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The combined alarm system based on ESP32CAM

In order to protect an apartment or office, it is enough to install a security and fire alarm system, the main task of which is to quickly notify property owners or a special service about a fire or unauthorized entry into the premises. A high-quality notification system is one that generates a reliable alarm signal and minimizes spurious action. To maximize the performance of the notification system, it is advisable to use a combined version that will be endowed with internal «intelligence», which will allow you to identify the danger, notify about it, and, if necessary, neutralize the threat. Using a combined detector, which, in addition to sending a danger signal, simultaneously sends a photo of the protected room, will significantly increase the probability of correct detection of a dangerous situation and reduce the probability of a false alarm. The paper shows the possibility of creating a combined system for remote monitoring of unauthorized entry into the room and fire alarm based on the low-cost ESP32-CAM module, which is ideal for independent projects in the field of IoT.

Keywords: fire alarm system; motion sensor; ESP32-CAM.

General statement of the problem and analysis of the main studies in which the solution of the problem is initiated. The protection of property, valuables, and especially human life is an important part of the existence of the modern world. In order to protect an apartment or office, it is enough to apply security and fire alarm systems. The main task of such equipment is to quickly notify property owners or a special security service about fire or unauthorized entry into the premises [1].

As a sensitive element, in most cases alarm systems use a pyroelectric infrared motion sensor, which measures the contrast of infrared radiation from different sensitive areas. These sensors are great for projects where you need to detect the presence or absence of a person within a specific workspace [2, 3]. Smoke and heat detectors, as well as fire sensors are widely used as fire alarm devices. For example, the thermal fire detector «Arton SPT-3V» is designed to monitor the temperature increase in closed rooms of various buildings and structures [4]. The Arton SPD-3 smoke detector detects smoke using an infrared emitter and photodetector [5]. Fire sensors are designed to detect flames and can respond to both ultraviolet and infrared radiation [6, 7].

A high-quality notification system is one that generates a reliable alarm signal i.e. only in a case of danger and minimizes spurious action. Improving the quality of the notification system is achieved by the additional use of video cameras. To maximize the performance of the notification system, it is advisable to use a combined version that will be endowed with internal «intelligence», which will allow you to identify the danger, notify about it, and, if necessary, neutralize the threat [8]. In this case, a number of sensors are used that are connected to controllers and actually form a sensor network based on modern telecommunications technology – the Internet of things [9].

So *the purpose of the article* is the consideration of the possibility of creating a combined remote control system for unauthorized entry into the room and fire alarm, based on the Internet of things (IoT) technology.

Problem statement and its solution. Modern alarm systems of leading companies, such as «Tiras» or «Ajax» provide the use of both wired and wireless connections in the network and GSM network of the mobile operator to control from anywhere in the world, transmit event notifications and software updates. These systems are designed to serve organizations with a large number of sensors. For example, the AJAX system provides the ability to connect up to 100 different sensors. This means that the cost of these systems is proportional to the complexity of the technologies used in their creation. For example, the basic wireless alarm AJAX StarterKit costs UAH 7,599 before the start of Russian aggression) [8]. Therefore, it is advisable for the protection of small objects such as apartments to consider the possibility of creating a combined system for remote control of unauthorized entry into the premises and high-quality fire alarm based on the inexpensive ESP32 Wi-Fi module, which is ideal for independent projects in the field of IoT. The ESP32 has a 32-bit dual-core processor with a clock speed of 160 to 240 MHz. The ESP32-CAM module combines the ESP32 board for development and the OV2640 2MP camera. Due to the fact that the board has a built-in camera, such a device can be used as a video camera of surveillance systems with the function of face recognition, photo recording and many other purposes. The ESP32-CAM also has a slot for an SD memory card up to 4 GB, which can be useful for saving images captured by the camera. You can control the camera and display both streaming video and photos using a local WEB server [10]. Fig. 1 shows an image obtained by the authors using the ESP32-CAM module using this resource. Note that to program the ESP32-CAM module in the Arduino IDE, you must use a USB-UART converter.

You can also control the camera via mobile apps. For example, in [11] the principles of controlling the OV2640 camera operating in photo recording mode as part of the ESP32-CAM module are considered via mobile app «Telegram». The results of controlling the camera via the Telegram bot in photo recording mode, taking into account the recommendations set out in [12], are shown in Fig. 2.
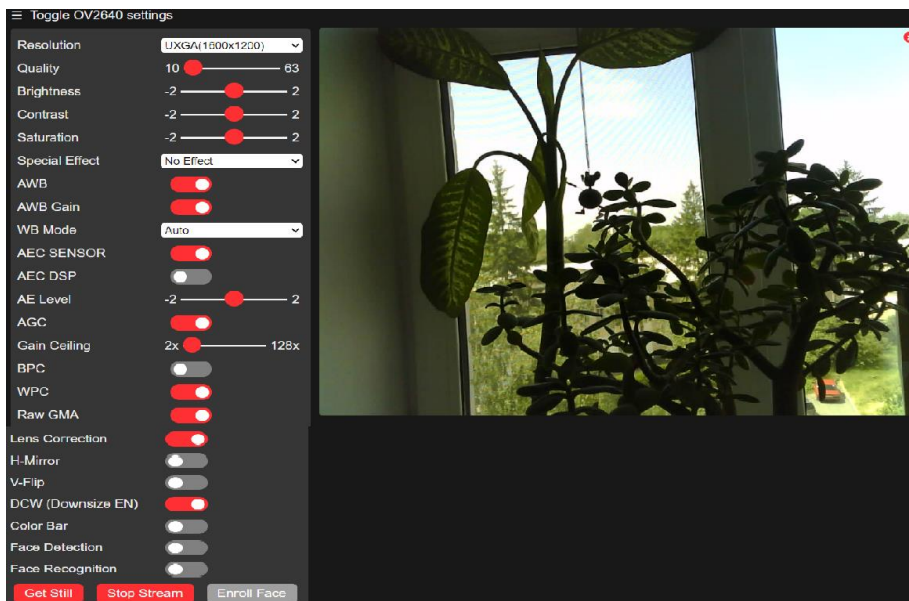

Fig. 1. Displaying the OV2640 camera image on a Web page

As you can see from the figure below, the camera is controlled using three commands:
/ start – sends a welcome message with ESP32-CAM board control commands;
/ photo – ESP32-CAM takes a new photo and sends it to the Telegram chatbot;
/ flash – enables the ESP32-CAM LED flash.

Fig. 2. OV2640 camera control via Telegram bot

The ESP32-CAM module has a certain number of GPIOs that can be connected to, for example, a motion and smoke or fire sensor. And the simultaneous use of the information of these sensors together with the built-in OV2640 camera will increase the reliability of the information of the notification system with the display of work results in the Telegram mobile application.

To test the possibility of simultaneous operation of the motion sensor and the OV2640 camera, we will create a project in which the ESP32-CAM automatically takes photos and sends the photo to the Telegram bot when the

motion sensor is triggered [13]. The layout of the developed device is shown in Fig. 3. The motion sensor contains two sensitive elements. This is due to the fact that it is not the level of emission that is important, but the presence of movement within its sensitivity zone. When the sensor is at rest, both sensors detect the same amount of emission. For example, it can be the emission from a room or the environment. When a warm-blooded object (human or animal) passes by, it crosses the sensitivity zone of the first sensor, resulting in two different emission level values generated at the sensor output. When a person leaves the sensitivity zone of the first sensor, the values are aligned. It is changes in the readings of the two sensors that are recorded and generate a digital pulse HIGH in the presence of movement or LOW, when there is no movement. The sensor operates with a power supply from 3V to 9V, providing a sensitivity range of up to 6 meters. To provide the required viewing angle of 110° x 70°, the sensor is equipped with a Fresnel lens.
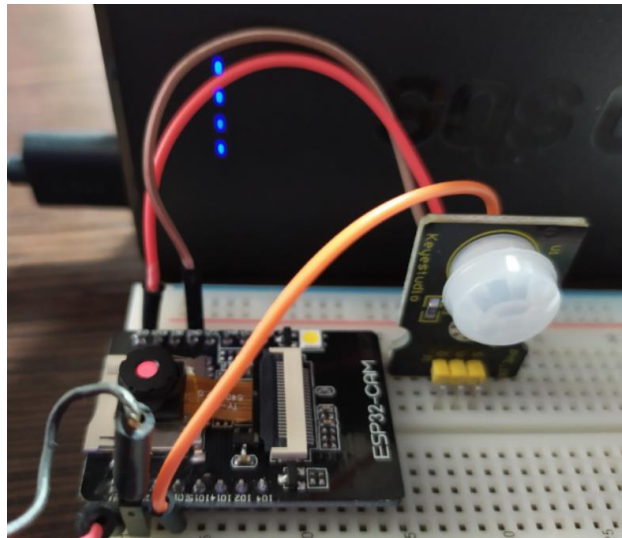
Fig. 3. Using a motion sensor with ESP32-CAM

A «Power-bank» with an output voltage of 5V was used to power the alarm device. The motion sensor output was connected to the desired GPIO and powered from the output of the 3.3 V voltage converter built into the ESP32-CAM board. As preceded by Fig. 4, after simulating the movement, automatic photographing takes place with sending a message about the operation of the motion sensor to the mobile application «Telegram» along with the received photo.
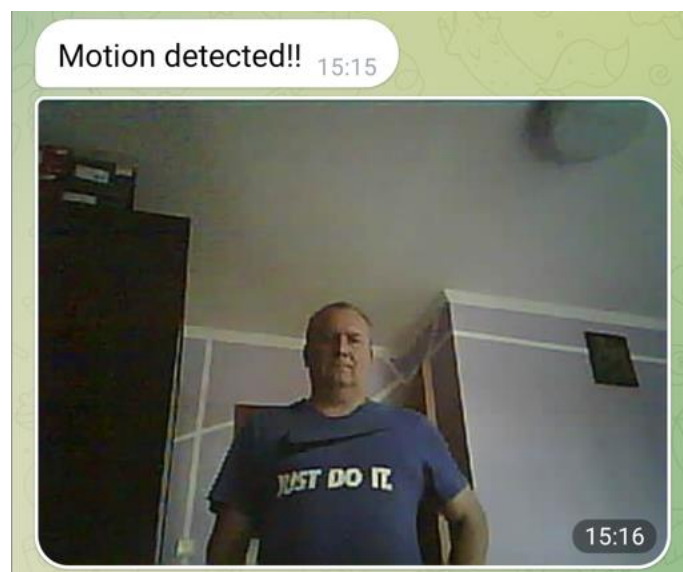
Fig. 4. Automatic photographing when the motion sensor is triggered

The operability of the fire alarm device was checked using an MQ-2 smoke detector. The MQ-2 sensor belongs to semiconductor devices. The sensor element consists of an aluminum oxide-coated ceramic tube and a sensitive layer of tin dioxide applied to it. Inside the tube is a heating element that heats the sensitive layer to the temperature at which it begins to react to a certain gas. By measuring the resistance of the sensor element, you can determine the concentration of carbon monoxide or smoke in a certain volume of air [14]. The MQ-2 smoke detector module is powered by a 5V source. The voltage at the analog output «A0» of the module is proportional to the gas concentration in the air, and the voltage at the digital output «D0» changes from high to low when a certain threshold is exceeded, which is set by the variable resistor of the module. The layout of the developed device is shown in Fig. 5.

Due to the fact that in this case we are not interested in the specific value of the concentration of combustion products in the air, but only in the fact of exceeding the set threshold, we will use the output «D0» to connect the sensor to the microcontroller. If there is a low potential at this output, the microcontroller will generate a command to take photos with the OV2640 camera.
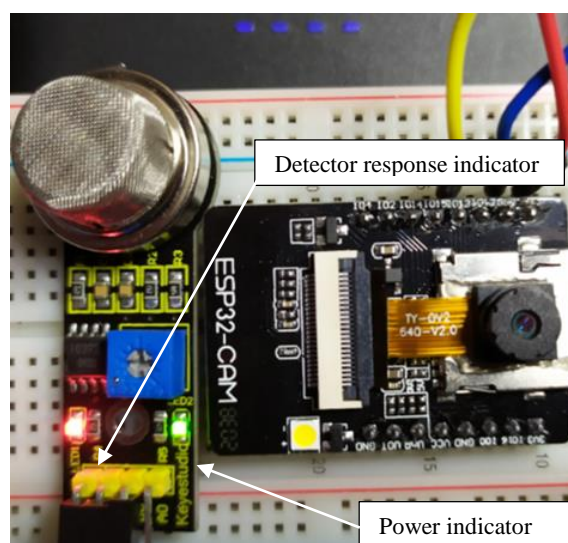

Fig. 5. MQ-2 smoke detector threat detection

After uploading the program code to the microcontroller and connecting to the «Power-bank», a connection was made to the Wi-Fi access point and a message was sent to the Telegram mobile application about the start of the bot. If the MQ-2 smoke detector is not triggered, only a green LED lights up on board, indicating that power is being applied to the module (Fig. 5). When the MQ-2 smoke sensor is triggered, a red LED turns on board, and a low potential appears on the digital output «D0», according to which the microcontroller generates a command to take photos with the OV2640 camera and sends a message about the smoke sensor being triggered to the Telegram mobile application along with the resulting photo. After restoring the original state of the smoke detector, the red LED turns off, indicating that the detector has stopped detecting the source of the danger.

Conclusions. Thus, the possibility of creating a combined remote control system for unauthorized entry into the room and fire alarm based on the inexpensive ESP32-CAM module is proved. Using a combined detector, which, in addition to sending a danger signal, simultaneously sends a photo of the protected room, will significantly increase the probability of correct detection of a dangerous situation and reduce the probability of a false alarm.

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Андреєв О.В., Дубина О.Ф., Нікітчук Т.М.
Комбінована система сигналізації на базі ESP32CAM

Для того щоб захистити квартиру або офіс, достатньо встановити охоронну та пожежну сигналізацію, головне завдання якої швидке сповіщення власників нерухомості або спеціальної служби про пожежу або несанкціоноване проникнення до приміщення. Якісною системою сповіщення вважається та, яка формує достовірний сигнал тривоги та мінімізує помилкові спрацьовування. Для максимальної продуктивності системи сповіщення доцільно використовувати комбінований варіант, що буде наділений внутрішнім «інтелектом», який дозволить виявити небезпеку, сповістити про неї, а також за необхідності нейтралізувати загрозу. Використання комбінованого сповіщувача, який, крім надсилання сигналу небезпеки, одночасно надсилає і фотографію приміщення, що охороняється, суттєво підвищить вірогідність правильного виявлення небезпечної ситуації і зменшить ймовірність хибної тривоги. У роботі показана можливість створення комбінованої системи дистанційного контролю за несанкціонованим проникненням до приміщення та пожежної сигналізації на основі недорогого модуля ESP32-CAM, який ідеально підходить для самостійних проєктів у галузі IoT.

Ключові слова: пожежна сигналізації; датчик руху; ESP32-CAM.