

## MICROCONTROLLERS IN AUTOMATION SYSTEMS OF ESCAPE ROOMS

### MIKROKONTROLLERI AUTOMATIZĀCIJĀS SISTĒMĀS KVESTU-ISTABĀM

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**Annotation.** *This article is devoted to the automation of various entertainment processes. Nowadays this topic is the most relevant because entertainment industry is in high demand but automation in this field isn't spread widely. The solution of the problem is shown on the example of creating of automation system of the separate escape room using soft and hardware application Arduino. The advantage of automation processes allows not to hire a worker who watches all processes in the room and control them manually that allowing to refer a game as honest as possible. In addition on Arduino base different new ideas may be realized, which are important factors of the success of people working in this field.*

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**Keywords:** *automation processes, escape room, microcontroller Arduino.*

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### Introduction

Entertainment is one of the most important spheres of a human's daily life, which influence on the state of society, because the need to relax is one of the main needs of human. The world entertainment industry produces billions of dollars and it is an important part of the economy of most countries. Range of entertainment of modern people is wide and varied and is "a mirror" of modern culture and technical progress. In spite of this the directions of the industry where automation is used, aren't very diverse. Automation is one of the direction of scientific and technical progress where self-regulating technical means are used. There are many examples in the field of entertainment such as: laser combat, cuzar, and different slot machines. Besides there is a whole direction of the escape rooms. It is an intellectual game with a certain plot, where player are locked in the special room and they are to get out it in the time that is available to them finding special things and solving puzzles. As a rule, people lose interest in the same rooms that's why they find new room with new tasks. Introduction of microprocessor- based devices allows to change the task very fast and easily what caused a desire to visit the escape room again.

### Materials and methods

The authors of this article had to automate several separate stages of the escape room. To implement similar tasks it is convenient to use microcontrollers with the ability to connect a large number of sensors and other peripherals, so the authors of the article use Arduino Nano as the processor board. This compact processor board has 14 digital outputs, six of which are pulse-width modulation outputs, and eight analog inputs. The flash memory of the ATmega328 microcontroller on which the platform is built is 32 KB, while 2 KB are used for the bootloader, 2 KB for RAM, 1 KB for EEPROM, the clock frequency is 16 MHz [1]. For programming hardware, built on the hardware-software Arduino, a free software shell IDE is used [5]. The Arduino programming language is a standard C ++ language with some features that allows to write the working program easier [5].

One of the developed stages was the secret door opening when the figures were placed in certain places according to their weight. Thus, at this stage, two challenges are manifested: the development of automatically opening door mechanism and the mechanism for recognizing figures in accordance with their weight. The door opening can be realized in several ways.

1. Dual electromagnetic lock (holding force is 250 kg, and the current consumption is 1 / 0.5 A) is connected to the microprocessor through a relay [1].

2. Electric latch lock - "latch". In the initial position, the lock is locked. To open it a necessary power(12w) must be got to the solenoid. The power connection to the lock is carried out by the relay using two conductors with a two-pin connector at the end [4].

3. The stepper motor 28BYJ-48, connected through the driver ULN2003, is very cheap and convenient for using, but it has a number of drawbacks. It does not work correctly when it's overloaded, in addition, to work with different program code, you need to use additional libraries for management, that complicates the procedure for using the engine.

4. The servomotor is a drive which controlled through negative feedback, that allows to perform the motion parameters precisely. The servomotor is a mechanical drive which has in its composition a sensor and a control unit that automatically maintains the necessary parameters on the device according to the specified external value [1].

In the implementation of this task, a servomotor has been selected, since it is the simplest for using, the cheapest and the most compact device of all of the above mentioned options. The secret door has a small mass, so the servomotor can cope with this task easily.

The following sensors can be used for the recognition mechanism of relevant figures.

1. Strain gauge RI033 is a load cell that implements the balance operation. This sensor has a drawback because due to the uneven position of the object, the measurements can be inaccurate, and the locker door might not be opened [3].

2. The pressure sensors (Force Sensitive Resistors (FSRs)) allow to assess the level of pressure, force of pressure and weight [3]. They are easy to use and inexpensive. But their disadvantages have the same nature as the load cell.

3. RFID tags are a technology for contactless data exchange, based on the use of radio-frequency electromagnetic radiation. RFID is used for automatic identification and accounting of objects. A chip is placed on the object, which, after the object is put in its place, is read by an RFID reader [2]. For convenience, this method was chosen.

At the second stage of the escape room the sequence of cylinders is at disposal of the participants. On the surface of the cylinders different characters are shown. Rotating the cylinders, participants are to build the necessary sequence of characters, after which the locker will be opened, where important for players object is hired. The character detection can be done in several ways.

1. IR (infrared) receiver sensor TSOP18 is able to receive and process infrared signals in the form of pulses of the set duration and frequency [2]. It has rather complex structure. At this stage the element can be applied in the following way. A remote control is installed into each cylinder at the place of the necessary character, which continuously sends a signal, and behind each cylinder on the wall a special sensor is fixed. Once all the sensors get the signals, the above locker will be opened.

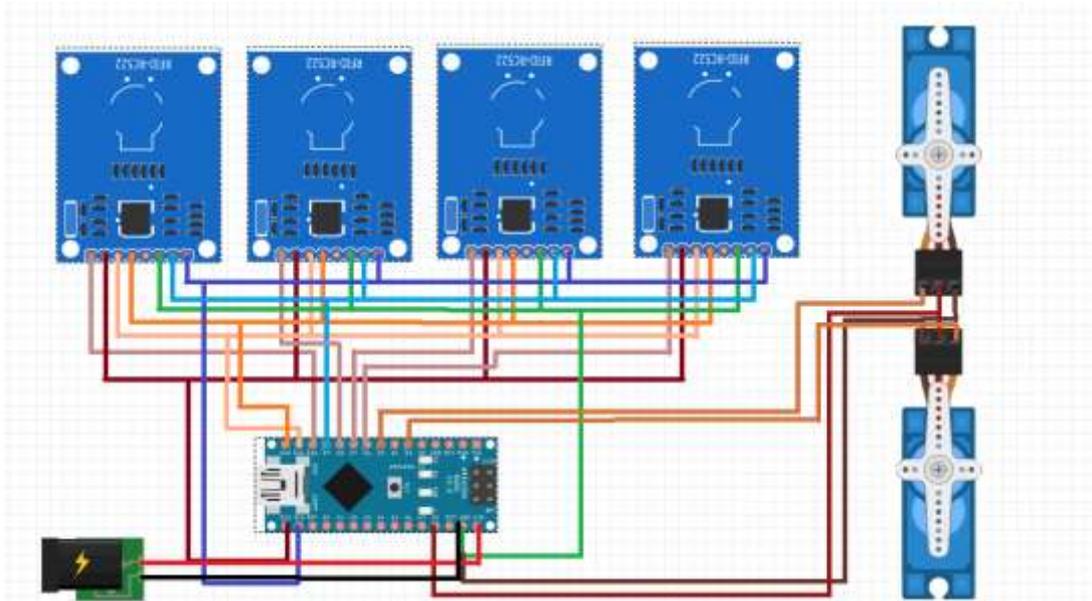
2. Magnetic contact sensor (reed switch) consists of master (magnet) and executive (the reed switch) parts. When the reed switch contacts get into magnetic field the contacts in it short [5]. This cheap element has such important advantages as compactness, durability and high performance, that's why it was chosen to perform the task. To open the locker, the master part is fixed at the base of each cylinder directly below the desired character, and the executing part of the reed is placed under each cylinder on the horizontal surface. When all contacts are shorted, a appropriate signal is sent to the board, the locker is opened.

The process of the locker opening is similar to the process of secret door opening at the previous stage, so the servo is also used here.

## Results

The automation systems have been designed, assembled and tested for all necessary the escape rooms stages.

In the first case, one Arduino Nano board, four RFID «tags-readers» [pairs](#) that corresponds to the specified figures number, two servos and one 5 V power source have been [used](#) to implement the task(fig. 1).

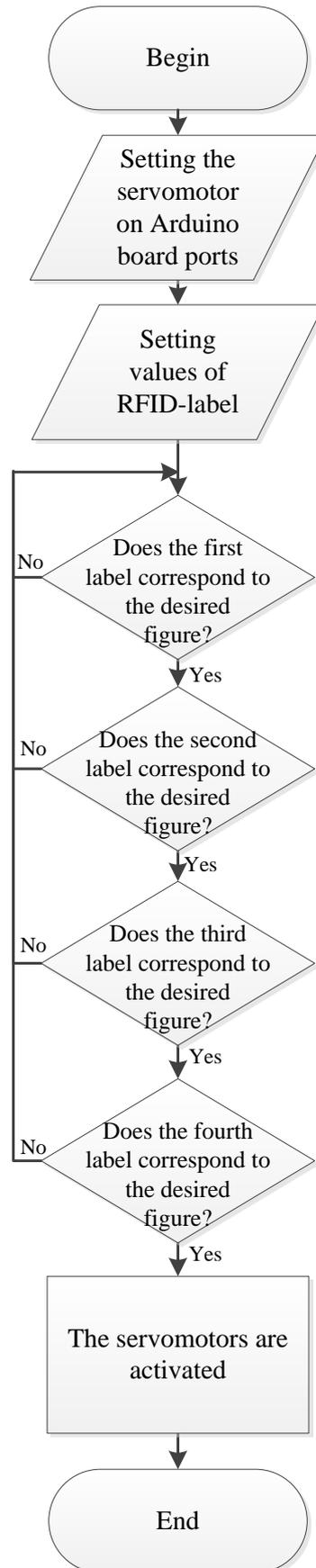


*Fig.1 The electrical circuit of escape room stage with the figures detection*

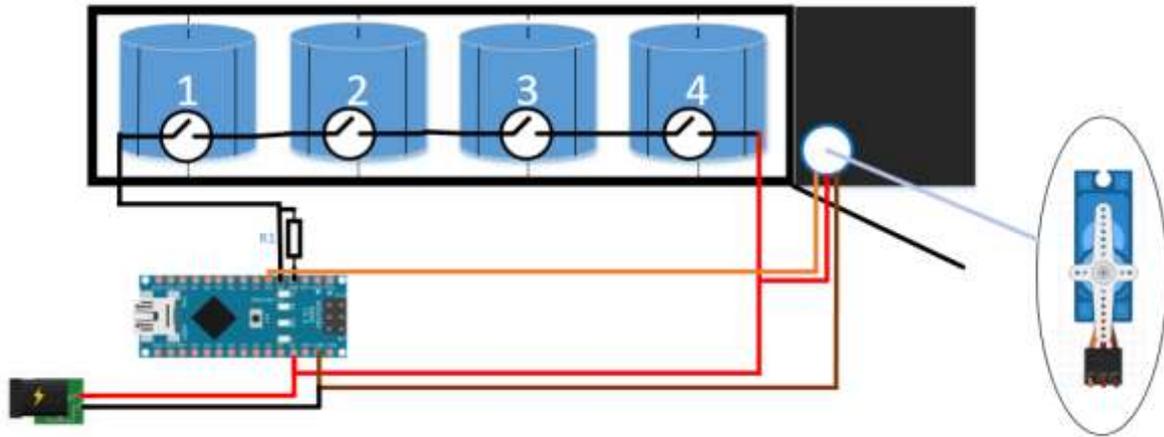
A strict position of all the characters is a main feature of the stage of the escape room. Therefore, the microprocessor must be programmed to read the status of all RFID tags at the same time. The program code for the device corresponds to the algorithm which is shown in fig.2.

The device testing showed that it worked correctly. After the participants of the quest put the figures in their places, the servomotor work and unlock the casket are triggered. If ever one figure isn't at its place the access to the secret locker will be denied.

In the second case, one Arduino Nano board, one 5 V power source, one servo and four “magnet-reed switch” pairs were used in the automation system assembly (fig. 3).

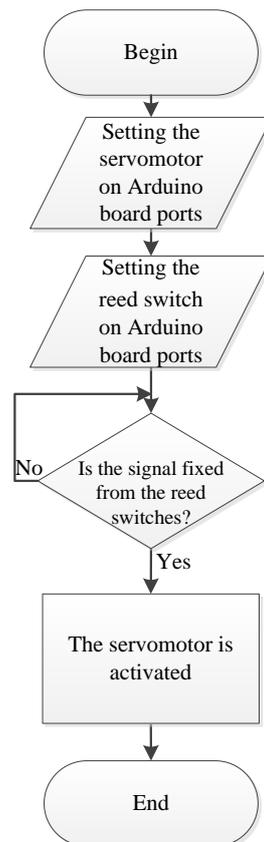


**Fig. 2 The block diagram algorithm of the program for the escape room stage with figures detection**



**Fig.3 The electrical circuit of escape room stage with the rotating cylinders**

It can be seen from the electrical circuit of the device that all reed switches are connected with each other in series and that a sequence of sensors is connected with the board, but not each sensor individually. The serial connection is determined to the peculiarities of the switch reed structure. This means that the concept of the program will differ from the previous case, because there is no need to check each reed switch individually, information is read from only one digital input (fig.4).



**Fig. 4 The block diagram algorithm of the program for the escape room stage with rotating cylinders**

Having tested this automation system we saw that the device is worked correctly. Only if all cylinders are positioned correctly the participants of the game will have access to the object, hidden in the cabinet.

### **Summary**

Thus, automation of separate escape rooms stages is possible with the help of microcontrollers. This relatively inexpensive and simple solution of this task can not only simplify the manual control of the room by a person, but also allows change the concept of a particular escape room easily in the future. For example, for the escape room stages that are shown in this project triggering mechanisms may be realized by using other combinations of objects arrangement or also change these objects to others ones. Any stage of the game can be easily complemented to various different effects such as: suddenly light on, the sound enables, etc. All these effects will allow to maintain the popularity of the particular game at a high level and to implement new bold ideas which in turn benefited the entertainment industry.

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