

doi:10.15199/48.2022.01.15

The smart home systems projects based on the Arduino platform

Abstract: This work presents the control system of intelligent home systems from the Android application level. A plan was developed and two mock-ups were built - a smart home and an aquarium to illustrate the operation of the systems. Both models were created on the basis of the Arduino programming platform, which is characterized by high modification possibilities, allows for a practical and at the same time interesting way to present the issue on a real example of a smart home model.

Streszczenie: W niniejszej pracy został przedstawiony system sterowania inteligentnymi systemami domowymi z poziomu aplikacji dla systemu Android. Opracowano plan i zbudowano dwie makiety – inteligentnego domu oraz akwarium w celu zobrazowania pracy systemów. Oba modele powstały na bazie platformy programistycznej Arduino, która charakteryzuje się dużymi możliwościami modyfikacji, umożliwia w praktyczny, a zarazem ciekawy sposób przedstawienia zagadnienia na rzeczywistym przykładzie modelu inteligentnego domu. (Projekty systemów inteligentnego domu oparte na platformie Arduino).

Keywords: Arduino platform, modern technologies, smart home systems.

Słowa kluczowe: platforma Arduino, nowoczesne technologie, systemy inteligentnego domu.

Introduction

The development of electronics in recent decades has resulted in the creation of many systems that facilitate people's daily lives. Such systems may include intelligent home systems. Thanks to the use of intelligent building installations, it is possible to automate the operation of various devices with low financial outlays. Examples include controlled gates, roller shutters or controlled room temperature [1]. It is also possible to create controlled environmental conditions in the aquarium [2]. In this work, two models of solutions in the smart home and smart aquarium model programmed on the basis of the Arduino platform are proposed.

The Arduino system is a fairly popular, inexpensive environment, with great possibilities of free expansion with new functions. It is an open source electronic and programming platform with easy-to-use software and hardware. The Arduino is able to read various inputs - like for example pressing a button, and then convert that information into an output - like lighting an LED or starting a motor. The Arduino board can be connected to various types of displays, e.g. LCD or OLED, RFID reader, temperature, humidity, pressure, gas, smoke, ethanol sensors, motion sensor, Ethernet module, WiFi module, GSM module, SD card module or module engine controller.

Arduino environment

Arduino are single-board microcontrollers that can be used in various applications such as alarms, meters, industrial device drivers [3]. This publication proposes the use of the Arduino environment in the programming and construction of a smart home model and an intelligent aquarium with controlled parameters. Arduino offers both microcontrollers and software dedicated to their operation. Ease of use and open-source documentation led to the rapid popularity of Arduino and contributed to the choice of this environment in the models presented. The dynamic development of the platform has also contributed to the development of many Arduino compatible systems called "shields" used to expand the functions offered by the microcontroller. There are also many boards with sensors, relays or drivers ready to be connected to Arduino via wires, without the need for soldering.

In the Arduino microcontroller board, the main elements are: USB connector, enabling communication with the computer and performing the role of power supply, input and output sockets for connecting external electronic modules in the presented projects, for example: motion sensors, temperature sensors or air humidity sensor, sLED and IR LEDs and much more. The system can be powered via the USB connector on the board, and via an external power supply or battery. Once the microcontroller is programmed, it does not require connection with the computer. The Arduino module can be used for small projects such as traffic lights using LED diodes or indoor lights. The board can also be used for more complex and demanding projects, such as an example of an intelligent building system that requires communication with other electronic devices, such as a smartphone. Table 1 shows the Arduino models available for use on the market.

Table 1. Available Arduino models.

Basic series	Series MKR	Series Nano, Series Portenta
Arduino Uno	Arduino MKR Zero	Arduino Nano
Arduino Uno WiFi	Arduino MKR WAN 1300	Arduino Nano Every
Arduino Leonardo	Arduino MKR 1310	Arduino Nano 33 IoT
Arduino Mega 2560	Arduino MKR 1000	Arduino Nano 33 BLE
Arduino Pro Mini	Arduino MKR Vidor4000	Arduino Nano 33 BLE Sense
Arduino Micro	Arduino MKR NB	Arduino Portenta H7
Arduino Due ARM Cortex	Arduino MKR GSM	
Arduino Yún	Arduino MKR 1010	
Arduino Pro	Arduino MKR FOX	
Arduino Fio		

Prepared on the basis of [5]-

The used microcontroller has a microprocessor, memory and general purpose inputs and outputs, i.e. GPIO (General Purpose Input Output Pins) [6]. The microcontroller has built-in circuits and does not need any additional elements for proper operation. The built-in systems are: serial transmission controllers, analog - digital or digital - analog

converters or timer - counters. Microcontrollers are used to control electronic devices e.g. RTV and household appliances, automation systems or computer components. They are also often used to control devices remotely.

The aim of the presented research was to create the smart home devices, programmed in the Arduino environment, without the use of ready-made, programmed, but much more expensive electronic systems. A mock-up of a smart home created using the Arduino Mega 2560 board is presented, along with a mobile application that allows to control the system using a smartphone via Bluetooth technology and there is presented a model aquarium, programmed using the Arduino Uno board, in which the habitat of fauna and flora is controlled.

The smart house mockup programmed in the Arduino environment

The smart home mockup was created using the ATmega 2560 microcontroller embedded on the Arduino Mega2560 Rev3 board (fig. 1), so it was necessary to program all electronic components in the Arduino environment [7].

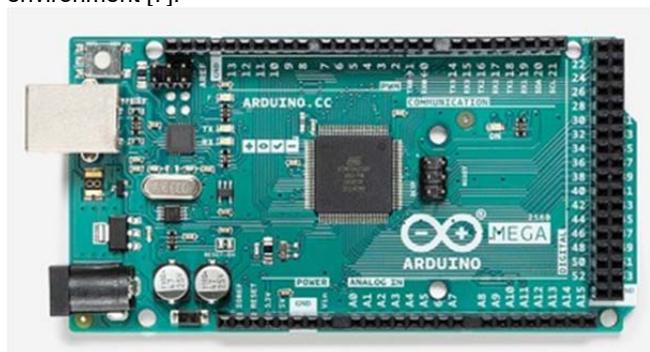


Fig. 1. Arduino MEGA 2560 microcontroller [4]

The Arduino Mega 2560 controller is characterized by 54 digital inputs / outputs, 15 of them can be used as PWM outputs, it also has 16 analog inputs. Arduino Mega has 256kB of Flash memory and 8kB of SRAM memory. The main advantage of this model is the large number of inputs and outputs, which is why this model was used in the model.

Remote control of the programmed mock-up is possible through the use of a Bluetooth module, thanks to which the mock-up is able to communicate with a pre-programmed mobile application. The mock-up is equipped with a Bluetooth module, internal and external lamps, digital temperature sensor, motion sensor, IR transmitter and receiver, limit sensors and a movable entrance gate and garage roller blind.

The programming of the components of a smart home mock-up has been divided into 6 stages:

- Declaring inputs, outputs and variables
- Lighting programming
- Configuration of the alarm system
- Coding of the entrance gate mechanism
- Coding of the garage door mechanism
- Implementation of a temperature sensor.

The use of the Arduino Mega 2560 microcontroller in the model allowed for the free use of input and output pins, thanks to the appropriate size of this board. Each element has been individually connected to the inputs and outputs.

The model allows you to shine lights in rooms - it has the ability to turn on the lighting in each room separately. After the alarm system is activated, the user is informed with a sound and light signal. The alarm system can be violated in two possible ways: opening the front door and detecting movement in the mock-up garage. Then a light

and sound alarm will be triggered using red LEDs and a buzzer. After activating the entrance gate, it will be opened using a motor and a gear. During the closing of the gate, when the IR receiver loses the light beam it receives, the gate will stop its operation and return to the open state so that, when closing, it does not hit the disturbing object.

The project is designed in such a way that it has the possibility of further expansion, for example it is possible to add window sensors or CCTV monitoring, or a remotely activated fountain. It is possible to transform



Fig. 2. The smart home project programmed in the Arduino environment wireless communication technology or add voice control.

Aquarium controller based on the Android environment

The second proposed device built and programmed in the Arduino environment is an aquarium controller that allows you to automate the operation of a home aquarium. In order to make the model, it was necessary to design and build elements such as:

- lighting beam,
- CO₂ dispenser,
- heater controller,
- fertilizer dispensers.

All components were equipped with the necessary sensors and probes as well as the necessary software so that the controller could receive information about their correct operation. The system also includes a water level sensor and a flood sensor, which inform the user if there is too much or too little water. During the design and construction of devices, the main consideration was their reliable operation, safety and low price. The most important feature was the possibility of full control of all necessary components by one device.



Fig. 3. The Arduino Uno microcontroller used in the aquarium controller model [5].

The block diagram of the controller is presented in Figure 4. The most popular version was used - Arduino Uno (Figure 3). It has 14 universal GPIO pins, including 6 with the possibility of generating an 8-bit PWM signal. It also has 6 analog inputs and communication interfaces such as UART, I2C or SPI. It is powered with the voltage of 7-12V or USB type B, which is also used for programming. The microprocessor used in the board is ATmega 328P with the following memories: SRAM 2kB, Flash 32kB and EEPROM 1kB [4]. The driver was programmed in the Arduino IDE environment.

The driver does the work for the user and automatically checks all parameters in the aquarium and on their basis independently controls the settings and controls the devices without human intervention. Thanks to this, even in the absence of the owner, optimal conditions for living and development of both fish and plants are maintained, for which lighting is extremely important. Thanks to the designed lighting strip, it is possible to simulate the lighting of sunrise, sunset or strong daylight.

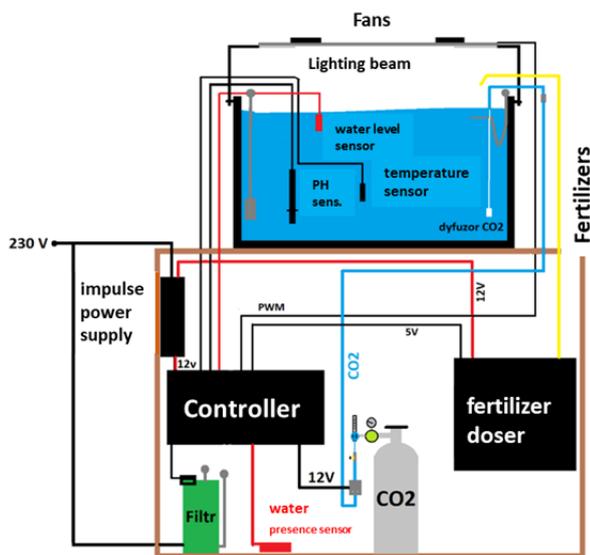


Fig. 4. Block diagram of an aquarium controller programmed in the Arduino environment

Providing the best possible source of light in the aquarium ensures optimal conditions for the growth of plants and the life of fish, and the dosing of fertilizers or carbon dioxide does not make sense if the tank is not sufficiently illuminated. From the entire range of electromagnetic waves of visible light for plants, only a small part of this spectrum is of the greatest importance and it is about 450 and 650 nm wavelengths, i.e. blue and red. These two ranges have the best effect on the proper development and color of plants, as they are absorbed in the greatest amounts by chlorophyll in the photosynthesis process. In aquarium designs, White Full Spectrum LEDs are used as light sources, which in addition to blue and red also emit light waves in the interval between these colors and perfectly reflect the colors and stimulate plant growth.

The construction of a model aquarium, operated by the controller, makes it possible to have fish and plants without the need to constantly look after the tank. An application has been created which is responsible for monitoring and setting all parameters of the controller (Fig. 5), it enables the preview of the current parameters in the aquarium at any time and place. Thanks to the proposed system, changing the temperature, lighting power or fertilizer dose requires only moving the slider on the smartphone - the

system will do the rest. In the event of a leak in the tank or filter, the phone will activate an alarm informing about a possible leak and the necessary intervention.

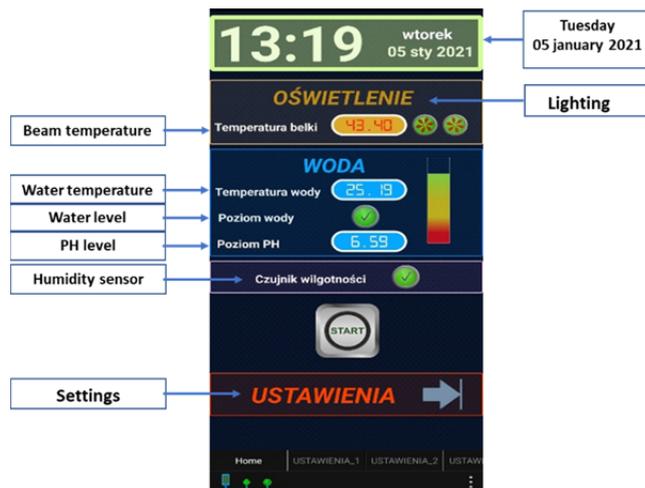


Fig. 5 Start screen after launching the application (the application was developed in Polish - the symbols on the screen have been translated in frames in the figure).

Having an aquarium with plants and fish required a lot of work related to its maintenance - water exchange, cleaning and dosing of food and fertilizers. Thanks to the use of a system of devices and a controller, the time needed for the daily and burdensome maintenance of the aquarium is saved. The high-tech plant tank is a special case where the use of automation is necessary due to the large number of devices and processes that require constant control.

Thanks to the components used in the system it is possible to further expand the project with a waterproof housing that protects the controller and electronics against flooding and splashing, designing a PCB to reduce the number of wires, as well as equipping with additional functions such as automatic fish feeding or water change in the tank.

Conclusions

The 20th century is a breakthrough in the development of broadly understood electronic technology, also in the technology of smart home systems and smart devices. The system that makes up a smart home is a collection of devices that make up one structure. Its task is to increase the comfort and convenience of using the apartment and relieve residents of many activities that can be automated with the installation of home automation [8]. Using such technology, it is possible for all home devices to be connected to the Internet and controlled by a phone or tablet, and ordinary houses can become intelligent buildings [9, 10]. Smart home systems provide the user with great comfort and a sense of security and thus have become so popular all over the world.

Arduino is different from other platforms on the market. It is an environment for many operating systems - Windows, Macintosh and Linux, based on the Processing development environment, an easy-to-use development IDE used not only by engineers, but also by artists and designers. The hardware and software are open source - user can download a circuit diagram, then buy all the components and make your own board, without paying a penny to the Arduino makers, and the hardware is cheap.[8,11].

The concept of an intelligent house, intelligent building dates back to the 1980s. It was created in the United States, when there was a great demand for modern

production solutions along with the progress in the fields of information technology, electronics and telecommunications. This period is considered to be the beginning of the design of systems to control lighting, heating and ventilation in buildings. This was to ensure the comfort and safety of users. At the same time, it meant lower operating costs [5].

In the examples proposed in the paper both models were created on the basis of the Arduino programming platform. In the smart home mock-up, thanks to the implemented Bluetooth module, the mock-up communicates with a pre-programmed mobile application, which makes it possible to control a smart home from a distance. Using the smartphone interface, the user is able to turn on or off the light in each room of the mock-up, arm the alarm, open or close the garage roller shutter and entrance gate, or read the current temperature in the mock-up. The proposed mock-up of a smart home can be used as a tester before starting the implementation of a real intelligent building system. When building smart homes, it is not necessary to use pre-programmed intelligent systems, and it is possible to use cheap solutions, which is proved by the created mock-up. The aquarium controller made in the proposed model gives many possibilities, and above all, it allows you to reduce costs and time. Thanks to it, you can constantly monitor the technical parameters of the aquarium and care for the optimal conditions of the fauna and flora of the reservoir.

Internet technologies have become very popular recently. Companies offer an increasing number of commercial solutions to make our homes "smart" [12]. In the article, the authors proved that a home automation control system can be created by yourself using inexpensive, easily available modules, such as Arduino Uno or Arduino MEGA. Currently, intelligent houses are not the dominant construction investment, but in the near future they will probably start to dominate in construction, especially single-family ones.

In intelligent building systems, communication is an indispensable design element. In projects, it is possible to use both wired and wireless forms [13]. The presented models confirm the possibility of control via a mobile application.

Conflicts of Interest: The authors declare no conflict of interest.

Autors:

Anna Koziorowska, PhD, DSc. Eng., Rzeszow University, College of Natural Sciences, ul. Rejtana 16c, 35-959 Rzeszów, Poland. e-mail: akozioro@ur.edu.pl

Dominik Potyrała, MSc, Rzeszow University, College of Natural Sciences, ul. Rejtana 16c, 35-959 Rzeszów (student)

Michał Macek (Wątroba), MSc, Rzeszow University, College of Natural Sciences, ul. Rejtana 16c, 35-959 Rzeszów (student)

Robert Krasowski, PhD, Non-public Education Center in Limanowa, ul. Bronisława Czecha 5G, 34-600 Limanowa Poland. e-mail: robertk2@onet.eu

REFERENCRES

1. Sulikowska, O., Brzuzy, A., System inteligentny dom: nowoczesna technologia stosowana w budownictwie, *Biuletyn Wojskowej Akademii Technicznej*, 2019, 68(2), 71-80.
2. Yi-Bing, L., ; Hung-Chun T., Fish Talk: An IoT based mini Aquarium system *IEEE Journals & Magazines. IEEE Access*. 2018, 7, 35457-35469
3. Holuk M., Budynek inteligentny – możliwości sterowania domem w XXI wieku, *Scientific Bulletin of Chelm Section of Technical Sciences*, nr 1/2008, Chelm, 2008
4. <http://web.csulb.edu/~hill/ee400d/Technical%20Training%20Series/02%20Intro%20to%20Arduino.pdf>
5. <https://www.arduino.cc/en/Main/Products>
6. McRoberts M., *Beginning Arduino*, Apress, USA, 2011
7. Monk S.: *Arduino + Android for the Evil Genius*, w tłumaczeniu Watrak A.: *Arduino i Android. Niesamowite Projekty*, HELION, Gliwice 2014.
8. Riley M.: *Programing Your Home: Automate with Arduino, Android, and Your Computer*, w tłumaczeniu Szczepaniak M.: *Inteligentny dom - Automatyzacja mieszkania za pomocą platformy Arduino, systemu Android i zwykłego komputera*, HELION, Gliwice 2013.
9. Schwartz S.: *Arduino Home Automation Projects*, w tłumaczeniu Waśko Z.: *Arduino Automatyka domowa dla każdego*, HELION, Gliwice 2015.
10. Adrian Ł., Jabłońska M., Janicki M., Klimek A., Pawlak J., Tkacz E., Znajdek K.: *Dom 2020 - projekt ekologicznego i inteligentnego domu energooszczędnego*, *Instal*, 2012 2, 37-40.
11. .Banzi M., *Wprowadzenie do Arduino*, Przekład: Maria Chaniewska, APN Promise 2014.
12. Zaidan AA, Zaidan BB. A review on intelligent process for smart home applications based on IoT: coherent taxonomy, motivation, open challenges, and recommendations. *Artificial Intelligence Review*, 2020, 53, pages141–165.
13. Powroźnik P, Kusmierek D.: *Praktyczny aspekt określenia zasięgu pomiędzy bezprzewodowymi urządzeniami w systemach zarządzania budynkiem*, *Przegląd Elektrotechniczny* 2018, 94, 11, pp. 67-71.