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Development of Crowd Detection Warning System Based on Deep Convolutional Neural Network using CCTV

Muhammad Nurwidya Ardiansyah [1,*], Marifa Kurniasari [2], Muhammad Dzulfiqar Amien [3], Danang Wijaya [4], Pradana Setialana[5]

[1,3,4,5] Faculty of Engineering, Universitas Negeri Yogyakarta, Yogyakarta, 55281, Indonesia
[2] Faculty of Economics, Universitas egeri Yogyakarta, Yogyakarta, 55281, Indonesia
E-mail: muhammadnurwidya.2019@student.uny.ac.id *
* Corresponding Author

ABSTRACT

The 2019 corona virus (Covid-19) pandemic is a global problem for now. One way to deal with the spread of the corona virus is to maintain a distance of at least one meter and stay away from crowds. Therefore, a crowd detection warning system based on a deep convolutional neural network (deep CNN) was developed using CCTV. The development of this system was carried out using the NVIDIA Jetson Nano microcontroller as the computing hardware. Crowd object detection uses the OpenCV library, the YOLOv3-Tiny algorithm, and the euclidean distance method to calculate the distance between 'person' objects. Based on the tests carried out on function and performance, the results obtained that this crowd detection warning system can detect 'person' objects with an accuracy rate of 92.79. In addition, this system has also been able to detect several types of colors from objects so that warning messages can be given more specifically on the color of the clothes of the 'person' in the detected crowd.

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1. Introduction

Crowd is a situation where there is an irregular and temporary group of people. During this Covid-19 pandemic, crowds or gathering places have a greater risk of transmitting the corona virus[1]. The Increase in positive cases of coronavirus disease 2019 (Covid-19) continues to this day. The government has made efforts to suppress the increase in Covid-19 cases by implementing various health protocol policies, namely wearing masks, washing hands using running water, and maintaining a minimum distance of one meter. However, until the implementation of Community Activity Restrictions or known as PPKM there were still many people who did not heed health protocols, especially in maintaining a safe distance. This is evidenced by the fact that it is still happening in many places.

The crowd warning technology that has been implemented in Indonesia by Ministry of Communication and Informatics is the use of mobile phone movement data form the Base Transceiver Station (BTS) which will then provide a warning via a short message in the form of an SMS blast. Basically, mobile phones that are used as the main media in detecting movement and giving warning messages have the possibility of less affective results. This is because people do not necessarily carry cellphones or even carry more than one cellphone which results in a reduced level of accuracy in detecting crowds. In addition, alerts in the form of SMS are likely to be ignored when the message is received also require a time lag for the message to be read so that it cannot provide an immediate

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warning.

Based on these problems, we need a technology that can help detect crowd formation more accurately. In addition, a form of warning message is needed that is easier to catch directly by the people who are in the crowd. The technological innovation that is presented as a solution that meets these needs a crowd detection warning system using Closes Circuit Television (CCTV) connected to loudspeakers to provide warning messages. CCTV is a monitoring system for an area using a video camera that transmits signals or broadcasts aimed at the scope of certain devices for monitoring [2]. The use of CCTV in this system was chosen because it can know the conditions directly in a place and can be replaced in a strategic location so as to prevent the formation of crowds.

CCTV technology is also applied in the manufacture of a warning system for violation of marking lines when stopping at traffic lights. This warning system is used so that motorists who stop at a red light do not stop exceeding the road marking line through a warning message in the form of sound. However, in the implementation of road marking violation warning system technology, its is often encountered by motorists who ignore the warning because the warning message has not been directed to one of the drivers specifically.

Based on the problems that have been described, a crowd detection warning system will be developed by taking into account the level of awareness of the people who will receive the warning massage. The use of a microcontroller as the main computing medium and the application of a deep convolutional neural network algorithm in adding object color detection features to the system so that warning messages can be specific and increase the level of accuracy of warning messages delivered.

2. Method

The development of a crowd detection warning system is carried out using the Waterfall method. This development method was chosen because it has a sequential process from analysis to maintenance and at each stage of the process has its own specifications so that a system can be developed as desired or on target. In addition, in this development method each process cannot overlap each other so there is no confusion in system development.

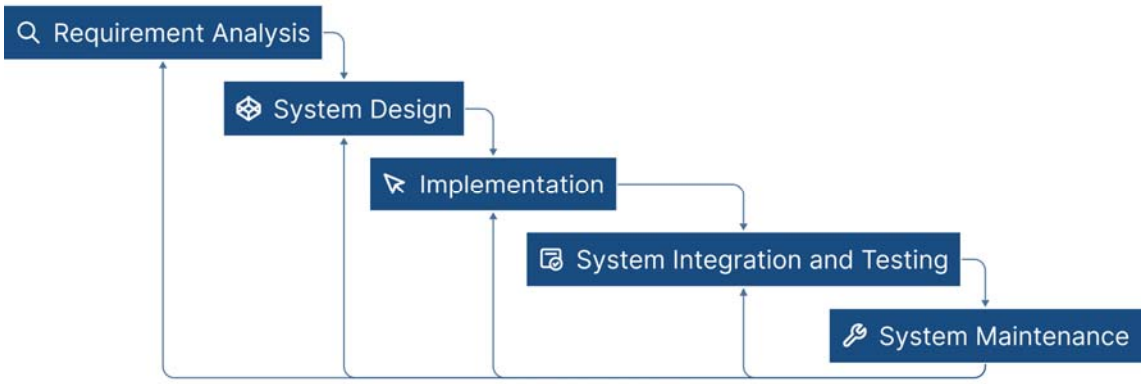

Fig. 1. Waterfall Method

2.1 Requirement Analysis

Gather further information on system development through literature study. This is intended to avoid the incompatibility of needs analysis in the development of system prototypes. The requirements in question are prototype components in the form of hardware, software, algorithms, and libraries that are used to support the creation of a crowd detection warning system.

2.2 System Design

At this system design stage, a prototype design is carried out with the aim of providing an overview of the architecture or a series of prototypes and the working principles or system procedural algorithms so as to help provide a complete picture of the things that must be done. Broadly speaking, the architecture or initial design of the prototype system to be developed can be described as shown in Figure 2. While the initial description of the working principle of the crowd detection warning system is shown in Figure 3. which will then be adjusted to several conditions so as to improve system performance.

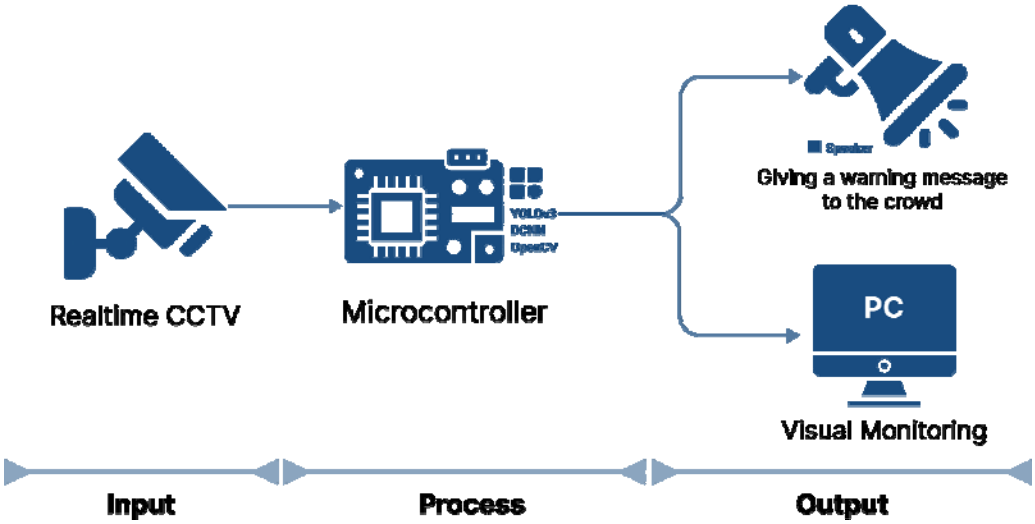

Fig. 2. Prototype Architectural Preliminary Design

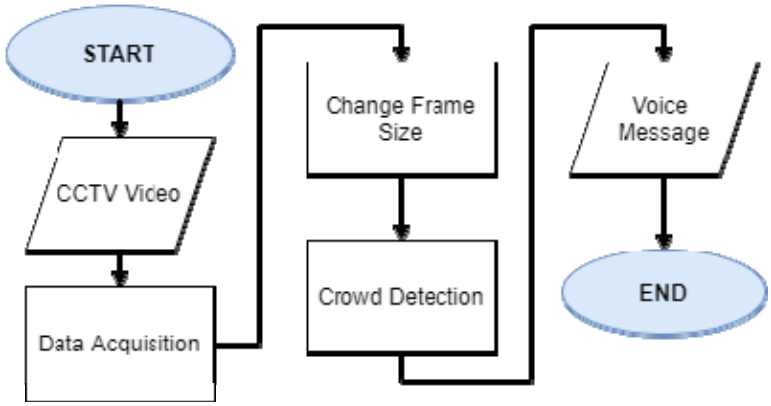

Fig. 3. Preliminary Overview of the Working Principle of the System

2.3 Implementation

This implementation stage is the initial stage of the prototyping process of a crowd detection warning system. The initial stage in question is preparing the device to be used and making a crowd detection warning program. In general, the entire prototyping process carried out is as follows:

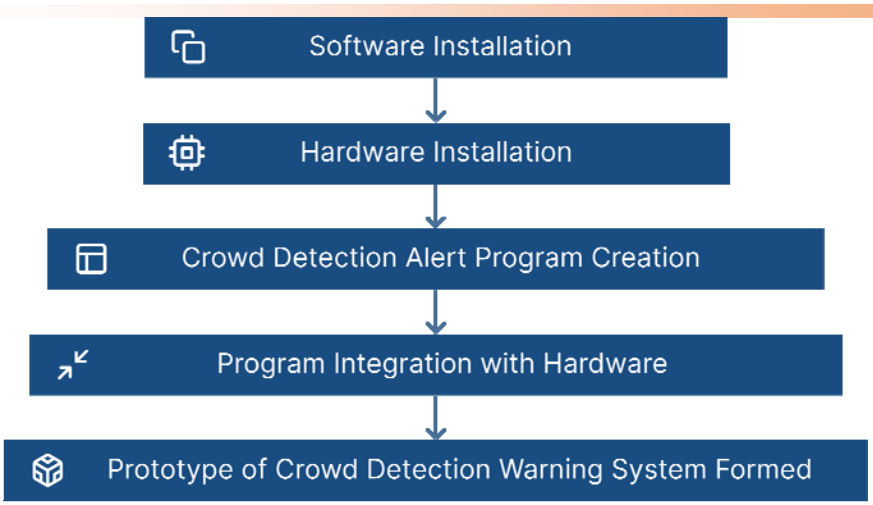

Fig. 4. Planned Stages of Prototyping Process

The hardware and software installation process needs to be done before starting the program creation. This is because the program will be created on the NVIDIA Jetson Nano microcontroller device and the program also requires libraries to be added such as OpenCV and YOLOv3 which contain deep convolutional neural network algorithms. The NVIDIA Jetson Nano is an entry-level circuit-board on NVIDIA Jetson which is a small and powerful single-board computer that enables parallel operation of multiple neural networks for applications such as image classification, object detection, segmentation, and speech processing [3]. OpenCV has several applied fields such as facial recognition, gesture recognition, mobile robotics, and augmented reality [4].

2.4 System Integration and Testing

At this stage, hardware components are combined or integrated with a crowd detection warning program so that a prototype of a crowd detection warning system based on a deep convolutional neural network using CCTV can be formed. Then, the prototype of the crowd detection warning system will be tested. The tests that will be carried out are function tests and system performance tests.

2.5 System Maintenance

At this maintenance stage, improvements will be made regarding deficiencies found when testing the prototype crowd detection warning system. In addition, adjustments were made to the prototype of the crowd detection warning system in order to improve system performance.

3. Results and Discussion

3.1. Prototyping of Crowd Detection Warning System

In the needs analysis stage, various adjustments were made to the procurement of prototype components from the initial planning in an effort to support the prototype of a crowd detection warning system. The following is a list of the final results of the component requirements used in prototyping:

1. NVIDIA Jetson Nano is used as the main computing medium in system development.
2. CCTV as a device to enter video data from conditions directly somewhere.
3. Router as a connecting device between the microcontroller and CCTV.
4. Cooling fan to cool the microcontroller so it doesn't heat up and maintain device performance.
5. The adapter is used to connect the microcontroller to a power source.

6. LAN cable as a data transmission medium from CCTV to the microcontroller
7. Speaker as an output device for warning voice messages from the system.
8. USB audio as a connecting medium between the microcontroller and the speakers
9. NVIDIA Jetson Nano case serves to maintain and protect the microcontroller
10. Micro SD is used as a storage medium on the microcontroller
11. USB hub as a supporting medium in adding a USB port

At the system design stage, additions and adjustments are made to the working principle or procedural algorithm for making the initial program so that the final results of the system's working principles are as follows:

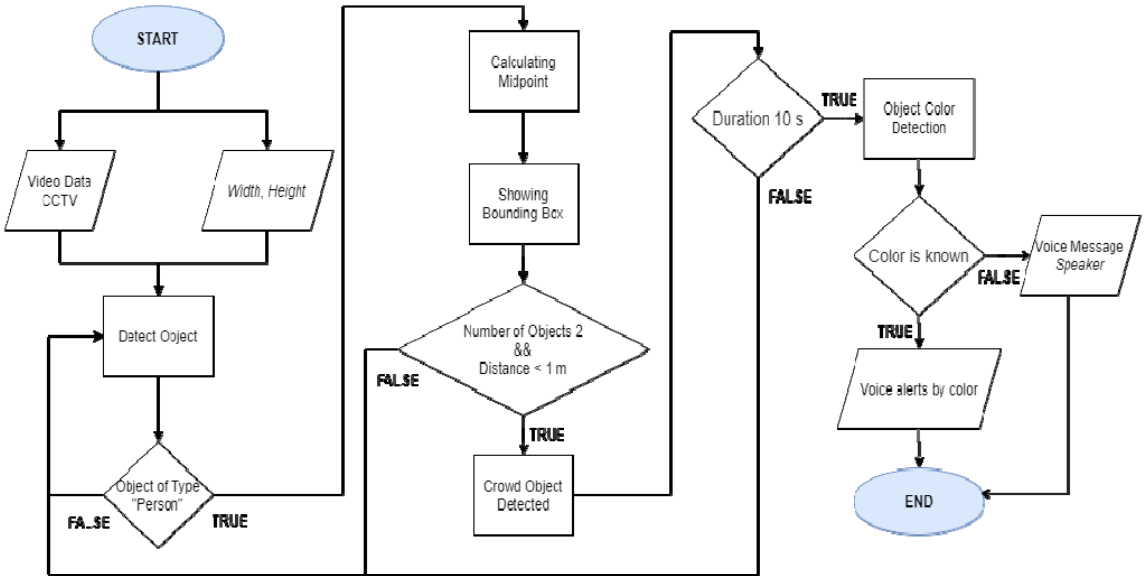

Fig. 5. Final Result of Crowd Detection Warning System Working Principle

While the final results of the system architecture design or system prototype design based on the addition and adjustment of components that have been made are as follows:

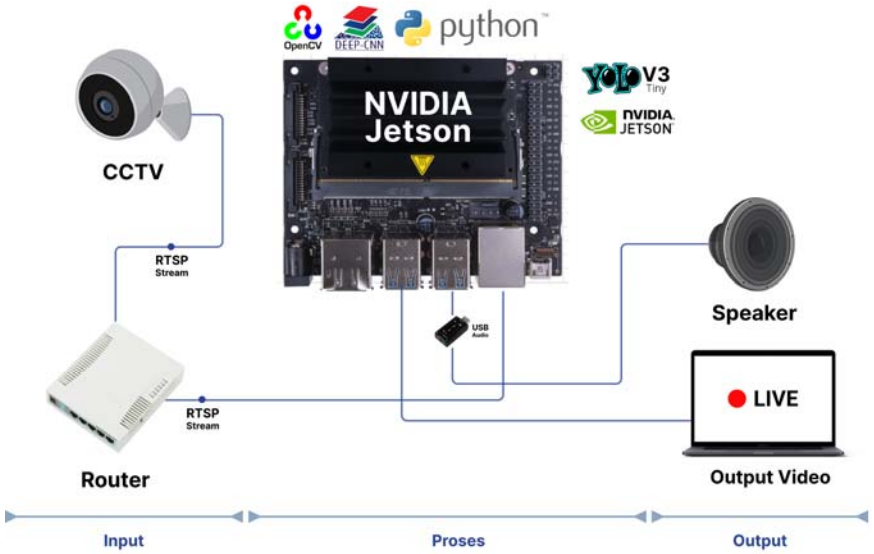

Fig. 6. Final Design Result of Crowd Detection Warning System Prototype

The programming phase uses the Python programming language and the OpenCV library and adjustments are made to the use of YOLOv3 to YOLOv3-Tiny to improve system performance. Programs are saved and run on the NVIDIA Jetson Nano microcontroller.

After the program is made to get input video recordings in real time, CCTV is integrated into the microcontroller using the Real Time Streaming Protocol (RTSP) protocol. RTSP has an extensible framework that is used to enable control using TCP (Transmission Control Protocol) and UDP (User Data Protocol) for real time data transmission, namely audio and video [5]. While a warning in the form of sound will be issued by the speaker connected to the microcontroller using USB audio. The final results of the prototype stage of a crowd detection warning system based on a deep convolutional neural network using CCTV are as follows:

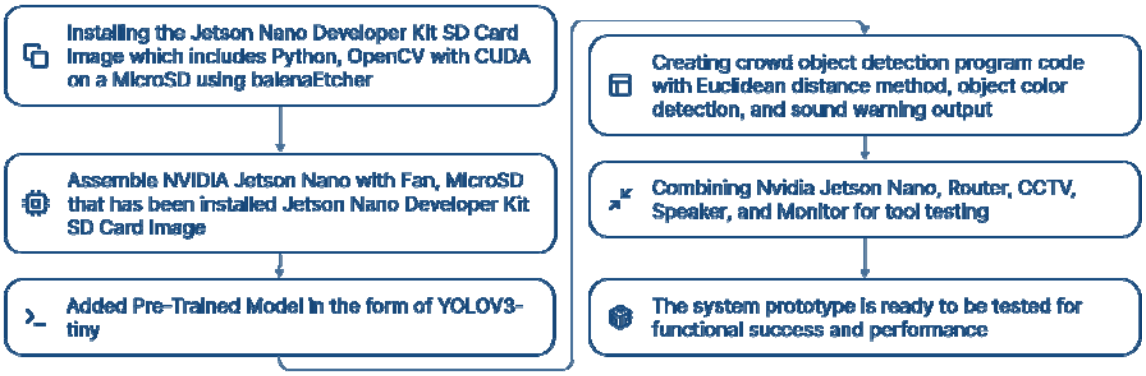

Fig. 7. Final Result of Prototype Making Process Stages

3.2. Prototype Testing

Prototype testing is carried out as a form of evaluation of the crowd detection warning system both in function and performance. Therefore, the test is carried out in the form of a function test and a performance test with the following test results:

3.2.1 Function Test

This function test is carried out with the aim of knowing that every process of the crowd detection warning system can be run. The results obtained from this test are that the prototype has managed to work well as a crowd detection warning system based on a deep convolutional neural network using CCTV.

3.2.2 Performance Test

In testing the performance of this crowd detection warning system prototype was found that the accuracy of detecting people reached 90% and above as shown in Figure 9. In addition, the test results showed that the system succeeded in detecting the color of the object as shown in Figure 10. Therefore, the system can provide a more specific warning message by mentioning the color of the shirt.

4. Conclusion

The crowd detection alert system has been successfully developed using the Python programming language. In object image processing, this system uses the OpenCV library. In addition, the system also uses Yolov3-tiny with a deep convolutional neural network to detect objects. From Yolov3-tiny the object's accuracy level can be known. The distance between objects that enter the crowd is calculated using the Euclidean distance method. The results of the warning system are 10 seconds apart with simple color detection. The available time lag is intended to prevent system malfunctions.

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