (*Google sheets*), *Google apps script* y el entorno de desarrollo integrado de Arduino. Como resultado se cuenta con un prototipo de bajo costo, que proporciona credenciales de acceso controlado a internet para múltiples usuarios.

Prototipo, Credenciales, Usuario, Automatización, Proceso

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Introduction

Currently, there are real cases where financial and process results have been improved, thanks to a set of planned actions applying best practices in the vending market. (Junco Lamus, R., 2021).

A vending machine is a mechatronic device that offers a certain commercial product for a certain monetary value. This type of machine is found mainly in places of high public concurrence where it is necessary to establish a simplified, effective and efficient trading protocol. (Calvachi, P. A. D. H., Naranjo, R. E. A., Merchán, P., & Ibarra, A, 2013).

Such is the case of the mechanical construction of a vending machine for handmade masks to be offered through the machine at the Museo de la Ciudad (Quito), the project is requested and financed by the United Nations Development Program (PNUD). (Chérrez Yugcha, J. A., 2022).

Also, the design and construction of a didactic vending machine has been carried out, the students simulate being immersed in a work with a deadline as many companies that work on a project basis do. (MORALES-AGUILAR, E., SANTILLAN-FLORES, S. E., GONZÁLEZ-LÓPEZ, J. M., & VILLALVAZO-LAUREANO, E., 2020).

In addition, we have implemented a business based on an automatic recycling system that provides incentives for users through RVM (Reverse Vending Machines), whose objective is to increase the formal recycling of PET bottles in Lima. (Barycki Korytkowski, H. C., & Soldi Vargas, F. M., 2022).

A great number of tasks and processes have been automated thanks to the fact that nowadays we have within reach technologies that, when combined, contribute to achieve the objective of making our tasks and processes easier.

One area in which the implementation of a vending machine can be used is in the sale of wireless internet access credentials in rural areas, which until now in many places has been done in the traditional way, by purchasing the access credentials at the local store.

Taking this business model as a starting point, the following problems arise regarding the administration and availability of the service:

1. Limited time availability.

At present, in order to acquire access credentials, one must go to the point where the credentials are sold; the business in charge of selling the tokens has a defined schedule of operation and therefore purchases cannot be made outside those hours, which makes it difficult to acquire tokens outside of the hours of operation.

2. Difficulty in tracking sales
.

Not having a shared sales record makes it difficult to track the number of tokens sold during the days when the business responsible for selling the access credentials is not physically present. This situation generates uncertainty because, without updated information, it is not known how many tokens are available and whether it is necessary to create new tokens to provide greater availability.

3. Poor administration.

The only way to know the number of credentials sold is by physically going to the store in charge of selling the credentials.

As a result, there is poor administration of the tokens that are delivered.

In addition, the sale or acquisition of these access credentials can only be made if the business in charge is open. This particular situation limits the sale and acquisition of tokens, since the business may be closed for various reasons.

It has been observed that there is no optimal control that allows to know in an agile way the number of credentials sold and consequently there are no tokens available according to the different packages offered.

Having identified this situation, it has been determined that there is a need to have an option that is able to offer the sale and purchase in a 24-hour schedule.

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It is intended to solve this problem with a web application to achieve the management of the tokens that are made available for sale, allowing efficient management through a real-time report of the tokens that have been sold, also performs a summation of the money that is in the vending machine credentials for internet access, you can also consult the set of credentials to identify whether it is necessary to add more.

For the implementation we used:

1. Google *Sheets*

Google Sheets is a cloud-based spreadsheet program hosted by Google. It is available to any user who signs up for a Google account. Users can easily upload or enter data and then write code to analyze the data. All data entered into Google Spreadsheets is stored on a cloud server (i.e., Google Drive), allowing accessibility whenever a person logs into their Google account, regardless of location or computer.

2. Google Apps Script

It is a rapid application development platform that streamlines and facilitates the creation of business applications that integrate with Google Workspace. Apps Script. Among other things, you can: Add custom menus, dialog boxes and sidebars to Google documents, spreadsheets and forms. Write custom functions and macros for Google Spreadsheets. Publish web applications, either standalone or integrated into Google Sites. Interact with other Google services, including AdSense, Analytics, Calendar, Drive, Gmail and Maps. Create plug-ins and publish them to the Google Workspace Marketplace. (Google developers, 2022), Google Apps Script, (2022).

3. NodeMCU ESP8266 v3

It is an open source firmware and open source development that plays a vital role in designing a suitable IoT product using a few lines of script. The module is mainly based on ESP8266 which is a low-cost Wi-Fi microchip that incorporates a full TCP/IP stack and microcontroller capability. It is presented by the manufacturer Espressif Systems. The ESP8266-E NodeMcu is a complex device, which combines some features of the ordinary Arduino board with the ability to connect to the Internet. (Al Dahoud, A., & Fezari, M., 2018), (Aprendiendo Arduino, 2022), (MakersChile, 2022) y (Mengual, Joan, 2022).

Figure 1 NodeMcu ESP8266 V3 Board

The objective of this research is to find the technology to solve these problems, as well as to present the proposed solution, which consists of building a vending machine that provides users with access to the Internet and is capable of operating 24 hours a day.

This article gives a brief description of the problem to be addressed and the tools that were used, then presents the methodology that was used: the functional requirements to build the machine, the functional design of the system, the technical design of the system, the specification of components, the code, unit tests, component tests and acceptance tests are listed; then the results and conclusions are presented.

Methodology to develop

The activities were ordered according to the steps of the V methodology for project management. (Digital Guide ionos, 2022) y (Ceras, Clara, 2022). como se muestra en la Figura 2.

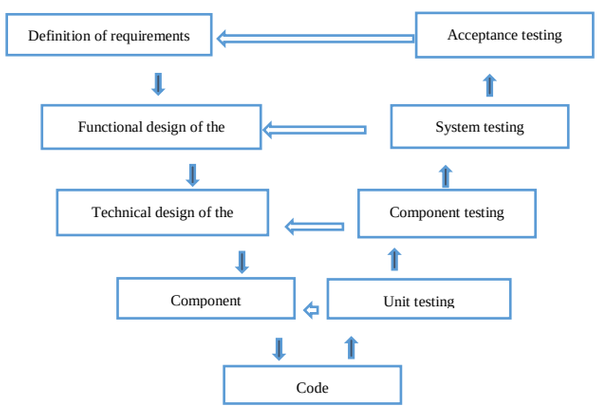

Figure 2 Methodology in V
Own Elaboration

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Definition of requirements

The functional requirements are as follows:

RF01: The vending machine must be able to read a text file containing the credential data that allows access to the wireless network.

RF02: The vending machine must have a multi-currency coin acceptor to accept payment for the sale of access credentials, the accepted currencies will be: $1.00, $2.00, $5.00, $10.00 pesos.

RF03: The vending machine must be able to identify the amount entered in the multi-currency purse to define the login profile of the access credential that the customer will be able to acquire according to the amount entered.

RF04: The vending machine must process the purchase of packages when any of the following amounts are covered: $5.00, $10.00, $15.00, $20.00.

RF05: The vending machine must have an LCD screen that serves as an interface between the user and the machine to display different messages.

RF06: The vending machine should record the credentials that have been sold to maintain optimal control of those available for sale.

RF07: The vending machine must update the list of credentials available for sale.

RF08: The vending machine must have a button to activate coin detection.

RF09: The vending machine must have a button to confirm the purchase of credentials.

RF10: The vending machine shall have a reset button.

1. Functional design of the system

At this stage, a design was developed that was capable of functioning and satisfying the requirements.

Figure 3 shows the state diagram showing the activities performed by the vending machine.

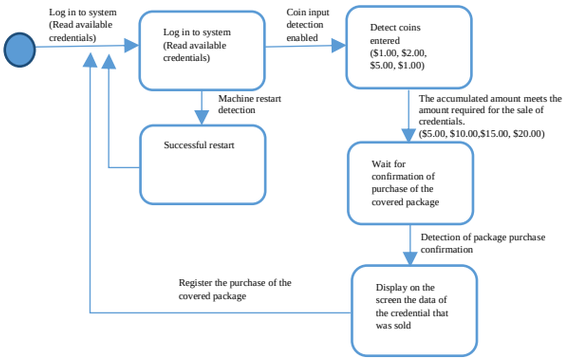

Figure 3 State diagram of the vending machine
Own Elaboration

The functional design approach took into account the actual operation of the vending machine.

2. Technical system design

Figure 4 shows the design of the physical components that make up the vending machine.

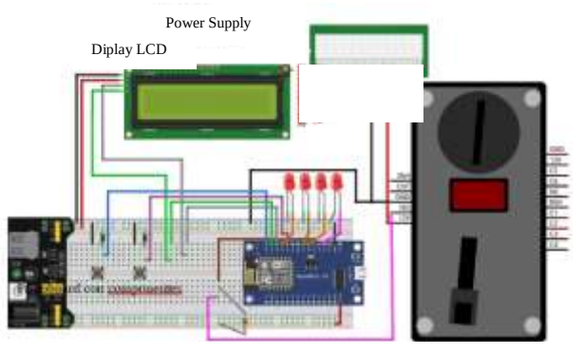

Figure 4 Technical design of the automaton machine

3. Component specification

In this stage, the components used to achieve the correct operation of the vending machine were defined,

Table 1 shows the components used for the construction of the access credential vending machine:

Descripción	Imagen
Development board ESP-8266-E	
LCD display	
Multi-currency coin purse	

Power Supply	
Push Buttons	
LED lights	

Table 1 Components used
Own Elaboration

4. Code

At this stage, as a first step, the Arduino IDE was configured in order to program the ESP-8266-E board. In Figure 5, we can see part of the code to be uploaded to the ESP-8266-E board.

Figure 5 Programming window of the Arduino IDE

It was necessary to configure the permissions within the Google account to allow writing to the Google Spreadsheet application.

Figure 6 shows how the script was configured and programmed to achieve communication between the ESP-8266-E board and Google Spreadsheet.

Figure 6 Google Spreadsheet Script Programming Window

Once the code was written in the script, the implementation was done so that the Google system would allow the script to work.

5. Unit testing

At this stage, the correct operation of the different components selected was corroborated.

The connections of the pins of the ESP-8266-E board with the buttons that will be used to activate the coin input detection to the multicurrency coin acceptor were verified.

The connection between the ESP-8266-E board and the multi-currency coin acceptor was corroborated since the negative wires must be joined in order to have a single circuit.

A very important component is the LCD display as it performs the function of informing the customer of the status of the machine, it shows information of amount that has been entered and once the customer presses the button to confirm the purchase, the LCD displays the user and password with which the customer will be able to connect to the wireless network.

Another very significant component is the power module, this component provides the necessary power to the ESP-8266-E board and also has a connection to the multi-currency coin acceptor.

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6. Component testing

In this stage, the components that make up the project were tested. In order to perform these tests, it was necessary to corroborate the interconnection between the different components, as well as the correct operation of the code programmed for each component in particular.

The connections of the pins of the ESP-8266-E board were verified with the buttons that have been included in the vending machine, the first button is the activation of the detection of the coin entry to the multi-currency purse, the second button included in the system is the confirmation of the purchase of a package.

The tests were carried out by simulating the pressing of the coin deposit detection button and yielded the following results, which are shown in Figure 7.

Figure 7 Arduino IDE Serial Monitor when the coin detection button is pressed

The tests were performed by simulating the click of the purchase confirmation button as shown in Figure 8.

Figure 8. Image of the result on the serial monitor when clicking the purchase confirmation button.

When performing tests it was of utmost importance to focus on the multi-currency coin acceptor, as well as the different components, the connection between it and the ESP-8266-E board was verified; once the connection was verified, operation tests were performed with the programmed code.

The tests corroborated that the coin acceptor will send the correct number of keystrokes according to the inserted coin.

Once the connection has been established, the machine will wait for the button to be pressed to initiate the coin insertion detection and when the button is pressed, the machine will start to supervise if any interruptions are generated by the multi-currency purse to know if any coin has been inserted and also to know what denomination the coin is.

Once it has identified whether coins have been deposited in the vending machine, it will show the total accumulated amount. Figure 9 shows the accumulated amount on the screen.

Figure 9 LCD display showing total accumulated amount

Once the user has paid for the entire package, whether it is $5.00, $10.00, $15.00 or $20.00, he/she can press the purchase button and the machine will display the user and password as shown in Figure 10, with which he/she will be able to connect to the wireless network.

Figure 10 LCD screen showing the user and Password that has been acquired.

Once the time during which the user and password that was acquired will be displayed has expired, the machine will return to the standby state, where it will be monitoring the pressing of the coin input detection button.

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7. Acceptance tests

Once the system tests were completed, the acceptance tests were performed.

To perform the acceptance tests, the first step was to verify the power supply, since it is essential that the machine is supplied with the correct voltage. Figure 11.

Figure 11 Power supply for the machine circuit

Subsequently, we verified that the machine turned on and successfully established the connection to the wireless network.

To verify that these steps are carried out correctly, the LED lights blink according to the number of coins entered once the amount is accumulating.

After having established the connection, the machine makes a record in the spreadsheet, this record contains the legend "Start" and in another cell, the date and time the record was made is stored. In Figure 12 we can see the start record highlighted in yellow in the Google Spreadsheet.

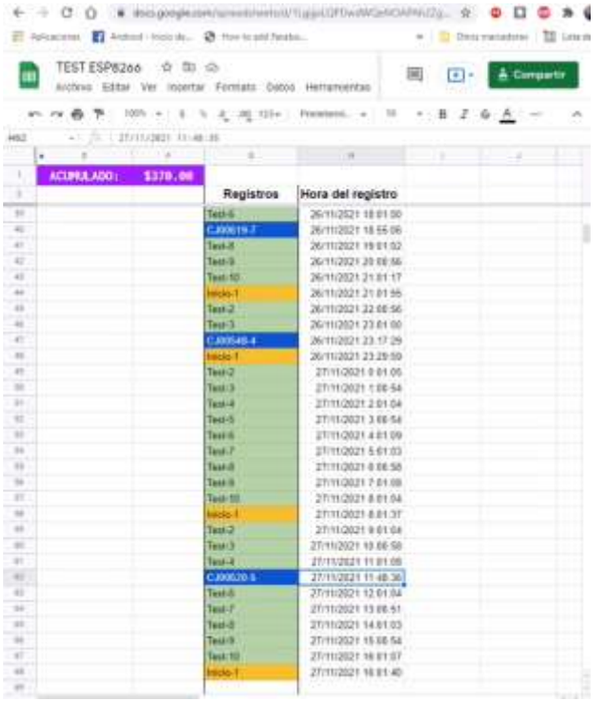

Figure 12 Startup record highlighted in yellow in the Google Spreadsheet

In order to provide a summary option of the information that is being stored in the spreadsheet, a tab was created that contains a summary of the information of the credentials that have been sold. As can be seen in Figure 13.

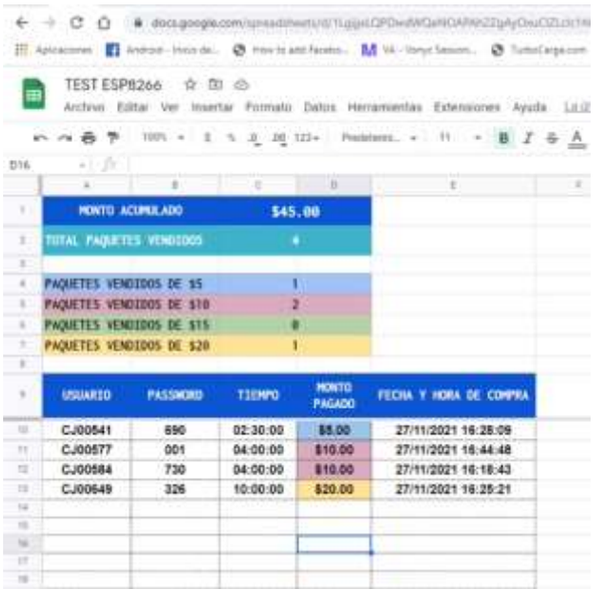

Figure 13 Summary of sales in the Google Spreadsheet

Results

The results obtained from the development of the project "vending machine for the sale of access credentials to a wireless network" are shown below.

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By developing this solution, hardware and software products could be obtained, the first product is the vending machine shown in Figure 14.

Figure 14 Vending machine

Another product is the file that is responsible for separating the data that are provided through a text file, this spreadsheet separates in columns the user data, password and browsing time, as shown in Figure 15.

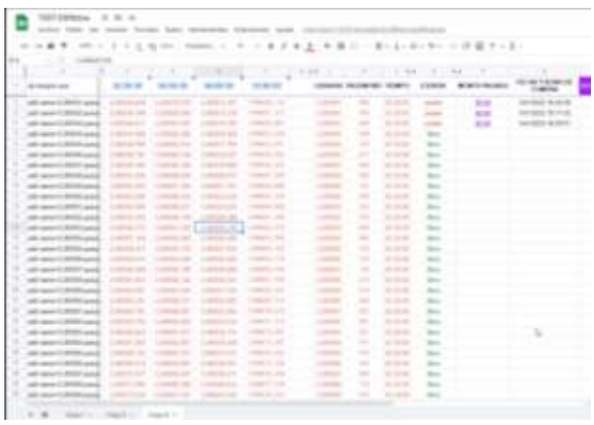

Figure 15 Google spreadsheet with required fields

Within this spreadsheet, there is a tab where the acquired credentials are registered, in this tab there is also the information of the date and time when the registration was made, as well as the amount accumulated so far, this action of registering the data is achieved through the Script that performs the function of intermediary between the ESP-8266-E board and the Google spreadsheet. As shown in Figure 16.

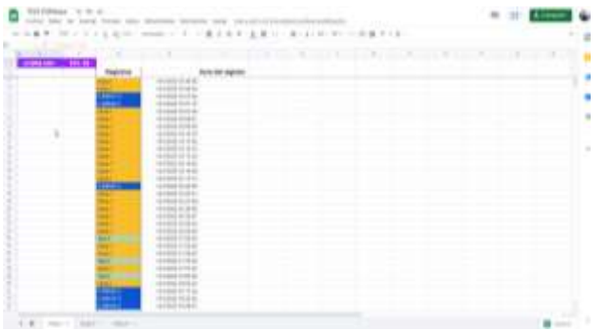

Figure 16 Google spreadsheet tab showing the log of purchased credentials

Within the spreadsheet, there is another tab that contains a summary of the records made, the summary shows the number of packages sold for each of the types of packages.

Figure 17 shows the summary of the sales made.

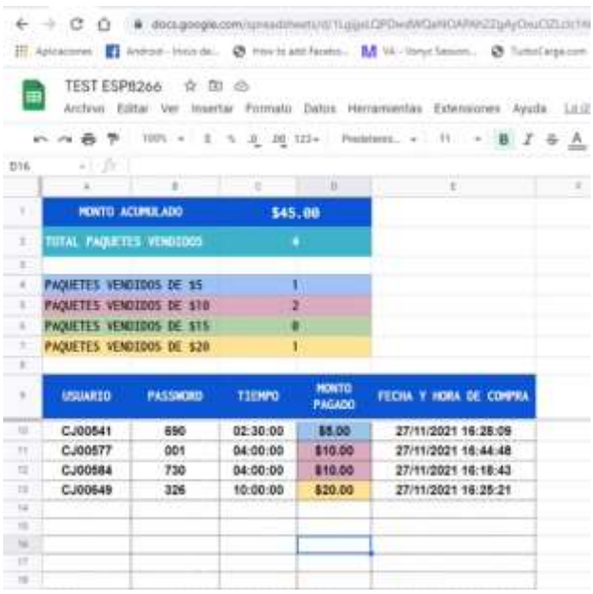

Figure 17 Spreadsheet tab showing the summary of sales made

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Conclusions

This paper presented the proposal for the design and construction of a machine for the sale of credentials for access to a wireless network, economic, which will be used to implement in a rural community in order to automate the process that is currently done in a traditional way.

The proposed machine will be used in businesses that already offer access credentials to connect to the internet, what was sought is a way to make these same tokens work with the equipment that is already in place, This process eliminates the problem of selling tokens that were printed on sheets of paper. With this proposal, the confidentiality of the passwords is guaranteed since only the person who enters the coins, selects the amount and authorizes the transaction will be able to see the user and the assigned password.

Finally, we can conclude that a prototype of a low-cost and functional vending machine was built that allows the acquisition of credentials 24 hours a day without the need to wait for a person to provide it.

In future work the vending machine will be implemented in a rural community to conduct a study on the level of acceptability of the machine to be introduced as a business model.

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Solar concentrating and redirecting systems for application in an agricultural construction

Sistemas de concentración y redireccionamiento solar para su aplicación en una construcción agropecuaria

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Abstract

This work deals with the design and evaluation of a concentrator-luminoduct system for daylighting. A concentrator with a truncated cone profile was designed to capture, transfer and diffuse sunlight, which was concentrated and transported by reflection along the walls of the system and finally projected to the interior of an agricultural building. The illuminance achieved by the system with and without concentration was compared and a significant difference in illumination levels was found. The concentrator obtained concentration factors between 1.7 and 3.6. The critical aspects that determined the concentration of natural light were the angle of acceptance (45.68º), the orientation (45º and 90º) and the reflectance of the material used (95%), in addition, it was possible to reduce the dimensions of these systems, conserving the illuminance. It was proven that this system increased the illumination of the interior space where the light did not reach naturally, improving the illuminance levels (300-500 lx), according to CIE (Commission Internationale l'Eclarige). It was demonstrated that the system represents a viable and adaptable solution for naturally illuminating buildings.

Agricultural, Reflectance, Concentrated, Illumination, Solar collection

Resumen

El presente trabajo trata sobre el diseño y evaluación de un sistema concentrador- luminoducto para iluminación natural. Se diseñó un concentrador con perfil troncocónico para captar, transferir y difundir luz solar, esta fue concentrada y transportada mediante reflexión a lo largo de las paredes del sistema y finalmente proyectada al interior de una construcción agropecuaria. Se comparó la iluminancia lograda por el sistema con y sin concentración encontrándose una diferencia significativa en los niveles de iluminación. El concentrador obtuvo factores de concentración entre 1.7 y 3.6. Los aspectos críticos que determinaron la concentración de luz natural fueron el ángulo de aceptancia (45.68º), la orientación (45º y 90º) y la reflectancia del material utilizado (95%), además, se logró reducir las dimensiones que ocupan estos sistemas, conservando la iluminancia. Se probó que este sistema aumentó la iluminación del espacio interior en donde la luz no llegaba de forma natural, mejorando los niveles de iluminancia (300-500 lx), según CIE (Commission Internationale l'Eclarige). Se demostró que el sistema representa una solución viable y adaptable para iluminar construcciones naturalmente.

Agrícola, Reflectancia, Concentrada, Iluminación, Captación solar

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Introduction

Most human and biological activities on earth are governed and powered by the sun, as the sun has been a source of illumination throughout human history. The development and use of efficient artificial lights has led humans to separate themselves from the healthiest and best source of illumination: natural light. Studies have shown the benefits in health, safety and labor productivity when buildings are naturally illuminated (Boyce, 2022; Roche, 2000). In addition to the quality of natural light, another reason to use it is its compatibility with lighting control systems to achieve a reduction in the use and cost of conventional energy, thus achieving a sustainable system.

Undoubtedly, sunlight is beneficial inside facilities that house living beings (air quality, non-toxic materials and occupants' health) (Gissen, 2002), resulting paradoxical the use of artificial light during daylight hours, being that there is a great abundance of natural light for illumination (Muhs, 2000). Consequently, although artificial light provides sufficient levels of illumination, it cannot provide physiological and psychological comfort (Brainard & Glickman, 2003) (Jenkins & Munner, 2003:2004), benefits of natural light. However, transporting natural light into the facility is sometimes not possible with simple windows and/or domes. Solar concentrators coupled with light pipes are passive systems, and represent a simple solution to the problem of natural light deficiency.

Normally, any light transport system refers better performance when it has a system of concentration and tracking of the sun, with which small diameters can be used, but with respective increases in the costs of the system, in addition, highly reflective materials and collimation systems are required.

On the other hand, another important factor that directly determines the performance of daylight transport systems is the direct sun component. The performance of these systems is reduced when only the diffuse component of the light is present (cloudy sky). Solar concentrators have been used for heat production purposes and to improve the efficiency of solar cells, but have not been used for daylighting purposes in agricultural buildings.

The natural light transport systems that have been developed, applied and studied worldwide have been used to illuminate interior spaces of large architectural buildings (lumiducts, lenses, prismatic guides and optical fibers) (Callow, 2003). Researchers have focused on evaluating and improving the efficiency of the components of these systems (collection, transport and emission-distribution), using experimental modeling techniques, which makes the research costly and of little applicable scope (Mohammed & Carter, 2006; Hansen, et al, 2006; Jenkins & Munner, 2003:2004; Callow & Shao, 2003; Carter D., 2002).

From the above, we can deduce and verify the emergence of new details susceptible of study and applicability to other areas, such as agriculture and livestock, in order to reduce costs in the consumption of non-renewable energy and those of the natural lighting system itself.

Therefore, the study of this thesis evaluates passive and active daylight transport systems and investigates the solution by means of a new configuration of a tracking system with solar concentration and redirection, which captures, concentrates and disperses natural light, with application in agricultural installations, and which represents an efficient and feasible solution.

Methodology

1. Mathematical modeling

The model that is selected to calculate the performance of the lumiducts is shown schematically in Figure 1, in general the mathematical model includes the determination and selection of the sky conditions:

– Calculation of daylight availability (lx),
– Dimensions of the entrance aperture of the system,
– Collection area (solar concentration, depending on the solar elevation angle),
– Incoming light power (available light depending on collection area),
– Light reflected and not reflected by the system),
– Extracted and distributed light (illuminance levels obtained).

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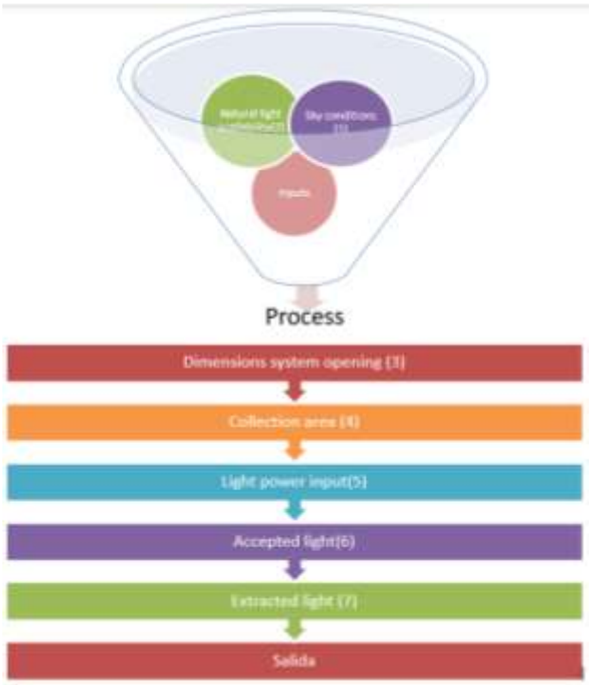

Figure 1 Schematic diagram of daylighting model performance calculation
Source: Own

2. Availability of daylight

To design and analyze the performance of light transport systems, it is necessary to know the amount of light according to geographical location, which can be determined by measurements of horizontal illuminance at hourly average intervals, direct and diffuse, or from the illuminance distribution of the sky vault. Included are means of obtaining daylight data, which includes direct measurement of daylight or solar radiation, models based on measured data, and theoretical models. Additionally, models to estimate the luminance distribution for clear and cloudy sky conditions according to CIE, and the theoretical irradiance values described and determined by Bounger's Law.

3. Sky models

Daylight can be evaluated for different conditions, this section describes the sky model used in this work. Figure 2 shows the scheme for calculating daylight availability (γ_s solar altitude, γ_p altitude angle path in the sky), for clear or clear sky. CIE standard.

While Figure 3 shows the scheme for calculating daylight availability (γ_s solar altitude, γ_p altitude angle path in the sky), for clear or clear sky. CIE standard.

Figure 2 Schematic for calculating daylight availability (γ_s solar altitude, γ_p altitude angle path in the sky), for clear or clear sky. CIE standard
Source: Own

Figure 3 Schematic for calculating daylight availability (γ_s solar altitude, γ_p altitude angle path in the sky), for cloudy sky. CIE standard
Source: Own

To calculate the luminance distribution of the sky, it is necessary to locate the solar position on the celestial vault and the appropriate geometry that describes it (sky types). By finding the luminance of the sky, it is converted to illuminance.

4. Study model propose

For the present study, a Dome+Fresnel (passive concentration) + Lumiduct + Emitter type model was considered, hereafter referred to as DFLE.

The daylighting system will be mounted in a prototype house, on which light sensors will be mounted at the entrance and exit of the system, this will allow measuring the amount of light that is transported within the system.

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For this, the following 8 configurations will be made, where:

$\emptyset = inlet\ diameter$,
$L = length\ of\ the\ lumiduct$, and
$angle = angle\ of\ entry\ of\ the\ rays$

Table 1 shows the study configurations.

Configuration	Parameters
1	$\emptyset = 254\,mm\,(10\,")$ $L = 1m$ $angle = 90°$
2	$\emptyset = 356\,mm\,(14\,")$ $L = 1m$ $angle = 90°$
3	$\emptyset = 254\,mm\,(10\,")$ $L = 2m$ $angle = 90°$
4	$\emptyset = 356\,mm\,(14\,")$ $L = 2m$ $angle = 90°$
5	$\emptyset = 254\,mm\,(10\,")$ $L = 1m$ $angle = 45°$
6	$\emptyset = 356\,mm\,(14\,")$ $L = 1m$ $angle = 45°$
7	$\emptyset = 254mm\,(10\,")$ $L = 2m$ $angle = 45°$
8	$\emptyset = 356mm\,(14\,")$ $L = 2m$ $angle = 45°$

Table 1 Experimental configurations
Source: Own

Results

The results obtained from the 8 models generated for this study are presented graphically below, showing the behavior of illuminance, measured on a normal, cloudy or clear day in two different months, December and January.

Why consider these months, because they are considered critical in the year, they are the months with the least amount of illuminance, in addition to having less time of natural lighting, the behavior in these critical months can identify if the system is viable and efficient.

1. Configuration 1. ∅=254 mm (10 "), L=1m, angle=90°.

The graph in Figure 4 shows the number of lux allowed for this configuration:

It can be observed that maximum interior illumination levels of 1000 lux are reached, which exceeds the average visual comfort in work areas of 400 lux for light work and 500 lux for specialized work.

In addition, at an average level, it can be noted that the system handles values that allow work to be carried out, since the measurement is taken at a height of 65 cm.

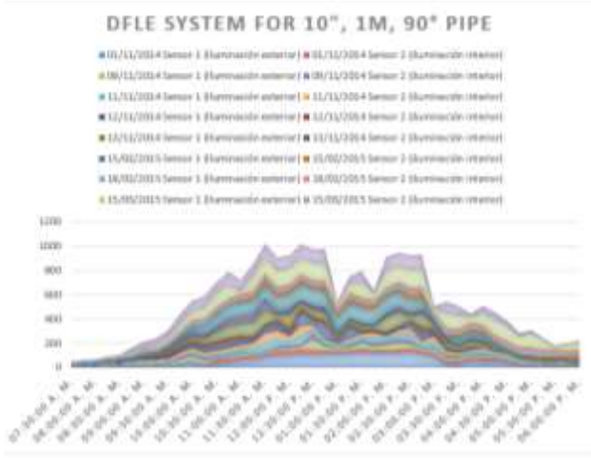

Figure 4 Graph of results for configuration 1
Source: Own

2. Configuration 2. ∅=356 mm (14 "), L=1m, angle=90°

The graph in Figure 5 shows the number of lux allowed for this configuration:

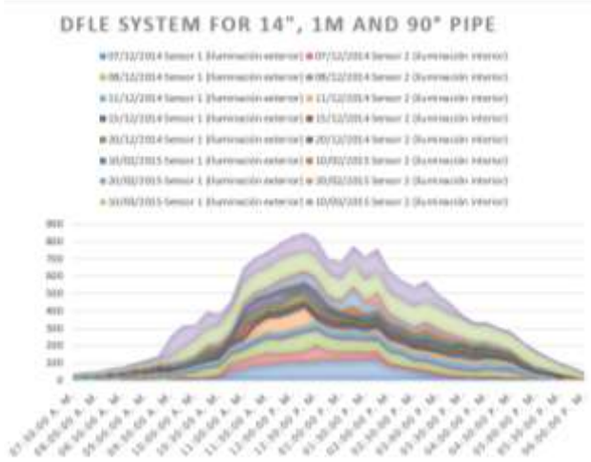

Figure 5 Graph of results for Configuration 2
Source: Own

As can be seen in this configuration, average values between 100 and 850 lux were obtained, which makes the system efficient, since it allows both light and special works, also measured at 65 cm from the ground.

3. Configuration 3. Ø=254 mm (10 "), L=2m, angle=90°.

In the graph shown in Figure 6, the behavior of the given system for configuration number 3 can be observed.

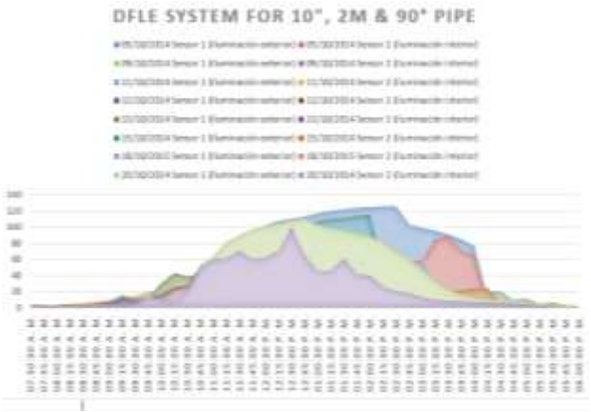

Figure 6 Graph of results for configuration 3
Source: Own

It can be observed that for this system, in spite of the fact that the length of the lumiduct is increased to 2m, illuminance values of between 100 and 1100 lux are obtained, which allows both light and special works to be generated, and will allow the length of the lumiduct to be increased, without affecting the amount of illuminance that enters the work site.

4. Configuration 4. Ø=356 mm (14 "), L=2m, angle=90°

The graph in Figure 7 shows the behavior of the system.

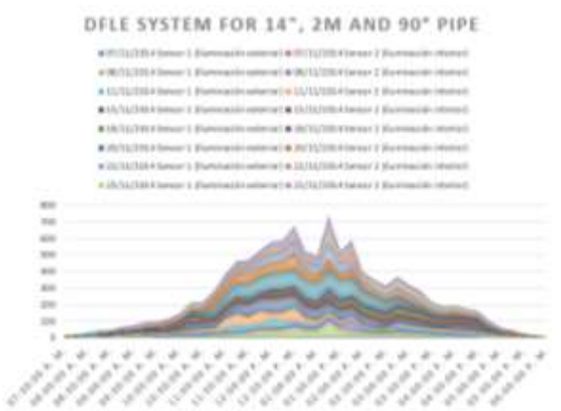

Figure 7 Results graph for configuration 4
Source: Own

The performance of this system shows that internal illuminances are received in an average of 100 to 750 lux, recommended for indoor work. Therefore, the length of the lumiduct can be increased and the illumination levels do not decrease with respect to a shorter length.

5. Configuration 5. Ø=254 mm (10 "), L=1m, angle=45°

The graph in Figure 8 shows the illuminance results of the System using configuration 5.

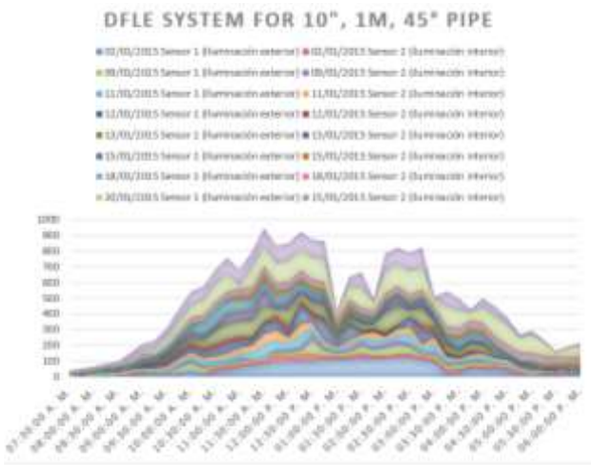

Figure 8 Graph of results for configuration 5
Source: Own

As can be seen in the graph in Figure 102, the illumination levels for this daylighting model configuration are in the range of 75 to 900 lux, which allows indoor work to be performed between the hours of 10:00 to 17:00. Note that even when using a 45° elbow, the system is able to transport the light rays indoors.

6. Configuration 6. Ø=356 mm (14 "), L=1m, angle=45°.

The graph in Figure 9 shows the results obtained from the modeled system under configuration 6.

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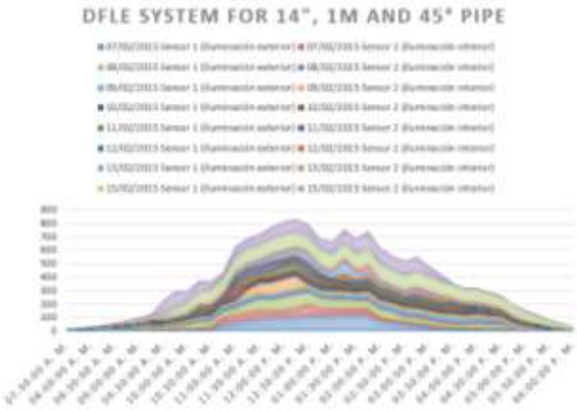

Figure 9 Graph of results of configuration 6
Source: Own

It can be observed that the behavior of the system shows that the amount of interior illuminance is in the range of 65 to 800 lux, which allows to develop works inside the building, it can be observed that the angle given to the system does not affect the transport of light rays into the interior.

7. Configuration 7. Ø=254 mm (10 "), L=2m, angle=45°

The graph in Figure 10 shows the results obtained in terms of illuminance in the configuration 7 system.

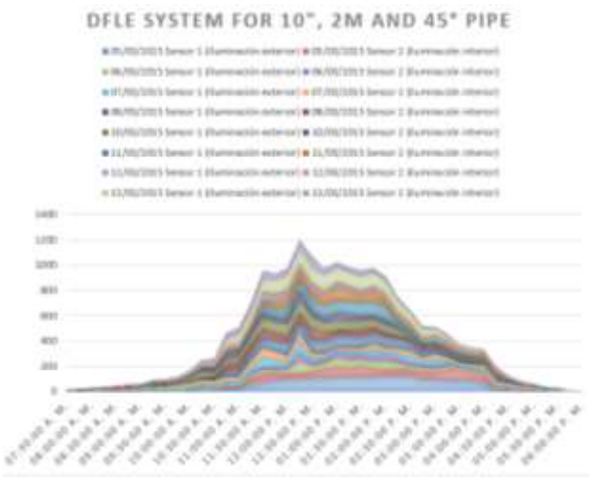

Figure 10 Graph of results for configuration 7
Source: Own

It can be observed that this system shows good levels of interior illumination, since values from 100 to 1200 lux were obtained, which allows performing specialized work inside the building, once again the angle does not affect the transport of light into the interior.

8. Configuration 8. Ø=356 mm (14 "), L=2m, angle=45°

Figure 11 shows the graph of the results obtained for this configuration.

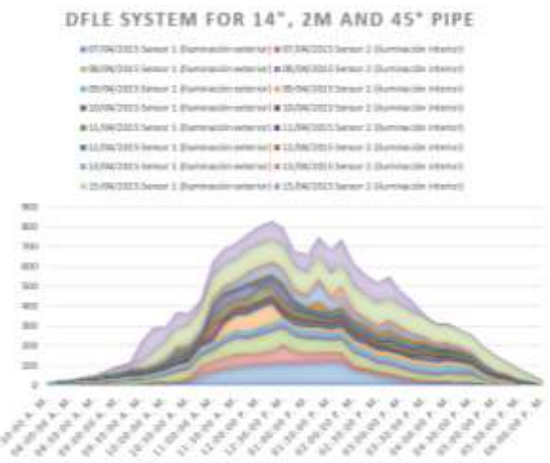

Figure 11 Graph of results for configuration 8
Source: Own

It is observed that under this configuration, the system obtains an average illuminance value of between 65 and 800 lux, which allows for good interior illumination, allowing the development of various tasks and jobs.

Acknowledgments

Special thanks to the Tecnológico de Estudios Superiores de Valle de Bravo, since its support has allowed the development of this project, important stages have been accomplished that lead to an advance in technological development and in the training of human resources.

Conclusions

The concentrator obtained concentration factors between 1.7 and 3.6. The critical aspects that determined the concentration of natural light were the angle of acceptance (45.68º), the direction (45º and 90º) and the reflectance of the material used (95%). In addition, it was possible to reduce the space taken up by these systems, conserving the illuminance. It was proved that this system increased the illumination of the interior space where the light did not reach in a natural way, improving the illuminance levels (300-500 lx), according to CIE (Commission Internationale l'Eclarige).

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It was demonstrated that the system represents a viable and adaptable solution to illuminate constructions naturally.

It was also noted that the selected parameters do not really influence to a great extent the quality of natural light that is introduced in an agricultural construction, but it is the fact of the days of the year, the sky conditions, and the position of the structure to be illuminated.

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Aligning system for a pick-and-place BGA soldering equipment

Sistema de alineación para un equipo de selección y colocación componentes BGA para un equipo de soldar

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Abstract

The necessity to have semiconductor components inside mobile, thinner and lighter devices, has created a new form to solder these electronics components to their main boards. This work for soldering superficial mounting semiconductors has become a precision task. For that reason, nowadays, the construction of equipements to pick and place semiconductors, has got an important attention. A high accuracy aligning systems are required in those equipements. In this work, an aligning prototype for superficial soldering systems is presented, using a laser devise with a set of mirrors, and an aligning mechanic system, which is low-cost, modular and upgradeable.

Superficial mounting, Aligning system, Automation prototype

Resumen

La necesidad de tener componentes semiconductores en dispositivos móviles livianos y delgados, ha hecho que la forma de soldar estos componentes a sus tarjetas base se haya vuelto ahora de forma superficial y una tarea que demanda mucho cuidado. Por tal razón actualmente se construyen sistemas que sean capaces de colocar a los semiconductores en su lugar dentro de la tarjeta para que estos puedan ser soldado. Dicha tarea requiere un equipo que pueda tener un sistema de alineación de una gran precisión. Este trabajo presenta un sistema alineador para equipos de soldadura de montaje superficial, utilizando un sistema laser, con un conjunto de espejos y un sistema mecánico posicionador de bajo costo, modular y actualizable.

Montaje superficial, Sistema de alineación, Prototipo de automatización

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† Researcher contributing as first author.

Introduction

Nowadays, in the manufacturing of electronic boards for several devices such as cellular phones, computers, tablets, house appliances, TVs, etc., which uses semiconductors devises, the use of micro-placing systems is required. High-resolution optical systems demand a micrometer precision aligning, using X, Y and Z mechanisms, according to Mearig 1995. Also, the use of micro-placing equipment with automatic control to align is required in the construction of laser beam devises in order to keep in its place the laser beam generator cavity, Pascariu 2003. In this work, an aligning mechanism is developed based on a laser with a micrometer precision and this system allows to align a BGA component soldering pick-and-place equipment.

The misalignment effect on the ball pins under BGA semiconductor can be a server problem during reflow soldering, even using flux the correct contact between board tracks and electronic devise can be in risk of a weak union, which can produce that union cracks later with time, as explained in Chan 2001.

Moreover, another important thing to consider is the restoring force arising and the self-alignment occurring during reflow soldering, Krammer 2014. The microplacing devises are widely used in the fields of optic, medicine, industry, mechatronics, mechanics, aeronautics and, electronics, among others, where movements in the order of micrometers are required.

The design and construction of microplacing devises, needs of a high accuracy and a resolution, as described by Talavera 2016 and Huang 2013. Also, the development for a three-axe microplacer in Carrero 2021. Construction of two flexible mechanism activated by SMA, Abiud 2015.

Finally, in Vona 2006 microplacer are used to control robos considering friction compensation. In fact, recent works for XYZ table, such as Filer 2022, Hernandez 2022, Maldonado 2002 and Saavedra 2022 where new strategies to control the system are presented and not only hardware descriptions are reported

Pick-and-place systems

Evidently BGA component soldering is a complex task, since semiconductor must be picked and placed in its right place, high accuracy is needed. These pick-and-place devises are design from low integration equipment to high density circuit boards, their cost is depending on the component-handling capacity, in the figure 1, and a basic pick-and-place machine is presented.

For example, on every bord there are spots especially located so the system knows the board orientation and the exact place for BGA components. This positioning is accomplished by an image recognition system and an X-Y table. The equipements based on image reignition, tend to be expensive, a commercial image recognition machine is presented in figure 2. Additionally, since they are commercial devises, they usually are closed architecture, so maintenance is only done by manufacturer.

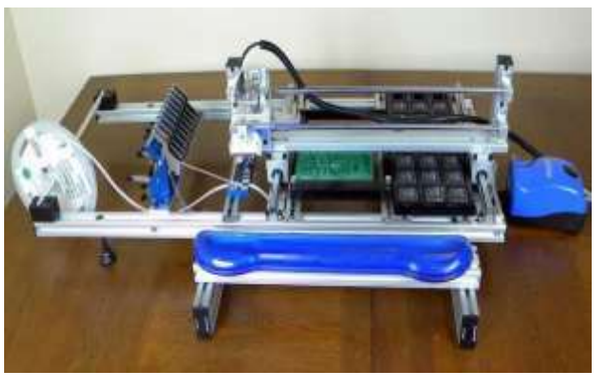

Figure 1 A commercial equipment model SMT pick-and-place system SMT-PLC-2

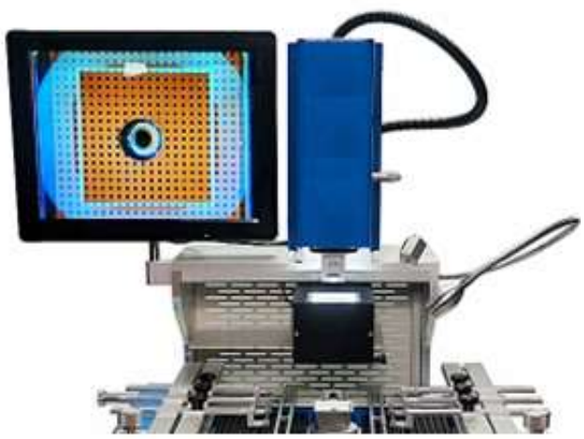

Figure 2 An image recognition and position equipment

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Aligning system operation

First, this work is focused on the alignment by means of a green laser, which is based on an experimental setup very similar to a Michelson-Morley interferometer. When the alignment is taking place in the mechanism and force a laser beam through one of the holes, which are drilled on a n inner side of the structure left arm. BGA pins are simulated by these holes and PCBs are settled in rectangular sets where they must be soldered. It is inside these holes, where the intensity of the optical light power, is measured by a photodetector.

Afterwards, vertical and longitudinal axes are moved different distances in millimeters, until the same optical power measurements are accomplished. In this form, alignment is corroborated. Then, the pick-and-place soldering station will be aligned with this system. The control stage is the one in charge of performing the micromovements in each axe, the vertical and the horizontal one. In figure 3, this part of the platform is presented

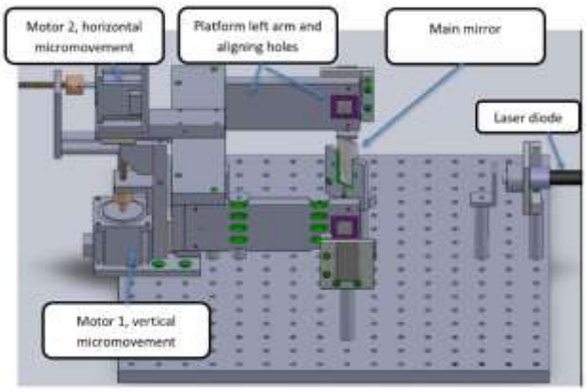

Figure 3 Design of the aligning system and its parts

System proposed

Afterward, the aligning platform is form by two stepper motors connected to a Tb6560 driver, which is connected and controlled by an ATmega 2560 board, as seen in figure 4. the system is communicated to the computer by USB-port. The X and Y axes are mechanism mounted on lineal rails; both axes are moved by the two stepper-motor with micrometric screws. The tow motors are independently controlled by the main board and the optical power meter. The screw shaft-connected to the motors give linear movements with a chord pitch resolution of 0.3175 mm.

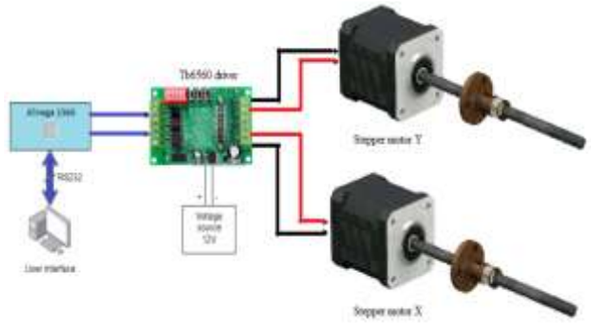

Figure 4 Electronic stage to move the stepper motors

Hence, the optical system is developed and presents some similarity with a Michelson-Morley interferometer. It uses a CCD camera, a set of mirrors is used to split the laser in two directions, come back to one point and get back to the laser power intensity meter, The part of the system for laser measurement is presented in figure 5.

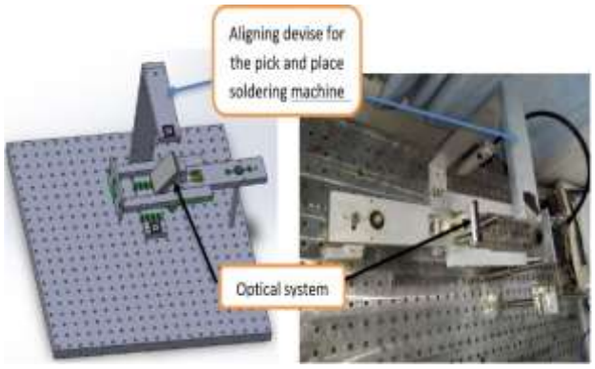

Figure 5 Power intensity meter settled on the platform

Then, the complete system is integrated and conformed to align pick-and-place machines, the aligning station and function can be observed in figure 6.

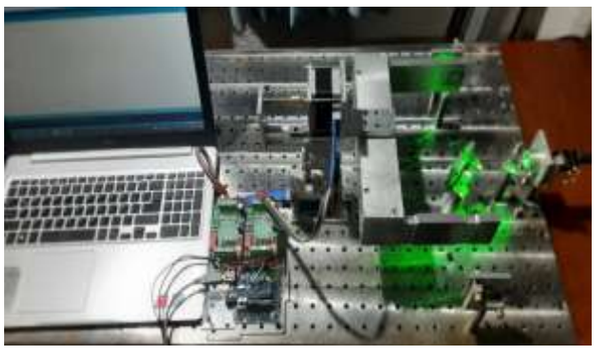

Figure 6 Aligning platform in operation

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Finally, in order to determine the system is aligned and the pick-and-place machine can start moving, a leaser power meter is used, now with that, it is able to observe and determine the mechanism is completely aligned, as illustrated in figure 7. At this part of the project the measurement is observed on a display; however, the objective is to take this signal to the computer interface so the system performances all the aligning process by itself.

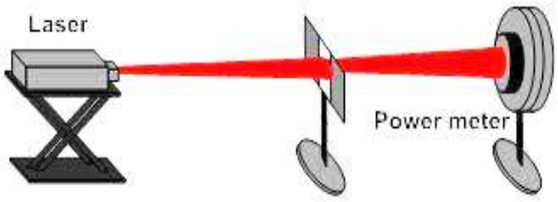

Figure 7 Aligning platform in operation

Results

The system shows a high accuracy when moving, since micrometric screw were used to move each axe and motors are configurated to turn in half steps. Displacement of 0.01 mm were measured during its aligning test. A new design of aligning is presented for Pick-and-Place machines and other systems, where alignment is required

Conclusions

A high accuracy aligning system is achieved by using a laser beam, a set of mirrors and stepper-motor controlled platform. The system has the advantage of easily being reconfigured and updated at low cost. Micromovements are ensured and performed thanks to the micrometric screw. A Michelson-Morley interferometer was developed and manufactured.

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Two Axis Solar Tracker Monitoring

Monitoreo de Seguidor Solar de Dos Ejes Tipo Monoposte

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Resumen

Los seguidores solares han surgido como una alternativa para una mayor captación de energía solar para los paneles solares. Sin embargo, los seguidores solares pueden llegar a fallar o tener cambios repentinos en su seguimiento, por lo que se requiere conocer las variables del seguidor solar en todo momento. Esto se puede lograr a través de una comunicación tipo IoT, esta consiste en emplear microcontroladores, computadoras de placa reducida y una comunicación que envie los datos a algún servidor. Este trabajo propone un esquema de monitoreo para los seguidores solares de dos ejes tipo monoposte. A diferencia de los trabajos publicados en el estado del arte, este tiene mayores funcionalidades y flexibilidad, utilizando una comunicación Wifi con la Raspberry PI 4B. El esquema de monitoreo se ha validado experimentalmente, implementando en los motores para un seguidor solar de dos ejes tipo monoposte, proporcionando un excelente desempeño a lo largo de sus trayectorias.

Monitoreo, Seguidor solar, Paneles solares

Abstract

Solar trackers have emerged as an alternative for increased solar energy collection for photovoltaic panels (PV). However, PV trackers could eventually fail or have unexpected changes during tracking, requiring continuous knowledge of the solar tracker parameters at any time. It is possible to accomplish with IoT communication, which consists of implementing microcontrollers, embedded computers and network communication to transmit the information to a server. This paper presents a monitoring scheme for two-axis single pole solar trackers. In contrast to the published papers in the state of the art, it has more functionality and greater flexibility, employing a Wi-Fi connection with the Raspberry PI 4B. This monitoring scheme has been experimentally tested using the motors for a two-axis single pole solar tracker, resulting in an excellent performance along their trajectories.

Monitoring, Solar tracker, Solar panels

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I. Introduction

In recent years, there has been a growing interest in producing electricity in a more environmentally friendly way, while seeking to maximize electricity production in order to stop producing electricity by polluting means. Solar panel technology is very important on a global scale for the production of clean electrical energy [1],[2]. However, there are complications in the collection of solar energy, as a consequence it is necessary to use solar tracking systems [3,5]. The literature mentions that there are two types of trackers according to the type of movement: one-dimensional or two-dimensional. The two-dimensional can change in two axes and according to their support they are known as carousel or monopost.

The two-axis monopole type solar trackers need to know the altitude and azimuthal angle of the sun, both of which change constantly throughout the day. Two-axis tracking captures more solar energy compared to single-axis tracking. The most commonly used method is polar tracking better known as altitude-azimuthal tracking. The principle of operation is to track the polar axis, which is parallel to the Earth's rotation axis. The other axis is perpendicular to the polar axis, called the declination axis. When the two-axis monopole type solar tracker is in operation, it rotates at the same speed as the Earth's rotation but the direction of rotation is opposite.

The performance of the solar tracking action is by consuming the least electrical energy, which implies a balance between generation and tracking. In addition to solar tracking, it is essential to implement a monitoring system to view the tracking variables in real time. In [6-13] the Arduino Uno platform is used for monitoring the solar energy parameters and the factors affecting its deficiencies along with the ThingSpeak platform interfaced with Wemos.

The system developed in [14] uses an ESP32 IoT board and a web application. This was designed with HTML, CSS and JavaScript. Other works employ the connection between Arduino and Pi Raspberry Pi [15],[16]. Their IoT application was open-sourced as an API and ThingSpeak [15,17].

On the other hand, monitoring systems have been designed with ESP32 Wi-Fi modules. The ESP8266 Wi-Fi module is based on ESP8266 to transmit sensor data with an ESP 32 microcontroller and a local Thinger.IO server [18]. In [19] the Arduino Mega was used for data transfer to the Cayenne API using an additional Ethernet board and RJ45 cable.

Modbus communication has also been employed in the energy management monitoring and the information is sent through a Modbus to Ethernet converter, thereby sending the solar radiation information with an IoT board. The board uses an Intel Atom quad-core 2.4 GHz processor and a Broadcom BCM 2837 64-bit quad-core 1.2 GHz CPU [20].

In this work, we propose to use an Arduino Mega to read the 1024 PPR (Pulse Per Revolution) encoders of the motors of a two-axis monopole type solar tracker. The Arduino collects the PPR data at a sampling rate of 15s. Simultaneously, the PPR data is sent to a small board computer (Raspberry PI 4B), via SPI (Serial Peripherical Interface) communication.

The Raspberry does a conversion of the PPRs to zenith and azimuthal degrees of inclination in order to send them to a web page via IOT communication. Such IOT communication is carried out from the Raspberry in a WiFi environment, addressing the ThingSpeak server. Within ThingSpeak a system called SCADA has been designed using the DIN EN ISO 924 standard that allows to better interpret the data in simple graphs.

The data acquired daily are stored in matrices within ThingSpeak that allow to have a backup and to generate histograms in off-line conditions, thus maintaining a backup system in case of eventual anomalies.

This paper is divided into 5 sections. Section II presents the monitoring system of the two-axis monopole solar tracker and a description of its components. Section III shows the complete monitoring scheme of the two-axis monopole solar tracker through a block diagram. Finally, sections IV and V show the experimental results and the corresponding conclusions.

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II. Monitoring system of the two-axis monopole type solar tracker

The remote monitoring of the variables is achieved through platforms that allow the transmission of data to any point where the user in question is located and without the need to move to the site where the process is being carried out. An indispensable part is that the data can be observed in real time, in order to know the status of the process at a given moment.

Figure 1 shows the approach of this work. First, data acquisition is performed on the Arduino (Figure 1.a) and transferred via SPI to a Raspberry Pi (Figure 1.b). After processing the information, the Raspberry Pi sends this data via WiFi to the ThingSpeak platform using a generated API key (Figure 1.c). With this platform it is possible to receive the information and then display it graphically in a SCADA system, which has diagrams and graphs describing the trajectory of the motor axes. The ThingSpeak system has a sampling time of 15 seconds in the free version. Thus, the data is sent in intervals of this time period.

III. Monitoring algorithm for the two-axis monopole type solar tracker

In the solar tracker monitoring is done in conjunction between an Arduino Mega and Raspberry Pi 4B. Both platforms are low cost and allow acquiring the measurements from the encoders, which are embedded in the motor shafts. The motors are DC and permanent magnet, have a reduction gear and dual shaft drives to generate the rotary motion for the two-axis monopole type solar tracker. Both motors are electronically managed by two H-type full bridges, achieving the adjustment of the motion according to the pulse width modulation.

Figure 2 presents the monitoring algorithm of the two-axis monopost type solar tracker. According to this figure it can be seen that the arduino is in a lower level, because it is in charge of the pulse width modulation, using modulation frequency is 1 kHz and the duty cycle changes between 80% to 92%.

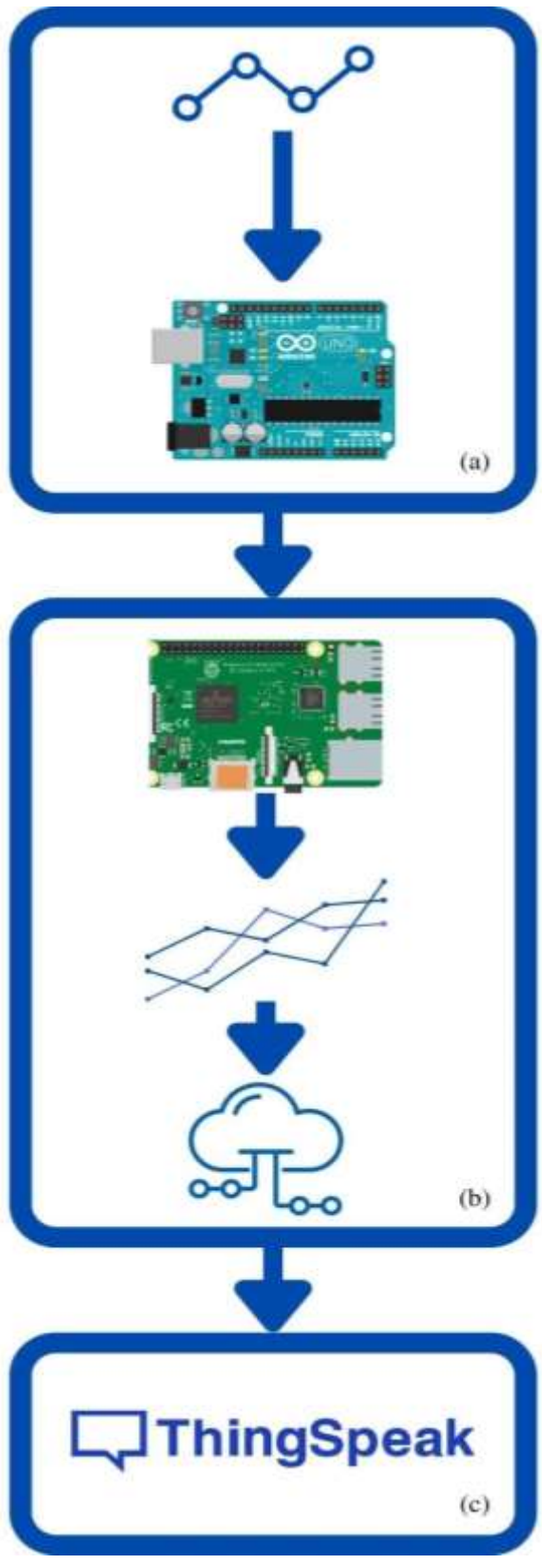

Figure 1 Development of the monitoring of a solar tracking system considering the stages: (a) Data acquisition using Arduino. (b) Data reception, conditioning and sending using Raspberry Pi. (c) Data monitoring using the ThingSpeak platform.

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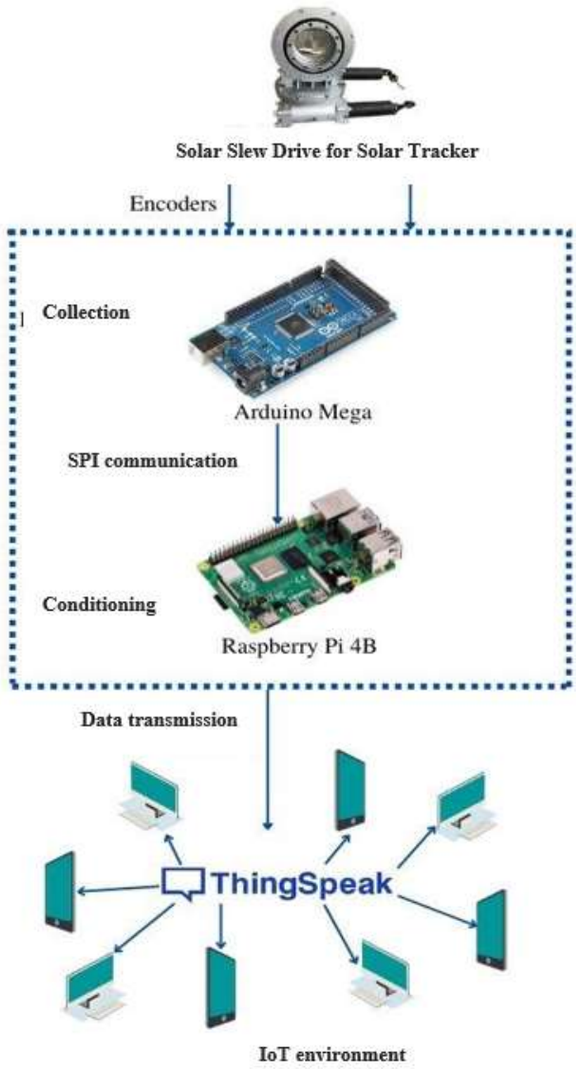

Figure 2 Schematic used for solar tracking monitoring using IoT tools (Raspberry Pi and ThingSpeak)

In addition to changing the duty cycle, the Arduino (slave) is in charge of sending the data from the encoders via SPI communication to the Raspberry. The Raspberry acts as the master because it interrupts the Arduino every 15s to send it the PPRs data. The Raspberry interprets the PPRs and converts them into degrees of zenith and azimuthal tilt, which correspond to each axis of the motor.

This information aggregation action is known as tracker data acquisition, the Raspberry sends the data set via WiFi. At this point, an API Key address is used. The API is the access key to the ThingSpeak IoT platform site. On the ThingSpeak platform, the information is routed to the server. Here the data is queried for display in the SCADA system (Figure 2). The SCADA system provides the opportunity to remotely access any device with access to the platform.

Finally, the ThingSpeak program allows the information sent by the Raspberry during each sampling period to be stored in a database. This database is used for the history of the azimuthal and zenithal axis positions within the SCADA system.

IV. Results

The information obtained with this monitoring system for solar tracking is shown in the SCADA system graph (Figure 3 and Figure 4). Figure 3 displays the azimuthal axis trajectory and the final degree of the trajectory which was 362.20°. Figure 4 displays the azimuthal axis trajectory and the final degree of the trajectory which was 367.55°.

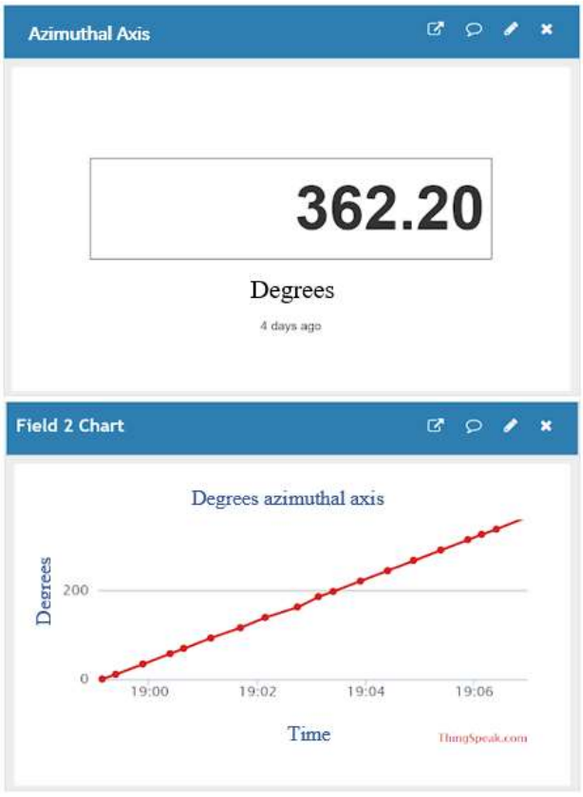

Figure 3 Design of the azimuthal axis motion monitoring in ThingSpeak, showing the most recent value and a plot against time

The platform shows, on the one hand, the position in degrees of the respective axis of the last data string received. In parallel, from the database generated with the historical information, a graph of the movement generated by each motor is displayed.

In order to check the operation of this system, both motors are energized at full voltage to generate a sequence of progressive data.

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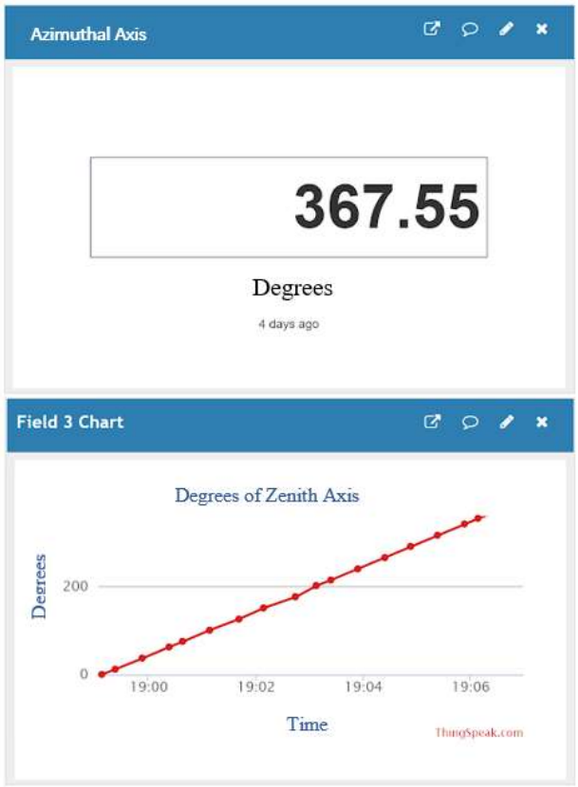

Figure 4 Graphical design of the zenith axis motion monitoring in ThingSpeak, showing the most recent value and a plot with respect to time

Figures 5 and 6 show the differences between the data sent to the ThingSpeak platform and the expected behavior of the azimuthal and zenith axes for each sampling time, resulting in a total of 19 iterations to achieve a 360º turn.

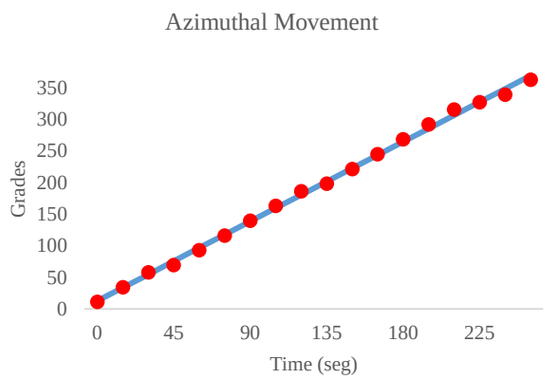

Figure 5 Comparative plot between the expected data (Blue) and those obtained in ThingSpeak (Red) on the azimuthal axis

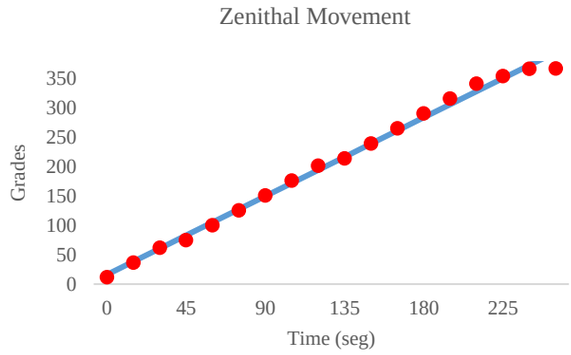

Figure 6 Comparative graph between the expected data (Blue) and those obtained in ThingSpeak (Red) in the zenith axis

In order to check the effectiveness of this system, the relative error obtained between the obtained data and the expected data was calculated according to the formula

$$e_r = \frac{\sum_0^n \left|\frac{x_i - x_v}{x_v}\right|}{n} \quad (1)$$

where
n = total number of data
x_i = value acquired in each iteration
x_v = expected value

The relative error is 0.0304 and 0.0432 for the azimuthal and zenithal axes respectively, which shows that the proposed system has a sampling accuracy between 96% and 97%.

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Conclusions

This paper shows the implementation of a monitoring system on the variables of interest related to two-axis monopole type solar trackers.

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The monitoring scheme is deployed in a SCADA system, which was designed based on the DIN EN ISO 924 standard that allows better interpretation of the data in simple graphs.

The data collection system was structured with an Arduino Mega and a Raspberry in a WiFi environment, addressing the ThingSpeak server. The proposed monitoring system ensures the sending of the data in a sampling frequency of 15s, in addition to the storage in a database for query in histograms. In addition, the tracking of trajectories in the zenith-azimuthal engines was demonstrated and the effectiveness of this system was verified. Through the calculation of the relative error between the obtained data and the expected data, yielding a value of 0.0304 and 0.0432 for the azimuthal and zenithal axes, respectively. Demonstrating that the proposed system has a sampling accuracy between 96% and 97%.

The analytical and experimental evaluations confirm that the proposed monitoring system has a correct operation on the ThingSpeak platform, where the variables of the respective axis degrees are displayed. It was proved that the proposed monitoring system allows knowing the related variables of the two-axis monopost type solar tracker, being able to migrate this system to any type of solar tracker.

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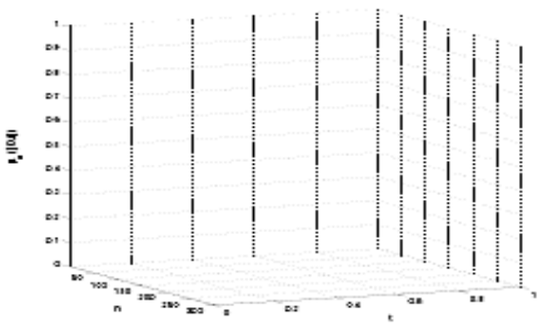

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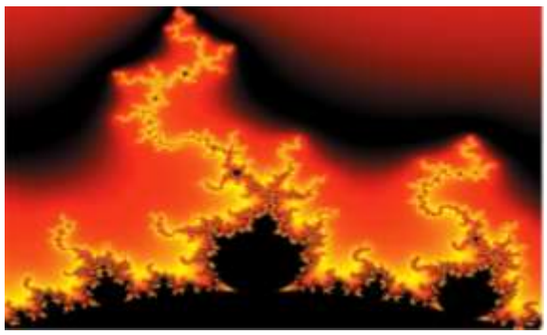

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