Labview Virtual Instrument Based on Intelligent Management and Monitoring of Microclimate in Precision Pig Farming with Wireless Sensor Network

Belma Gaazi, Plamen Daskalov, Tsvetelina Georgieva, and Eleonora Kirilova
Department of Autromatics and Mechatronics, Ruse 7017, Bulgaria
Email: {bgaazi, pdaskalov, cgeorgieva, ekirilova}@uni-ruse.bg

Abstract —The article proposes a Labview based virtual instrument for visualization on technological and economic parameters in precision pig farming with WSN (Wireless Sensor Network). The dynamic economic model is applied in the virtual instrument, which calculates the economic effective temperature with a direct search optimization algorithm. On the front panel are visualized the current values of profit, feed consumption and heating depending on the input and measured parameters. Based on the received data, the relevant outputs for the control are activated. The proposed system offers a useful cost-effective way to manage in the precision pig farm.

Index Terms—Labview, WSN, precision pig farming, economic effective temperature

I. Introduction

Pig farming in Bulgaria is one of the most promising branches of stock breeding in Bulgaria. In the context of increasing competition, more and more efforts are being made to improve the quality and reduce the cost of production [26]. To achieve this goal, it is necessary to improve the living environment in the livestock housing and lower energy costs, with emphasis on computer based management support and real-time production monitoring capabilities with state-of-the-art computer technology and wireless sensors networks [1]-[3]. The application of wireless sensing networks in the field of agriculture is an increasingly widely used technological innovation in building decision-making systems to solve and facilitate a number of problems in this sector [4], [5], [8], [9], [19]. Therefore, in advanced precision farming, sensor data networks are used to derive the optimal solution for managing and adjusting environmental parameters to achieve higher productivity and optimize resource use [7], [10], [11].

Modernization in the field of agriculture is needed in order to develop and it is necessary to emphasize the automated processes with decision-making systems [25], [27]. New concepts of information management mean that farmers need to be ready to acquire skills to use new technologies to collect and analyze data coming from sensors in different formats [10], [15].

The microclimate in livestock breeding must provide an optimum animal environment, which in turn influences the growth, consumption of feed, which determines the economic efficiency of the production. One of the main components that increase productivity in agriculture is the choice of appropriate management technology, and it is related to the efficient and economical use of energy resources with the potential to reduce production costs [23], [24]. The main task in livestock management is choosing the right temperature to maximize growth and minimize feed costs. The aim is not to choose the biologically optimal temperature by a norm [21] but to calculate the cost-effective internal temperature in relation to the other factors influencing it [22].

This article presents the concept of a virtual supervision system enabling the control and monitoring of the temperature at the pig farm. Therefore it will be possible to improve the comfort of use of the system, to increase growth and to reduce the energy costs by optimization algorithm.

Three tasks are essential to achieve precise control of the production environment: 1) monitoring the microclimatic parameters [6], [12], [13]; 2) analysis of observed data and decision-making, accompanied by optimization [25]; and 3) application of control mechanisms.

II. Structure Scheme of the System

The system is a set of input and output parameters, some of which are setting by an operator such as:

- 'm' – the mass of the animal, kg;

'Np' - Number of animals kept in the building,, pcs.

- 'da' - humidity of outdoor atmospheric air, g/kg and 'Vw' - wind speed, m/s is the average for the season, 'Gb' - the air exchange in the building is set according to the norm basis for the type and age of farmed animals, m/s.

- 'CenaQf' - current price of electricity for business customers, BGN/kWh,

'CenaF' - average price of fodder, BGN/kg and 'CenaM' - average purchase price of pork meal, BGN/kg.

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Corresponding author email: bgaazi@uni-ruse.bg.
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- 'ta' and 'tb' are the measured current values of the external and internal temperature of the sensor devices, ℃.

An economic model [20] is applied to the graphical user interface 'GUI', which calculates the economic effective temperature that is appropriate to maintain in the room to maximize profit with minimal energy and feed costs. The economic model includes heat and moisture equations for animals (1), (2), heating (3), growth (4) and feed consumption (5).

$$Q_p = f\,(\,tb,\, N_p,\, m\,); \qquad (1)$$

$$D_p = f\,(\,tb,\, N_p,\, m\,); \qquad (2)$$

$$Q_f = f\,(\,t_a,\, d_a,\, V_w,\, G_b,\, D_c,\, D_p,\, Q_p,\, tb\,); \qquad (3)$$

$$Pr1 = f\,(\,tb,\, m\,); \qquad (4)$$

$$xP1 = f\,(\,tb,\, m\,); \qquad (5)$$

Required parameters are entered in the economic-efficient model by an operator. Values of the external and internal temperature of the sensor devices are measured. The calculation procedure is started from the program. The output parameters are calculatedusing optimization algorithm with a direct search method in the 'Optimization' block. The current values which are visualized on the front panel 'GUI interface' are for profit, costs and economic effective temperature that is appropriate to be maintained in the pig farm [20] (Fig.1).

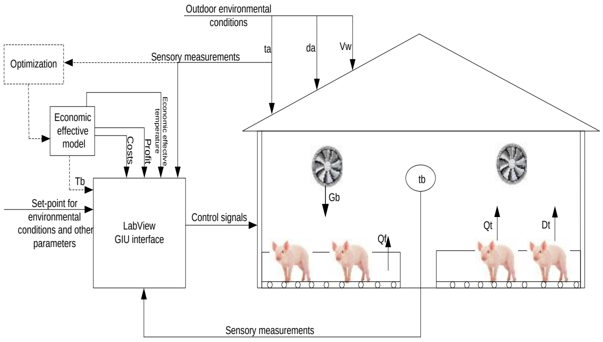

Fig. 1. Structural scheme of the system

III. Technical Implementation of the System

Based on the selected wireless sensors and the base station, a sensor network is formed to allow to be measured the temperature in selected points. Information on the observing environment is provided wirelessly to the MIB520 USB Base Station (Gateway) connected to a computer by IRIS 2.4GHz wireless sensor devices powered by batteries (Fig. 2).

Fig. 2. MIB520 USB Gateway and wireless sensor (MDA100)

The sensor devices allow measurement of the temperature distributed in the spacing space. At larger distances above 100 m from the base station, the data packets are send to a close neighboring sensor module. These modules transmits the information to the base station from the relevant sensor device id etc. they can work as routers. The structure of the sensor network is shown in Fig. 3.

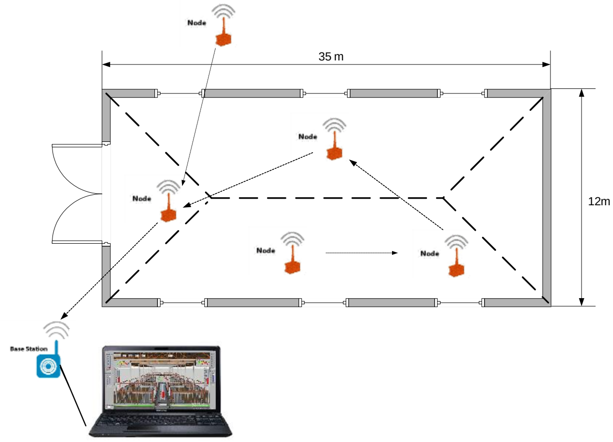

Fig. 3. Wireless sensor network structure

IV. Program Implementation in the Labview Environment

To implement the proposed system, a Graphical User Interface (GUI) was develop in the LabView programming environment. The Labview Interface has been widely used in the development of monitoring and management systems in the field of precision livestock farming [14]-[18].

The application of LabVIEW environment for the building of the virtual supervision system makes it possible to create the systems adapting themselves to the individual needs of their user and, consequently, to implement such a system for various objects and various production processes.

Many libraries with a large number of functions for data acquisition, signal generation, mathematics etc., along with numerous for functions such as integration, filters, and other specialized abilities usually associated with data capture from hardware sensors is enormous. In addition, LabVIEW includes a text-based programming component named MathScript with added functions for signal processing, analysis, and mathematics. MathScript can be integrate in graphical programming using script nodes and uses a syntax that is compatible generally with MATLAB [27].

A. VI - Virtual Instrument

The general appearance of the GUI is shown in Fig. 4. The interface contains a panel presenting data from sensor modules and displaying temperature in a farm for fattening pigs in degrees Celsius. The information is represented by five sensors measuring external (1 sensors) and internal temperature (4 sensors) respectively in digital and graphical form.

In the second subsection (Fig. 5), is graphically represented the level of the batteries on the sensor devices, which information is useful for easily detecting the sensor that need replacement of the batteries.

Fig. 4. Interface of the virtual instrument – Front panel

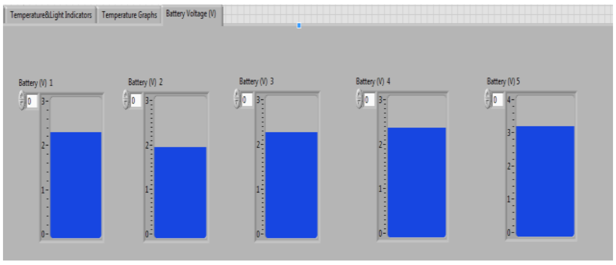

Fig. 5. Sub-section of the virtual instrument for the battery level on the sensor devices

B. Block Diagram

The block diagram of the program creates the algorithm of the software. In the created system, the block diagram is divided into several parts corresponding to different functions:

1) Initialization of sensor modules from the network

In this fragment of a block diagram is starting the program. As a first step, is detected the base station connected to the corresponding com port on the computer. Once the base station is identified, the sensor network and the recognized number of sensor modules are initialized. Each recognized sensor module which are pre-programmed under the number is arranged in a ascending order list and then the information is read from them.

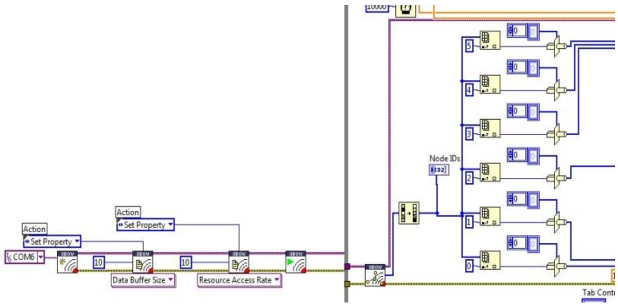

Fig. 6. Fragment of block diagram initializing the sensor network and the individual sensor modules

2) Collection of data from sensor devices

The data from the particular sensor modules is forwarded to the  block (Fig. 7), which the output are received the digital information for temperature and battery level voltage, which is visualized on the front panel.

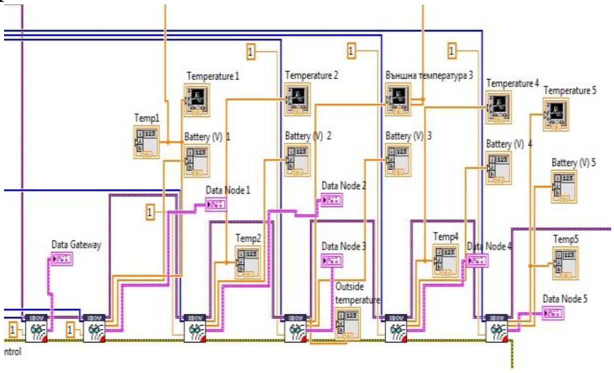

Fig. 7. Block block diagram to collect data from sensor modules

3) Optimization in Matlab environment and displayed of measured data on the front panel

Pig farm optimization of production can be supported with a production function mechanistically derived from dynamic growth and feed intake information [23]. Production–theoretical optimization requires, first, an accurate description of underlying processes and, second, possibilities for calibrations with available on-farm data. For the optimization procedure, it is necessary to measure the outside temperature, which will return a value for an optimal internal economic effective temperature that is appropriate to be maintained in the room (Fig.8). This obtained temperature is which that obtained maximum growth with minimum feed and energy costs.

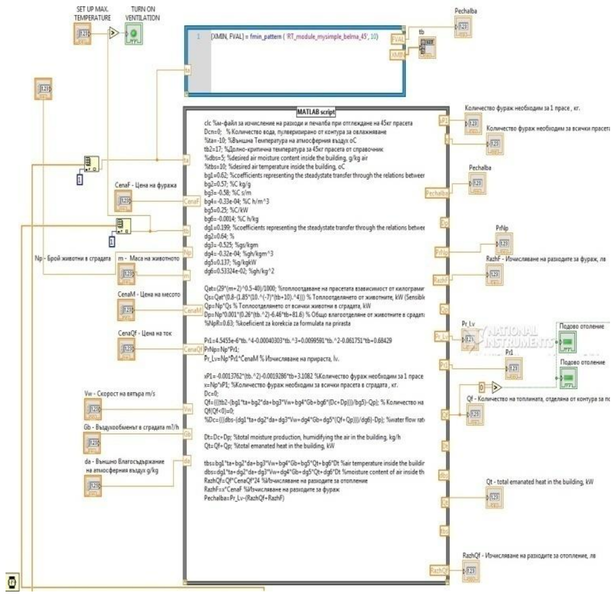

Fig. 8. Fragment of the block diagram executing the computation procedure in a matlab script node

For optimization procedure we used MathScript Node on the block diagram, represented by the blue rectangle (Fig. 8). Using MathScript Node, we can enter .m file script import it from a text file created in the Matlab programming environment. In this section is define named input and outputs on the MathScript Node border to specify the data to transfer between the graphical LabVIEW environment and the textual MathScript code.

The cost-effective temperature and the profit are obtained after calculation procedure on the output of the MathScript node.

The MATLAB script used in the gray rectangle calculates current data of the growth, feed and energy costs and profit in real time (Fig. 8).

V. Test on the System and Rezults

The system is tested for performance with integrated model for 45 kg fattening pigs in a standard panel building. The results of the current measurements and the results obtained from the optimization are shown in Fig. 9.

Fig. 9. Simulation test on the Graphical User Interface (GUI)

In the section on the left are displayed the measured outside temperature and the values of the optimization procedure for the economic effective temperature (tb), which is appropriate to be maintained in the room, and the profit (Pechalba) obtained at this temperature. In the main field, are displayed current data on the temperature inside the room and the values of feed, profit and needed heatingenergy.

VI. Conclusion

The systems integration through the creation of a supervision system for monitoring and controlling the technical and climatic parameters occurring at the farm makes it possible to increase the capabilities of the whole management system. This system enable the extension of the functions with tasks relatedto production planning and management of the process using collection and data processing from wireless sensor network systems.

The status of system is monitored and the user is provided with the complex access to information from one place.

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Belma Gaazi was born in Ruse, Bulgaria, in 1986. She received the B.S. degree from the Ruse University in 2010 and the M.S. degree from the Ruse University in 2011, both in automation engineer. She is currently pursuing the Ph.D. degree with the Department of Automatic and Mechatronic, Ruse University. Hers research interests include modeling, optimization, and graphical user interfaces.

Plamen Daskalov was born in Ruse, Bulgaria, in 1958.Hegraduated HTS "Angel Kanchev" - Ruse in 1984- Engineer in Automation of production. He defended his PhD thesis in 1992. In 2000 year he is elected Assoc. professor. In 2012 year he is elected Professor in Automation of Production. In 2016 year elected Vice Rector in Development, Coordination and Continuing Education and Director of the Centre for Continuing Education with the University of Ruse "Angel Kanchev". His research interests include Identification and modelling of process and systems in agriculture; Application of computer systems and IT in managing the technological processes in precise farming; Automation of processes in livestock buildings and greenhouses; Evaluation of quality of agricultural products via digital images and spectral characteristics.

Tsvetelina Georgieva was born in Kozloduy, Bulgaria in 1978. She defended his PhD thesis in 2007. In 2012 year he is elected Assoc. professor. Hers research interests include industrial networks in computer control systems and evaluation of quality of agricultural products via digital images and spectral characteristics.

Eleonora Kirilova was born in Ruse, Bulgaria, in 1984. She received the B.S. degree from the Ruse University in 2006 and the M.S. degree from the Ruse University in 2007, both in automation engineer. She defended his PhD thesis in 2013. Hers research interests include evaluation of quality of agricultural products via digital images and spectral characteristics.