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Smart plants care system using Bluetooth technology

Giorgiu Alexandra-Maria

Abstract

This paper discusses the replacement of manual processes and the way in which the possibility of human errors in plant care is eliminated. The benefits that the intelligent system brings are the reduction of human errors, the reduction of time for plant care such as watering the flowers, checking the humidity of the plants, moving them to a brighter place.

Keywords: system, errors, efficiency, Bluetooth, smart

1 Introduction

Nowadays, the automation and efficiency of intelligent systems is increasingly pursued. This work in turn represents a replacement of manual plant care processes. The realization of this automatic process is done by taking and processing the data by a light detection sensor, a humidity sensor and a water level sensor. The data, once transmitted to a microcontroller, are analyzed in order to make decisions for the constant maintenance of brightness and soil moisture according to certain specified parameters. At the same time, the monitoring of the water level in the tank is done by the level sensor which, in case of emptying the container, will notify the user through a message sent by the microcontroller.

After processing, these data will be displayed to the user through an Android application that can be installed on any smartphone starting from version Android 9.0 or later and that uses Bluetooth technology. The application was created from the desire to facilitate the maintenance of plants, reduce costs by optimizing the consumption of resources, reduce human errors (for example adding too much or not enough water), save time and precisely monitor external factors, thus also having the facility to receive status through a notification to the user with the status of the entire system in real time.

For an easier visualization and for the ease of physical design of the components that serve the work, a 3D prototype was made, with the appearance and approximate dimensions of the smart Plant Care System through Bluetooth technology (Figure 1.0.).

Figure 1.0. Smart plant care system through Bluetooth technology - Prototype in SketchUp

2 Introductory notes

2.1 The .NET platform

.NET is an open-source development platform, a free cross-platform, for making various applications. For this, multiple programming languages, editors and libraries can be used to create web applications, phone applications, desktop applications, games and IoT (applications that use the Internet).

The main solutions offered by the .NET platform are the following:

- Interoperability with existing code
- Full language integration (inheritance support, exception throwing and debugging for multiple programming languages)
- base class library
- Code implementation in a simpler way [1].

Regardless of the programming language supported by this platform, the code can run on any compatible operating system. Different components that help the implementation:

- Cross-platform .NET – for websites, console applications on Windows, servers, macOS, Linux
- NET Framework – supports websites, desktop applications, services
- Xamarin – a .NET implementation for building and running applications on all known mobile operating systems [2].

2.2 Control system with negative feedback loop

In a closed-loop control system the input signal is affected by the output signal. Using this information from the output to modify the system's input signal in some way, a feedback signal is applied to that system. Many times, the applied signal from the system output is compared with a reference input signal, and the result of their difference being used as the input signal on the control system. Often the input reference signal is closely related to the desired output signal, and this being a constant value with respect to time is called the input set point [3].
Such a closed-loop system of a soil moisture control system is shown in figure 1.3.1., where the input data is the optimum moisture, the error is the difference between the optimum soil moisture and the actual recorded value, and the response is given by the loop negative response.

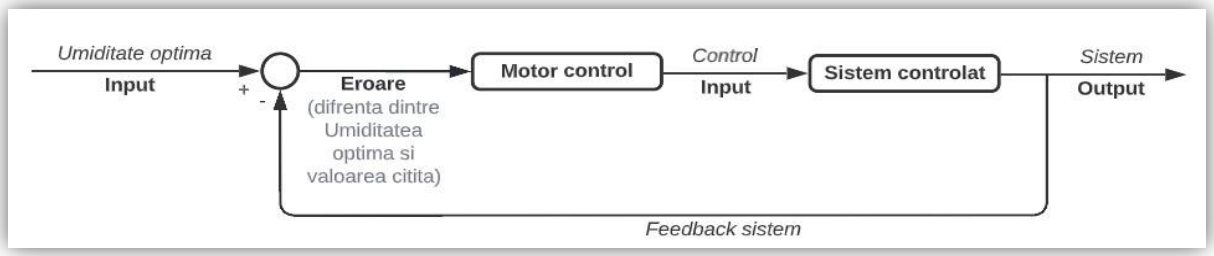

Figure 1.3.1. Closed loop control system

Due to the negative feedback (negative because the output signal is subtracted from the input signal) the accuracy of the system with respect to the desired value is greatly improved compared to the response of an open-loop system, this is because the goal of the control system is to minimize the error between the output and the reference value input.
A disadvantage is that in a closed-loop system oscillations can occur at the output that would not occur in an open-loop system. These oscillations can occur in an attempt to minimize the error as much as possible.

3 System architecture

As part of the project, the system is made up of four major components. The control system part is composed of three modules:

- sensor part (light sensor, water level sensor, soil moisture sensor)
- actuator part (water pump, LEDs)
- the communication part (Bluetooth)

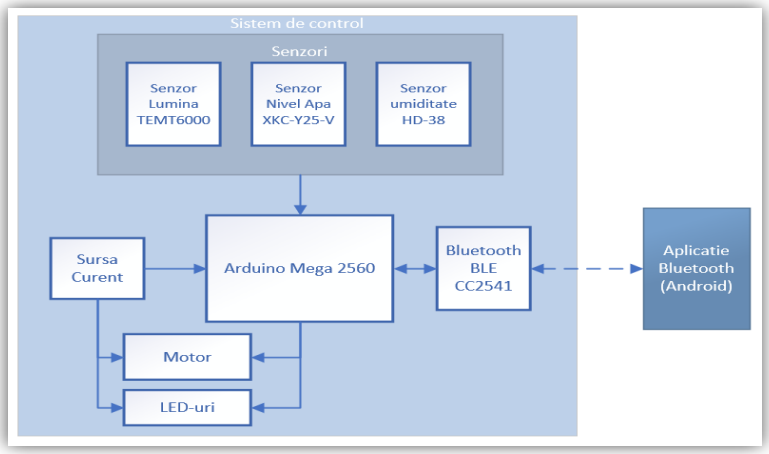

Figure 4.1. System block diagram

The fourth component of the entire system is the mobile application that uses the Android operating system.
The functionality of the whole system has as its first step the reading of data through the sensors, the data is analyzed and processed according to the program with which it is programmed on the Arduino development board and it will make decisions according to certain parameters.

The criteria by which the system will act:

- If the brightness reaches a specified minimum threshold, the LEDs will be on, and when the maximum threshold is reached, they will be off.
- If the soil moisture level falls below the specified limit, the motor will be turned on to pump water for the plant, otherwise, if the moisture level exceeds the set maximum threshold, the motor will be turned off.
- If the water level in the tank is below the set level of the sensor, a message will be generated for the user to add water, otherwise, a status will be displayed to inform the user that the tank is still full.

All this data is checked every 60 seconds to be updated in real time. The control system will send the data to update it within the mobile application as well.

4 Software component

4.1 Algorithm Implementation for Arduino Mega 2560

The code implementation for the Arduino Mega 2560 development board was done in the Arduino IDE 1.8.19. The first part of the program includes the Arduino.h libraries, <WS2812FX.h> [19] and which serve to recognize the internal functions of the Arduino language, namely the LED library.
Also, in the first part of the program, you can find the definition of some variables for the set pins and variables with predefined values that will later be used when comparing with certain values.

To be able to check values for the variable MOTOR_START_COUNTING_5s which will be a flag that will signal the moment when 5 seconds have passed, a boolean type variable (this one having only the value of 0 or 1 - High or Low) will be declared similarly for variables that signal engine that has been running for 60 seconds, LED status, LED pin status. The declaration of such a flag for the example given above is done as follows (similarly for the other flags used):

boolean MOTOR_START_COUNTING_5s LOW;

4.2 Code implementation and structure of the greenApp mobile application

To view the data and how to manage the smart plant care system, a mobile application has been created that can be installed on any smartphone device, starting from an Android version 9.0 or later.
The system is implemented to access data without the need for physical connections, the application using Bluetooth technology for short distance control, where the communication protocol used to transmit and receive data is called Bluetooth 4.0.
The greenApp application was implemented with the aim of facilitating the maintenance of plants that have specific moisture and light requirements. For example, for a cactus, the brightness level must be increased, and the humidity level must be very low, whereas for an orchid, the brightness level can be average, but the soil humidity level must be very high.
Another advantage that greenApp brings is the reduction of costs by optimizing the use of resources and reducing human errors. An error could be that when we water the plants, we can add much more than needed or not enough water, this problem is solved by the control system that constantly monitors the plant through sensors and makes intelligent decisions so that the level of brightness and humidity will always be the most optimal.
A user warning system has been implemented for the situation where during plant monitoring the water level in the tank is detected as almost empty. The user will be alerted by a message in the water level status section.
The system status is monitored in real time; thus, a data update is performed every 60 seconds.

Open page from the first button shows us the name of the accessed page in the top bar, a suggestive title in the middle of the screen, the text with the description of the application and an image of the device. (Figure 5.1.)

Figure 5.1. Application description page

5 Conclusions

In the framework of this work, we created a smart plant care system through Bluetooth technology with the aim of finding a way to replace manual processes and eliminate human errors. The fact that we forget to do certain things, like watering the plants is perfectly normal, but why not find a way in which we can save both time and resources.

The benefits that the smart system brings can be: reducing or even eliminating the time lost to do repetitive operations such as watering flowers, reducing costs by using the smart system that "knows" how to use the necessary amount of water for each individual plant, increasing the quality of the results by finding the most optimal solution and eliminating the possibility of "drowning" of plants or their drying due to lack of water.

The functionality of the system is to take data such as soil moisture and brightness through sensors and process them in order to make decisions. The system also has a water level sensor that verifies in real time the state of the liquid in the container. If

the water level drops to the set limit, the user will be warned through the application. These decisions are made based on certain parameters entered and ensure the most efficient use of resources.

Another advantage is that the system is independent of physical connections, real-time monitoring of the data is achieved through a mobile application that connects via Bluetooth to an Arduino Mega 2560 board. The communication protocol is Bluetooth 4.0, and the mobile application is compatible with smartphones s that have an Android 9.0 or newer operating system. For the future project, the next step is to implement a new communication technology such as Wi-Fi and store user data in a database to create graphics that can be generated based on user configurations and preferences. Another method of improving the whole system is to mount a camera for take daily pictures and add them to a gallery.

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