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Creating a smart bedroom for children by connecting PIR and LDR sensors to a microcontroller Arduino UNO ATmega328P

Ragmi M. Mustafa[1], Kujtim R. Mustafa[2], Refik Ramadani[1]
[1]Faculty of Computer Science, Public University "Kadri Zeka", Gjilan, Republic of Kosova
[2]Faculty of Electrical and Computer Engineering, University "Hasan Prishtina", Prishtina, Republic of Kosova

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ABSTRACT

Intelligent electronic systems are increasingly prevalent in modern society. The development of smart bedrooms for young children, especially those with developmental disabilities, it is based on the responses of passive infrared (PIR) and light dependent resistor (LDR) sensors. The PIR sensor detects children's movement during the night, triggering the microcontroller to send a bit of 1 to the microcontroller pin connected to an electromagnetic relay, which then switches on a 220 VAC light to illuminate the bedroom. This only occurs if the LDR sensor has high resistance, indicating that the environment is completely dark. The functionality of this intelligent system mainly depends on the program code (sketch) uploaded to the Arduino UNO microcontroller module. The microcontroller is programmed to perform specific functions based on the sensors data. It is based on the responses of PIR and LDR sensors. The PIR sensor detects children's movement during the night, triggering the microcontroller to send a bit of 1 to the microcontroller pin connected to an electromagnetic relay, which then switches on a 220 VAC light to illuminate the bedroom. This only occurs if the LDR sensor has high resistance, indicating that the environment is completely dark.

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Corresponding Author:

Kujtim R. Mustafa
Faculty of Electrical and Computer Engineering, University "Hasan Prishtina"
Afrim Vitia 2, 10000 Prishtina, Prishtina, Republic of Kosova
Email: kujtim.mustafa@uni-pr.edu

1. INTRODUCTION

This paper presents the development of an intelligent lighting system for children's bedrooms, designed to enhance safety and convenience during nighttime. By measuring movement and ambient light intensity, the system automatically activates a soft light when children wake up, addressing a common challenge for families with young children. The implementation utilizes various electronic components, including a light dependent resistor (LDR) for measuring ambient light levels and a passive infrared (PIR) sensor for detecting motion. Additionally, a relay module with a coil core rated at 5 VDC, featuring both normally closed (NC) and normally open (NO) contacts, is used to control the lighting. All components are interconnected using copper wire jumpers to form an effective electrical system.

At the core of this smart system is the Arduino UNO ATmega 328P microcontroller, which serves as the programmable logic device. The electrical connections are designed to handle continuous currents supplied by a 5 VDC source, with potential influences from alternating current at 220 [VAC] in certain setups as shown in the Figure 1. The functionality of the system is governed by a sketch-a program developed in C or C++ within the Arduino IDE environment.

This sensor-based system not only improves the care of children but also supports elderly individuals, couples, and persons with special needs, enhancing their autonomy and safety during nighttime. Unlike traditional methods of controlling bedroom lighting-such as manual switches or parental presence-this innovative approach eliminates these drawbacks, fostering greater independence for children and peace of mind for parents. While similar systems may exist, this research highlights the unique integration of these technologies in creating a practical solution tailored for modern families.

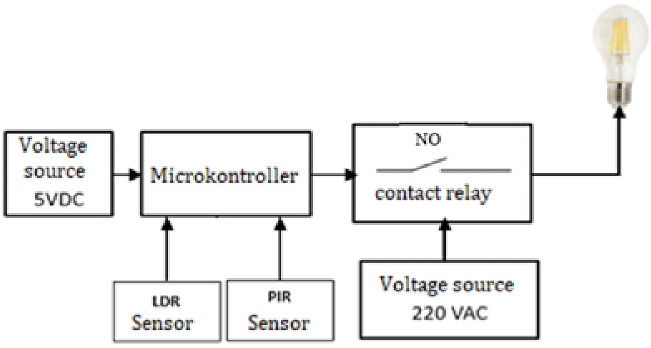


Figure 1. Block scheme of the intelligent bedroom for children

2. EQUIPMENT USED

The following tools were utilized for this scientific study and its functionalization: LDR sensor, PIR motion sensor, prototype board for breadboard connection, contact relay 220 V,10 A with coil 5 VDC, resistors 10 kΩ, 220 Ω, light emitting diode (LED) and electrical conductor with pin-jumper and light pot were integrated with the Arduino UNO module to create an effective and responsive lighting solution for children's bedrooms.

2.1. Arduino UNO module

The Arduino UNO microcontroller was selected for this project due to its open-source nature and sufficient input/output ports, making it ideal for experimenting with the concepts presented in this paper. It is equipped with the ATmega328P microcontroller, which features:

- 14 digital input/output pins (6 of which can be used as PWM outputs).
- 6 analog inputs.
- USB connection.
- Reset button.

This configuration allows for versatile connectivity and control over various sensors and components. As illustrated in Figure 2, the Arduino UNO module is connected to a computer via a USB cable, where the program code for the smart bedroom system is developed and uploaded using the Arduino integrated development environment (IDE) version 1.8.19 or any compatible version [1]. Table 1 lists the technical specifications of the Arduino UNO ATmega328P module [2].

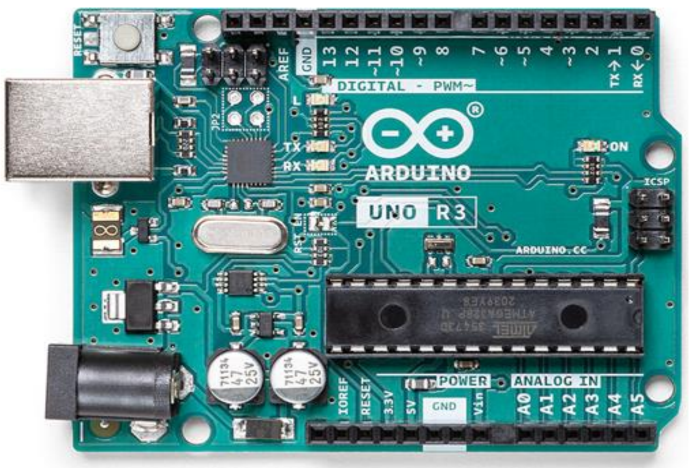


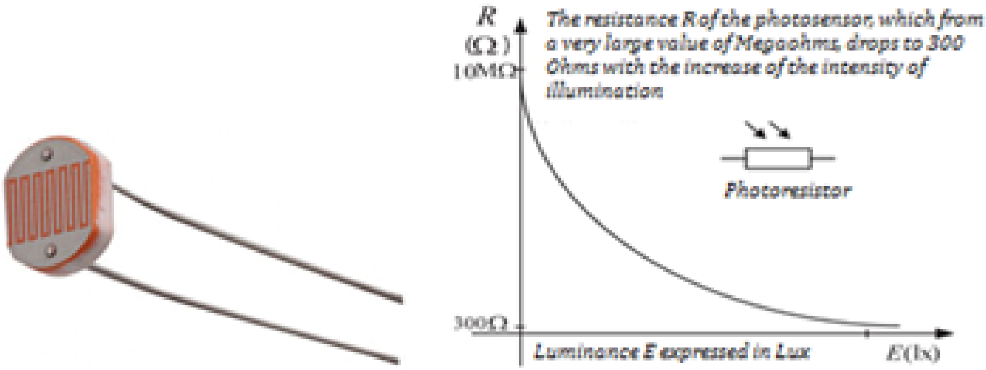
Figure 2. View of the ATmega328P chip and the Arduino [2]

Table 1. Technical characteristics for the Arduino UNO module

Devices in the Arduino ATmega328P module	Technical specifications
Microcontroller	ATmega328P
Operating voltage	5 VDC
Input voltage	7-12 VDC
Digital I/O pins	14 (6 of which they are outputs PWM)
PWM digital pins	6
Analog pins	6
Current directed per pin	20 mA
Current directed to pin 3,3 V	50 mA
Flash memory	32 KB
Static random-access memory (SRAM)	2 KB
Electrically erasable programmable read-only memory (EEPROM)	1 KB
Speed-frequency of work	16 MHz
Processor	8– bit AVR

2.2. LDR sensor

The LDR is a type of sensor whose name reflects its functionality. This semiconductor-based sensor exhibits a decrease in resistance when exposed to light. As light intensity increases, the resistance of the LDR diminishes, allowing for accurate measurements of ambient light levels. Figure 3 illustrates the LDR sensor, Figure 3(a) depicts its physical appearance, and Figure 3(b) presents a graph illustrating the relationship between resistance and light intensity [3], [4].



(a) (b)

Figure 3. LDR Sensor appearance and resistance graph depending on light intensity [5] (a) depicts its physical appearance and (b) presents a graph illustrating the relationship between resistance and light intensity

The operating principles of the LDR sensor are illustrated in Figure 4. When light strikes the sensor's surface, it stimulates the movement of electrons within the material, resulting in increased conductivity. Consequently, the sensor's resistance decreases as the light intensity increases, allowing for effective detection of ambient light levels [5], [6].

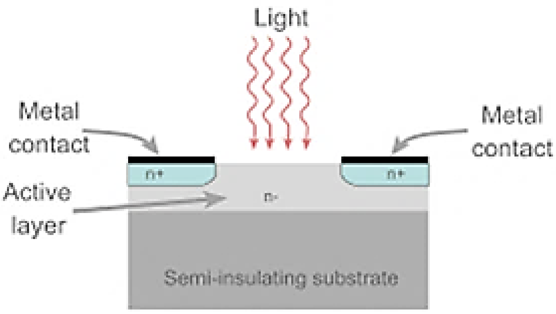


Figure 4. Working principles of the LDR sensor [5]

2.3. PIR sensor

The demand for sensors has surged across various industries, leading to significant advancements in their development, making them more reliable and cost-effective [7]-[9]. PIR sensors are passive devices that detect the heat emitted by moving objects within their monitoring range. Known for their high accuracy, quick response time, low cost, and minimal power consumption, PIR sensors are widely utilized for motion detection. Figure 5 illustrates the mechanism of the PIR sensor, highlighting its functionality in detecting movement.

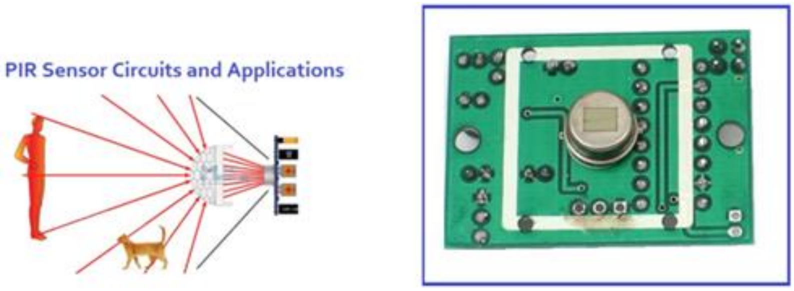


Figure 5. Working principle of the PIR motion sensor [10]

PIR sensors are favored in numerous applications due to their distinct advantages over other motion sensors. They are commonly employed in smart buildings for internet of things (IoT)-based energy management, autonomous instrument control, intrusion detection, and applications involving artificial intelligence. Among these, IoT-based energy management systems in smart buildings have garnered significant attention, particularly in response to the growing concern over excessive energy consumption [8]-[11]. Also referred to as passive infrared sensors, PIR sensors are depicted in Figure 6, showcasing their design.

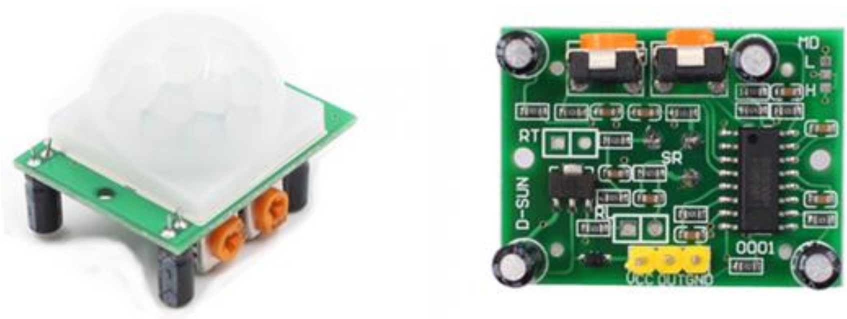


Figure 6. PIR sensor for motion detected [11]

The technical characteristics of the PIR sensor used in this project are:

- Input voltage: DC 4.8~20 VDC
- Current: 50 μA
- Output signal: LOW: 0 VDC, HIGHT: 3.3 VDC (HIGH output when we have motion detection)
- Field of view: <100 degrees
- Maximum motion detection distance: 6 m

2.4. Contacting relay

Electrical contact relays are among the most prevalent components in modern technological systems. They are found in a wide range of applications, including tanks, aircraft, ships, washing machines, microwave ovens, and medical devices. In fact, it is difficult to find an industry that can operate effectively without relays. Many advanced automatic control systems in industrial settings utilize hundreds or even thousands of relays. In the power generation sector, no electrical equipment is allowed to function without the appropriate protective relays [6]. Figure 7 showcases one of Thomas A. Edison’s 200 patents related to relays [12], while Figure 8 illustrates an electromagnetic relay featuring two types of contacts: NC and NO [12].

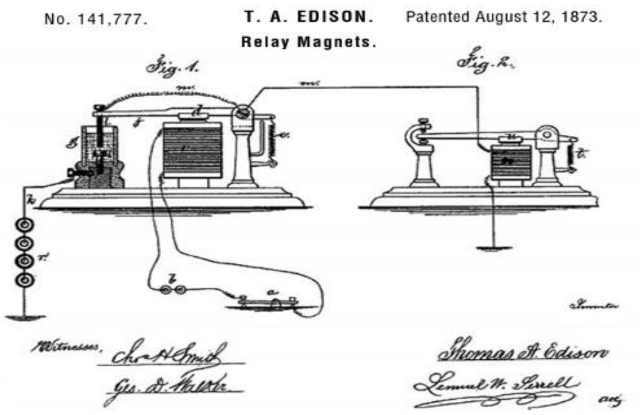


Figure 7. One of Thomas A. Ediso's patterns releated to relays [12]

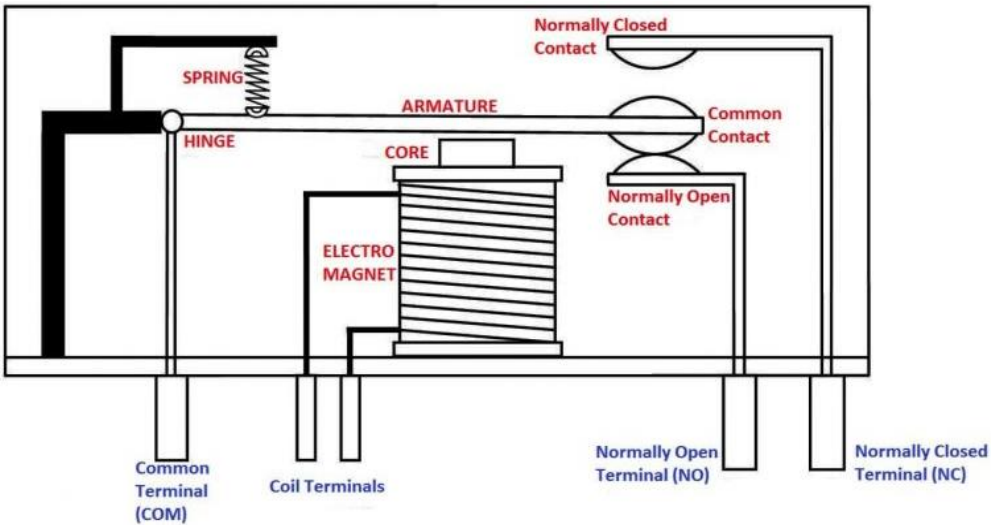


Figure 8. Example of electromagnetic relay enabling two types of contacts NC and NO [12]

When voltage is applied, typically provided by a programmable logic controller (PLC) or microcontroller, it generates a small but sufficient current to close the NO circuit, while simultaneously opening the NC circuit. The electromagnetic relay operates based on the principle of electromagnetic induction generated by the coil. This mechanism is fundamental to the relays utilized in our project. Figure 9 illustrates the operating system of the electromagnetic relay [13].

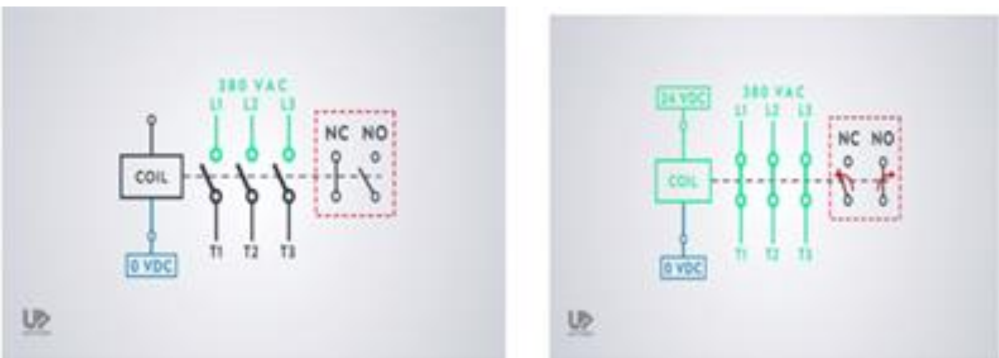


Figure 9. Working principle of the electromagnetic relay [13]

2.5. Resistor

Resistors are essential components found in most electronic circuits, serving as crucial elements for controlling the flow of electric current. These passive electrical components regulate electron flow, enabling current to flow freely based on their resistance values. Resistors can manage signal levels in electronic circuits, reduce current flow, and function as voltage dividers. They play a supportive role for active components such as transistors, microcontrollers, and integrated circuits [14].

The property of resistance in a resistor can be quantified using Ohm's Law. To help users identify resistance values, resistors are often marked with colored bands that correspond to specific resistance values based on a decoding scheme. Figure 10 illustrates resistors with various color bands [15].

Figure 10. The appearance of a resistor and its colors [15]

The formula for calculating the resistance value according to Ohm's Law can be derived from the voltage formula:

$$U = R * I \tag{1}$$

So, it follows that the formula for resistance is:

$$R = \frac{U}{I} \tag{2}$$

Figure 11 illustrates an example of how to determine the resistance value of a resistor by interpreting the colored strips on its body. Resistors typically use a color code to indicate their resistance values, with each color corresponding to a specific digit or multiplier.

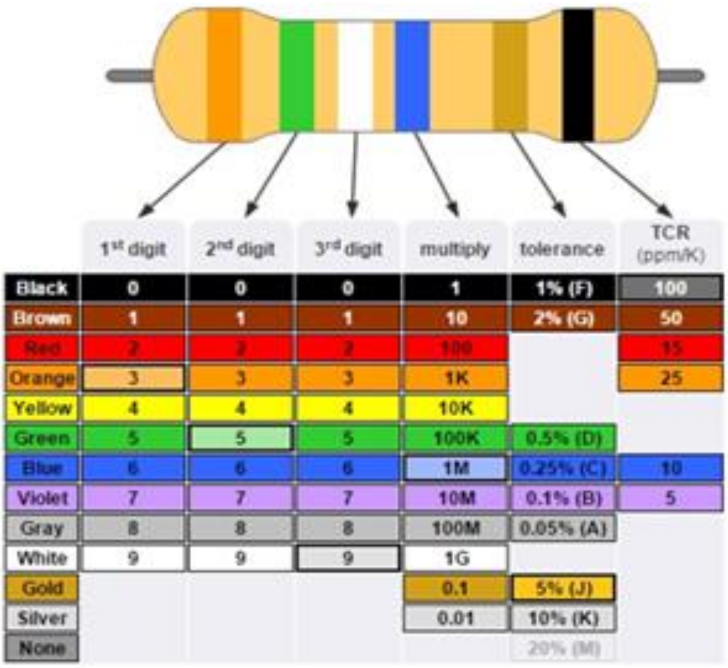


Figure 11. Resistor color scheme (this helps understand resistor values) [14]

Therefore, the resistance of the sensor in this case is:

$$R = 35 \cdot 1\ [M\Omega] \pm 5\% = 35\ [M\Omega] \pm 5\% \tag{3}$$

We must always use various combinations of resistor connections to achieve the desired level of resistance value. The parallel connection and the series connection are the two types of resistor connections that we have available, but naturally, they must frequently be combined to obtain the required values as shown in Figure 12 [15].

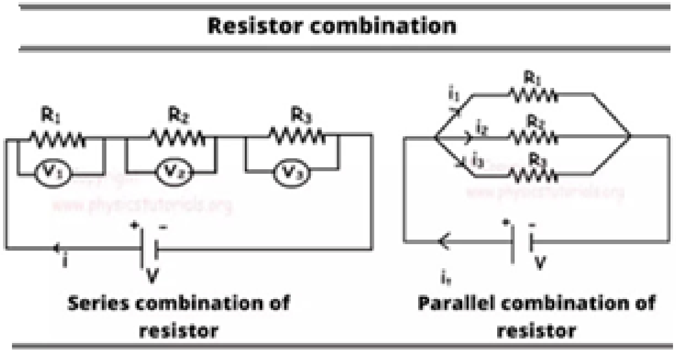


Figure 12. Series and parallel connections of resistors [15]

2.6. LED diodes

The most obvious kind of semiconductor diode is the LED diode. When a current passes through them, they release a relatively small bandwidth of visible light in various colour wavelengths, as well as invisible infrared light for remote controls or laser-like light or laser-like light [16], [17]. Since they are conceptually quite like PN diodes, “light emitting diodes,” or LEDs as they are more commonly known, are essentially just a specialized type of diode. Accordingly, an LED will allow current to flow in one direction but will obstruct it in the other [18]. LED diodes are ubiquitous in applications requiring illumination or signaling. They are commonly utilized in a variety of technological devices for signaling purposes, such as indicators and displays. Additionally, LEDs are increasingly used for general lighting due to their energy efficiency, high lumen output, low heat generation, and remarkable stability. Their low electricity consumption makes them an ideal choice for sustainable lighting solutions [17]. Figure 13 showcases the LED diode as a critical electronic component, highlighting its design and functionality. In Figure 14 shows the working principle of an LED diode.

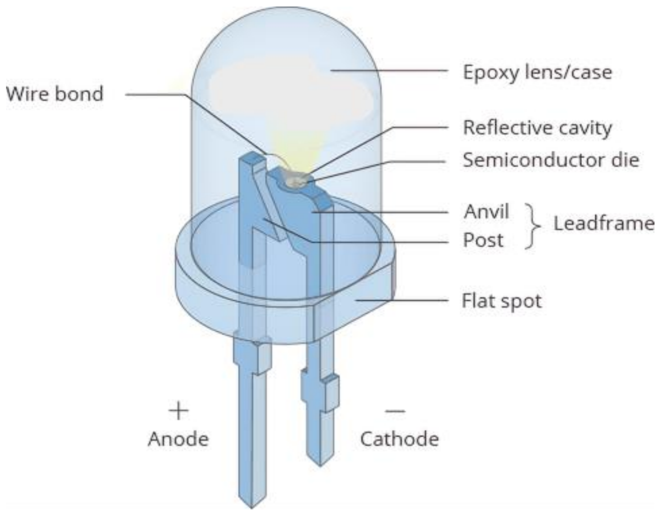


Figure 13. Parts inside the LED diode [17]

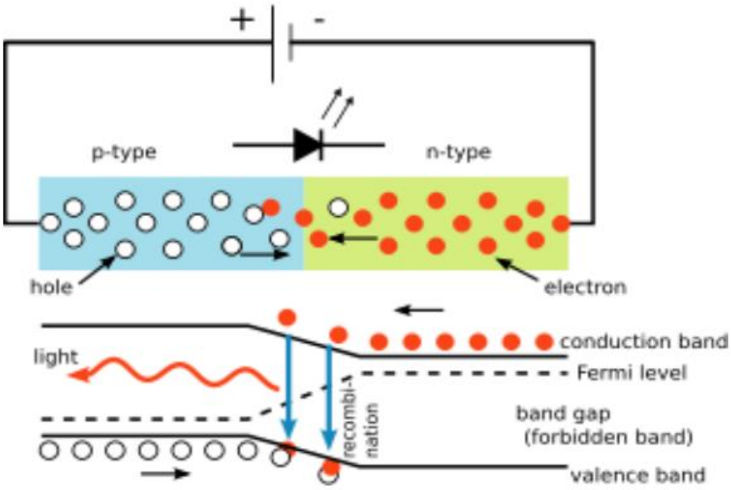


Figure 14. Working principle of LEDs with PN-contact [19]

2.7. Scheme of electronic connections for the realization of the smart-intelligent room

To realize the smart bedroom for children, we utilized specific tools outlined in the methodology section of this scientific work. Central to our project is the Arduino UNO microcontroller, depicted in Figure 15. As an open-access programmable electronic module, the Arduino UNO offers a variety of input and output pins, enabling seamless integration with various sensors and electronic devices. The accompanying software sketch code facilitates this integration [20]. Collectively, these components allow for the digitization of a bedroom tailored for children aged 7 to 10, particularly those with developmental disabilities, as well as elderly individuals and couples interested in technology. Notably, while several authors have employed similar electronic equipment in their research, none have specifically addressed the concept of a smart bedroom.

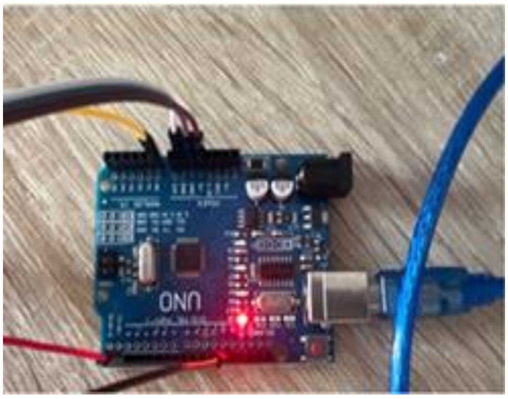


Figure 15. Arduino Uno and some electronic connections

The connections on the microcontroller are as follows:

- Microcontroller port of 5 VDC is connected to the breadboard with red jumper to distribute 5 VDC voltage to other devices.
- The microcontroller port of GND connections is placed with black jumper on the breadboard to provide grounding to other devices.
- Analog port A0 is connected to the LDR sensor to receive the light level signal (of course also using the adequate resistor to protect the A0 pin of the Arduino UNO).
- In the digital connection of pin 2, the PIR sensor is placed to receive incoming signals - inputs whenever movements occur in its monitoring field.

The digital connection on pin 12 is designated as an output which controls the connected relay. Figure 16 shows the connection of the LDR sensor to the prototype breadboard.

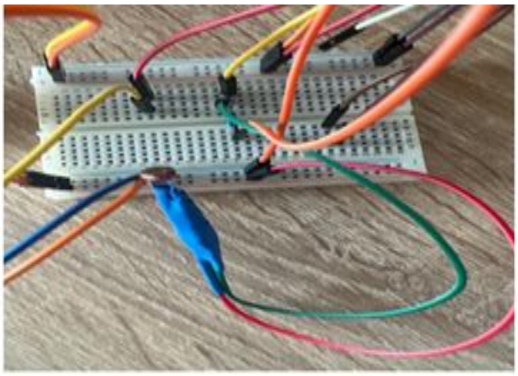


Figure 16. LDR sensor connected to the breadboard

The red cable, which has a voltage of 5 VDC, is connected to the breadboard's LDR sensor, which provides the system with information on the illumination light's intensity. The most suitable amount of resistance that can be provided for this sensor is a 10 kΩ resistor, which is connected in series with the green cable that is connected to the breadboard. The path then continues to microcontroller pin A0, which is suitable for measuring the analogue signal that the LDR sensor receives [21]. Figure 17 depicts how this electronic connection appears.

Given that the LDR sensor is an excellent semiconductor, its resistance varies with the intensity of light falling on it. The change in resistance occurs according to an exponential function. When the light intensity is high, then the resistance of the LDR sensor is offered to zero value. To protect the Arduino Uno module from destruction, precisely its A0 port, then we use the 10 kΩ resistor as a voltage divider. Whereas the variable resistor is a moment of the operating mode under the average luminance of the LDR sensor [20]-[22].

The resolution of the A/D (analogue to digital) converter is 10 bits, which means that the microcontroller processor is 10 bits for a supply voltage of 5 VDC, and the read values of the analogue signal are in the range [0,1023]. Given that there are only two possible bits (0 and 1), the resulting digital values can range from 0 to 2^{10}.

$$2^{10}=1024 \tag{4}$$

What are the causes of the values listed above falling within the range [0,1023]? Therefore, the formula for the return of digital read values at each instant in voltage must be found! The voltage U_0 on pin A0 of the Arduino UNO module is measured using (5).

$$U_0 = the\ value\ read\ by\ the\ sensor\ on\ the\ pin\ A0 \cdot \frac{5\,[V]}{1023} \tag{5}$$

Figure 18 depicts the connection of the PIR sensor for detecting the movement of hot bodies or living beings (people, dogs, cats, rabbits, birds, and similar). Where U_0 represents the voltage at pin A0 of the Arduino UNO.

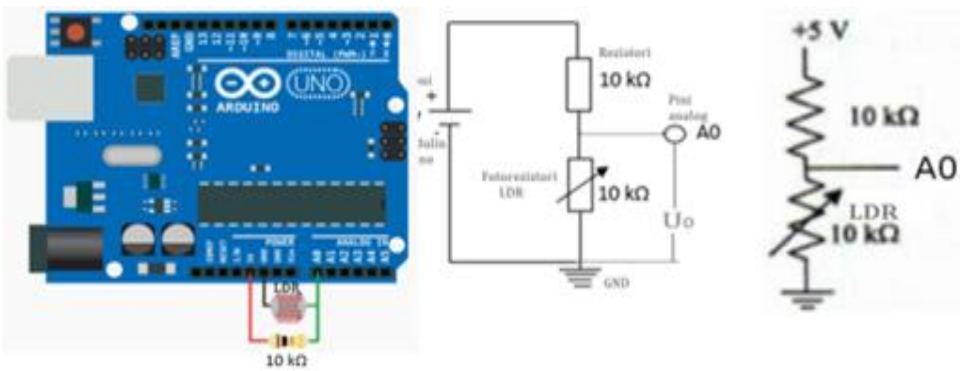


Figure 17. Connecting LDR photoresistor to Arduino Uno [22]

The PIR sensor is mounted on the breadboard by being connected to three cables, two of which enable the polarization-supply of the sensor and one of which [22], the yellow cable, provides the sensor with information about the presence of hot bodies in motion. Internal processing is done on the data before it is sent as digital information to the microcontroller via the yellow cable, the breadboard, and digital pin number 2 of the microcontroller. The microcontroller's pin 2 is configured to only accept INPUT signals [23]. When there is no movement detected, this type of PIR sensor outputs LOW (0), while when movement is detected, it outputs HIGH (1) [24], [25].

The electromagnetic relay's wiring diagram is shown in Figure 19. It has two contacts, one NO and the other NC, and it has a coil supply of 5 VDC. The PIR sensor is mounted on the breadboard by being connected to three cables, two of which enable the polarization-supply of the sensor and one of which [22], the yellow cable, provides the sensor with information about the presence of hot bodies in motion. Internal processing is done on the data before it is sent as digital information to the microcontroller via the yellow cable, the breadboard, and digital pin number 2 of the microcontroller. The microcontroller's pin 2 is configured to only accept INPUT signals [23]. When there is no movement detected, this type of PIR sensor outputs the tension LOW or sends bit (0) in pin 2, while when movement is detected, it outputs conveys tension HIGH or sends bit (1) [24], [25]. The electromagnetic relay's wiring diagram is shown in Figure 19. It has two contacts, one NO and the other NC, and it has a coil supply of 5 VDC. Three cables are used to attach the relay to the breadboard. Two of the cables are used to power the relay, and the third, a brown cable, is connected to the relay's IN1 pin, which is how the microcontroller communicates [26]-[28] whether to turn the relay on or off. The NO type of this relay's options suits us in this case, so we connected the cable for voltage 220 VAC to the input COM1 and used the relay's output to connect the light to NO1 as shown in Figure 20.

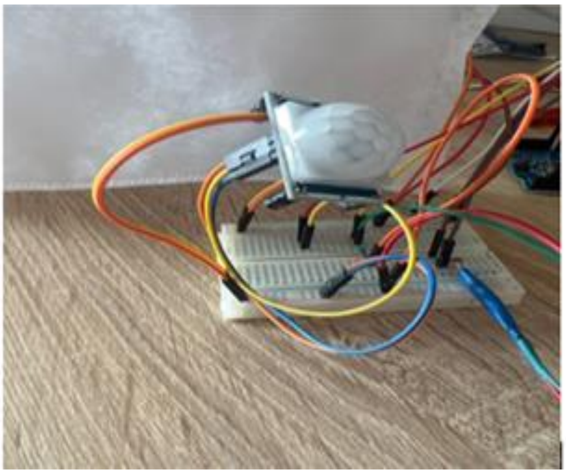


Figure 18. PIR motion detection sensor

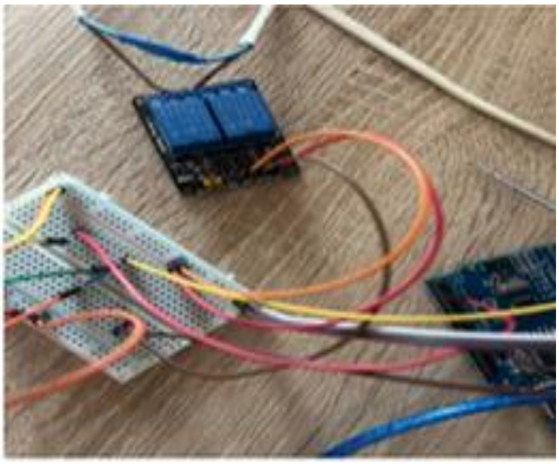


Figure 19. Electromagnetic relay

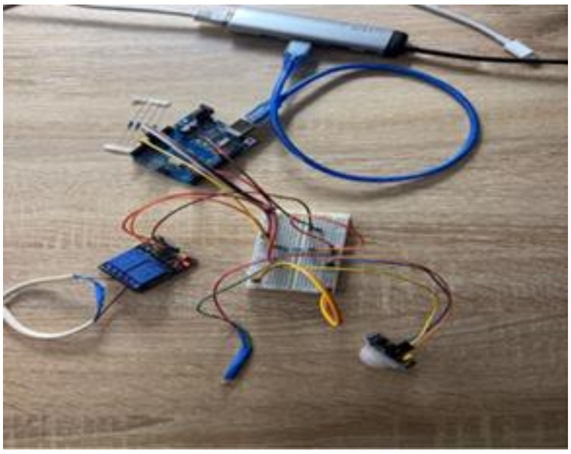


Figure 20. Completion of all electronic connections for the realization of the intelligent children's room

3. RESEARCH METHOD

The construction of a smart bedroom for children relies heavily on the integration of various smart electronic devices and the development of a software code to ensure their effective operation. Each component has been rigorously tested and confirmed to function as intended. The programming code, or sketch, is written in C++ within the Arduino UNO environment [29], utilizing the appropriate software for the microcontroller after establishing the wiring diagram for the smart bedroom's operation [30]-[32].

When measurements are necessary, the microcontroller monitors changes in the LEDs, PIR, and LDR sensors. These measurements indicate variations in sensor resistance values, prompting the microcontroller to send a bit 1 signal, which corresponds to a voltage of 5 VDC, from one of its output ports. This action activates the actuator for the contact relay, connecting the circuit to the light's 220 VAC supply. Thus, this smart bedroom system operates using two types of supply voltages: 5 VDC from the microcontroller and 220 VAC from the the city's power grid [33]-[35]. As shown in the Figure 1 presents the block diagram illustrating the electronic component connections in alignment with the concept of creating a smart bedroom for children. The experimental method primarily underpins this paper. While our research draws comparisons with existing works cited in the references [7], [21], [23]-[25], [27], [28], [30]-[32], it distinctly focuses on the application of smart bedroom technology for children. To our knowledge, no other studies have specifically addressed this concept in the same manner. While in study [7] the PIR sensor is used to achieve the highest level of infrared absorption with the most suitable sector angle for better sensitivity, in our study, the PIR sensor is used solely for the purpose of detecting children's movement in the bedroom within its observation sector, allowing the light to switch on and illuminate the room. Knight [21], the LDR sensor is used to measure the level of ambient brightness and to assess electrical quantities such as current, voltage, and the sensor's resistance. This is all done with the purpose of creating conditions in the program code (sketch) to illuminate streets, public squares, sidewalks, or similar areas in an urban center. In our study, the LDR sensor is used to detect darkness with the purpose of lighting the bedroom in the event of darkness to ease children's panic when they wake up in the middle of the night for physiological needs. Atmaja [23], similar to our study, both PIR and LDR sensors are used to monitor human movement to trigger the lighting of one light and also to measure the level of brightness in order to trigger another light. In our study, both sensors play a role in relation to lighting a bedroom light. In our case, the condition for switching the light on is built into the program code. Rajakumar [24] describes how the PIR sensor is used in a family room to turn the light on when there is human movement inside, with the goal of saving electricity. Similarly, in our study, the PIR sensor operates in the same way but with an advantage: the light turns on automatically in cases of darkness, utilizing the LDR sensor. In the first case, it is likely that the light would turn on even during the day when there is natural light. Pawar [25] describes home automation using LDR and PIR sensors, as well as a temperature sensor, with the goal of saving energy. Similarly, in our study, we have used the PIR and LDR sensors, but not for energy-saving purposes; instead, they are for ensuring children's safety in the bedroom during the night. Moreover, several scientific papers already published in various journals and indexed on Web of Science, particularly on the Scopus platform, address the use of these two sensors connected to the Arduino UNO module for controlling various phenomena. Our paper also uses these two sensors but stands out as the only one that builds a security system for children in the bedroom at night during darkness. This paper has been tested and works perfectly in a bedroom of a family with two children who have down syndrome and developmental disabilities in the Republic of Kosovo. All of this was done at their request, directed to the Department of Digital Electronic Systems and Microcontroller Programming at the Faculty of Computer Science at "Kadri Zeka" University in Gjilan.

By utilizing the input and output capabilities of the Arduino UNO microcontroller, we have successfully developed an integrated electronic system designed for practical use. This system is securely constructed, posing no risks to users. Its operation is fully automated and ensured through the C++ program code written in the Arduino UNO environment, culminating in a well-defined sketch. The program code is presented as follows in the Algorithms 1 and 2.

Algorithm 1. System setup

```
Purpose: Initialize the pins for the PIR sensor, LDR sensor, LED, and relay, and enable serial communication.
        Input:
        motionSensorPin = 2 (PIR sensor pin)
        ldrPin = A0 (LDR analog pin)
        ledPin = 13 (LED pin)
        relayPin = 12 (Relay pin)
        Serial communication baud rate = 9600.
        Output: Pins initialized and ready for operation.
        Steps:
        Set motionSensorPin as INPUT.
        Set ledPin as OUTPUT.
        Set relayPin as OUTPUT.
        Begin serial communication at 9600 baud rate.
```

Algorithm 2. Monitoring and control logic

```
Purpose: Detect motion and darkness, control the relay, and log system activity.
Input:
ldrThreshold = 500 (Light intensity threshold).
delayTime = 1000 ms (Delay time).
Output: Relay and LED control, system status logs.
Steps:
Motion and Light Detection:
If motionSensorPin = HIGH AND ldrPin < ldrThreshold:
Set relayPin = LOW (Activate the relay).
Relay Monitoring:
If relayPin = LOW:
Set testIfMoving = false.
For i = 0 to 9:
If motionSensorPin = HIGH AND ldrPin < ldrThreshold:
Set testIfMoving = true.
Break the loop.
Log system status (relay, PIR sensor, LDR values).
Wait for delayTime.
If testIfMoving = false:
Set relayPin = HIGH (Deactivate the relay).
Status Logging:
Log the state of ledPin, motionSensorPin, ldrPin, and relayPin.
Wait for delayTime.
```

4. RESULTS AND DISCUSSION

To construct a smart bedroom for children, a solid understanding of electrical engineering, electronics, microcontroller technology, and programming particularly in C or C++ is essential. This hardware and software system utilizes several components, including a PIR sensor, an LDR sensor, an LED diode, an electromagnetic relay with both NO and NC contacts, a lighting pot, and electrical conductors for connections. The operation begins when the electromagnetic relay actuator receives a 5 VDC voltage supply, specifically when the ATmega328P microcontroller sends a bit 1 signal to output pin 12 of the Arduino UNO, to which the electromagnetic relay is connected. This occurs when the PIR sensor detects movement in the bedroom and the LDR sensor registers darkness, indicating high resistance. The LDR is connected to analog pin A0 on the Arduino. When these conditions are met, the relay switches from NC to NO, and simultaneously, the LED connected to output pin 13 lights up, signaling that the relay is powered.

As the relay connects the 220 VAC voltage to supply a 100 W light bulb, the intelligent bedroom illuminates. If the conditions are not met meaning either no movement or light is detected the system remains inactive, and the LED will not turn on. This configuration employs a logical AND operator in the software, ensuring both sensors must be activated for the light to function. The program continually executes while the system is powered, constantly checking for the required conditions. The PIR sensor detects movement, while the LDR measures ambient light levels. Upon detecting movement and darkness, the system will illuminate the space for a predetermined duration (e.g., ten seconds), after which the light will turn off unless motion is still present. If the room is already lit either by another light source or natural light the system remains dormant. This smart bedroom system is designed for children aged seven to fifteen, including those with developmental disabilities, elderly adults, and couples who appreciate technology even at bedtime. Future readers of this paper can utilize the general scheme outlined in Figure 1, alongside the program code (sketch) provided, to successfully build and customize the smart bedroom for personal or commercial use. Notably, this system can be constructed for a cost of only a few dozen dollars.

Moreover, the intelligent bedroom system is highly adaptable and can be extended or modified. Not only is the Arduino UNO module open-source, but the entire system can be tailored to various environments, such as vehicle garages, basements, residential corridors, schools, healthcare facilities, and workplaces. Ultimately, the system can be built or expanded according to customer specifications and needs.

5. CONCLUSION

The smart bedroom system for children, developed using PIR and LDR sensors, has demonstrated its functionality and numerous benefits. This system is both practical and user-friendly, making it suitable not only for children but also for other groups such as elderly individuals, couples, and those with special needs. One of its primary advantages is its ability to assist children in maintaining orientation within the bedroom at night, thereby reducing the likelihood of panic in the dark. The system is cost-effective, with construction expenses remaining within an affordable range of just a few tens of US dollars. Moreover, both the hardware and software components are straightforward to maintain, ensuring long-term usability. However, to ensure safety, the electronic system must be well insulated to prevent user contact, particularly with the 220 VAC electrical circuit. Additionally, the circuit powering the electric lamp should include a suitable fuse based on the lamp's power requirements. To optimize performance, careful placement of the sensors is essential. The PIR sensor should be positioned strategically to avoid unnecessary activations, ensuring its monitoring arc does not cover the area above the children's beds. Similarly, the LDR sensor should be installed in locations exposed to natural light sources, such as windows or external lighting. Future enhancements could include the addition of an alarm buzzer for audible alerts, as well as the integration of other sensors and actuators to expand the system's functionality. Overall, the smart bedroom system offers a safe, affordable, and adaptable solution to improve nighttime experiences for children and other potential users.

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AUTHOR CONTRIBUTIONS STATEMENT

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Ragmi M. Mustafa	✓	✓		✓	✓	✓			✓	✓	✓		✓	
Kujtim R. Mustafa	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		
Refik Ramadani		✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

DATA AVAILABILITY

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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BIOGRAPHIES OF AUTHORS

Ragmi M. Mustafa graduated from the Faculty of Electrical Engineering in 1987 at the University of Pristina in the Republic of Kosovo. He worked as a professor of electrical engineering and also of informatics and computer science in a high school. As an electronics engineer, he worked in factories as a private company in production machine installations and maintenance. It is specialized in Italy and Switzerland for the management, maintenance, and management of machines with automatic computer control such as Blow Molding Machines and Injection Molding Machines. He completed his doctoral studies at the University of Tirana in the field of information systems in 2013. Since 2015, he has worked as an associate professor at the "Kadri Zeka" University, Gjilan, Republic of Kosovo, at the Faculty of Computer Sciences. He can be contacted at email: ragmi.mustafa@uni-gjilan.net.

Kujtim R. Mustafa received the degree "Bachelor of Computer Engineering" from Faculty of Electrical and Computer Engineering - University of Prishtina, master's degree "Master of Computer Engineering" from the same university. Actually, he is doing his Ph.D. in computer engineering in the same faculty and university, in the field of web services, in the field of web services. He has worked on many projects as a software architect and software developer using REST API technologies and other service technologies such as WMS and WFS services for graphical data. He has experience in all software development life cycles such as planning, analysis, designing, implementation, testing, and integration. He has experience and knowledge in implementing Agile methodologies and has excellent knowledge in Agile methodology iterations. He is working as an IT specialist in a World Bank project "REGIP" which is an ongoing project in the field of Cadastre. His job is to deal with digital systems, propose advancement of systems. The systems are mainly for GIS applications. His focus in research is services and data manipulation regarding the services of textual and graphical data transfer. Now he works as a teacher assistant at University "Hasan Prishtina" Republic of Kosova. He can be contacted at email: kujtim.mustafa@uni-pr.edu.

Refik Ramadani was born on 13.11.1990 in Gjilan. Bachelor's and Master's degree in computer science at the University of Southeast Europe in Tetovo, North Macedonia, as well as Ph.D. candidates in the Department of Informatics and Mathematics - Direction: Computer systems in Education (ICT) in Veliko Tarnovo/Bulgaria. Since 2013, he has been working as a Managing Director at Led-Com.CH Company. From 2018, he works as a Director at the Trade Center - M&A Mall sh.p.k. - Interex. From 2016, he works as a lecturer and assistant at "Kadri Zeka" University, in the following faculties: economics, computer science and law. In the Faculty of Economics, he works as: assistant in the informatics subject for economics, business informatics and project technology. In the Faculty of Computer Science: assistant in the subject: communication and business technology, digital business, business information analysis, business building as well as assistant in the Master's E-government in the subject: information systems management. In the Faculty of Law: lecturer and assistant in the subject: informatics for lawyers and in the Master's program, the subject E-government. He can be contacted at email: refik.ramadani@uni-gjilan.net.