ISSN 2410-3454

Journal of Engineering Applications

Volume 9, Issue 28 – July – December – 2022

ECORFAN®

Journal of Engineering Applications, Volume 9, Issue 28, December, 2022, is a journal published biannually by ECORFAN - Bolivia. 21 Santa Lucía, CP-5220. Libertadores - Sucre - Bolivia. WEB: www.ecorfan.org, revista@ecorfan.org. Editor in Chief: JALIRI-CASTELLON, María Carla Konradis. PhD. ISSN-2410-3454. Responsible for the last update of this issue of the ECORFAN Informatics Unit. ESCAMILLA-BOUCHÁN, Imelda. PhD, LUNA-SOTO, Vladimir. PhD. Updated as of December 31, 2022.

Journal of Engineering Applications

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Presentation of the content

In the first article we present *Application of teaching-learning methodologies for the conceptual design of a Vertical Garden mobilization system using MMF*, by AGUILAR-GUGGEMBUHL, Jarumi, GARCÍA-CASTILLO, Fernando Néstor and CORTÉS-PÉREZ, Jacinto, with secondment at the Tecnológico de Estudios Superiores de Chalco and Universidad Nacional Autónoma de México respectively, as a second article we present *Effect of modification of zinc oxide nanostructures on contact angle*, by HERNÁNDEZ-HERNÁNDEZ, Celia Massiel, MELO-MÁXIMO, Lizbeth, MELO-MÁXIMO, Dulce Viridiana and ESTRADA-MARTÍNEZ, Fortino Fabián, with adscription in the Instituto Tecnológico de Tlalnepantla and Tecnológico de Estudios Superiores de Monterrey-Campus Estado de México, as third article we present *Ergonomics study applied to automotive systems and motor vehicles*, by TELLEZ-HERNÁNDEZ, Rubén, TENORIO-CRUZ, Fermín, JUÁREZ-CORTES, Erik and LÓPEZ-VÁZQUEZ, Rosalba, with secondment at the Universidad Tecnológica de Tecamachalco, as the fourth article we present *Capture and labeling image system for agriculture applications*, by MONTECILLO-PUENTE, Francisco Javier, MARTINEZ-SCOTT, Marcia Maribel, MORENO-ZACARIAS, Pedro Eduardo and CRUZ-LOERA, María de la Luz, with secondment at the Instituto Tecnológico Superior de Salvatierra.

Content

Article **Journal of Engineering Applications**
December 2022, Vol.9 No.28 1-13

Application of teaching-learning methodologies for the conceptual design of a Vertical Garden mobilization system using MMF

Aplicación de metodologías de enseñanza-aprendizaje para el diseño conceptual de un sistema de movilización de Huerto Vertical utilizando MMF

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DOI: 10.35429/JEA.2022.28.9.1.13 Received: July 10, 2022; Accepted: December 30, 2022

Abstract

The project consisted of design and construction of a mechanical prototype that allows the growth of vegetables in a rotary vertical garden. For the vegetables to grow properly, the structure of the prototype rotates in order to provide them homogeneous sunlight. Currently, the movement of vertical structures is carried out with motors and mechanical transmission systems; however, in this case it was to carry it out with shape memory materials (SMMs), which could rotate the system with the application of electric current, hot air or sunlight. During the development of the prototype, it was possible to use previously designed equipment where experiments can be carried out to characterize the behaviour of the SMMs, applying different voltages to them. This work shows the methodology used to involve students, from two institutions, in the design stages, taking advantage of experimental tests, digital resources on the internet; as well as the application of active methodologies such as project-based learning and flipped classroom. Finally, a proposal is presented for the remote operation of the equipment used in the characterization of the materials and their use as learning technics.

Engineering education, Project Based Learning, Flipped Classroom

Resumen

El caso de estudio consistió en el diseño y construcción de un prototipo mecánico que permita el crecimiento de hortalizas en un huerto vertical. Para que las hortalizas tengan un apropiado crecimiento, la estructura del prototipo gira con la finalidad de otorgarles luz solar de manera homogénea. Actualmente el movimiento en estructuras verticales es realizado con motores y sistemas de transmisión mecánicos; sin embargo, en este caso se propuso llevarlo a cabo con materiales con memoria de forma (MMF), los cuales podrían hacen girar el sistema con la aplicación de corriente eléctrica, aire caliente o luz solar. Durante el desarrollo del prototipo fue posible utilizar equipos previamente diseñados donde se pueden realizar experimentos para caracterizar el comportamiento de los MMF, aplicándoles diferentes voltajes. En el presente trabajo se muestra la metodología usada para involucrar a los estudiantes, de dos instituciones, en las etapas del diseño, aprovechando la realización de pruebas experimentales, recursos digitales en internet; así como la aplicación de metodologías activas como el aprendizaje basado en proyectos y aula invertida. Finalmente se presenta una propuesta para la operación a distancia de los equipos utilizados en la caracterización de los materiales y su utilización como elementos de aprendizaje.

Enseñanza en la ingeniería, Aprendizaje basado en proyectos, Aula invertida

Citation: AGUILAR-GUGGEMBUHL, Jarumi, GARCÍA-CASTILLO, Fernando Néstor and CORTÉS-PÉREZ, Jacinto. Application of teaching-learning methodologies for the conceptual design of a Vertical Garden mobilization system using MMF. Journal of Engineering Applications. 2022. 9-28:1-13.

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Introduction

In Mexico as in the world, agriculture has for centuries been an essential part of societies, providing them mainly with food and livestock (Matarin, Urrestarazu, & García, 2014). One of the most important parts of modern agriculture is horticulture, which contributes to feeding families, helps maintain good nutritional levels and is also a means for farmers to gradually learn to adopt new technologies from the simple to the complex (Kozai & Niu, 2016).

Although since ancient times there are records of dissemination of knowledge to conserve and improve the practice of agriculture (Gómez & Luque, 2007), with the growth of population there are new problems to solve, such as considering that the space to cultivate and the distribution of agricultural products become more complex within large cities (Pérez, 2021) and (Banerjee, 2014). Authors such as Kalantari, Mohd, Akbari, & Fatemi, (2017), Cazorla (2021) and Chozo (2021) mention that in the next 50 years, 80% of the population will live in urban areas. This is why one of the options that has recently been considered is vertical farming, which allows considerable quantities of agricultural products to be grown in small spaces. However, this type of agriculture presents several complexities such as: water distribution, placement, geographical location, sun distribution on plants, among others (Kalantari, Mohd, Akbari, & Fatemi, 2017) and (Benke & Tomkins, 2017).

The above makes the proposed designs for this type of agriculture diverse (Soria, 2018) and (Banerjee, 2014), which is evident in a number of patents that attempt to solve such problems from a technical point of view (Patent No. US4295296A, 1981) and (Patent No. US9010022B2, 2011). The disadvantages of some vertical designs include inadequate light distribution for proper plant growth or harvesting. In order to solve this, rotating devices have been designed that allow sunlight to be evenly distributed on each plant (Benke & Tomkins, 2017) (Banerjee, 2014) and harvesting is easy. These devices are driven by means of motors, geared motors, mechanisms and control systems that can eventually be both complex and costly, especially when increasing light input (Kalantari, Mohd, Akbari, & Fatemi, 2017).

One option to realise the required turning movement in vertical seeding structures is through the use of shape memory materials (MMF) as they exhibit effects that conventional materials do not possess: single shape memory effect, superelastic and double shape memory effect (Otzuka & Wayman, 1998). Particularly the single shape memory effect can be used in this case because it consists of the recovery of apparently plastic deformations by increasing the temperature above the critical temperature of the material (Melton, 1998). These materials are called smart because one of their main advantages is that they function as sensors and actuators at the same time (Hassanien, Al-Emran, & Shaalan, 2020), which simplifies their implementation in devices that need to generate movement (Hassanien, Al-Emran, & Shaalan, 2020).

Considering the aspects mentioned above, a collaborative project was developed between two Mexican institutions to carry out the design and construction of a mechanical prototype that allows the growth of vegetables in a vertical structure powered by MMF. The project was financed with federal and state resources after participation in a national call for proposals where the feasibility of the project was evaluated. During its implementation, teaching and learning methodologies were applied (project-based learning and inverted classroom), as well as experimental tests and digital resources on the internet, so that the participating students could learn the necessary theoretical aspects involved in the problems presented for the mobilisation of the vertical garden and thus have a more active participation in all stages of the project.

This work shows some stages of both the mechanical design and the construction of the proposed prototype, with the aim of highlighting the results obtained by the participating students and identifying a series of methodological steps that can be used as a strategy for teaching-learning, at undergraduate level, when developing short-term application projects. Finally, an additional proposal for the remote operation of the equipment used in the characterisation of the MMFs is described, which will be integrated into the general methodology used in this case study, in order to be applied in future projects between the two institutions.

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Methodology

Researchers, professors, graduates and undergraduate students of Industrial Engineering and Mechanical Engineering, belonging to the Tecnológico de Estudios Superiores de Chalco and the Applied Mechanics Laboratory of the Centro Tecnológico Aragón, FES Aragón UNAM, respectively, participated in the project. The methodology, results and discussion presented in this work are only focused on the teaching aspects in order for the undergraduate students who participated in the project to acquire new knowledge and contribute as much as possible to the development of the project.

Teaching and learning methodologies

Project-based learning was used in this case because it is an educational methodology based on the philosophical need for a purpose in the teaching-learning processes and because its current formulations identify this purpose with the existence of an external objective (for example, in this case, building the prototype) that is used as a context for instrumentalising the learning of both models and scientific procedures, giving rise to scenarios in which students self-manage and plan to varying degrees (Domenech-Casal, 2017). For its part, the flipped classroom pedagogical model was used because it consists of inverting certain learning processes that previously took place in the classroom, transferring them outside the classroom, i.e., carrying them out at home, and vice versa (González & Abad, 2020). Additionally, it was used because this teaching methodology involves students reading, visualising, reflecting on and understanding the content prepared by the teacher, and then resolving any doubts and problems that arise in the classroom (González & Abad, 2020).

Student activities during the development of the project

The activities for the students were divided into three main parts:

1. Identification of techniques and processes used for growing vegetables both conventionally and vertically.

Due to the fact that the students participating in this project are trained with a profile that is not related to the subject of agriculture and livestock, as mentioned by (Abella et. al., 2020), it was necessary to motivate them to become familiar with central themes related, in this case, to the production of vegetables and the development of urban gardens. Among the most important technical aspects they had to observe were those used for conventional vegetable growth and to identify the problems and adaptations that are required for the correct vertical growth of vegetables. The aim was that, when proposing and designing vertical prototypes for vegetable cultivation, they would consider fundamental aspects in the cultivation, growth, maintenance and behaviour of a selected vegetable, as well as the technological options recently used. For this purpose, digital material was compiled on the planting process, specialised horticultural production manuals to identify parameters of plant growth and health, as well as the processes of plant adaptation to vertical systems. Some of these materials were observed in the classroom, others were left for consultation at home, applying inverted classroom strategies (González & Abad, 2020) and (Bishop & Verleger, 2014) so that their doubts were resolved in subsequent sessions. Some examples of the support materials used are (Jeavons, 1991), (PPD, 2016) and (Baixauli & Aguilar, 2002).

2. Identify the main aspects of mechanical design used in vertical structures

Once the students were involved in the application of technologies for food cultivation, emphasis was placed on the arrangements used in the design of conventional vertical systems by showing them various experiences of mobilised vertical cultivation. For this purpose, videos, digital theses and thematic manuals were used, which were explained to them in person and others as homework, guiding them to work on essential activities following the methodology proposed by (Abella et. al., 2020). Some examples of the support materials used are (Cazorla, 2021), (Chinchilla, 2020), (Valadez, 2014), (Soria, 2018), (Banerjee, 2014) and (Tendencias Tecnológicas, 2019).

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For the generation of design proposals adapted to regional conditions, challenges were posed (Abella et. al., 2020), such as the development of prototypes using recycled materials in their construction and manual mobilisation. Conceptual designs in CAD software and their scale construction were requested. Part of the bibliography provided to the students as support for the design of the mobilised vertical structure or vertical orchard are those reported by (ANelA, 2015), (Lawrence, 2014), (Benke & Tomkins, 2017) and (Herrera, 2020).

3. Movement of the structure using MMF

Since the mechanical behaviour of MMFs is highly anisotropic, temperature-dependent and hysteretic (García-Castillo, Cortés-Pérez, Amigó, Sánchez-Arévalo, & Lara-Rodríguez, 2015) (Taillard, Arbab-Chirani, Calloch, & Lexcellent, 2008) (Novák, Šittner, Vokoun, & N., 1999) and (Novák, Šittner, & Zárubová, 1997), it was necessary to provide students with a basic course on these materials. In this course, they were provided with a bibliography covering the theoretical aspects considered for the understanding and study of MMFs (Tobushi, Date, & K., 2010) (Jiujiang, Naigang, Huang, Liew, & Liu, 2002), (Melton, 1998) (Kumar, 2008); as well as on their use in various applications (Tobushi, Date, & K., 2010) (Zhuet. Al., 2001a) (Zhu et. al., 2001b) (Kaneko & Enomoto, 2011) (Melton, 1998). It should be noted that the literature on these topics was divided and the studies and research that have been developed by the FES Aragon working group were shared separately. Some of these works include both theoretical aspects and applications (Castillo, 2016) (Cortés J., 2007) (Cortés R. , 2013) (Cortés U. R., 2018) (García-Castillo, Cortés-Pérez, Amigó, Sánchez-Arévalo, & Lara-Rodríguez, 2015) (González S. C., 2013) (González S. C., 2016) (Lizardi, 2018) (Riveros, 2015) (Taboada, 2016).

In addition, previously designed and built didactic equipment was used so that the students could have a better understanding of the behaviour of the materials and could carry out characterisation tests. Figure 1. a) shows a conventional spring (MMF)-spring series arrangement and how the shape memory spring contracts as the applied voltage increases. Figure 1. b) shows an analogous configuration, but with a wire (MMF)-conventional spring combination.

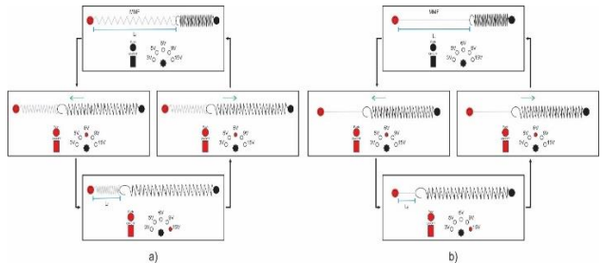

Figure 1 Arrangements used for the characterization of MMFs a) Spring-loaded b) Wire-loaded

Results

The results are focused on some of the activities carried out by the students during the development of the project, highlighting the conceptual design of the vertical structure and how to generate the rotational movement in it.

Design and construction of prototypes

The students proposed several structures after applying the methodology described in the previous section. Some of them were built with materials or elements that were available to them. The designs first made in CAD and then built can be divided into two main parts:

1. Prototypes without the use of MMF.

Prototype 1. Metal with bicycle parts

The proposed prototype consisted of a rectangular structure 31.5 in high by 17.71 in long and 12 in wide, built with 1 ½ in rectangular steel profile. It consisted of a proposed bicycle pulley as a transmission mechanism coupled to a chain with half-inch steel tube rungs joined by welding, which transported pots for planting. The mobilisation of the prototype was manual and they found both the need to hold the rungs carrying the pots at both ends and the independence of the rotation of the pots for the correct rotation. In figure 2 a) and b) you can see the prototype made in the CAD software while in figure 2 c) its construction.

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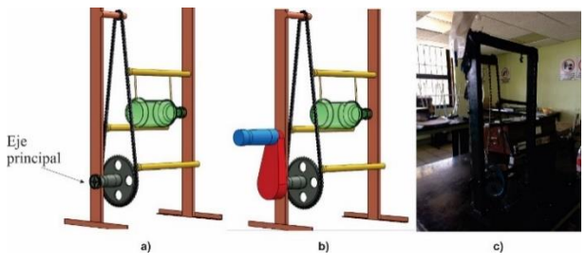

Figure 2 Prototype 1. a) In CAD indicating the main axis to generate the movement. b) In CAD with manual drive. c) Constructed

Prototype 2. Wooden with office chairs and PET bottle rings.

The proposed prototype consisted of a rectangular structure 70.86 in high by 24 in long and 4.59 in wide, built with 2 in x 1 in pine wood strips. In this proposal, reinforced crosspieces were placed at the bottom as a base for support, while for the rotating system, reused bases from discarded chairs and broomsticks were used as crosspieces to support hanging pots. Rings from bottle necks were placed on the crossbars to allow the bottles to rotate freely, thus immobilising their horizontal displacement. PET bottles from 2-litre soft drinks were used for the pots. Their movement was also manual. The prototype is obviously sensitive to humidity and of low resistance, so it was clear to the students (in this and in the other prototypes developed) that in the final design the materials used for its construction would have to be different.

In figure 3 a) and b) you can see the prototype made in CAD software while in figure 3 c) its construction.

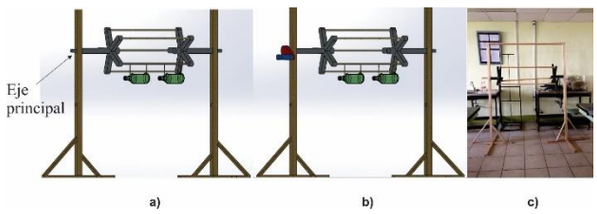

Figure 3 Prototype 2. Made of wood with office chairs and PET bottle rings. a) In CAD showing the main axis to generate the movement. b) In CAD with manual drive. c) Constructed

Prototype 3 Metal with bicycle wheels

This prototype has dimensions of 63 in high by wide, it was built with used bicycle wheels and half inch steel tubes. To support it, 1 ½ in x 1 ½ in steel angles were used and the movement was manual.

Like the previous prototype, PET bottles were used for the pots. In figure 4 a) you can see the prototype made in the CAD software while in figure 4 b) you can see the construction of this prototype.

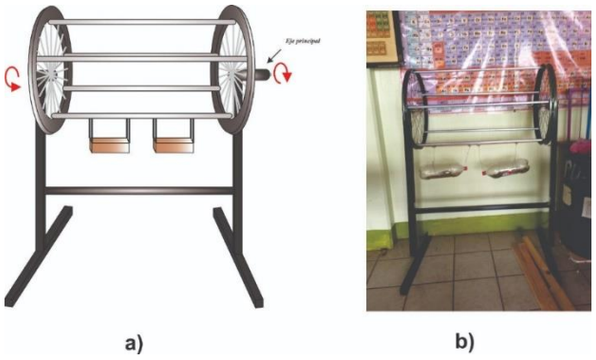

Figure 4 Prototype 3 Metallic with bicycle rims. a) In CAD indicating the main axis to generate the movement. b) Constructed

Prototype 4. MDF rail prototype

In this MDF prototype, the possibility of using a rail to direct the crossbars to transport the pots was considered. It has dimensions of 17.71" high by 17.71" long and 10" wide. In figure 5. a) you can see the prototype made in the CAD software while in figure 5. b.) you can see its construction.

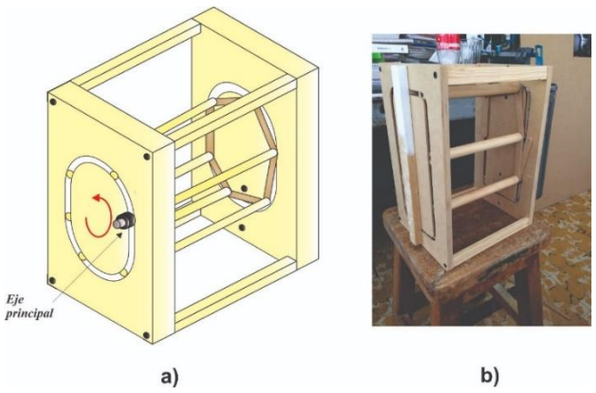

Figure 5 Prototype 4. MDF rail type prototype. a) In CAD indicating the main axis to generate the movement. b) Constructed

Prototype 5 Integration of experiences

Prototypes 1 to 4 allowed the students to integrate their experiences to solve technical problems and make decisions for the final design. The structure whose dimensions were 59 in high, 59 in long and 44 in wide was manufactured in 1 ½ in 14-gauge PTR and for the movement system a transmission shaft, catarinas, bearings and 40 pitch chain were used.

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Figure 6. a) shows the prototype made in the CAD software while figure 6. b) shows its construction.

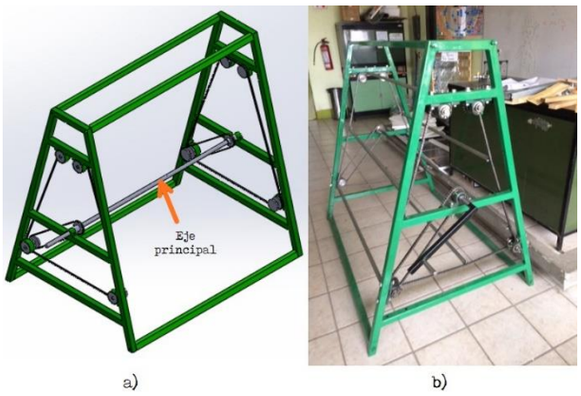

Figure 6 Prototype 5 Integration of the experiences. a) In CAD indicating the main axis to generate the movement. b) Constructed

Movement with motors and placement of pots for vegetable cultivation.

As can be seen in figures 2 to 6, each prototype has a main axis in its design to place a handle or attach any type of mechanism that fulfils the function of achieving the rotating movement. The prototype "Integration of the experiences", shown in figure 6, was fitted with a 60 Hertz single-phase alternating current motor with its geared motor.

In all the prototypes, the pots are placed on the crossbars for planting vegetables. In prototypes 2 and 3, PET bottles with a capacity of 3 litres were used as pots for growing vegetables, these were hung using bottle necks to achieve their independence by turning the crossbars and rope. For prototype 5, bottle necks were also used to hang the pots, but these were made of recycled high density polyethylene with dimensions 7.87 in x 6.2 in x 23.62 in, inside each pot, a mixture composed of 40 parts by 10 parts of coconut fibre and compost was used as planting substrate.

2. Prototypes using MMF

For the project, Ni-Ti wires and springs were purchased to carry out characterisation tests using the arrangements shown in figure 1. This characterisation was used to calculate the weight that each design could lift. Figure 7 shows the 5 prototypes with proposals to obtain the rotary movement of the structure, where the integration of some devices using MMF can be appreciated.

The arrangement in figure 7 a) does not perform a complete rotation since it consists of 4 cantilever beams; however, it is possible to take advantage of the rotation in only one direction. As far as the configuration in figure 7 b) and c) is concerned, they have the same working principle, except that in the first one the rotation of both pulleys is used. For the next arrangement, figure 7 d), a crank-crank-slide mechanism is proposed where the displacement generated by the contraction and stretching of the MMF is used. Finally, for the last arrangement, the coupling of a heat engine is considered, which works with hot and cold water. As it can be noticed, only the system that does not allow the complete rotation in a continuous way is the one integrated in the prototype 1.

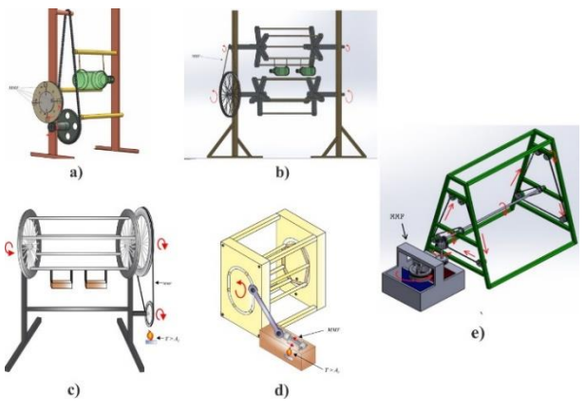

Figure 7 Prototypes with motion using MMF

Discussion

The design proposals made by the students show that they assimilated the knowledge that was transmitted to them during the realisation of the project. Despite the good results obtained by the students, some important aspects found regarding their performance and the methodology used should be noted.

- Active methodologies and short-term application projects

It was evident from the beginning of the project the need to use active methodologies for students to learn better. This is because they have been widely used for years with students at all school levels. However, these methodologies are often not used individually.

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For example, in the inverted classroom, despite having advantages such as: allowing the teacher to give a more individualised treatment covering all phases of the learning cycle (Vidal, et. al., 2016), allowing the student to obtain information in a time and place that does not require the physical presence of the teacher; as well as organising the order of their learning, they are not sufficient in our case study. The main reason for this is that in the case of higher education, the learning methodologies used should focus on the student learning through the application of knowledge in real cases. That is why project-based learning was used, which has some advantages such as: developing skills aimed at solving a problem that is part of reality, independent work, use of ICT, among others (Marti et. al., 2010) and (Vidal, et. al., 2016). In the project developed, some of these advantages mentioned in both methodologies were noticed when looking at the performance of the students, where new competences were shown (Shuhailo & Derkach, 2021). Despite this, it should be considered that, although the methodology (ABP) has been applied for the last 40 years in engineering education because it has presented good results (Chen, Kolmos, & Du, 2021), it is sometimes focused on being applied in courses that are only contemplated in the curricula (Sandoval et. al., 2021), (Mingorance et al., 2017). Even the success cases reported are with the use of projects that have already been completed, i.e. when the problem has been solved (Abella et. al., 2020). Cases such as the one shown in this paper tend not to be used as a teaching course because they are funded projects, due to be delivered in the short term and clearly not within a specific subject. In the case of this type of project, the active methodologies considered relevant can be used, but other aspects must undoubtedly be taken into account. This example and others show the current need to develop hybrid learning methodologies (Azevedo & Morales, 2021). In addition to the above, sometimes there is no culture of pedagogical training in these projects due to the pressure generated by the delivery of these projects and similar situations that the teacher or researcher does not encounter in regular courses.

- Expertise, permanence and time of the students within the working group.

As previously specified, the project required the use of MMFs which have a complex thermo-mechanical behaviour. Topics such as mechanical anisotropy, hysteretic behaviour, non-linear mathematical models, among others had to be explained in a different way considering the time to complete the project. In general, funded projects require previous evaluations to be approved and this often leads to proposing topics that are beyond the scope of knowledge of the undergraduate students. In this case this problem was less of a problem because the students involved had been in the working group for a considerable time and helped those who had not.

- Multidisciplinary working group

The project involved the participation of researchers, professors and graduates from the participating institutions working in engineering areas such as industrial, mechanical, electrical and electromechanical engineering. Having a multidisciplinary group allowed the students the possibility of having more support alternatives to clarify their doubts.

Remote handling of equipment

The points mentioned above were discussed from the beginning by the responsible group of both institutions by comparing them with the experience they have had in terms of application projects and university-industry linkage projects. However, one of the additional disadvantages encountered was that the two universities involved were at a considerable distance from each other. This led to communication problems, especially between students at different universities. A similar problem occurred with the characterisation of the MMFs due to the fact that the equipment used for this purpose is located in one of the participating institutions. It is for this reason that this activity was mainly carried out by students who were close to the equipment. This aspect can generate a major problem in the students' knowledge assimilation because it is well known that the development of laboratory practices in the different specialties plays an important role in complementing the objectives and contents of the Educational Teaching Process (Mar et. al., 2016).

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In fact, in general, due to various factors, each higher education institution has different teaching resources which are available according to its trajectory and research development, which limits the comprehensive learning of some students.

For this reason it is important to establish a plan that allows the use of the resources of both universities without the need to move. In this sense, the evolution of technology has contributed to the development of various areas of society, with distance education being one of its main beneficiaries (Andújar & T.J., 2010). Even more so in these times of pandemic, distance education has become the only option for continuing education at all levels of education around the world. In fact, nowadays, alternatives have been created such as simulators or remote laboratories, which can be accessed from anywhere with the use of the internet, presenting advantages over traditional ones because they invite enquiry in a safe and economical way (Martínez, 2021). Remote laboratories allow real systems to be operated and controlled remotely by means of an experimental interface running on a computer connected to a network, known as a telelaboratory, remote laboratory or web-based teleoperation. However, although the advantages that these laboratories facilitate are evident, as of 2016, only 5% of universities and research centres in the world that offer distance learning courses incorporate these types of laboratories in their study programmes (Mar et. al., 2016).

Thanks

The experience described was developed within the framework of the project, Application of materials with shape memory, for the movement of horizontal vegetables made of recycled material, which benefited from the Convocatoria de Apoyo a la Investigación Científica y Tecnológica 2017, issued by Tecnológico Nacional de México.

Explicit thanks are extended to the students involved, the working group of the Applied Mechanics Laboratory of the Aragon Technology Centre at FES Aragon and students of Industrial Engineering of the Tecnológico de Estudios Superiores de Chalco, TESCHA.

As part of the collaboration between the two institutions, the intention is to integrate the use of remote teaching equipment in future projects, which could help interaction between students from both institutions to be more dynamic, as it will allow students who are far away to use the equipment. Figure 8 shows schematically the connection that would be used.

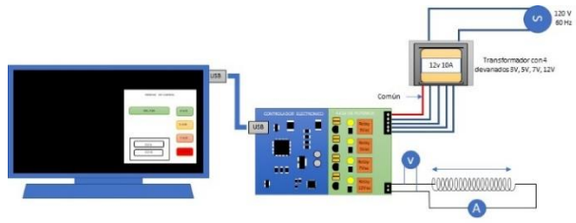

Figure 8 Scheme for the use of remote teaching equipment

Conclusions

The students participating in the project were able to propose conceptual designs of prototype structures for vertical planting of vegetables and their mobilisation using MMF. This was possible because during the development of the project a series of steps were carried out in order to make the students' learning as fast as possible and thus to have their participation more active. The methodological steps reported in this work focused only on aspects of teaching and learning of the students. Because this type of projects are short-term and funded (TecNM, Convocatoria de Apoyo a la Investigación Científica y Tecnológica 2017, Profesores con SNI y Perfil PRODEP) they have very specific characteristics that require more teaching resources than the active methodologies applied can provide. Given the exchange conditions, the methodology used can be improved in future projects by incorporating the manipulation of teaching equipment remotely.

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ISSN: 2410-3454

Article **Journal of Engineering Applications**

December 2022, Vol.9 No.28 14-18

Effect of modification of zinc oxide nanostructures on contact angle

Efecto de la modificación de nanoestructuras de óxido de zinc sobre ángulo de contacto

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DOI: 10.35429/JEA.2022.28.9.14.18 Received: July 15, 2022; Accepted: December 30, 2022

Abstract

The hydrophobic coatings are one of the most used processes to prevent the deterioration of materials and increase its lifetime, since they have non-stick, low friction, anti-wetting, high and low temperature resistance, chemical and dielectric properties, etc. This work presents the chemical production of zinc oxide (ZnO) nanostructures that were deposited on glass substrates by two methods: spin-coating and dip-coating. The doped substrates were modified by temperature and exposure to ultraviolet light (UV). The contact angle of the surface was measured after making some modification, revealing an initial change compared to the uncoated substrate. Later, the angles were varied, comparing between the two deposition methods. The higher contact angle was presented by spin-coating sample, after rising its temperature and a first exposure to UV light; an increase of 30% was observed in comparison to the uncoated substrate; In contrast, the smallest angle was obtained in dip-coating sample after raising its temperature, reducing around 55% of its size compared to the uncoated substrate.

Hydrophobicity, Zinc oxide, Nanostructures

Resumen

El uso de recubrimientos hidrofóbicos es uno de los procesos más empleados para evitar el deterioro de los materiales y prolongar su vida útil ya que poseen propiedades anti-adherentes, baja fricción, anti-humectantes, resistentes a altas y bajas temperaturas, resistencia química y dieléctrica, entre otras. El presente trabajo se basa en la producción química de nanoestructuras de óxido de zinc (ZnO) que se depositaron sobre sustratos de vidrio por dos métodos diferentes: spin-coating y dip-coating. Los sustratos dopados fueron modificados mediante temperatura y exposición a luz ultra violeta. Se caracterizó midiendo el ángulo de contacto de la superficie después de realizarle alguna modificación, lo anterior mostró un cambio inicial comparado con el sustrato sin recubrir, posteriormente los ángulos fueron variando obteniendo una comparativa entre los dos métodos de deposición. El mayor ángulo de contacto lo presentó la muestra realizada por spin-coating después de elevar su temperatura y una primera exposición a luz ultravioleta, aumentó un 30% contra el ángulo medido en el sustrato sin recubrir; de manera contraria el ángulo más pequeño se obtuvo en el sustrato por dip-coating después de elevar su temperatura, este redujo aproximadamente un 55% de su tamaño con respecto al sustrato sin recubrimiento.

Hidrofobicidad, óxido de zinc, nanoestructuras

Citation: HERNÁNDEZ-HERNÁNDEZ, Celia Massiel, MELO-MÁXIMO, Lizbeth, MELO-MÁXIMO, Dulce Viridiana and ESTRADA-MARTÍNEZ, Fortino Fabián. Effect of modification of zinc oxide nanostructures on contact angle. Journal of Engineering Applications. 2022. 9-28:14-18.

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Introduction

The support provided by nanotechnology for the design and development of new materials, modifying their properties based on shape, size and functionalization, has opened new horizons in new material properties [1, 2].

Hydrophobicity and Hydrophilicity

The Greek roots define hydro as water, philia as affinity, and phobia as lack of affinity, thus forming hydrophobicity (water repellency) and hydrophilicity (water affinity). A surface is considered hydrophobic when the angle formed between the surface and a fluid exceeds 90°, below 90° the surface is hydrophilic [3].

ZnO nanostructures

Zinc oxide is an attractive compound for various applications in nanotechnology due to its unique qualities and physical and chemical properties. The procedure to grow nanostructures is simple and inexpensive, therefore, there are multiple synthesis methods such as chemical vapor deposition, chemical synthesis, physical vapor deposition, green chemistry, among others [4, 5]. Zinc oxide shows a particularity, since the inclination it forms with the surface of liquids is nanostructured, it shows physicochemical properties such as hydrophobicity or hydrophilicity [6].

As zinc oxide nanostructures grow, they modify its behavior by increasing or decreasing their surface area. Exposure of these compounds to ultraviolet light and temperature can modify their wettability, causing a change of state [7].

These small structures can be used for the growth of various nanostructures with similar properties, but different dimensions. For example, nanowires belong to the 1D classification because one of their dimensions is in the nanometric order, although it extends to micrometers [8].

Methodology

The synthesis of the nanostructures was chemically conducted with zinc acetate and sodium chloride, both diluted in methanol. This solution was kept under stirring for two hours at a controlled temperature of 60 °C.

Once the substrates were clean, 10 µL of the solution were deposited by spin coating at 10,000 rpm; additionally, dip coating was performed with a single immersion in the solution. Later, both were left drying at room temperature.

Figure 1 Spin and dip coating process

Both samples were modified increasing temperature and irradiating them with ultraviolet light, to change the contact angle after each process.

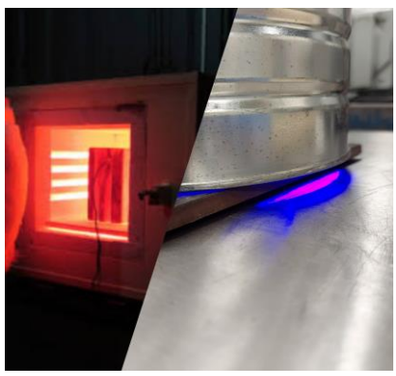

Figure 2 Procedure to modify the behavior of nanostructures

The samples were placed in a furnace at 300 °C for 90 minutes; once the sample cooled, its contact angle was measured. Next, samples were subjected to ultraviolet light for 60 minutes, again measuring the contact angle; finally, further irradiation for 90 minutes were conducted, measuring the contact angle.

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Figure 3 Drop of water photograph for contact angle measurement

When all contact angles were acquired, measurement in ImageJ software was conducted. Similarly, the angle was measured in clean substrate without doping.

Results

The contact angles changed significantly with the deposition of nanostructures. Figure 4 shows the measurement of a drop on the surface of uncoated substrate, observing an angle of 63.064°.

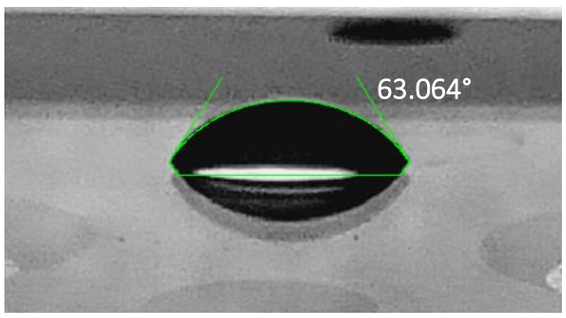

Figure 4 Unmodified substrate contact angle

The samples made by spin coating presented large angles, however, a decrease in the angle occurred as the irradiation time with ultraviolet light increased.

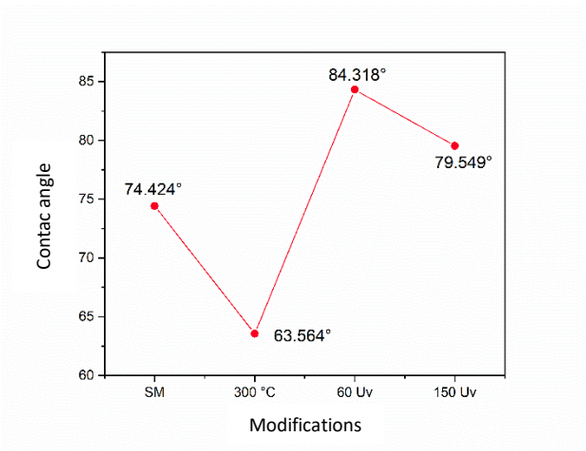

Figure 5 Contact angles behavior of spin-coating samples

As can be seen in Figure 6, the shape of the droplet on the surface changed with the modifications, Figure 6b shows a more elongated droplet with the lowest contact angle; on the other hand, the highest angle is presented in figure 6c where a drop with the shape of a half sphere is observed.

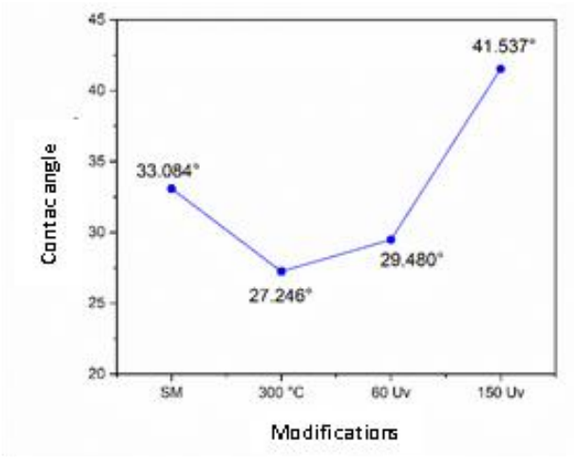

Figure 6 Measurement of the contact angles of the samples by spin coating. a) sample with zinc oxide nanostructures, b) sample after 90 min at 300 °C, c) sample after 60 min exposed to ultraviolet light, d) sample after 150 min exposed to ultraviolet light

The samples that were coated by dip coating showed an immediate decrease in the contact angle in comparison to uncoated substrate, however, with the modification processes, the angle increase, as shown in figure 5.

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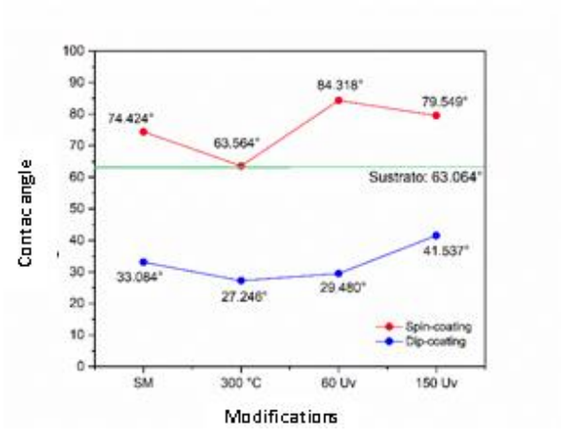

Figure 7 Contact angles behavior of dip-coating samples

The shape of the droplets on the surface changes significantly after the modifications. Figure 8 shows elongated drops with little height, giving measurements below 45°. Fig. 7d shows the greatest height, therefore, the highest angle in these 4 measurements.

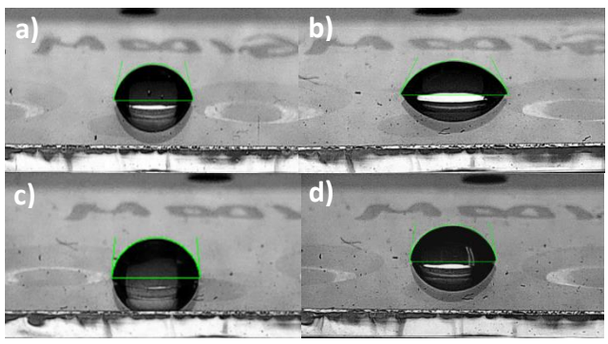

Figure 8 Measurement of the contact angles of the samples by dip coating. a) sample with zinc oxide nanostructures, b) sample after 90 min at 300 °C, c) sample after 60 min exposed to ultraviolet light, d) sample after 150 min exposed to ultraviolet light

The change in the value of the contact angles is visible by the shape of the drops, figure 9 shows the contact angles behavior compared to uncoated substrate.

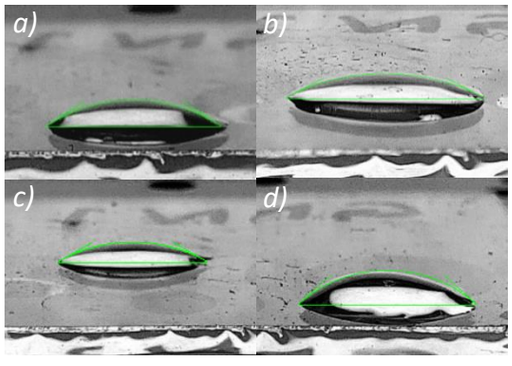

Figure 9 Change in contact angles against uncoated substrate

The green reference line corresponds to the measurement of the angle obtained on the clean substrate. The variation of the measurements is significant, the dip-coating sample presents low values, far from the reference line; whereas the spin-coating sample presents values above reference, but not reaching the required 90° to be considered as hydrophobic.

Acknowledgments

Authors acknowledge Tecnológico Nacional de México for opening the call, to Tecnológico de Estudios Superiores de Monterrey Campus Estado de México for the access to the Surface Engineering laboratory. To the scientific research, technological development and innovation projects M00-PR-03-R01 Project 8t0nc5 (14127)-Production of nanostructured thin films with antibacterial activity for biomedical applications, as well as to CONACYT for the national scholarship awarded.

Financing

CONACYT National Scholarship Program number 788152.

Conclusions

The results revealed a superficial change in the samples explained by the procedure followed to deposit the nanostructures and the modifications conducted in each sample. The water drop behavior on the clean and doped substrate changes instantly. The increase and decrease in the contact angle are attributed to the treatment applied to the nanostructures. Changing the properties through variations in temperature or irradiation can generate several applications. In addition, comparing two methods for the deposition of solutions gives the opportunity to continue with the investigation and be able to obtain larger angles.

ISSN: 2410-3454

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ISSN: 2410-3454

Article **Journal of Engineering Applications**

December 2022, Vol.8 No.28 19-25

Ergonomics study applied to automotive systems and motor vehicles

Estudio en ergonomía aplicado a sistemas automotrices y vehículos automotores

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DOI: 10.35429/JEA.202.28.9.19.25 Received: July 30, 2022; Accepted: December 30, 2022

Abstract

Objectives

Implement an ergonomics engineering proposal where an appropriate design is generated for the suitable well-being of an automobile driver, carrying out a detailed study of human anatomy.

Methodology

Apply knowledge of software design (CAD/CAM) by simulating ergonomics tests and computer impact tests. Catalog the benefits of improvement and study the existing models of the various technologies of three competitive companies as differentiating the car models under study.

A good car is constructed in every detail so that it is possible to concentrate fully on traffic while driving. The driver's pose is comfortable and relaxed. His attention is not irritated or distracted by cumbersome searches of the controls or by environmental disturbances such as excessive heat or cold, noise, or exhaust fumes. In addition to this conditioning, the best possible visibility during the day and at night protects the sight and the nerves, allowing foresighted driving, thus assuring the temporary life of the people.

Contribution

To protect the car driver's life and prevent physical degenerative and anatomical diseases by applying engineering studies in ergonomics.

Ergonomics, Degenerative, Conditioning

Resumen

Objetivos

Implementar una propuesta de ingeniería de ergonomía donde se genere un diseño apropiado al adecuado bienestar de un conductor de un automóvil, realizando un estudio detallado de anatomía humana.

Metodología

Aplicar conocimientos de diseño en software (CAD/CAM), simulando pruebas de ergonomía y pruebas de impacto por computadora, catalogar los beneficios de mejora y estudiar los modelos existentes de las diversas tecnologías de tres compañías competitivas, así como diferenciar los modelos de automóviles bajo estudio.

Un buen coche está construido en todos sus detalles de modo que sea posible concentrarse plenamente al tráfico al ir al volante. El conductor va sentado cómodo y relajadamente. Su atención no sufre irritación o descuido por engorrosas búsquedas de los elementos de mando ni por molestias ambientales como serían un excesivo calor o frío, ruido o molestias por gases de escape. A este acondicionamiento se añade la mejor visibilidad posible de día y de noche, que protege la vista y los nervios, permitiendo una conducción previsora por lo que asegura la vida provisoria de las personas

Contribución

A salvaguardar la vida de un conductor de automóvil y prevención de enfermedades físico degenerativas y anatómicas aplicando estudios de ingeniería en ergonomía.

Ergonomía, degenerativa, acondicionamiento

Citation: TELLEZ-HERNÁNDEZ, Rubén, TENORIO-CRUZ, Fermín, JUÁREZ-CORTES, Erik and LÓPEZ-VÁZQUEZ, Rosalba. Ergonomics study applied to automotive systems and motor vehicles. Journal of Engineering Applications. 2022. 9-28:19-25.

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Introduction

We will begin our study by providing the definitions of ergonomics as:

Ergonomics is the discipline that deals with the design of workplaces, tools, and tasks so that they match the physiological, anatomical, psychological characteristics and human capabilities.

However, over time it has been modified especially when it comes to applying it to the study of improvement in various areas of human activity specifically applied to the automotive industry (automotive) and people whose job is to drive a vehicle on a daily basis.

This research has to do with the contribution of the generalized study to the automotive field and is of vital importance because it helps greatly in the prevention of physical risk factors that make it possible to generate prevention of anatomical diseases and degenerative diseases or sequelae that may be exposed to a certain time (more than 5 hours a day), a person who in the day to day performs and drives a vehicle and is exposed to any type of events.

In addition to this the poor safety conditions regarding the handling and use of an unsafe vehicle, it is important to know if you are protected against any possible decompensation, technical or human failure and/or suffer an accident with serious consequences, even perish or live injured or disabled for the rest of their existence.

This is how a good study of re-engineering, ergonomics, human anatomy, physical or anthropomorphic, and study of the good handling of a vehicle, will be trained and prepared for a contingency focus on the needs of daily use of driving a vehicle. On the other hand, knowing the advantages that an analysis of automotive ergonomics could influence a healthy lifestyle and improve our level of healthy living, being aware of it since according to WHO that every day about 3500 people die on the roads in the world. Tens of millions of people are injured or disabled every year (WHO 2016).

On the other hand, applying the concepts of ergonomics, according to Aguirre Montenegro (August 2016) based on several types of research, when specifying ergonomics systemically, we talk about "the study of the human being-built environment system". The author defines "built environment" as the physical, concrete, material components, the product of the human being, which are part of the ergonomic system; for example, a car, a chair, a car seat, etc. It is a challenge for the good use and handles to enjoy and perform.

The research is based on another conceptualization that outlines the ergonomic system as the object of study of ergonomics, composed of three known and predetermined elements: the human being, the object/machine, and the physical space. Which are related to each other or to their parts, and interact to carry out work or activities that can be motor, sensory or rational (Meroño Gallut., 2006).

Development

To begin to make an analysis of the ergonomic study, one must first think under what type of conditions this study will be developed, in this case, the answer is the need to create an ergonomic design that fits the morphological and anatomical dimensions of an average citizen living in the region of Tecamachalco Puebla, Mexico; because the cars that generally exist in most Latin countries are of foreign origin and this type of vehicles are molded to the morphological and ergonomic conditions of their country of origin.

For this reason, it is common to see people who find that the car is too big and wide for them".

To start with the analysis we created a table in which all the parts of the body that were going to be measured were indicated: height, weight, back length, back width, arm length, arm, forearm, hand length, waist width, leg length, etc. As shown in Table 1.1 (Gómez Darío 2016). We proceeded to take a small population sample in the site where the study will be conducted, in this case, in the region of Tecamachalco Puebla, and collect the necessary data to start this study.

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Thus, the average of each of the parts of a body were statistically determined and an average standard of the person living in the city was found. Based on these results, proposals and analyses on the type of design that would be used were made without neglecting the safety and comfort factors.

The following results show a sample analysis which are the measurements of the average man, obtained from a data collection table 1.

Average measurements		
Height	174	cm
Arm length	25.6	cm
Forearm length	32	cm
Chest depth	24.1	cm
Hip depth	22.3	cm
Back width	39.7	cm
Hip width	34.5	cm
Leg length	41.6	cm
Calf length	36.1	cm
Weight	76-3	cm

Table 1 Average measurement

In these measurements, the visualized average man in a seated position from the comfort angles is what the driver will have when occupying the physical space (volume units). The comfort angles range from the smallest to the largest. Therefore, the lower limit and the upper limit of the mentioned angles are analyzed in the following figure. (A1, A22 Figure 1) Details of the analysis and measurements of the space are shown when occupied by the driver with the lower limit comfort angles.

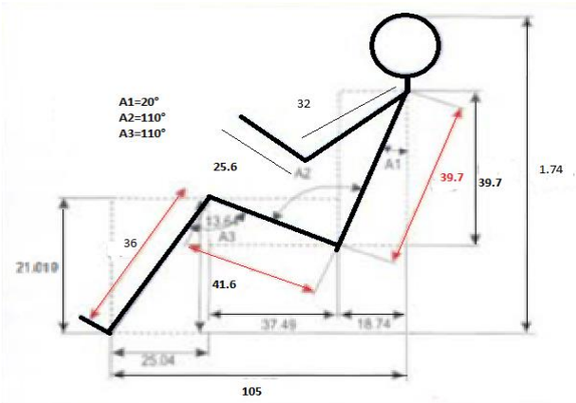

Figure 1 Average measurements in seated position.

These measurements vary according to the position of the passenger. It is also observed that there are two measurements that are the widest. 130 cm in height and 105 cm in width: based on this measurement, the area to be occupied by the individual in the front cabin is determined (Dario Gomez).

Figure 2 Average figure to be simulated

Subsequently, by observing the market of standard-size vehicles for five passengers the proposal design size is for two occupants. The following space is proposed for our front cabin (cab).

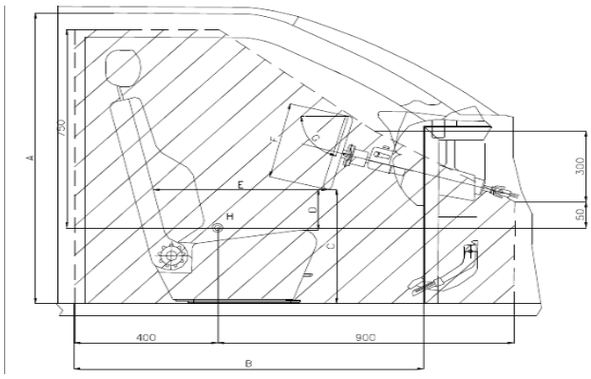

Figure 3 Pre-study design

With these measurements of the occupancy spaces in the cabin, we can undertake the designs of the elements that make up the front cabin. After that, the average man in a seated position is drawn in a 3D CAD program to have a better view of the space that the person will occupy. According to the measurements collected. This is done to evaluate the space occupied by the driver inside the vehicle. Now, with this information, the sketches of the parts of the driver's cab and its components to be operated are drawn.

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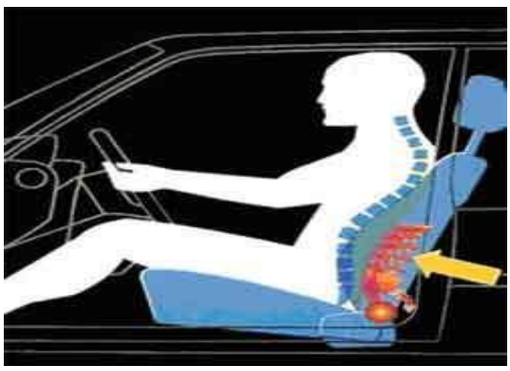
Figure 4 3D cabin simulation

There is another anatomical study with greater complexity. This study will not consider the lumbar are (Peláez, P.,)a Therefore, a good car is built in all its details so that it is possible to concentrate totally on traffic while driving (3).
The driver is comfortable and relaxed. His attention is not irritated or distracted by cumbersome searches of the controls or by environmental disturbances such as excessive heat or cold, noise, or exhaust fumes. To this conditioning, we added better visibility during the day and at night, which protects the eyes and nerves, allowing for foresighted and safe driving (Figure 1).

A)



B)

Figure 5 A) Lumbar study, B) Real simulated model taken from the original American source

The anatomically correct and relaxed riding position is decisive for reliable vehicle control. In addition to anatomy, ergonomics is also essential: quick and convenient access to the controls, adjustable steering wheel, adjustable headrest, etc. Pleasant cabin climate control is also a vital factor in physiological safety. If you have to sweat at the wheel, you can hardly concentrate on the traffic.

For safe and controlled driving, seat comfort is necessary. To achieve an optimum degree of seating comfort, manufacturers provide solutions such as:

- Electric displacement control.
- Electronic longitudinal, height, and lumbar adjustment (memory).
- Heating.
- Degree of the solidity of the cushion.
- Level of the lateral and lumbar support of the backrest, which should prevent fatigue.

The designers invested a great deal of money to build the controls arranged such that the controls are within easy reach of an average-sized passenger. The drives are grouped according to the functions they activate, prioritizing the safety elements, later the control elements, then the comfort elements, and finally the accessories.

The aim is to have the car's controls within easy reach of the driver. So, he can effortlessly operate the vehicle, avoiding distractions and thus preventing dangerous situations Figure 4.

Figure 6 Ergonomically designed operating controls

ISSN: 2410-3454

The ergonomic design of the front panel and the pedal group is essential since the control, signaling, and information elements must be within the driver's reach. The controls must be smooth to operate, easy to read, and simply accessible. Incorporating a control on the steering wheel that regulates the radio's functions keeps the driver from having to move his eyes and hand to the radio (auto stereo) Figure 7.

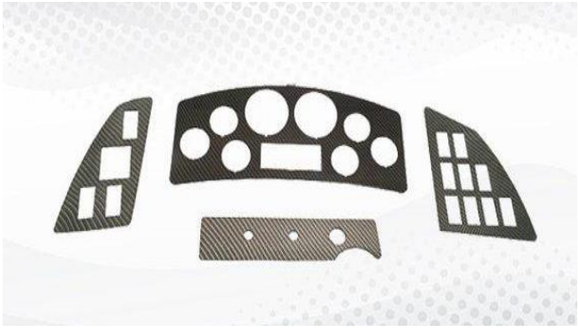


Figure 7 Ergonomic study of the digital front and side panel

In the content, all graphs, tables, and figures must be editable in formats that allow modifying size, type, and the number of letters for editing purposes. These must be of high quality, not pixelated, and observable even if the image is reduced to scale.

Each article should be presented separately in 3 folders: a) Figures, b) Graphics, and c) Tables in JPG format, indicating the number in Bold and the sequential Title.

Methodology

This study also takes into account the ergonomic-biomechanical risk actors (Muñoz, V. Z., Tomás, M. S. A.,) and, as a main approach, adopts a gender and age prism. The results show the prevalence of risk factors related to the existence of an increasingly aging and feminized population, with a higher rate of exposure to ergonomic-biomechanical factors, due to the development of activities derived from the use of hand tools.

From the cause-effect analysis, we have obtained a review of the most frequent occupational musculoskeletal disorders (MSDs) that could possibly occur (tendinitis, lumbago, muscle pain, among others) due to the development of agricultural activities, specifically in the oil sector, where the redesign of hand tools is proposed (in the case of the sub sector analyzed: the harvester and the use of tractor), the use of new technological tools (such as collaborative robots), as well as the implementation of activities oriented to a healthy aging as preventive organizational measurements of MSDs. This study of the redesign of technological tools complements this report in which it is foreseen that a protected population in an oleic work environment and in our case of transport and use of a vehicle coincide in the aspect of anatomical suffering.

Taking into account another study by (Perrazo, L. M., Díaz, M. R., Vaca, S. C., & Salazar, D. A.,2019) where overexertion by activities in which there is manual handling of loads, causes major injuries in the occurrence of musculoskeletal disorders. This research ergonomically evaluates the activities of handling and transporting loads in workers in freight transport maintenance. It uses an assessment method called MAC (Manual Handling Assessment Charts). The risk assessment is performed with the UNE-EN-1005-2 and (MAC) methods, the physical work capacity is established through the Manero staggered test, and the musculoskeletal symptomatology is analyzed through an adaptive version of the Nordic Kuorinka questionnaire. The results of the assessment indicate that 30.4% of the activities have an unacceptable high-level risk that negatively affects the lumbar area. The MAC method shows that 18.75% of the activities present a high risk of damage of physical integrity in terms of the staggered test 100% of the subjects of the staggered study have a high physical work capacity (PWC) for their age (>45 ml/kg*min). The body regions of the workers with the most negative impacts are the lower back, knees, and, to a lesser extent, the upper extremities.

ISSN: 2410-3454

Correa A, Mosqueda A, explains that: participatory ergonomics was born as a strategy to prevent work-related musculoskeletal disorders, reduce the physical and mental workload, and involve workers in the identification, planning, and control of risks in their work. The participatory ergonomic intervention has been promoted in Scandinavian countries and in North America. The concept, participatory ergonomics, began to be used in the early 1980s. Participation means giving workers the opportunity to exercise control over the design of their workstation and the tasks they perform. This is justified by the fact that workers know better than anyone else the risks of their workstation and this allows them to develop effective proposals for improvement According to Marie St-Vincent, a Canadian ergonomist, participatory ergonomics is when workers, accompanied by technicians, are actively involved in the diagnosis of problems, with solutions. There is still no positioning in our organizations; however, it is possible that from various areas those interventions are carried out to reduce and impact the risk factor, but these actions are carried out in a very isolated manner.

Results

The results, from analysis in figure 1 and 2, as well as table 1.1, which states that if all the elements of an average human are not appropriate for the size and physical design of the average citizen, you can opt for a more in-depth study of anatomy, and ergonomics specially to achieve adaptation to a more comfortable and comfortable size.

That by its design can be replaced by orthopedic devices, which would be molded to the automobile system. This study based on an analysis of design and ergonomics foresees the use of a vehicle taking in recommendation first the good handling and of course the recommendations of use but knowing how to choose a type according to the physical dimensions of a person whose physical measurements are known. This study indicates that if we prevent based on a study model of our anatomy is likely in full cause to have a better standard of living and health in the daily use of a vehicle, on the other hand establish a model suitable to our anatomy and ensure by manufacturer's indications all safety measures of use and driving.

Acknowledgement

This study was carried out in the department of the UST (University Senior Technician) at Industrial Processes, Automotive Area. in the Universidad Tecnológica of Tecamachalco (UTTecam), Puebla, Mexico. I thank the Department of Automotive for testing the cabin of cars and brands of which only the country of origin is mentioned.

Conclusions

For reliable vehicle control, it is relevant to know the anatomically correct and relaxed position. In addition to anatomy, ergonomics is a must: quick and convenient access to the controls, adjustable steering wheel, adjustable headrest, etc. Pleasant cabin climate control is also an essential factor in physiological safety: If you suffer discomfort at the wheel, you will hardly concentrate on the traffic. Clearly explain the results obtained and the possibilities for improvement

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ISSN: 2410-3454

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Article **Journal of Engineering Applications**

December 2022, Vol.9 No.28 26-32

Capture and labeling image system for agriculture applications

Sistema de captura y etiquetado de imágenes para aplicaciones de agricultura

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DOI: 10.35429/JEA.2022.28.9.26.32 Received: July 30, 2022; Accepted: December 30, 2022

Abstract

Artificial Intelligence methodologies and their learning has been used lately in the creation of image classification system. Such a system requires a training process that requires information, i.e. labeled images. This article presents a capturing and labeling image system for the creation and recognition base focus on agriculture. A case study of tomato jitomate (Lycopersicon esculentum) plants is analyzed to demonstrate the operation of the system and the methodology for capturing images. The system consists of a microcomputer raspberry pi 3, a video camera with pan-tilt-zoom control and a direction-adjustable lamp for capturing images. Besides, it also needs a graphical interface to select and label the regions of interest, this generates a file training that contains the knowledge base of interest. This contribution lies in the implementation of a system that accelerates the process of labeling and capturing images for agricultural applications.

Agriculture, Image capture, Learning

Resumen

El aprendizaje automático es una de las metodologías de la inteligencia artificial que se ha usado exitosamente en la creación de sistemas de clasificación de imágenes. Tales sistemas ocupan un proceso de entrenamiento que requiere información, por ejemplo imágenes clasificadas. En particular, los sistemas basados en entrenamiento supervisado requieren de imágenes o regiones etiquetadas en categorías. En este trabajo se presenta un sistema de captura e etiquetado de imágenes para la creación de una base de conocimiento enfocado a la agricultura. Un caso de estudio de plantas de jitomate (Lycopersicon esculentum) es analizado para demostrar el funcionamiento del sistema y la metodología para la captura de imágenes. El sistema consta de una microcomputadora raspbery pi 3 una cámara de video con control pan-tilt-zoom y una lámpara ajustable en dirección para la captura de imágenes. También, se usa una interfaz gráfica para seleccionar y etiquetar las regiones de interés, que genera un archivo que contiene la base de conocimiento de interés. Nuestra contribución radica en la implementación de un sistema que agilice el proceso de etiquetado y captura de imágenes para aplicaciones agrícolas.

Agricultura, captura de imágenes, aprendizaje

Citation: MONTECILLO-PUENTE, Francisco Javier, MARTINEZ-SCOTT, Marcia Maribel, MORENO-ZACARIAS, Pedro Eduardo and CRUZ-LOERA, María de la Luz. Capture and labeling image system for agriculture applications. Journal of Engineering Applications. 2022. 9-28:26-32.

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Introduction

Image classification has always been a major challenge for the computer vision community. The ImageNet Large Scale Visual Recognition Challenge (ILSVRC) in 2010, consisted of classifying 1.2 million high-resolution images into 1000 different classes. The scientific community paid attention to the proposal based on convolutional neural networks with 60 million parameters, 650 000 neurons and 5 convolutional layers in the different tests reached places 1 and 5, (Krizhevsky et al., 2012).

In the challenges it is important to define the framework where image types are described, evaluation metrics, categories and ILSVRC tests are presented, (Russakovsky et al., 2015). In this sense, the task of categorising images requires a lot of human resources, so the development of tools that allow their labelling is of great importance.

There are several reference knowledge bases for image classification. Google has a knowledge base with 50 million images with 345 categories, the images contain hand-drawn pictures (scribbles) that represent something (Guo et al., 2018). WordNet is for example a lexicographic knowledge base where relationships between words in more than 200 languages are recorded, (Miller, 1995). Also, neural networks have been used to track people from a drone, (García-García, 2022). Convolutional neural networks have been applied to issue alerts for image recognition, (Jerez et al, 2022).

One requirement of automatic classification systems is that they deal with large amounts of information that must be organised and labelled when supervised learning is used. Currently, systems with higher classification rates make use of artificial intelligence where deep learning has gained wide acceptance. Deep learning is a multi-layer neural network learning that demands a large amount of data, (Alzubaidi, et. al. 2021). The traditional machine learning scheme follows the following workflow: image capture, pre-processing application (adjusting scale, colour, rotation, etc.), feature extraction (colour, texture, point of interest, geometric structures, etc.), selection of the most discriminative features and finally classification.

In contrast, machine learning-based systems have a three-stage system: image capture, deep learning model and classification.

Precision agriculture is a strategy that collects, processes and analyses spatio-temporal individual data and combines it with other sources of information for better decision-making to improve the quality, efficiency, profitability and sustainability of agricultural processes. To achieve this, precision agriculture uses data acquisition technologies and data processing systems (DeLay et al., 2022).

On the other hand, for the study of plant materials, the development phenology according to the BBCH scale for Solanaceae (Feller et al., 1995) is taken into account. According to this coding the main stages are: 0. Germination, 1. leaf development (main stem), 2. formation of lateral shoots, 3. longitudinal stem growth or rosette growth, shoot development (shoots) / tillering (main stem), 4. development of harvestable vegetative parts of the plant or vegetative organs of propagation / budding, 5. emergence of inflorescence (inflorescence). Emergence of inflorescence (main stem) / spiking, 6. Flowering, 7. Fruit development, 8. Colouring or ripening of fruit and seeds, 9.

In the seminal work of (Fisher R.A., 1936 & 1950) he presented a method of grading Irish flower varieties based on physical flower lengths for which a knowledge base called Irish dataset was created.

For the development of automatic image classification systems focused on agricultural applications such as counting leaves, fruits, flowers or detecting stages of development, it is of great importance to define the image capture process and its labelling, in order to obtain an adequate knowledge base for the training stage of our classifier.

In addition to classifiers, neural networks are applied to predict the fruit load for olive trees, (Asensio Jiménez et al., 2022).

A very important aspect for the creation of knowledge bases is the architecture (hardware and software) that facilitates the recording of information such as those used in Industry 4.0, (Lopez et al. 2022).

ISSN: 2410-3454

This paper presents the implementation of a system that streamlines the process of tagging and capturing images for agricultural applications. The paper is organised as follows: first a discussion on phenological categorisation is presented, then a description of the image capture and labelling system is presented, then the structure of the knowledge base is presented, then the case study tomato plants (Lycopersicon esculentum) is presented. Then, the capture system is presented in a distributed format where two or more devices can be networked to capture and tag images. Finally, the results obtained and conclusions are presented.

Phenological categorization of plant development

The BBCH scale for Solanaceae (Feller et al., 1995) describes the developmental stage of plants. Table 1 shows the phenology of development for coding in developmental stages and their number of stages with their two- and three-digit description code.

Cod. 2 dig.	Cod. 3 dig.	Description
Principal growth stage: Germination 0		
0	0	Seed, dried
To:		
9	9	Emergence: cotyledons break through the soil surface
Principal growth stage 1: Development of leaves (main stem))		
10	100	Cotyledons, unfolded Emergence: cotyledons break through the soil surface completely
To:		
19	109	9 or more main stem leaves, unfolded
Principal growth stage 2: Fromation of side shoots		
21	201	1st apical primary side shoot visible
To:		
Principal growth stage 3: Stem elongation (main shoot)		
30	300	onset of stem elongation
To:		
39	309	Nine or more visible extended internodes
Principal growth stage 5: Inflorescence emergence		
51	501	1st visible inflorescence (1st erect bud)
To:		
59	519	19th visible inflorescence
Principal growth stage 6: Flowering		
61	601	1st inflorescence: 1st flower open
To:		
69	619	19th inflorescence: 1st flower open
Principal developmental stage 7: Fruit development		
71	701	1st fruit cluster: 1st fruit has reached its typical size
To:		
79	719	19th fruit cluster. The 1st fruit has reached its typical shape and size.
Principal growth stage 8: Ripening of fruits and seeds		
81	801	10% of the fruits reach their typical ripe colour.
To:		
89	807	70% of the fruits reach their typical ripe colour.
Principal Developmental Stage 9: Senescence		
97	907	dead plants

Table 1 BBCH scale for developmental stages in tomato
Source: (Feller et al., 1995)

This scale is a candidate for labelling plants at different stages of development. The stages of development will depend on the interest of the application, for example, if the germination stage is of interest, the detection of 00,01,03,04,07 and 09 are the moments to be categorised.

Another application can be the appearance of flower buds and fruits which can be the stages 5x, 6x, 7x and 8x respectively. Also, the moment when the plant dies can be of interest, in this case it is important to detect the 9x stage.

Image capture and labelling

In this work, the creation of an image-based knowledge base and its labelling is of major interest. However, in order to take images that can be useful in an image classification system, they must meet some characteristics, such as:

- Lighting. There must be the necessary amount of light for colours, shapes and textures to be seen.
- Light reflection. Care must be taken to ensure that the shots are not saturated with light. This produces images with a white appearance. It is important to direct the light so that this phenomenon does not occur.
- Focus and zoom. The images must be in focus, so the zoom plays an important role and must be adjusted so that the images are sharp.

Taking into account the points described above, for the implementation of the image capture system we used a lamp adjustable in position and orientation, a raspberry pi 3 microcomputer with raspbian operating system and a tilt-pan-zoom camera model Logitech PTZ Pro 2 USB HD 1080P, see Figure 1. We chose to use a raspberry instead of a PC because it has the computational resources for only the acquisition of images, and the choice of a PC would be a waste of resources. For the user to register the data to the knowledge base, a graphical interface was created to speed up the capture process.

ISSN: 2410-3454

Therefore, for the implementation of the capture system, raspbian was used as the operating system, OpenCV and Python as the programming language. OpenCV is a library for computer vision that allows connecting digital image acquisition peripherals, such as 2D and 3D cameras.

Figure 1 Image capture system hardware: camera, lamp and raspberry pi 3

The user interface that allows capturing and labelling to be performed is shown in Figure 2, in addition to a small piece of Python code. This interface allows to configure the path where the images are saved and to select a variable size region of the image that represents some state of development.

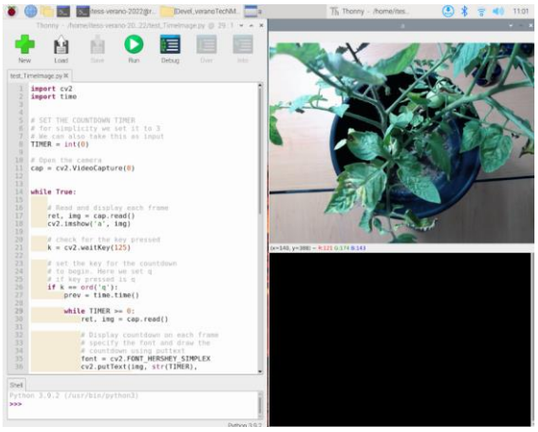

Figure 2 Image capture system hardware: camera. Lamp and raspberry pi 3

Image knowledge base

- The knowledge base is created by organising the images, registering the regions of interest and manually labelling them. The images are stored in a file structure as shown in Figure 3. In addition to the image capture, a record is created containing the following information:
- Plant i, i is the plant identifier.
- Day j, the jth day after the first capture.
- Image k, image k taken of plant i and day j.
- Region l, region l is composed of the coordinate of the upper left corner, as well as the width and the height.
- Region l label. The label represents the category to which region l corresponds..

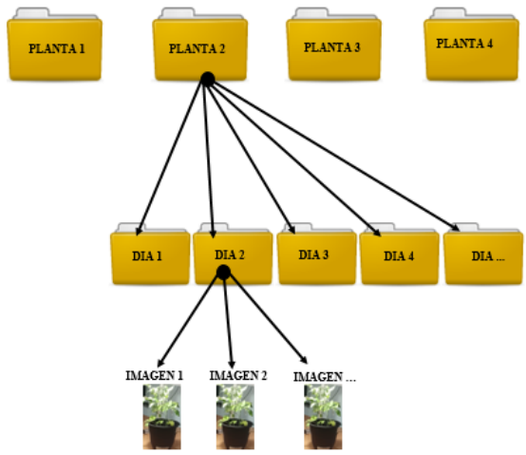

Figure 3 Suggested organisation of images.

The above labelling format allows an image to contain several regions of interest for the application. An example of a record in this format is shown in Table 2:

Plant	Day	Image	Region	Label
1	3	1	(0, 0, 50, 50)	leaf
1	3	1	(100,200, 80, 60)	stem
2	4	3	(200,200, 60, 60)	fruit
…	…	…	…	…
…	…	…	…	…

Table 2 Labelling registration form

The first and second rows represent plant1, day 3, image 1 and have two regions, one labelled leaf and one labelled stem. The third row represents plant2, day 4, image 2 and has one region labelled as fruit.

ISSN: 2410-3454

For our system the records are saved in a cvs format, however, other file types such as json or xml can be used. Similarly a database manager can be created to concentrate the records, this would allow for example to work with several distributed capture systems. On the other hand, supervised learning systems require a knowledge base for their training stage, see Figure 4.

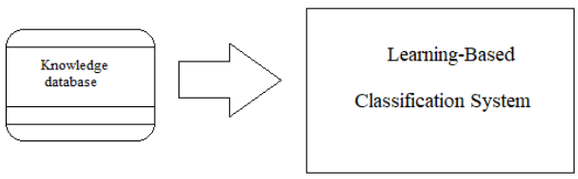

Figure 4 Diagram of a learning system

Case study for tomato (Lycopersicon esculentum) plants)

The steps in the procedure for creating a knowledge base are presented below:

1) Define the problem domain. The domain refers to the type of plant, plants, stage of development or diseases I want to classify. For our case study we define tomato (L. esculentum) plants.

2) Establish the categories of interest. Then the categories that I want to classify in the problem domain are established. For our case we will use the detection of the organs of tomato plants: main stem (stage 1), leaf (stage 2), flowers (main stage 6) and fruits (main stage 8).

3) Capture images using the capture and labelling system. In our case plant i is chosen, on day j, image k is captured and region l is selected and categorised.

For our case study, 5 tomato plants were chosen, records were made for 15 days, 5 images were taken per day and 8 regions (if there are 2 of each for the categories mentioned above). Figure 5 shows the image of the reference plants on day 0.

Figure 5 Images of the plants on day 0. In the top row from left to right plants 1, 2 and 3

During the image capture process, the regions of interest and their category are manually identified. For example, in Figure 5, stem and leaf are selected, the red and blue squares respectively.

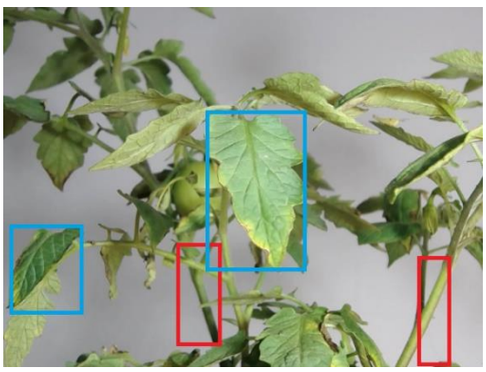

Figure 6 Image 1 of plant 1, day 0, stem and leaf regions.

One of the features to have when generating a knowledge base is to have a variety of information, e.g. you can zoom in and out, rotate the plant, and vary the camera pose. In addition to the plant's labels of interest, you can also define additional categories such as background or even undefined. As the plants continue to grow, Figure 7 shows their status on day 15. In picture 3, leaves in senescence state can be observed. Considering picture 5, it is possible to observe the development of the plant as the days go by and particularly, the growth of the fruits.

Figure 7 Pictures of the plants on day 15. In the top row from left to right plants 1, 2 and 3. And in the bottom row plants 4 and 5

ISSN: 2410-3454

Distributed Capture System

The application of information and communication technologies plays a very important role in the development of the proposed system. Taking advantage of the ethernet or wifi connectivity capacity of the raspberry microcomputers. Several systems can be networked and information can be stored in a remote storage space. Such a configuration is shown in the diagram in Figure 8.

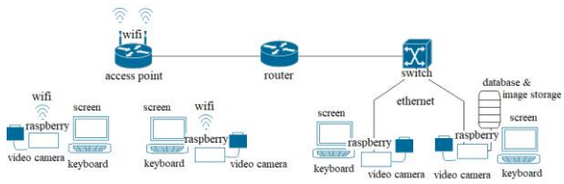

Figure 8 Distributed capture system. This system requires more infrastructure such as routers, switches and access points

This architecture allows images to be captured in different locations simultaneously, without the need to move the system. Attention must be paid to the lighting conditions and the quality of the cameras.

Results

A functional system for capturing and tagging images for the creation of a knowledge base was implemented. In addition, a distributed design is proposed that allows connecting several networked devices in order to make the capture of information more agile.

Also, a graphical user interface programmed in Python and using the OpenCV library was developed. To facilitate the capture and tagging of images, a file organisation structure and a format for tag registration were defined here.

The development of the system was applied in a case study where a knowledge base was created for tomato plants for the tags: stem, leaf, fruit, shoot, dead leaf, and background. Our knowledge base has 375 images and 3000 records.

Funding

The present work has been funded by the Tecnológico Nacional de México in the call 2022 Proyectos de Investigación Científica, Desarrollo Tecnológico e Innovación para Institutos descentralizados with project number k18k68 (14260).

Acknowledgements

To the student Juan Gregorio Tapia Ruiz of the Instituto Tecnológico Superior de Salvatierra for his valuable support in the implementation of the capture system both in hardware and software development.

Conclusions

This paper presents the importance of having information capture systems and the creation of knowledge bases. The process of tagging and the difficulty that can be encountered when generating information manually was discussed. It is therefore important to integrate different technologies for the creation of systems such as microcomputers, operating systems, networks and image acquisition peripherals. It is important to define categories according to the problem domain.

When developing classifiers, little emphasis is placed on the generation of information and the infrastructure and human resources required to create it.

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ISSN: 2410-3454

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Methodology
Contribution

Abstract (In Spanish, 150-200 words)

Objectives
Methodology
Contribution

Keywords (In English)

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* 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.

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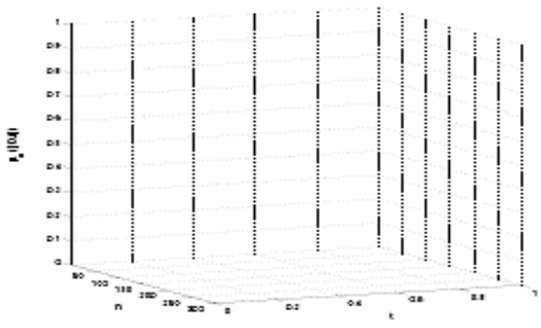
4



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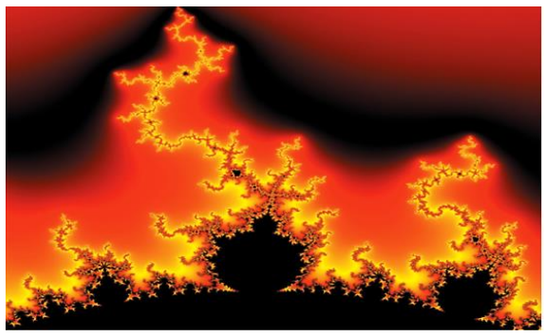

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For the use of equations, noted as follows:

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

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

Indicate if they were financed by any institution, University or company.

Conclusions

Explain clearly the results and possibilities of improvement.

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Keywords
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3. Analysis from the regression demand curve
4. Results
5. Thanks
6. Conclusions
7. References

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Journal of Engineering Applications

2410 3454
ISSN 2410 - 3454

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