AI-based Customer Behavior Analytics System using Edge Computing Device

Prajogo Atmaja, Dalta Imam Maulana
School of Electrical Engineering and Informatics
Institut Teknologi Bandung
Bandung, Indonesia
prajogo.atmaja@gmail.com, dalta00@gmail.com

Trio Adiono
University Center of Excellence and Microelectronics
Institut Teknologi Bandung
Bandung, Indonesia
tadiono@stei.itb.ac.id

***Abstract*—Customer behavior can be analyzed using an artificial intelligence algorithm, specifically object detection algorithm. However, the implementations are usually either using a cloud computing-based system or a high-end PC. These existing solutions require a high-traffic internet connection or a large-sized GPU. In this paper, we propose a system implementation using an edge-computation approach. The purpose of this paper is to port an existing deep learning-based in-store traffic monitoring system that is used for evaluating retail performance into an embedded computer, specifically NVIDIA Jetson Nano. This is done in order to minimize the cost, power consumption, and space needed to implement this system on a larger scale. The system can run in 10 frames per second using Single Shot Detector MobileNet v2 architecture.**

Keywords—Artificial intelligence; Customer behavior analysis; Edge computing;

I. Introduction

A method of AI-based in-store traffic monitoring system has been developed in the previous year [2]. The system was implemented in an Intel i5 processor-based laptop PC, utilizing a Single Shot Detector (SSD) MobileNet v2 neural network architecture. However, on a larger scale of implementation, such as chain retail stores, the usage of a PC may be costly and may also take some spaces inside a convenience store.

An embedded computer can reduce the whole cost by a large margin. Embedded computers nowadays can almost perform desktop PC-level tasks on the edge. Furthermore, an embedded computer does not take a lot of space. NVIDIA Jetson Nano fits the described system very well since this embedded computer comes with an integrated NVIDIA Graphics Processing Unit (GPU), which means that CUDA libraries can be utilized to accelerate the whole system to run at a reasonable frame rate [1].

II. System Design

The system is described as illustrated in Figure 1. The IP camera will feed the system a video stream into the NVIDIA Jetson Nano board to be processed. The video will then be rescaled to 600×400 pixel to improve the processing time. Different from the previously proposed system, this system does not show the IP Camera stream input. Instead, the system only generates the histogram plot and contour plot every 10 minutes without showing the IP Camera stream. Thus, it could reduce the load and improve the performance of the system. The plot results will then be sent into a cloud service for the ease of access.

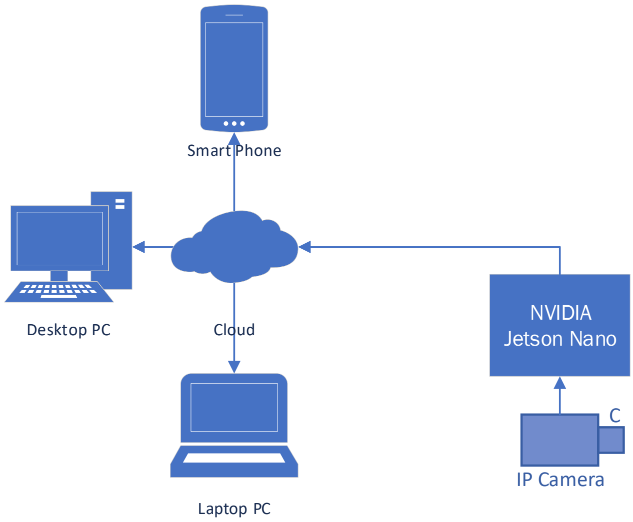

Fig. 1. System Design

III. Implementation Result

We can compare the specifications between the reference PC used in the previous paper with NVIDIA Jetson Nano in Table 1.

The system requires a higher version of OpenCV than the pre-installed version, which is OpenCV 3.3.1. Thus, it is necessary to reinstall the OpenCV to at least version 3.4.2. When installing a newer version of OpenCV, it is necessary to add a swap space for at least 2GB or edit the makefile to compile with only a single processor. This is done to prevent the whole operating system to freeze and restart due to lack of memory available.

Implementation of the system in NVIDIA Jetson Nano seems to be successful. Here, we can see the output of the data processing subsystem as a histogram plot and contour plot in Figure 2 and Figure 3 respectively.

TABLE I. SPECIFICATION COMPARISON

Components	Device	
	Laptop PC	***NVIDIA Jetson Nano***
CPU	Intel® Core™ i5-8250U Processor (Up to 4.10 GHz)	Quad-core ARM® Cortex®-A57 MPCore Processor (Up to 2.0 GHz)
GPU	Intel® UHD Graphics 620	NVIDIA Maxwell™ architecture with 128 NVIDIA CUDA® cores
Memory	8 GB DDR4 2400MHz	4 GB 64-bit LPDDR4 1600MHz - 25.6 GB/s
Dimension	340 mm × 240 mm × 23.7 mm	99 mm × 79 mm × 28 mm
Power Adapter	19.5V 3.3A (max) DC	5V 3A (max) DC

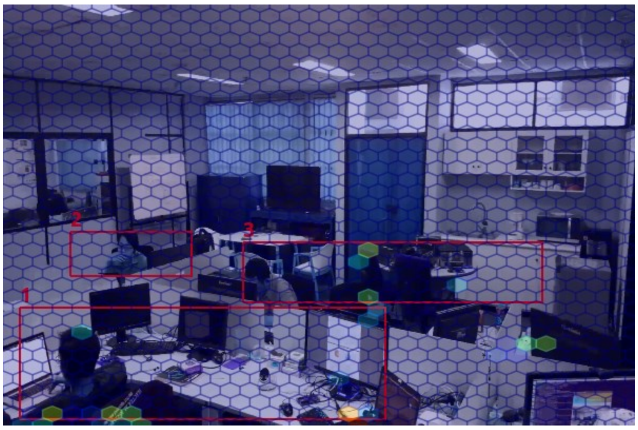

Fig. 2. Sample Histogram Plot

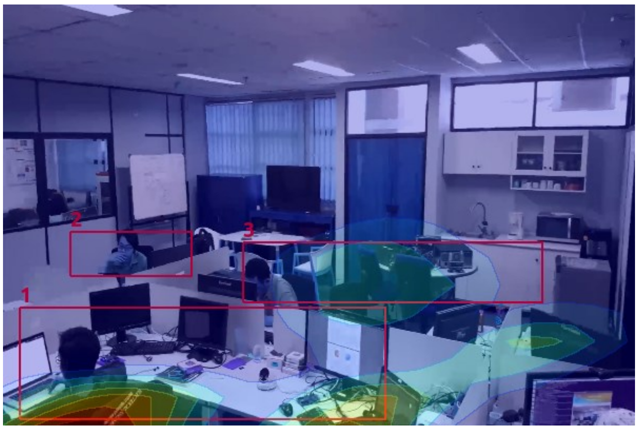

Fig. 3. Sample Contour Plot

Figure 4 shows the performance comparison between implementation in base reference and NVIDIA Jetson Nano. As we can see, there is an expected slight decrease in frame rate performance. However, despite the slight decrease in frame rate performance, the decrease in performance is still acceptable and the system is still usable. By porting the system into NVIDIA Jetson Nano, we can decrease the size by almost 90%. Also, the maximum power consumption can be decreased from 64.35W to 15W.

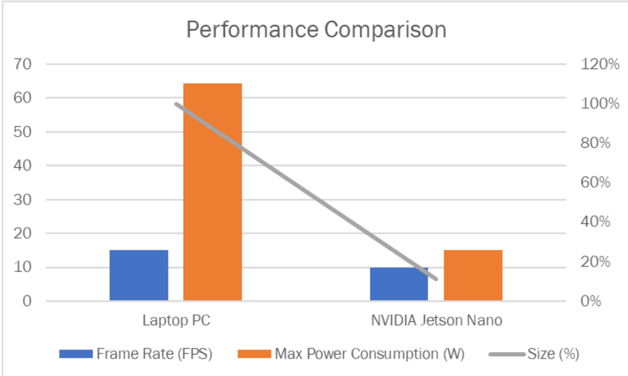

Fig. 4. Performance Comparison

IV. CONCLUSION

Deployment of a deep learning-based in-store traffic monitoring system has been successfully implemented in an embedded computer, specifically NVIDIA Jetson Nano. The implementation achieves 10 FPS on average using SSD MobileNet v2 neural network architecture.

REFERENCES

[1] NVIDIA Corporation, "Jetson Nano Developer Kit," 18 March 2019. [Online]. Available: https://developer.nvidia.com/embedded/dlc/jetson-nano-dev-kit-user-guide. [Accessed 27 September 2019].

[2] D. I. Maulana, S. T. Amaral, D. N. F. Putri and T. Adiono, "Artificial Intelligence Based In-Store Traffic Monitoring System for Evaluating Retail Performance," in *2019 IEEE 8th Global Conference on Consumer Electronics*, Osaka, 2019.