ISSN 2444-4995

Journal of Technological Prototypes

Volume 6, Issue 17 – January – June – 2020

ECORFAN®

Journal of Technological Prototypes, Volume 6, Issue 17, January – June 2020, is a journal edited sixmonthly by ECORFAN. 38 Matacerquillas street, Postcode: 28411. Moralzarzal –Madrid WEB: www.ecorfan.org/spain, journal@ecorfan.org. Editor in Chief: SUYO-CRUZ, Gabriel. PhD, ISSN On line: 2444-5010. Responsible for the latest update of this number ECORFAN Computer Unit. ESCAMILLABOUCHÁN, Imelda. PhD, LUNASOTO, Vladimir. PhD, 38 Matacerquillas street, Postcode: 28411. Moralzarzal – Madrid, last updated June 30, 2020.

Journal of Technological Prototypes

Definition of Journal

Scientific Objectives

Support the international scientific community in its written production Science, Technology and Innovation in the Field of Engineering and Technology, in Subdisciplines of technological development, digitized technology, technological impact, computer aided teaching, computers reliability, heuristics, computing, machine arithmetic instructions, artificial intelligence, algorithmic languages, programming languages.

ECORFAN-Mexico SC is a Scientific and Technological Company in contribution to the Human Resource training focused on the continuity in the critical analysis of International Research and is attached to CONACYT-RENIECYT number 1702902, its commitment is to disseminate 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 interlocution of the International Scientific Community with other Study Centers in Mexico and abroad and promote a wide incorporation of academics, specialists and researchers to the publication in Science Structures 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 Technological Prototypes is a Journal edited by ECORFAN-Mexico S.C in its Holding with repository in Spain, is a scientific publication arbitrated and indexed with semester periods. It supports a wide range of contents that are evaluated by academic peers by the Double-Blind method, around subjects related to the theory and practice of technological development, digitized technology, technological impact, computer aided teaching, computers reliability, heuristics, computing, machine arithmetic instructions, artificial intelligence, algorithmic languages, programming languages with diverse approaches and perspectives, that contribute to the diffusion of the development of Science Technology and Innovation that allow the arguments related to the decision making and influence in the formulation of international policies in the Field of Engineering and Technology. The editorial horizon of ECORFAN-Mexico® extends beyond the academy and integrates other segments of research and analysis outside the scope, as long as they meet the requirements of rigorous argumentative and scientific, as well as addressing issues of general and current interest of the International Scientific Society.

Editorial Board

Arbitration Committee

Assignment of Rights

The sending of an Article to Journal of Technological Prototypes 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 topics of technological development, digitized technology, technological impact, computer aided teaching, computers reliability, heuristics, computing, machine arithmetic instructions, artificial intelligence, algorithmic languages, programming languages and other topics related to Engineering and Technology.

Presentation of Content

In the first article we present *Thermal analysis of a parabolic trough solar collector with synthetic oil as working fluid using a computational tool* by ENCISO, Contreras Ernesto, DE LA CRUZ, Alejo Jesús, ALCOCER, Guillermo Irving Cardel and BARBOSA, Saldaña Juan Gabriel with adscription in the Tecnológico de Estudios Superiores de Ecatepec and Instituto Politécnico Nacional, in the netx article we present *Unified mobile accessibility guidelines (UMAG)* by LÓPEZ-GONZÁLEZ, Néstor-Apolo & GONZÁLEZ-BELTRÁN, Beatriz-Adriana with adscription in the Universidad Autónoma de México - Azcapotzalco, in the netx article we present *Rehabilitation in variance osteotomy of left knee and left knee arthroscopy by gonarthrosis grade III: 4 phase model. About a case* by GONZALEZ-LORENCE, Armida, SÁNCHEZ-ORDUÑA, Govani G., AYALA-LANDEROS, José G. and ROMÁN-FLORES, Sonia E., with adscription in the Tecnológico Nacional de México/Instituto Tecnológico de San Juan del Río.

Content

Article **Journal of Technological Prototypes**
June 2020 Vol.6 No.17 1-9

Thermal analysis of a parabolic trough solar collector with synthetic oil as working fluid using a computational tool

Análisis térmico de un concentrador solar de canal parabólico con aceite sintético como fluido de trabajo utilizando una herramienta computacional

ENCISO, Contreras Ernesto†*, DE LA CRUZ, Alejo Jesús, ALCOCER, Guillermo Irving Cardel and BARBOSA, Saldaña Juan Gabriel´

Tecnológico de Estudios Superiores de Ecatepec
´Instituto Politécnico Nacional

ID 1st Author: *Contreras Ernesto, Enciso* / **ORC ID:** 0000-0003-4388-331X, **CVU CONACYT ID:** 333418

ID 1st Coauthor: *Alejo Jesús, De La Cruz* / **ORC ID:** 0000-0001-5072-3985, **CVU CONACYT ID:** 173289

ID 2nd Coauthor: *Guillermo Irving Cardel, Alcocer* / **ORC ID:** 0000-0002-3008-8072

ID 3rd Coauthor: *Saldaña Juan Gabriel, Barbosa* / **ORC ID:** 0000-0001-8590-8082, **CVU CONACYT ID:** 84440

DOI: 10.35429/JTP.2020.17.6.1.9 Received January 15, 2020; Accepted April 01, 2020

Abstract

This work describes the use of a computational tool to assess a previously built parabolic trough solar collector (PTC) that uses a working fluid in liquid state. This work is focused on the thermal analysis of a PTC collector considering two common used synthetic oils: Syltherm 800 and Therminol VP1. The designing characteristics of the commercial LS3 solar collector was selected and as solar resource, the solar irradiance that reaches Mexico City was used with twelve monthly average values along the year. The computational tool provides thermal and flow data for every synthetic oil and for every solar irradiance value used. The most important data computed is the mass flow, which is obtained through iterative processes until the necessary value is found, in order to satisfy the working fluid final temperature for the synthetic oil, once the optimum mass flow value is found, the collector thermal parameters are computed, such as: heat gain, heat losses, thermal efficiency, and the temperatures for the absorber and coating tubes. The computational tool can assess any PTC collector with any working fluid in liquid state, and the data obtained can be used to improve of modify the design of the collector for a better performance.

PTC collector, thermal analysis, synthetic oil

Resumen

Este trabajo describe una herramienta computacional para evaluar el desempeño de un concentrador solar de canal parabólico (PTC) previamente construido que usa un fluido de trabajo en estado líquido. Este trabajo se enfoca en el análisis térmico del concentrador, considerando dos aceites térmicos comúnmente usados: Syltherm 800 y Therminol VP1. Se utilizaron los datos del concentrador comercial LS3 y como fuente de energía, se utilizó la irradiancia solar de la Ciudad de México con doce valores promedio. La herramienta computacional proporciona parámetros térmicos y de flujo para cada aceite térmico y para cada valor de irradiancia solar. El dato más importante que se calcula es el flujo másico, el cual se obtiene a través de procesos iterativos hasta que se encuentra el valor necesario para satisfacer la condición de temperatura final del aceite térmico, una vez que el valor óptimo es encontrado, se calculan los datos térmicos del concentrador, éstos son: flujo de calor útil, flujo de calor perdido, eficiencia térmica y las temperaturas para los tubos absorbedor y transparente. La herramienta computacional puede evaluar cualquier concentrador PTC para cualquier fluido de trabajo en estado líquido y los datos obtenidos pueden servir para mejorar o modificar el diseño del concentrador mejorando su desempeño.

Concentrador PTC, análisis térmico, aceite térmico

Citation: ENCISO, Contreras Ernesto, DE LA CRUZ, Alejo Jesús, ALCOCER, Guillermo Irving Cardel and BARBOSA, Saldaña Juan Gabriel. Thermal analysis of a parabolic trough solar collector with synthetic oil as working fluid using a computational tool. Journal of Technological Prototypes. 2020. 6-17: 1-9.

* Correspondence to Author (email: eencisoc@hotmail.com)
† Researcher contributing first author

Introduction

The overexploitation of conventional sources of energy is one of the most serious problems that is affecting the entire world in many aspects, as a result of this activity, the prices of the fossil fuels are increasing every day what is causing the shortage in some places where the fuel must be bought from other countries. Also, the use of fossil fuels is the most dangerous source of air pollution causing the diminishing quality of the air, affecting the human health and in general the entire life of the world. Other problem that the mankind is facing, because of the use of fossil fuels is the global warming, this effect is causing the raising of the global world temperature and as a consequence, the climate is changing augmenting the strength of natural phenomena such as hurricanes, droughts, flooding, heatstrokes, etc.

To solve or diminish the problems before mentioned, an alternative is the use of renewable energies to supply or substitute the conventional sources of energy. The use of renewable energies has been increasing for the last twenty years, some reasons are the decrease of the technology price, the information diffusion about the advantages of it use and the emergent technologies that reduce que price or the size of the total installation.

Among the renewable energies investigated, the solar energy has the most potential for using in different ways, such as: energy generation, heat processes for the industry or to heat water for houses, hotels, hospitals, etc. Only in two days, the planet receives the energy equivalent to all the fossil fuels reserves known until now, this is equivalent to 60 times the annual consumption of the human society, this data provides an ideal of the solar energy potential to satisfy the energy human necessities (Arancibia, 2010).

Among the devices built to take advantage of the solar energy for being transformed into thermal energy, the parabolic trough collectors (PTC) are the most mature, developed and advanced solar technology to reach medium temperatures (60 - 400 °C).

The larger application for electric generation using PTC collectors with synthetic oil as heat transfer fluid is the solar power plant SEGS located in southern California, E.E.U.U., with a total installed capacity of 354MW, divided into eight zones, SEGS I with a capacity of 14MW. SEGS II-VI with a capacity of 30MW each one and SEGS VIII-IX with 80 MW each one (Kalogirou, 2009).

The majority of PTC collectors or power plants use synthetic oil as heat transfer fluid, although different working fluids have been analysed. The commercial Eurotrough ET-150 PTC collector was investigated energetically and exergetically for a great temperature range from 300K to 1300K using different heat transfer fluids, pressurized water, Therminol VP-1, nitrate molten salt, sodium liquid, air, carbon dioxide and helium, the study was realized using a the EES tool where the maximum efficiency is varying depending on the inlet temperature and mass flow (Bellos et al, 2017).

Even the direct steam generation system has been under study for the last years, the need to remove the heat exchanger is one of the advantages, nevertheless this kind of steam generation presents some problems, the flow must show some specific flow patterns to avoid larges temperature gradients in the absorber tube, these gradients cause the excessive deflection for the tube and if a coating tube is used to surround the absorber tube, this could be damaged or broken, also an absorber tube with higher thermal conductivity is recommended (Almanza, 1997, Rojas, 2008).

In order to reduce the electricity cost and improve the overall efficiency, some studies have been developed to predict the thermal behavior of PTC collectors, such as a numerical model based on Finite Volume Method where hot water and steam generation are used as heat transfer fluids (Hachicha, 2016), also a numerical study was carried out to analyze the dependent on the heat loss from the absorber tube at its operation temperature to predict the useful heat gain, selecting evacuated and non-evacuated glass tubes employed as a control radiative and convective heat losses (Premjit, et al, 2011).

ISSN 2444-4995

The heat transfer fluid enhancement in a PTC collector become essential to transfer the maximum amount of heat, which can reduce the total system size, some studies are focused on the feasibility of heat transfer augmentation techniques for PTC absorber tubes. These includes the use of nanofluids with or without inserts and use of inserts with base fluids, also the study was applied depending on the kind of flow, laminar or turbulent, the use of inserts with base fluid is beneficial in laminar region while nanofluids with insert is justified for turbulent regime (Sandeep and Arunachala, 2017).

The computational tools have become an important role in the knowledge generation and technology development, the design and simulation of processes and devices could be made changing the variables involved without the necessity to build a prototype, this advantage becomes the processes cheaper and flexible.

In this work, a developed computational tool is used to realize the thermal analysis of a parabolic trough solar collector that uses synthetic oil as heat transfer fluid, the data used for this purpose were obtained from the LS3 (Luz Solar third generation) PTC collector constructed in Sandia National laboratories, E.E.U.U. and used for electric generation. The next sections of this work presents the methodology used to obtain the flow and thermal data using the designing parameters and construction materials of the PTC collector selected in order to assess its overall performance.

Methodology

In this work, the characteristics and designing of the commercial LS3 solar collector are used to realize the flow and thermal analysis. The LS3 solar collector was developed by the American-Israeli company Luz Industries Ltd. and currently is applied in the Solar Electric Generation Systems located at the southern of California, E.E.U.U., this collector was based on a broad space frame structure, which is more resistant to bending and torsion (Günther et al, 2011).

Currently the commercial solar collector plants based on PTC collectors principally used for electrical generation uses synthetic thermal oil as working heat transfer fluid (HTF) because of its thermal characteristics. The HTF has the task to accumulate the thermal energy in the collectors absorber tube and to transport it to the power block, after that, the energy gained by the synthetic oil is transferred to the water using a heat exchanger, once the temperature water is increasing, the evaporation process begins to reach the steam necessary to supply the turbine, this energy transferred by the synthetic oil is the energy used to develop the Rankine cycle for the mechanical power production and consequently the electrical energy generation.

The use of synthetic oil as HTF has some advantages and currently is the configuration most used to produce thermal energy. The synthetic oil contains relative lower heat capacity; this characteristic is convenient because the fluid needs only less quantity of energy to increase the temperature, also presents more advantages such as: high evaporation temperature; the regular temperature for the synthetic oil in a PTC collector for electrical generation is around 400 ℃, low freezing temperature this is important because the majority of the solar fields have no freezing protection, thermal stability, low viscosity to reduce the frictional losses into the absorber tube, low cost investment and the availability.

For the purpose of this work, two heat transfer fluids are being analyzed, Syltherm 800 and Therminol VP1, which has been used for many applications in commercial PTC collectors power plants.

Absorber tube thermal analysis

The computational tool developed for PTC designing and assessment to realize the thermal analysis considers some assumptions. The HTF is considered always in liquid state and the mathematical models used to predict the main variables are considered as average values.

ISSN 2444-4995

ENCISO, Contreras Ernesto, DE LA CRUZ, Alejo Jesús, ALCOCER, Guillermo Irving Cardel and BARBOSA, Saldaña Juan Gabriel. Thermal analysis of a parabolic trough solar collector with synthetic oil as working fluid using a computational tool. Journal of Technological Prototypes. 2020

The solar energy available to be transferred into the absorber tube depends on the area of aperture, the solar irradiance must be provided or estimated using measured values or computed using a mathematical model, other important parameters involved into the analysis are the thermal characteristics of the HTF as well as the optical parameters of the parabola material, the absorber tube selective surface and the absorber and coating tubes materials.

The absorber tube is considered to be surrounded by a concentric coating transparent tube to minimize the convection heat losses and only one coating tube is considered.

The process begins with the computation of heat gained by the HTF, as shows the equation (1).

$$Q_u = \dot{m}C_p(T_{fe} - T_{fi}) \quad (1)$$

Where, $\dot{m}$ represents the mass flow (kg/s) and is considered the most important parameter involved into the calculations for the entire process, C_p is the heat capacity (J/kg), T_{fe} and T_{fi} are the outer HTF temperature at the end of the absorber tube and the inner HTF temperature at the beginning of the absorber tube respectively (°C).

The heat transfer coefficient (W/m^2K) for the working fluid depends on the Reynolds number (dimensionless) and two factors related with this value and can be computed using the equations (2) to (5).

$$Re = \frac{4\dot{m}}{\pi D_{ri}\mu_l} \quad (2)$$

$$Xi = \frac{1}{(1.82\log(Re) - 1.64)^2} \quad (3)$$

$$\lambda = 1 + \frac{900}{Re} \quad (4)$$

$$h_l = \left(\frac{k_l}{D_{ri}}\right)\left(\frac{0.125\ Xi\ Re\ Pr_l}{\lambda + 4.5Xi^{0.5}(Pr_l^{0.666} - 1)}\right) \quad (5)$$

In the recent equations, μ_l represents the dynamic viscosity of the working fluid $(Pa \cdot s)$, Pr_l is the Prandtl number (dimensionless), k_l is the thermal conductivity (W/mK) and D_{ri} is the absorber tube internal diameter (m).

All the variables must be computed simultaneously as the mass flow is varying in order to compute the outer temperature of the absorber tube as well as the temperatures of the coating tube.

The outer and inner surfaces of the absorber tube are unknown and must be computed, this can be realized using the Newton´s cooling law and the Fourier´s law, this is possible with the assumption that the heat flow across the absorber tube is conserved.

$$Q_u = \frac{T_{ri} - T_{l-av}}{\pi L D_{ri} h_l} \quad (6)$$

$$Q_u = \frac{2\pi L k_r (T_{re} - T_{ri})}{\ln\left(\frac{D_{re}}{D_{ri}}\right)} \quad (7)$$

Where, T_{ri} and T_{re} are the inner and outer absorber tube temperatures (°C), T_{l-av} is the working fluid average temperature (°C), L is the total length of the absorber tube (m), D_{re} is the outer absorber tube diameter and k_r represents the thermal conductivity of the absorber tube (W/mK).

The mathematical model also considers the thermal losses. The inner temperature of the HTF is imposed by the user and depending of the average fluid temperature the computational tool obtains the thermal characteristics of the synthetic oil. The heat losses begin at the outer surface of the absorber tube passing through the coating tube to the air of the ambient, the figure (1) represents a diagram of the heat losses.

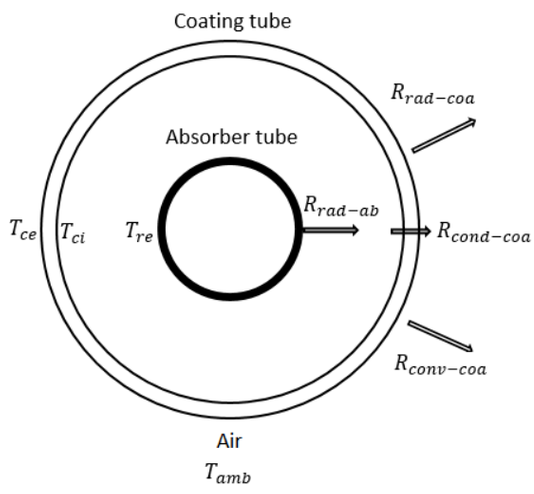


Figure 1 Thermal losses from the absorber and coating tubes of a PTC collector

Considering the conservation of the heat lost from the absorber tube surface to the inner surface of the coating tube, regarding only the thermal losses for radiation, thermal losses for convection are not considered because of the assumption that the space between both tubes is evacuated, after that the heat passing through the coating tube as heat conduction and finally, from the outer surface of the coating tube to the ambient air, two effects are considered, the thermal radiation and convection, the next equations governs the heat lose analysis (Duffie and Beckman, 2013).

$$Q_l = \frac{\pi D_{re} L \sigma (T_{re}^4 - T_{ci}^4)}{\frac{1}{\varepsilon_r} + \frac{1-\varepsilon_c}{\varepsilon_c}\left(\frac{D_{re}}{D_{ci}}\right)} \quad (8)$$

$$Q_l = \frac{2\pi k_c L (T_{ci} - T_{co})}{\ln\left(\frac{D_{co}}{D_{ci}}\right)} \quad (9)$$

$$Q_l = \pi D_{co} L h_a (T_{co} - T_a) + \varepsilon_c \pi D_{co} L \sigma (T_{co}^4 - T_a^4) \quad (10)$$

In the previous equations, T_{ci} and T_{co} are the inner and outer temperatures of the coating tube (℃), T_a is the ambient air temperature (℃), D_{ci} and D_{co} are the inner and outer coating tube diameters (m), σ is the Stefan-Boltzmann constant (W/m^2K^4), k_c is the coating tube thermal conductivity (W/mK), ε_c and ε_r represents the emissivities of the coating and absorber tube respectively, and finally, h_a is the heat transfer coefficient of the ambient air (W/m^2K).

The equation (8) only considers the radiation losses because of the assumption that the space between the absorber and coating tube is evacuated, the equation (9) represents the conduction heat passing through the coating tube and the equation (10) considers the effects of convection and radiation from the coating tube to the ambient air.

Finally, to complete the thermal analysis, the heat transfer coefficient of the ambient air must be computed, this is possible using the velocity of the air and for the mathematical model, forced convection across the external surface of a cylinder is considered. The Nusselt number of the air in function of the Reynolds number is computed as follows.

$$Re_a = \frac{V D_{ce}}{\upsilon_a} \quad (11)$$

For $Re_a > 0.1$ to $Re_a \leq 1000$

$$Nu = 0.4 + 0.54 Re_a \quad (12)$$

and for $Re_a > 1000$

$$Nu = 0.3 Re_a \quad (13)$$

$$h_a = \frac{Nu\, k_a}{D_{ce}} \quad (14)$$

Where, V is the air velocity (m/s), Nu is the air Nusselt number (dimensionless) and k_a is the air thermal conductivity (W/mK).

The process before mentioned is followed for the computational tool to realize the absorber tube thermal analysis, the next section presents the results using the designing of a real PTC solar collector using thermal oil as working fluid.

Results

The thermal analysis of the absorber tube in a PTC collector using this computational tool needs some initial parameters that the user can introduce to the interface freely. These parameters according to the construction materials of the commercial LS3 PTC collector are shown in the table (2).

Parabola dimensions	
Aperture (m)	5.7
Length (m)	12
Rim angle (°)	80
Intercept factor	0.93
Construction materials characteristics	
Reflectivity of the parabola surface	0.94
Selective surface	
Absorptivity	0.96
Emissivity	0.15
Absorber tube	
Internal diameter (m)	0.059
External diameter (m)	0.07
Thermal conductivity (W/mK)	15
Coating tube (Pyrex)	
Internal diameter (m)	0.101
External diameter (m)	0.115
Thermal conductivity (W/Mk)	1.2
Transmisivity	0.96
Emissivity	0.9

Table 1 Construction characteristics of the LS3 solar collector.

Source: (Fernández-García et al, 2010)

The energy source (solar irradiance), depends on the place where the PTC is pretended to be installed, the solar irradiance is intermittent and for the assessment of a PTC collector, a monthly average value must be used. Mexico City is the place selected for this analysis, due to the great available solar energy along the year.

The computational tool can analyse the thermal characteristics of the PTC collector considering the twelve values of average monthly solar irradiance. The table (2) shows the twelve values considered for this work.

Solar irradiance average for every month in Mexico City (W/m^2).	
January	474.01
February	530.24
March	543.79
April	548.79
May	502.65
June	507.17
July	436.16
August	460.04
September	406.76
October	467.58
November	497.40
December	442.47

Table 2 Solar irradiance monthly average values for Mexico City
Source: (Enciso et al, 2018)

Other important variable is the solar irradiation incidence angle, due to the length of the PTC collectors, if a solar tracking system is considered to be implemented, only one axis solar tracking system can be installed, the most used and for this reason, the same considered for this analysis is the North-South oriented and East-West displacement.

The computational tool also can compute an average solar incidence angle along the year and depends on the latitude from the place where the PTC collector is going to be installed, for Mexico City and the solar tracking system considered, the incidence angle is $\theta = 17.47°$.

Finally, ambient data and properties for the working fluids are needed.

The properties for the working fluid are obtained from the average fluid temperature, the temperatures at the beginning and at the end of the PTC collector can be introduced freely by the user, the LS3 collector was designed to operate at a maximum temperature of 390°C for electric generation, this temperature value is considered for this thermal analysis and an initial temperature of 30°C, the table (3) shows the data used in this analysis.

Average ambient data for Mexico City	
Temperature (°C)	22
Air velocity (m/s)	1.9
Working fluid properties	
Syltherm 800	
Heat capacity (J/kgK)	1933
Thermal conductivity (W/mK)	0.0993
Prandtl number	18.688
Dynamic viscosity (Pa · s)	$0.96 \text{ X } 10^{-3}$
Density (kg/m^3)	763.78
Therminol VP-1	
Heat capacity (J/kg)	2075
Thermal conductivity (W/mK)	0.112
Prandtl number	6.819
Dynamic viscosity (Pa · s)	$0.368 \text{ X } 10^{-3}$
Density (kg/m^3)	904

Table 3 Thermal properties for the working fluids.
Source: (Enciso, 2012) https://es.weatherspark.com/y/5674/Clima-promedio-en-Ciudad-de-M%C3%A9xico-M%C3%A9xico-durante-todo-el-a%C3%B1o

All the variables before explained and mentioned must be introduced to the software interface, the computational tool shows in separate section, the properties that must be introduced for every part of the PTC collector. The figure (2) shows the software interface for PTC collector assessment. This software is validated and can be consulted in Enciso, 2012.

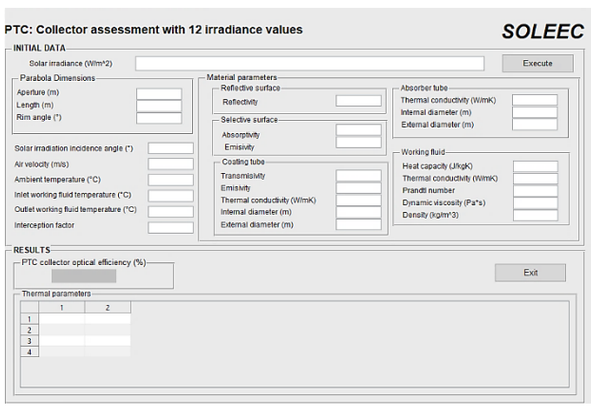


Figure 2 Interface of the computational tool to realize an assessment of a PTC collector with 12 average values of solar irradiance

Once the software interface is executed, the results for the thermal analysis for every solar irradiance value is showed in form of table for the better comprehension. The tables (4) and (5) show the results for both synthetic oils analyzed in this work.

Month	Heat gain (W)	Heat losses (W)	Mass flow (kg/m^3)	Efficiency (%)	Outer surface absorber tube (℃)	Inner Surface coating tube (℃)
January	1391.8	15822	0.0021	4.29	660.86	193.73
February	1670.1	17042	0.0025	4.60	678.62	204.49
March	1809.3	17540	0.0027	4.86	685.66	209.29
April	1809.3	17540	0.0027	4.82	685.66	209.29
May	1530.9	16471	0.0023	4.45	670.45	199.70
June	1600.5	16767	0.0024	4.61	674.69	202.09
July	1252.6	15062	0.0019	4.20	649.40	187.78
August	1391.8	15822	0.0021	4.42	660.86	193.73
September	1183.0	14646	0.0018	4.25	642.79	183.03
Octuber	1391.8	15822	0.0021	4.35	660.86	193.73
November	1530.9	16471	0.0023	4.50	670.45	199.70
December	1252.6	15062	0.0019	4.14	649.40	187.78

Table 4 Evaluation of the PTC collector using Syltherm 800 synthetic oil as heat transfer fluid.

Month	Heat gain (W)	Heat losses (W)	Mass flow (kg/m^3)	Efficiency (%)	Outer surface absorber tube (℃)	Inner Surface coating tube (℃)
January	5453.1	13833	0.0074	16.82	629.72	175.93
February	7619.4	14176	0.0103	21.01	635.36	179.48
March	8142.3	14265	0.0110	21.89	636.70	179.48
April	8366.4	14293	0.0113	22.29	637.27	180.66
May	6573.6	14016	0.0089	19.12	632.66	177.11
June	6723.0	14032	0.0091	19.38	633.04	178.29
July	3959.1	13598	0.0054	13.27	625.81	173.57
August	4930.2	13753	0.0067	15.67	628.35	174.75
September	2838.6	13414	0.0039	10.20	622.79	172.39
Octuber	5229.0	13795	0.0071	16.35	629.13	175.93
November	6349.5	13978	0.0086	18.66	632.07	177.11
December	4183.2	13636	0.0057	13.82	626.39	173.57

Table 5 Evaluation of the PTC collector using Therminol VP-1 synthetic oil as heat transfer fluid.

The mass flow is the most important parameter in the results, this is directly related to the computation of the other thermal parameters, the computational tool takes an initial mass flow value and develops an iterative process to predict the necessary mass flow in order to reach the temperature of the working fluid dictated by the user, that means, the mass flow represents the necessary time that the working fluid must be exposed to the solar irradiance to reach the temperature condition. As can be seen in table (5), due to the characteristics of every synthetic oil, the mass flow for Therminol VP1 is higher in average 70.36% than Syltherm 800 for reaching the 390°C desired, so the residential time for the working fluid is less, this characteristic is beneficial and can be observed in the other thermal characteristics.

The first parameter directly influenced by the mass flow is the heat gain, this represents the quantity of useful energy for the collector from all the energy that reaches the entire collector, the higher the mass flow, the higher the heat gained by the collector, that means that using Therminol VP1, the working fluid transfer more energy to the storage tank, and at the end of a period of time, more energy is collected. The month which the collector take more advantage of the solar energy is april with $8366.4\,W$ against september with the less energy collected with $2838.6\,W$ this represents 66.07% less energy. Comparing the month with the major quantity of heat gain for both synthetic oils, for Syltherm 800 the heat gain in april is $1809.3\,W$, this is 78.37% less useful energy in comparison with Therminol VP1, even in the month with less solar irradiance (september) using Therminol VP1 collects more useful energy. The importance of analyzing every month is to design the minimal size of the PTC collector in order to satisfy the quantity of energy necessary to cover the useful energy needed of the process for all the year.

The heat losses also play an important role in the thermal analysis, the thermal radiation is the most significant mechanism of lost thermal energy, so when the absorber tube external temperature increases, the thermal radiation losses also increase. The absorber tube temperature in both cases is relatively high having an average along the year of $665.81℃$ for Syltherm 800 and $630.7℃$ for Therminol VP1, this represents the increase of the thermal losses for both cases affecting directly to the overall thermal efficiency.

The mass flow also is important for the thermal losses, when the mass flow increases, the absorber tube temperature decreases, as a consequence, the thermal losses also decreases. Considering the before mentioned and the heat gain, the overall thermal efficiency can be estimated for the PTC solar collector. As show the tables (5) and (6), the use of Therminol VP1 increases 73.29% the thermal efficiency against the efficiency when Syltherm 800 is used, so if the total energy collected in a period of time is considered, the use of Therminol VP1 is recommended.

ISSN 2444-4995

Using the computational tool, the user can assess a PTC collector with any working fluid that is remaining in a single phase state, the user can introduce freely the characteristics of every PTC collector section and the properties of the working fluid. The advantage of using a computational tool is the capacity to evaluate an existing PTC collector and the results can be used as starting point for the collector's improvement and, if necessary, to consider the collector´s redesign.

Conclusions

This work describes the use of a computational tool for PTC collector assessment. The analysis considers the designing characteristics of the commercial solar collector LS3 with two synthetic oils, Syltherm 800 and Therminol VP1 as working fluids remaining in liquid state during the process. Mexico City is the place where the PTC collector is pretended to be installed so the solar irradiance for this place is used as energy source.

An interface was designed, divided in sections where the user must provide the characteristics of the parabola, tubes materials, ambient data, the characteristics of the fluid and the solar irradiance. The results, in form of charts, show the thermal and flow characteristics of the PTC collector for every working fluid and for every average monthly solar irradiance values along the year.

The solar irradiance is intermittent and is necessary an average to use a single value for each month. April is the month for Mexico City with the maximum solar radiation quantity while september provides the less available energy, this is important because the designer can determine the PTC installation size in order to guarantee the temperature condition of the working fluid.

The thermal properties of every working fluid play an important role and the most important parameter computed is the mass flow, this variable is directly involved in the other thermal characteristics. The results show that the mass flow for Therminol VP1 is higher than for Syltherm 800 for 70.36% average for every month, this is beneficial because, if the mass flow increases, the heat gained by the collector also increases and diminishes the thermal losses.

The absorber tube temperature is the most important parameter for thermal losses, for both cases this value is relatively high with an average of 665.81℃ for Syltherm 800 and 630.7℃ for Therminol VP1. The radiation is the most significant heat transfer mechanism for thermal losses and a high absorber tube temperature represents a great thermal losses rate. The thermal efficiency increases 73.29% when Therminol VP1 is used compared with Syltherm 800.

This computational tool has the advantage of evaluating any PTC solar collector that uses any working fluid remaining in liquid state and the results can be used to modify or redesign the PTC collector in order to improve the performance.

References

Almanza, R., Lentz, A., and Jiménez, G. (1997). Receiver behavior in direct steam generation with parabolic troughs, *Solar Energy*, 61 (4), 275-278.

Arancibia, C., and Best-Brown, R. (2010). Energía del Sol, *Ciencia*, 61 (2), 10-17.

Bellos, E., Tzivanidis, C., and Antonopoulos, K., A. (2017). A detailed working fluid investigation for solar parabolic trough collectors, *Applied Thermal Energy*, 114, 374-386.

Duffie, J., A., and Beckman, W,. A. (2013). *Solar engineering of thermal processes*, New Jersey, Estados Unidos, Wiley and Sons Inc.

Eck, M., Zarza, E., Einckoff, M., Rheinländer, J., and Valenzuela, L. (2003). Applied research concerning the direct steam generation in parabolic troughs, *Solar Energy*, 74, 341-351.

Enciso, C., E. (2012). *Desarrollo de un software para el diseño de concentradores solares de canal parabólico*. Tesis de Maestría. Instituto Politécnico Nacional. Ciudad de México, México.

ISSN 2444-4995

ENCISO, Contreras Ernesto, DE LA CRUZ, Alejo Jesús, ALCOCER, Guillermo Irving Cardel and BARBOSA, Saldaña Juan Gabriel. Thermal analysis of a parabolic trough solar collector with synthetic oil as working fluid using a computational tool. Journal of Technological Prototypes. 2020

Enciso, C., E., Barbosa, S., J., G., Mora, O., A., Bonilla, B., W., C., Salazar, P., M., Aguilar, A., J., C., A., and Durán, M., P. (2018). Analysis and design of an integrated solar combined cycle power plant using the software SOLEEC, *Journal of Renewable and Sustainable Enegy*, 10, 1-13.

Fernández-García, A., Zarza, E., Valenzuela, L., and Pérez, M. (2010). Parabolic-trough solar collectors and their applications. *Renewable and sustainable energy reviews*, 14, 1695-1721.

Günther, M., Joemann, M., and Csambor, S. (2011). *Advanced CSP teaching materials*. Enermena.

Kalogirou, S., (2009). *Solar Energy Engineering Processes and Systems*, Elsevier.

Premjit, D., Yashavant, J., and Abhik, K., D. (2011). Numerical investigation of parabolic trough receiver performance with outer vacuum shell, *Solar Energy*, 85, 1910-1914.

Rojas. M., E., De Andrés, M., C., and González L. (2008). Designing capillary systems to enhace heat transfer in LS3 parabolic trough collectors for direct steam generation (DSG), *Solar Energy*, 82, 53-60

Sandeep, H., M., and Arunachala, U., C. (2017). Solar parabolic trough collectors: A review on heat transfer augmentation techniques, *Renewable and Sustainable Energy Reviews*, 69, 1218-1231.

ISSN 2444-4995

Article **Journal of Technological Prototypes**
June 2020 Vol.6 No.17 10-21

Unified mobile accessibility guidelines (UMAG)

Directivas unificadas para la accesibilidad móvil (DUAM)

LÓPEZ-GONZÁLEZ, Néstor Apolo†* & GONZÁLEZ-BELTRÁN, Beatriz Adriana

Universidad Autónoma de México - Azcapotzalco

ID 1st Author: *Néstor Apolo, López-González* / **ORC ID:** 0000-0002-9909-8575

ID 1st Coauthor: *Beatriz Adriana, González-Beltrán* / **ORC ID:** 0000-0002-1718-9060

DOI: 10.35429/JTP.2020.17.6.10.21 Received January 25, 2020; Accepted April 01, 2020

Abstract

The attributes of a software product such as usability and accessibility are crucial, they allow the user to reach his/her goals, and additionally they give a better user experience. The first of them, usability, is oriented to satisfy the needs of the user with average capabilities and the second, accessibility is related to the users with disabilities. There is a lot of work published about web accessibility but, it is not the same case for mobile accessibility. This paper focuses on mobile accessibility guidelines, its overall aim consists of a set of unified mobile accessibility guidelines, based on guidelines such as Android, the British Broadcasting Corporation (BBC) and the World Wide Web Consortium (W3C). The method consisted of: Examine and organize the existent guidelines; find elements/components and properties/attributes related to them; verify if the guideline applies to the mobile environment then, unify guidelines if there are two or more of them. The result of this work consists of a set of unified guidelines to develop a mobile accessibility guidelines standard.

Guidelines, accessibility, mobile

Resumen

De entre los atributos de calidad de un producto de software se tienen a la usabilidad y la accesibilidad, ambos permiten a los usuarios la completitud exitosa de las tareas que realizan con el software no importando sus capacidades: La usabilidad enfocada al usuario con capacidades promedio y la accesibilidad orientada a los usuarios con discapacidad. Aunque existe gran variedad de trabajo desarrollado sobre la accesibilidad web, no es el mismo caso sobre la accesibilidad móvil. Este artículo se centra en las directivas de diseño para la accesibilidad móvil y su objetivo principal consiste en unificar las propuestas de directivas de Android, de la British Broadcasting Corporation (BBC) y del World Wide Web Consortium (W3C), esto como preámbulo para el desarrollo de un estándar específico sobre la accesibilidad móvil. El método utilizado para la unificación consistió en examinar y organizar las directivas de los autores mencionados; identificar elementos/componentes, así como propiedades/atributos que compartieran dichos conjuntos; verificar si la directiva tiene aplicación al ámbito móvil y proceder a unificarla si existen dos o más de ellas. El resultado es un conjunto de directivas de diseño para la accesibilidad móvil unificadas para dar pie al desarrollo de un estándar.

Directivas, accesibilidad, móvil

Citation: LÓPEZ-GONZÁLEZ, Néstor Apolo & GONZÁLEZ-BELTRÁN, Beatriz Adriana. Unified mobile accessibility guidelines (UMAG). Journal of Technological Prototypes. 2020. 6-17: 10-21.

* Correspondence to Author (email: al2173804201@azc.uam.mx)
† Researcher contributing first author

Introduction

The use of mobile devices (smartphones, tablets and smart watches, among others) is increasing (Anderson and Perrin, 2017), which implies that people must interact with mobile applications (apps) in order to do working and daily tasks. It is important to highlight that users have different extents of capabilities, on the one hand we have an average user, it means that user has the most people capabilities, but on the other hand we have disabled users (Lieberman, 2018), that is users with auditory, cognitive, learning, neurological, physical, speech and/or visual disabilities (W3C, 2017).

No matter the extent of users' capabilities, they must be able to operate and manipulate a mobile user interface. If we talk about average users, the accomplishment of the quality attribute of software named usability allows to reach that purpose, in case of disabled users, must be considered the quality attribute of software named accessibility.

The International Standardization Organization (ISO) has defined both quality attributes in 9241-11:2018 standard. Usability is defined such as "extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use", (ISO, 2018), and accessibility is defined such as "extent to which products, systems, services, environments and facilities can be used by people from a population with the widest range of user needs, characteristics and capabilities to achieve identified goals in identified contexts of use" (ISO, 2018).

It is important to remark that this paper focuses on mobile accessibility guidelines that support to developing mobile user interfaces operated and manipulated by disabled users, that is, unified guidelines that allows to implement the software quality attribute named accessibility on mobile apps.

In order to provide support to implement the accessibility attribute on mobile user interfaces, the World Wide Web Consortium (W3C), Android, the British Broadcasting Corporation (BBC), Apple, Blackberry, Microsoft, among others, have developed mobile accessibility guidelines.

It is important to say that a lot of work about web accessibility have been developed (Mariño and Pagnoni, 2020), but not for mobile accessibility. The ISO/IEC 40500:2012 standard is oriented to web accessibility. This standard is based on the Web Content Accessibility Guidelines (WCAG) developed by W3C which can be adapted to the mobile environment.

At the present time there is not a specific standard to rule mobile accessibility. This paper focuses on the unification of the existent accessibility guidelines, in order to, in future works, to develop a mobile accessibility standard. The accessibility guidelines' proposers considered for this analysis were: BBC for the reason that it broadcasts to the world on radio, TV and online, offering news and information in 29 languages (BBC, 2019); The W3C because is a worldwide leader in web accessibility topics; and Android as it developed the most famous mobile operating system in the world (Android, n.d.).

The accessibility guidelines' proposers discarded were: Apple because the guidelines shown on its website focuses on assistive technology which is out of the reach of this work; BlackBerry as it were displaced by Android and Apple; and Windows Universal Platform (WUP) developed by Microsoft for the reason that its guidelines are oriented to a wide variety of devices such as mobile, personal computers, Xbox, HoloLens, Devices + IoT and surface hub (Microsoft, n.d.). Next are shown the sets of guidelines that were considered for the unification: BBC, Android and W3C (López and González, 2020). Also, the methodology used to unify the guidelines is described and finally, the unified mobile accessibility guidelines proposal is presented.

BBC Mobile accessibility guidelines

The guidelines developed by BBC are based on three principles: 1. Use platform and web standards as intended; 2. Use standard user interface controls where possible; and 3. Support platform accessibility (BBC, 2017a). Guidelines are grouped in eleven issues: Audio and video, design, editorial, focus, forms, images, links, notifications, scripts and dynamic content, structure and text equivalents. (BBC, 2017b):

First issue, audio and video includes the following recommendations: Provide subtitles, sign language, audio descriptions and transcriptions for embedded media (**B1.1**); and, audio must not play automatically, provide a pause/stop/mute button (**B1.2**), likewise, separate volume controls for background music, ambient sounds, narrative and editorially significant sound effects must be provided (**B1.4**). You have to keep in mind two considerations more: Relevant metadata for all media must be provided (**B1.3**) and narrative audio in games or interactive media should not conflict with native assistive technology (**B1.5**).

The design issue, groups the following suggestions: The color of text and background content must have sufficient contrast (**B2.1**); information or meaning must not be conveyed by color only (**B2.2**); core content must still be accessible when styling is unsupported or removed (**B2.3**); touch targets must be large enough to touch accurately, that is to say 7-10 mm (**B2.4**); an inactive space should be provided around actionable elements (**B2.5**); users must be able to control font sizing and user interface scaling (**B2.6**); links and other actionable elements must be clearly distinguishable (**B2.7**); when focused, all actionable and focusable elements must have a visible state change (**B2.8**); user's experience should be consistent (**B2.9**); interfaces must provide multiple ways to interact with content (**B2.10**); interactive media, including games, should be adjustable for user ability and preference (**B2.11**); lastly, content must not visibly or intentionally flicker or flash more than three times in any one-second period (**B2.12**). Regards to editorial issue, recommendations are: Consistent labelling should be used across websites and native applications (**B3.1**); the language of a page or app must be specified, and changes in language must be indicated (**B3.2**); ultimately, additional instructions should be provided to supplement visual and audio cues (**B3.3**). Guidelines about focus issue are: Only interactive elements must be focusable (**B4.1**); there must not be a keyboard trap (**B4.2**); content order must be logical (**B4.3**); actionable content must be navigable in a meaningful sequence (**B4.4**); actions must be triggered when appropriate for the type of user interaction (**B4.5**); and alternative input methods must be supported (**B4.6**).

Recommendations when you use forms are: All form controls must be labelled (**B5.1**); a default input format must be indicated and supported (**B5.2**); labels must be placed close to the relevant form control, and laid out appropriately (**B5.3**); form elements such as controls and labels must be properly grouped (**B5.4**); finally, focus or context must not automatically change during user input (**B5.5**).

About images issue, it is suggested that images of text should be avoided (**B6.1**). Equally important, must be considered that background images that convey information or meaning must have an additional accessible alternative (**B6.2**).

Links issue, consider the following suggestions: link and navigation text must uniquely describe the target or function of the link or item (**B7.1**); links to alternative formats must indicate that an alternative is opening (**B7.2**); and, repeated links to the same resource must be combined within a single link (**B7.3**).

Four guidelines has been developed for the notification issue: notifications must be both visible and audible (**B8.1**); standard operating system notifications should be used where available and appropriate (**B8.2**); lastly, clear error messages (**B8.3**) and non-critical feedback or assistance should be provided (**B8.4**).

The recommendations about scripts and dynamic content are: apps and websites must be built to work in a progressive manner that ensures a functional experience for all users (**B9.1**); media that updates or animated content must have a pause, stop or hide control (**B9.2**); automatic page refreshes must not be used without warning (**B9.3**); a timed response must be adjustable (**B9.4**); finally, interaction input control should be adaptable (**B9.5**).

Guidelines related to structure issue are: All pages or screens must be uniquely and clearly identifiable (**B10.1**); content must provide a logical and hierarchical heading structure (**B10.2**); containers should be used to describe page/screen structure (**B10.3**); and, controls, objects and grouped interface elements must be represented as a single accessible component (**B10.4**).

ISSN 2444-4995

Finally, suggestions concerning the text equivalents issue are next: Alternatives must briefly describe the editorial intent or purpose of the image, object, or element (**B11.1**); decorative images must be hidden from assistive technology (**B11.2**); tooltips must not repeat link text or other alternatives (**B11.3**); elements must have accessibility properties set appropriately (**B11.4**); and visual formatting alone must not be used to convey meaning (**B11.5**).

Android Material Design: Accessibility

Android provides a set of accessibility guidelines based on three principles: Clear, robust and specific. First principle consists in help users navigate by designing clear layouts with distinct calls to action. On the other hand, second principle is oriented to design the app to accommodate a variety of users. Finally, specific principle is focused on support assistive technologies specific to the platform, to support the input methods of touch, keyboard, and mouse (Android, n.d.).

Guidelines are organized in seven issues: Assistive technology, hierarchy, color and contrast, layout and typography, writing, sound and motion and implementing accessibility (Android, n.d.).

In respect of screen readers (**A1.1**) is suggested that the content must be labelled in order to TalkBack can read a text-only version correctly (**A1.1.1**), it means you have to make sure that the app can work with screen readers (**A1.1.2**). The interface can be explored by touch that is to allow users to run their finger over the screen to hear what is directly underneath or by linear navigation that is to say backwards or forwards on screen to read pages linearly, from top to bottom (**A1.1.3**). When directional controllers are used, they should to allow users to jump from selection to selection in a linear fashion (**A1.2.1**).

In regard to hierarchy (**A2.1**), is suggested: Clearly visible elements (**A2.1.1**), sufficient contrast and size (**A2.1.2**), a clear hierarchy of importance (**A2.1.3**) and key information that is discernable at a glance (**A2.1.4**).

Additionally, you should consider placing important actions at the top or bottom of the screen, reachable with shortcuts (**A2.1.5**) and related items of a similar hierarchy next to each other (**A2.1.6**). Also, it is relevant: that users knows where they are in the app and what is important (**A2.1.7**); provide visual and touch feedback (**A2.1.8**); visual feedback (labels, colors and icons) and touch feedback show users what is available in the UI (**A2.1.9**); and use multiple visual and textual cues like color, shape, text, and motion to emphasize which information is important (**A2.1.10**).

About focus (**A2.2**) is recommended that: Input focus flows from the top to the bottom of the screen (**A2.2.1**); it can traverse from the most important to the least important item (**A2.2.2**); determine your focus points and movements, considering the order in which elements receive focus, the way in which elements are grouped and where focus moves when the element in focus disappears (**A2.2.3**); focus location must be clear, you can use visual indicators and accessible text for that purpose (**A2.2.4**); focus control, when keyboard is used or the user reads the content, can be implemented for frequently used tasks (**A2.2.5**); navigation should have a clear flow, it means, task can be done in a few steps (**A2.2.6**); finally, navigation controls must be easy to locate and clearly written.

Related to grouping (**A2.3**), is suggested that items can be grouped using headings that communicate what the groupings are. These groups organize content spatially (**A.3.2.1**).

There are two guidelines about transitions (**A2.4**): Transversal focus between screens and task must be continuous (**A2.4.1**); and focus should locate on the element that was previously focused when a task is interrupted and then resumed (**A2.4.2**).

ISSN 2444-4995

Also, guidelines indicate that should be used color (**A3.1**) and contrast (**A3.2**) to help users see and interpret the content of the app, interact with elements and understand actions (**A3.3.1**). Additionally, is recommended: use primary, secondary and accent colors (**A3.3.2**); provide sufficient color and contrast between elements to see and use the app (**A3.3.3**); contrast ratio between a color and its background ranges from 1-21 based on its luminance (**A3.2.1.**); finally, the higher the difference between the two numbers in the ratio, the greater the difference in relative luminance between the colors (**A3.2.2**).

On the other hand it is recommended: logos and decorative elements with an important function must be distinguishable (**A3.3.1**); for users who are colorblind, or cannot see differences in color, other design elements can help express the same amount of information (**A3.4.1**); multiple visual cues help communicate important states (**A3.4.2**); and elements such as strokes, indicators, patterns, texture, or text can describe actions and content (**A3.4.3**).

An important issue to consider are touch targets which should be at least 48 x 48 dp, it means size of about 9mm, regardless of screen size (**A4.4.1**). The recommended target size for touchscreen elements is 7-10 mm (**A4.1.2**). In respect of pointer targets, they should be at least 44 x 44 dp and they should be separated by 8 dp of space or more (**A4.1.3**).

In order to increase the accessibility of design (**A4.2**), it must be considered to use flexible and responsive designs (**A4.2.1**). About related items, they can be grouped in proximity to one another (**A4.2.2**).

Typography issue includes guidelines about accessibility text (**A5.1**), elements with state changes (**A5.2**) and hint speech (**A5.3**). First, visible and nonvisible alternative text must be descriptive and meaningful (**A5.1.1**) as well as, clear, short and succinct (**A5.1.2**). Screen readers must be able to announce a control's type or state (**A5.1.3**).

Also, it is recommended; use action verbs to indicate what an element or link does if tapped, rather than what an element looks like (**A5.1.4**); links text should specify what will occur if an action or link is selected (**A5.1.5**); ultimately, make sure that an element has the same description no matter the page it is located (**A5.1.6**).

Secondly, when elements with state changes (**A5.2**) are used, it is suggested: announce the icons according to how it is presented to the user (**A5.2.1**); if the icon is a property of an item, screen readers will verbalize the current state (**A5.2.2**); if the icon is an action, if the icon is selected, the text label can specify the action that occurs (**A5.2.3**); and, the users may be navigating with a keyboard, fingers or mouse, so keep that in mind when telling them how to interact with a control (**A5.2.4**).

Thirdly, about hint speech (**A5.3**), is suggested to use it moderately and in case of complex user graphic interfaces (**A5.3.1**).

Next issue, sound (**A6.1**) and motion (**A6.2**), includes guidelines that suggest: provide visual alternatives such as closed captions or transcriptions (**A6.1.1**); users can navigate across app using sound when descriptive labels to UI elements have been added (**A6.1.2**); avoid sounds that interfere with screen readers, you should provide controls for users to pause or stop sounds (**A6.1.3**); lastly, avoid extra sound added to native elements (**A6.1.4**).

About motion issue, you should consider what W3C says: Enable content that moves, scrolls, or blinks automatically to be paused, stopped, or hidden if it lasts more than five seconds (**A6.2.1**); limit flashing content to three times in a one-second period to meet flash and red flash thresholds (**A6.2.2**); and avoid flashing large central regions of the screen (**A6.2.3**).

Sound and motion recommendations include two guidelines about timed controls, first avoid timers when controls that perform high-priority functions are provided (**A6.3.1**) and second, controls that enable important functions can allow users to turn them on again, or perform the same function in other ways (**A6.3.2**).

ISSN 2444-4995

Finally, relating to implementing accessibility (**A7.1**) is important to consider meeting each platform's accessibility standards and supporting its assistive technology (**A7.1.1**). Documentation (**A7.2**) must be included, it entails that features with special accessibility considerations can be included in help documentation (**A7.2.1**), additionally, it must be relevant, accessible and visible (**A7.2.2**).

Regarding to testing and research (**A7.3**) is suggested: Test the app with various assistive technologies turned on (**A7.3.1**); have users with impairments test your app (**A7.3.2**); consider how individual elements can be made more accessible while also fitting together in a coherent user flow (**A7.3.3**); make the major tasks as usable as possible for a wide range of users (**A7.3.4**); finally, learn about user's needs and what they want out of the app (**A7.3.5**).

Web Content Accessibility Guidelines (WCAG 2.0)

The guidelines proposed by World Wide Web Consortium (W3C) are grouped into four principles: Perceivable, operable, understandable and predictable. The guidelines that are part of each principle are shown below (W3C, 2008).

To begin, the perceivable principle includes guidelines about text alternatives, which must be provided and allow the user to change them into other forms such as large print, braille, speech, symbols or simpler language for any non-text content (**W1.1**). Also, it is important to highlight that any content that is not a sequence of characters, must have a text alternative (**W1.1.1**).

In regard to time based media (**W1.2**), it is important to provide: Equivalent information for audio that is not live and/or an audio track that presents equivalent information for video that is not live (**W1.2.1**); captions for all prerecorded audio content (**W1.2.2**); an audio description or an alternative for time-based media of the prerecorded video (**W1.2.3**); captions for all live audio content (**W1.2.4**); audio description for all prerecorded video content (**W1.2.5**); sign language interpretation for all prerecorded audio content (**W1.2.6**); an extended audio description for all prerecorded video content where pauses in foreground audio are not sufficient to allow audio descriptions to convey the sense of the video (**W1.2.7**); an alternative for time-based media for all prerecorded synchronized media and for all prerecorded video-only media (**W1.2.8**); and an alternative for time-based media that presents equivalent information for live audio-only (**W1.2.9**).

Guidelines about adaptable issue, that consist of create content that can be presented in different ways without losing information or structure (**W1.3**), suggest that: Information, structure, relationships and a correct reading sequence can be determined by software (**W1.3.1**, **W3.1.2**); instructions provided to understand and operate content, include more than just sensory characteristics of components such as shape, size, visual location, orientation, or sound (**W1.3.3**).

In respect of distinguishable issue, it is important to point out use more than color to conveying information, indicating an action, prompting a response, or distinguishing a visual element (**W1.4.1**). Also, must be provided a mechanism to pause or stop automatically played audio, as well as a mechanism to control audio volume (**W1.4.2**).

About text and images of text, it is important to highlight that they must have a contrast ratio of at least 4.5:1 (**W1.4.3**). In addition, text can be resized without assistive technology up to 200 % without loss of content or functionality (**W1.4.4**) and does not requiring horizontal scrolling.

ISSN 2444-4995

Also, must be considered that: text be used to convey information rather than images of text (**W1.4.5**); the visual presentation of text and images of text has a contrast ratio of at least 7:1 (**W1.4.6**); and the user can select the foreground and background colors of the block of text.

Moreover, the width of the block of text is no more than 80 characters or glyphs (40 if Chinese, Japanese or Korean) and text must be not justified. Additionally, line spacing is at least space-and-a-half within paragraphs and paragraph spacing is at least 1.5 times larger than the line spacing (**W1.4.8**). Finally, images of text are only used for pure decoration or where a specific presentation of text is essential to convey information (**W1.4.9**). On the other hand, prerecorded audio-only content that contains speech must not to contain background sounds, on the contrary, background sounds must be at least 20 decibels lower than the foreground speech content and they can be turned off (**W1.4.7**).

Second principle, operable, groups guidelines about how the user interface components and navigation become operable, it means make available all functionality from a keyboard (**W2.1**). Additionally, the functionality of content must be operable through a keyboard interface without requiring specific timings for individual keystrokes (**W2.1.1**, **2.1.3**). Also, the keyboard trap does not occur (**W2.1.2**). It is strongly recommended to provide users enough time to read and use content (**W2.2**) and that user will be able to turn off, adjust and extend, at least 20 seconds, the time limit (**W2.2.1**). Moreover, the timing is not an essential part of the event or activity presented by the content (**W2.2.3**).

It is suggested that for any moving, blinking, scrolling and auto-updating there is a mechanism for the user to pause, stop, or hide it. About auto-updating is important to provide a mechanism for the user to control the frequency of the auto-updates (**W2.2.2**). In case of an interruption occurs, it can be postponed or suppressed by the user (**W2.2.4**). Finally, if an authenticated session expires, the user can continue the activity without loss of data after re-authenticating (**W2.2.5**).

About seizures (**W2.3**), it is suggested that web pages do not contain anything that flashes more than three times in any one second period, or the flash is below the general flash and red flash thresholds (**W2.3.1**, **W2.3.2**).

About navigable issue, that means to provide ways to help users navigate, find content, and determine where they are (**W2.4**), it is recommended to include a mechanism to bypass blocks of content that are repeated on multiple Web pages (**W2.4.1**), as well as titles (**W2.4.2**), headings that be used to organize content (**W2.4.10**), and labels that describe topic or purpose (**W2.4.6**). Additionally, multiple ways are available to locate a Web page (**W2.4.5**) as well as information about the user's location within a set of Web pages (**W2.4.8**). Moreover, navigable issue includes guidelines about focus and links too. First, the focusable components receive focus in an order that preserves meaning and operability (**W2.4.3**); secondly, the keyboard focus indicator is always visible (**W2.4.7**). Finally, it is important to highlight that the purpose of each link can be determined from the link text alone (**W2.4.9**) or from the link text together with its programmatically determined link context (**W2.4.4**).

Third principle means that the information and the operation of user interface must be understandable. The understandable principle groups guidelines about readable issue, which suggests that the default human language of each Web page and the human language of each passage or phrase in the content can be determined by software (**3.1.1** and **3.1.2**). It is necessary that a Web page includes a mechanism for identifying: Specific definitions of words or phrases used in an unusual or restricted way, including idioms and jargon (**3.1.3**); the expanded form or meaning of abbreviations (**3.1.4**); specific pronunciation of words where meaning of the words, in context, is ambiguous without knowing the pronunciation (**3.1.6**) and is available a version that does not require reading ability more advanced than the lower secondary education level (**3.1.5**).

Guidelines related to predictable issue, that means make Web pages appear and operate in predictable ways (**W3.2**), suggest about changes of context that:

They are initiated only by user request or a mechanism is available to turn off such changes (**W3.2.5**), and they are not initialized when a component receives the focus (**W3.2.1**) or when is changed the setting of any user interface component (**W3.2.2**).

Additionally, the components that have the same functionality within a set of Web pages must be identified consistently (**W3.2.4**). Finally, navigational mechanisms that are repeated on multiple Web pages occur in the same order each time they are repeated (**W3.2.3**).

Input assistance issue, that refers to help users avoid and correct mistakes, includes suggestions about provide labels or instructions when content requires user input (**W3.3.2**) in addition to provide contextualized help (**W3.3.5**). If an input error occurs, it must be automatically detected, as well as the item that is in error, and described to the user in text (**W3.3.1**), providing suggestions to correct it (**W3.3.3**).

Web pages that cause legal commitments or financial transactions, that modify or delete user-controllable data in data storage systems or that submit user test responses, it is important to allow reversible submissions. Data entered by users must be checked for input errors and must be provided an opportunity to correct them. A mechanism is available for reviewing, confirming, and correcting information before finalizing the submission (**W3.3.4**, **W3.3.6**). The fourth principle, robust refers to the content must be robust enough that it can be interpreted reliably by a wide variety of user agents, including assistive technologies. Guidelines included in this principle pretend to maximize compatibility with current and future user agents, including assistive technologies (**W4.1**). Moreover, guidelines suggest use the markup languages correctly (**W4.1.1**) and programmatically set, for all user interface components, names, roles, states, properties and values; changes to these items are available to user agents, including assistive technologies.

Methodology

The methodology used to unify guidelines is shown in Figure 1. It is comprised of next steps:

1. We must identify the element/component that guideline refers to, that is, if guideline is related to audio, font, video, links, among others.

2. Now, we need to identify the property /attribute related to guideline previously selected in step 1. For example, audio has the next properties/attributes: playing, stopping, volume control, pausing, and closed captioning, among others.

3. Once identified the information referred in step 1 and 2, it is time to search the guidelines in each set. The guidelines selected must have related to the element/component and property/attribute identified.

4. We have to verify that selected guideline can be directly implemented on mobile environment, conversely, we have to verify that it can be adapted to the mobile environment. Both cases, the guideline will be considered for the unification process.

5. If there are two or more guidelines, they will be unified, on the contrary, the guideline will be considered as its original form.

6. As a result, we have a unified guideline.

ISSN 2444-4995

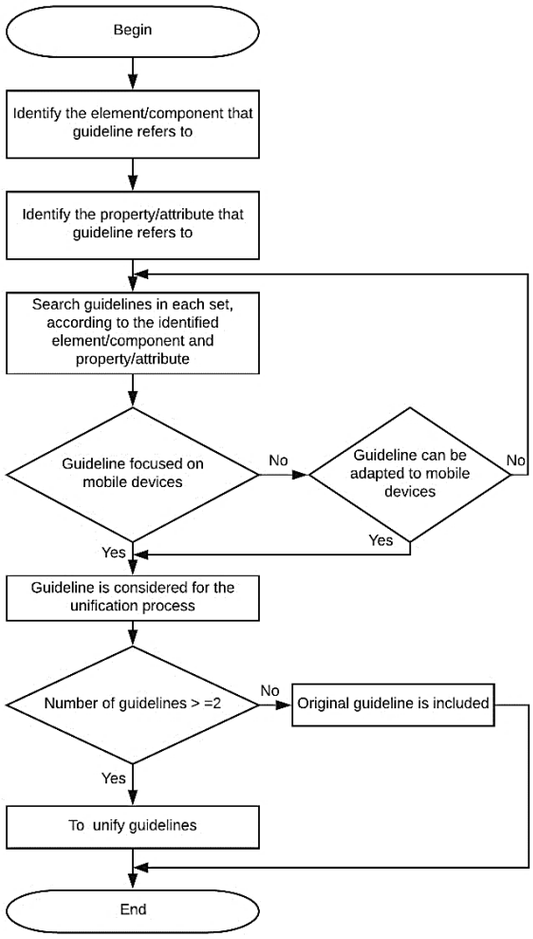


Figure 1 Methodology for unifying mobile accessibility guidelines
Source: own elaboration

Results

As a result, unified accessibility guidelines are shown in table 1, which are categorized in 21 topics: 1. Focus, 2. Links, 3. Audio, 4. Video, 5. Text, 6. Color, 7. Contrast, 8. Data input, 9. Assistive technology, 10. Notifications, 11. Labels, 12. Structure, 13. Navigation, 14. Behavior/Functionality, 15. Actionable elements, 16. Errors, 17. Instructions, 18. Help, 19. Keyboard, 20. Temporizers and 21. Image. The organization of the guidelines was made in order to provide an easy identification and reading when they are implemented by the designer or programmer. Also, in Table 1 you will find two columns: reference and guideline. The column called reference shows the identifiers of the guidelines that originate the new unified guidelines. The code used to identify each guideline is comprised of two elements: a capital letter related to the name of the proposer (**B**BC, **A**ndroid or **W**3C) and the number of the guideline. The second column contents the unified accessibility guidelines, which are shown below.

1. Focus	
Reference	**Guideline**
B2.8 B4.1 A2.2.4 W2.4.7 W3.2.1	The focus must be, all the time, visible and easily identifiable, it means that user can know where the focus is located. In order to achieve this goal, it is recommended to include visual indicators and accessible text. It is important to consider that a change of context must not be initialized when a component receives the focus.
B4.3 B4.4 A2.2.1 A2.2.2 A2.2.3 W2.4.3	When focus navigation is defined, it is important to consider that: • The sequence of the focus must be useful for the user. • Preferably from top to bottom. • From the most to the least important element. • Match the focus navigation with the order of the content.
A2.4.1 A2.4.2	The focus navigation must not be interrupted, it means, must be continuous. When a task is interrupted, and later is restarted, the focus must be situated where it was located before the interruption.
2. Links	
Reference	Guideline
B2.7 B7.1 B7.2 B7.3 B11.3 A5.1.4 A5.1.5 W2.4.4 W2.4.9	The links must be distinguishable for users. It is recommended: ● The text of the link must show its purpose, it means, the consequence of being selected. ●If a link addresses to an alternative version, then it must be indicated. ● If different links address to the same resource, then they must be blended. ● The screen readers must not read the text of the link. ● The text of the link must be succinct.
3. Audio	
Reference	Guideline
B1.1 B1.2 B1.3 B1.4 B1.5 A6.1.3 A6.1.4	When audio is being incorporated, it is suggested: ● Include alternative content such as closed captions, sign language, descriptions and transcriptions. ● Avoid auto playing. ● Provide stop, pause, close, volume and play controls. ● Must not be included extra sounds. In case of being included, they must not conflict with assistive technology. ●Background sounds must be 20 decibels lower than the foreground sounds.
4. Video	
Reference	Guideline
B1.1 B1.2 B1.3 B1.4 W1.1 W1.4	When video is being incorporated, it is recommended: ● Include alternative content such as closed captions, sign language, descriptions and transcriptions. ● Avoid auto playing. ● Provide stop, pause, close, volume and play controls.

5. Text	
Reference	Guideline
B2.6 A4.3.1 A4.3.2 A4.3.3 A5.1.1 A5.1.2 W1.4 W1.4.8	When text is being shown, it is recommended to consider: ● The text must be descriptive, meaningful, succinct and distinguishable. ● Text alignment must not be justified. Line spacing must be at least 1.5 lines. ● Must be used scalable pixels (sp). ● Text must be compatible with assistive technology. ● The letter spacing must be enough in case of letter size be increased by user or the block of text includes CJK (Chinese, Japanese and Korean) characters or others. ●The font size must be customizable.
6. Color	
Reference	Guideline
B2.2 B11.5 A3.1.1 A3.1.2 A3.1.3 W1.4.1 W1.4.8	When colors are shown, it is recommended: ● Use primary, secondary and accent colors. ● The background and foreground colors must be customizable by user. ● Do not use only color to convey information, meaning or request a response.
7. Contrast	
Reference	Guideline
B2.1 A3.1.1 A3.1.3 W1.4.3 W1.4.6	The contrast ratio (minimum) between text and images must be, at least 4.5:1. When contrast increases ratio must be 7:1. The color of the text and background must have enough contrast in order to ease the reading, interacting and interpretation of the content.
8. Data input	
Reference	Guideline
B4.6 B5.2 B9.5 W3.2.2 W3.3 W3.3.1	About data input, is suggested: ● Provide a variety of data input methods. ● A default format data input must be provided. ● When a user interacts with a control, it must be adaptable. ● Help the user to avoid and correct errors. When errors are detected, it must be identified, and text described to user.
9. Assistive technology	
Reference	Guideline
B1.5 A1.1.1 A1.1.2 A1.1.3 A1.1.7 A7.1.1 W4.1	The content or the elements of the graphic user interface must not interfere with assistive technologies. The compatibility with assistive technologies must be maximized. In case of a screen reader is used, the content must be properly labeled. The text read by screen readers must be meaningful and helpful. Accessibility and assistive technology standards must be considered.
10. Notifications	
Reference	Guideline
B8.1 B8.2	Regarding to notifications, is suggested: ● They must be visuals and audible ● Operating System standard notifications must be used where they are available and appropriated.

11. Labels	
Reference	Guideline
B3.1 B5.1 B5.3 B5.4 W3.3.2	The controls displayed in the form must be correctly labeled. Labels must be close to the control. Labeling must be consistent. Labels must be correctly grouped. Labels must be included when user data input is needed.
12. Structure	
Reference	Guideline
B10.2 B4.3 A2.3.1 W1.3.2 B10.1 B10.3 A2.1.1 W2.4.10 W2.4.6 A2.1.5 A2.1.4 A2.1.6 W2.4.1	The content must be logically structured, with a clear hierarchy and a correct reading sequence. The pages and forms must be easily and uniquely identifiable. It is recommended to use headers and titles that describe the topic or purpose. The most important actions must be located on the top of the screen meanwhile the least on the bottom. The key information must be identifiable at a glance. Group elements with a similar hierarchy
13. Navigation	
Reference	Guideline
A2.1.7 A2.1.8 A5.1.6 W2.4.8 W2.4 W3.2.3	Help the user to know where he is located within app. When a mechanism is used in different pages or locations, it must work, be displayed and described in the same way.
14. Behaviour/functionality	
Reference	Guideline
B 9.1 B.9.2 B.9.3 A5.2.3 A5.2.5 W3.2	Auto-updating must not initialize without a prior notice. Controls must be provided to pause, stop and hide. The elements are shown in the way that they are used. The software must work in a progressive and predictable way for all users.
15. Accionable elements	
Reference	Guideline
B2.4 B2.5 B2.7 A4.1.1 A4.1.2 A4.1.3	Actionable elements must be clearly distinguishable; an inactive space must be included surround them. Actionable elements must have enough size in order to interact with them, it means 48 x 48 dpi or 9 x 9 mm. Also, they must be between 7 and 10 mm in size. Point targets must be 44 x 44 dp.
16. Errors	
Reference	Guideline
W3.3.1 W3.3.3 W3.3.4 B8.3	If an error is automatically detected then the failing element must be identified, and the error must be described in text. Also, help must be provided in order to avoid and correct the errors. The error and correction messages must be clear. It is important to consider: ● Information submission can be cancelled. ● Mechanisms must be provided to verify, confirm and correct information before submitting.

ISSN 2444-4995

17. Instructions	
Reference	Guideline
B3.3 W3.3.2	Provide additional instructions when visual and audio complements are included. Labels and instructions are provided when the content require user data entry. Instructions must be succinct.
18. Help	
Reference	Guideline
B8.4 A2.1.7 A2.1.8 A2.1.9 A7.2.1 A7.2.2 W3.3.1	Help or/and feedback must be provided, which can be visual and tactile. Help must be provided to avoid and correct errors. Help documentation must be accessible and relevant.
19. Keyboard	
Reference	Guideline
B4.2 W2.1.1 W2.1.2 W2.1.3	Keyboard trap must be avoided. All the functionality must be available using the keyboard. No timing.
20. Temporizers	
Reference	Guideline
B9.4 A6.3.1 A6.3.2 W1.2 W2.1.1 W2.1.3 W2.2 W2.2.1 W2.2.3	Temporizers must be avoided when high priority functions are included. Conversely, the user will be able to control, deactivate, set up or execute the function in different way. No timing for keystrokes. When live events and no interactive and synchronized media are shown, timing is critical. Must be provided enough time to read and use the content
21. Image	
Reference	Guideline
B6.1 B6.2 B11.2 A3.3.1 W1.1 W1.1.1 W1.4.5 W1.4.9	When images are included: ●Provide alternative text ●Decorative images must be hided when assistive technology is used. ●Images must be distinguished when they have an important function. About images of text: ●They must be just decorative. ●Text showed in images must be avoided. ●They are used just if they convey information. ●They can be customized by user.

Table 1 Unified mobile accessibility guidelines
Source: own elaboration

The Table 1 shows the unified guidelines which can be easily read by developers and/or designers in order to increase or implement the mobile accessibility on apps.

Conclusion

There are a lot of guidelines related to web accessibility, some of them have been adapted to the mobile environment but the definition of mobile includes a wide range of devices, it means that smart glasses, smartphones, smartwatches, wearables, among others are considered mobile devices.

Even though there are sets of mobile accessibility guidelines, based on web accessibility guidelines, we consider that is mandatory to develop a specific standard about mobile accessibility in order to provide specific recommendations to implement or increase the accessibility on apps. This work of unification is a previous step to develop a specific mobile accessibility standard.

The set of guidelines unified shown has two purposes, first they can contribute to support the user (designer and/or programmer) to implement or increase the extent of accessibility when a mobile app is developed, and second, they are a preamble to standardize the mobile accessibility guidelines, this as a consequence of in the current days there is not an specific standard about mobile accessibility guidelines.

It is important to say that at the present time, the WCAG 2.0 are in process of standardization, however, these guidelines are focused on web accessibility and include recommendations oriented to the content shown on mobile devices such as tablets, smartphones, smartwatches, smart tv, among others. We consider that the mobile device term is of a very wide scope, so it is recommended, as a future work, to develop a specific accessibility guidelines for each of the mentioned devices.

References

Anderson P. and Perrin A. (2017). *Tech adoption climbs among older adults*. Retrieved June 5, 2019, from http://www.pewinternet.org/wp-content/uploads/sites/9/2017/05/PI_2017.05.17_Older-Americans-Tech_FINAL.pdf

Android (n. d.). *Accessibility*. Retrieved September 19, 2019, from https://material.io/design/usability/accessibility.html#

Android (n. d.). *Imaginación sin límites*. Retrieved September 7, 2019, from https://www.android.com/intl/es-419_mx/

BBC (2017a). *Principles*. Retrieved August 23, 2019, from

BBC (2017b). *Mobile accessibility guidelines*. Retrieved August 9, 2019, from https://www.bbc.co.uk/guidelines/futuremedia/accessibility/mobile

BBC (2019). *What do I need to know about the BBC?*. Retrieved September 10, 2019, from https://www.bbc.com/academy-guides/what-do-i-need-to-know-about-the-bbc
https://www.bbc.co.uk/guidelines/futuremedia/accessibility/mobile/principles

ISO (2018). *Ergonomics of human-system interaction — Part 11: Usability: Definitions and concepts*. Retrieved October 6, 2019, from https://www.iso.org/obp/ui/#iso:std:iso:9241:-11:ed-2:v1:en

Lieberman, M. (2018). *Technology Can Address Digital Accessibility*. Retrieved December 2, 2019, from https://www.insidehighered.com/ digital-learning/article/2018/05/02/technology-can-help-address-accessibility-challenges-many-say

López, N. and González, B. *Análisis de las directivas de diseño para la accesibilidad móvil*. Retrieved March 5, 2020, from http://revistatd.azc.uam.mx/index.php/rtd/article/view/63

Mariño, S. I., and Pagnoni, V. (2020). *Accesibilidad Web en Dispositivos móviles. Evaluación de un portal educativo de alcance nacional*. Retrieved February 15, 2020, from https://dialnet.unirioja.es/servlet/articulo?codigo=7250808

Microsoft (n. d.). *What's a Universal Windows Platform (UWP) app*. Retrieved August 20, 2019, from https://docs.microsoft.com/en-us/windows/uwp/get-started/universal-application-platform-guide

W3C (2008). *Web Content Accessibility Guidelines (WCAG) 2.0*. Retrieved August 2, 2019, from https://www.w3.org/TR/WCAG20/

W3C (2017). *Diverse abilities and barriers*. Retrieved July 17, 2019, from https://www.w3.org/WAI/people-use-web/abilities-barriers/#diversity

ISSN 2444-4995

Article **Journal of Technological Prototypes**
June 2020 Vol.6 No.17 22-31

Rehabilitation in left distal femoral varus osteotomy and left knee arthroscopy by gonarthrosis grade III: 4 phase model. About a case

Rehabilitación en artroscopia de rodilla izquierda y osteotomía varizante de fémur distal izquierdo por gonartrosis grado III: modelo de 4 fases. A propósito de un caso

PÉREZ-ÁNGELES, José Manuel

ID 1st Author: *José Manuel, Pérez-Ángeles* / **ID:** 0018 (2020)

DOI: 10.35429/JTP.2020.17.6.22.31 Received January 25, 2020; Accepted April 01, 2020

Abstract

Objective: describing the evolution of rehabilitation in a 47-year-old patient operated on knee arthroscopy and varus osteotomy of the left distal femur due to grade III gonarthrosis secondary to valgus angular disease, she underwent both surgical procedures in a single time. This fact allows a single rehabilitation process to be carried out for the 2 diseases, achieving an earlier functional recovery that if it had been operated in 2 times.

Knee, Osteotomy, Arthrosis, Pain, Rehabilitation

Resumen

Objetivo: describir la evolución de rehabilitación en una paciente operada de artroscopia de rodilla y osteotomía varizante de fémur distal izquierdo por gonartrosis grado III secundario a enfermedad angular en valgo. Fue sometida a ambos procedimientos quirúrgicos en un solo tiempo. Este hecho permite realizar un único proceso de rehabilitación para las 2 enfermedades, consiguiendo una recuperación funcional más temprana que si se hubiera intervenido en 2 tiempos.

Rodilla, Osteotomía, Artrosis, Dolor, Rehabilitación

Citation: PÉREZ-ÁNGELES, José Manuel. Rehabilitation in left distal femoral varus osteotomy and left knee arthroscopy by gonarthrosis grade III: 4 phase model. About a case. Journal of Technological Prototypes. 2020. 6-17: 22-31.

† Researcher contributing first author

Introduction

Gonarthrosis is considered as one of the diseases that most frequently cause a significant social, economic and health impact. It represents a degenerative process that affects one or more of the compartments that this joint represents. The cause is still unknown. It occurs late in life, clinically manifests with pain, deformity and limitation of joint movement. The changes in the articular hyaline cartilage are considerable, the subchondral bone becomes sclerosed and forms marginal osteophytes. According to the EPISER study, a prevalence of symptomatic gonarthrosis in the population older than 20 years of 10.2% was detected in 300 autopsies, being 33.7% in people older than 70 years. It occurs in women more frequently than in men (2.4: 1 respectively) [1].

The clinical practice guidelines consider non-pharmacological measures as the initial intervention, and form the fundamental pillar, being therapeutic exercise and patient education as important measures [2].

As part of the treatment, the pharmacological type is divided into two groups: a) symptom modifying drugs, aimed at controlling pain, and b) structure modifying drugs, aimed at preserving the articular cartilage, as well as slowing down the evolution of the disease [3].

Non-pharmacological interventions or measures are the cornerstone of osteoarthritis intervention strategies. A biopsychosocial approach should be carried out in an assessment of the arthrosic patient: assessment of physical condition, daily activities, educational needs and motivation for self-care [4].

There is evidence in favor that the self-care program reduces healthcare costs, decreases the number of admissions to hospitalization and emergency consultations, promoting an improvement in the doctor-patient relationship. Self-care support is carried out in multiple ways: consideration of problems from the patient's point of view, providing self-care education in group or individual sessions, etc [5].

When conservative treatment is not successful, surgical treatment is necessary. This treatment is reserved for cases in which other minor therapies have failed. The objective of the surgery is to reduce pain and improve joint functionality; For this, different surgical techniques are used in order to preserve or restore joint surfaces, replace joints with artificial implants and fuse joints (arthrodesis).

Osteotomy is a treatment of choice in patients under 50 years of age for knee osteoarthritis. In 2002, Kanamiya6 et al. Reported the benefits of this procedure in the regeneration of cartilage in the medial compartment after surgery.

There is a little written on rehabilitative treatment in distal femoral varus osteotomy concomitant with arthroscopic treatment in the context of previous symptomatic gonarthrosis. In the scientific literature, an infinite number of descriptions and studies on the treatment of this pathology can be found with the postoperative period of total knee arthroplasty and knee arthroscopy, but no clinical case has been found describing the rehabilitation evolution in a patient with a postoperative osteotomy on knee. The case presented, age, previous osteoarthritis, occupation and comorbidities of the patient made it possible to propose a unique intervention for rehabilitative treatment, this shortening the rehabilitation time and achieving an earlier functional recovery.

ISSN 2444-4995

Clinical case

This is a 47-year-old female patient, weighing 171.96 pounds and 5.24 ft tall, a housewife, with no significant history, who began her current long-term illness with a predominance of pain and functional impotence in the knee. left that exacerbated household activities. She goes to her family medicine unit, where she is sent to a well-known orthopedic hospital in the city of Puebla, where she is diagnosed with Kellgreen & Lawrence III left knee gonarthrosis. On physical examination, the patient presented a unilateral valgus deformity, with limitation to active knee mobility caused by pain at 90º flexion. No motor deficit was observed. The ambulation of this patient was precarious, she did not need accessories for walking.

In the radiological study (Fig. 1), a decrease in the joint space was observed, predominantly in the medial compartment, with the presence of subchondral sclerosis and decreased patellofemoral space.

Figure 1 Post-operative radiography. Varus left femur osteotomy showing the correct alignment of the operated axis of the knee and the increase in the medial joint space.

In the fluoroscopic control (Fig. 2) and in the control radiographs (Fig. 3), the final result can be observed where the correct alignment of the axis of the operated knee can be seen, in addition to a marked increase in the medial joint space.

ISSN 2444-4995

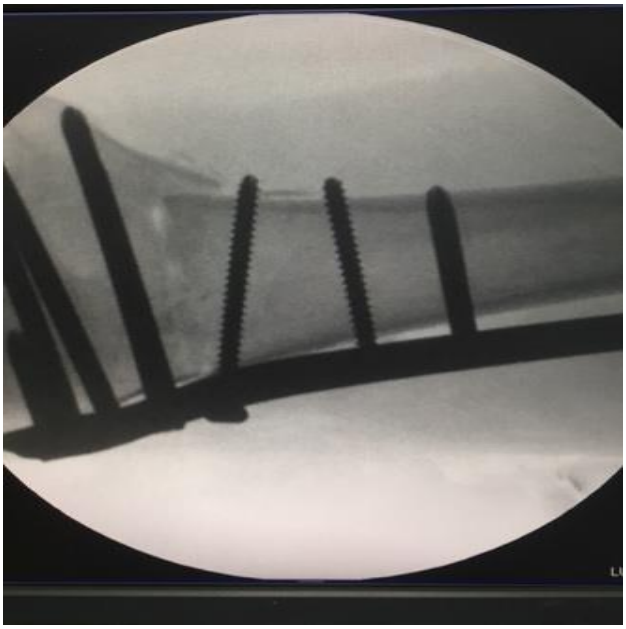


Figure 2 Flouroscopic control. Final result at the end of the surgery

Figure 3 Post-operative radiography. Varus left femur osteotomy showing the correct alignment of the operated axis of the knee and the increase in the medial joint space

The rehabilitation plan (Fig. 4) consisted of 4 months of work with 2 to 3 sessions of home physical therapy per week.

In early postoperative rehabilitation, it was considered to prioritize mobility, with the aim of avoiding adhesions and keeping blood circulation active. Rehabilitation consisted of active and active mobilization exercises, passive kneecap mobilizations, quadriceps toning, progressive re-education of gait and control of pain, inflammation and edema with the use of physical agents.

Rehabilitation model

1st phase (1- 7 days after surgery)	2nd phase (1- week- 1 month after surgery)	3rd phase (1 month- 3 months)	4th phase (3 months- 4 months)
Immediate post-operative 1. Cryotherapy. 1.1 30 minutes 3 times a day. 2. Inelastic compression bandage on the affected limb. 2.1 Change of bandage the morning after surgery. 2.2 Thrombotic surveillance. 3. Assisted continuous and active passive mobilization. 3.1 n sets of 10 passive repetitions in knee flexion and extension. 3.2 Active mobilization of healthy joints (hip flexion,	**Early post-operative.** 1. Surgical wound healing every 3rd day. 1.1 Healing with microdacyne and dressing change. 2. Cryotherapy. 2.2 15 minutes 2 times a day. 3. Inelastic compression bandage of the affected limb to control inflammation and edema. 4. Assisted active mobilization. 4.1 N series of 10 active repetitions in knee flexion and extension. 5. Muscle toning. 5.1 Isometric contractions in the lower left limb. N series with N repetitions.	**Orthopedic rehabilitation.** 1. Active mobilization of the affected limb. 1.1 Use of static pedalboard with tolerance duty cycles using the Borg test. 2. Strengthening of the operated limb with progressive resistance exercises using the Troiser test. 2.1 Changes should be shown in the first 8 weeks. 2.2 permanent changes in the 16 weeks of treatment. 3. Full support on the operated limb, weight distribution between both lower limbs.	**Reintegration to activities.** 1. Muscular strengthening of the operated limb. 1.1 Same handling with progressive resistance. 2. Reincorporation to work activities. 2.1. Training based on your work activities. 3. Tasks assigned for discharge. 3.1 Weight reduction with static pedal exercise for 20 minutes. 3.2 General strengthening with resistance leagues. 5 days of training using 1 or 2 muscle groups per day. to. 3 sets of 15 repetitions. b. 3 exercises per muscle group.

ISSN 2444-4995

extension, abduction and adduction). 3.3 Assisted active mobilization in knee flexion and extension. 4. Left ankle pumping exercise. 4.1 Slow active mobilization 5 minutes. 5. Anti-inflammatory cryotherapy at the end of the exercise. 5.1 30 minutes after exercise.	6. Proprioception. 6.1 Partial weight unloading in the operated lower limb. 6.2 Discharge under pain threshold. 6.3 Download 10% body weight every 3 days. 7. Progressive resistance exercises on healthy limbs. 7.1 Use of yellow resistance league with N series of N repetitions. 7.2 Make progression 3 weeks. 8.Interferential current in knee joint 0.3 Hz alternating mode 15 minutes.	4. Tolerance squat with support on rails. 5. Proprioception and reeducation of gait. 5.1 Support on stable surfaces. 5.2 Up and down stairs. 5.3 walk on stable and unstable surfaces.	4. Follow-up every 2 months to reassess the functionality of the patient.

Table 1 Rehabilitation model used in a post-operative arthroscopy left knee and varus left femur osteotomy patient.
Source: table prepared by the author

At 2 months (Figure 4) and 4 months (Figure 5) of the intervention, an appointment was taken in an outpatient orthopedic clinic and radiographic control, where bone consolidation was observed, with no evidence of loosening and correct limb alignment.

Figure 4 Control radiograph 2 months after surgery. The formation of the bone callus in the osteotomy line is appreciated.

After 4 months of intervention and rehabilitation, the patient does not report pain, she has a range of motion in knee flexion that goes from 0º-115º and a good muscular trophism, currently she walks with a 1-point cane due to right degree gonarthrosis II. The management of this patient must be individualized. The results of the treatment have been effective, the evolution was satisfactory with total independence in their activities of daily life. According to the clinical case presented, the rehabilitative management of this patient is demanding and there is no international bibliography.

ISSN 2444-4995

Figure 5 Control radiograph 4 months after surgery. Bone remodeling and consolidation in the osteotomy line can be seen

Discussion

In the case that is presented, the patient had pain on active mobility of 90º in flexion, with valgus deformity of the knee, with poor gait, and motor deficit, for which reason she was tributary to left knee arthroscopy and varus left distal femur.

The initial approach was to perform a total knee arthroplasty, since it offers more stability and favors a functional recovery, as well as a faster rehabilitation.

The age of this patient was the cause that changed the approach strategy, proposing to perform in a single surgical act the 2 techniques; arthroscopy knee, and varus osteotomy distal femur.

Since this is a case not previously described, there was no bibliography to decide on a specific rehabilitation program, so the approach and preparation of the program was purely theoretical. Performing both procedures at the same time involved greater surgical aggression, but it involves a single surgical and rehabilitation process, and this reduced recovery time.

Another factor to take into account is the risk of infection, since it was high in this patient given its characteristics (obesity and probable diabetes).

The rehabilitation model was structured with the following objectives:

1. Decreased symptoms after varus osteotomy surgery and left knee arthroscopy.
2. Improvement of patient functionality.
3. Decreased recovery time.
4. Reintegration to activities of daily living.

In order to comply with the treatment objectives, emphasizing the recovery phases and the recovery stages, the 4 recovery phases were:

1. Immediate post-operative treatment.
2. Late post-operative treatment.
3. Orthopedic rehabilitation.
4. Reintegration to activities.

Objectives phase 1: immediate post-operative treatment.

I. Cryotherapy: 30 minutes of application 3 times a day.
II. Inelastic compression bandage for the operated limb: this compression reaches pressures of up to 45mmHg at rest.

ISSN 2444-4995

III. Active Twin Pumping Exercises: Active movement in plant flexing and dorsiflexing reaches pressures up to 95mmHg, making pumping efficient.
IV. Initial mobility: passive-continuous and active knee-assisted mobilization below the pain threshold, kneecap mobilization. Active mobilization of the rest of the body segments.
V. Walk with assistant: 4-point walker.

Total number of hospital sessions: 2 (cryotherapy only as a physical agent).

Progression criteria:

- Pain on an analog visual scale of 8 or less.
- Functional mobility arches:
  i. Extension -10º
  ii. 30º flexion
- Edema and minimal heat.

Phase 2 objectives: Late post-operative treatment.

I. Healing and care of the surgical wound. Dressings change every third day and withdrawal of the points in 15 days.
II. Inelastic compression bandage for the operated limb: 40mmHg at rest.
III. Active twin pumping exercises: Active movement in plant flexion and dorsiflexion reaches pressures of up to 95mmHg making efficient pumping.
IV. Full-range mobility: assisted active mobilization below the pain threshold.
V. Strengthening: isometric resisted in the operated limb. Number of series and repetitions to tolerance. Maximum isometric exercises in extension to fix the kneecap.
VI. Proprioception: partial discharge of weight on the operated limb, below the pain threshold. 10% of body weight every 3 days.
VII. General strengthening: progressive resistance exercises in healthy extremities, use of resistance leagues, series and repetitions to tolerance.
VIII. Pain management: Interferential current in knee joint 0.3 Hz alternating mode 15 minutes. Cryotherapy 15 minutes 2 times a day.

Total number of home sessions: 20.

Progression criteria:

- Pain on an analog visual scale of 6 or less.

- Increased mobility:

  i. Flexion □ 80º
  ii. Extension -10º to 0º

- Minimum force:

  i. Daniels 3 limb operated.
  ii. Daniels 4 rest of body segments.

Phase 3 objectives: Orthopedic rehabilitation.

I. Active mobilization of the operated limb: use of a pedal for rehabilitation with work cycles based on the Borg test.
II. Specific strengthening of the operated limb with progressive resistance exercises using the Troiser program.8 The objective of this muscle strengthening program is to improve the active stability and function of the injured knee.

   a. Changes should show in the first 8 weeks:

ISSN 2444-4995

i. Improving the timing of motor units.
ii. Improving coordination and muscle activation.
iii. Increased frequency of motor unit discharge.
iv. Decreased activation of antagonist muscles.

b. At the end of 16 weeks, it should show:

i. Increased muscle volume as a consequence of increased strength.
ii. Increased muscle contractile material.

c. Expected results in the training program:

i. Increased static muscle strength.
ii. Hypertrophy.
iii. Maximum muscle strength.
iv. Activation of anaerobic systems, improving the extraction of O^2 from myoglobin.

Muscle strength work protocols obtained from NSCA.	
Troisier Static Work	Hettinger & Muller
• Direct or indirect load. • Basal load: 50% Maximum static force. • Development: N contractions until exhaustion. • Rest: 6 seconds with 6 rest.	• Direct load. • Basal load: 33-50% Maximum static force. • 1/3 daily contractions. • Rest: 2-6 seconds of contraction with 2-6 seconds of rest.

Table 2 Comparison of 2 muscle strength work protocols obtained from the National Strenght and Conditioning Association
Source: Table prepared by the author

III. Full support with distribution of loads between lower limbs: this patient had her instrument for gait walking changed for a 4-point cane, starting with gait training on household surfaces, so that this helps to a faster rehabilitation of the environment.
IV. Tolerance squat: using handrails from her home to support herself, she was asked to squat below the pain threshold, with the passage of the sessions, the patient managed to perform the full squat.
V. Proprioception and gait re-education: use of stable and unstable surfaces such as pillows and sponge bases. His march was performed on home stages, as well as going up and down stairs.

Total number of home sessions: 30

Progression criteria:

– Pain on an analog visual scale of 3 or less.
– Increased mobility:

i. Flexion □100º
ii. Extension 0º

– Minimum force:

i. Daniels □4 operated limb.
ii. Daniels 5 rest of body segments.

Objectives phase 4: Reintegration to activities.

a) Muscular strengthening of the operated limb: same management with progressive resistance.
b) Training based on their activities: they re-educate and guide the patient in reintegration into their home and work activities, adapting some activities and improving their ergonomics.

ISSN 2444-4995

c) Tasks assigned for discharge:

i. Weight reduction and control: follow-up with a nutritionist, in addition to a pedal aerobic exercise program, in 20-minute cycles.
ii. Muscle strengthening: following a strength training program, with series of 15 repetitions, training 1 to 2 muscle groups per day.
iii. Follow-up of the patient: every 2 months a visit is scheduled to assess the evolution, and verify if a reoperation is necessary.

Total number of home sessions: 15.

Discharge criteria:

– Increased patient's perception of safety when walking on unstable or unfamiliar terrain and using stairs.
– Improvement in balance between both sides in strength, measured by the Daniels scale.
– Increase in equilibrium, measured by the Tinneti and Berg balance scales.

These findings were clinical without having carried out any analysis in this regard. The factors that are considered fundamental are the education of the patient about the importance of a rehabilitation, the perseverance to follow his sessions, and later his physical care.

Methodology

We present a clinical case of a 47-year-old female patient with no significant history presenting her current long-term condition with predominance of pain in the left knee, post-arthroscopy surgery and varus osteotomy of left distal femur, beginning her physical rehabilitation the day after surgery, with satisfactory results.

The combination of both surgical procedures in the same act, makes a functional recovery earlier and more effective, than if it had been operated in 2 times.

Results

The main results obtained qualitatively with this rehabilitation program have been the following:

1. Reduction of recovery time from 7 months on average to 4 months.

2. Increased patient's perception of safety when walking on unstable terrain and using stairs.

3. Improvement of balance and strength between both sides, measured by Daniels scale.

The factors that have been considered to achieve adherence to this program are patient education on the importance of rehabilitation, the consistency of following rehabilitation at home and the availability of material resources.

Conclusions

The interventions of how and when to intervene in this pathology are not established.

ISSN 2444-4995

After the review, poor prognostic factors include established gonarthrosis, lack of therapist-patient work involving reciprocal depression, and obesity. Age, sex, and surgical techniques have not been obstacles to the excellent results. In this case, a combined therapy was used that forced an early mobilization of the knee and muscular strengthening with progressive loading that allowed us a faster recovery and a reintegration to activities.

The evaluation of the results has been based on the subjective sensation of the patient with the influence that pain has on the state of mind, and on the consideration of the results. It seems to be the most appropriate, despite the low objectivity of this assessment.

Ethical responsibilities

Protection of people and animals. The author declares that no human or animal experiments have been performed for this research.

Confidentiality of data. The author declares that he has followed the protocols on the publication of patient data.

Right to privacy and informed consent. The author has obtained the informed consent of the patient referred to in this article. The document is in the possession of the corresponding author.

References

[1] A. Esrafilian A, Taghi Karimi M, Eshraghi A: Design and evaluation of a new type of knee orthosis to align the mediolateral angle of the knee joint with osteoarthritis. *Advances in Orthop*. 2012, ID 104927.

[2] B. National Institute for Health and Clinical Excellence. Osteoarthritis: national clinical guideline for care and management in adults. London: NICE; 2008. Disponible en: www.nice.org.uk/CG059.

[3] C. Hochberg MC, Altman R, Brandt K, Clark B, Dieppe P, eGriffin M, et al. Guidelines for the medical managment of ostearthritis. Arthritis and Rheumatism 1995; 38: 1.541-6.

[4] D. Fernandes L, Hagen KB, Bijlsma JWJ, Andreassen O, Christensen P, Conaghan PG, et al. EULAR recommendations for the non-pharmacological core Management of hip and knee osteoartritis. Ann Rheum Dis. 2013;72:1125-35.

[5] E. Brady T. Strategies to support self-management in osteoarthritis: five categories of interventions, including education. Orthop Nurs. 2012;31:124-30.

[6] F. Kanamiya T, Naito M, Hara M, Yoshimura I. The influences of biomechanical factors on cartilage regeneration after tibial osteotomy for knees with medial compartment osteoarthritis: clinical and arthroscopic observations. Arthroscopy. 2002 ; 18 (7): 725-9.

[7] G. Guía de Práctica Clínica (2012) tratamiento con artroplastía de rodilla en pacientes mayores de 60 años. Secretaria de Salud de México.

ISSN 2444-4995

Article **Journal of Technological Prototypes**
June 2020 Vol.6 No.17 32-38

Smart glasses for blind people

Lentes inteligentes para ciegos

GONZALEZ-LORENCE, Armida*†, SÁNCHEZ-ORDUÑA, Govani G., AYALA-LANDEROS, José G. and ROMÁN-FLORES, Sonia E.

Tecnológico Nacional de México/Instituto Tecnológico de San Juan del Río, Ave. Tecnológico No. 2, Col. Centro, San Juan del Río, Qro. C.P. 76800

ID 1st Author: *Armida, González-Lorence* / **ORC ID:** 0000-0001-6926-7238, **CVU CONACYT ID:** 200848

ID 1st Coauthor: *Govani G., Sánchez-Orduña* / **ORC ID:** 0000-0002-1985-5282, **CVU CONACYT ID:** 1027502

ID 2nd Coauthor: *José G, Ayala-Landeros* / **ORC ID:** 0000-0002-6967-5175, **CVU CONACYT ID:** 284339

ID 3rd Coauthor: *Sonia E., Román-Flores* / **ORC ID:** 0000-0002-5797-6456, **CVU CONACYT ID:** 436716

DOI: 10.35429/JTP.2020.17.6.32.38 Received January 24, 2020; Accepted April 01, 2020

Abstract

According to the Statistic and Geography National Institute (Instituto Nacional de Estadística y Geografía, INEGI) it is estimated that in México about 6% of the population suffers some kind of disability, from this percentage a little more than 58% have some visual disability (INEGI, 2018). This research presents the creation of the first prototype of Mexican glasses that allows the recognition of objects within images and interprets them using sound, with the purpose of giving autonomy to the blind people.

Object recognition, Blind people, Sound Interpretation

Resumen

Según el Instituto Nacional de Estadística y Geografía (INEGI), se estima que en México alrededor del 6% de la población sufre algún tipo de discapacidad, de este porcentaje un poco más del 58% tiene alguna discapacidad visual (INEGI, 2018). Esta investigación presenta la creación del primer prototipo de anteojos mexicanos que permite el reconocimiento de objetos dentro de imágenes y los interpreta con sonido, con el propósito de dar autonomía a las personas ciegas.

Reconocimiento de objetos, Ciegos, Interpretación con sonido

Citation: GONZALEZ-LORENCE, Armida, SÁNCHEZ-ORDUÑA, Govani G., AYALA-LANDEROS, José G. and ROMÁN-FLORES, Sonia E. Smart glasses for blind people. Journal of Technological Prototypes. 2020. 6-17: 32-38.

* Correspondence to Author (email: armida.lorence@itsanjuan.edu.mx)
† Researcher contributing first author

Introduction

To be born without the sight capacity or becoming blind because of an illness or an accident, causes too much problems to the people, living on a world that isn´t prepared for the blind people (CDC, 2017).

Although there exist special systems such as “Braille”, the blind’s people brain gets adapt to visual incapacities in a way they aren´t an obstacle for their life. The blind people´s life could be as incredible, like any normal person, but they need to try hard with the difficult of access cities and the presence of regular obstacles at sidewalk and streets (Longitudeonda, 2016).

In general, the science and new technologies have done a lot for disabled people (Schuager, 2016). The former director of ONCE Guadalajara, Juan Antonio Saiz, who has been blind for 38 years because of glaucoma; surfs the Internet and talks on his cell phone thanks to special programs that read to him the information (Longitudeonda, 2016), “Between you and me there is no difference with a computer or a mobile, only that you use the sight and I use the ear," he explains.

Blind people don’t have usually the same quality life as a normal person (sumedico.com, 2018), and currently, there isn't enough interest for developing complete solutions that improve their life, with the use of the smart glasses presented in this work is pretended that blind people could move more autonomously, allowing them to improve their quality life as physically as emotionally, without having so many difficulties in their social insertion.

In these way, through the use of these daily life guidance, a higher percentage of blind people will be able to incur in the working world, and also could better the quality life for their families.

Background

Blind people/The visual cortex adopts auditory functions

At Israel, was realized a study (PANORAMA, 2015), where certain sounds were associated to different objects, with the idea that the objects could be recognized when the sounds were heard. Once the blind people recognized the sounds were studied with a resonance while the learned audios were reproduced.

The scientists saw that normally certain brain areas are associated with the sight work to convert the sound into an image concept (PANORAMA, 2015).

The brain is stimulated with light, even though it can't see it

Whether in cases of partial vision loss, and in those who are completely blind, light has an effect on your brain. The retina, however damaged and not very functional, has light receptors that, when feeling the slightest stimulus, alerts and puts the brain into action, activating a series of cognitive functions that are performed during the day, following the circadian rhythm (PANORAMA, 2015).

Image Processing

It is a complex process that requires a set of steps where the recognitions successively transform data to information, so that the computer can recognize it (Reconocimiento de patrones, 2018).

Pattern recognition that is also called reading pattern, figure identification and shape recognition; involves the recognition of signal patterns.

The patterns are obtained by the process segmentation, extraction and descriptions of features, where each object is represented by certain descriptors (González, 2008).

The recognition system must assign to each object its own category or class (set of entities that share some feature and are different from the rest). In order to recognize the patterns, follow the next procedures:

- Data acquisition.
- Feature Extraction.
- Decision making.

The main idea of pattern recognition is the classification: classifying a signal depending on its specific features.

Signals, characteristics and classes could be of any form, an example is that it is possible classify digital images of letters in classes from "A" to "Z" depending on their pixels, or could also classify bird classes by birdsong sounds depending of the sound frequency (Reconocimiento de patrones, 2018).

OpenCV

OpenCV (Open Source Computer Vision) (Jonathan G. O., 2017) it's a programming library of open source that is mainly directed for computer vision on real time, developed by the Russian division of Intel at the center of Nizhni Nóvgorod. It´s use is free by the license of open source BSD.

The OpenCV is a multiplatform library (Jonathan G. O., 2017).

The OpenCV library it's an API of about 300 functions that are written in 'C' language, characterized by:

- Free use for commercial and non-commercial purpose. It doesn't use an external numeric library, although sometimes could be used, if it is available at the runtime.

- Compatible with The Intel Processing Library (IPL) and uses the Intel Integrated Performance Primitives (IPP) to improve its performance if there are available at system (Jonathan G. O., 2017).

Python

Python is a dynamic interpreted programming language, it´s philosophy emphasizes the use of syntaxes of a legible code to get an easier reading. It is a multi-paradigm programming language and it's available on several platforms (Zaforas, 2017) (Python Org, 2019).

Python features

Interpreted: It doesn't need any compiler process and performs the error detection in real time.

Multiplatform: Available for Windows, Linux and MAC.

Free: It does not need programing license.

Python has a big diversity of libraries, data types and functions on its own language, this helps to make common works without the need of programming all (Abellán, 2019).

Hardware devices

Raspberry Pi 3 b

Raspberry is a low-cost board computer, developed at UK by Raspberry Pi Foundation to stimulating the teaching informatics at schools. The Raspberry Pi 3 model B is the third generation of Raspberry Pi and it comes in a package with an impeccable presentation into an envelope with the Raspberry Pi logo (Ro-botica Global S.L, 2017).

It could be used as a low-consumption web server, built a Smart TV, a printer server, made a cloud, or even use as a GPS (Ro-botica Global S.L, 2017).

To work with it, it is needed medium storage (Raspberry Pi uses SD or microSD memory card), plug it in the microUSB to charger at least 2500mah and put everything in the casing provided so that everything is safe and its appearance is more attractive (Gallego, 2015). Plenty Linux operating systems have been optimized for the Raspberry Pi, to use this board, it can be downloaded from the official website, the RASPBIAN OS operating system. The downloaded file has an ".img" extension and is recorded on the SD card of the Raspberry Pi (Ro-botica Global S.L, 2017).

Raspberry Pi Camera

The Raspberry Pi camera module is a custom design for this device. It's directly connected via data bus to the motherboard through the CSi interface. The dimensions of the camera module board are 25x20x9mm.

One of its main features is its low weight (3 g), that makes it ideal for mobile applications where the weight and size are very important, reason why this camera fits exactly this project needs. The resolution of the sensor is 5 megapixels, composed by one fixed focus lens. (2,592 x 1,944 pixels static images and 1080p30, 720p60 and 640x480p60 / 90 video). Finally, the camera is compatible with the latest version of Raspbian (Raspberry Pi preferred operating system) (Gallego, 2015).

Processing image algorithm

Figures 1 and 2 show the image processing algorithm code to detect objects.

ISSN: 2444-4995

```
import requests
import cv2
import argparse
import numpy as np

while (True):
    ap = argparse.ArgumentParser()
    ap.add_argument('-i','--image', required=True, help = 'path to input image')
    ap.add_argument('-c','--config', required=True, help = 'path to yolo config file')
    ap.add_argument('-w','--weights', required=True, help = 'path to yolo pre-trained weights')
    ap.add_argument('-cl','--classes', required=True, help = 'path to text file containing class names')
    args = ap.parse_args()

    def get_output_layers(net):
            layer_names = net.getLayerNames()
            output_layers = [layer_names[i[0] - 1] for i in net.getUnconnectedOutLayers()]
            return output_layers
    def draw_prediction(img, class_id, confidence, x, y, x_plus_w, y_plus_h):
            label = str(classes[class_id])
            url = "http://192.168.137.153:81/objeto/5ceb74996d38c3de4e83682c/" +label
            data = {'objeto': label}
            requests.post(url = url, data = data)
            print (label)
            color = COLORS[class_id]
            cv2.rectangle(img, (x,y), (x_plus_w,y_plus_h), color, 2)
            cv2.putText(img, label, (x-10,y-10), cv2.FONT_HERSHEY_SIMPLEX, 0.5, color, 2)
    image = cv2.imread(args.image)
    Width = image.shape[1]
    Height = image.shape[0]
    scale = 0.00392
    classes = None
    with open(args.classes, 'r') as f:
        classes = [line.strip() for line in f.readlines()]
    COLORS = np.random.uniform(0, 255, size=(len(classes), 3))
    net = cv2.dnn.readNet(args.weights, args.config)
    blob = cv2.dnn.blobFromImage(image, scale, (416,416), (0,0,0), True, crop=False)
    net.setInput(blob) boxes = []
```

Figure 1 Image processing algorithm code, Part I
Source: prepared by the authors

```
    blob = cv2.dnn.blobFromImage(image, scale, (416,416), (0,0,0), True, crop=False)
    net.setInput(blob) boxes = []
    outs = net.forward(get_output_layers(net))
    class_ids = []
    confidences = []

    conf_threshold = 0.5
    nms_threshold = 0.4
    for out in outs:
        for detection in out:
            scores = detection[5:]
            class_id = np.argmax(scores)
            confidence = scores[class_id]
            if confidence > 0.5:
                center_x = int(detection[0] * Width)
                center_y = int(detection[1] * Height)
                w = int(detection[2] * Width)
                h = int(detection[3] * Height)
                x = center_x - w / 2
                y = center_y - h / 2
                class_ids.append(class_id)
                confidences.append(float(confidence))
                boxes.append([x, y, w, h])
    indices = cv2.dnn.NMSBoxes(boxes, confidences, conf_threshold, nms_threshold)
    for i in indices:
            i = i[0]
            box = boxes[i]
            x = box[0]
            y = box[1]
            w = box[2]
            h = box[3]
            draw_prediction(image, class_ids[i], confidences[i], round(x), round(y),
            round(x+w), round(y+h))
    cv2.imshow("object detection", image)
    cv2.imwrite("object-detection.jpg", image)
    cv2.destroyAllWindows()
```

Figure 2 Image processing algorithm code, Part II
Source: prepared by the authors

Developed prototype design

First the Raspberry Pi camera captures the image using JavaScript, then this is sent to a local server that works with MongoDB and Ruby on Rails; subsequently the image is processed by OpenCV language and Python, then the recognized object data is saved on a small database; finally, the database is consulted by the Raspberry Pi to emit the interpretation of the recognized object with the sound that identifies the object presented on the image, at figure 1 can see the operation diagram.

Figure 3 Physical prototype´s functioning diagram
Source: prepared by the authors

Prototype´s functioning

From 4 to 7 figures, is shown how the prototype´s modules operate.

Figure 4 Prototype´s circuit view
Source: prepared by the authors

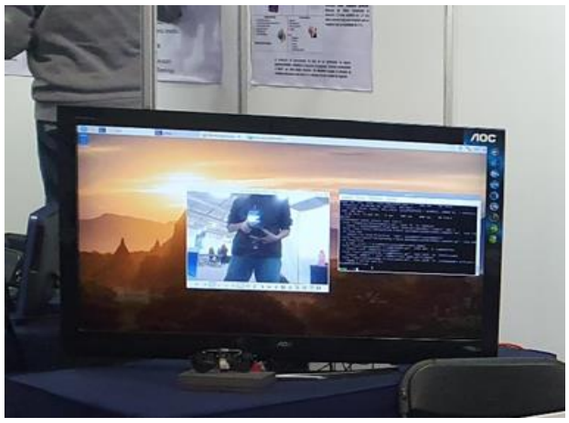


Figure 5 Image captured by the Raspberry Pi
Source: prepared by the authors

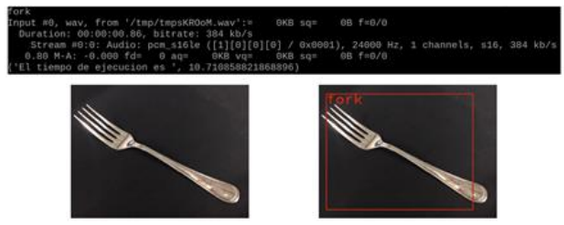


Figure 6 Image comparison, before and after recognition with OpenCV
Source: prepared by the authors

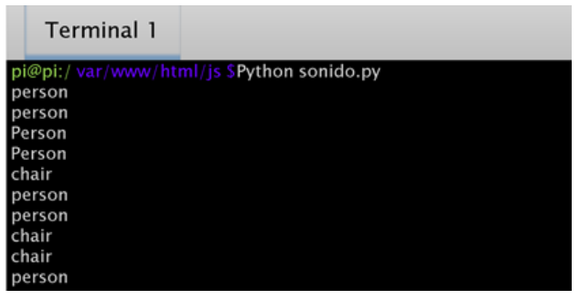


Figure 7 View of the sound emitted by the Raspberry Pi
Source: prepared by the authors

Prototype (final view)

The figure 8 and figure 9 show how looks like the prototype, where everything is protected by the hat, hence it looks more fancy and also helps to avoid any painful moment when the blind person wears it.

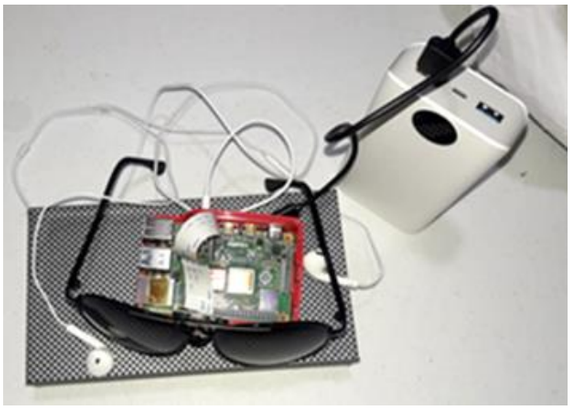


Figure 8 Inside the prototype Final view
Source: prepared by the authors

Figure 9 Prototype Final view
prepared by the authors

Results and Discussion

At Table 1, is possible to appreciate the interpretation of the images that were achieved by the algorithm relating them with its corresponding sound as the translation for blind people.

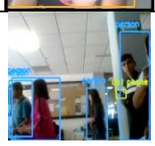
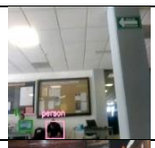
Experiment Number	Image	Sound
1		Person Cellphone
2		Person Cellphone Person Person Person
3		Person TV
4		Chair Bed
5		Bed Cellphone Teddy Bear

Tabla 1 Prototype experimentation
Source: own elaboration

The results of this work are very satisfactory as shown on table 1, when the experiments are developed its always possible to obtain de sound of the objects presented on the image. Also were done certain different operation experiments, such as: Raspberry Pi manipulation alternatives, necessary resources operation, bridging a local server (using MongoDB and Ruby on Rails) for the image capture and subsequent shipment processing and return data to Raspberry Pi.

By the anterior results, it's can be deducing that the life's quality of the blind people can be better just because they can know which are the objects in front them, and so, they can avoid or reach these according to their intentions.

These new intelligent glasses can provide autonomy to the prototype´s carrier and help him to do his daily activities.

Another very important result is that, this new alternative for blind people just cost 185 usd. compared to other technologies that costs around $2,000.00 usd. (Barbuzano, 2018), doing it a very viable option to better the life of poor blind people.

ISSN: 2444-4995

Therefore, this new alternative for blind people could be very acceptable in the market because of its functionality and its very low-cost cost.

Conclusions

Through the prototype developed in this investigation, always its possible correctly identify and "to say" the present objects in each image, which represents an autonomy for blind people. And, because it's possible the information management in real time, it represents an additional benefit for the ones who uses it.

And although the objective of this work is completely achieved, in a close future, the prototype could be significantly enriched on a theoretical and technological aspect, by adding it new capacities like to calculate distance from person that wears it to the identified object, that could benefit the blind ones and even their families.

Acknowledgements

Authors express their gratitude to the "TecNM / Instituto Tecnológico de San Juan del Río" and the "Consejo de Ciencia y Tecnología del Estado de Querétaro" (Concyteq) for financing this work through the Project "Nuevos Talentos Científicos y Tecnológicos 2019".

Authors, also give a special thankful, to the effort of the undergraduate engineering students: Monserrat Cruz-López, Luis E. Correa-Camacho and Fabian K. Herrera-Canales, who helped the realization of this work.

References

Abellán, M. Á. (2019, febrero 27). *¿Qué es Python?* Retrieved from https://www.programoergosum.com/cursos-online/raspberry-pi/244-iniciacion-a-python-en-raspberry-pi/que-es-python.

Barbuzano, J. (2018, Abril 15). *5 ejemplos de tecnología para personas ciegas: más allá del Braille*. Retrieved from OpenMind: https://www.bbvaopenmind.com/tecnologia-para-invidentes-mas-alla-del-braille/

CDC, C. N. (2017, Octubre 4). *Obstáculos a la participación*. Retrieved Marzo 20, 2019, from https://www.cdc.gov/ncbddd/spanish/disabilityandhealth/disability-barriers.html

Gallego, R. (2015). *PROYECTO FIN DE CARRERA, SISTEMA DE BAJO COSTE PARA EL SEGUIMIENTO DE PERSONAS.* Leganés, Madrid: Escuela Politécnica Superior de la Universidad Carlos III de Madrid.

González, R. C. (2008). *Digital Image Processing.* Pearson.

INEGI. (2018). *La discapacidad en México,2014.* Retrieved from Instituto Nacional de Estadística y Geografía: http://internet.contenidos.inegi.org.mx/contenidos/productos/prod_serv/contenidos/espanol/bvinegi/productos/nueva_estruc/702825090203.pdf

Jonathan, G. O. (2017). Reconocimiento de los objetos utilizando OpenCV y Python. In *Tesis.* Retrieved Febrero 26, 2019

Longitudeonda. (2016, marzo 1). *Longitud, «El dia a dia de un invidente,»*. Retrieved from https://longitudeonda.com/index.php/el-dia-a-dia-de-un-invidente/

PANORAMA. (2015, Febrero). *PANORAMA.com.ve.* Retrieved from Conoce cómo trabaja el cerebro de las personas ciegas: https://www.panorama.com.ve/contenidos/2014/04/25/noticia_0026.html.

Python Org. (2019). *Python Software Foundation*. Retrieved from https://www.python.org/psf-landing/

Reconocimiento de patrones. (2018, Agosto 28). Retrieved Febrero 26, 2019, from https://es.wikipedia.org/wiki/Reconocimiento_de_patrones

Ro-botica Global S.L. (2017). *Robótica Educativa & Personal.* Retrieved from https://www.ro-botica.com/Producto/RASPBERRY-PI-3-MODELO-B/

Schuager, M. (2016, Marzo 28). *Aipoly, una app de reconocimiento de imágenes para personas con discapacidad visual*. Retrieved from wwwhat's new: https://wwwhatsnew.com/2016/03/28/aipoly-una-app-de-reconocimiento-de-imagenes-para-personas-con-discapacidad-visual/

sumedico.com. (2018, 12 03). *¿A qué retos se enfrentan las personas con discapacidad?* Retrieved 03 20, 2019, from https://sumedico.com/a-que-retos-se-enfrentan-las-personas-con-discapacidad/

Zaforas, M. (2017, 11 13). *¿Es Python el lenguaje del futuro?* Retrieved 02 27, 2019, from https://www.paradigmadigital.com/dev/es-python-el-lenguaje-del-futuro/

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

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

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

International Identification of Science - Technology and Innovation

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

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

ID 3rd Coauthor: (ORC ID - Researcher ID Thomson, arXiv Author ID - PubMed Author ID - Open ID) and CVU 3rd coauthor: (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 Coauthor, Surname (IN UPPERCASE), Name 2nd Coauthor and Surname (IN UPPERCASE), Name 3rd Coauthor. Paper Title. Journal of Technological Prototypes. 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

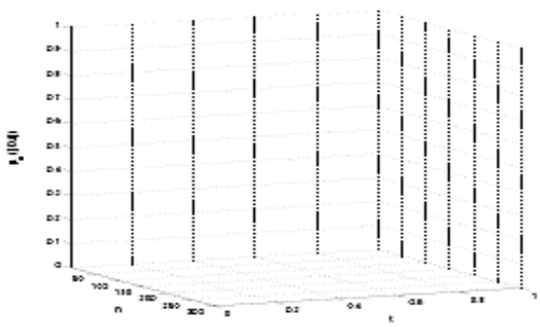
[Title No.12 in Times New Roman, single spaced and bold]

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.

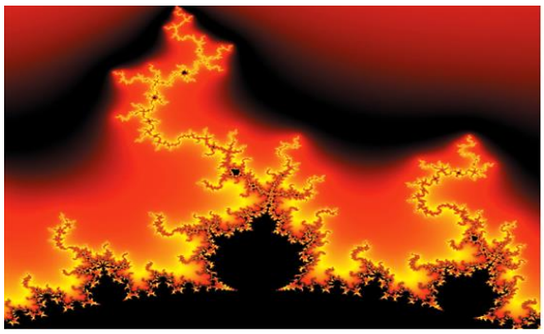


Figure 1 Title and *Source (in italics)*

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:

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

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.

ISSN 2444-4995

Conclusions

Explain clearly the results and possibilities of improvement.

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 Coauthors

-Authentic Signature in Color of the Acceptance Format of Author and Coauthors

ISSN 2444-4995

Reservation to Editorial Policy

Journal of Technological Prototypes 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 Technological Prototypes 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, SC in its Holding Spain for its Journal of Technological Prototypes, 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 Coauthors	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)
RESEARCH GATE (Germany)
GOOGLE SCHOLAR (Citation indices-Google)
REDIB (Ibero-American Network of Innovation and Scientific Knowledge- CSIC)
MENDELEY (Bibliographic References Manager)

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

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

Journal of Technological Prototypes

2444 4995
ISSN 2444 - 4995
www.ecorfan.org