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Anomaly Detection for Security in Children's Play Areas Based on Image Using Multiple Lines Detection Method

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***Abstract*—This study aims to build a device as a security system to detect anomalies of children moving in play areas based on the multiple line detection (MLD) method in a streaming image. We developed this device to help parents monitor their children's activities when playing in dangerous areas of the home to protect children from kidnapping. In this study, the MLD method can detect the children's activities when playing in three zones: the safe zone with green lines in the image, the caution zone with yellow lines, and the danger zone with red lines. The hardware used to build the devices in this study consists of three components: a camera to stream the image activities of children, a Raspberry Pi to process the image using OpenCV, and a buzzer for early security systems. The results of this study show that when the device detected the children playing in the safe zone, the system commanded the buzzer to turn off. Furthermore, when the camera detects that the children are playing in the caution and danger zone, the device then commands the buzzer to turn on as an early warning security system for the parents.**

Keywords: ***anomaly, security, children, image, multiple lines detection***

I. Introduction

In terms of the children's activity routines, playing is one of the most common activities that they do both inside and outside of the house. However, the crime of kidnapping is one of the problems in society especially the parents when they cannot monitor the children playing in the danger area of the house, for example when playing near the fence door or outside the house. The less of utilities and devices technology that can be used to protect the children from the kidnapping can make the kidnapper easily to abduction the children when playing in the danger area of the house. Therefore, based on those problems, the urgency of this study is to develop a device that can be used to protect children from kidnappers when they are playing in dangerous areas of the house, so it can help the parents protect and monitor their children when playing in the house.

Some researchers have studied the development of devices and systems to protect the children from the kidnappers. Kodikara et al. [1] have developed an intelligent surveillance system to protect children from kidnappers using Artificial Intelligence Care (AICare). In that study, the researchers detected the kidnapper based on the face recognition of the children when covered by the kidnapper's body. Next, Tian & Ma [2] built a device that can detect the kidnapper's trajectory when abducting the children. They used a double kidnapping detection and recognition (DKDR) framework and a simultaneous localization and mapping (SLAM) method to track the kidnapper's trajectory. Hadi et al. [3] presented the development of a device to protect children from kidnappers using an image processing algorithm on the intel Galileo board. The researcher detected the kidnapper in that study using the face recognition method when pressing the bell in the house by attaching the camera in the front of the house. Sharma et al. [4] have developed a device to protect children from abduction when doing activities outside of the home. They used a push button mechanism attached to the belt as a warning security system when the children were abduction by kidnappers. Furthermore, Gerry et al. [5] applied a device to prevent kidnapping of children at home using CCTV. In that study, they used the You Only Look Once (YOLO) algorithm and the Convolutional Neural Network (CNN) method to recognize the faces of kidnappers when abduction the children in the home.

According to the methods shown in the previous studies, some researchers have developed devices to protect children from kidnappers based on face recognition methods, trajectory trackers using SLAM, and push-button techniques. However, the contribution of this study is to develop a device that can be used to monitor children's activities when playing at home to protect them from kidnappers based on the multiple lines detection (MLD) methods detected from the streaming image. We used the MLD method in this study because it can be used to detect the children's activities based on

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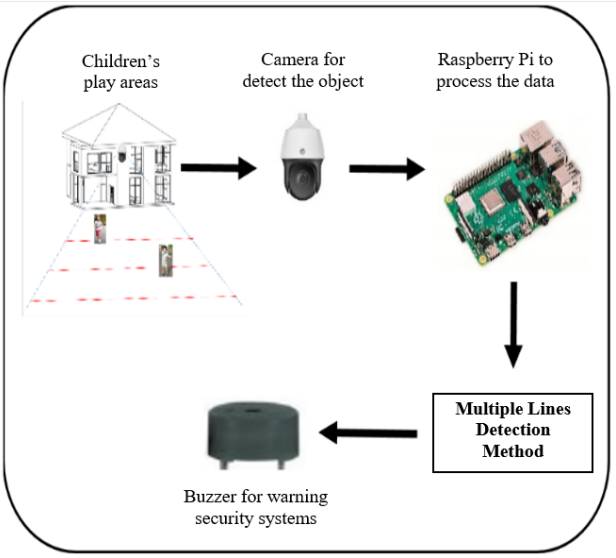

Figure 1. Design of architecture systems

lines in the streaming image with three levels of security system zone: green lines for safe zones, yellow lines for caution zones, and red lines for danger zones. We detected children according to zones because the location of the area for children's play is important to protect them from kidnappers, for example, very small children should only play in the backyard or in a supervised play area [6]. In the MLD method, we detected the children's activities from each zone based on the changing of Red, Green, and Blue (RGB) value readable from each line of the zone. Especially, when the system detected that the changing of RGB values was significant in green lines, the system then detected that the children were playing in a safe area, when the changing of RGB value was frequently detected in yellow lines, the device then detected the children playing in a careful zone. Furthermore, when the changing RGB values were high in red lines, the systems then detected the children playing in dangerous areas. In our developed device, when the camera detects the children playing in a safe area, the Raspberry Pi in the device commands the buzzer to turn off. After that, when the system detects the children playing in the caution and danger area, the device commands the buzzer to turn on frequently as a security system to save the children from the kidnappers.

This paper consists of four chapters to elaborate on our developed systems. In the first chapter, the introduction, we elaborate on the problem and previous studies related to our research. In the second chapter, we presented the MLD method to detect children's activities and protect them from the kidnappers based on three zones of activities: safe zone, caution zone, and danger zone. In chapter three, we explained the experiment and results of our study. Furthermore, chapter four shows the conclusion and advice of our developed study.

II. METHOD

In this study, we have designed a system architecture to protect children from kidnappers when they are playing in the home or yard. The device developed in this study can be used to help parents monitor their children when playing in the house or yard without a parent's keeper. Furthermore, Figure 1 shows the system architecture designed in our study.

According to the information shown in Figure 1, we developed the device in our study based on three main hardware components: a camera to capture the streaming image, a Raspberry Pi to process the image using OpenCV and detect children's activities using the MLD method, and a buzzer for warning security systems. The camera is an input device consisting of a lens and optic drive to capture and stream the image for input visual information of the systems [7]. The camera function in this study is to stream the image of the house yard to detect the children's activities when playing in the dangerous area of the home, for example, when playing near the fence door, house door, and outside the home. In this study, we used an image processing technique to process the image with the MLD method. The concept of image processing is the conversion of an image to a digital form and the performing of a set of operations on it so that useful information can be obtained from it [8]. Furthermore, the Raspberry Pi function in our device is to process the image data using the OpenCV library and then manage the buzzer to turn on or off based on the command of Raspberry Pi's general purpose input/output (GPIO). Raspberry Pi is a kind of microcomputer that can be used to process data like computer performances [9]. After that, the buzzer function in this study is a warning system in the form of a beep sound when the device detects the children are playing in the caution and danger areas. Buzzer or Piezoelectric Buzzers is an electrical device that can produce a beep sound when getting an electrical voltage from the DC source [10].

The basic idea of the MLD method in our study was derived from research that used lines in the streaming image to count people when crossing the lines in the image [11]–[13]. In digital image processing, each pixel in the image has color information in the form of RGB [14], where the RGB values of each pixel can be changed when the camera detects a new raw information image at different times. In the MLD method, we detected the frequency of children moving from each zone in the streaming image by calculating the average of RGB values in lines when the camera captured a new image in each frame per second. We used multiple lines from each zone in this study to detect the accuracy of children moving when doing the activities in the zone of safe, caution, and danger. Equation (1) below shows the formula used to calculate the average of RGB values from each line to detect the frequency of children's activities from each zone: safe, caution, and danger.

$$RGB\ value = \frac{RGB\ line\ 1\ +\ RGB\ line\ 2\ +\ RGB\ lines\ n}{Number\ of\ lines}. \quad (1)$$

To analyze the efficiency of the MLD method, we collect the amount of data based on the average of RGB

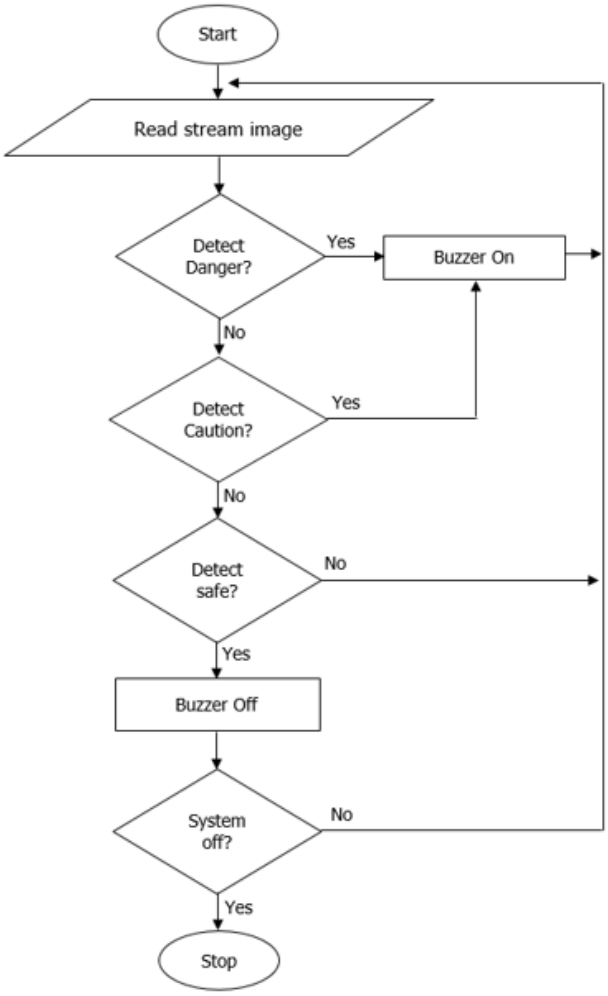

Figure 2. Flowchart systems

values that change from each frame readable from the streaming image. We analyze it when the children do activities in the dangerous area of the house that enable the kidnappers to abduct the children when playing in that area, for example, when the children play near the house door or yard door.

In this study, we have designed the flowchart systems to manage the device so it can be used to detect the children's activities when playing in safe, cautious, and dangerous areas. Based on the information of the flowchart system, in the first step, the device reads the stream image captured from the RGB camera, and after that, the Raspberry Pi processes the image data captured from the camera using the OpenCV library and Python language to calculate the average value of the RGB from each pixel in the lines. The function of OpenCV in image processing is a tool for manipulating images or videos in the form of digital image processing [15]. Then the Python programming language is a high-level programming language that can be used to process the image created by Guido Van Rossum [16]. In this study, the MLD method runs when the Raspberry Pi processes the image using OpenCV. We use the MLD method to determine the level zone of children's activities when playing in the yard or at home: danger, caution, and safe.

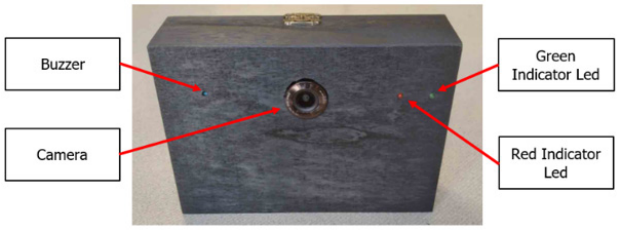

Figure 3. Device result from outside view

In the danger zone, we used four red lines in the image to detect the children's activities when playing in the danger area, for example, in the yard door or the house door. Each line in the image detected from red lines has pixels with the amount of RGB values. To detect the children's activities in the danger zone, we compare the average value of RGB detected from each frame of the image. If the systems detected that there is a low difference in RGB value changing from each frame, it can be concluded that no children are playing in the danger area. On the other hand, if the system detects a high difference of RGB values changing from each frame, the system detects that any children are playing in the danger zone, and then commands the buzzer to turn on as a warning security system to the children to not play in that area..

Furthermore, in the caution zone, we used four yellow lines to determine the caution area in which children can do activities. When the systems detect that there is a low RGB changing value from each frame, the system detects that no children are playing in that zone. However, if the systems detected the average values of RGB in yellow lines changing with high frequency, the systems detected that any children were playing in that area. In this condition, the systems then command the buzzer to turn on to give a warning to the children to not play in the caution area.

In the safe zone, we used green lines in the image to detect the activities of the children when playing in the safe area. In this condition, if the systems detect low RGB values that change from each frame in the image, it can be concluded that no children are playing in the safe area. However, when the RGB values of each frame change with high frequency, it can be concluded that any child is playing in that area. In this condition, the systems command the buzzer to turn off to identify that the children playing in the safe zone. In this study, we used a piezo buzzer device as a warning security system that can be turned on if the GPIO of Raspberry Pi gives a high condition to the buzzer, and turned off if the GPIO gives a low condition. Figure 2 shows the flowchart system designed in our study.

III. Result and Discussion

In this study, we have developed a security system device that can be used to detect the children's activities when playing in the yard and at home to save them from the kidnapper. We used the MLD method to detect the anomaly of children moving in the three areas: safe, cautious, and dangerous. Figure 3 shows the device developed in our study shown from the outside, and Figure

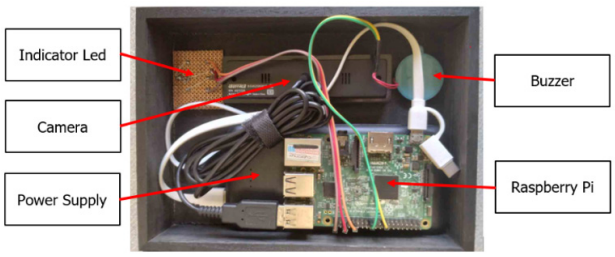

Figure 4. Device result from inside view

Table 1. Device analysis results to detect the security systems

Test	Position	Buzzer	Results
1	Safe	Off	Success
2	Caution	On	Success
3	Danger	On	Success
4	Safe	Off	Success
5	Danger	On	Success
6	Caution	On	Success
7	Danger	On	Success
8	Safe	Off	Success
9	Caution	On	Success
10	Danger	On	Success

4 shows the inside condition of the designed devices.

Based on the information in Figures 3 and 4, it can be seen that the hardware used to develop the devices in our study consists of LED indicators, RGB camera, Raspberry Pi, buzzer, and power supply. The LED function in our developed device is an indicator when the device is turned on for the green LED, and the red LED indicates when the children play in the caution and danger areas. The RGB camera works in this study to stream the video or image, then send the streamed image data to the Raspberry Pi over a USB connection. We used Raspberry Pi 3 model B+ in our study to process the image data using OpenCV and to determine the children's zone activities based on the MLD method, after that, control the buzzer sound based on the command from the GPIO pin of Raspberry Pi. In this study, when the device detects the children playing in a safe area, the system will command the GPIO pin Raspberry Pi to turn off the buzzer. On the other hand, if the device detects the children playing in the caution and danger area, the system will command the GPIO Raspberry Pi to turn on the buzzer. Furthermore, the battery used in our device is 5 Volt DC to supply the power to all of the components.

In this study, we experimented to analyse the efficiency of the designed device to detect children's activities repeatedly based on the information in Table 1. When we experimented, the device to detect children's activities was attached above the location of the children's playing area, and after that, we analysed the efficiency of the MLD method to detect children's activities when playing in the home. In our experiment, we collected the image data of the RGB values of each line (safe, caution, and danger zone) when the children were not playing in the area and when the children doing activities in the area, after that,

Figure 5. The device detected the children playing in the safe zone

Figure 6. The device detected the children playing in the caution zone

we calculated the average of RGB values of each zone's line based on the formula shown in (1). Furthermore, Figure 5 below shows the green lines and streamed image when children play in the safe area, Figure 6 shows when children play in the caution area with yellow lines, and Figure 7 shows the red lines for the danger area.

According to the experimental illustration shown in Figures 5, 6, and 7, we show the MLD analysis in Figures 8, 9, and 10 to detect the children's activities when playing in safe, cautious, and dangerous areas, respectively. Regarding the graph information presented in Figures 8, 9, and 10, we calculate the RGB average value from each zone's lines based on the formulation designed in (1). To obtain the graph lines, in the first step, we collect the RGB data from each line (safe, caution, and danger) when the children were not playing in the area or performing activities in the area. We collected the data analysis in this experiment frame-by-frame when the camera streamed the image data continuously. After collecting the RGB data, we calculate the total RGB values for each line and then divide it by the number of lines used to detect the children's activities in each zone. Finally, we obtain the average RGB values from each zone to determine the change in the graph lines.

In this study, when the device did not detect children playing in the designated area, the change in the RGB

Figure 7. The device detected the children playing in the danger zone

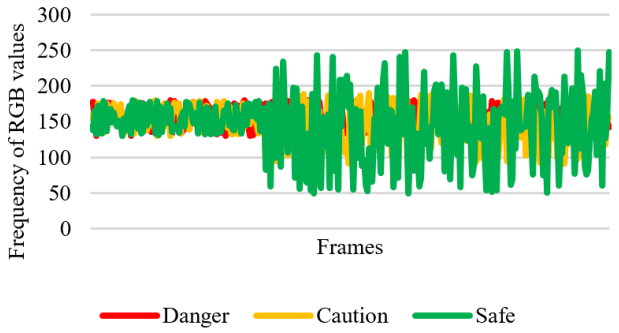

Figure 8. Frequency of RGB changing in the safe zone

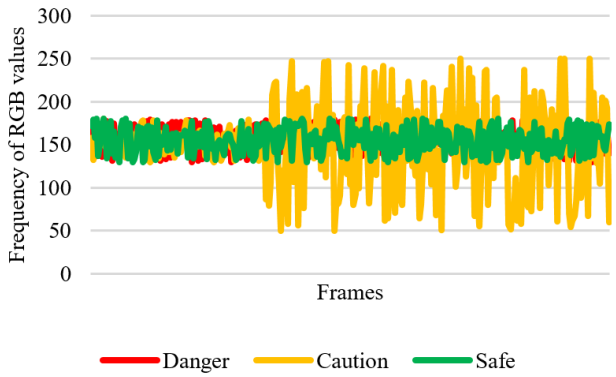

Figure 9. Frequency of RGB changing in the caution zone

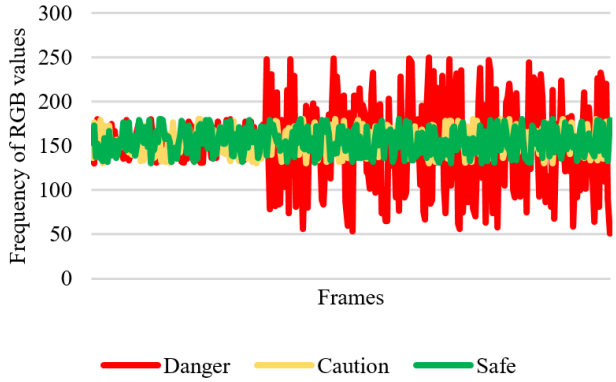

Figure 10. Frequency of RGB changing in the danger zone

value of each zone was not significant. On the other hand, if the device detected the children playing in the area, the changing of RGB value from each zone becomes significant. Based on the graph analysis result shown in Figures 8, 9, and 10, it can be seen that the change in the graph frequency becomes significant if the device detects that the children play in the safe, caution, and danger zones, respectively. Furthermore, Figure 8 shows the graph analysis when the children play in the safe area, Figure 9 shows when the children play in the caution area, and Figure 10 presented when the children conduct the activities in the danger area.

According to the analysis results shown in Figures 8, 9, and 10, we determine the security systems of the device to detect the children's activities when playing in safe, cautious, and dangerous areas based on the flowchart systems shown in Figure 2. As shown in Figure 8, when the device detected the children playing in the safe area, the system then commands the buzzer to turn off. Furthermore, when the device detects the children playing in the caution and danger area as shown in Figures 9 and 10, the system commands the buzzer to turn on to give a warning to the children to not play in that area: caution and danger.

In this study, we have successfully analysed the use of the buzzer function to provide a warning security system when children are detected playing in an area. Table 1 below shows the analysis result of the device can detect the children's activities when playing in safe, cautious, and dangerous areas, then after that, analyse the success of the buzzer to turn off and turn on when the children playing in the safe, caution, and danger area, respectively.

Based on the analysis results shown in Table 1, it can be seen that the MLD method proposed in this study can be used to detect the anomaly of children's activities when playing in an area of the home. This can be used to help parents monitor the children's activities, so it can be useful to keep the children from being kidnapped when the children play in the cautious and dangerous area of the home that enables the kidnapper to abduct the children. In our study, the basic idea of the MLD method is to detect the children's activities based on the frequency of RGB value changes detected using the multiple lines from each zone: safe, caution, and danger. When the systems that detected the change in RGB values were significant in the safe lines, it can be concluded that the children did the activities in the safe area and commanded the buzzer to turn off. Furthermore, when the system that detected the frequency of the RGB value was significant in the caution and danger area, it can be concluded that the children playing in the caution and danger area, after that commanded the buzzer to turn on as a security system to avoid the children from kidnapping.

In this study, we have determined the benchmarking of our method for detecting children's activities using the MLD method based on the study conducted in [11]–[13]. In those studies, the use of the line in the streaming image was used to count the number of people when cutting the

lines. We developed that method in our study to detect the children's activities so that it can be used as a security system to save the children from kidnapping when they play in dangerous areas of the home, for example, when playing near the door yard or home. Furthermore, based on the results of the analysis shown in this study, it can be concluded that the MLD method is effectively used to help parents monitor their children while playing in the yard or at home to protect them from kidnappers.

IV. Conclusion

In this study, the development of a device as a security system for detection the children's activities were carried out based on the MLD method. Our idea in the MLD method is to detect the activities of the children based on the change of RGB value in the line when the children play in the three zones detected from the streamed image: safe, cautious, and dangerous. In the safe zone, we detect the children's activities when the RGB value in green lines has a high changing frequency between frames, the caution zone with yellow lines, and the danger zone with red lines. When the device detects the children playing in the safe zone, the system commands the buzzer to turn off to indicate the children are playing in the safe area. Furthermore, when the device detects the children playing in the caution and danger area, the system commands the buzzer to turn on as a warning security system to the parents and children. The results of this study show that the device designed in this study can warn children not to play in the caution and danger areas so that the children are safe from the kidnappers. In the future, we will develop a device that can detect children's activities for a security system developed using Internet of Things technology.

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