Chapter 147

Supervisory lean desktop dedicated to hardware with wireless communication for monitoring ambience in biosystems

Crossref doi 10.56238/tfisdwv1-147

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ABSTRACT
With the evolution of hardware aimed at monitoring different types of Biosystems, it has become increasingly necessary the development of Human-Machine Interfaces (HMI). The objective of the project was to develop a desktop application, for the acquisition of data from these devices. The software was developed in python and validated with specific hardware via Bluetooth wireless communication. In conclusion, the results showed promise taking into account the amount of tools used.

Keywords: Desktop Application; Wireless communication; Hardware; Firmware.

1 INTRODUCTION

The use of technologies to monitor the environments applied in Biosystems, with emphasis on agricultural production, can be used to reduce losses and waste in their production chains, making it crucial the development of increasingly optimized production systems, both in the production of food of plant and animal origin.

Consequently, the development of embedded systems has become extremely important in order to enable strict control in the most diverse types of food production systems over the last few years. In a simplified way, an embedded system is one that can consist of a microcontroller, or microprocessor, which has the function of performing specific tasks and applications, different from general purpose devices such as computers and mobile phones, which are used by the population, which have not only one function, but an infinite range of different applications (Shipped, 2013) .

In most cases, to monitor an environment it is necessary to use electronic devices or embedded systems, which have integrated sensors and also the ability to transmit data via wired or *wireless communication*. Many industrial systems use *wireless* technology to communicate between various devices, thereby avoiding problems related to situations in which they are used. The information that is transmitted by these devices can have numerous applications, being able to act in different processes, measurements and data management in equipment dedicated and exclusive to this purpose, making this technology gain more and more popularity (Lugli and Nephew, 2012).

According to Nunes (2015), with the advancement of this technology it becomes possible the development of Redes of Sensores in Fio (RSSF), or also called *the Wireless Sensor Network* (WSN),which emerged as a technology with great potential for use in various segments and economic activities, since it can align monitoring, wireless communication and low power consumption on easy-to-install platforms. Also according to the author, in the last decade RSSF technologies began to be used in agriculture, such as in the use of monitoring of environmental conditions in lettuce greenhouses, where each sensor allows the measurement of parameters such as: light levels; temperature and relative humidity of the air, the environment and also the soil, as performed and described by Vieira (2004).

Generally, the most common parameters in ambiences that can directly affect food production, relate to temperature and relative humidity of the air, in different types of Biosystems, ranging from the storage of fruits, greenhouses, sheds and silos. In addition to the temperature and relative humidity of the air, other parameters can also influence the production of certain products, which are more specific, such as: luminosity; air speed; concentrations of organic and inorganic gases.

The benefits of monitoring environmental conditions are not restricted only to plant production, but also to animal production. In meat processing, productivity and quality are factors that can be directly influenced by environmental conditions, since animal welfare is crucial for production, because it reduces stress in animals, such as in birds, which can affect their growth rate, genetic potential and even the survival of these animals. To increase productivity in poultry sheds, nutrition, genetic improvement , animal health, management and appropriate facilities should be combine, the latter being of great importance for animal comfort (Alves, 2009; Damasceno et al. , 2010).

However, even with all this control, there are still limiting factors in the development of these monitoring systems. Itis necessary to perform many stages in its development, ranging from *hardware development*, firmware implementation and *software development*, which requires a very large period, directly affecting the availability of these systems to producers.

In this context, the overall objective of this work was *to develop a desktop* application, in 1 month, to be used *on* computers, through efficient tools, aimed at optimizing development time and, at the same time, making available in different functions for its interface dedicated to monitoring Biosystems, being the theoretical reference production system related to broiler aviaries.

The specific objectives were to perform communication between the computer and the embedded system using a *luetooth B wireless* communication system, store the data received in a D-ane sane b in the cloud and present the temperature and relative humidity values transmitted by *the monitoring hardware* for the application user.

2 MATERIAL AND METHODS

For the implementation and development of *the desktop application*, it became necessary to select from the various systems development *languages for software s the* appropriate language, the *chosen for this work was python*, version 3.10. The reason for the choice concerns the learning curve for the programmer, availability of a wide range of libraries dedicated to the development of various applications, possibility of automating tasks, integration with *other software*, reduced amount of lines of code, operation on multiple platforms and open-source *availability* (Python, 2022).

The development of the *desktop application* interface, was elaborated throughthe *framework library kivy*, *also open-source* and *written in python*, its release is considered relatively new and its most stable version occurred in 2020. Among its inummertheadvantages s can be cited: compatibility with *Linux; Mac OS X; Windows; Android* and *iOS*; natural user interface, fast graphics accelerated by *hardware and* broad ecosystem (Souza, 2021; Vasilkov, 2015).

The code editor used for application development was *Visual Studio Code* (*VS Code*), version 1.68, also available for cross-platform *such as Windows, Mac, and Linux* (Microsoft, 2022). For storage ofthe data obtained from temperature and relative humidity via *hardware*, the Bhook of Dados in cloud *Firebase Realtime Database* (Google, 2022) was used.

To validate the development of the *desktop application* usedin *specific components for hardware*, used in studies applied to the monitoring of environmental conditions in Biossistemas of the institution's home of work, Faculty of Sciences and Engineering UNESP - Campus de Tupã, for the digital systems laboratory. The components used were respectively:

- Microcontroller MSP430FR2155;
- Development kit with recording interface MSP-EXP430FR5994;
- Wirelesscommunication module *Bluetooth* JDY-31;
- Modulo digital sensor of temperature and relative humidity of hdc1080 air.

The microcontrolleris a 16-bit RISC architecture, and can operate at a frequency of up to 24 MHz, temperatures of -40 to 105 °C and a power voltage of 3.3 V. The temperature and relative humidity sensor module used has a relative humidity accuracy of ± 2 %, temperature accuracy ± 0.2°C, 14-bit resolution, low power consumption (100 nA) in hibernation mode, and excellent stability in high relative humidity.

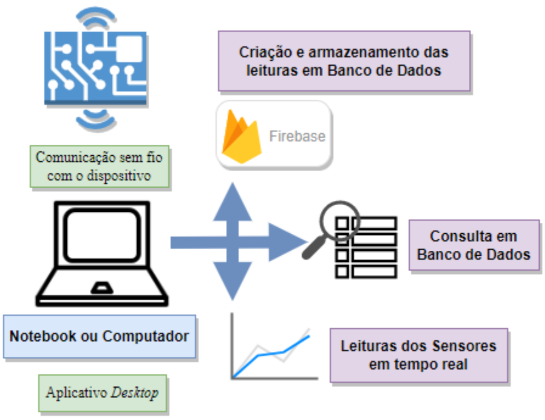
The iar *embedded workbenck software form platform* was used , which is used in conjunction with the recorder for programming of all microcontroller models of the MSP430 series. For this article, the requirements of the project are: serial data transmission; transmission rate of 1-second readings and storage in Banco of Dados in the cloud. The pretexts are: to make communication between different devices possible; seek time optimization for data processing and reduction of local memory space usage. The *developed desktop* application was run using an Acer® *model notebook*, aspire 3 A315-54-54B1 with Intel Core i5 processor, 10th generation, 8GB of RAM and 1TB of HD, 15.6" Windows 10.

3 RESULTS AND DISCUSSION

To develop the Desktop *Application's Minimum Viable Product* (MVP), *it* became necessary, a priori, to determine in which situation the use of the application would be crucial. In this work, in particular, the production environment used as a reference basis for monitoring concerns the aviarys of broiler s, since the success of production in cutting aviculture is closely linked the reduction of climate effects on animals, and it is necessary to characterize their environment (Sebrae, 2008).

Once determined the language and tools necessary for the *execution of the desktop application*, schematizing all the minimum functions that the system needs to have for its proper execution and operation is a determining step in the development of the proposed system. Figure 1 briefly illustrates all the functions necessary for system development.

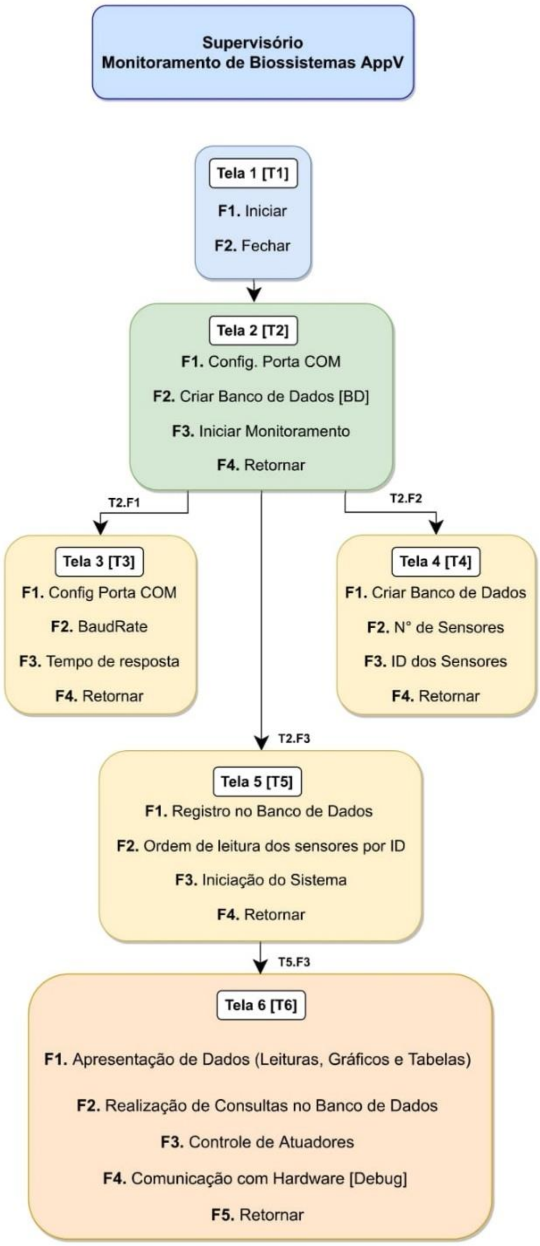
Figure 1. Minimum functions proposed for the application.



After choosing the programming language, code editor and *framework required* for application development, the initial planning for the system MVP and development of *the desktop* application screens, called AppV Biosystems Monitoring, was elaborated.

Figure 2 illustrates how desktop application *screens* are described according to each function.

Figure 2. Organization of the screens of the proposed application.



With the planning of the screens of the proposed *desktop* application it became possible to start its development.

The *python language* and *the kivy framework used* in this work greatly facilitated the development of the application, both in relation to the availability of libraries, as well as the ease of *development of the layout* ofthe application.

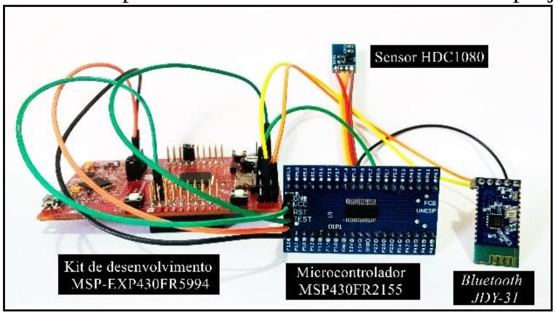
Table 1 presents the python libraries needed for the development of the proposed application, as well as its respectivefunctions.

Table 1. Functions and their respective libraries used in the *desktop application*.

Function	Library (*Python*)
Application interface	*kivy/kivyMD*
Data analysis	*Pandas*
Serial communication	*Pyserial*
Date and time	*datetime*
Communication with Database in the Cloud	*requests*
Structuring and manipulation of data	*Json*
Charting	*Matplotlib*
Operation with *arrays*	*numpy*
Mathematical interpolations	*scipy.interpolate*

Once you have specified the minimum proposed functions, organization of the screens and libraries required for application development, it is necessary to use *the hardware* to validate the operation of the system. Figure 3 shows thehardware components used in the project.

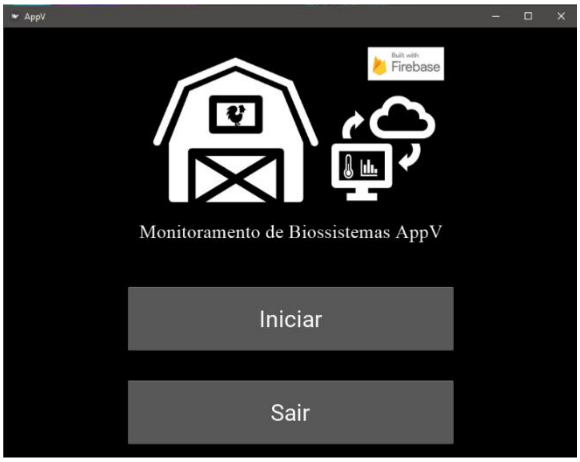
Figure 3. Components of the *hardware* used in the project.



Using thelibraries, described in Table 1, it became possible to develop a program, based on the planning of screens presented in Figure 2 and *the hardware* in Figure 3.

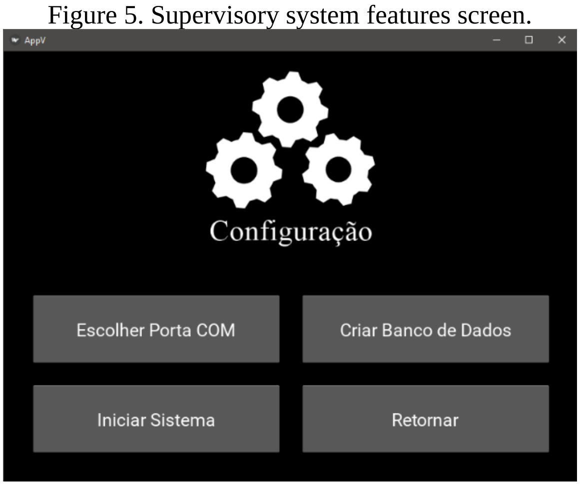
Figure 4 presents the startup screen of the developed application.

Figure 4. App startup screen.



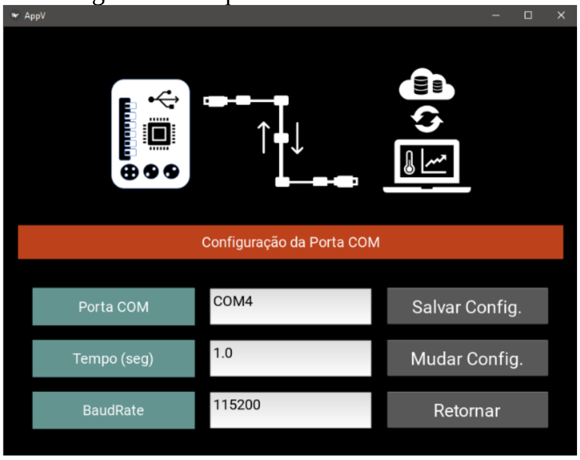
As one of the objectives of the work is related to the optimization of development time, one of the criteria followed is the use of only *standard components of the kivy framework*, which avoided the use of customized components such as: buttons, *labels*, *textinputs* and others. Figure 5 presents the screen with the basic functions of the system, being respectively: choice of the COM port required to initiate serial communication between the device and *the desktop application*; creation of the Database where sensor readings will be stored; system startup and return to the previous screen.

Figure 5. Supervisory system features screen.



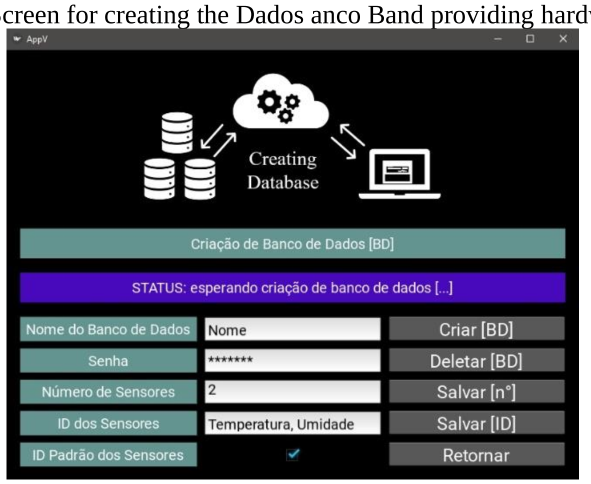
For the startup of the supervisory system, the first step of the application comprises the configuration of the serial COM port, time between readings and *BaudRate* configured on the device, to which will be carried out communication between this embedded system, that is, *the hardware* with integrated sensors and the application. Figure 6 illustrates the completion of the information needed to initiate communication with the embedded device.

Figure 6. Screen configurations required for serial communication with *hardware*.



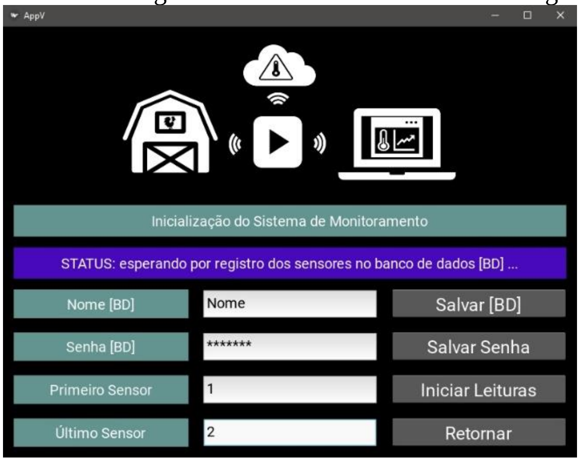
After performing the serial COM port settings, response time, *and baudrate* of the device, it becomes necessary to create theD-anco B, where the reads will be stored. On this same screen, the system receives the number of reads, or sensors, as well as the id of each read received from the *hardware* to the application. Figure 7 illustrates the screen that has the functionality of creating Bdata ancos and other data necessary for the operation of the system.

Figure 7. Screen for creating the Dados anco Band providing hardware *data*.



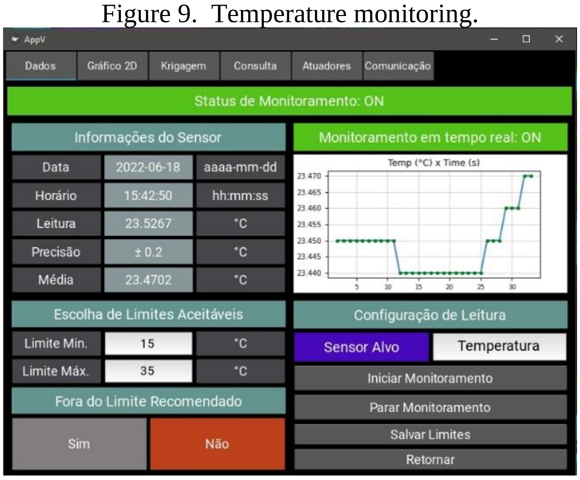
With the Banco of Dados created, number of sensors and their respective identifications, it becomes possible to start the supervisory system, it should be indicated in which B anco of Dados created the readings will be stored, as well as the first and last sensor that will be requested by the supervisory system. Figure 8 shows the application screen for filling out this data needed for system startup.

Figure 8. Screen for selectingthe D-anco b ados where the readings will be stored.



When it comes to aviaries, animals need to be set in thermoneutral zones, since there is an energy expenditure to maintain body temperature, and for chicks a temperature should remain between 33 and 34 °C and for animals already adults a temperature of 15 °C to 28 °C, with humidity ranging from 40 to 80 % (ROVARIS et al., 2014, apud WELKER et al., 2008). In this sense, *textinputs* wereadded to the insertion of minimum and maximum acceptable limits to the monitored production system, to which is checked for each new reading received. Figure 9 shows the system running after 40 seconds, using *the validation hardware*, with the request for the temperature reading of the HDC1080 sensor.

Figure 9. Temperature monitoring.

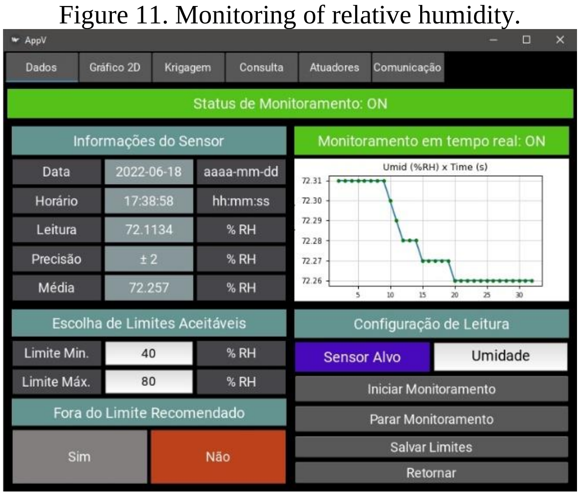


It is worth noting that the graphic presentation of the readings in real time can be expanded by selecting the tab, "2D Graph", in order to facilitate the visualization of the data acquired by the supervisor developed, as indicated in Figure 10.

Figure 10. Extended graphic presentation.

The same procedures can be followed to monitor the relative humidity of the air, mean cujas relate to the cumulative average of each reading performed per second, to provide the average between the beginning and the end of monitoring. Figure 11 shows the operation , after 30 seconds, of the supervisory system for the request of relative humidity.

Figure 11. Monitoring of relative humidity.

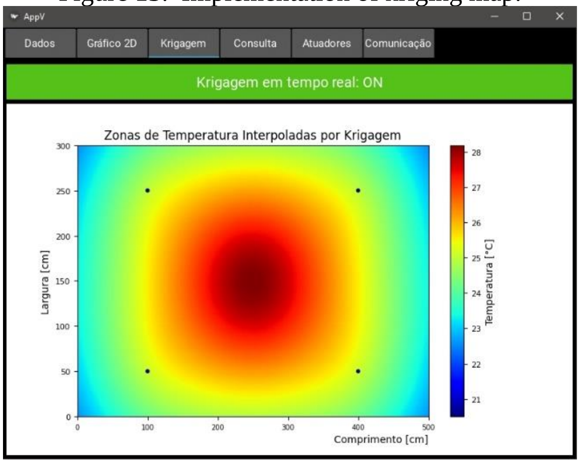


As described above, for a better visualization of the obtained data, it is possible to enlarge the chart using the option "2D Graph", as shown in Figure 12.

Figure 12. Extended graphic presentation to read relative humidity.

One of the advantages of *developing python applications* is the wide range of application possibilities, by presenting different libraries, with this different systems can be implemented in *desktop or mobile applications*, such as kriging maps. Figure 13 illustrates the use of these maps in a simulation of a small environment of dimensions of 300 cm wide by 500 cm long, with 5 temperature samples at equidistant points.

Figure 13. Implementation of kriging map.



According to Queiroz (2017) kriging is an interpolation used as one of the tools of geostatistical representation by maps most important for the interpretation of ambiences in sheds, since they present easy interpretation. It was used, for the simulation presented in Figure 13, the inverse of the distance para the implementation of this kriging and only 5 temperature points, since its presentation has only illustrative and non-analytical character, since for practical tests it becomes necessary a greater number of sampling points s, as well as modeling of data with semivariograms (GeoExamples, 2012; GISGeography, 2022).

The *programming of the python application* also facilitates communication between the embedded system and the user, making it possible to perform the activation of actuators remotely, such as fans and humidifers used in poultry systems, through the *pyserial library* presented in Table 1. In this sense, the AppV Biosystem Monitoring application acts as a Human-Machine Interface (HMI).

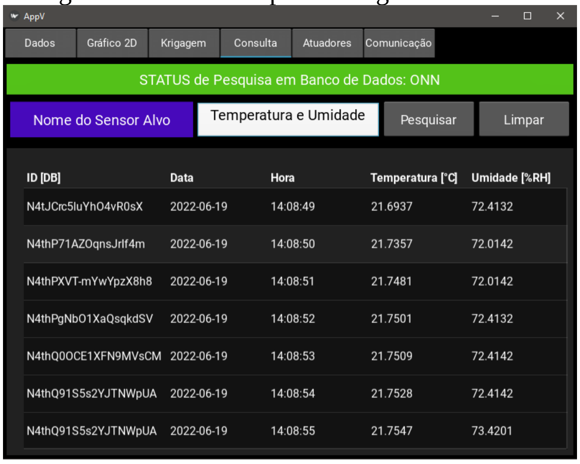
Figures 14 and 15 illustrate the *layout developed for* this application with the purpose of making possible the activation of actuators and direct communication with *the hardware* for *debugs*.

Figure 14. Screen for actuators for climate control of monitored ambiences.

Figure 15. Screen for direct serial communication between *hardware* and desktop *application*.

The application also provides queries in theD-ados B anco created, through *the json libraries*, *requests*, *and kivyMD*, as evidenced by Figure 16.

Figure 16. Screen for performing consultations.



From the above, it is evidenced the great potential *that applications written in python*, especially using the *framework library kivy*, can offer developers who have the purpose of monitoring and controlling biosystems, in a practical and simple way, by providing a wide range of functions that, consequently, can optimize systems, as well as reduce losses and waste in their production chain.

4 CONCLUSION

Despite thedevelopment of the application ser dedicated to computers, the library used (*kivy*) has cross-platform quality, that is, it can be used for *both desktop and mobile applications*. The development of *the desktop application* written in *python* presented great practicality compared to the use of other development systems currently available, such as *low-code development platforms*, taking into account the period of development, functions available, ease of access, practicality of use and simple graphical interface.

It is worth mentioning that despite *using wireless* communication (*Bluetooth*) *the desktop application* also presents or well functioning with wired networks, since the *pyserial library was* used, evidencing the development potential for communication with embedded systems with wired or wireless networks.

Although the systems used as a reference base, throughout this work, refer to aviaries, the application developed can be applied in several other systems, such as grain storage silos, greenhouses, crabs and also fruit storage systems, to examples of controlled and dynamic atmospheres, where temperature levels, relative humidity and gases of the environment must have strict control, as they can directly influence the period of conservation of these foods.

In this sense, it aims to carry out, in future projects, *tests with the desktop application developed in practical* tests in real Biossystems, with the purpose of disseminating the *use of applications written in* *python*, in systems of monitoring ambiences, due to its rapid development allied to its wide range of application possibilities in different areas of agribusiness.

ACKNOWLEDGMENT

This study was financed in part by a scientific initiation grant, process no. 2021/07319-9, Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP).

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