Embedded Monitoring System for Preventing Lonely Death based on Edge AI

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***Abstract*—In this paper, we propose an monitoring system employing an edge AI module. The proposed system reduces latency and alleviates data leakage issue with an edge AI module. In addition, power efficiency was optimized by implementing a wake-up function depending on human detection results. In order to verify the feasibility of the entire system, we implemented the edge AI module on field programmable gate array (FPGA). The accuracy of movement detection was measure at 0.953.**

***Index Terms*—Embedded Monitoring system, Edge AI**

I. Introduction

Recently, the growing number of aging population including solitary senior citizens has become a serious social problem. In aging society, lonely deaths are considered to be one of the major issues. A lot of study regarding monitoring system for solitary senior citizens is under study.

Prior works about monitoring system is primarily implemented based on sensors such as IR motion sensors, photoresistor sensors, and temperature sensors to detect the status of an target [1]. However, sensor-based monitoring system requires one or more sensors in order to control entire target's living radius. Multi sensor based monitoring system is not economical, especially for elderly living alone [1]. Additionally, the IoT sensors are vulnerable to variation of temperature and humidity in sensing environment and this property leads to an incorrect output [2]. In some cases, wearable sensors or clothing attachment sensors that have to be worn constantly are utilized for more precise observation [3], which lowers the quality of life by limiting the convenience [4]. As the functionality of monitoring system gets more complicated, the number of sensors and the volume of the data is growing far quickly. This increment causes the high load of network in the process of transmitting input data to central server for data processing [5]. Employing the computing paradigm built on a centralized data center not only causes latency issues and transmission errors due to data explosion but also poses a risk of large-scale data leakage [5][6]. In addition, the tendency of monitoring system running 24 hours a day results in high power consumption. To address these challenges, we propose embedded monitoring system for preventing lonely death. The proposed design accomplishes more stable than multi-sensor based monitoring system by utilizing a camera module resistant to variation of environment. By computing on edge nodes, our proposed system overcomes the weakness of cloud computing, and makes sure that system gets response in real-time. The system ensures reliability through an architecture that blocks data transmission between MCU #1 that deals with sensitive personal data and MCU #2 that interacts with external server.

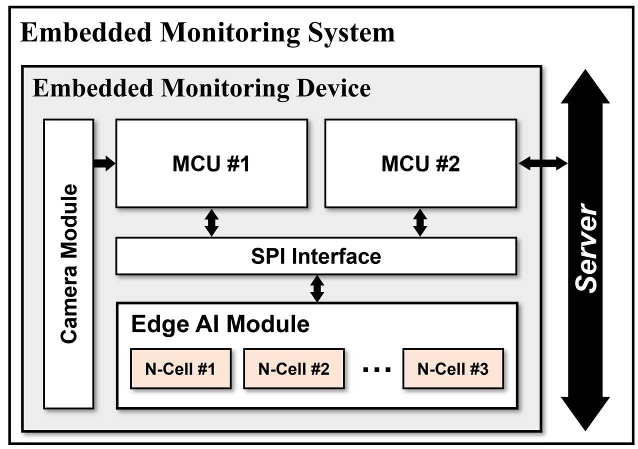

Fig. 1. The block diagram of intelligent monitoring system

II. System Architecture

Fig. 1 shows the architecture of the monitoring system. The proposed device consists of an edge AI module, two of MCUs, and a camera module. The MCU #1 receives raw image data from the camera module and detects the presence of a human with Blazepose model. This model is one of machine learning models supported by MediaPipe platform. When human is detected, the proposed system detects human movement additionally. The edge AI module, which is a key function for detecting movement, supports K-Nearest Neighbor (k-NN) algorithm with multiple number of neuron cells (N-cells) consisting of vectors memory stored training dataset [7]. In every N-cells, the trained data are calculated with the received test data for finding minimum distance. In the proposed system, the status of user such as sitting, lying, and standing are trained in each cell. When a new image data is transmitted to edge AI module, category of N-cell with minimum distance is output. MCU #2 determines human

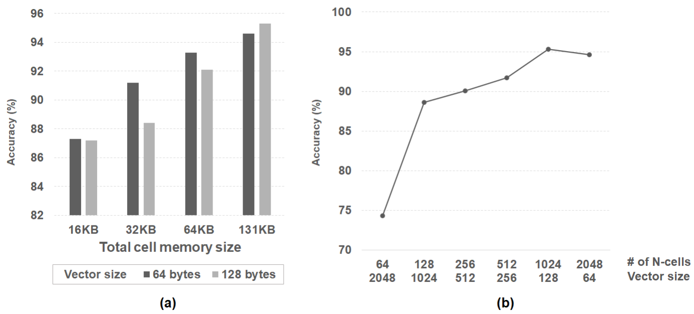

Fig. 2. Accuracy of each specification

movement based on the category which is the result of the edge AI module. If the motionless state continues for certain period of time, an abnormal detection signal transmitted to server is generated.

III. Simulation

The edge AI module employed in the proposed system has different accuracy depending on configuration of the number of N-cells and size of input vectors. So, before implementing edge AI to hardware, we measured the accuracy at various specification with a software simulator that imitates the functionality of edge AI module. A simulation was conducted on a total of 6,144 frames and training data are trained with a specific number of N-cells. Fig. 2 (a) shows the result of accuracy depending on total cell memory size. We limited the total cell memory size to 131k bytes that is available resources of our FPGA and case of 131k bytes get the highest accuracy. Fig. 2 (b) shows accuracy under various parameters configuration when the total memory cell is 131k bytes. The model with 1024 number of N-cells and 128 bytes size of input vector has the highest accuracy at 0.953.

IV. Implementation

In order to verify the functionality of our proposed system, we implemented embedded monitoring device as shown in Fig. 3. The edge AI module was implemented on the field programmable gate array (FPGA) with the optimized model adopted by software simulation. The experiment was carried out at hardware environment with frame data in which a person enters and leaves a particular place repeatedly with specific behavior such as sitting, standing and lying down. The proposed system showed same accuracy of 0.953 as the software simulation result and performed a wake-up function that operates additional computation only at situation with person. We confirmed that an abnormal detection signal was generated correctly when movement is not detected for a certain period of time.

V. Conclusion

In this paper, we proposed the embedded monitoring system for preventing lonely death based on edge AI. The proposed system ensures high reliability through an architecture that the edge AI blocks MCU #1 performing data processing and MCU #2 communicating with external server. In addition, the proposed system gains scalability that copes with high workload by implementing wakeup function. The accuracy of the proposed system is 0.953 at software simulation. We demonstrated the feasibility of the proposed system with FPGA prototyping.

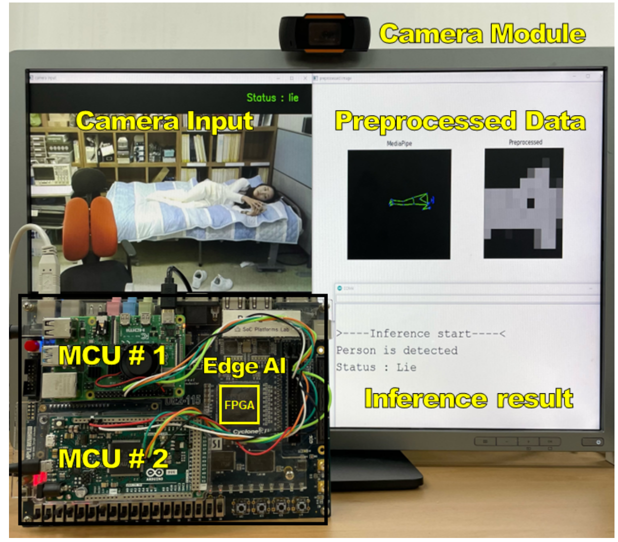

Fig. 3. Experimental environment

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