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Software for Recording and Capture Video Sequences for Poultry and Laying Hens Facility (Bioterium)

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Abstract

Behavior can sometimes be observed directly, and can also be affected by the presence of human observers. Technological devices have strongly advanced our understanding of certain aspects of animal behavior, and the small cameras borne in a straight line by study animals offer a reliable alternative to direct observation. One possible way to make animal welfare assessments easier and faster could be the application of audio and video data analysis. In this research, the main goal is to reach the requirements determination, and the construction to build a concurrent alternative to CCTV software based on new proprietary software, developed in Matlab® language, to record and capture video sequences in digital memory hardware. The proposed software stakeholders' needs are written attending the specification in the ISO/IEC/IEEE 29148:2011 standard, and the life cycle adapted to the development was based in the standard ISO/IEC/IEEE 12207:2008. The main user interface was generated using the Matlab® GUI (Graphical User Interface). In the results, a resumed table with the final document of Requirement Specification (StRS) was generated and the main interface is coded. The system validation took place in the animal houses (bioterium) over a period of three months and the data collection and software usability reach the attendance to all the requirements listed. Thus, in the conclusions, it was observed that its users considered the developed software a good tool to help researches in the poultry and laying hens' facility (bioterium).

Keywords: Video Capture, Software, Sampling, Animal Behaviour, Requirements Analysis.

1. INTRODUCTION

In the studies by [1], the authors point out that animal behavior is a potential tool for identifying welfare status of heavy breeders in commercial production systems, which was previously also discussed by other authors like [2], [3], [4] and [5].

Birds exposed to high ambient conditions modify their behavior and physiological homeostasis by trying to reduce body temperature. In general, different species may react similarly to heat stress but show individual variations in the intensity and duration of their responses [6].

Other works with similar objectives and techniques were visited, in search of the state of the art, which were developed by researchers such as [7], who investigated the possibility of estimating the bodyweight

of live broilers using digital image processing. Also in their research [1], the authors draw attention to the fact that the image processing method is essential for increasing measurement accuracy and reliability analysis. An important indicator for this proposal, because good digital image processing requires good video and frame capture.

Applying similar techniques, [8] quantified the surface temperature distribution of the birds' body, thus determining the ratio of heat loss rate and cooling rate as a function of bird weight and age, besides performing morphological evaluations through image analysis.In their research [9], the authors used a combination of low-cost cameras equipment and statistical analysis of optical flow patterns to analyze the behavior of 24 commercial gallus gallus broilers.

As the use of image processing for research in this area of knowledge is relevant, the investment in the development of image and video acquisition systems to assist in the development of the researchers' work is justified.

The researchers' studies [10] highlight a spectral scanning line image processing system developed to obtain real-time inline images of broilers in commercial processing plants, also draws attention as a relevant application to the present study. The authors also concluded that real-time detection and immediate removal of unhealthy poultry carcasses could increase the yield of processing plants and helped to ensure the safety of poultry products and is, therefore, a tool to help in improve operations and increase production to meet consumer demand, with the potential to adapt to other high-speed tasks relevant to food quality and safety inspection.

The objective of the study by [11] was to test the hypothesis that important outcome measures in the exploration of welfare-based broiler groups can be derived from statistics obtained from the optical flow of group movements, video or Closed-circuit television (CCTV) within commercial farms. The authors point out that they can be obtained automatically and continuously throughout the life of a group of birds. This research, which aligns directly with the present proposal, because the use of CCTV systems software is adaptations that do not always lead to positive video capture results for researchers.

In [12], the authors performed a broiler behavior and welfare assessment using conventional surveillance cameras, which has great potential as a complement to good management and as an aid to improve broiler management. The authors highlight the fact that currently, suitable cameras are available, and automated analysis of camera video sequences can be performed from statistical descriptors of "optical flow" patterns produced by poultry movements in farms. Research that also brings important information to the present proposal, but still, the researchers used commercial software adapted to their research.

According to [13], the evaluation and interactive controls of the thermal comfort of animals by image analysis overcome the problems inherent to the conventional method, as they use animals themselves as biosensors in response to environmental reflexes through behavioral analysis. In this case, the emphasis on the non-intrusive way to obtain data will be used in the development of the work of this research.

Digital image processing has also been widely applied in other agribusiness sectors, which can be reinforced by the work of [14] applied to swine, and the work of [15] in which the body measures of cows from Holstein breed were determined by digital image analysis and these were used to estimate the live weight of each cow. For this purpose, an image capture arrangement was created on a dairy farm. This points, therefore, to the growing importance of the application of this technique, which has been reducing

equipment costs every day due to the great popularization for this area of research activities and decision support in production environments.

Thus, in this research, it was considered the development of software dedicated to building a concurrent alternative to CCTV based software, thus mitigating the problems arising from the use of systems adapted for animal behavior research.

2. LITERATURE REVIEW

According [16] the question of how management or environmental stimuli may influence poultry and laying hen's behavior and/or well-being is of considerable importance for fundamental studies of behavioral response to stimuli and as a means of assessing appropriate management and environmental designs for commercial production.

Behaviour, as stated by [17] can sometimes be observed directly, but this can be unfeasible in many circumstances. Furthermore, behavior can also be directly affected by the presence of human observers.

Technological devices have strongly advanced our understanding of certain aspects of animal behavior, and the small cameras borne directly by study animals offer a reliable alternative to direct observation, allowing the collection of behavioral data on domestic, and possibly other amenable species [18].

Behavior is an objective measurement that can be used to quantify the welfare conditions of commercially reared broilers. However, work conducted to identify and validate accurate behavioral observation methodologies is limited [19].For these reasons, [19] point one possible way to make animal welfare assessment easier and faster could be the application of audio and video data analysis.

A recurring problem in developing research that requires video collection for animal behavior and welfare analysis is the need to use video capture and recording systems based on hardware and software originally developed for CCTV security camera systems. This type of use can be seen in the work in which the researchers used TCP/IP surveillance cameras and the video was captured digitally using portable laptops with external USB hard drives and recorded continuously for 24 hours [20].

Also in a similar research, [16], where the behavioral data of two groups of birds were acquired with a video recording system that consisted of CCD cameras (Panasonic, AG-6730), a time-lapsed VCR (Panasonic, PV-V4520) and a TV monitor, where we can see the use of commercial systems of surveillance to record the videos. Due to this adaptation, the configurations made available by the manufacturers may not be the most convenient for researchers.

Continuous sampling, according to [20] is considered to be the gold standard utilized across all species, as it offers the most complete assessment of an animal's behavior by providing a complete record of all behaviors and durations observed over a time period [21]. However, continuous sampling requires a substantial investment of time, labor, and resources on the scientist's behalf, mainly computational resources.

In the two articles presented [16] and [18], we can see that researchers had to make recordings for 24 consecutive hours and this leads to the consumption of a lot of memory space on computer hard drives or removable memory devices for storage. The authors point the risk of failure that should be highlighted in a video so big, which could compromise the data collection for the experiment.

This kind of problem was also reported in the experiment of [22] where the video recordings were made with infrared cameras, recording video for eight hours per night, from 22:00 h until 06:00 h. The Recordings were made on two consecutive nights per week resulting in 1024 h of video of which 717 h were analyzed. Technical errors, according to authors, resulted in missing video footage (307 h - approximately 30% of data loss).

A clear vision of the desired characteristics of the video acquisition to reach a better result can accelerate software development projects and increase the likelihood of developing a successful system [23]. According to [24] and [25], clarity of a vision refers to having a vision that is well articulated, easy to understand, and represented in an accessible way to all product partners consisting of customers, business, and technology.

In [26], short videos of well-expressed key concepts, such as a vision, are an effective and persuasive tool, which can produce significant value as a documentation option. In [27] we see that the authors understand that to support this perspective by emphasizing that a video, as a timed medium, "needs to focus on the essentials of the visionary system".

An important issue, explored in this research, is related to the search, the requirements determination, and the construction to build a concurrent alternative based in a new software, developed in the scientific Matlab® language, to record and capture video sequences in a digital memory hardware, seeking to avoid the risks and problems previously faced by researchers. This new software should capture predetermined short time intervals, sequentially and with proper naming, in order to facilitate the whole process of storage and analysis for researchers in this area of expertise and increasing the security against data loss.

The developed software is focused to be used in behavior analysis of the poultry and laying hens housed in facilities known as bioterium (a place where laboratory animals are raised and maintained, in environmental, nutritional and health controlled conditions, for use in research data collection).

3. MATERIAL AND METHODS

The experiment with requirements gathering for software development and data collection was carried out at the State University (UNESP), School of Science and Engineering, Tupã, SP, Brazil, in the same terms proposed by [28].

The first round of questions and interviews was conducted with the users of the vivarium of the UNESP Tupã School of Science and Engineering, in order to begin the process of understanding the main requirements of the application to be designed.

3.1. Software Documentation, Designing, and Modelling

One of the most widely used documentation options, that were chosen for the elaboration of this research, to convey stakeholders' needs is a written specification as suggested by standards such as ISO/IEC/IEEE 29148:2011 [29] and to guide the life cycle adopted, ISO/IEC/IEEE 12207:2008 [30] Systems and software engineering — Software life cycle processes.

Taking into consideration these two standards, the development of the software object of this research was based on the search of all the necessary requirements to attend to the researchers regarding their needs

for the capture and storage of the videos obtained from the animal houses (bioterium).

3.2. Software Requirements Analyzes

At this stage of development, a new round of consultations was made with researchers (teachers and postgraduate students) and technicians who regularly use the facilities of the bioterium to identify their real needs regarding video capture for their experiments.

The method used for gathering, documenting and analyzing requirements was based,as shown in [31] research, the upper-level framework of ISO/IEC 15288 is elaborated in considerably more detail in ISO/IEC 29148 which describes the transformation of needs into requirements in a process that can be summarized as:

a) Requirements definition begins with stakeholder intentions (also referred to as needs, goals, and objectives). These stakeholder intentions are called Stakeholder Needs in the SEBoK [32] and ISO/IEC 15288, so that term is used from this point on.

b) Using the ConOps and the OpsCon as guidance, requirements engineers lead stakeholders through a structured process from Stakeholder Needs to the more-formal set of Stakeholder Requirements, which will be documented in the Stakeholder Requirement Specification (StRS).

c) The requirements in the StRS are then transformed by requirements engineers into System Requirements, which are contained in the System Requirement Specification (SyRS).

Thus, efforts were directed so that in the requirements analysis of the proposed software, the necessary clarifications were reached for the stakeholder intentions or needs, the necessary requirements documents named Requirement Specification (StRS) were built and finally, the necessary ones were made transformations for the final definition of system requirements.

According to [31] the Figure 1 shows a copy of a Figure from ISO/IEC 29148 with reference to which the standard says that the StRS and the SyRS are intended to represent different sets of requirements information items: the StRS (at the business management level and the business operational level) and SyRS (at the system operational level).

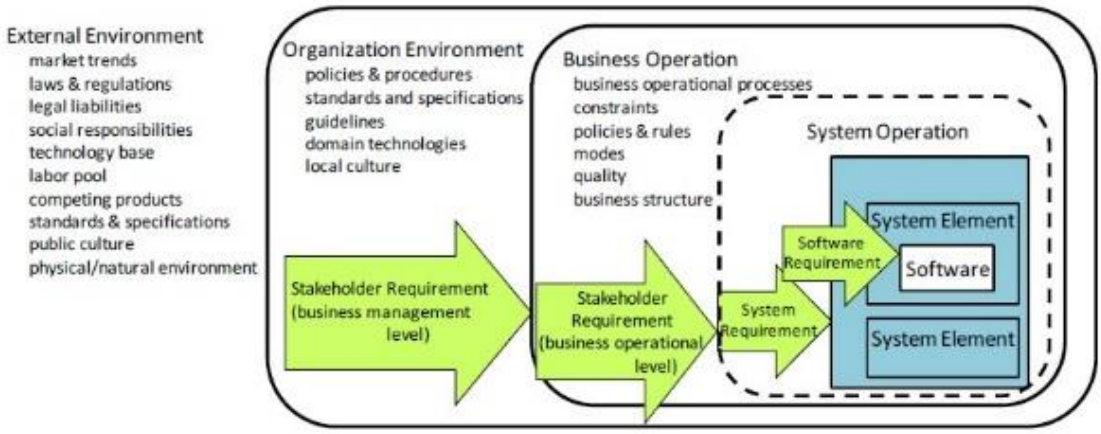

Figure 1: A copy of Figure 4 from ISO/IEC 29148 [16].

The ISO / IEC / IEEE 12207: 2008 standard, in addition to the previous requirements gathering step, provides a set of other steps that must be taken to build the software, and in Figure 2 it can be seen that the first phase of the cycle of life refers to the "Acquisition".

According [33], this "Acquisition" process involves identification of system requirements, analysis and design of the prospective systems, and the identification and acquisition of its components or services necessary to develop the components.

After this phase, the life cycle showed in Figure 2 directs the development to the next steps that allow the effective development of the software, i.e. its construction, to meet the requirements raised and documented in the previous step.

Supply: This process involves the delivery of system components, intended to satisfy the system requirements, which were defined during the acquisition process [32].

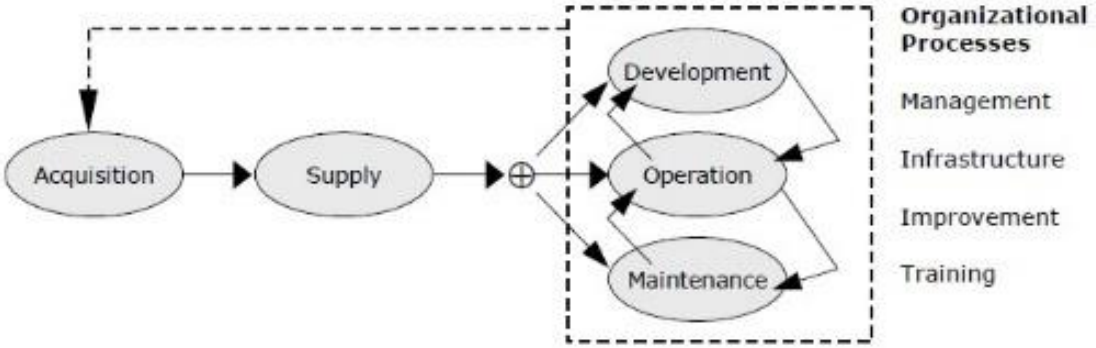

Figure 2: ISO/IEC 12207 Life cycle [33].

Thus, the software "Video Recorder_02" was designed and modeled in order to attend the "Acquisition" and "Supply" steps, obtaining all the requirements collected in the initial phase of the life cycle, so that any user, choosing the correct time interval to record the videos in the generated interface, can produce the sequences of videos under the correct conditions.

Then the construction and validation phase was contemplated within the process stages indicated in the standard ISO/IEC 12207 observing the following items "Development", "Maintenance" and "Operation":

Development: this process involved the production of the new system that occurs either through the integration of existing components or the implementation of hardware or software (for example, programming), or some combination of these two types of activities [32].

3.3. Software coding

In compliance with the "Development" process [33] of the life cycle, the software was built through its coding using the Matlab® GUI (Graphical User Interface) and, associating the knowledge obtained in the literature and from the users indications in the requirements analysis, and in the modeling process, generating an algorithm to be transported to the proposed software.

Maintenance: This process involved the correction of software faults or in its enhancements in order to realize new requirements [32].

3.4. Software validation

To get the correction of faults in the system or its enhancement, the validation took place in the animal houses (bioterium) at State University (UNESP), School of Science and Engineering, Tupã, over a period of three months, from July 2019 to September 2019, where the application was stressed, recording videos in all-time modes provided by the interface. Time recording individual videos, time recording 6-hour videos, time in 12-hour mode and also 24-hour mode.

The models are built in the East-West direction, situated at latitude 21o 55 '39' 'S, 50o 29' 30 " W, altitude 495 m, climate type Cwa (wet temperate climate with dry winter and hot summer), its surroundings consisting of flat area covered with grass.

The video camera images were transmitted via coaxial cable installed inside the reduced models in the animal houses (bioterium) and passed through underground piping to the Environmental Comfort laboratory to the computer where the software was installed in the experiment period.

To capture the images and to test the software, were installed on the roof of the sheds, at 90 ° angle with floor view, model AP2688W video cameras, POWER® manufacture with 1200 line analog CCD image sensors, 2.8mm aperture lenses to 170 ° and NTSC video standard.

The collection of obtained videos was observed in order to identify the automatic nominations of the snippets of the capture sequence, the acquisition times, the frames and the quality of the images obtained.

It was also verified, in the individual recordings, the memory spaces that were occupied by the set, in order to evaluate the internal or external hard disk drive usage.

Finally, the functionalities of the system were checked against the requirements for its final confirmation (validation) in order to confirm the usability.

Operation: This process involves the ongoing activity of setting a system into a functioning state: that is, into a state where users can begin to realize its benefits [32].

4. RESULTS AND DISCUSSION

4.1. Requirements Analysis

According to [29] the stakeholders' needs was written as specification as suggested by standard ISO/IEC/IEEE 29148:2011, thus, the results of gathering information, via interviews and questionnaires, for real needs identification regarding video capture for experiments with researchers (professors and postgraduate students) and technicians who regularly use the animal facility resulted in the list of needs.

The final document of Requirement Specification (StRS) was built, and in Table 1, the most relevant points gathered of this document are listed, and the correspondent specifications defined to meet the requirement description during the development (coding) are also shown.

Table1. Most Relevant requirements identified and corresponding specifications to be used in the software codification from the final generated StRS document.

Requirements	Specification Description
1. Preview required for adjusting bioterium cameras;	To allow camera access in preview mode, two-button commands have been inserted just below the preview window, which allows you to trigger the selected camera input for viewing without

	recording so that focus and framing adjustments can be made. The first button on the left of the interface preview frame enables the preview and the other button on the left turns off the preview.
2. Possibility of direct access to the storage folder of the captured videos;	Between the two preview buttons has been inserted into a command button that allows you to directly open the folder created by the system to be the repository of the captured videos.
3. Possibility of cameras signal source channel selection, through native windows driver capture;	The system is designed to provide access to two input devices channels of camera drivers. Once the drivers are installed in windows, through the interface it is possible to select, in the form load which driver to use.
4. Provide visual signaling at the interface to identify system status, it is recording, processing or in standby mode;	The system was designed to present in its operating interface, a set of animated icons that illustrate the moment of processing, capture, recording or display in which it is. Animated texts also identify whether the system is in standby mode or operating with other activities.
5. Possibility to record a single short video for testing;	In the interface form on the left side, just below the camera driver selection box, there is a configuration area with a set of command buttons, and the first one at the top gives access to a single recording video, lasting two minutes.
6. Possibility to make recordings over long periods, but fragmenting the videos to avoid data loss;	In the interface form, in the configuration area, there is a set of command buttons, where the first one, at the top, gives access to the recording of a single video, lasting 2 minutes for testing. Below we have commands that allow sequential recording of two-minute videos separated by one-minute intervals for 6 hours, 12 hours and up to 24-hour intervals.
7. Avoid large hard disk occupancy when recording long periods, up to 24 hours;	The 800x600 pixel video mode was chosen to be able to perform a 2-minute block recording. Thus, the hard disk memory occupations were, for each command button, as follows: a single 2-minute video - occupancy of approximately 80Mb; for recording 6 hours of 2-minute videos separated by one-minute intervals - occupancy of approximately 6.5Gb; for recording 12 hours of 2-minute videos separated by one-minute intervals - occupancy of approximately 20Gb; and for 24-hour recording of 2-minute videos separated by one-minute intervals - occupancy of approximately 40Gb;
8. The system must name each file sequentially;	The system is designed to automatically name each video captured with the “hhmmss_ddmmyy.avi” structure and record them all in sequence within the same repository folder.
9. Seek ease of use of the	To facilitate access and use of the application, we chose to use

application.	only one form of interaction with the user. In this form all features, visualization and commands are accessible.

These requirements specifications were taken as a reference for the software production process according to the standard ISO / IEC / IEEE 12207: 2008 [30], which made the generated interface meet the users' wishes.

All descriptions of needs have taken into account the indications of [19] to obtain a possible way to make animal welfare assessments easier and faster.It was also sought to solve and avoid the possibility that the problems presented by [22], such as technical errors resulted in missing video footage, would happen again.

The requirements were selected and prioritized in order to make the software easy to understand, and represented in an accessible way, as stated by [24] and [25].

It was also taken into consideration in modeling what was stated by [26], which points to the fact that short videos are an effective and persuasive tool.

The case of continuous sampling, according to [20] despite being considered the gold standard utilized, but requires a substantial investment of time, labor, and resources on the scientist's behalf. To solve this, the requirements correlated to this issue were also taken into account, considering the capture of short videos separated by also short intervals, in order to safeguard and to avoid data losses as much as possible.

For this reason, during software design, the option of short videos lasting two minutes apart by one-minute intervals was the right choice to reduce the large disk space occupancy for video storage and mitigated the risk of losing large intervals and consequently of the "data" of the experiments.

The users very well rated these results.

4.2. Software coding:

In compliance with the "Development" process of the life cycle [32], the software was built through its coding using the Matlab® GUI (Graphical User Interface). This feature helps to automatically generate the object-oriented code that specifies the app's layout and design.

The digital interface for video capture generated, to facilitate access and use of the application, use only one form of interaction with the user. This option speeds up the usage process and makes it easy for users to view all available configurations and functionality in the same visual environment.

The size of the videos to be recorded was also an important choice in order to rationalize disc usage and allow comfortable viewing for future image analysis.

The format adopted was 800x600 pixels and the recording duration, as previously mentioned, was set at 2-minute intervals.

To meet sequential recording requirements and easy location of the videos in the repository folder, the way to automatically name the videos via software was the "hhmmss_ddmmyy.avi" structure, attending the requirements specification.

The main user interface generated using the Matlab® GUI (Graphical User Interface), it is presented in Figure 3.

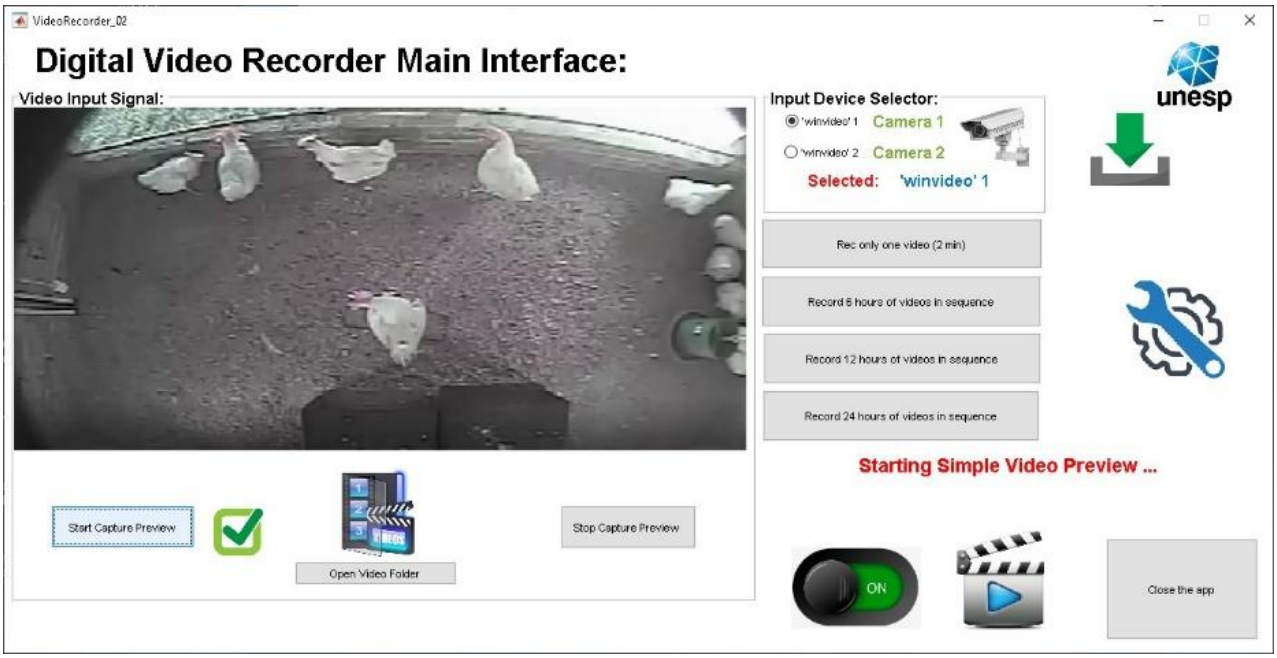

Figure 3: Developed Software main user interface.

It was observed that, as presented by [23], the work of clarifying the requirements for an application, with the generation of a document such as Requirement Specification (StRS), allows achieving a better result in modeling and can accelerating software development projects and increasing the likelihood of developing a successful system.

With the availability of this new dedicated software as a proposal for the replacement of CCTV systems software adapted, the problems that were obtained by the researchers [16], [18], [20], [21] and [22] will be avoided and research such as those performed by the authors [17] and [18] may occur without limitations and may be performed with greater certainty in the future.

With the results obtained, researchers no longer need to use commercial recording systems developed for surveillance and CCTV use, if the configurations made available by manufacturers are not the most convenient, but have the new option available for your convenience.

The usability of the system functionalities, in the validation period, were checked against the requirements by the users previously interviewed and all were unanimous in saying that the generated application met their expectations.

5. CONCLUSION

In this work, the proposal of the construction to build a concurrent alternative to CCTV commercial equipment based on new dedicated software "Video Recorder_02", developed in Matlab® language, to record and capture video sequences in digital memory hardware it has been achieved.

The data collection and software usability reach the attendance of all the requirements listed in the final Requirement Specification (StRS). This tool allowed us to reach the proposed objectives and in the laboratory validation process, and it was also observed that its users considered the developed software a good tool to help researches in the poultry and laying hens' facility (bioterium).

6. ACKNOWLEDGMENT

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