Prototype User Interface for an Automatic Sheep Weighing Control System: Implementing ISO 9241-210:2019, ISO 29110, IEEE 830

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Abstract

The implementation of IoT (Internet of Things) technology in agroindustry has allowed the establishment of automation mechanisms in various processes in the Mexican countryside, one of the main activities developed in agroindustry consists of breeding sheep for human consumption. This process consists of several stages, among which are feeding, application of vaccines, monitoring of fattening. The weighing of sheep destined for fattening has been carried out manually, using traditional scales and paper notes, so it has been necessary to automate the process through the use of: RFID (Radio Frequency Identification)systems and web platforms. This document describes the process of designinga prototype of user interfaces based on ISO 9241-210:2019 UCD (User CenteredDesign), as well as the management of requirements through the implementation of the IEEE 830 standard. The development and implementation of the software product will be guided by the ISO 29110 standard attending to the processes of PM (Project Management) and IS (Software Implementation). For the development of the web platform and theapplication, intuitive interfaces are required that improve the user experience,given that the average of our users only have basic education.

Keywords

User Centered Design, Project Management, RFID, ovinos, IoT, IEEE 830, ISO, Software Implementation

1. Introduction

Mexico is one of the main producers of sheeps, the sheeps provide various products for human consumption: milk, meat and wool. The last study carried out in Mexico during 2016, indicates that the national production of sheep was almost 118 thousand tons of which 60,300 tons were destined for human consumption [1].

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The state of Mexico is the main producer of sheeps, concentrating 30% of the production followed by Hidalgo and Veracruz. According to data from the Information Food Agroindustry Service of Mexico, a production of 191,726 tons of sheeps has been achieved during the last 3 years, of which the state of Zacatecas contributes 13,254 tons, 6,912% of the national production [2]. The Victoria ranch located in the municipality of Villa de Cos, in the state of Zacatecas produces around 13.2 tons per year, this meat production accesses a weekly weighing process, in order to monitor thegrowth of the animals and guarantee their correct feeding and development.

The livestock sector has evolved in recent years. The application of new technologies, such as the IoT (Internet of Things), follow a very clear objective, to improve livestock productivity through automation as a central axis, taking advantage of the resources involved in the processes of the agroindustry. The IoT is the main engine to transform processes in any industry, the expansion of the Internet of Things goes beyond communication between people and digital content, thanks to sensors, devices and microcontrollers, this interconnection extends to thousands of objects. IoT systems involve the acquisition of data and the delivery orders to devices that interact, or are part of the real world. The vast majority of IoT uses are found in almost all industrial sectors.

The Internet of Things refers to a technology based on the objects connection to the Internet, which exchange, aggregate and process information about their physical environment to provide value-added services to end users. It also recognizes events or changes, and such systems can react autonomously. Its purpose is, therefore, to provide an infrastructure that overcomes the barrier between objects in the physical world and their representation in information systems.

Information technologies in conjunction with the IoT allow us to establish mechanisms of control and processing information using Hardware devices, which transmit that information to user interfaces for the interpretation of data. For this reason and according with the production of Rancho Victoria, it is estimated that on average 500 sheep are weighed weekly, this process is carried out manually, for which a large number of personnel are occupied. The data obtained is recorded on paper and then captured in a spreadsheet to be processed, such processing has sometimes taken more than 1 week.

The main objective of this work is to develop a User Interface Prototype for an Automatic Sheep Weighing Control System Implementing the ISO 9241-210:2019, ISO 29110 and IEEE 830 standards, establishing at all times the user-centered design and development, in order to offer an intuitive and easy-to-use software product, most of the possible users of the system and don't have greatknowledge about the use of technology. The study of users will be described later in phase 1 of UCD (Specify the context of use) by applying the "person" technique.

2. Related works

Technology has transformed agricultural activity, in traditional livestock have been observed various problems that directly affect production, diseases in animals, malnutrition and poor quality of meat, are some of the consequences of inadequate control in the processes. Meat industry for human consumption in Mexico represent one of the main activities in the agricultural sector. Due to the importance of software systems, telecommunications, sensors and microcontrollers,it is essential to develop products that allow managing and automating agrodindustry processes [3].

In Latin American, countries like Argentina, Colombia and Peru, research has been carried out in the agro-industrial sector:

2.1 – IoT applied to extensive livestock farming

Promote agricultural growth, through the development of a unit (NODE) consisting of a microcontroller, sensors, A/D converter module actuators and communication module to meet the needs of arid areas where the animal must travel long distances to look for its food [4].

2.2 – Design of a prototype to classify sheeps according to their live fat level by capturingultrasound images

An additional station has been designed for a feedlot handling sleeve, which allows measuring the live fat of a sheep and classifying the animals according to their level of body fat. In this way, the amount of fat in the final meat product can be predicted [5].

In Mexico, research has been presented in the following directions:

2.3 – SoftRes: Proposal for an application to support farmers

To achieve the technification of agroindustry, various investigations have been developed as well as proposals for software and hardware products to control the feeding and health of livestock, if we don´t control these two fundamental aspects could affect the quality of meat, SoftRes is a tool to support farmers in the control of food and veterinary services [6].

2.4 – Electronic weighing system for sheeps

The control and monitoring of animal weight from birth until it is sold for reproduction is paramount for the farmer, during the growth of livestock weighings are carried out, usually every 28 days to determine weight gain. To have a system that allows to identify and weigh the specimens, for this reason the Electronic Weighing System (SIPE) has been developed applying IoT hardware technologies such as: Arduino UNO board, bluetooth, RFID, etc [7].

3. Materials and Methods

User-Centered Design

ISO 9241-210:2019 highlights the importance of the user as the focus for software product development, constitutes a framework for people-centred design by integrating different design and development processes in a particular context; complementing existing methodologies[8].

User-centered design can be defined as, a software design methodology according to Travis Lowdermilk [9], according to Moreno Rocha & Peralta Calvo, it is an interactive methodology that guarantees usability or a design approach directed by information from people [10]. ISO 9241-210:2019 offers recommendations for developing products based on different states (See Fig. 1) [11].

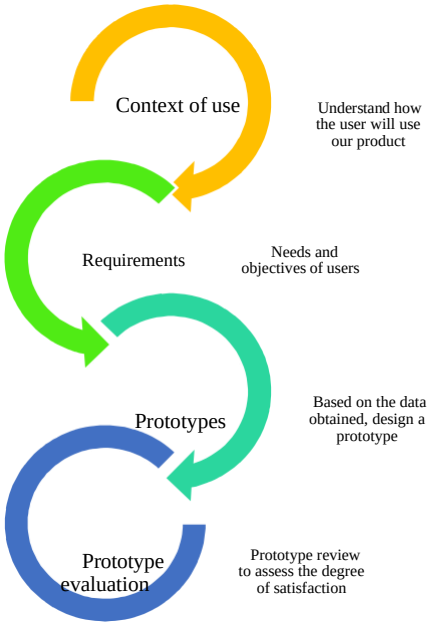


Figure 1: UCD States based on ISO 9241-210:2019

Project Management and Product Implementation

The software industry recognizes the value of small organizations to produce quality software, ISO/IEC 29110 [11] applies to these organizations no larger than 25 people, used to establish implementation processes using any methodology, for example, agile, incremental, waterfall, etc. ISO/ IEC 29110 defines two processes (Figure. 2), Project Management (PM) and Software Implementation (IS), the purpose of PM is to establish and respect a series of systematized activities during the implementation of the project that allows us to meet the objectives.

The objective of IS is to automate the processes of analysis, design, construction, testing and release of the software product based on the client requirements.

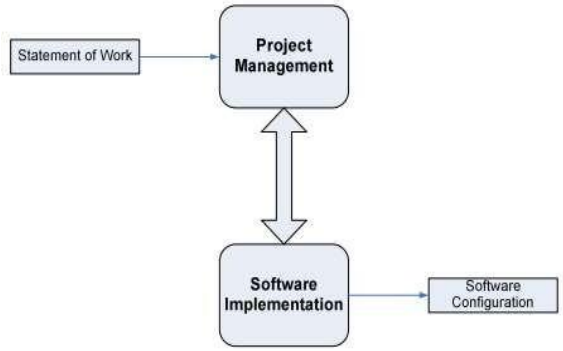


Figure 2: Basic profile ISO 29110

UCD states based on ISO 9241-210:2019:

1. Specify the context of use

During this stage, the different types of users who will use the system, the working conditions and the context on which the application will work are identified. Based on the implementation of the "person" technique, it is intended to obtain information about our users.

2. Requirements specification

Identify the software requirements, the needs of our users as well as their objectives for and develop the product applying the IEEE-830 standard based on a system introduction, general description and specific requirements.

3. Prototypes

Based on the information collected in the previous phases it is possible to design the prototype.

Prototype evaluation

At this stage, the prototypes are evaluated to verify their operation and verify that they meet the requirements and needs of the users.

3.1 Step 1: Specify the context of use

Identifying the context in which our software product will be used is a vitally important step to start our developments, in accordance with ISO 9241-210: 2019, meeting the needs of our potential users. These users have been identified through a general interview where information has been obtained regarding their knowledge in handling computer equipment. In addition, through the use of the "Persona" technique, two user profiles were identified, these profiles range between 39 and 49 years old.

3.2 Step 2: Specify requirements

Derived from the information obtained in the previous stage, it has been possible to identify the specific users, their characteristics, technical knowledge and behavior for the use of computer technologies. The software requirements that will serve as the basis for the development of the interfaces have been specified by specifying requirements according to the IEEE-830 standard [10].

3.3 Stage 3: Solution proposal or prototypes

Through the information we have obtained in stages 1 (specify the context of use) and 2 (specify requirements) we are able to design a prototype, which allows us to obtain additional information related to the interaction between our users and the application. To develop the prototype, Figma[2][12] was used.

4. Results

The results of each of the stages proposed by DCU serve as the basis for the development of the prototype, the information obtained in each of them is described below.

[2] Figma, disponible en: https://www.figma.com/

4.1 Specification of the Context of Use

Two techniques have been used to define the context in which our application will be used, in order to identify our "target user" the "person" technique was applied to obtain information about the behavior of users, their technical knowledge and degrees. Additionally, a survey was applied through Google Forms to 21 participants. The largest number of survey participants is in the range of 30 to 50 years.

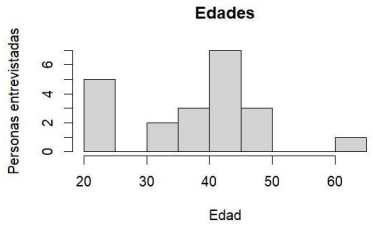


Figure 3: Age of the interviewees

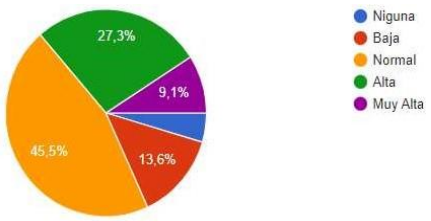


Figure 4: Level of experience using applications that implement IoT technology

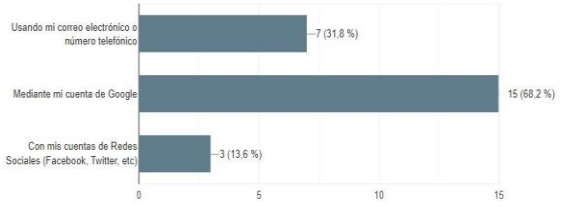


Figure. 5– How would you like to register for an application or platform?

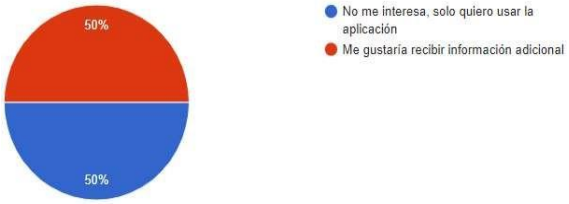


Figure 6: You would like to receive additional information about the application in your email?

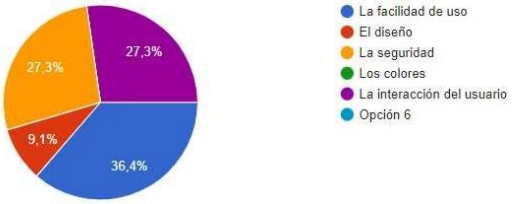


Figure 7: For you what is the most important thing in an application?

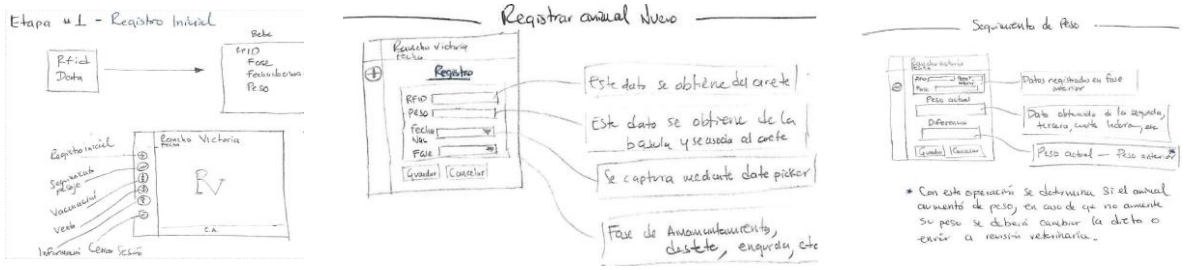
45% of respondents normally use applications that implement IoT features, it is important to mention that 65% of respondents prefer to register in applications using a Google account, which means that traditional email registrations are not preferred by users. It should be noted that survey participants point out that the most important features in an application are: ease of use 36.4% and user interaction27.3%.

4.2 Requirements Specification

Based on the information obtained in the Context of use stage, the basic requirements for software development have been specified in accordance with the IEEE-830 standard. Once the requirements were defined, a prototype was generated that can be modified once it has been evaluated in the later stages.

4.3 Prototypes

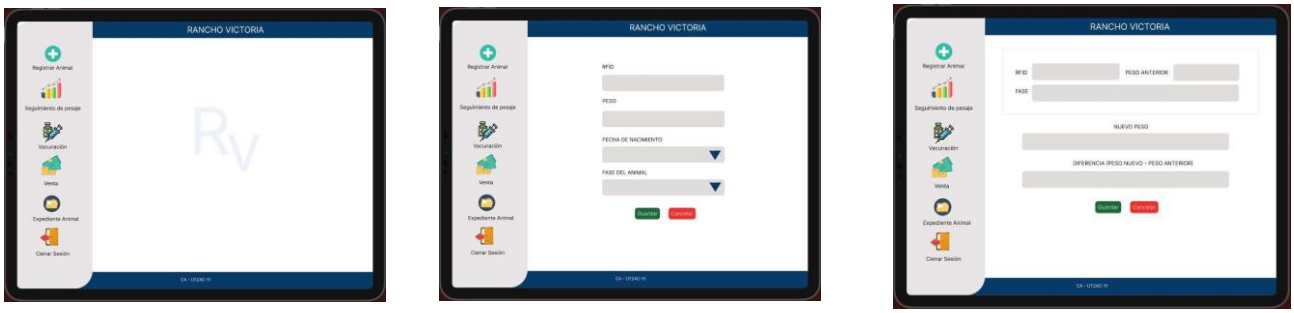
Several prototypes have been designed by applying various tools. In a first stage, a paper prototype was developed (see Figure.8), which arises from the application of the "persona" technique where DCU plays an important role in placing the user at the center of the design.



a) b) c)

Figure 8: Paper prototypes: a) Initial Registration, b) Animal Registration c) Weighing monitoring

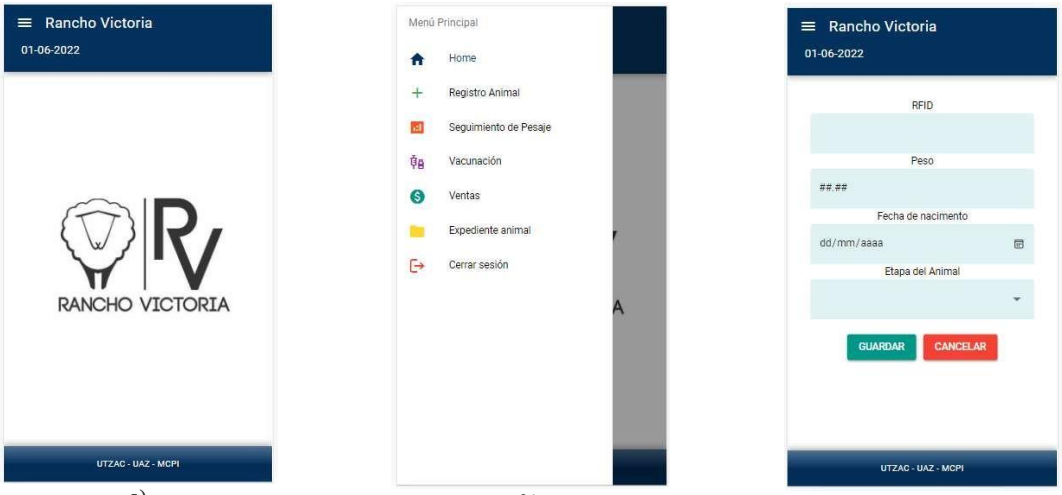
Digital model is designed with the help of Figma, an application for the design prototypes on different devices.



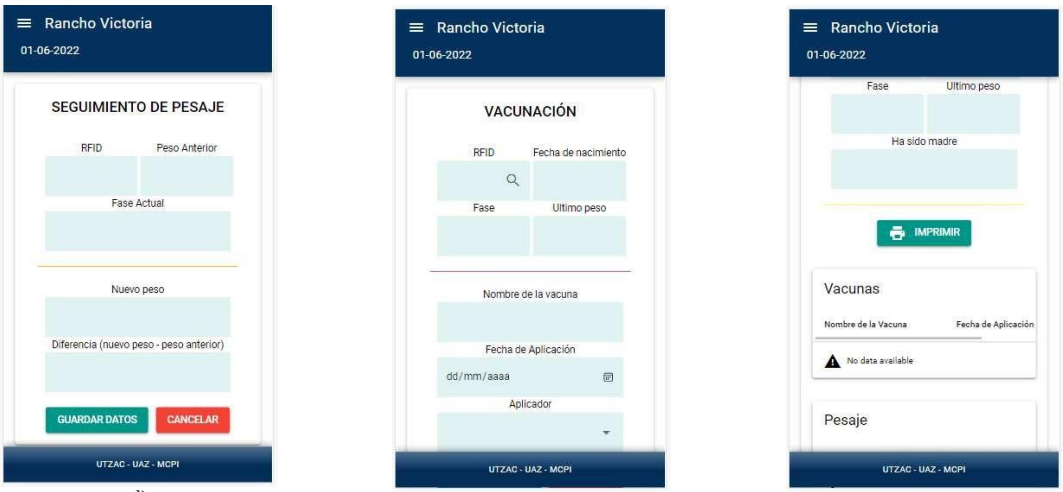
a) b) c)

Figure 9: Prototypes in Figma a) Home Screen, b) Animal Register c) Weigh monitoring

During the first stages of design, a basic digital prototype was developed, where the user registration was not requested because it was an application intended for a single company, however, a second prototype was developed (Figure.12).



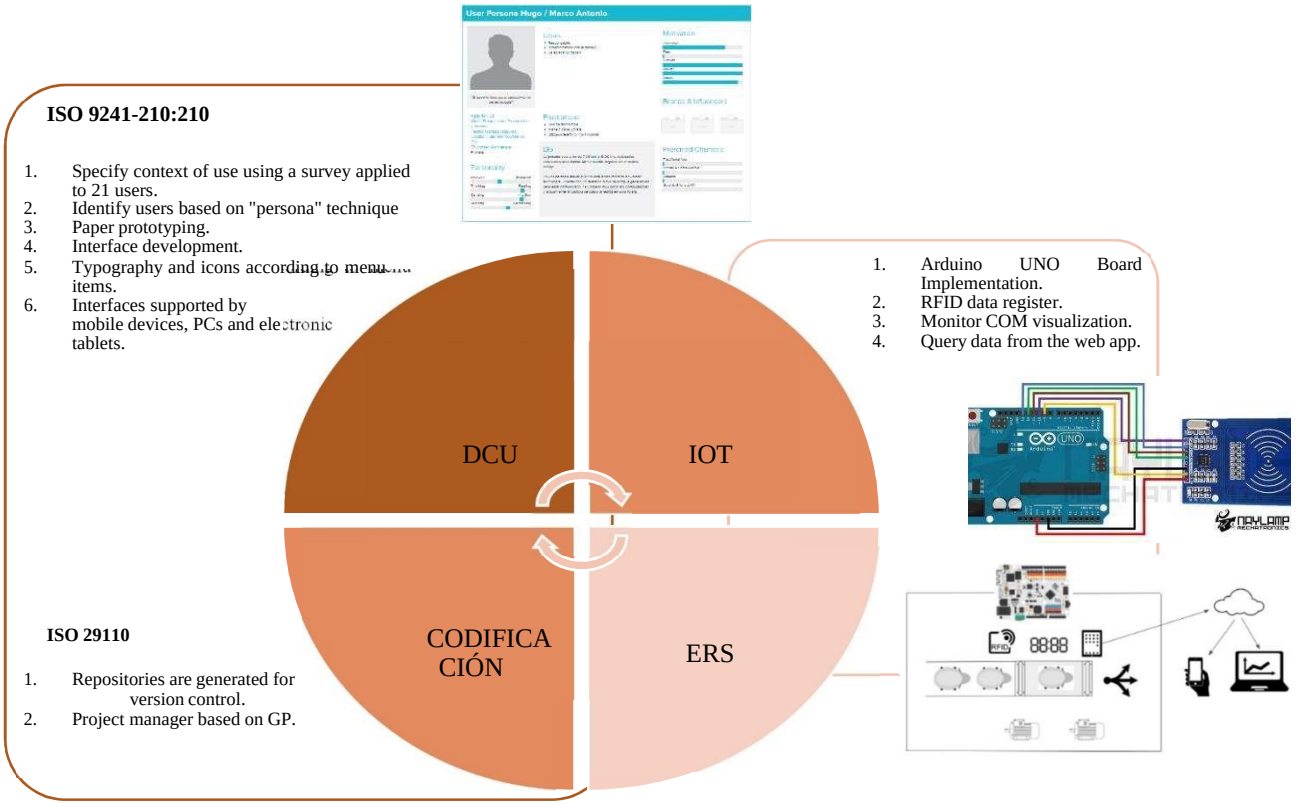
a) b) c)



d) e) f)

Figure 13: Interfaces: a) Main, b) Main menu c) Animal Registration, d) Weigh monitor, e) Vaccination, f) Animal Folder

4.4. Implementation of IoT, ISO 9241-210:210, ISO 29110 and IEEE 830



4.3 Prototype evaluation

According to the different methods of evaluation, the interface usability evaluation was developed with the support of 5 users, based on the research of Jakob Nielsen usability tests are formulated to find problems in the design of a software product [13]

a) b) c)

Figure 13: Prototypes and tests: a) Arduino and IoT, b) Persona Technique c) Software task evaluation

To evaluate the prototype of interfaces, a group of users (focus group) was used, ranking from an age between 32 and 47 years, who were asked to use the application from different devices, to measure the level of satisfaction and experience when using the prototype (Table 1).

It has been requested in the same way that our users perform a series of specific tasks of our application to evaluate the average time in which these activities are carried out, among which are: Login (1), capture animal (2), weighing monitoring (3), vaccination (4) and animal file (5). The data are presentedin the table 1:

Table 1
Usability testing to complete activities

		Average minutes to complete activity					
User	Tasks completed	Login	Register Animal	Weighing Tracking	Vaccination	Animal Folder	Average (mins)
1	5	4	4	5	4	6	5
2	5	5	6	5	5	7	6
3	5	6	7	6	4	7	6
4	5	4	5	5	3	5	4
5	5	5	7	4	5	6	5

4.4 Evaluation Results

Table 2
Users Feedback

# User	Feedback	Action	Impact
1	When you log in using google, the application does not show any notification of valid or invalid access.	Implement Qnotify to issue an on-screen message to the user.	High
1	In the animal registration module the drop-down calendar is not displayed correctly on electronic tablets larger than 10"	Change the calendar qinput for compatibility with all devices	Low
3	When consulting the history of the animal it would be important to download a csv or xls file for later visualization	Enable the export table feature in qtable to allow file download	Middle

5	When recording the weight of an animal it is convenient that the electronic system emits a sound, and a notification is displayed on the screen	Implement a buzz on the Arduino board to emit a sound in case of achieving the correct registration	High

5 Discussions and conclusions

Until recently, software development stood out for offering solutions and solving problems identified through the Software Requirements Specification, leaving aside the user, forgetting transcendental issues such as usability, user experience and needs of the same user.

Currently the user plays a fundamental role in the development of software products. Apply UCD in our developments does not guarantee a correct usability, during the process of creation, the user is the center of attention, we involve our end users in the design and development of an application that theywill use by them, which allows us to know their needs and therefore satisfy them.

Developing products that users love is possible thanks to UCD and its various stages, we will be able to understand how our product will be used (context of use), define the user needs (specification of requirements) and offer a product based on the information we have obtained thanks to the feedback ofour users (prototype evaluation).

The incorporation of IoT has made it possible to collect information on parameters that were previously considered impossible to measure. This offers farmers a greater capacity to make decisions based on data in order to ensure animal welfare, increase productivity, optimize and automate processes, remember that everything that can be measured, can be improved.

6 Future Works

In most research problems where regression analysis is applied, more than one independent variable is needed in the regression model. The complexity of most scientific mechanisms is such that, in order to predict an important result, a regression model is required. When this model is linear in coefficients it is called the multiple linear regression model.

For the case of *k* independent variables, *X1,X2,.....,Xk, the mean of Y| X1,X2, ,Xk* is given by the multiple linear regression model.

It is intended to implement prediction models using machine learning algorithms capable of predictingthe growth of an animal based on the data obtained week after week, and to make comparisons betweenanimals and detect growth patterns or, in case an animal is detected with zero growth, have the possibility of identifying failures in the animal diet and correct them.

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