Virtual Training System for an Industrial Pasteurization Process

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Abstract. This article presents the development of a training system in a virtual environment, a pasteurization plant, which allows interaction with the industrial process. The environment has structures, equipment and other instrumentation that is presented in a real pasteurizer plant. Thus, the proposed system manages textures and movements in a Unity 3D graphic environment, specially designed to develop monitoring and manipulation skills of this industrial process. The interface and the animation of the process are developed in Unity 3D software, together with the modeling of all the elements; in CAD design software. The experimental tests allow the operator to interact with the virtual environment and have knowledge of the different stages of pasteurization in the dairy industry.

Keywords: Virtual reality · Unity 3D · Pasteurization

1 Introduction

Virtual Reality has opened up field with supporting applications in design, industrial training and commercial activities. With virtual reality a very detailed perspective of structures and installations can be shown and it facilitates the design and appreciation of an environment [1]. Virtual reality systems are proposed as an economic advantage, as the user is given intuitive knowledge of the structure and functioning of a real system [2]. Thus, virtual applications have participated in the creation of various support systems, both in education, medicine, military training, tourism and museography, leisure and entertainment, and industrial applications and engineering.

In Virtual Reality in Industrial Applications and Engineering can create a specialized virtual environment, running in real time, which can provide critical and high-priority information of a process [3]. In terms of industrial training, a virtual system can serve as an effective and very useful instructional module. Virtual industrial training seeks to implement collaborative environments that facilitate the participation of several users in the development of processes where they acquire skills and become familiar with the activities that will be carried out in real life. Through virtual reality a series of very realistic scenarios are presented, the same ones that show industrial infrastructure and real processes. These virtual processes integrate real parameters and units, which are very effective in contributing knowledge to new users of the facilities [4]. With a complete virtual environment, reliable design criteria and key points in

L. T. De Paolis and P. Bourdot (Eds.): AVR 2019, LNCS 11614, pp. 430–441, 2019.
https://doi.org/10.1007/978-3-030-25999-0_35

quality maintenance can be given, in this way the virtuality of the equipment becomes a very useful and effective tool for maintenance processes [5].

In recent years the success of the industries has involved the ability of the working staff both to perform and improve their daily activities and to solve technical problems that arise in a process. The dairy industry does not make the exception since here it handles an industrial process called pasteurization, which involves parameters and variables such as temperature and fluid level. The pasteurization process consists of the thermal variation of liquids (generally foodstuffs such as milk), with the intention of eliminating or reducing the germs that exist in these, that is to say, it consists of taking the liquid to a high temperature and in a matter of seconds changing it to a low temperature, obtaining the elimination of bacteria present in the milk.

Also with the advance of technology, in the virtual industrial training, we seek to implement collaborative environments that facilitate the participation of several users in the development of real processes of the industry. This type of systems can be exposed through web portals, which facilitates their use, allowing participation in virtual tasks through a web browser commonly installed on any computer [6].

In order to improve industrial training methods, this work proposes the creation of a virtual didactic tool, effective for the practice and manipulation of a milk pasteurization process. The implementation of a virtual system of a pasteurization process is presented as a solution to the difficulties of staff training, where they can familiarize themselves with the process and learn from it, in a safe way and without having the need to access the physical plant, which frees us from occupational risks. This means that thanks to the tools and characteristics that Virtual Reality has, it is possible to build an environment similar to the real one and capture it in a computer to the point that the users do not notice the difference.

The structure and instrumentation developed in the system are developed based on P&ID diagrams of a dairy pasteurizer industry, which includes the animation of valves, switches, pumps and motors, all necessary for the operation of the process.

The present work is divided into the following sections, including; 1 introduction, 2 methodology used for the development of the system, 3 Virtualization of the environment through CAD software, animation of the process in Unity 3D, 4 analysis of results, and finally, 5 presents conclusions and future work.

2 Methodology

This work is designed for the training of operators in an industrial pasteurization process, through virtualization and emulation of the process of a pasteurizing plant. The system focuses on the interaction of the operator with the virtual plant. The objectives of this work are to design and test a virtual reality environment for the manipulation and learning of the operation and processes of a pasteurizing plant, which will allow the users or operators of the plant to acquire knowledge based on the experimentation that takes place in the virtual plant and this under safe conditions for both people and industry and is also immune to accidents and damages that generate losses to the company.

The system is adapted to the daily environments of the company, where you can evaluate the efficiency of the plant in high and low working conditions, and thus avoid possible failures; it is also designed to run from a personal computer to specific devices for virtual use (Oculus, Joystick, RV Helmets, etc.).

The work is carried out in stages, which includes the creation, animation and interaction of the pasteurizer plant process. Figure 1 shows the general scheme of the implementation methodology.

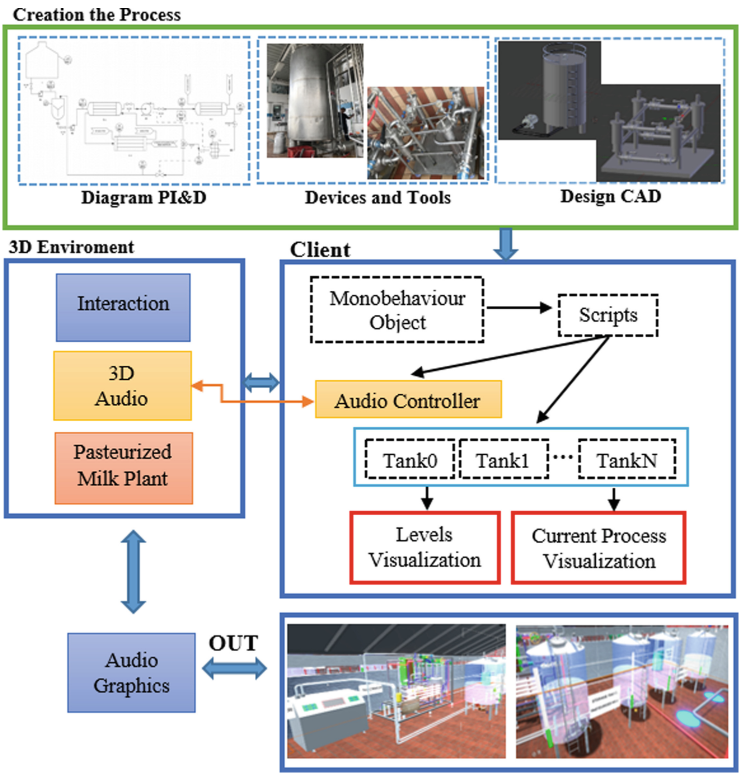


Fig. 1. Virtual training system architecture

3 Virtualization of the 3D Environment

3.1 Investigation

For the implementation of a VR system it is necessary to integrate a certain number of components and parameters, which work independently, but have the same purpose, which is to achieve the best immersion of the user in a virtual environment. For this reason it is very important to take into account all the details that are presented in the real environment.

For all these reasons, it is necessary to carry out an investigation about the dairy industries, where you will become familiar with the stages of the pasteurization process as well as with the devices and instrumentation that are handled in the plant. For this purpose, it is taken as support, research technical sheets of the industries that carry out this process, P&ID and HMI diagrams of pasteurization processes (see Fig. 2) and the safety standards that are executed in these processes, with the sole purpose of having a representation of the real process in a virtual environment [7]. The technique chosen for the virtualization of the industrial pasteurization plant is based on the interaction with programs that allow the creation of 3D equipment and instrumentation (Blender, Unity 3D, Adobe Fuse), and the animation and functionality of the process.

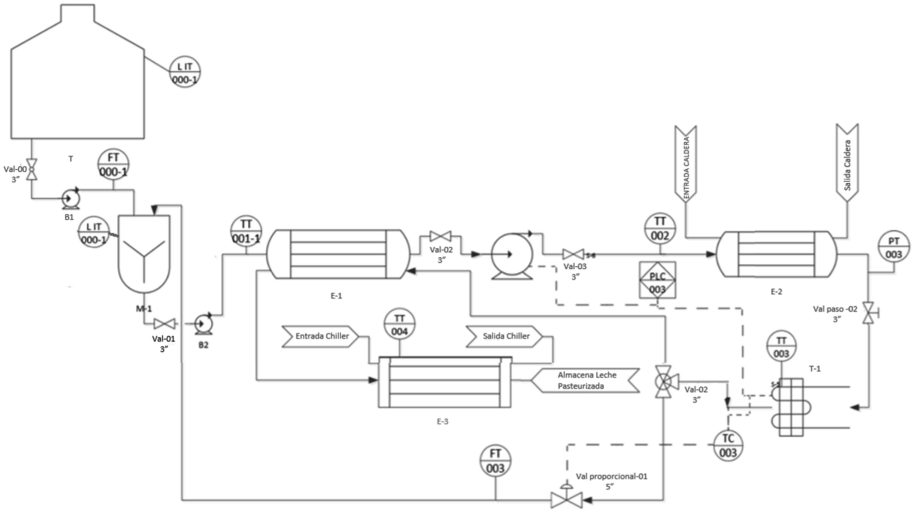
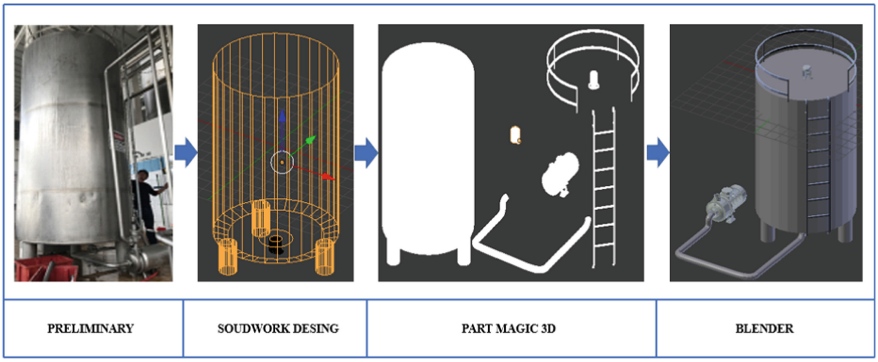


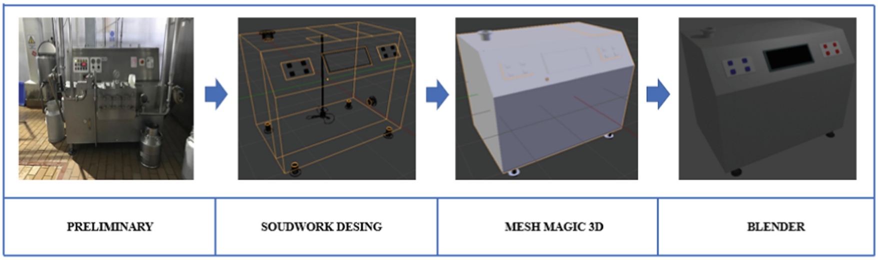
Fig. 2. P&ID diagram [13]

3.2 CAD Design

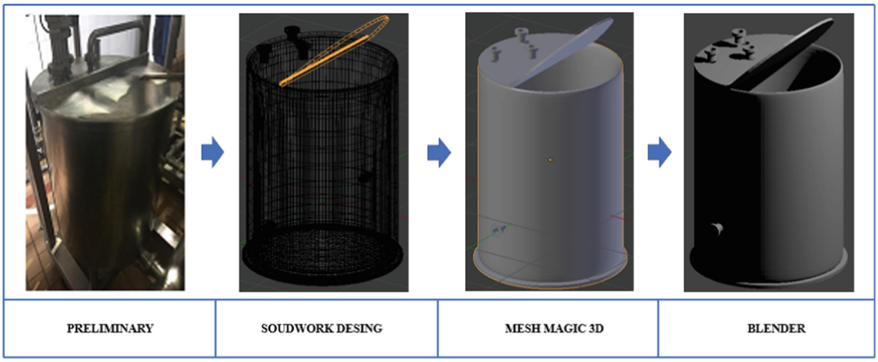
The virtualization process begins with the references previously obtained. To design a milk pasteurization plant, it is necessary to have the PI&D plans of the process, to be able to carry out the conversion of the objects from 2D to 3D, (see Fig. 3) and of the technical manuals of the operation, to be able to detail the movements of the objects and to be able to give them the different animations of their utility, that is to say to give them a high level of detail to the objects, this by means of computerized drawing techniques carried out in Blender.



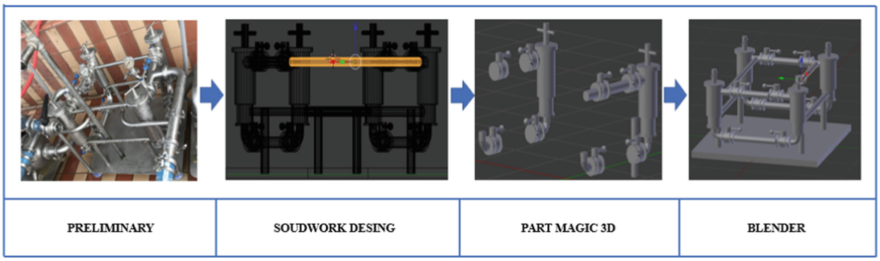
(a) Reception and storage tank.



(b) Milk Homogenizer



(c) Input Mixing Tank



(d) Milk filtering instrument

Fig. 3. CAD design of process instrumentation.

The details that are given to the objects are of great import, they may not represent a change in their functionality, but if they improve the experiences in the interaction with the users, as a result the appropriate components and instrumentation of the process are generated [14].

In addition, the avatars were designed using Adobe Fuse software, characteristic for their ease of development (see Fig. 4), which are differentiated by the type of access they are granted, *i.e.*, a Scada system was applied for user access, where each has different privileges.

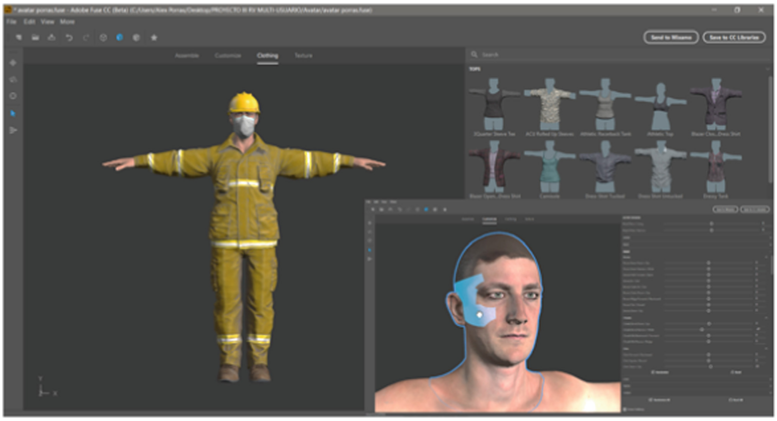


Fig. 4. Creating Avatar

3.3 Environment Creation

The plans of the civil infrastructure are necessary to make a virtual survey the most similar of the industry, where walls, doors, windows, etc. are detailed. The Pasteurization industry is located in the city of Salcedo in the province of Cotopaxi, Ecuador. In addition, it is important to mention that textures are imported to improve the design of the virtual environment, (see Fig. 5) ensuring a friendly environment for users to feel more how-two and familiar. All these objects were designed in Blender and imported into Unity 3D in a fbx file.

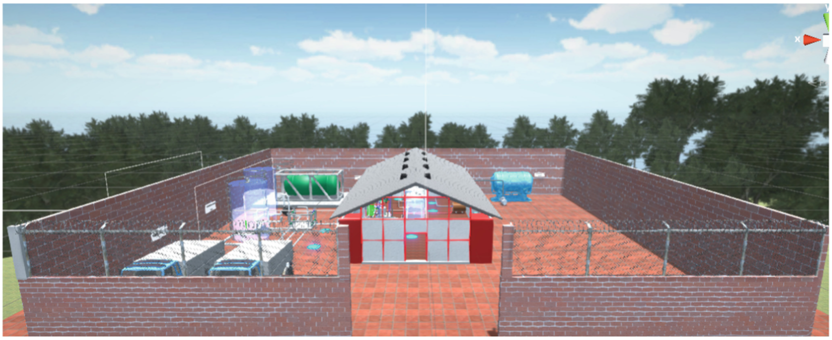


Fig. 5. Virtual environment of the pasteurizing plant (Color figure online)

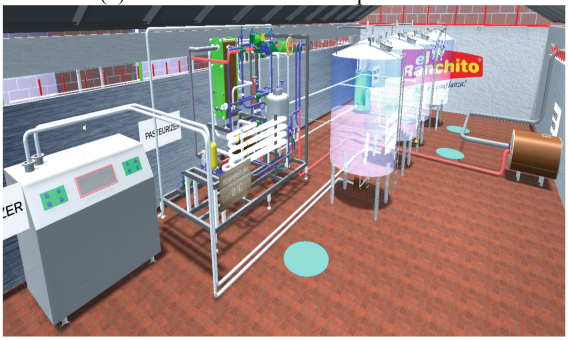
Thinking about improving the immersion experience in the virtual environment, different colors and activation spaces (celestial circle) were assigned to the devices that act in the plant, which goes according to its operation [8, 9]. Red color for a pump in "off state" and green color for a pump in "on state". Another important element are the control valves. Movements were also assigned according to their functionality, a right turn for "closed state" and a left turn for "open state". For a switch, the "state on" button is displayed pressed and a switch in "state off" button is displayed protruding.

3.4 Unity 3D Platform Integration

The Unity 3D graphic engine is a software of great features, compatible with several elements that are not included in the program, the same ones that allow you to improve and expand the applications that are realized in this one [10]. This is why the pasteurization process in the virtual environment is fully suited to the real plant environment, including animations, movements, and sounds. In order to include the animations of the process it is necessary to generate commands of handling and programs, by means of code VBScript, to, this it is necessary to generate the executable file and to tie it to the platform Unity 3D [11, 12].

These animations include the visualization of the level of the tanks of reception, mixture and storage of the milk. It also details the activation of an alarm in the event that the liquid level has exceeded the level of the tank producing a spill (see Fig. 6). Another aspect and the most important in the pasteurization process is the change of temperature to which the milk is submitted, this animation consists of the change of color of the pasteurization instrument, in high temperatures Red color and in low temperatures blue color, clearly appreciating this process (see Fig. 6b).

(a) Animation of milk reception tanks.



(b) Animation of the pasteurizing plant

Fig. 6. Unity 3D Plataform. (Color figure online)

4 Analysis of Results

This section presents the virtualization of the training system of the pasteurization process, which focuses on the interaction of the user with the process, allowing to obtain a great experience of the actions carried out in the different stages that pasteurized milk entails. These actions focus on the operation of the control valves, for the passage or not of the milk, between the different tanks (reception, storage and mixing). As well as the activation of switches for the on and off of the pumps connected to the tanks and to the homogenization instruments. The different stages of the virtualized pasteurization process are detailed below.

i. ***Milk reception***
At this stage, the milk from the supplier trucks is stored in the reception tanks at room temperature by means of the connected pipe (see Fig. 7), which is sent to an impurity filter and then the reception value in the tank is measured (see Fig. 8).

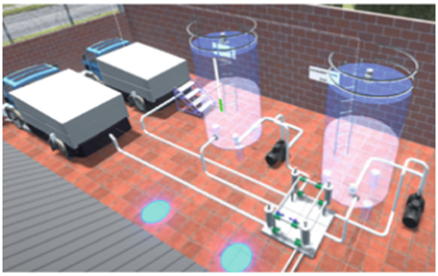


Fig. 7. Trucks and reception tanks

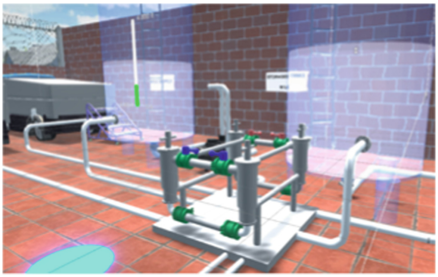


Fig. 8. Reception filtering

ii. ***Storage of cold milk***
At this stage, the milk temperature is changed by a heat exchanger at a temperature of 8 °C (see Fig. 9), for subsequent storage in other tanks (see Fig. 10).

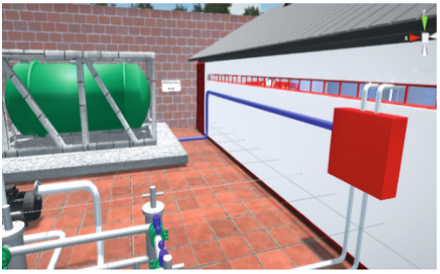


Fig. 9. Heat exchanger and cold water tank

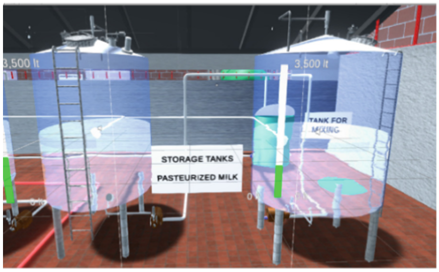


Fig. 10. Reception filtering

iii. ***Mixture of preservatives***
This stage is in charge of sending a percentage of milk from the cold milk tanks to a small tank where inputs for pasteurized milk are added (see Fig. 11).

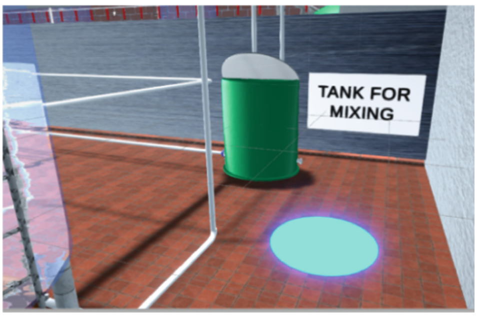


Fig. 11. Input tank

iv. ***Pasteurization***

This stage is carried out by means of heat exchangers, the thermal process of raising the temperature to approximately 78 °C and lowering it to 8 °C see Fig. 12, with the intention of reducing the presence of pathogenic agents (such as certain bacteria, protozoa, moulds, yeasts, etc.) that may be contained in the milk. Due to high temperatures the vast majority of bacterial agents die. All this change of temperature is shown in the virtual environment animation.

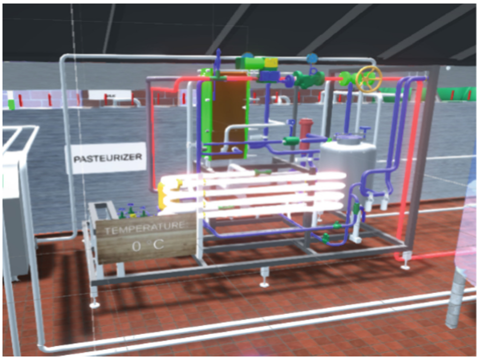


Fig. 12. Pasteurizer

v. ***Homogenisation***

After the previous stage, a homogenizer (see Fig. 13.) is sent by pipeline to spray the whole milk through small nozzles under pressure; the size of the fat globules is reduced to a size in which the cream is no longer separated.

Fig. 13. Homogenizer

vi. ***Storage of pasteurized milk***

In this final stage, the pasteurized milk is stored through a pipe to a tank with its respective filling measurement value, and then sent to another packaging process (see Fig. 14).

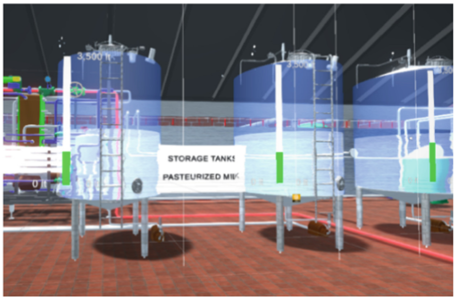


Fig. 13. Pasteurized milk storage tanks

5 Conclusions

The virtualization of the pasteurization plant through 3D modeling of the elements and instrumentation present in the industrial process, allows to obtain a great audiovisual experience in the immersion of the users with the virtual environment. The advantage of this is the qualification and training that the users obtain about the pasteurization process without exposing themselves to manipulation and operation risks, present in the real process equipment. At the same time, it becomes a tool to become familiar with the stages handled by the pasteurizing industry; in addition, making the user develop his skills in an efficient way and improve the performance with the virtual immersion.

In future works the 3D virtualization of an industrial process linked to the mathematical modeling of the dynamics of the elements that intervene in it, allows to emulate the real functioning of this industrial process, in addition it allows us to perform control algorithms in which we can optimize the operational resources; to manipulate control data at different levels of privileges, with a multi-user web server system.

Acknowledgements. The authors would like to thanks to the Corporación Ecuatoriana para el Desarrollo de la Investigación y Academia–CEDIA for the financing given to research, development, and innovation, through the CEPRA projects, especially the project CEPRA-XI-2017-06; Control Coordinado Multi-operador aplicado a un robot Manipulador Aéreo; also to Universidad de las Fuerzas Armadas ESPE, Universidad Técnica de Ambato, Escuela Superior Politécnica de Chimborazo, Universidad Nacional de Chimborazo, and Grupo de Investigación ARSI, for the support to develop this work.

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