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Automated Farming System Using Distributed Controller: A Feasibility Study

M.M. Rashid*, Alioune Sall, Tahsin F Hasan

Department of Mechatronics engineering,
International Islamic University Malaysia, Kuala Lumpur, Malaysia

*Corresponding author: mahbub@iium.edu.my

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Abstract— Agriculture is fundamental to a human being because it has itranted humanity's evolution. It is among the essential activities that ensure the development of the human being. So, it is capital to ensure good work and the efficiency of agricultural production. Thus, the research is focused on the domain of agriculture automation to increase the agriculture production yield with less water consumption and less risk in Africa, particularly in Senegal, where agriculture delays reaching food self-sufficiency because of rudimentary materials. The farmers are using a hilar, plough, and hoe for doing their daily tasks. The watering can still be used to water a large area of crops and is done randomly. The chemical pesticide is done manually using a manual sprayer, which causes enormous risks of diseases to the farmers and destroys the field and even the crops. This thesis describes an approach to automated farming by the use of a Sprayer Robot based on Arduino. Besides the Sprayer Robot, the paper also presents an automated irrigation system based on the Senegalese climatic parameters and soil textures through CROPWAT and CLIMWAT. The automatic irrigation system is done with a programmable logic controller, the master controller of the overall design, including the Sprayer Robot. Moreover, a SCADA graphical interface is also implemented for the monitoring of the whole system. The project, tested in simulation with the CROPWAT and CLIMWAT data, could give no reduction yield if applied and also reduced risk of diseases due to chemicals.

Keywords: *Communication planning, tools, Factors affecting the quality and method*

1. INTRODUCTION

This research will focus on agriculture automation and will ensure the easiness of using farming in advanced technologies. Facing an increase in its population and the food insecurity which threatens the national territory of Senegal since 2012, the

This research will focus on agriculture automation and will ensure the easiness of using farming in advanced technologies. Facing an increase in its population and food insecurity that threatens Senegal's national territory since 2012, the Senegalese government had set up a lot of programs for the development of agriculture that would help achieve food self-efficiency in Senegal. But in fact, almost all of these programs have not succeeded in reaching their targets because of several reasons that the researcher will develop in the problem statement section (DAPS, 2013).

Besides, in poor countries, agriculture is underdeveloped compared to western agriculture. Particularly in Senegal, the rural population represents 55% of Senegal's total population, estimated at 13.5 million in December 2013. The agriculture- the fishing sector is an important economic sector; it contributes 14% of GDP and employs around 50% of the labour force (Havard, 2015). Despite this, more than half of rural people, usually tiny subsistence farmers, live below the poverty line and 30% are affected by food insecurity (Havard, 2015). Agriculture is based on cash crops (peanuts, cotton, horticultural products in part) and food crops (mainly cereals). Most of these are seasonal and rain-fed, centred on the wintering period. But irrigated areas, representing only 5% of the agricultural area, and off-season production tend to develop. Climatic hazards, declining soil fertility and pest attacks have a substantial impact on production (DAPS, 2013)

Motor pump use also exists for agricultural cooperatives and a few peasants (DAPS, 2013). Irrigation is done at intervals of time according to the appreciation or experience of the farmer. No information on climate or soil is considered. Thus, it is obligatory to update this field by doing some research to come out with some good solutions. Globally, mechanization is a crucial input for agricultural crop and has been neglected by many countries, especially in Africa (FAO, 2019). Increasing the power supply to agriculture means that more tasks can be completed, and more significant areas can be farmed to produce greater quantities of crops while conserving natural resources. Applying new technologies which are ecologically friendly allows farmers to harvest crops more efficiently by using less power.

So, this research is to help the agricultural policies in Senegal. It is known that farming is needed to quickly reach the food self-efficiency that has been proceeded many years ago without satisfactory results. Therefore, one of the purposes of this research is to figure out some ways to lead the farmers to do their jobs better by modernizing it while showing the African governments that mechanization agriculture does not only mean making a big investment in tractor or other machinery.

2. METHODS

The research starts with a deep analysis of problems and a literature review. After the period of the literature review, the period of data collection will come through one Senegalese farm field, which can be used as a witness. The study will provide information for developing the irrigation system and the distance between lines of the crop. Then, the connexion will be established with the Senegalese Institute of Agricultural Research to get the needs of each type of crops concerning a specific region and the dosage of chemical preparation that can eliminate weeds and the needs of water.

Once all of the above is done, the study's start will be made by the robot's conceptual design and programming, which can be spraying the pesticide in two opposite directions. First of all, we have the designing process of the robot, which starts by setting its dimensions. Afterwards, we will choose the different types of materials we will need and create a mechanical part of the design. The electrical component consists of selecting the motors, power supplies, sensors, and wiring diagram. The last part of this process consists of choosing the controller and building up the robot.

Secondly, we will design the irrigation system by choosing pumps and pipes based on the depth of the well and the distance from the well to the plant. The study of humidity, temperature, and wind speed sensors can allow us to get data from the soil and the environment for commanding the water pump. Thus, resolve the problem of manual watering. This part will be done essentially in software by programming and simulation. After that, it will be the stage for the researcher to come out with the PLC's choice and its components. To do the programming and the research starts with a deep analysis of problems and literature review. After the literature review period, the period of data collection will come through one Senegalese farm field that can be used as a witness. The study will provide information for developing the irrigation system and the distance between lines of the crop. Then, the connexion will be established with the Senegalese Institute of Agricultural Research to get the needs of each type of crops concerning a specific region and the dosage of chemical preparation that can eliminate weeds and the needs of water. Once all of the above is done, the start of the study will be made by the conceptual design and programming of the robot, which can be spraying the pesticide in two opposite

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stage for the researcher to come out with the PLC's choice and its components. To do the programming and then examine each system's interconnection in the PLC and its flows. The work of the irrigation system will be stimulated through the PLC. Finally, the researcher will implement the monitoring interface by SCADA and allow the farmers to set the concerning plant parameters and know what happens in their farms. The methodology flowchart can be seen in Fig. 1.

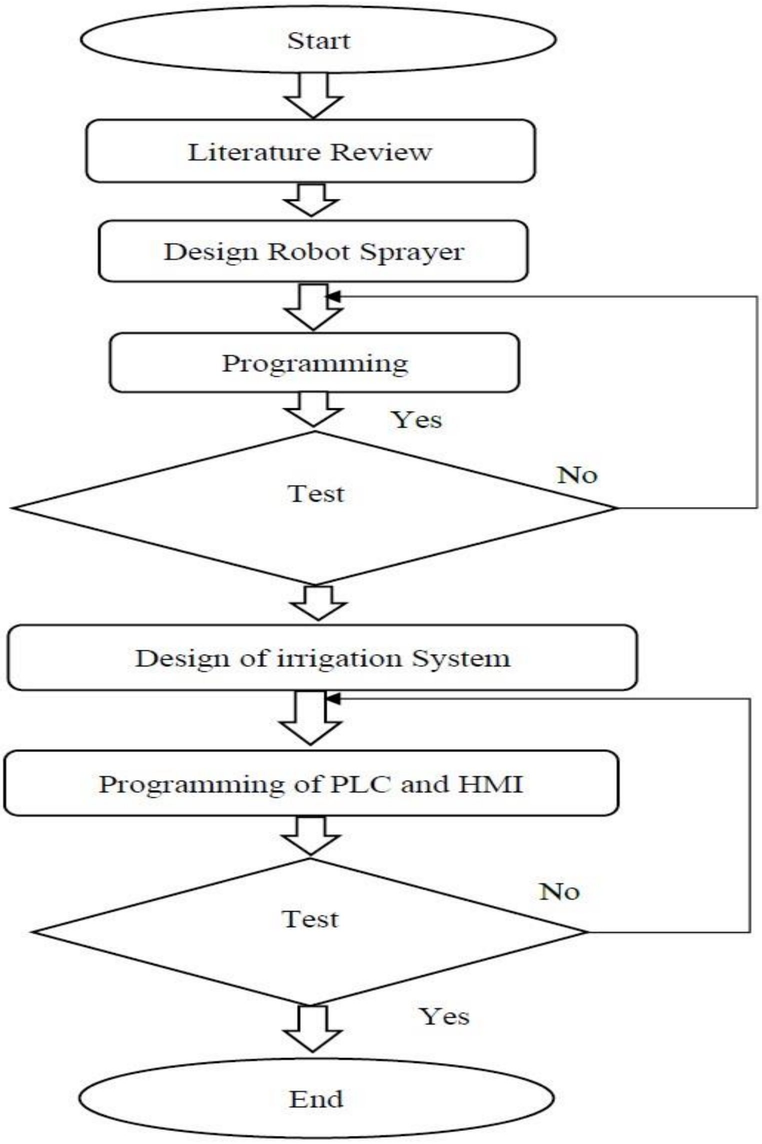

Fig. 1. System flow chart

3. CONTROLLER DESIGN

The control system is a mean of allowing to increase the competitively of a product established by the system. It can improve productivity, enhance the flexibility of the process, increase the quality of the product, adapt to particular contexts, and increase security. For that reason, the control system is a crucial task in order to achieve the purpose of this project. The control system of a process involves transferring some or all of the coordination tasks previously performed by human operators to a set of technical objects called the command part. The control part memorizes the know-how of the operators to obtain the continuation of the actions. This is to be carried out on the materials of work in order to elaborate the added value. It exploits a set of information taken from the operative part to develop the succession of orders necessary to obtain the desired actions. The operative part is equivalent to the process and the physical machine. The control part is equivalent to the automation and the programmed system.Figure 2 illustrates the structure of a control system.should be absolute

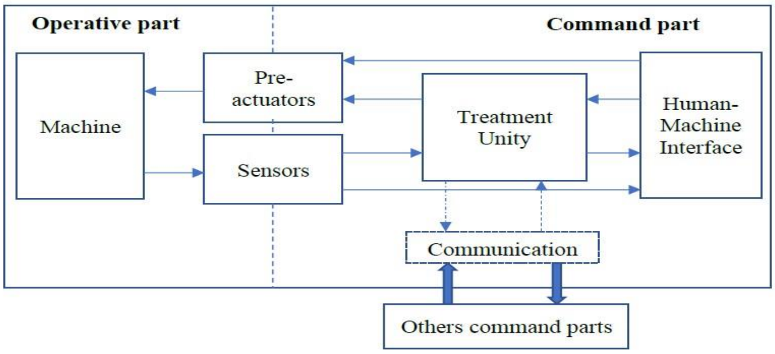

Fig. 2. Structure of a control system

The system first checks the highest level of water inside the tank. If the water does not reach the highest level of the tank, the PLC turns on the pump until the highest level is reached. After reaching this level, it turns off the pump. Then, the PLC checks the soil moisture sensors to see if the management allowable depletion is reached. The controlled valves are opened until the soil moisture sensor reaches the field capacity and the valves are closed.The temperature and humidity sensors will allow us to have information about when the next rrigation will occur.

Figure 3 depicts the working principle explained in this section and Figure 4 the block diagram connections of the irrigation.

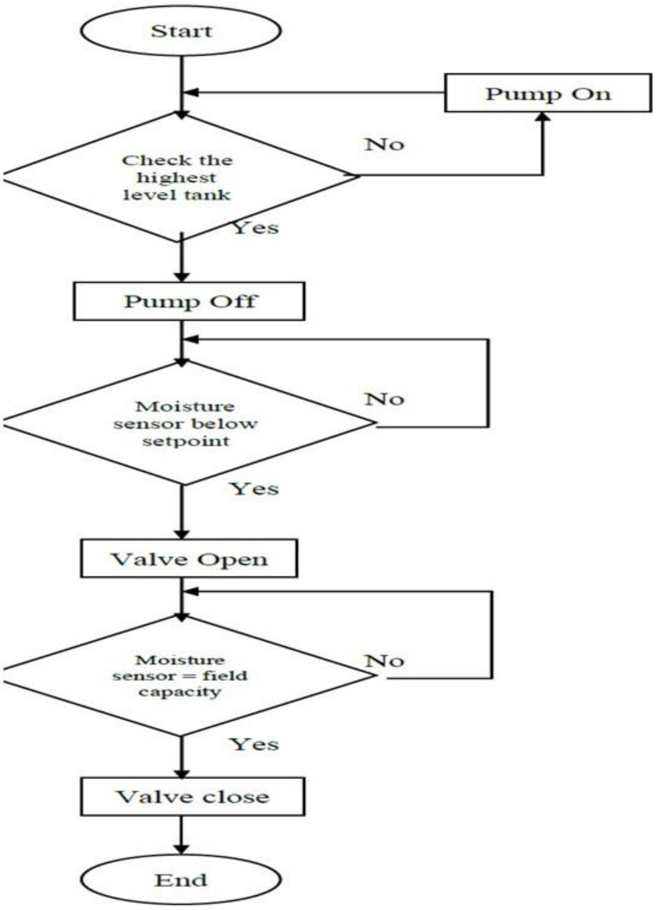

Fig. 3. Control algorithm flowchart

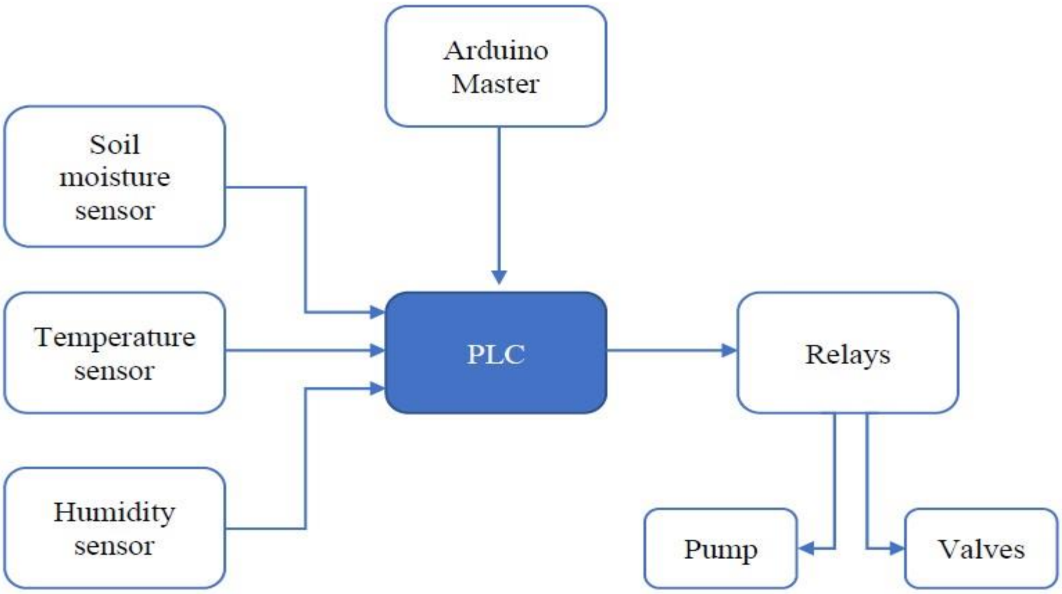

Fig. 4. Block diagram of the irrigation system

Table 1 Input/output assignment

Name	Address	Type
CMD_close_valve	%M108	EBOOL
CMD_open_valve	%M107	EBOOL
CMD_Pump	%M106	EBOOL
FD_Setpoint	%MW10C	REAL
FD_Setpoint_mais	%MW15C	REAL
FD_Setpoint_tom	%MW16C	REAL
FD_Setpoint_veg	%MW14C	REAL
High_level_tank	%M105	EBOOL
Humidity	%MW60	REAL
Input_humidity	%MW50	INT
Input_in_temp	%MW40	INT
Input_soil_moisture	%MW30	INT

Table 2 Input/output assignment

Low_level_tank	%M103	EBOOL
MAD_Setpoint	%MW90	REAL
MAD_Setpoint_mais	%MW120	REAL
MAD_Setpoint_tom	%MW130	REAL
MAD_Setpoint_veg	%MW110	REAL
RobotRun	%M102	EBOOL
Soil_Moisture	%MW70	REAL
StartRobot	%M100	EBOOL
StopRobot	%M101	EBOOL
Tank_1_Close	%M121	EBOOL
Tank_1_Enable	%M123	EBOOL
Tank_1_Level	%MW10	REAL
Tank_1_Open	%M120	EBOOL
Tank_1_Power	%MW20	REAL
Tank_1_Valve	%M122	EBOOL
Temperature	%MW80	REAL

4. RESULT

Regarding the robot, in the graphical interface, the user can order to run or stop the robot through the button StartRobot and StopRobot. The symbol in the robot box in figure 5 shows the robot's status.

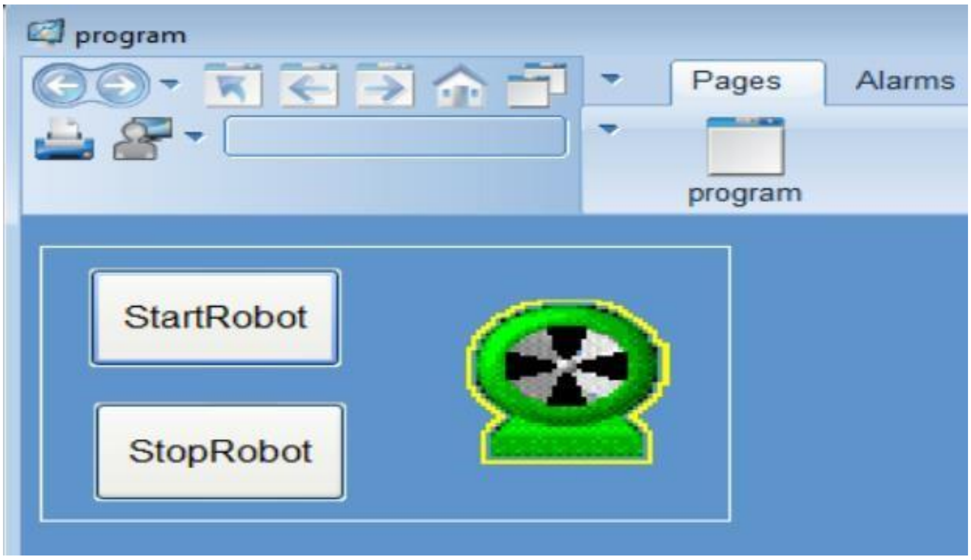

Fig. 5. When the robot is on start mode.

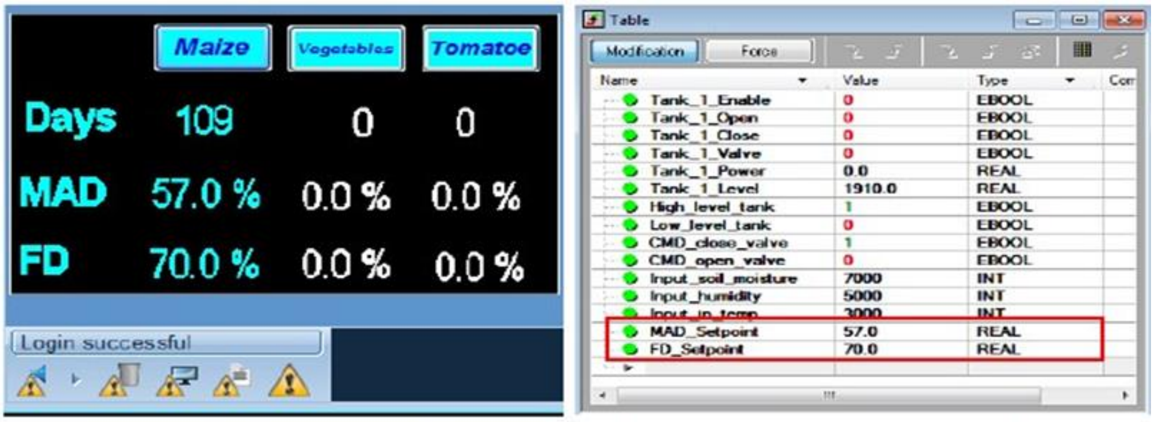

Fig. 6. Maieze SCADA database box and PLC input/output table

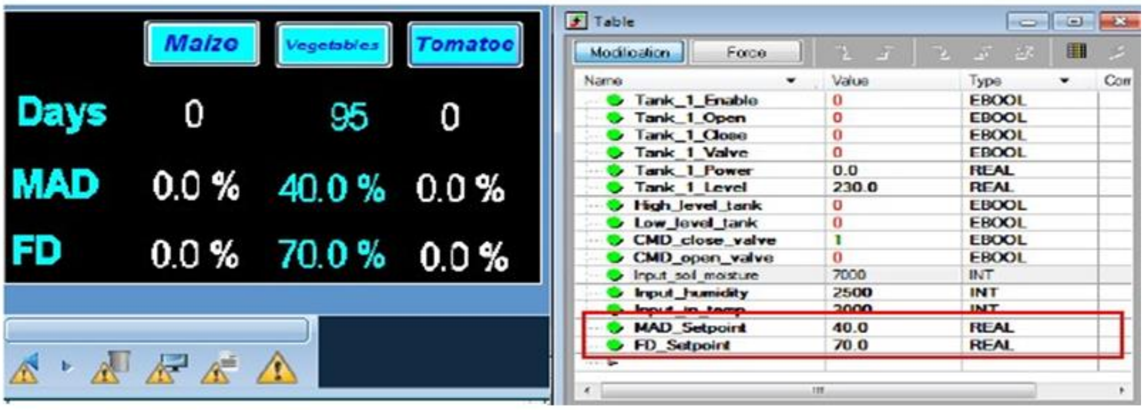

Fig. 7. Vegetable SCADA database and PLC input/output table

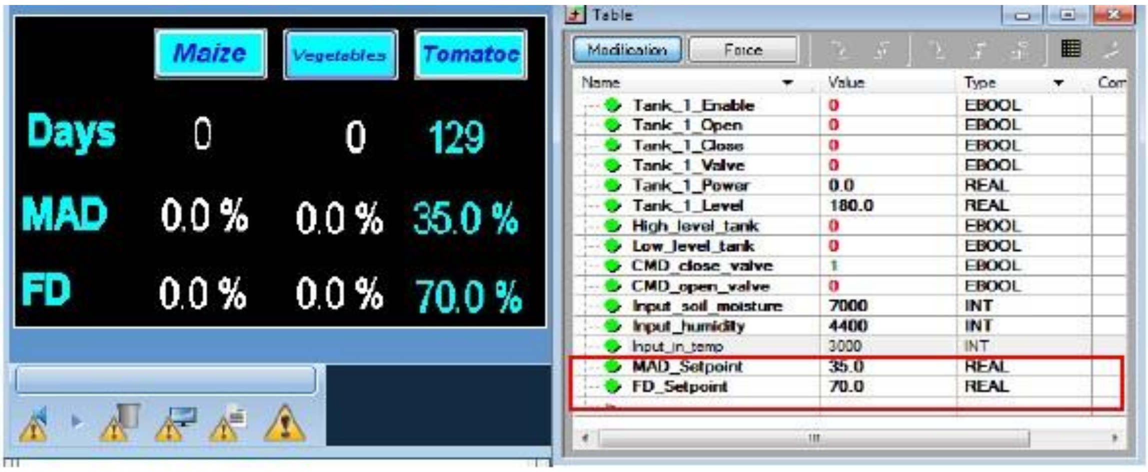

Fig. 8. Tomato SCADA database and PLC input/output table

From the results discussed above, it can be assessed that the master controller of the whole automated farming system has satisfactory performance, even it still remains some option that can be improved. The system loads perfectly the data from the database but it requires the database file to be launched before in the same computer.

The SCADA interface gives a perfect representation of the automated farming system and from the entire tests done, it can be resumed that the automated farming system is ready to be implanted in a practical situation.

5. CONCLUSION

The research contributions are summarized as follows. The design of a Spraying Robot can evolve in outdoor farming by using railways and no GPS tracking as guidance. The method of a graphical interface in irrigation is connected with a databas that does not need an internet connection to work. Implementation of Input/output – Bluetooth communication between the robot and the PLC. There were several challenges faced during this research, such as:

a) Establishing communication between the PLC and the sprayer robot.

b) To link the database with the SCADA by the use of Cicode.

c) The connection link between the two Bluetooth modules respectively for the robot.

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