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Intelligent Emergency Alarm System based on Multimedia IoT for Smart City

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ABSTRACT

These-days technology related to IoT (Internet of Thing) is widely used and there are many types of smart system based IoT like smart health, smart building and so on. In smart health system, it is possible to check someone's health by analyzing data from wearable IoT device like smart watch. Smart building system aims to collect data from sensor such as humidity, temperature, human counter like that and control the building for energy efficiency, security, safety and so forth. Furthermore, smart city system can comprise several smart systems like smart building, smart health, smart mobility, smart energy and etc. In this paper, we propose multimedia IoT based intelligent emergency alarm system for smart city. In existing IoT based smart system, it communicates lightweight data like text data. In the past, due to network's limitations lightweight IoT protocol was proposed for communicating data between things but now network technology develops, problem which is to communicate heavy data is solving. The proposed system obtains video from IP cameras/CCTVs, analyses the video by exploiting AI algorithm for detecting emergencies and prevents them which cause damage or death. If emergency is detected, the proposed system sends warning message that emergency may occur to people or agencies. We built prototype of the intelligent emergency alarm system based on MQTT and assured that the system detected dangerous situation and sent alarm messages. From the test results, it is expected that the system can prevent damages of people, nature and save human life from emergency.

Key Words : Smart Alarm System, Artificial Intelligence, Smart City, Multimedia IoT

1. Introduction

Nowadays, technology related to IoT has become common and is widely used in ordinary life so that you can find electronics about IoT in the market. For example, smart health care can manage people's health intelligently based on health data obtained from wearable IoT devices and can alarm to guardian or hospital if there is a health problem. Smart building solution is a solution which gets data from some sensors and analyze the data for energy efficiency and facilities management of building and smart grid is a solution that intelligently controls electricity production and distribution for efficiency. Field of smart system based IoT is various from smart health care [1], smart mobility [2, 3] to smart grid, so it is possible to construct a smart city by integrating several smart systems.

In this paper, we propose intelligent emergency alarm system based on multimedia IoT for smart city. In the case of previous smart city system based IoT, it is to communicate small-size data and analyze them for efficiency, safety, security and so forth. Previously, there was technical limitation about network, hardware like that so protocol for lightweight data transfer was proposed, for example MQTT, CoAP and etc, and the lightweight protocol is using in smart system widely until now. The proposed system is a system to communicate video and analyze the video for checking emergencies. In our system, it communicates heavier data than previous system because

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technologies develop and now there are little problems about heavy data transmission. We selected 2 types of social issue which are fire and solitary death for intelligent alarm system because preventions of fire and solitary death can save people's lives.

This paper is organized as follows. Section 2 describes the related researches. Section 3 describes the proposed system and the corresponding scenarios. Section 4 describes the prototype implementation of the proposed system and finally Section 5 discusses the conclusions and future work on experimental results.

2. Related Work

Studies on smart system based on IoT for smart city have been actively conducted in recent years. [4-7]

Smart City is a collection of various smart environments such as smart health care, smart building, smart mobility and so forth. Therefore, there are many prototypes of IoT system to construct smart city and research related to smart system is actively being carried out.

IoT based fire detection systems [8, 9] have been studied because detection the fire is necessary for prevention large-scale disaster, the damage of human life like that. They are fire detection systems based on temperature data, gas data, smoke data from IoT devices in the room. However, it is inappropriate to apply a fire protection system in an outdoor environment. Also, outdoor fire detection system based on image analysis [10, 11, 12] have been researched. In the systems [10,11], fire/smoke are detected by color-based detection and moving pixel detection. But only color information and moving pixel information, it can be cause problems by moving red or orange things. In the system [12], fire is detected by intensity-based segmentation, so the method needs light information that is from fire for fire detection, so it is not available during the day. If a fire occurs outdoors, it may lead to a large fire unless it is prevented in advance. Large fires can lead the damage of human life, loss of property and bring out disaster that down-town, mountain and so on are burned down. So smart fire detection system which is applicable outdoor is need.

Solitary death, or Kodokushi, means living alone, separated from others, leading to lonely death which is found after a long time. It refers to a social problem that has arisen decades ago in Japan and recently it started to be regarded as a big social problem in Korea. Currently, a solution to prevent solitary death is that someone like social worker goes directly to people separated from others to check that they are all right. There is no digital system to prevent it yet because it became a social issue now.

3. Proposed System

We proposed intelligent emergency alarm system using multimedia IoT for smart city. Unlike existing IoT-based smart systems that collect text data from some sensors and inspect the data for efficiency, safety and so forth, in our system video is sent from camera and analyzed in cloud by utilizing AI algorithm like CNN and YOLO for detecting emergencies. We selected 2 types of scenarios which are outdoor fire detection and solitary death prevention due to that these problems which are large-scale fire and solitary death can cause damage, loss which can be a big social issue.

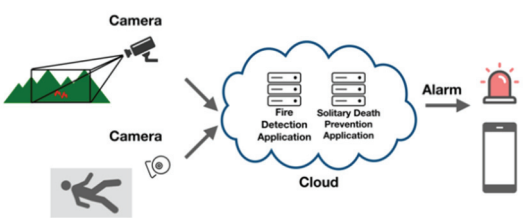

Fig. 1. Architecture of Intelligent Emergency Alarm System.

3.1 Outdoor Fire Detection Scenario

The first scenario is about outdoor fire detection. The system has to analyze the video obtained from a camera which shoots outdoor such as CCTV for detecting a fire. If fire is detected by AI algorithm, especially CNN, it has to send alarm to fire-fighting facility to prevent it from becoming a bigger fire. Also, the system can send emergency alarm to someone near fire to run away from the scene not to hurt.

3.2 Solitary Death Prevention Scenario

The second scenario is relating to solitary death prevention. Solitary death can easily prevent if wearing a IoT device but it is a little annoying to wear it. So, the proposed system utilizes IP camera which can capture

human motion at home. Video captured at home has human or human movement when a person is at home. If no movement in the video, except person's travelling, it means that there is no human activity at home. In other words, it is possible that the person is in emergency situation at home. Proposed system tries to detect human from the video but if there is no motion, it sends emergency alarm to police or hospital.

4. Prototype Implementation

We implemented prototype of intelligent emergency alarm system onto Ubuntu 18.04 LTS and utilized MQTT (Message Queue Telemetry Transport) protocol [13] for data transfer. MQTT [13] is M2M protocol which has publish-subscribe messaging pattern so MQTT messages communicate with a specific topic. MQTT was designed extremely lightweight so it is widely used for light connection or small data transmission. However, when implementing prototype of smart system, we took advantage of MQTT protocol for text data about alarm as well as for video transmission.

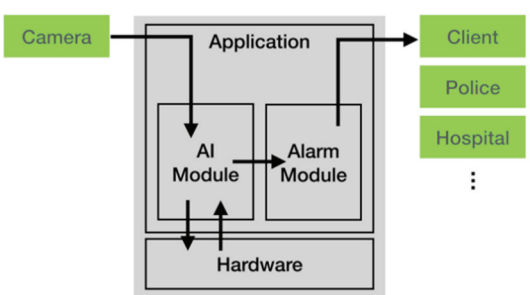

Fig. 2. Components of Proposed System.

4.1 Outdoor Fire Detector

The video analysis for outdoor fire detection was performed by CNN (Convolutional Neural Network). CNN is deep neural network for image analysis, image classification, partly video classification and many types of CNN are researched for getting higher classification accuracy. We utilize Xception [14] which is one of CNNs and gets higher accuracy than Inception V3[15]. We exploited Xception to detect outdoor fire in the video. To make an outdoor fire detector, we carried out fine-tuning training the 33 upper layers of the Xception's weight with 220 fire images.

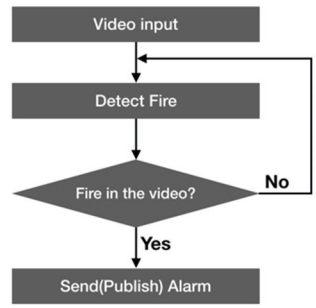

Fig. 3. Outdoor Fire Detection Workflow.

4.2 Solitary Death Prevention Scenario

To build a solitary death preventer, object recognition algorithm is necessary for detecting and tracking a person or people in the video. YOLO [16] is a kind of object recognition algorithm and has high recognition accuracy and fast recognizing speed. In other words, if YOLO cannot recognize person in the video for some time or even if YOLO can find person object but person object is not moving, it means that there is no human movement.

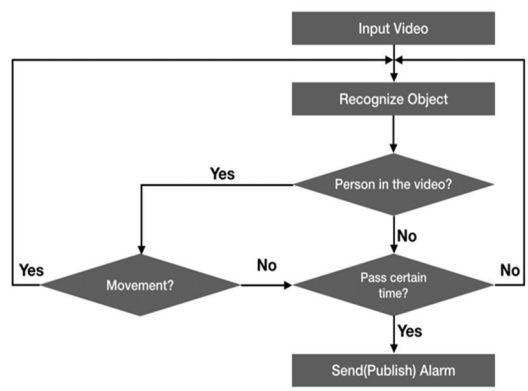

Fig. 4. Solitary Death Prevention Workflow.

4.3 Alarm System

In case of outdoor fire detector, raspberry pi sent video to outdoor fire detection and the fire detection application analyses the video for each frame by using fine-tuned Xception which is fire detector. If fire detector detects fire in the frame, the application sends alarm to topic related to fire and after that subscribing clients get the alarm message. Fig. 2 indicates outdoor fire detection workflow. Also, solitary death preventer recognizes a person with YOLO in the

video. If the system cannot be found person object or person object does not move for some time, the system sends alarm to subscriber following to solitary death prevention topic. After that subscribers can get the warning message. We set up the alarm process that unless person object is not recognized or there is no motion during 100 frames the system sends a warning and it is possible to change the certain time so that the application can be applied actually.

4. Experiment Result

We used one Raspberry Pi 3 which is client in MQTT and one desktop server which is a broker and some clients in MQTT to implement the prototype. Raspberry Pi had sample videos for scenario and sent/published videos to broker and then the broker published video to subscriber which is operating video analysis application.

Outdoor fire detector, which is based on Xception network, tried to detect a fire for each frame of video. If no fire, nothing happens but if outdoor fire detector detects a fire, fire detector sends fire alarm message. Outdoor fire detector is a subscriber in MQTT, so fire detector publishes alarm to the broker. Clients which are subscribing to topic about fire can get alarm message sent from outdoor fire detector. Fig. 4 shows the test result that the outdoor fire detector detected a fire in the video and detector sent an alarm to subscriber, so subscriber got a warning message about fire.

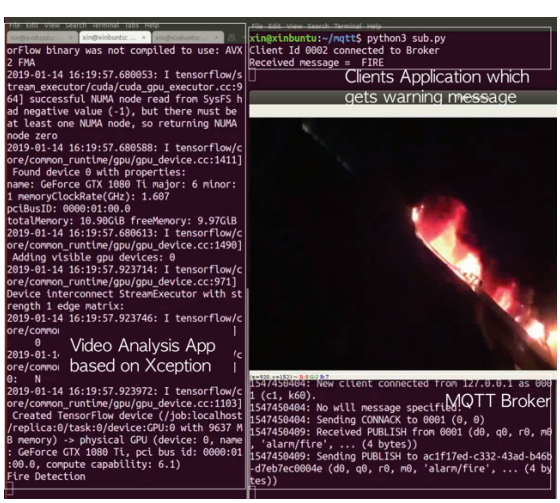

Fig. 5. Outdoor Fire Detection Prototype Test Result.

In case of solitary death prevention, the camera sent the broker and subscribing application which obtained the video with solitary death topic recognizes a person object with YOLO. If no recognition or no movement during some time, preventer sent an alarm message about solitary death. Fig. 6 indicates that solitary death preventer has not found person object during some time, so the system sent an alarm to broker and application which is subscribing to a topic related to solitary death got the message that solitary death is doubtful.

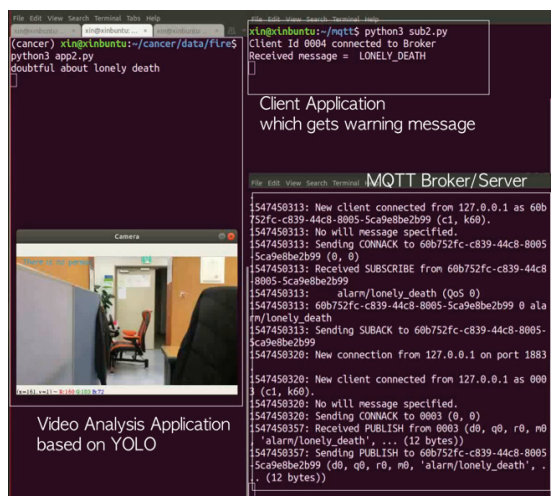

Fig. 6. Solitary Death Prevention Prototype Test Result.

5. Conclusion and Future Work

In this paper, we have proposed intelligent emergency alarm system based on multimedia IoT for smart city and built prototype of the system. On the prototype, camera sent fire video over MQTT and the proposed system carried out video analysis through fine-tuned Xception for outdoor fire detection. If a fire in the video, the system sent an alarm message. Also, in case of solitary death prevention, it analyzed the video based on YOLO to find human movement and if no movement for some time, the system sent warning message to broker. It confirmed that the intelligent alarm system works well in 2 scenarios and notifies emergency to clients. However, privacy issue can arise because there are faces which have portrait rights in the video. By recognizing face in the video through face detection algorithm and blurring the face part, the portrait

problem can be solved. Furthermore, as a future work, we will consider more scenarios of emergency that can be detected via video, for example, robbers on the road or traffic accidents and so forth. With new scenarios, we will create intelligent alarm system by adding another emergency detector.

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