Automatic monitoring system for the elderly based on internet of things

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Abstract. The population group aged 60 years and over based on the age category from the Indonesian Ministry of Health is included in the elderly category and based on population projection data for 2020 the number reaches 27.08 million people or around 9.9% of the total Indonesian population. As a vulnerable age group, the elderly has several characteristics, namely physical abilities that have begun to decline and even some have disabilities which can prevent them from being able to take action when something is harmful to them physically. This study focuses on building an automatic monitoring system for the elderly in a closed environment. The system will monitor in a non-stop and real-time way using a variety of hardware equipped with sensors and artificial intelligence algorithms implemented in the system software so that the system can track the subject's position, learn the subject's behavior and then be able to detect abnormal behavior, for example in the elderly, the subject falls down, wobbles, shows an expression of panic or pain. The final result of this research is an automatic monitoring system which consists of the integration of various hardware and software which are interconnected in a computer network for monitoring and protection of the elderly.

1. Introduction
The population group aged 60 years and over based on the age category from the Indonesian Ministry of Health is included in the elderly category and based on population projection data for 2020 the number reaches 27.08 million people or around 9.9% of the total Indonesian population [1]. The elderly group is classified as the non-productive age group who is unable or not expected to work, generally vulnerable in terms of needing support from other families as life support, many of the elderly are less able to protect themselves due to physical limitations due to degenerative diseases so they need supervision and protection of family members who are of productive age. Even so, the increasing quantity of the elderly population with a good quality of life standard can be seen as the success of human development through indicators of increasing life expectancy [2].

As a vulnerable age group, the elderly has several characteristics, namely physical abilities that have begun to decline and even some have disabilities which can prevent them from being able to take action when something is harmful to them physically [3]. Currently, the CCTV (Closed Circuit Television) network-based environmental surveillance system is the most widely used security system for many purposes. This camera-based surveillance system in system security review is a passive security system because in operation it requires humans as operators to supervise the area being monitored so that in the need for specific surveillance of certain subjects this type of model is inadequate because there is no mechanism to detect risks or hazards faced by the subject apart from information in the form of moving images that require human intervention as an operator to analyze the information [4].
This study focuses on building an automatic monitoring system for the elderly in a closed environment. The system will monitor in a non-stop and real-time way using a variety of hardware equipped with sensors and artificial intelligence algorithms implemented in the system software so that the system can track the subject's position, learn the subject's behavior and then be able to detect abnormal behavior, for example in the elderly, the subject falls down, wobbles, shows an expression of panic or pain. The final result of this research is an automatic monitoring system which consists of the integration of various hardware and software which are interconnected in a computer network for monitoring and protection of the elderly.

2. Literature Survey

The need for security, including the control of certain subjects and objects from various security risks, has become the concern of researchers in the field of information technology and security. Along with the rapid development of technology, various models of security and surveillance system devices have been developed and implemented. Several technologies have been implemented, some are still prototypes and require further development and testing. Security systems are essential in protecting homes, buildings and property from security threats. A conventional security system consisting of CCTV that records images for 24 hours non-stop requires a large memory and a large consumption of electrical power due to continuous recording which is the motivation of research [5] to develop a security system model called Multilevel Home Security System (MHSS) which is in principle an additional module for conventional CCTV.

This security system device model utilizes sensors where the trigger or trigger of the recording function is a motion detected by the camera sensor so that memory usage and power consumption can be effectively suppressed because CCTV does not need to record continuously. Another innovation by [6] and [7] which developed a smart camera-based security system with an image enhancement algorithm. The resulting security system aims to monitor houses or other properties automatically by relying on cameras and equipped with several sensors. The system can record when motion and collisions are detected in the monitored area. The recording is then processed with an enhancement algorithm to improve the quality of the stored moving image.

In particular, for specific subject surveillance systems, there are several recent studies carried out, some of which [8] designed a child surveillance system using a wireless network that serves to alert parents when a child being supervised leaves a predetermined zone and then the system can provide information on the position of children accurately using GPS assistance. Then another study with the topic of surveillance systems is from [9] which produced a school child surveillance system. The product of this research is a system that detects the presence of school children starting from the school bus arriving at school to return home.

The system uses technology NFC (Near field Communication) which communicates with the RFID attached to the student card to monitor the child's whereabouts if the system cannot confirm the child's presence, the system will send a report to the supervisor. Another study concerning the surveillance system was carried out by [10] who proposed the concept of various methods and tools that can be used to create a protection mechanism for the elderly and persons with disabilities from falls. This system proposes a device model design consisting of a combination of hardware and software that can prevent incidents from occurring by providing warnings against potential hazards and also detecting when they occur.

3. Proposed System

In general, the stages of the research are described as follows:

In the first stages, this research focuses on designing hardware structures consisting of input and output components that are connected through the Main Control Unit (MCU). Each input and output component consists of several sub-components as shown in system component block diagram in Figure 1.
The input component provides data through the sensor components which will then be forwarded to the MCU. The sensors will be triggered by an event that occurs which is captured via a web camera, PIR sensor and impact sensor, such as when the subject shows an expression of pain, falls from a sitting or standing position, panic and others that can be associated as a danger to the elderly. The second phase focuses on building electronic circuits and microcontroller programming in the MCU which is the main control unit that acts as a brain that processes information from the input components to then give instructions to the output components according to the given algorithm as shown in figure 2.

The output component is a component that will provide information to users in various forms and media. The final phase of design is developing system software to support the logic and business processes of the system. System software also functions for system administrators to control all system input and output components including enabling and disabling sensor and monitoring features.

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**Figure 1.** System Component Block Diagram

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**Figure 2.** Schematic of the interaction between computer vision algorithm modules

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**4. Result**

**4.1 System Scheme**

The monitoring system is divided into three layers as shown in Figure 3. Each layer has its own function and consists of different components. The control component of the unit consists of an intel Galileo board which is a micro-sized computer that functions as the main processing unit and a place for attaching various other components. The sensor component consists of various modules that function to
provide data input to the control unit, while the output component is a device module that will convey information to the user.

![Network Camera](image1)

![IP Camera](image2)

**Figure 3.** Design System Scheme

a. **Network Camera**
Cameras are installed in every corner of the room to monitor indoor subjects. The camera is equipped with an infrared sensor to be able to record in the dark, supports HD quality and wireless connection via NVR. The IP camera and NVR used can be seen in Figures 4 and 5.

b. **RFID Transmitter and Receiver**
The RFID transmitter in the form of an RFID tag is useful for detecting the position of a subject in a room. The RFID tag can be attached to a wheelchair or stick used by the subject while an RFID receiver is installed in each room in the surveillance area.

c. **Fall and Impact Sensor**
The sensor is implemented on a carpet that is installed in the surveillance room, the sensor will work to send a signal to the MCU when a collision occurs which is associated with the subject being monitored falling. To avoid false detection, sensors need to be calibrated by adjusting the threshold value using the required parameters.

### 4.2 System Interaction
The interaction between the input and output components is controlled by the MCU based on the events that occur and is detected by the sensors as the input module, the signal from the input module is then forwarded to the MCU and then manifested in actions presented to the output device. Table 1 shows the interactions between the input and output components based on the event that was triggered.

| Input Component | Output Component | Triggered Event |
|-----------------|------------------|-----------------|
| Network Camera  | Buzzer, SMS Gateway | The circuit will be triggered when the camera processed the image and identified certain abnormal event. |
| RFID Transmitter | Camera, LED | The circuit will be triggered when the RFID receiver receive signal from RFID transmitter indicating subject has left the monitoring area. |
| Fall & Impact Sensor | LED, Buzzer | The circuit will be triggered when the MCU receives a signal from the fall and the impact sensor that indicates the subject has fallen or hit hard. |

4.3 System Testing and Analysis
System software to support business process, logic system and control all system functions such as enable or disable sensors and surveillance feature as seen in figure 6.

As shown in Figure 6. In the main menu, users can set the configuration of sensor modules connected to the system via the sensor menu input tab, including to activate or deactivate certain sensors. In the output tab the user can set the system connectivity to NVR server, SMS gateway server, LEDs and Buzzer. This server setting is needed to set the output from the system to be connected properly so that if an event occurs and the application triggers a certain output, the output command to the output device can be executed properly. In the video settings tab, users can set the type of recording, audio and video codec used, including the bitrate level used, this setting is useful for adjusting image quality and video output which has an impact on the required storage quality.

The following in table 2 presents the results of system testing using several threat scenarios and how the system reacts in the face of any existing threat scenarios.
**Table 2.** Input and Output Interaction Based on Triggered Events

| Scenario                                      | Involved Components (I/O)                        | Testing Result                                                                                                                                 |
|-----------------------------------------------|-------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| Subject has fall down                         | Input: Fall sensor<br>Output: LED, Buzzer       | the system detects fall down subjects through signals sent by the fall sensor and then the MCU commands the system to turn on the LED and sound the buzzer |
| Subject has left the room                     | Input: RFID<br>Output: Camera, LED              | The system detects a signal from RFID which means the subject leaves the surveillance area then the MCU instructs the system to turn on the LED and start recording from the network camera. |
| the subject is doing suspicious activities    | Input: Camera<br>Output: Buzzer, sms gateway    | the system detects suspicious activity from the subject through gesture monitoring from the camera software and then the MCU instructs the system to send a message to the caregiver and sound the buzzer. |

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