ISSN 2531-2952

Volume 7, Issue 21 — July — December — 2023

Journal Applied Computing

ECORFAN®

Journal Applied Computing, Volume 7, Issue 20, June - 2023, is a biannual Journal edited by ECORFAN-Spain. Matacerquillas Street 38, CP: 28411. Moralzarzal-Madrid. WEB: http://www.ecorfan.org/spain/rj_arquitectura_dis.php, revista@ecorfan.org. Editor in Chief: VALDIVIA - ALTAMIRANO, William Fernando. PhD. ISSN 2531-2952. Responsible for the last update of this issue ECORFAN Computer Unit. ESCAMILLA-BOUCHÁN, Imelda PhD. LUNA-SOTO, Vladimir PhD. Updated as of June 30, 2023.

Journal Applied Computing

Definition of the Journal

Scientific Objectives

Support the International Scientific Community in its written production of Science, Technology in Innovation in the Humanities and Behavioral Sciences Area, in the Sub-disciplines of international architecture, technological innovation in architecture, industrial design, business design techniques, multimedia design, advertising design, web system design, residential architecture.

ECORFAN-México SC is a Scientific and Technological Company that contributes to the formation of Human Resources focused on continuity in the critical analysis of International Research and is attached to the RENIECYT of CONACYT with number 1702902, its commitment is to disseminate the research and contributions of the International Scientific Community, academic institutions, agencies and entities of the public and private sectors and contribute to the linking of researchers who carry out scientific activities, technological developments and training of specialized human resources with governments, companies and social organizations.

Encourage the dialogue of the International Scientific Community with other study centers in Mexico and abroad and promote a broad incorporation of academics, specialists and researchers to the Serial publication in Science Niches of Autonomous Universities - State Public Universities - Federal IES - Polytechnic Universities - Technological Universities - Federal Technological Institutes - Normal Schools - Decentralized Technological Institutes - Intercultural Universities - S&T Councils - CONACYT Research Centers.

Scope, Coverage and Audience

Journal of Applied Computing is a Journal edited by ECORFAN-México S.C in its Holding with a repository in Spain, it is a peer-reviewed and indexed scientific publication on a quarterly basis. It supports a wide range of contents that are evaluated by academic peers by the Double-Blind method, around topics related to the theory and practice of systems theory, networks, interconnectivity of companies, corporate governance, satellite communication, connectivity, TV transmitters and transmission, microwave links, radio communications and radio receivers, radiocommunication, radio receivers, TV receivers, Telephony, Radio and TV transmitters with diverse approaches and perspectives, which contribute to the dissemination of the development of Science Technology and Innovation that allow arguments related to decision-making and influence the formulation of international policies in the Field of Engineering Sciences and Technology. The editorial horizon of ECORFAN-México® extends beyond academia and integrates other segments of research and analysis outside of that field, as long as they meet the requirements of argumentative and scientific rigor, in addition to addressing topics of general and current interest of the International Scientific Society.

Editorial Committee

Arbitration Committee

Assignment of Rights

The sending of an Article to Journal of Applied Computing emanates the commitment of the author not to submit it simultaneously to the consideration of other series publications for it must complement the Originality Format for its Article.

The authors sign the Authorization Format for their Article to be disseminated by means that ECORFAN-Mexico, S.C. In its Holding Spain considers pertinent for disclosure and diffusion of its Article its Rights of Work.

Declaration of Authorship

Indicate the Name of Author and Coauthors at most in the participation of the Article and indicate in extensive the Institutional Affiliation indicating the Department.

Identify the Name of Author and Coauthors at most with the CVU Scholarship Number-PNPC or SNI-CONACYT- Indicating the Researcher Level and their Google Scholar Profile to verify their Citation Level and H index.

Identify the Name of Author and Coauthors at most in the Science and Technology Profiles widely accepted by the International Scientific Community ORC ID - Researcher ID Thomson - arXiv Author ID - PubMed Author ID - Open ID respectively.

Indicate the contact for correspondence to the Author (Mail and Telephone) and indicate the Researcher who contributes as the first Author of the Article.

Plagiarism Detection

All Articles will be tested by plagiarism software PLAGSCAN if a plagiarism level is detected Positive will not be sent to arbitration and will be rescinded of the reception of the Article notifying the Authors responsible, claiming that academic plagiarism is criminalized in the Penal Code.

Arbitration Process

All Articles will be evaluated by academic peers by the Double-Blind method, the Arbitration Approval is a requirement for the Editorial Board to make a final decision that will be final in all cases. MARVID® is a derivative brand of ECORFAN® specialized in providing the expert evaluators all of them with Doctorate degree and distinction of International Researchers in the respective Councils of Science and Technology the counterpart of CONACYT for the chapters of America-Europe-Asia- Africa and Oceania. The identification of the authorship should only appear on a first removable page, in order to ensure that the Arbitration process is anonymous and covers the following stages: Identification of the Journal with its author occupation rate - Identification of Authors and Coauthors - Detection of plagiarism PLAGSCAN - Review of Formats of Authorization and Originality-Allocation to the Editorial Board-Allocation of the pair of Expert Arbitrators-Notification of Arbitration -Declaration of observations to the Author-Verification of Article Modified for Editing-Publication.

Instructions for Scientific, Technological and Innovation Publication

Knowledge Area

The works must be unpublished and refer to issues of systems theory, networks, interconnectivity of companies, corporate governance, satellite communication, connectivity, TV transmitters and transmission, microwave links, radio communications and radio receivers, radio communication, radio receivers. radio, TV receivers, Telephony, Radio and TV transmitters and other topics related to Engineering Sciences and Technology.

Presentation of the Content

In Issue 21, is presented an article *Debugging and programming a RISC-V processor, using the IEEE 1149.1 standard*, by RICO-GARCÍA, Paulina, YAÑEZ-VARGAS, Juan Israel, PARRA-MICHEL, Ramón and CONDE-ALMADA, Ernesto, with adscription at Universidad Politécnica de Juventino Rosas and CINVESTAV Unidad Guadalajara, in the next article *IoT-based monitoring system of climatological variables in the cultivation of Capsicum chinense Var. Mayapan*, by CHAN-PECH, Victor Alfonso, MANRIQUE-EK, Josué Abraham, COB-CALAN, Nubia Noemi and CARDOZO-AGUILAR, Guadalupe, with adscription at Instituto Tecnológico Superior de Calkiní, in the next section *Pedestrian detection system for automobiles using computer vision and artificial intelligence using Raspberry Pi 4 and webcam*, by SERRANO-RAMÍREZ, Tomás, SÁMANO-FLORES, Yosafat Jetsemaní, GUTIERREZ-LEÓN, Diana Guadalupe and BARRIENTOS-GARCÍA, Alejandro, with adscription at Universidad Politécnica de Guanajuato, in the next section *Web system for automatic irrigation in a greenhouse*, by RAFAEL-PÉREZ, Eva, GARCÍA-CERVANTES, Oscar Daniel, MORALES-HERNÁNDEZ, Maricela and RIOS-MALDONADO, Vicenta, with adscription at Instituto Tecnológico de Oaxaca.

Content

Article	Page

Article

Journal Applied Computing
December, 2023 Vol.7 No.21 1-9

Debugging and programming a RISC-V processor, using the IEEE 1149.1 standard

Depuración y programación de un procesador RISC-V, usando el estándar IEEE 1149.1

RICO-GARCÍA, Paulina[1]†*, YAÑEZ-VARGAS, Juan Israel[1], PARRA-MICHEL, Ramón[2] and CONDE-ALMADA, Ernesto[2]

[1]Universidad Politécnica de Juventino Rosas, Maestría en Ingeniería con Especialidad en Sistemas Inteligentes
[2] CINVESTAV Unidad Guadalajara

ID 1st Author: *Paulina, Rico-García /* **ORC ID**: 0000-0003-2540-6309

ID 1st Co-author: *Juan Israel, Yañez Vargas* / **ORC ID**: 0000-0001-5749-8442

ID 2nd Co-author: *Ramón, Parra-Michel* / **ORC ID**: 0000-0003-2327-2482

ID 3rd Co-author: *Ernesto, Conde-Almada* / **ORC ID**: 0009-0008-4880-408X

DOI: 10.35429/JCA.2023.21.7.1.9

Received July 10, 2023; Accepted December 10, 2023

Abstract

RISC-V processors are an open source ISA (Instruction Set Architecture), which means that anyone can design and modify them to meet the specific objectives of any development. Thanks to the flexibility it brings with it, it is possible to add a debugging and programming logic unit to this processor to get a real sense of how the processor works, a unit that will be key to identifying errors during the design of the processor, as well as errors that may occur during the manufacturing process. This article presents the methodology used to incorporate hardware that allows the processor to be debugged, using the IEEE 1149.1 standard as a reference.

JTAG, IEEE 1149.1, RISC-V, Boundary Scan Chain, Processor, Register, Debugging, FTDI, FPGA, Hardware, RTL, Methodology, Driver, Development, Verification, Flexibility, Technology and Innovation, Incorporate, Modify

Resumen

Los procesadores RISC-V son una ISA (Instruction Set Architecture) de código abierto, lo que significa que cualquiera puede diseñarlos, así como modificarlo para cumplir con los objetivos particulares de cualquier desarrollo. Gracias a la flexibilidad que trae consigo es posible sumar a este procesador una unidad lógica de depuración y programación que permita tener una noción real del funcionamiento del procesador, unidad que será clave para la identificación de fallas durante el diseño del procesador, así como defectos que puedan surgir en el proceso de fabricación. En el presente artículo es presentada la metodología empleada para la inserción de hardware que permita la depuración del procesador usando como referencia el estándar IEEE 1149.1.

JTAG, IEEE 1149.1, RISC-V, Cadena de exploración de límites, Procesador, Registro, Depuración, FTDI, FPGA, Hardware, RTL, Metodología, Driver, Desarrollo, Verificación, Flexibilidad, Tecnología e Innovación, Incorporar, Modificar

Citation: RICO-GARCÍA, Paulina, YAÑEZ-VARGAS, Juan Israel, PARRA-MICHEL, Ramón and CONDE-ALMADA, Ernesto. Debugging and programming a RISC-V processor, using the IEEE 1149.1 standard. Journal Applied Computing. 2023. 7-21: 1-9

* Corresponding autor: (e-mail: m21030004@upjr.edu.mx)
† Researcher contributing as first author.

Introduction

Integrated circuits, present in countless devices that are now part of everyday life, are an area of development where there is much to be done. Beyond the fact that they are already everywhere, innovation and the creation of different solutions make this a niche of constant change.

A few years ago, technological development was reserved for powers with technology and knowledge so hermetic that it could only be accessed by being part of the industry. Today there are open source initiatives that make these development possibilities more accessible.

Thanks to the latter, technology design is possible, with well-established development processes that allow to go from requirements gathering to having the hardware assembled in an FPGA or as a finished ASIC.

Within the design and manufacturing flow of any technology it is important to keep in mind that identifying errors in early stages will represent less waste of any kind of resources. Hence the importance of having a debug and programming unit that allows greater control over the hardware at the simulation level during the functional tests that are performed at the design stage or physical tests that help to detect any defect in later stages of manufacturing where it is possible to identify in the silicon dice any physical defect, this helps to generate a certain level of certainty that the user will receive a complete product.

Standards such as JTAG are used to test the correct functioning of any circuit; thanks to the insertion of boundary scan chains, a TAP controller, as well as instruction registers, bypass registers, etc., it is possible to monitor the behaviour of a circuit with the help of different instructions such as SAMPLE, PRELOAD, EXTEST or BYPASS, etc., which makes it possible to identify faults or divergences from the initial functional objective of the design. This without the strict need to have access to the primary inputs and outputs of the circuit, which contributes to the intervention methodology being a more generic process.

Literature Review

Circuit design is an area with a lot of work to do, thanks to the presence of circuits in practically any electronic device, the contribution of new methodologies or solutions is constant. Some of the references related to this research and that contribute to the knowledge for its development are presented below. The reference (Shan Gao *et al* 2021.) proposes a fast on-chip debug design using the JTAG interface applied to a RISC-V processor. The novelty of this paper is the integration of a debug bus to reduce data input by switching data from serial to parallel. This is aimed at reducing the amount of input data. This makes it a less exhaustive operation.

In the article (Shan Gao *et al* 2022.) a debugging method adopting JTAG interface is presented to perform debugging functions for a RISC-V processor with IoT applications. This method was verified at RTL level by simulations and synthesised at gate level in 180nm libraries. The most important contribution of this methodology is that the most common debugging operations were simplified into instructions, which avoids a large data input through the shift register chain.

In this paper, an RTL-level verification methodology is proposed using the ARM debug interface (Ke, H. *et al* 2012.) where the ARM7TDMI SoC is taken as an example. An RTL simulation method using the ARM JTAG interface is proposed. Through EDA software (Synopsys VCS) the JTAG is tested to complete the code testing stage. To achieve this development, use is made of the ARM core, the EmbeddedICE logic controller circuit and the JTAG control circuit, which is composed of the TAP controller and scan chains.

Finally, a RED (Reused Embedded Debugger) design is presented where the JTAG interface is used. This model also has an additional hardware module (EICEM Embedded ICE Module) for more critical real-time debugging. The debugger proposed in the paper (Jung, D. *et al* 2003.) works as a stand-alone system through a PC interface, requiring no extra equipment cost which decreases the cost and time of testing the chip. The RED architecture is composed of three blocks; the boundary scan architecture, the boundary scan registers and EICEM.

Methodology

For the development of this research, a recursive methodology is proposed, working on three development blocks as shown in Figure 1; the starting block is the description of the hardware that will be added to the design to integrate the IEEE 1149.1 standard (IEEE Std 1149.1-2013) to the processor, in this sense, the requirements that the latter indicates as mandatory are contemplated as a minimum, in addition, certain elements developed specifically for the purpose of this research will be integrated. For example, dedicated registers, to monitor internal design registers that are of interest for analysis or debugging.

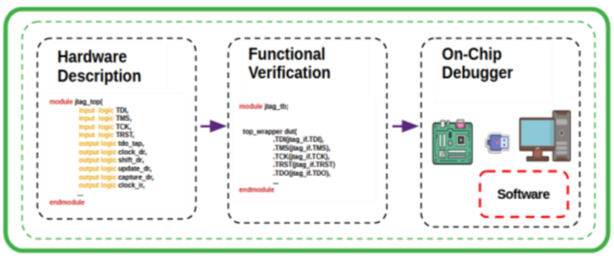


Figure 1 Methodology of research development
Source: Own work [Draw-LibreOffice]

Once the additional hardware is described, the correct functioning of the generated design will be verified. For this purpose, a test bed is developed to stress the design by sending different test vectors that, in addition to stimulating the design as such (without contemplating the JTAG hardware), stimulate the JTAG ports that allow verifying that this debugging mechanism complies with the requirements of the standard; in this development can be executed at least the instructions that the standard defines as mandatory that may or may not affect the operation of the design according to the instruction, as well as the instructions added for very specific purposes that were developed specifically to meet the objectives of this project.

All this to verify that at simulation level the design behaves as planned and with certainty to continue with the next stage of the proposed methodology. It is worth mentioning that we talk about recursion between the blocks of the methodology because the development is not a linear process (one stage is completely finished and the next one continues), because as certain modules and/or hardware components are described.

It is essential to verify that their operation is correct, since waiting to verify the final module could lead to many more connection problems or logical failures in the design. This would result in a more complex process to detect and solve them, which would increase the development time, as well as the consumption of other resources such as effort, money, etc.

For the simulations, a wide coverage is sought; where the design is stressed with typical scenarios and others that are not so typical so that this helps us to give certainty that under any circumstance the design will work as required or, failing that, to identify operating errors where the design does not comply with what is requested and thus make the relevant changes to solve the failure.

For the development of the third block of the methodology, once the design meets the requirements at simulation level, it is loaded into an FPGA card (as this is the most practical way to physically test a design before taking it to a silicon die or if this as such will not be implemented on a chip); once the FPGA is programmed with the design and this is stored in the memory of the latter is intended to communicate with it through the JTAG interface of an FTDI module.

Establishing this communication between devices allows data vectors to be inserted through the ports of the JTAG added to the design, so that it can be corroborated that the design works in the same way as it did with the simulation. This last phase, as well as serving as a functional verification, will be the communication methodology that will be used at the FPGA level for debugging and programming the processor, as sending and receiving data through the FTDI interface will finally allow the integration of the debugging and programming module in a practical way.

The proposed communication (FTDI-FPGA) was given by the characteristics of the board used (Figure 2).

The specifications of the devices mentioned are given below:

FPGA → *FPGA Lattice LFE5U-85*

FTDI → *FT2232H*

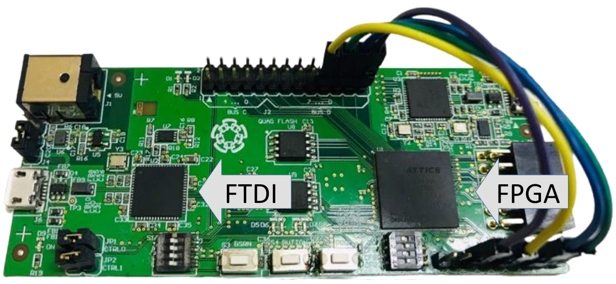


Figure 2 Card used for development
Source: Own work

Hardware Description

"JTAG insertion”

To add the JTAG interface to the core, we initially described and integrated the base hardware of the standard that encapsulates the processor as shown in Figure 3. Among the added elements are the boundary scan chain (cherry boxes), the state machine or TAP Controller, which is the core of JTAG operation, instruction decoder, instruction, bypass and device identification registers, as well as some multiplexers that allow the choice of the output according to the given instruction.

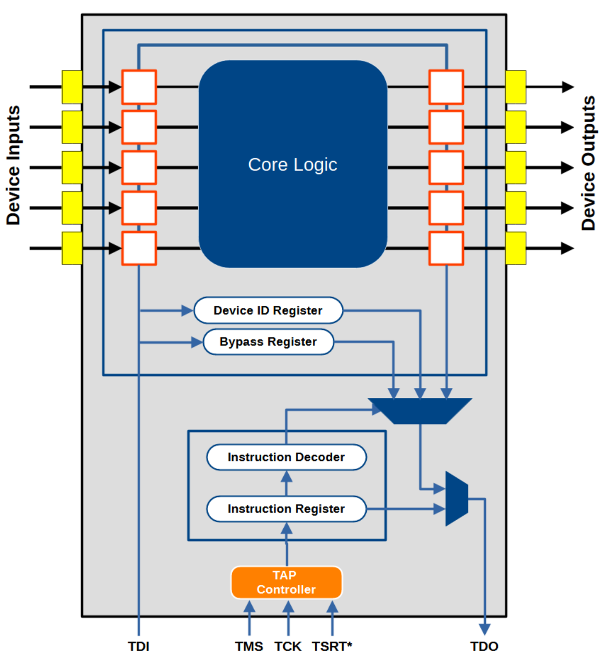


Figure 3 Base elements of JTAG
Source: Own work [Draw-LibreOffice]

Once we had this initial architecture and based on the requirements, we continued with the development of a second design stage, where the objective was to add the necessary logic to be able to scan the internal registers of the processor.

Based on the registers of interest, it was decided to take the elements of the different modules separately and generate an instruction for each one of them; with the aim of having as a result a serial output that concatenates the values of all the registers contained in each module, which allows us to have outputs that are not as long as if we did it with a single instruction for all the registers (which complicates the identification of any particular register) and also allows us to execute specific instructions that would avoid the use of the added hardware in sections that are not of interest at the moment. The architecture with these new registers and interconnections made to obtain the internal information of the processor is shown in Figure 4.

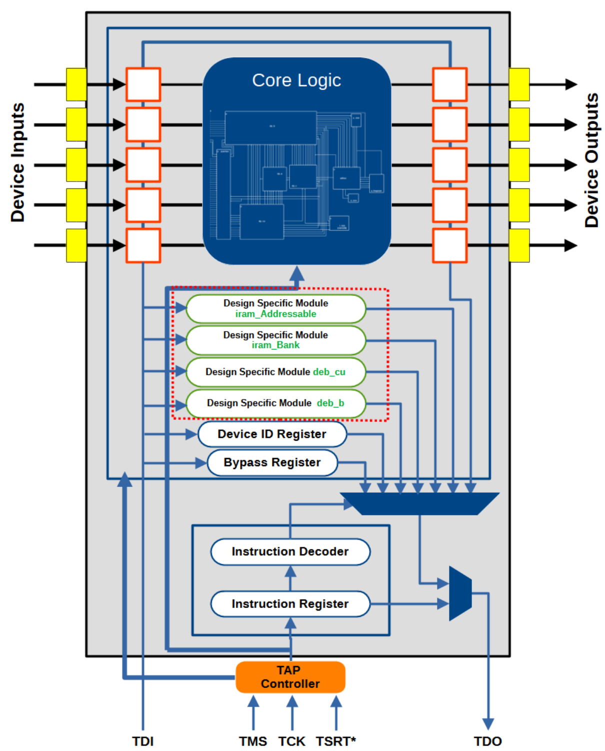


Figure 4 JTAG architecture added
Source: Own work [Draw-LibreOffice]

The red box shows the added registers, plus there are some interconnect changes that allow the results of the JTAG state machine to be taken to the processor to interact with the internal registers.

Functional Verification

In the functional verification phase, the aim is to create a simulation that stresses the design with stimuli that allow us to see how it behaves. In this sense, we worked with a base simulation where the processor is stimulated, with the objective that it is working or that it has information in the registers. Once the core has zeros and ones being processed, the internal registers are intervened to collect the information that is stored in each one of them at that moment.

This is for the aggregated instructions (red box - Figure 4). Similarly, instructions were tested where data is sent to the primary inputs through the boundary scan chain and relayed to the Logic Core for it to work with this information, or generic instructions such as bypass, for example.

On-Chip Debugger

For the communication between the Host computer and the design hosted in the FPGA, first the design is synthesised, routed and loaded to the FPGA, for this the tools indicated in Figure 5 were used.

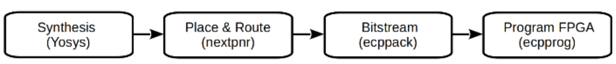


Figure 5 FPGA programming tools
Source: Own work [Draw-LibreOffice]

Once the design is loaded the objective is to establish communication between the computer and the latter, to stimulate it and monitor the results, the flow foreseen to establish this data exchange channel is as shown in Figure 6.

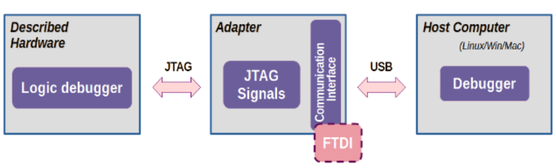


Figure 6 Information flow between computer and design
Source: Own work [Draw-LibreOffice]

The middle block in this diagram represents (Debug Adapter) the FTDI chip which has an integrated JTAG interface through which data will be sent to the interface integrated in the design, the connection made between these two devices is shown in Figure 7.

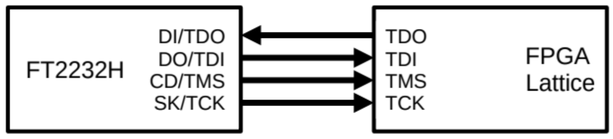


Figure 7 FTDI-FPGA interconnection
Source: Own work [Draw-LibreOffice]

The FTD2XX (D2XX FTDI) library and drivers from FTDI were used to complete the data transfer.

Tests and results

During the development of the hardware description, several simulations were carried out to corroborate that the functioning of the integrated elements was correct. For example, Figure 8 shows the scan execution of the registers of interest of one of the modules that are part of the processor.

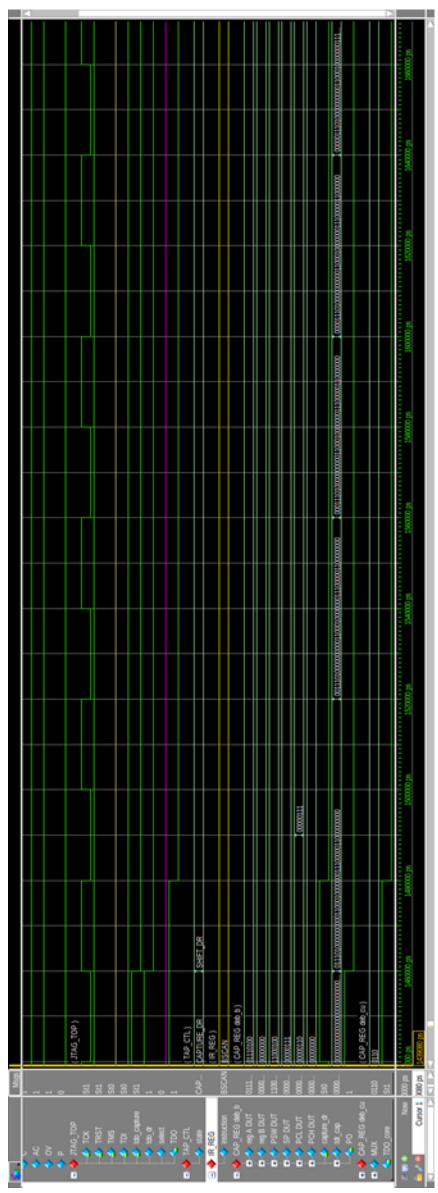


Figure 8 BSCAN instruction simulation
Source: Own work [ModelSim]

In the simulation we can see the registers of interest for the deb_b module in the group "CAP_REG deb_b", the content of these is concatenated and sent through "tdr_cap" to the TDO port of JTAG, in the image we can see how these bits are being displaced each time one of these is sent as output.

Figure 9 shows the same simulation time, but with a much more open view where we can see the output of TDO; which coincides with the bits that were captured and are being shifted to this port.

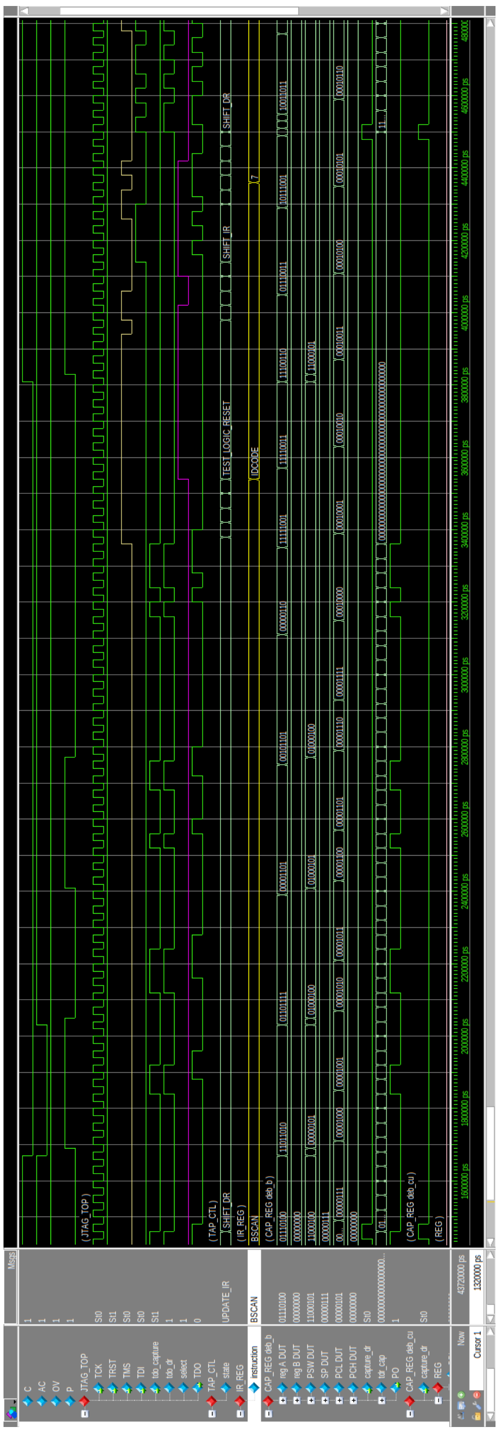


Figure 9 Simulation BSCAN instruction output data via TDO port

Source: Own work [ModelSim]

Other instructions such as INTEST or SAMPLE have so far not been tested on this processor as such, however, in previous stages of development this JTAG architecture was integrated into a RAM memory where these instructions were already tested.

NOTE: These instructions have not been tested on the processor because some modifications to the core RTL are still pending.

To test these instructions with the RAM memory, the following data vector was sent:

1 ram_dataInput_i[31]
1 ram_dataInput_i[30]
1 ram_dataInput_i[29]
1 ram_dataInput_i[28]
0 ram_dataInput_i[27]
1 ram_dataInput_i[26]
1 ram_dataInput_i[25]
0 ram_dataInput_i[24]
0 ram_dataInput_i[23]
1 ram_dataInput_i[22]
0 ram_dataInput_i[21]
1 ram_dataInput_i[20]
0 ram_dataInput_i[19]
1 ram_dataInput_i[18]
1 ram_dataInput_i[17]
0 ram_dataInput_i[16]
1 ram_dataInput_i[15]
0 ram_dataInput_i[14]
1 ram_dataInput_i[13]
0 ram_dataInput_i[12]
1 ram_dataInput_i[11]
1 ram_dataInput_i[10]
0 ram_dataInput_i[9]
0 ram_dataInput_i[8]
1 ram_dataInput_i[7]
0 ram_dataInput_i[6]
1 ram_dataInput_i[5]
0 ram_dataInput_i[4]
1 ram_dataInput_i[3]
1 ram_dataInput_i[2]
0 ram_dataInput_i[1]
1 ram_dataInput_i[0]
0 ram_writeAddress_i[2]
0 ram_writeAddress_i[1]
0 ram_writeAddress_i[0]
0 ram_readAddress_i[2]
1 ram_readAddress_i[1]
0 ram_readAddress_i[0]
0 ram_writeEnable_i
1 ram_writeClock_i

ISSN-2531-2952

This vector is reflected in the design inputs (RAM for evidence of these results) at 1840ps time in the simulation shown in Figure 10.

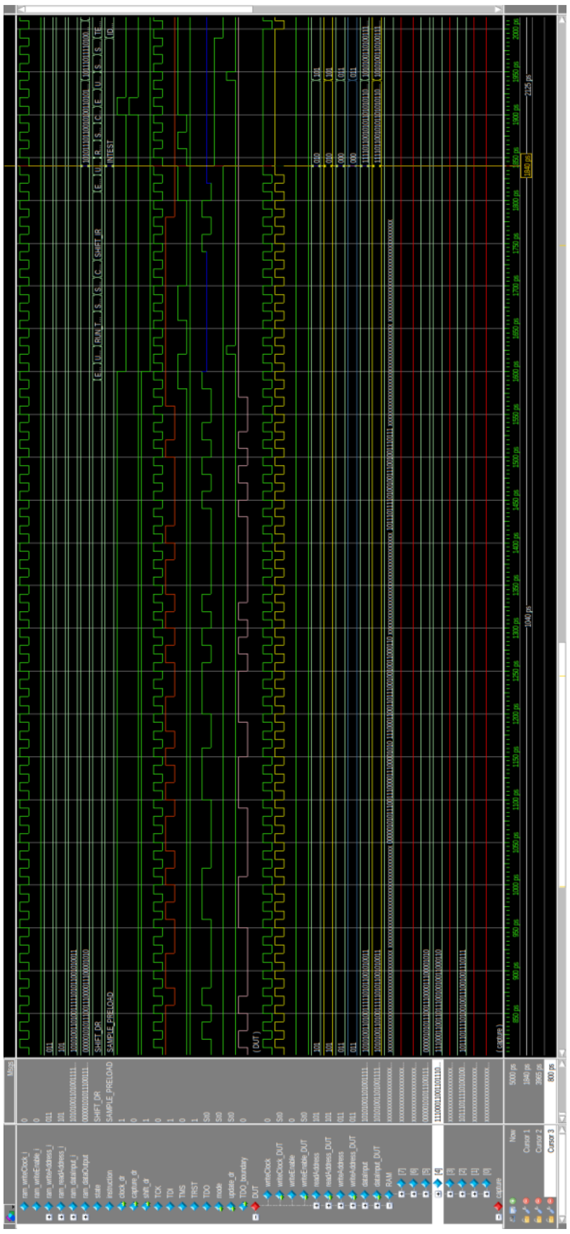


Figure 10 SAMPLE/PRELOAD simulation - INTEST
Source: *Own work [ModelSim]*

These simulations prove that the JTAG interface is working properly; it remains to test all the instructions with the processor, which, as mentioned, is awaiting some adjustments.

Talking about the physical part, tests were made by loading the design and sending data through the JTAG interface integrated in the FTDI chip. Where the main objective is to verify that the data is being sent to the FPGA and the design loaded on the board actually operates with these and gives us as output the expected result.

For these tests we again make use of the memory with the integrated JTAG, as an initial test only the BYPASS instruction was sent, since the objective up to this point is to verify that the communication between components is carried out.

In the simulation of Figure 11, the information vectors sent to each input pin are shown in a simple way, as well as the expected output in the TDO port of the standard.

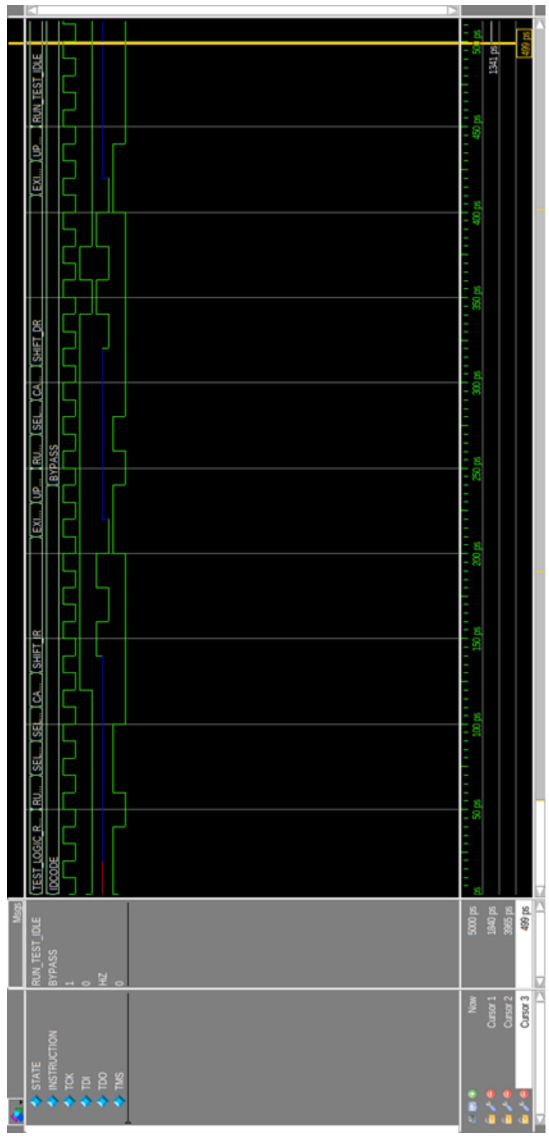


Figure 11 BYPASS simulation
Source: Own work [ModelSim]

To send the information, a C script was generated which, when compiled and sent to the FTDI chip, sends the data through its own ports (TDI, TMS, TCK) to the FPGA pins assigned to the similar ones described in the design.

ISSN-2531-2952

With the help of an oscilloscope we could observe that the data are being sent correctly and also the output data expected by the TDO port are correct, in Figure 12 you can see the output that TDO (blue signal) has around 300ps which is the expected output of the BYPASS instruction, in addition to the data that are sent to the TDI port, which also match with what was presented in the simulation.

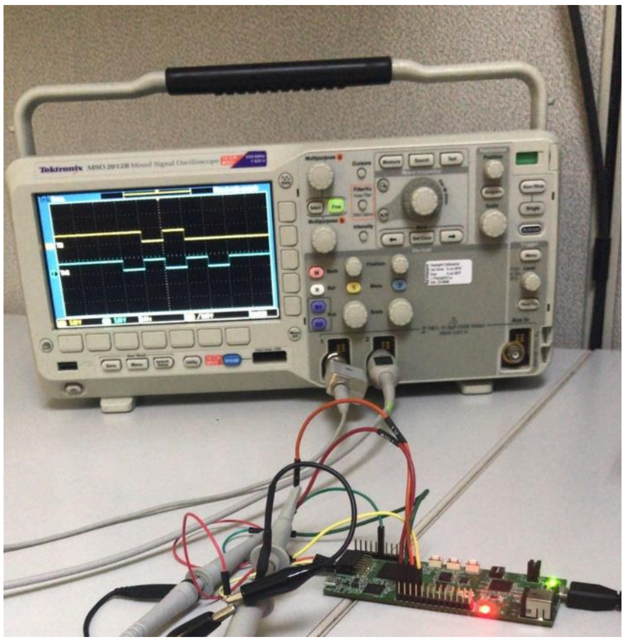


Figure 12 Physical results of BYPASS training
Source: Own work

Conclusions

The JTAG interface complies well with the IEEE 1149. 1 standard, as the instructions used to debug the design work as it indicates, and the added instructions fulfil the specific purpose of this project, which is the monitoring of the processor's internal registers.

With work to be done, but with a well established base and even put under test (with the RAM memory) that has given good results so far, it remains as future work to work in detail with each instruction using the processor as a Logic Unit within the JTAG encapsulation, to ensure that as already happened with the test design everything works correctly both in simulation and physical once the processor is loaded into the FPGA.

The present development where the JTAG interface is integrated to a processor gives us the awareness that this standard is a very flexible tool that is of great help for the performance testing of any design, because being able to stimulate it completely without having to do it necessarily through the primary inputs allows this activity to be less complex and less extra resources are needed to meet the objective.

In addition, hardware designers can seamlessly integrate new instructions that provide specific functions for a particular design without affecting the basis of the standard, which allows the integration of these devices with any other device that has the standard and can work together seamlessly using JTAG as the communication interface between them.

References

Gao, S., Xiao, W., Yang, Z., Wu, D., & Gao, W. (2021). A fast on-chip debugging design for RISC-V processor. *Journal of Physics: Conference Series, Vol 1976.* DOI: https://doi.org/10.1088/1742-6596/1976/1/012056

Gao, S., Wu, D., Xiao, W., Wang, Z., Yang, Z., & Gao, W. (2022). A novel method for on-chip debugging based on RISC-V processor. *MATEC Web of Conferences, 355.* DOI: https://doi.org/10.1051/matecconf/202235503055

Ke, H., Zhongliang, D., & Siyuan, L. (2012). RTL Verification of ARM SoC by JTAG. *International Journal of Digital Content Technology and Its Applications, 6, 77-84.* URL: https://www.researchgate.net/publication/269786095_RTL_verification_of_ARM_SoC_by_JTAG

Jung, D. S., Kwak, S., & Lee, M. H. (2003). Reusable embedded debugger for 32 bit RISC processor using the JTAG boundary scan architecture. *IEEE Asia-Pacific Conference on ASIC.* DOI: https://doi.org/10.1109/apasic.2002.1031569

ISSN-2531-2952

"IEEE Standard for Test Access Port and Boundary-Scan Architecture," in IEEE Std 1149.1-2013 (Revision of IEEE Std 1149.1-2001), vol., no., pp.1-444, 13 May 2013, DOI: 10.1109/IEEESTD.2013.6515989.

D2XX Programmer's. *Guide Future Technology Devices International Limited (FTDI)* URL: https://ftdichip.com/wp-content/uploads/2023/09/D2XX_Programmers_Guide.pdf

.

Article

Journal Applied Computing

December, 2023 Vol.7 No.21 10-16

IoT-based monitoring system of climatological variables in the cultivation of *Capsicum chinense* Var. Mayapan

Sistema de monitorización de variables climatológicas en el cultivo de *Capsicum chinense* Var. Mayapan

CHAN-PECH, Victor Alfonso†*, MANRIQUE-EK, Josué Abraham, COB-CALAN, Nubia Noemi and CARDOZO-AGUILAR, Guadalupe

Instituto Tecnológico Superior de Calkiní En El Estado De Campeche, Avenida AH-Canul, Sin Número, San Felipe, 24900 Calkiní, Campeche

ID 1st Author: *Victor Alfonso, Chan-Pech* / **ORC ID**: 0009-0009-9274-4704, **Researcher ID Thomson**: JNT-1825- 2023

ID 1st Co-author: *Josué Abraham, Manrique-Ek* / **ORC ID**: 0000-0002-1369-35269727, **Researcher ID Thomson**: 1-5873-2018, **arXiv Author ID**: EFYDCI-9MW4UV

ID 2nd Co-author: *Nubia Noemi, Cob-Calan* / **ORC ID**: 0000-0002-9340-8325, **Researcher ID Thomson**: JNT-2124- 2023

ID 3rd Co-author: *Guadalupe, Cardozo-Aguilar* / **ORC ID**: 0000-0001-80332280, **Researcher ID Thomson**: 1-5874- 2018, **arXiv Author ID**: TLTSYW-VLXBVS

DOI: 10.35429/JCA.2023.21.7.10.16

Received September 15, 2023; Accepted December 30, 2023

Abstract

Currently, monitoring in agricultural crops represents relevance, because there are various applications of the use of software and hardware based on the construction and adaptation of sensors for automation, based on processes of isolation and control of climatological variables that seek to minimize risks. This project contributes to the improvement of agricultural productivity by offering functionality and flexibility in the scenario of precision agriculture in the cultivation of *C. chinense* var. Mayapán through the implementation of IoT. To carry out this project, an electronic system was designed that consists of coupling sensors to measure relative humidity, temperature and precipitation, to an ESP32 module and subsequently programming it in the Arduino IDE and sending it through the internet to a graphical interface in the Ubidots platform with the purpose of showing information to the user in real time. For the system to achieve interaction with the sensors, a Wi-Fi wireless connection was used through the MQTT protocol.

ESP32, IoT, Ubidots

Resumen

Actualmente el monitoreo en cultivos agrícolas representa relevancia, debido a que existen diversas aplicaciones del uso de software y hardware basados en la construcción y adaptación de sensores para su automatización, basado en procesos de aislamiento y control de variables climatológicas que buscan minimizar riesgos. Este proyecto contribuye al mejoramiento de la productividad agrícola ofreciendo funcionalidad y flexibilidad en el escenario de la agricultura de precisión en el cultivo de *C. chinense* Var. Mayapán mediante la implementación del IoT. Para llevar a cabo este proyecto se diseñó un sistema electrónico que consiste en el acoplamiento de sensores para medir la humedad relativa, temperatura y precipitaciones, a un módulo ESP32 y posteriormente programarlo en el IDE Arduino y enviarlo mediante el internet hacia un interfaz gráfico en la plataforma Ubidots con la finalidad de mostrar la información al usuario en tiempo real. Para que el sistema logre la interacción con los sensores, se usó conexión inalámbrica Wi-Fi por medio del protocolo MQTT.

ESP32, IoT, Ubidots

Citation: CHAN-PECH, Victor Alfonso, MANRIQUE-EK, Josué Abraham, COB-CALAN, Nubia Noemi and CARDOZO-AGUILAR, Guadalupe. IoT-based monitoring system of climatological variables in the cultivation of *Capsicum chinense* Var. Mayapan. Journal Applied Computing. 2023. 7-21:10-16.

* Correspondence to the Author (e-mail: 6401@itescam.edu.mx)

† Researcher contributing as first author.

Introduction

The development of agriculture is one of the main economic activities of the State of Campeche, it is carried out since ages, however, during its work, different parameters have been underestimated that currently serve for the improvement of techniques and systems applied in the agricultural sector to optimise processes and improve production.

This paper seeks to propose an alternative solution to achieve better production with higher crop yields, by optimising resources, reducing costs and increasing profitability, in order to implement a suitable monitoring system with IoT knowledge ensuring precision agriculture.

The importance of having a monitoring system in the cultivation of C. chinense Var. Mayapán is a tool that will allow controlling, monitoring and acquiring data in real time guaranteeing decision making.

The Internet is a great information tool, currently having one of its phases corresponding to the Internet of Things (Internet of Things, IoT). IoT plays a great role, its application in the agricultural sector is of importance where ICT tools can be developed and used to ensure precision agriculture for better crop management and monitoring of variables in order to improve production yields, feasibility and environmental quality.

Theoretical framework

Traditional agriculture is deficient in yield and quality, because it is partially dependent on various external factors directly related to weather conditions. Currently, there is a large amount of information, precision and immediacy of data that allow decisions to be made at a certain time of cultivation to achieve productivity and profitability with the implementation of technology (Nuñez-Agurto et al., 2020). Technified agriculture has the advantage over traditional agriculture, which seeks to maximise productivity, product quality and is based on the control of variables such as: soil, water, humidity, light, wind, temperature, among others (Aldape et al., 2022).

Internet of Things (IoT)

The IoT is an infrastructure with the ability to link connections between physical objects, processes, internet and people, offering data capture and storage, facilitating the sharing of information in specific databases in order to have control and access to this information from any point or location where a person with internet access is located (Cortes et al., 2020). IoT is driven by the combination of processes and methods that employ different sensors, a network and an encoding device, which are intended to provide an end user with a reliable, readable and visual representation of data (Montoya et al., 2017).

Precision agriculture

Precision agriculture provides favourable solutions that facilitate decision making in the improvement of agricultural crops, its implementation allows to achieve: efficiency, rational use of costs and financial resources, higher productivity and yield (Rambauth Ibarra, 2022). Decision-making based on the use of ICT is achieved through monitoring systems with the use of digital platforms where IoT presents feasible, modern and safe processes (Chanchí-Golondrino et al., 2022).

Technological progress or modernisation nowadays allows obtaining data of interest using technified instruments that during this time has allowed applications in various areas from the development of pest monitoring systems, disease diagnosis, management systems, to the control and monitoring of climatological variables (Bastos Stephens et al., 2022).

MQ Telemetry Transport Network Protocol (MQTT)

It stands for Message Queue Telemetry Transport. MQTT was created by Dr. Andy Stanford-Clark of IBM and Arlen Nipper of Arcom in 1999. It functions as a publish/subscribe messaging transport where its characteristics are: bandwidth efficient, data independent, and continuous session acknowledgement because it uses a TCP/IP stack as the basis for communication; it is an open source protocol whose development is based on optimising constrained processes and low bandwidth, high latency or unreliable networks (Burbano-Robles, 2022).

December, 2023 Vol.7 No.21 10-16

ESP32 microcontroller

The ESP32 microcontroller was fundamental for its application in this project, which allows sending and receiving information from the Internet, reading analogue sensors and actuators used in the C. chinense Var. Mayapán.

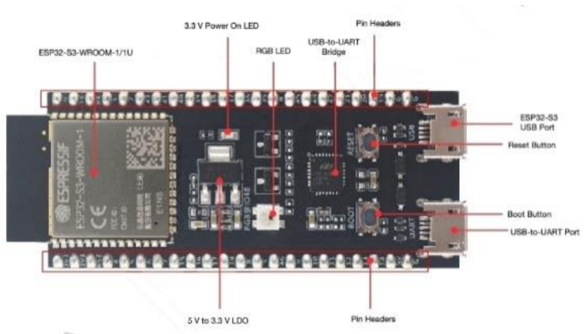


Figure 1 ESP32 module used in the project
Source: (MOUSER ELECTRONICS, 2023)

The ESP32 is a System-on-Chip designed by Espressif Company and manufactured by TSMC. It integrates on a single chip a dual-core 32-bit Tensilica Xtensa processor at 160 Mhz (with the possibility of up to 240 Mhz), WiFi and Bluetooth connectivity. In addition, it adds many functions and improvements, such as more power, Bluetooth 4.0, hardware encryption, temperature sensor, hall sensor, touch sensor, real time clock (RTC), more ports, more buses.

Sensors used

DHT22 sensor

The DHT22 sensor measures temperature and relative humidity. Among its components it is based on a thermistor for temperature measurement and has an internal capacitive sensor for humidity, thus being efficient in reading simultaneously.

Sensor DHT22	
Model	DTH22
Operating Voltage	3.3V-6V
Operating current	2.5 mA
Output signal	Digital-por Bus de datos
Sampling rate	0.5 Hz
RH measuring range	0%RH-100%RH
Operating temperature	-40°C-125°C
Humidity measurement accuracy	2%-5%
Temperature measurement range	-40°C-80°C
Accuracy	±0.5°C-±1°C

Table 1 Technical specifications of DTH22
Source: (MechatronicStore, 2023)

Sensor PCF-FST-200-201

The wind sensor is easy to mount on different measuring instruments, where it can indicate values from small wind movements. The protection of this sensor ranges from a metal alloy to avoid oxidation and the most sensitive part is sealed against water and small particles.

Figure 2 Wind sensor
Source: (PCE INSTRUMENTS, 2023)

ARD-355 Steren sensor

This sensor has the ability to send its output signal digitally or analogically, depending on the connection pin used and is adjustable for sensitivity. It is compact in size for optimum and convenient use.

Figure 3 Precipitation (rain) sensor
Source: (Steren, 2023)

Targets

General:

To evaluate the measurement of climatological variables on a permanent basis using IoT technology in the cultivation of C. chinense Var. Mayapán.

ISSN-2531-2952

Specific:

- Obtain the programming of microcontrollers for reading climatological variables in the Arduino IDE.
- Link the servers with the hardware for the monitoring system.
- Read the sensors connected to the ESP32 module through the Ubidots platform.

Methodology to be developed

Implementation of the monitoring and control system

The sensors are an essential part of the monitoring system, so the most accurate sensors were chosen for reading the variables connected to the ESP32 microcontroller.

- Temperature and relative humidity: DHT22
- Precipitation: Model ARD-355
- Wind: PCF-FTS-200-201

Diagram of the connections of the ESP32 microcontroller and the sensors.

The following diagram of the general architecture of the IoT monitoring system was developed to schematise the different sensors that will be linked to the ESP32 microcontroller for subsequent constant monitoring through devices connected to the Internet.

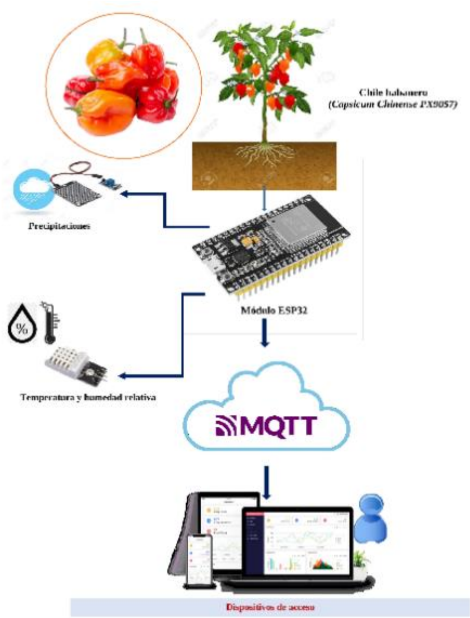


Figure 4 IoT architecture in cultivation of C. chinense Var. Mayapán
Source: Own Elaboration

Schematic diagram

The diagram of the connection of the different sensors with the ESP32 microcontroller was made, because the board has different pins with multiple functions assigned by default to define the properties in the software.

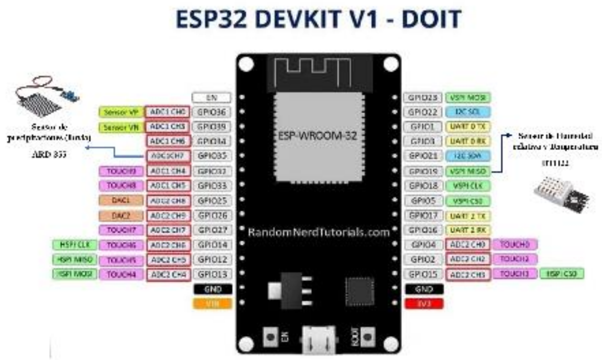


Figure 5 Schematic diagram of sensors with connection to the ESP32 microcontroller
Source: Own Elaboration

Construction of the prototype

The assembly was carried out by connecting the sensors to ground and the signal was connected directly to the analogue inputs of the ESP32 microcontroller to read each one.

ESP32 board configuration

To carry out the configuration within the Arduino IDE, we accessed the File > Preferences option. It was necessary to locate the section URL's Manager > Additional Card and there the following link was pasted: https://dl.espressif.com/dl/package_esp32.index .json proceeded to save and give Ok.

Next, go to the Tools tab and click on Board > Card Manager. Next, type ESP32 and choose the option called Espressif Systems, proceed to install and close the window.

Go back to Tools > Board and select ESP32 Arduino and select ESP32 Dev Module and click on it.

Finally, the Arduino IDE is now configured to start working with the ESP32.

Creating an Ubidots account

First, we entered the official Ubidots platform and went to the Sing up option.

Once we got to this point, we had to choose the version of the account we were going to work with by selecting For Educational or Personal use and correctly selecting "Take me to Ubidots stem".

Then the window for registration appeared, where it was necessary to add a user name, email address and a password, selecting at the end the section "My IoT project is for personal, non-commercial use".

After logging in with the creation of the personal account it is necessary to go to Devices > Devices. Here you select to add a blank device. It was named under the name "esp.32-cul. -de-chile".

After having added the device it was necessary to start adding the different variables to be monitored: temperature, relative humidity, wind and precipitation by selecting the option Raw and added one after the other.

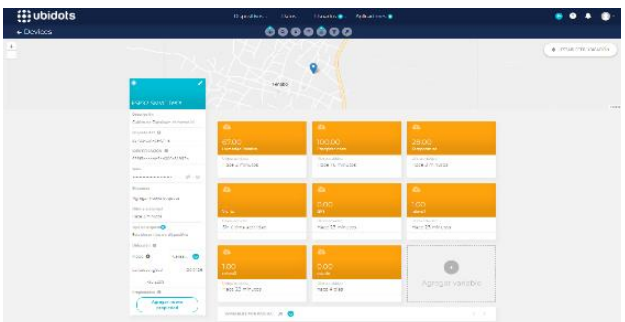


Figure 6 Ubidots platform
Source: Ubidots

Once the variables had been added, the user went to the Data > Demonstration panel section and then selected add widget.

The widget for each variable to be measured was added and configured as required for the best visualisation of each one, where finally the completed Dashboard (user interface) is shown for the control and monitoring of the variables.

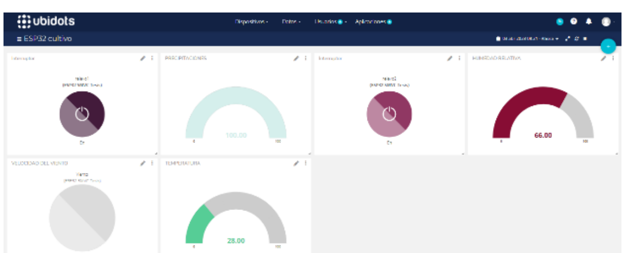


Figure 7 Dashboard
Source: Ubidots

Link IDE Arduino and Ubidots

The program made in Arduino IDE is divided into four files: the main program, configuration program, variables definition and the last one the configuration pins to be used in the ESP32 microcontroller.

Figure 8 Interfacing the ESP32 board file commands to the Arduino
Source: Arduino

First, in the pins file (pinout.h) the configuration was made where the GPIO pins corresponding to the sensors and actuators were added.

Next, the variables definition file (credentials.h) was used to configure the variables and the names of the variables previously defined in Ubidots were added, as well as the Ubidots URL, the Ubidots token, the Ubidots Client ID, the name of the WI-Fi network and the password of the modem to be used.

The following file "clientmqtt" contains the code that allows the MQTT client to function correctly.

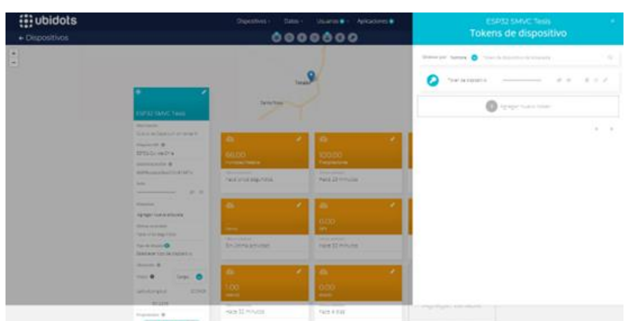


Figure 9 Ubidots interface configured with token and IDE Client
Source: Ubidots

ISSN-2531-2952

We go to the Ubidots platform in the Devices section we access the ESP32 microcontroller and enter variables in order to copy and paste the name of the variables in the variables configuration file found in the Arduino IDE where the program was compiled and downloaded to the ESP32 card, at that time the card already has the program that when turned on is capturing the information from the sensors. The information is sent by WiFi to the modem, which looks for the Ubidots page that was previously configured the token and the IDE Client of the platform.

Immediately we proceeded to open the Ubidots platform with our username and password registration, we access the Data section followed by Dashboard where you can finally have access graphically and allows easy way to monitor the variables in a friendly way.

Results

In order to carry out the corresponding operational tests, the sensors were connected to the ESP32 module for the visualisation of the operation, as well as the communication link between the client and the server.

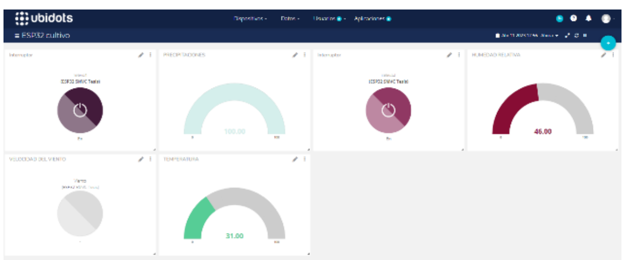


Figure 10 Client communication with the MQTT server
Source: Ubidots

It was possible to determine the results thanks to the communication of the ESP32 module with the client for the observation of the readings of the values indicated by the different sensors used in the monitoring system working correctly and in the best way suitable for the visualisation in the graphic interface with the widgets of each climatological variable for its monitoring in the Ubidots platform in real time.

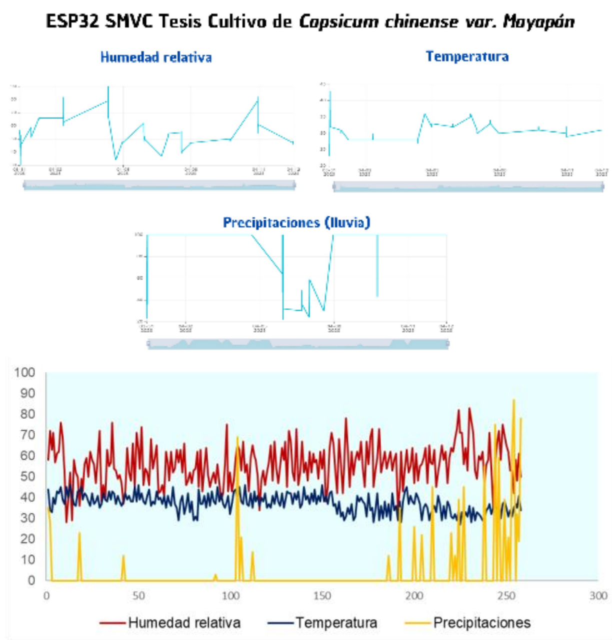


Figure 11 Logging of sensor readings from the monitoring system on the Ubidots platform
Source: Own Elaboration

Finally, the server allows and facilitates the registration of the readings during the period of time estimated by the user within the platform in a precise manner, establishing the day, time and value of the variables being measured.

Acknowledgements

This work was funded by the TecNM with code 14092.22-PD through the project "Monitoring system of climatological variables, based on IoT for agricultural crops".

The economic support granted by the CONAHCyT under the project No. 322133 "Acquisition of scientific infrastructure to carry out in silico, molecular and biochemical studies in the Biotechnology laboratory of the ITESCAM.

Conclusions

The development of the prototype worked correctly by achieving the communication of the ESP32 module with the Ubidots platform using a client with MQTT protocol to create a graphic interface for the real-time visualisation of the reading of the different sensors for the monitoring system of climatological variables in the cultivation of C. chinense Var. Mayapán. The system presented great relevance after achieving the ability to carry out remote monitoring from anywhere with a device with Internet access.

It is concluded that the transition of the Internet, reaching the 4.0 phase corresponding to IoT, seeks to consolidate as a tool in different areas such as informatics, agricultural innovation, biochemistry and mechatronics. The growing interest and need to understand how the effects of climate change impact agricultural crops in the physiological development of plants and morphological characteristics that occur leads us to make the implementation of advances in technology with various solution platforms applied to engineering for the creation of visual interfaces to establish communication with devices with Internet access.

References

Aldape, H. G., Chávez López, E., Reyes Del Ángel, C. A., & Oyarvide Martínez, O. D. (2022). *MONITOREO DE CULTIVOS CON INTERNET DE LAS COSAS POR MEDIO DE UNA RED DE SENSORES*.

Bastos Stephens, G., Joaquín Cerda, J. A., López Guerrero, J. A., & Córdoba Retana, J. (2022). *Transformation of agriculture through the implementation and use of the In-ternet of Things in Costa Rica*. https://orcid.org/0000-0003-2754-7682

Burbano-Robles, L. A. (2022). *ESTACIÓN AUTÓNOMA DE PARÁMETROS AGRÍCOLAS BASADO EN INTERNET DE LAS COSAS*.

Chanchí-Golondrino, G.-E., Ospina-Alarcón, M.-A., & Saba, M. (2022). Sistema IoT para el monitoreo de variables climatológicas en cultivos de agricultura urbana. *Revista Científica*, *44*(2), 257–271. https://doi.org/10.14483/23448350.18470

Cortes, V., Marco, C., & Garcia, F. V. (2020). *DISEÑO E IMPLEMENTACIÓN DE UN SISTEMA DE RIEGO AUTOMATIZADO Y MONITOREO DE VARIABLES AMBIENTALES MEDIANTE IOT EN LOS CULTIVOS URBANOS DE LA FUNDACIÓN MUJERES EMPRESARIAS MARIE POUSSEPIN*.

MechatronicStore. (2023). *Sensor de Temperatura y Humedad Relativa Dht22*.

Montoya, E. A. Q., Colorado, S. F. J., Muñoz, W. Y. C., & Golondrino, G. E. C. (2017). Propuesta de una Arquitectura para Agricultura de Precisión Soportada en IoT. RISTI - Revista Ibérica de Sistemas e Tecnologías de Información, 24, 39–56. https://doi.org/10.17013/risti.24.39-56

Nuñez-Agurto, D., Benavides-Astudillo, E., Rodríguez, G., & Salazar, D. (2020). Propuesta de una Plataforma de Bajo Costo Basada en Internet de las Cosas para Agricultura Inteligente. *Cumbres*, *6*(1), 53–66. https://doi.org/10.48190/cumbres.v6n1a5

Rambauth Ibarra, G. E. (2022). Agricultura de Precisión: La integración de las TIC en la producción Agrícola. *Computer and Electronic Sciences: Theory and Applications*, *3*(1), 34–38. https://doi.org/10.17981/cesta.03.01.2022.04

Article
Journal Applied Computing
December 2023, Vol.7 No.21 17-22

Pedestrian detection system for automobiles using computer vision and artificial intelligence using *Raspberry Pi* 4 and webcam

Sistema de detección de peatones para automóvil mediante visión por computadora e inteligencia artificial empleando *Raspberry Pi* 4 y cámara web

SERRANO-RAMÍREZ, Tomás†*, SÁMANO-FLORES, Yosafat Jetsemaní, GUTIERREZ-LEÓN, Diana Guadalupe and BARRIENTOS-GARCÍA, Alejandro

Universidad Politécnica de Guanajuato, Departamento de Ingeniería Automotriz, México.

ID 1er Author: *Tomás, Serrano-Ramírez* / **ORC ID**: 0000-0001-6118-3830, **Researcher ID Thomson:** G-6039-2018, **CVU CONAHCYT ID:**493323

ID 1er Co-author: *Yosafat Jetsemaní, Sámano-Flores* / **ORC ID**: 0000-0003-4173-6236, **CVU CONAHCYT ID**: 444850

ID 2do Co-author: *Diana Guadalupe, Gutiérrez-León* / **ORC ID**: 0000-0001-5051-880X, **Researcher ID Thomson:** G-6035-2018, **CVU CONAHCYT ID:** 443892

ID 3er Co-author: *Alejandro Barrientos-García* / **ORC ID**: 0000-0002-8446-5985, **CVU CONAHCYT ID:** 329409

DOI: 10.35429/JCA.2023.21.7.17.22 Received July 10, 2023; Accepted December 30, 2023

Abstract

Traffic accidents involving pedestrians have increased in recent years, causing a large number of deaths worldwide, some of the main causes being: distracted drivers or pedestrians, car blind spots, adverse environmental conditions among others. With the advent of autonomous driving systems at different levels, the development of pedestrian detection systems has become a priority task. In this work, an economical and easy-to-install pedestrian detection system for automobiles is proposed, which uses the Raspberry Pi 4 card, webcam and an LCD screen as hardware. In the software part, a computer vision system with artificial intelligence is implemented using the TensorFlow Lite library for the classification of people in real time, Python and Open CV as programming language and computer vision library. The aim is for the system to visually alert the driver about the presence of pedestrians on both sides of the road or that get in the way of driving in order to avoid possible accidents.

Pedestrian detection, TensorFlow, *Raspberry Pi*

Resumen

Los accidentes de tránsito que involucran peatones, se han incrementado en los últimos años, causando un gran número de muertes a nivel mundial, siendo algunas de las principales causas: conductores o peatones distraídos, puntos ciegos en el automóvil, condiciones ambientales adversas, entre otras. Con el advenimiento de los sistemas de conducción autónoma en sus diferentes niveles, el desarrollo de sistemas para la detección de peatones se ha vuelto una tarea prioritaria. En este trabajo se propone un sistema de detección de peatones para automóvil económico y de fácil instalación, el cual utiliza como hardware la tarjeta Raspberry Pi 4, cámara web y una pantalla LCD. En la parte del software se implementa un sistema de visión por computadora con inteligencia artificial utilizando la librería TensorFlow Lite para la clasificación de personas en tiempo real, Python y Open CV como lenguaje de programación y librería de Visión por computadora. Se busca que el sistema alerte al conductor de forma visual sobre la presencia de peatones a ambos lados del camino o que se interpongan en la trayectoria de conducción con el objetivo de evitar posibles accidentes.

Detección peatones, TensorFlow, *Raspberry Pi*

Citation: SERRANO-RAMÍREZ, Tomás, SÁMANO-FLORES, Yosafat Jetsemaní, GUTIERREZ-LEÓN, Diana Guadalupe and BARRIENTOS-GARCÍA, Alejandro. Pedestrian detection system for automobiles using computer vision and artificial intelligence using *Raspberry Pi* 4 and webcam. Journal Applied Computing. 2023. 7-21:17-22.

* Correspondence from the Author (E-mail: tserrano@upgto.edu.mx)
† Researcher contributing as first author.

Introduction

According to the World Health Organization (World Health Organization, 2022), globally 1.3 million pedestrians die each year as a result of road traffic crashes and between 20 and 50 million more suffer non-fatal injuries, which in a significant percentage of cases result in permanent disability. There are several factors that contribute to these accidents, including driving errors, vehicle malfunctions, environmental factors such as poor signage, lack of pavements or poor lighting conditions. In addition, the pedestrian is also a major contributor (Hasan and Hasan, 2022), due to the increase of distractors such as the use of portable IoT devices on the road such as smartphones, headphones, among others.

Although the statistics are alarming, with the advent of driver assistance technologies such as Autonomous Emergency Breaking (AEB) and pedestrian detection systems, a 25%-27% reduction in pedestrian hit-and-run risk is achieved (Cicchino, 2017).

Different technologies have been implemented in automobiles for pedestrian detection including: ultrasonic sensors, piezoelectric sensors, microwave radar, Laser Imaging Detection and Ranging (LIDAR), Infrared IR sensors and Computer Vision (Chan and Bu, 2006).

Of these technologies, computer vision has taken a leading role in pedestrian detection, due to the emergence of new and increasingly efficient artificial intelligence algorithms, embedded systems with sufficient computing power to process such algorithms in real time, and the economy of conventional digital camera sensing. In addition, computer vision systems emulate the functioning of the human eye-brain vision system, which has proven to be extremely efficient.

Computer vision methods for pedestrian detection have undergone two stages of evolution (Han et al., 2021), the first of which covers the period 2001 to 2013, corresponding to detection using classical pattern recognition algorithms.

In this stage, the procedure consisted of processing the images obtained by the digital camera one by one, first implementing algorithms to improve the quality of the image, then applying algorithms for feature extraction such as Haar or Histogram of Oriented Gradients and then using pattern recognition algorithms such as Support Vector Machine or Decision Tree for the prediction of the object, in this case the pedestrian. The disadvantage of such an approach is the requirement of considerable computational power and poor classification performance.

The second stage consists of the period from 2014 to the present, which is highlighted by the implementation of Convolutional Neural Networks (CNN) in computer vision and pedestrian detection systems. This brought a considerable improvement, because CNNs are computationally efficient, automatically optimise model parameters, automatically extract features and above all, are highly accurate in classifying objects in images.

Nowadays, due to the increased processing power of single-board computers and the efficiency of CNN-based computer vision systems, it is possible to implement pedestrian detection systems for driving assistance, which are not only distinctive of high-end cars, but can be installed in any car at a competitive cost and with high performance.

The proposed system is in line with this approach, employing as sensor an inexpensive webcam with a resolution of 1.3 Mega pixels and data transmission via USB 3.0. For video processing the Raspberry Pi 4 embedded system is used, a single board computer the size of a bank card which has the following features: a quad-core processor at 1.8 GHz and 64 bits, 4GB LPDDR4 ram memory, two USB 3.0 ports, two USB 2.0, HDMI, WiFi, Bluethooth, 40 GPIO input and output pins, among others.

On the software side, a model pre-trained by Google for object detection based on CNN and implemented using the TensorFlow library is used, as well as the Python 3 programming language, the OpenCV computer vision library and the Raspberry OS operating system, giving preponderance to the use of free software.

ISSN-2531-2952

Hardware development

The following is a list of the equipment used for the realisation of this project:

- Logitech C920 webcam.
- Raspberry Pi 4 with 4GB of RAM.
- 10.1 inch LCD monitor.
- 120 W power invertir.
- Wireless keyboard and mouse.

A Logitech C920 3 megapixel Full HD 1080p 30 fps webcam was used, which is responsible for capturing the video signal in the pedestrian detection system. The camera was selected for its sensor quality, its ability to adjust luminance for different light conditions, auto focus and 78° viewing angle.

The camera was installed on the sunroof of the car pointing forward in order to capture the video feed from the road, similar to what the driver would see. Figure 1 shows the camera and its installation position in the car.

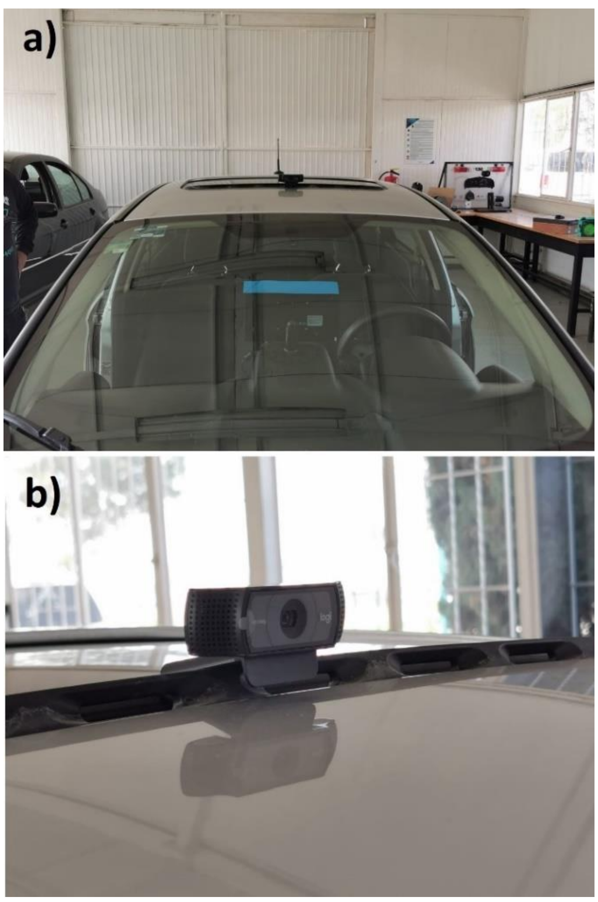


Figure 1 Logitech C920 webcam and its installation on the sunroof of the car to capture the video signal, a) front view and b) side view

A Raspberry Pi 4 single board computer was installed inside the car cabin, which is powered by a 120 W inverter connected to the battery. In turn, the computer was remotely controlled by a wireless keyboard and mouse. Figure 2 shows the Raspberry Pi board, the inverter and its installation inside the car.

Figure 2 Raspberry Pi 4 board mounted inside the cabin of the car and powered by an inverter connected to the battery

The Raspberry Pi 4 board was in charge of running the pedestrian detection system implemented through Artificial Intelligence, remembering that this is a complete computer controlled by the Raspberry Pi OS operating system, which manages the execution of the detection model.

Next, a 10.1-inch colour LCD monitor connected to the Raspberry Pi was used to provide real-time feedback on the detection of pedestrians on the road and the possible alerts derived from it. It was placed inside the cockpit, on the dashboard and facing the driver (Figure 3).

Figure 3 In-dash colour LCD screen, which displays real-time pedestrian detection on the road and corresponding alerts

Software development

For the development of the pedestrian detection system, the implementation of its components was contemplated using free software, with the advantages that this entails, so the use of open source libraries and programmes is a priority. Below is a list of the programs used for the implementation of this project:

- Raspberry Pi OS
- Python 3
- Open CV
- TensorFlow Lite

The first step consisted of installing the Raspberry Pi OS operating system on the Raspberry Pi 4 board. As this is a small board computer, the OS is necessary for the management of all processes and programs. The second step involved the installation of the Python 3 interpreter, in which the pedestrian detection system will be programmed. Python is a modern high-level programming language, used for the creation of free software, which does not require compilation, thus reducing testing and debugging time.

The third step consisted of installing Open CV, a computer vision library whose function is to capture and process the video signal, providing a set of basic functions for mathematical image processing, colour space shifting and pixel manipulation.

The fourth step involved the installation of TensorFlow Lite, an open source library developed by Google to implement deep learning models on resource-constrained edge devices. TensorFlow Lite models have a faster inference time and require less processing power, so they can be used for faster performance in real-time applications.

Once the necessary software components have been installed, the pedestrian detection system is developed, using as a basis the model trained by Google and developed using the TensorFlow Lite library for object recognition; this model is based on deep neural networks.

As soon as the model receives the video stream, the system classifies the objects for which it was trained and provides the position in the image. Among the objects it can classify (73 different types of objects) are people, cars, vans, motorbikes, chairs, tables, among others. Figure 4 shows a field test of the basic system mounted on the car.

Figure 4 Field test of the basic car-mounted detection system, showing the detection of people and cars

Once the basic detection system has been implemented, it is configured for pedestrian detection and alert signalling. If the system detects people in front of the vehicle, standing in the way, the system displays a red "stop person in front" message. In case the pedestrian(s) is/are approaching from the right or left, but not obstructing the road, a corresponding yellow message "caution person on the right" or "caution person on the left" is displayed. In case of pedestrians approaching from both sides, but without obstructing the road, the yellow message "be careful pedestrians on both sides" is displayed".

ISSN-2531-2952

Figure 5 Test of the pedestrian detection system in the laboratory

Results

Once the pedestrian detection system was fully developed and tested in the laboratory, the hardware was mounted on a 2017 Ford Fiesta Sedan, which was then driven outside, encountering pedestrians and vehicles in different situations. The number of objects to be detected simultaneously, the lighting conditions and the speed at which the stimuli occur can be a challenge to overcome. Some images of the field tests are shown in Figure 6.

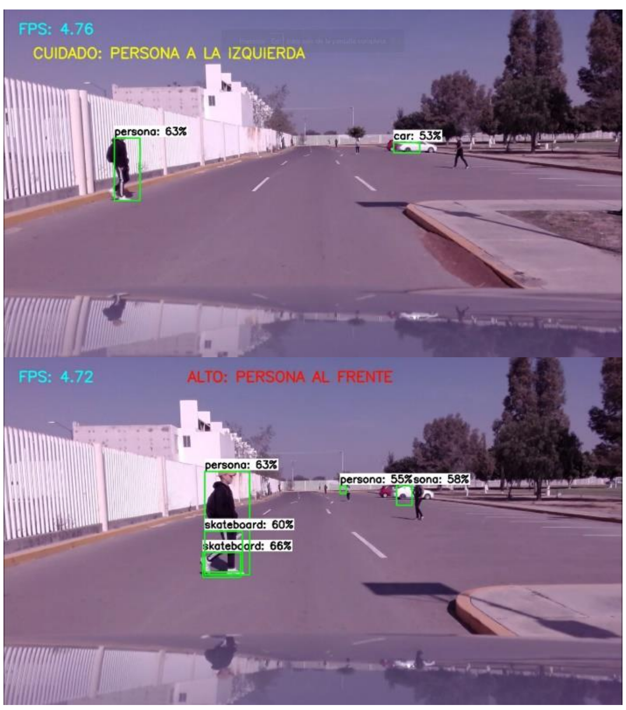


Figure 6 Test of the pedestrian detection system mounted in a car and in a real driving situation

Conclusions

The proposed pedestrian detection system shows promising results, working correctly for each of the vehicle-pedestrian situations that were considered. However, there are issues to improve, such as the number of frames per second that the Raspberry Pi 4 is able to process with the detection system, achieving a maximum of 4, which limits it to low-speed driving situations. On the other hand, false positives and false negatives are present, leading to cases where a pedestrian is mistaken for other objects or simply not detected at all. Although the number of error cases is lower, the occurrence of errors can lead to a serious accident, so improving classification performance is still an area of opportunity.

References

World Health Organization (2022).” Road traffic injuries”. https://www.who.int/news-room/fact-sheets/detail/road-traffic-injuries.

Hasan, R y Hasan, R (2022) "Pedestrian safety using the Internet of Things and sensors: Issues, challenges, and open problems" Future Generation Computer Systems, 134, pp. 187-203. https://doi.org/10.1016/j.future.2022.03.036

Cicchino, J. (2017). Effectiveness of forward collision warning and autonomous emergency braking systems in reducing front-to-rear crash rates. Accident Analysis & Prevention, 99-part A, pp. 142-152. https://doi.org/10.1016/j.aap.2016.11.009

Chan, C y Bu, C (2006) “Vehicle-Infrastructure Integrated Approach for Pedestrian Detection: Feasibility Study Based on Experimental Vehicle Platforms”, TRB Annual Meeting, Paper No. 06-0118.

Dian, T. Han, Y. y Wang, B. (2021) “A Review of Intelligent Driving Pedestrian Detection Based on Deep Learning”, Computational Intelligence and Neuroscience, ID 5410049. https://doi.org/10.1155/2021/5410049.

Article
Journal Applied Computing
December 2023, Vol.7 No.21 23-30

Web system for automatic irrigation in a greenhouse

Sistema web para el riego automático en un invernadero

RAFAEL-PÉREZ, Eva†*, GARCÍA-CERVANTES, Oscar Daniel, MORALES-HERNÁNDEZ, Maricela and RIOS-MALDONADO, Vicenta

Tecnológico Nacional de México - Instituto Tecnológico de Oaxaca, Departamento de Sistemas y Computación. Avenida Ing. Víctor Bravo Ahuja No. 125 Esquina Calzada Tecnológico, Oaxaca, Oax., México. C.P. 68030.

ID 1st Author: *Eva, Rafael-Pérez* / **ORC ID:** 0000-0003-2793-1254, **CVU CONACYT ID:** 905268

ID 1st Co-author: *Oscar Daniel, García-Cervantes /* **ORC ID**: -0000- **CVU CONACYT ID:**

ID 2nd Co-author: *Maricela, Morales-Hernández* / **ORC ID:** 0000-0002-3521-2041, **CVU CONACYT ID:** 731036

ID 3rd Co-author: *Vicenta, Rios-Maldonado* / **ORC ID**: 0000-0002-1049-6631, **CVU CONACYT ID:** 90238

DOI: 10.35429/JCA.2023.21.7.23.30 Received July 15, 2023; Accepted December 30, 2023

Abstract

The irrigation system in greenhouses is a fundamental aspect in crop production since it is responsible for suplaying water to the plants. The San Sebastián greenhouse is irrigated by drip irrigation, the main characteristic of which is to provide the necessary amount of water and nutrients for the crops. The technological development has impacted irrigation systems in protected agriculture, allowing greenhouses to implement irrigation systems to automatically start and finish the irrigation process. This article describes the project based on a web-based system and a desktop application backed from real-time interface module through automated humidity and temperature sensors, with the objective of improving irrigation productivity and product quality. With the development of the Project, the irrigation automation process, the modules of the web system and the results produced by the system are exhibit. For this project, the Prototypes model was used using the PHP programming language.

Web system, Greenhouse, Automatic irrigation

Resumen

El sistema de riego en los invernaderos es un aspecto fundamental en la producción de cultivos ya que se encarga de llevar el agua a las plantas. El riego con el que cuenta el invernadero San Sebastián es por goteo cuya característica principal es aportar la cantidad de agua necesaria y nutrientes para los cultivos. El desarrollo tecnológico ha impactado en los sistemas de riego en la agricultura protegida, permitiendo que en los invernaderos se puedan implementar sistemas de riego de forma automática para el inicio y fin del proceso de riego. El presente artículo describe el proyecto basado de un sistema web y una aplicación de escritorio que se apoya del módulo de Adquisición de datos utilizando valores en tiempo real de los sensores de humedad y temperatura para el riego de forma automática, esto, con el objetivo del aumento en la productividad y calidad de los productos. Con el desarrollo del proyecto se muestra el proceso de automatización de riego, los módulos del sistema web y los resultados del sistema. Para este proyecto se utilizó el modelo en Prototipos utilizando el lenguaje de programación PHP.

Sistema web, Invernadero, Riego automático

Citation: RAFAEL-PÉREZ, Eva, GARCÍA-CERVANTES, Oscar Daniel, MORALES-HERNÁNDEZ, Maricela and RIOS-MALDONADO, Vicenta. Web system for automatic irrigation in a greenhouse. Journal Applied Computing. 2023. 7-21:23-30.

* Correspondence to the Author (E-mail: evarafaelperez@gmail.com)
† Researcher contributing as first author.

Introduction

Irrigation automation systems play a fundamental role in greenhouses for irrigating crops, one of the key factors in crop production is water, a basic resource for irrigation, which through the irrigation system provides the supply of water and the necessary nutrients, as well as the amount of water for the plants. The incorporation of automatic irrigation systems has also transformed the form and manner of irrigation in greenhouses, the way of production in agriculture has changed, currently agriculture automates its manual processes which makes production efficient and improves quality of the greenhouse product, an important element of the production system in protected agriculture, because the productive capacity largely depends on it (Fernández, 2012).

Protected agriculture is the production system carried out under various structures and covers, among which greenhouses stand out, whose basic characteristic is protection against the risks inherent in the production of crops in free exposure, their main function is to recreate the optimal and appropriate conditions of radiation, temperature, humidity and carbon dioxide, to generate the reproduction, development and growth of plants, increasing production in quantity, quality and commercial opportunity (Castañeda et al., 2007; Bastida, 2008; Moreno et al., 2011)

The project called “Web System for automatic irrigation in a Greenhouse” was developed with the objective of maintaining optimal irrigation in the plants, controlling the amount of water, reducing time and saving efforts, taking into account the characteristics of the drip irrigation system that It has the “San Sebastián” greenhouse. The results of the project are the web system, the desktop application and the data acquisition module.

For the purposes of this work, only the Data Acquisition module and the desktop application will be briefly mentioned; the detailed operation and design will be presented in another future work. This article contains the problem statement, the data acquisition module, the web system modules, the development methodology, the description of the phases, the results, the acknowledgments and finally the conclusions and bibliographic references.

Problem statement

Crop production under protected agriculture is a modern technique currently used in agricultural production. Irrigation is an essential component of sustained agricultural development. According to Demin (2014), crops need to absorb water from the soil in order to grow and develop. When the moisture content is low, absorption is difficult, which is why it is necessary to water to replenish it and make it available for the crop.

Over the course of eight years, different crops have been planted in the San Sebastián greenhouse and watered using a drip system, which operates up to eight times a day, providing a constant supply of water for the sixteen beds in the greenhouse, where each bed has a valve that is connected to a master valve that allows the flow of water, the process that is followed is manual by opening each valve to later measure the time, either based on your experience or with a predefined measurement (You can be by counting drops or clockwise). Which generates loss of time since the farmer spends time opening and closing valves, counting the drops that fall from the hose per bed, checking the clock and keeping an eye on whether the crops are being watered bed by bed. Another problem is the excess or lack of humidity since the farmer must put his hand into the soil to feel the humidity of the earth and thus determine if more water is required or if he should close the valve according to his experience, putting the harvest in danger, without taking Keep in mind that the needs of crops require a different amount of water, nutrients and depend on the phase in which it is found, whether germination, seedling, plant or in production, therefore the product often does not have quality and economic losses occur.

Data acquisition module

The data acquisition module aims to obtain or generate information on the values of the humidity and ambient temperature variables through electronic devices such as sensors and the Arduino for the operation of the Web system.

Through an interface it is linked to the web system that shows the values and the results it generates, which means that when requests are received from the server, it is linked in real time to the data acquisition module to start or close the irrigation open or close the valves connected to the master valve automatically.

Development methodology

For the functionality of the web system, the software development model based on Prototypes was used, which aims at the direct participation of the client in the construction of the required software, helping to improve the understanding of what is going to be developed when the requirements are not met or clear and serves as a mechanism to identify and define the software requirements, in addition the prototype evolves through an iterative process (Pressman, 2010, p. 37).

Figure 1 shows the phases: communication, rapid plan, rapid modeling and design, prototype construction, deployment, delivery and feedback.

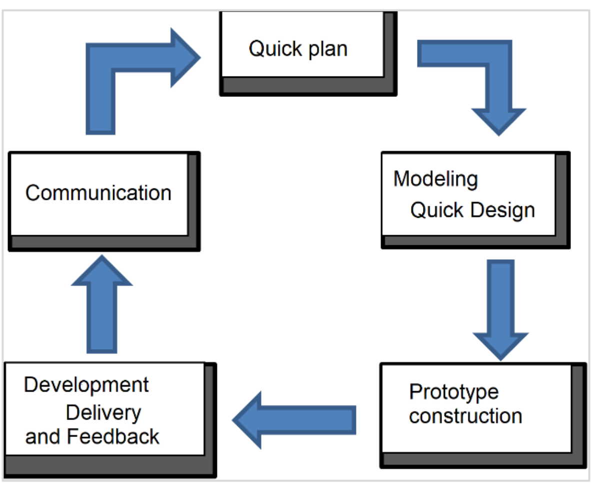


Figure 1. Adapted prototype model
Source: (Pressman, 2010, p. 37)

The phases are described below:

- Communication Phase, in this first stage interviews were carried out with the farmer to find out what the real needs were and the problems presented, for example: identifying manual processes, the irrigation system, manual preparation of fertilizer, fertilization, sowing periods , harvesting, cutting, weather conditions in terms of humidity and temperature, type of crops planted, quantity of crops, information that served to define the requirements, the definition of both general and specific objectives of the software, as well as types of users who will interact with the system.

For the functionality of the web system, three types of users were identified with different roles and privileges for access to the system:

- The Administrator user is the user who has full access to each of the modules, and is responsible for adding information to the system: User data, new crops and new irrigations, greenhouse data, beds and notifications.

- The Farmer user adds data on crops, irrigation period, number of irrigation times, greenhouses, beds and notifications.

- The worker user can only see information about crops, greenhouses and notifications.

- The Quick Plan phase is carried out when the results of the project from the previous stage are accepted, then a representation of the requirements is developed. For this system, the user story technique was used to model the user requirements. Table 1 shows an example of a user story to add the Farmer user type.

ISSN-2531-2952

User story	
Number: 1	User: Administrator
Story Name: Add User	
Priority: High	Risk: Low
Estimated points: 2	Assigned prototype: 1
Responsible: Oscar Daniel García Cervantes	
Description: As an administrator I want to add a new farmer to the system	
Validation: The administrator can add a new farmer as long as they are logged in within the system	

Table 1 User story: administrator user

- In the Rapid Design Modeling stage, different tasks were carried out such as the design of use cases, graphical user interfaces, two databases were created, the local database and the remote one using MySQL, which is a data management system. Most popular open source relational database based on SQL (Structured Query Language) Structured query language, capable of storing large amounts of data that also uses the client-server model. The server is where the data really resides and to have access, requests are made, this is where the client comes in, that is, requests are sent to the database server to obtain the data that the client requires. The remote database serves as a backup for the local database, if a problem occurs with it, it can be recovered through the backup, in addition the remote database is updated every time there is an internet connection adding the newer data.

In the case of use case models, according to Jacobson (2013) he mentions that "expresses all the ways of using a system to achieve a goal particular for a user. As an example, a use case model is shown to Log in to the system, first you have to Validate data using a username and password. See figure 2.

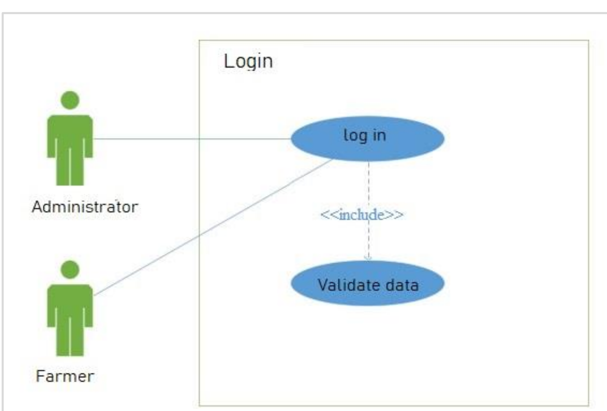


Figure 2 Login use case

- Prototype construction stage, in this stage the user, crop and greenhouse modules were developed for coding, the PHP (Hypertext Pre-Processor) programming language was used, that is, Hypertext Pre-Processor. It is an open source, general-purpose programming language for web development that runs on the server side.

- In relation to the operation of the web system, it is linked to the Data Acquisition module through the Water button to obtain temperature and humidity measurements.

- The last phase of deployment, delivery and feedback of the system, the functionality of the web system was reviewed through different types of tests, reviews were carried out by the farmer and they were adapted to the requested requirements.

Results

Next the results of the modules: users, crops and greenhouses are described below:

- Access to the system, to enter the system a username and password are required. See Figure 3.

Figure 3 System access screen

- Main Screen, this screen shows the main view of the web system, the options menu, the current system data obtained from the data acquisition module with the humidity value using the water button, see figure 4.

ISSN-2531-2952

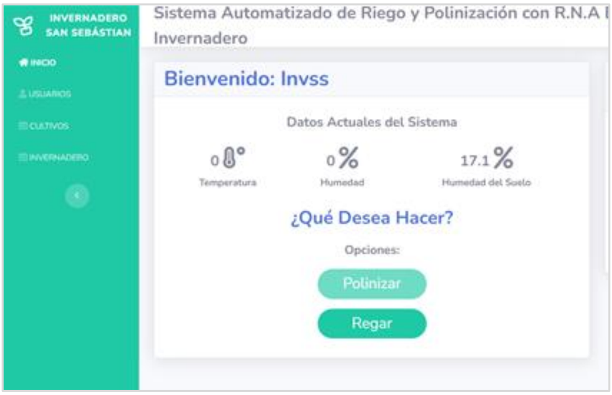


Figure 4 Main menu

- One of the main functions of the web system is irrigation, and this is where the farmer makes the request for the valves to be activated automatically and start irrigation. The main screen shows the water button, pressing the button links to the Data Acquisition module to obtain humidity, this is displayed in real time in the system, the duration of irrigation will depend on the times assigned in the system by the farmer depending on the type of crop that is planted at that time, the web system is configured to send and receive notifications for the start or closure of irrigation based on the humidity sensor value. See figure 5.

Figure 5 Water button

- When you press the water button, the server displays a screen where it shows the question to the Farmer, do you want to start irrigation? The decision-making by the farmer is essential, whether or not the start of irrigation in the greenhouse will depend on him. See figure 6.

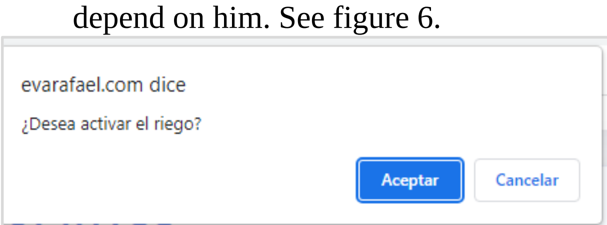


Figure 6 Accept button to start irrigation

Clicking on the Accept button starts the irrigation process, see figure 7.

Figure 7 Water button

- User module

This screen shows the users registered in the system using a board. You can also search for a user by name by typing one letter or more and clicking the Search button. See figure 8.

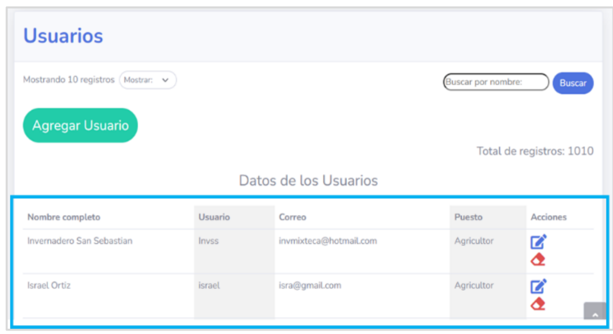


Figure 8 Registered users of the user module

- User registration below is the form for user registration, with the following fields: Full name, username, password, confirm password, user position and email, there are mandatory fields that are marked with an asterisk. See figure 9.

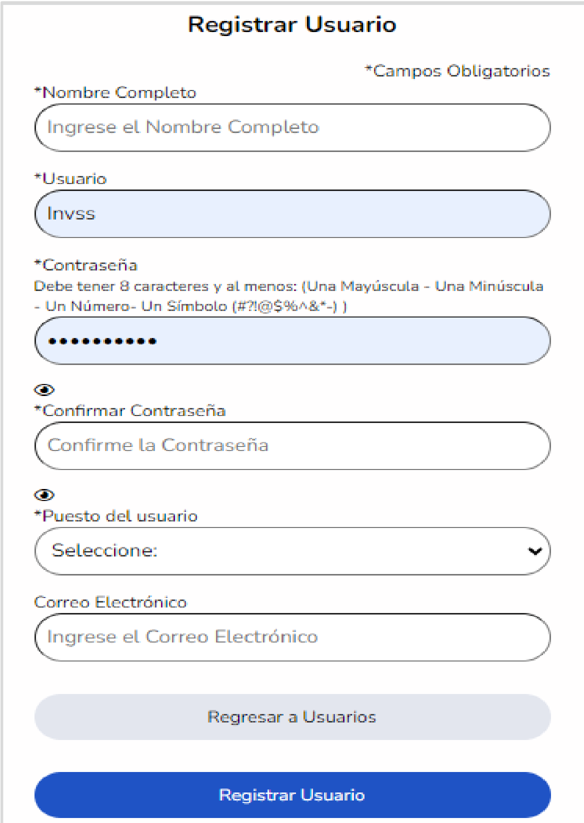


Figure 9 User registration

- Crop module

Figure 10 shows the crop module screen with the corresponding information for each of them. You can search for the crop name by writing one letter or more and clicking on the Search button.

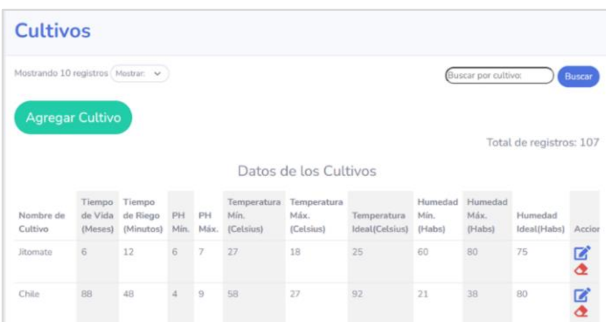


Figure 10 Crop module

- Crop registration

This screen shows the fields to register a crop to the system. There are mandatory fields that are marked with an asterisk, once the fields are filled out, press the Register Crop button to save the new crop. See figure 11.

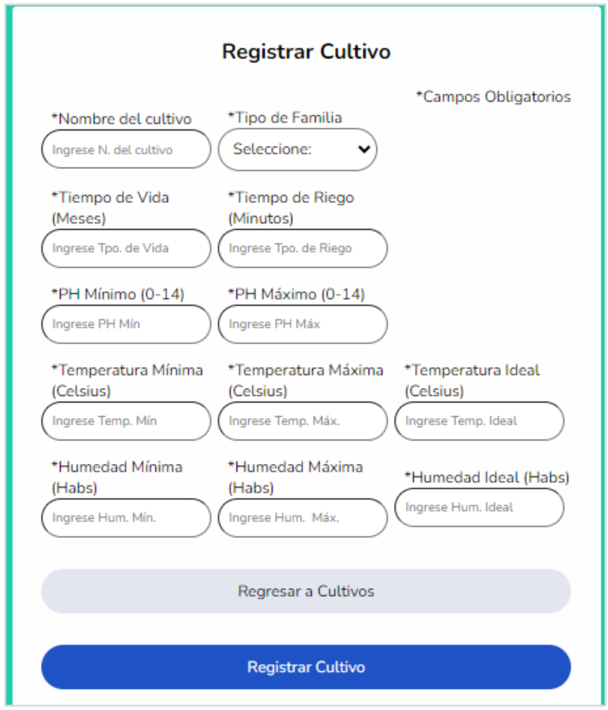


Figure 11 Crop record

- Greenhouse module

In figure 12 you can see the bed data, the number of beds and the crop found in each bed or group of beds in the greenhouse. It also has two options that allow you to edit the bed data and eliminate the number of beds. beds as required by the farmer, you can also search for a crop by name by writing one letter or more and clicking on the Search button.

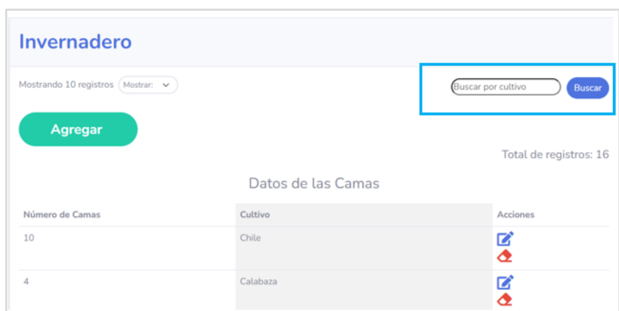


Figure 12 Greenhouse module

- Add beds

The Add button allows you to add a new bed record to the greenhouse module. In the form there are mandatory fields marked with an asterisk. Once the fields are filled out, press the Register Bed button to save the new record. See figure 13.

Figure 13 Register beds

Acknowledgments

To the Tecnológico Nacional de México/Instituto Tecnológico de Oaxaca for the facilities and spaces for the development of this research work.

The collaboration of the Farmers of the “San Sebastián” Greenhouse located in the community of San Sebastián Atoyaquillo, in the mixtec region.

The collaboration and dedication of the authors of the article, professors and students who participated responsibly in the research until the results presented were achieved are appreciated; The objective of this research is to be able to disseminate the findings to the academic community and the general public about the work carried out at the Institution.

Conclusions

The web system for automatic irrigation in a Greenhouse was developed with the objective of maintaining optimal irrigation in the plants, controlling the amount of water, reducing time and saving efforts as a low-cost alternative for farmers, crops and harvests under Greenhouses. Irrigation in greenhouses is a fundamental part for the development of the plant, the “San Sebastián” greenhouse has a drip irrigation system for the distribution and irrigation of crops, the main characteristic of which is that it provides the necessary amount of water and nutrients to the crops.

The system allows irrigation to be programmed, records the number of irrigation times, validates the times assigned to each irrigation, sends notifications of the start and closure of irrigation, relying on the Data Acquisition module to obtain the sensor value in real time, in addition to the modules that the web system has for proper functioning.

This project secures the foundations so that new functionalities can be added such as data analysis and the application of artificial intelligence in the future.

References

Castañeda, M., Rodrigo, V., Ramos, E., Peniche, V. and Rebeca del R. 2007. Analysis and simulation of the physical model of a greenhouse under climatic conditions in the central region of Mexico. Agroscience 3: 317-335.

Demin, P. (2014). Contributions to improve the management of irrigation systems Irrigation methods: fundamentals, uses and adaptations, 1, 24.

Fernández, S.C. 2012. Analysis and Evaluation of risks of natural incidents in the intensive agricultural production system of Almería. (Doctoral thesis) University of Almería. Spain.

Fernández Fernández, M. M., Aguilar Pérez, M. I., Carrique Pérez, J. R., Tortosa Domingo, J., García García, C., López Rodríguez, M., and Pérez Morales, J. M. (2014). Soil and environment in greenhouses. Seville: Ministry of Agriculture, Fisheries and Rural Development

Flórez Fernández, H., et al. (2021). Web applications with PHP. Bogota Colombia. U Editions.

Hernandez (2015). The importance of databases in companies. https://germenstartup.wordpress.com/2015/01/29/la-importancia-de-las-bases-de-datos-bbdd-en-las-empresas/

Jacobson, I., Spence, I., Bittner, K., Caraballo, L. A. S., & Jaramillo, C. M. Z. (2013). Casos de uso 2.0. La guía para ser exitoso con los casos de uso.

ISSN-2531-2952

December 2023, Vol.7 No.21 23-30

López Herrera, P. (2016). Comparison of the performance of MySQL and PostgreSQL Database Management Systems.

Moreno Reséndez, Alejandro; Aguilar Durón, Juanita; Luévano González, Armando. Characteristics of protected agriculture and its environment in Mexico

MySQL. (2020). MySQL Documentation. https://dev.mysql.com/doc/

Pressman S., R. (2010). Software Engineering. McGraw Hill

Ramos, M. J., Ramos, A., & Montero, F. (2006). Gestores de bases de datos. Madrid: Mc Graw Hill.

Universidad de Barcelona. (2020). OBS. Obtenido de ¿Qué son las metodologías de desarrollo de software?: https://obsbusiness.school/es/blog-project-management/metodologia-agile/que-son-las-metodologias-de- desarrollo-de-software

ISSN-2531-2952

[Title in Times New Roman and Bold No. 14 in English and Spanish]

Surname (IN UPPERCASE), Name 1st Author†*, Surname (IN UPPERCASE), Name 1st Co-author, Surname (IN UPPERCASE), Name 2nd Co-author and Surname (IN UPPERCASE), Name 3rd Co-author

Institutional Affiliation of Author including Dependency (No.10 Times New Roman and Italic)

ID 1st author: (ORC ID - Researcher ID Thomson, arXiv Author ID - PubMed Author ID - Open ID) and CVU 1st author: (Scholar-PNPC or SNI-CONACYT) (No.10 Times New Roman)

ID 1st co-author: (ORC ID - Researcher ID Thomson, arXiv Author ID - PubMed Author ID - Open ID) and CVU 1st co-author: (Scholar or SNI) (No.10 Times New Roman)

ID 2nd co-author: (ORC ID - Researcher ID Thomson, arXiv Author ID - PubMed Author ID - Open ID) and CVU 2nd co-author: (Scholar or SNI) (No.10 Times New Roman)

ID 3rd co-author: (ORC ID - Researcher ID Thomson, arXiv Author ID - PubMed Author ID - Open ID) and CVU 3rd co-author: (Scholar or SNI) (No.10 Times New Roman)

(Report Submission Date: Month, Day, and Year); Accepted (Insert date of Acceptance: Use Only ECORFAN)

Abstract (In English, 150-200 words)

Objectives
Methodology
Contribution

Keywords (In English)

Indicate 3 keywords in Times New Roman and Bold No. 10

Abstract (In Spanish, 150-200 words)

Objectives
Methodology
Contribution

Keywords (In Spanish)

Indicate 3 keywords in Times New Roman and Bold No. 10

Citation: Surname (IN UPPERCASE), Name 1st Author†*, Surname (IN UPPERCASE), Name 1st Co-author, Surname (IN UPPERCASE), Name 2nd Co-author and Surname (IN UPPERCASE), Name 3rd Co-author. Paper Title. Journal of Applied Computing Year 1-1: 1-11 [Times New Roman No.10].

* Correspondence to Author (example@example.org)
† Researcher contributing as first author.

Introduction

Text in Times New Roman No.12, single space.

General explanation of the subject and explain why it is important.

What is your added value with respect to other techniques?

Clearly focus each of its features

Clearly explain the problem to be solved and the central hypothesis.

Explanation of sections Article.

Development of headings and subheadings of the article with subsequent numbers

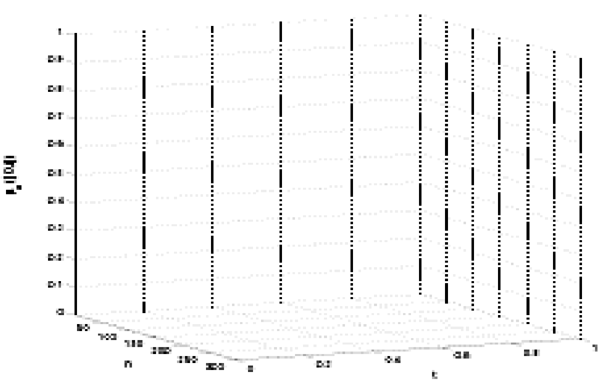
[Title No.12 in Times New Roman, single spaced and bold]

Products in development No.12 Times New Roman, single spaced.

Including graphs, figures and tables-Editable

In the article content any graphic, table and figure should be editable formats that can change size, type and number of letter, for the purposes of edition, these must be high quality, not pixelated and should be noticeable even reducing image scale.

[Indicating the title at the bottom with No.10 and Times New Roman Bold]



Graphic 1 Title and *Source (in italics)*

Should not be images-everything must be editable.

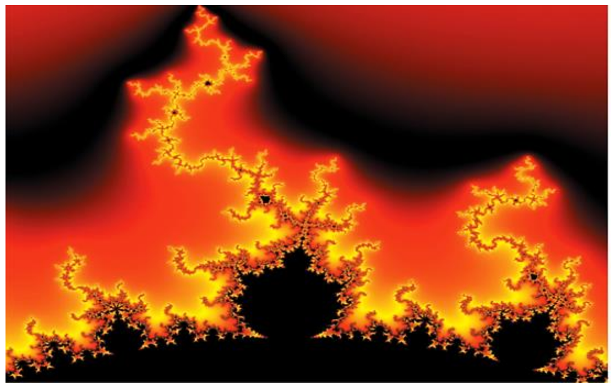


Figure 1 Title and *Source (in italics)*

Should not be images-everything must be editable.

Table 1 Title and *Source (in italics)*

Should not be images-everything must be editable.

Each article shall present separately in **3 folders**: a) Figures, b) Charts and c) Tables in .JPG format, indicating the number and sequential Bold Title.

For the use of equations, noted as follows:

$$Y_{ij} = \alpha + \sum_{h=1}^{r} \beta_h X_{hij} + u_j + e_{ij} \qquad (1)$$

Must be editable and number aligned on the right side.

Methodology

Develop give the meaning of the variables in linear writing and important is the comparison of the used criteria.

Results

The results shall be by section of the article.

Annexes

Tables and adequate sources thanks to indicate if were funded by any institution, University or company.

Conclusions

Explain clearly the results and possibilities of improvement.

ISSN-On line: 2531-2952

References

Use APA system. Should not be numbered, nor with bullets, however if necessary numbering will be because reference or mention is made somewhere in the Article.

Use Roman Alphabet, all references you have used must be in the Roman Alphabet, even if you have quoted an Article, book in any of the official languages of the United Nations (English, French, German, Chinese, Russian, Portuguese, Italian, Spanish, Arabic), you must write the reference in Roman script and not in any of the official languages.

Technical Specifications

Each article must submit your dates into a Word document (.docx):

Journal Name
Article title
Abstract
Keywords
Article sections, for example:

1. Introduction
2. Description of the method
3. Analysis from the regression demand curve
4. Results
5. Thanks
6. Conclusions
7. References

Author Name (s)
Email Correspondence to Author
References

Intellectual Property Requirements for editing:

- Authentic Signature in Color of Originality Format Author and Co-authors.

- Authentic Signature in Color of the Acceptance Format of Author and Co-authors.

- Authentic Signature in blue colour of the Conflict of Interest Format of Author and Co-authors.

Reservation to Editorial Policy

Journal of Applied Computing reserves the right to make editorial changes required to adapt the Articles to the Editorial Policy of the Journal. Once the Article is accepted in its final version, the Journal will send the author the proofs for review. ECORFAN® will only accept the correction of errata and errors or omissions arising from the editing process of the Journal, reserving in full the copyrights and content dissemination. No deletions, substitutions or additions that alter the formation of the Article will be accepted.

Code of Ethics - Good Practices and Declaration of Solution to Editorial Conflicts

Declaration of Originality and unpublished character of the Article, of Authors, on the obtaining of data and interpretation of results, Acknowledgments, Conflict of interests, Assignment of rights and Distribution

The ECORFAN-Mexico, S.C Management claims to Authors of Articles that its content must be original, unpublished and of Scientific, Technological and Innovation content to be submitted for evaluation.

The Authors signing the Article must be the same that have contributed to its conception, realization and development, as well as obtaining the data, interpreting the results, drafting and reviewing it. The Corresponding Author of the proposed Article will request the form that follows.

Article title:

– The sending of an Article to Journal of Applied Computing emanates the commitment of the author not to submit it simultaneously to the consideration of other series publications for it must complement the Format of Originality for its Article, unless it is rejected by the Arbitration Committee, it may be withdrawn.

– None of the data presented in this article has been plagiarized or invented. The original data are clearly distinguished from those already published. And it is known of the test in PLAGSCAN if a level of plagiarism is detected Positive will not proceed to arbitrate.

– References are cited on which the information contained in the Article is based, as well as theories and data from other previously published Articles.

– The authors sign the Format of Authorization for their Article to be disseminated by means that ECORFAN-Mexico, S.C. In its Holding Spain considers pertinent for disclosure and diffusion of its Article its Rights of Work.

– Consent has been obtained from those who have contributed unpublished data obtained through verbal or written communication, and such communication and Authorship are adequately identified.

– The Author and Co-Authors who sign this work have participated in its planning, design and execution, as well as in the interpretation of the results. They also critically reviewed the paper, approved its final version and agreed with its publication.

– No signature responsible for the work has been omitted and the criteria of Scientific Authorization are satisfied.

– The results of this Article have been interpreted objectively. Any results contrary to the point of view of those who sign are exposed and discussed in the Article.

Copyright and Access

The publication of this Article supposes the transfer of the copyright to ECORFAN-Mexico, S.C. in its Holding Spain for its Journal of Applied Computing, which reserves the right to distribute on the Web the published version of the Article and the making available of the Article in This format supposes for its Authors the fulfilment of what is established in the Law of Science and Technology of the United Mexican States, regarding the obligation to allow access to the results of Scientific Research.

Article Title:

Name and Surnames of the Contact Author and the Co-authors	Signature
1.	
2.	
3.	
4.	

Principles of Ethics and Declaration of Solution to Editorial Conflicts

Editor Responsibilities

The Publisher undertakes to guarantee the confidentiality of the evaluation process, it may not disclose to the Arbitrators the identity of the Authors, nor may it reveal the identity of the Arbitrators at any time.

The Editor assumes the responsibility to properly inform the Author of the stage of the editorial process in which the text is sent, as well as the resolutions of Double-Blind Review.

The Editor should evaluate manuscripts and their intellectual content without distinction of race, gender, sexual orientation, religious beliefs, ethnicity, nationality, or the political philosophy of the Authors.

The Editor and his editing team of ECORFAN® Holdings will not disclose any information about Articles submitted to anyone other than the corresponding Author.

The Editor should make fair and impartial decisions and ensure a fair Double-Blind Review.

Responsibilities of the Editorial Board

The description of the peer review processes is made known by the Editorial Board in order that the Authors know what the evaluation criteria are and will always be willing to justify any controversy in the evaluation process. In case of Plagiarism Detection to the Article the Committee notifies the Authors for Violation to the Right of Scientific, Technological and Innovation Authorization.

Responsibilities of the Arbitration Committee

The Arbitrators undertake to notify about any unethical conduct by the Authors and to indicate all the information that may be reason to reject the publication of the Articles. In addition, they must undertake to keep confidential information related to the Articles they evaluate.

Any manuscript received for your arbitration must be treated as confidential, should not be displayed or discussed with other experts, except with the permission of the Editor.

The Arbitrators must be conducted objectively, any personal criticism of the Author is inappropriate.

The Arbitrators must express their points of view with clarity and with valid arguments that contribute to the Scientific, Technological and Innovation of the Author.

The Arbitrators should not evaluate manuscripts in which they have conflicts of interest and have been notified to the Editor before submitting the Article for Double-Blind Review.

Responsibilities of the Authors

Authors must guarantee that their articles are the product of their original work and that the data has been obtained ethically.

Authors must ensure that they have not been previously published or that they are not considered in another serial publication.

Authors must strictly follow the rules for the publication of Defined Articles by the Editorial Board.

The authors have requested that the text in all its forms be an unethical editorial behavior and is unacceptable, consequently, any manuscript that incurs in plagiarism is eliminated and not considered for publication.

Authors should cite publications that have been influential in the nature of the Article submitted to arbitration.

Information services

Indexation - Bases and Repositories

LATINDEX (Scientific Journals of Latin America, Spain and Portugal)
EBSCO (Research Database - EBSCO Industries)
RESEARCH GATE (Germany)
GOOGLE SCHOLAR (Citation Indexes-Google)
MENDELEY (Bibliographic Reference Manager)
REDIB (Ibero-American Network of Innovation and Scientific Knowledge- CSIC)
HISPANA (Bibliographic Information and Guidance-Spain)

Publishing Services:

Citation and Index Identification H
Management of Originality Format and Authorization
Testing Article with PLAGSCAN
Article Evaluation
Certificate of Double-Blind Review
Article Edition
Web layout
Indexing and Repository
ArticleTranslation
Article Publication
Certificate of Article
Service Billing

Editorial Policy and Management

38 Matacerquillas, CP-28411. Moralzarzal –Madrid-España. Phones: +52 1 55 6159 2296, +52 1 55 1260 0355, +52 1 55 6034 9181; Email: contact@ecorfan.org www.ecorfan.org

ECORFAN®

Chief Editor
VALDIVIA - ALTAMIRANO, William Fernando. PhD

Executive Director
RAMOS-ESCAMILLA, María. PhD

Editorial Director
PERALTA-CASTRO, Enrique. MsC

Web Designer
ESCAMILLA-BOUCHAN, Imelda. PhD

Web Diagrammed
LUNA-SOTO, Vladimir. PhD

Editorial Assistant
TREJO-RAMOS, Iván. BsC

Philologist
RAMOS-ARANCIBIA, Alejandra. BsC

Advertising and Sponsorship

(ECORFAN® Spain), sponsorships@ecorfan.org

Site Licences

03-2010-032610094200-01-For printed material ,03-2010-031613323600-01-For Electronic material,03-2010-032610105200-01-For Photographic material,03-2010-032610115700-14-For the facts Compilation,04-2010-031613323600-01-For its Web page,19502-For the Iberoamerican and Caribbean Indexation,20-281 HB9-For its indexation in Latin-American in Social Sciences and Humanities,671-For its indexing in Electronic Scientific Journals Spanish and Latin-America,7045008-For its divulgation and edition in the Ministry of Education and Culture-Spain,25409-For its repository in the Biblioteca Universitaria-Madrid,16258-For its indexing in the Dialnet,20589-For its indexing in the edited Journals in the countries of Iberian-America and the Caribbean, 15048-For the international registration of Congress and Colloquiums. financingprograms@ecorfan.org

Management Offices

38 Matacerquillas, CP-28411. Moralzarzal – Madrid-España. Phones: +52 1 55 6159 2296, +52 1 55 1260 0355, +52 1 55 6034 9181; Email: contact@ecorfan.org www.ecorfan.org.

Journal of Applied Computing

"Debugging and programming a RISC-V processor, using the IEEE 1149.1 standard"

RICO-GARCÍA, Paulina, YAÑEZ-VARGAS, Juan Israel, PARRA-MICHEL, Ramón and CONDE-ALMADA, Ernesto
Universidad Politécnica de Juventino Rosas
CINVESTAV Unidad Guadalajara

"IoT-based monitoring system of climatological variables in the cultivation of Capsicum chinense Var. Mayapan"

CHAN-PECH, Victor Alfonso, MANRIQUE-EK, Josué Abraham, COB-CALAN, Nubia Noemi and CARDOZO-AGUILAR, Guadalupe
Instituto Tecnológico Superior de Calkiní

"Pedestrian detection system for automobiles using computer vision and artificial intelligence using *Raspberry Pi* 4 and webcam"

SERRANO-RAMÍREZ, Tomás, SÁMANO-FLORES, Yosafat Jetsemaní, GUTIERREZ-LEÓN, Diana Guadalupe and BARRIENTOS-GARCÍA, Alejandro
Universidad Politécnica de Guanajuato

"Web system for automatic irrigation in a greenhouse"

RAFAEL-PÉREZ, Eva, GARCÍA-CERVANTES, Oscar Daniel, MORALES-HERNÁNDEZ, Maricela and RIOS-MALDONADO, Vicenta
Instituto Tecnológico de Oaxaca

2 5 3 1 2 9 5 2
ISSN 2531 - 2952