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Security System (Motion Capture) Based on Raspberry Pi

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Abstract

This paper describes a state-of-the-art security system that uses motion capture technology to offer a reliable and flexible security solution for small-business and home settings. The Raspberry Pi, ESP32 camera module, and PIR (Passive Infrared) sensor are the three main components of the system, and they cooperate to identify and document any unusual behavior. As the system's central processing unit, the Raspberry Pi is in charge of coordinating all of its operations and making sure everything runs well. Because of its high-resolution video capture capabilities, the ESP32 camera module can record crisp footage of any motion it detects. The PIR sensor, on the other hand, is very good at detecting motion since it is made to detect even the smallest variations in temperature and infrared radiation. The camera records when motion is detected using the PIR sensor. The video is then either sent to a cloud-based storage service or stored locally on the Raspberry Pi for further viewing and analysis. The system is a complete security solution that can be readily integrated into pre-existing home automation systems. It also has features like real-time alarms, remote monitoring capabilities, and connectivity with smart home devices. Compared to conventional security systems, the suggested system has a number of benefits, such as being more affordable, simpler to install, and highly customizable. The system is easily upgraded and modified due to its open-source hardware and software, which makes it a desirable choice for people and organizations searching for a dependable and affordable security solution.

Keywords: Raspberry pi, security system, passive infrared, ES32 module

INTRODUCTION

Imagine a security system with the same level of perception and comprehension of its environment as humans. That is how motion capture technology works its magic. In our major paper, we use the amazing powers of the Raspberry Pi, a small but powerful computer, along with its camera module to delve into the area of security systems. Our work focuses on collecting real-time motions, which makes security smarter and more responsive than typical security settings, which frequently rely on still photos or limited viewpoints [1]. As technology advances at a never-before-seen rate in our modern world, protecting our homes and workplaces has become of utmost importance. The sense of security that we require is no longer adequately provided by the conventional lock-and-key techniques. The demand for creative and effective security solutions is rising as smart homes and networked gadgets become more common. This insight led to the development of the "Security System (Motion Capture) Paper," a ground-breaking project that aims to transform the way we protect our environment by utilizing the capabilities of the Raspberry Pi and its camera module [2]. Consider a security system that not only keeps an eye on your house but also has real-time

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intelligence. The Security System (Motion Capture) Paper seeks to accomplish just that. The Raspberry Pi, a credit card-sized microprocessor that has revolutionized the electronics industry, is at the heart of it all. The Raspberry Pi has become a shining example of creativity thanks to its mobility, affordability, and versatility. It has enabled professionals, hobbyists, and enthusiasts to design a wide range of applications. In this work, we take advantage of the Raspberry Pi's features and turn it into our security system's brain [3]. The Raspberry Pi comes with a camera module, a compact but capable gadget for taking pictures of our surroundings.

This camera module is a doorway to visual intelligence, not only a lens. We can now view, analyze, and understand our surroundings more clearly than ever before thanks to the integration of this module into our security system. We can take clear and accurate environmental observations thanks to the camera module's ability to record and store high-resolution photos and movies. This module becomes our eyes, giving us invaluable insights into the activities going on around our homes and offices thanks to its adjustable focus and inbuilt image processing capabilities. Our security system's capacity to comprehend motion is its fundamental component. Conventional security cameras only capture images; the viewer is left to do the analysis. But our system is proactive; rather than merely capturing motion, it interprets it. We explore the field of motion capture technology, using advanced algorithms to identify movements and discern between routine tasks and possible dangers. Our system's sophisticated comprehension of motion enables it to react dynamically, setting off alerts, recording pertinent video, and starting pre-programmed operations in response to identified activity. However, why is motion capture so important for security purposes? Its capacity to distinguish between benign movements, like swaying tree branches or passing cars, and suspicious activity, like an intruder approaching your home, holds the key to the solution. Our technology is able to recognize movements that resemble those of a human being by using advanced pattern recognition and machine learning algorithms. This means that you will only be notified when there is a legitimate reason to be concerned. This improves the overall reliability of the system and lowers false alarms [4].

Accessibility is one of the main ideas behind the Security System (Motion Capture) Paper. We are aware that not everyone is an expert on computers or a tech enthusiast. For this reason, we have painstakingly created an easy and user-friendly system. Whether you own a small business, are a community organizer, or are a homeowner, our interface makes it simple for you to operate and control your security system. Users of all backgrounds are empowered to take charge of their security without the need for substantial technical knowledge thanks to clear images, easy controls, and step-by-step tutorials [5]. The Security System (Motion Capture) Paper is essentially a statement about our dedication to safety, innovation, and community rather than merely a technical endeavor. It is an example of how human creativity and state-of-the-art technology may come together to bridge the gap between the digital and real worlds. We are redefining security as we set out on this adventure, opening the door to a more secure and interconnected future. Come along with us as we harness the power of the Raspberry Pi and its camera module to turn common places into intelligent, safe areas. One movement at a time, let's work together to make our homes, workplaces, and communities safer [6].

LITERATURE SURVEY

Using computer vision techniques for picture segmentation and image subtraction is the most often used method of developing motion detection algorithms [7]. The majority of the algorithm starts by separating the moving items in the foreground from the backdrop. They would need to take a series of still photos in order to initialize the background image in order to accomplish this. In order to create a real-time environment where background changes are taken into account, this backdrop image would be refreshed later. For instance, a moving object would become a part of the background image when it stopped moving [8]. It is evident that the foreground items can be obtained by image subtraction and basic arithmetic. The foreground moving objects are the product of subtraction algorithms, in which pixels in the present image are subtracted by corresponding pixels in the background image, or vice versa [9]. Once the foreground objects have been identified, the region of interest's focus is moved from

the entire image to these front objects. As previously discussed, the foreground-background segmentation stage is the initial step of a motion detection method. Many methods exist for separating the foreground from the backdrop. In order to enhance the standard image subtraction methods that just rely on pixel intensity values, Ming and Tim [10] proposed including color illumination invariance into the algorithm. Their research can therefore be successfully used to motion detecting regions with abrupt changes in lighting. Using edge detectors makes it possible to see moving objects more clearly. According to Ramesh, Rangachar, and Brian [11] as well as Milan, Vaclav, and Roger, utilizing edge detectors in conjunction with various images can improve motion detection outcomes by assisting in overcoming a number of constraints. In the field of image processing, numerous edge detector methods are being introduced. The subjects of edge detection are covered in almost all image processing texts. These texts on image processing include [10], [9]. Numerous online sources, including [8], also cover convolution techniques, which can likewise be used with edge detection algorithms. Researchers use a variety of methods to accomplish motion detection. Of them, we will talk about two here. The first is the traditional backdrop modeling strategy, which modifies the background using statistical data methodology. The second would be a technique discovered by the Ying-Li Tian and Arun Hampapur-led IBM research group [12].

Understanding what the thing is, or more accurately, recognizing it, comes next once all the moving objects have been labeled and segmented.

them. Sometimes, we might want to categorize them appropriately. The application in which the human motion detection system is used, however, determines the classification engine. Here, we'll go over one method of feeding data into the categorization engine. Depending on how we would want to identify the objects that are moving in the region of interest, a variety of attributes can be employed as inputs into the classification engine. In particular, we want to be able to tell moving objects apart from humans in our research. Song, Goncalves, Feng, and Perona [2], [3] have modeled the human body using a probabilistic structure in order to do this. They can pose estimate human motion using point tracking algorithms, allowing them to be distinguished from other moving objects. The point tracking algorithm in their study is based on Johansson's [13] stimuli, in which every body joint is displayed as a moving dot. Moore [1] claimed in his publications that tracking the moving dots or points can be done in a variety of ways. He claims that while the Kanade-Lucas-Tomasi algorithm is notable for its simplicity, it has a number of drawbacks. As a result, Moore [1] had put into practice a derivation method based on Birchfield's [15] research. Zivkovic and van der Heijden [13] also conducted an improvement effort in which they proposed an enhancement to the traditional Kanade-Lucas-Tomasi method. In their articles, they concentrate on the first characteristics point selection and offer a way to enhance the selection procedure to lower detection errors [14].

Block Diagram and Components

The block Diagram for Security System (Motion Capture) is shown in the above Figure 1.

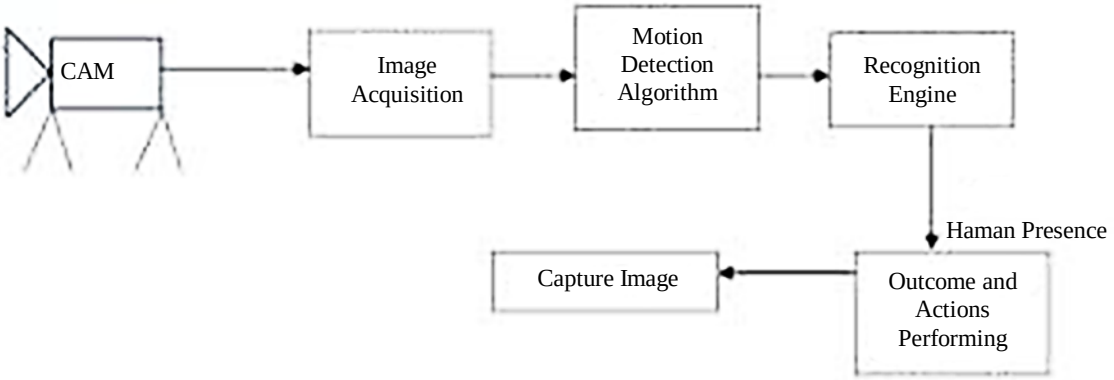

Figure 1. Block Diagram of security system (Motion Capture).

This paper Security System (Motion Capture) has three main components.

Raspberry Pi Pico

The world of embedded systems and Internet of Things development has been completely transformed by the Raspberry Pi Pico as shown in Figure 2, a microcontroller board that is seen in figure 2. A non-profit organization devoted to advancing computer science education and coding, the Raspberry Pi Foundation created this small, reasonably priced, and incredibly powerful platform. The Pico is based on the robust RP2040 microprocessor, which has two 133 MHz dual-core Cortex-M0+ CPUs, 264 KB of RAM, and 2 MB of flash memory.

The Pico is capable of doing sophisticated tasks like machine learning, audio processing, and high-speed data transport thanks to its remarkable mix of processing power and memory. The Pico is a great option for papers that need connectivity and data interchange because it comes with a variety of peripherals, such as USB, SPI, I2C, I2S, and UART interfaces. Additionally, a variety of programming languages, including as C, C++, MicroPython, and Circuit Python, are supported by the Pico, making it a highly adaptable tool for developers of all experience levels. Robotics and automation, home automation, and Internet of Things papers are just a few of the many applications that benefit greatly from the Raspberry Pi Pico's small size, low power consumption, and ease of use.

ESP32 Camera Module

Figure 3 illustrates the ESP32 camera module, a strong and adaptable accessory for the ESP32 microcontroller board made especially for applications.

that need the acquisition and processing of high-quality images. This module has an advanced camera function set that includes autofocus, auto-white balance, and exposure management. It also has a high-resolution CMOS image sensor that can capture photographs at up to 5 megapixels. The ESP32 camera module is a great option for applications like object detection, facial recognition, and motion tracking since it has a dedicated image processing unit that enables real-time image processing and analysis. Moreover, the module allows developers to fully utilize computer vision and machine learning in their papers by supporting a variety of well-known image processing libraries, such as OpenCV. The ESP32 camera module is a great option for Internet of Things applications that need high-quality image capture and processing, like surveillance cameras, smart home security systems, and driverless cars. It is also highly integrated with the ESP32 microcontroller, enabling smooth communication and data transfer between the camera and the microcontroller.

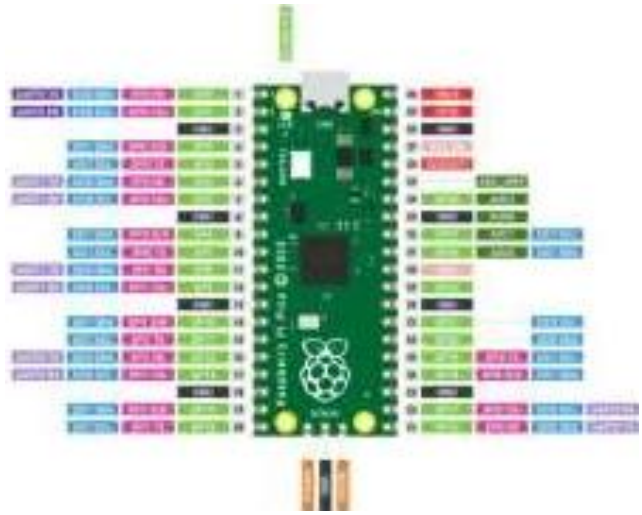

Figure 2. Raspberry Pi Pico.

Figure 3. ES32 camera module.

Figure 4. PIR sensor.

PIR Sensor

An electronic gadget that recognizes infrared radiation generated by objects within its field of vision is called a passive infrared (PIR) sensor, as seen in Figure 4. It is frequently utilized in applications for automatic lighting, security alarms, and motion detectors. The sensor's purpose is to track variations in infrared radiation, which are a sign of motion. It measures infrared radiation by dividing its detecting area into two parts, each of which has a pyroelectric sensor. One half of the sensor detects more infrared radiation than the other when an object moves within the detecting region. This differential change causes the sensor to send a motion-indicating signal. Because of its affordability, usability, and dependability, this technology is extensively employed in many different applications and is especially good at detecting human movement.

RESULT

The ESP32 microcontroller and ESP32 camera module are used in the security system article to effectively collect high-quality photos when motion is detected. The ESP32 microcontroller in the system is linked to the PIR motion sensor, which causes the camera module to take a picture when motion is detected. The OpenCV library is then used to process the collected image in order to improve its quality and identify any objects or movements. The system offers a dependable and effective way to keep an eye on and secure the monitored area by storing the taken pictures on an SD card for subsequent retrieval and analysis. The result of the article is a strong security system that successfully takes pictures when motion is detected, giving unmistakable visual proof of any activity in the monitored area.. Because of the system's real-time monitoring features, users may react promptly to any motion that is noticed, improving overall security and lowering the possibility of unwanted activity. The system is the perfect answer for a variety of applications, from home security to business surveillance, thanks to its simple interface with current security systems and effective storage capacities. Upper view of model through proposed methodology is shown in Figure 5.

Figure 5. Upper view of model through proposed methodology.

CONCLUSION

To sum up, our security system paper that makes use of motion capture technology and a Raspberry Pi is a big step in the direction of making homes, workplaces, and other locations safer. Through the utilization of the Raspberry Pi, we have effectively created a user-friendly and efficient method for tracking and identifying motion in real-time. This study highlights the possibilities of accessible and user-friendly technology while also improving security. It shows how creativity can enable people and groups to save their most precious possessions and dear ones. Because of its adaptability and ease of setup, security systems are becoming more widely adopted, increasing accessibility for all. Future developments in the field of smart security are made possible by the knowledge obtained from this study. With ongoing development and innovative application, Raspberry Pi-based security systems have the potential to significantly contribute to peace of mind, safety, and increased security for those in our surrounds.

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