

Edge Computing 기반 모바일 로봇을 위한 지능형 원격 제어 시스템 구현

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Implementation of the Intelligent Remote-Control System for Mobile Robots based on Edge Computing

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Abstract

Edge computing can solve the concerns about limited resources on the IoT devices. We utilized the benefit of edge computing and implemented an intelligent remote-control system for mobile robots. A testbed was developed comprises of a line follower mobile robot and edge remote server where the mobile robot can offload its data. The results show that the edge computing was two times faster than that of the local processing. Furthermore, the accuracy of the mobile robot to follow the line was higher with the edge computing than the local computation.

I. Introduction

In recent years, we have witnessed a rapid growth of data generated from the network edge, especially with the enormous popularity of mobile devices [1]. Many intelligent and real time mobile applications demand intensive computation and low latency. To support the computationally intensive yet delay-sensitive applications, edge computing is recognized as a new paradigm to push cloud frontier close to the edge for such service requirements [2]. Edge computing is a viable solution to meet mobile devices constrain resources and latency challenges.

In this work, the benefits of edge computing were exploited by implementing an intelligent remote-control system (RCS) for controlling mobile robot. With vast computation resources available at the edge server, this supports real time control of the mobile robot and makes remote edge computing the best option to implement more complex model that were not possible to be implemented at the robots.

remote edge server which has plenty of resources and more powerful computation ability is responsible for generating control command for the mobile robot. The overall system architecture of the testbed developed is shown in Fig. 1.

A line follower robot can navigate through a network by following a black track against a white background. The robot can control itself by doing local computation or offloading to a remote edge server. A visual input from the track scene is used to produce appropriate control commands on the mobile robot. The direction on which the robot move is classified based on the extracted feature from the image. The pictures from the camera reveal certain information about the direction that the robot is following. After deciding direction, motor commands to make the robot move in desired direction is sent to the wheels. The left and right turning movements of the robot are realized by controlling the different rotation speed of the wheels. A Proportional-Integral-Differential (PID) controller is implemented to keep the mobile robot on path.

II. System Architecture

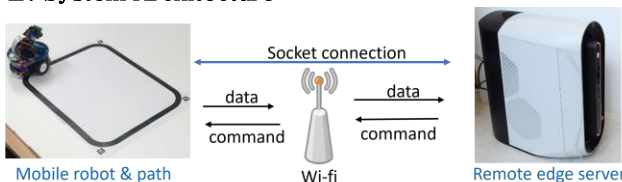


Figure 1. System Block Diagram

The implemented intelligent RCS has two main part: i) the line follower mobile robot and ii) the edge server. The mobile robot has relatively limited computation power to perform the computation-intensive task. A

III. Implementation of Intelligent Remote-Control System

To test the intelligent remote-control system, a test bed was constructed by connecting a mobile robot operated by a command and a remote-control server giving a command through a wireless network.

a) Mobile Robot:

The mobile robot runs on Raspberry Pi 3B+ equipped with a pi camera and two motors on the right and left to enable forward, left, and right movement of the robot. The mobile robot can achieve left and right turn

by altering the motor rotation speed and forward movement by keeping the same rotation speed of both motors. The testbed is used to analyze the edge computing and two experiments were conducted: i) local computation where all the processing were done at the mobile robot and ii) edge computation where computation was offloaded to the edge server. In local processing the following steps as shown in Fig. 2 are computed sequentially to make the mobile robot be able to follow the map correctly.

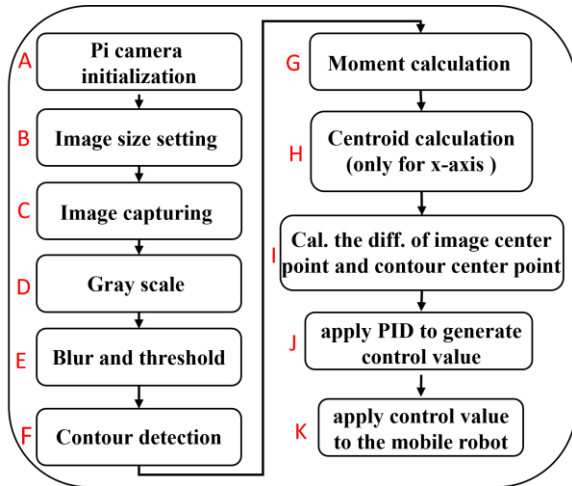


Figure 2. Local computing steps

b) Remote Control Server:

The edge server is equipped with Intel Core i7-9700K 3.6Ghz, 16GB RAM. Wi-Fi network was used to connect the edge server and the mobile robot. The mobile robot offloads its computation task to be processed to the edge server. The camera output of the mobile robot is transmitted to the edge server through socket communication. The edge server responds with the control command to the mobile robot. The control algorithm utilizing PID controller takes the output of the image processed result as input and generate a control command, thereafter the control command is applied to the motors. In edge computing the process from D-J in Fig. 2 will be offloaded to the edge server.

IV. Results

The results obtained shows that edge computing has better performance compared to local processing since in edge computing it takes less time in processing hence, we can control the mobile robot more precisely and in real time compared to local computing where there is much processing time makes it difficult for the mobile robot to follow the map. Fig. 3 is the graph showing average computation time in milliseconds for computing locally and at the edge. The result confirmed it is worth to utilize edge computing for latency sensitive.

On top of that another experiment was conducted to measure the deviation of the mobile robot to see how well it can follow the route. If the mobile robot follows

the route well the deviation will be small but if it does not follow the route well the deviation will be wide. Fig. 4 shows how edge computing outperformed local computing.

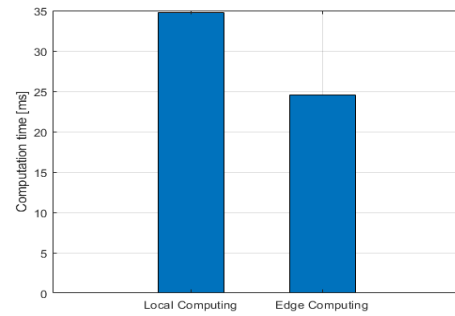


Figure 3. Computation time

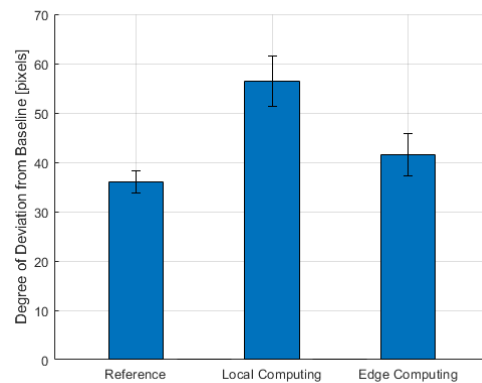


Figure 4. Deviation comparison

V. Conclusion

In this study the intelligent remote-control system for mobile robots based on edge computing is presented by utilizing a mobile robot following a path. The advantages of utilizing edge computing are presented. The results confirmed that increasing computation power will reduce processing time hence increase performance and accuracy of the remote control.

ACKNOWLEDGMENT

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (No. 2019R1G1A1100699).

Reference

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