Development of IoT self-tuning control device using Wi-Fi

Shinichi Imai
Graduate school, Tokyo Gakugei University,
4-1-1, Nukuikita-machi, Koganei, Tokyo, 184-8501, Japan.

E-mail: shimai@u-gakugei.ac.jp
http://www.u-gakugei.ac.jp/

Abstract

In this paper, development of IoT control device using Wi-Fi. In recent years, IoT has been attracting attention, and there are growing expectations in the industrial world for the utilization of data obtained from many sensors. These data are stored in databases in real time through communication between sensors and the cloud and communicating with the cloud. Meanwhile, digital controllers are widely used in the process industry as general-purpose controllers. However, it is difficult to incorporate AI, machine learning, and databases into general-purpose controllers due to data memory limitations. Therefore, in this paper, we develop an IoT self-tuning controller using Wi-Fi. As a result of experiments, the controller and computer were connected via Wi-Fi, self-tuning was performed on the computer side, and the calculated PID gains could be sent to the controller to achieve control.

Keywords: Wi-Fi, IoT, Control.

1. Introduction

In recent years, the utilization of advanced technologies such as IoT (Internet of Thinks) and AI (Artificial Intelligence) has been remarkable. IoT [1],[2],[3],[4],[5] is attracting attention, and expectations are rising in the industrial world for the utilization of data obtained from the many sensors installed in the system. These data are accumulated in a database in real time through communication between the sensor and the cloud. On the other hand, in the process industry, digital controllers are widely used for general purpose control. Currently, to obtain the desired control performance, it is necessary to appropriately calculate the control parameters according to the characteristics of the controlled object, but most of the actual controlled objects have nonlinearity or fixed control. Therefore, it often happens that sufficient control performance cannot be obtained with that parameter. Therefore, self-tuning methods and data-driven control methods have been proposed, in which control parameters are sequentially changed according to control characteristics. However, because data-driven control determines control parameters by accumulating a large amount of data in a database, it is difficult to implement with the capacity of conventional controllers. Also, from an existing controller. Therefore, in this paper, we will develop an IoT self-tuning control device using Wi-Fi. Specifically, a microcomputer called ESP-WROOM-02 is used instead of the conventional controller. ESP-WROOM-02 is very compact and can replace traditional controllers. It also has built-in Wi-Fi and Bluetooth. Connect the ESP-WROOM-02 and a computer via Wi-Fi, perform calculations for determining control parameters on the computer side, and send the calculated control parameters to the ESP-WROOM-02 controller. This can avoid controller data memory problems.

2. ESP-WROOM-02

ESP-WROOM-02 incorporates Espressif ESP8266EX.

The ESP8266EX integrates a Tensilica L106 32-bit RISC processor for ultra-low power consumption and reaches a maximum clock speed of 160MHz. A real-time operating system (RTOS) and Wi-Fi stack allows 80% of the processing power to be used for programming and developing user applications. The module also integrates antenna switches, RF baluns, power amplifiers, low noise receive amplifiers, filters, and power management modules at the SoC level, resulting in a small size for easy integration into space-constrained devices. increase. The external dimensions of the module are 18 x 20 mm. The type of flash used in this module is SPI flash with package size SOP8-150mil. The antenna applied to this module is a 3DBi PCB onboard antenna. Fig.1 shows ESP-WROOM-02. Table 1 shows the specifications of the ESP-WROOM-02.

3. IoT system

This IoT system consists of a "sensing system" that acquires numerical values with sensors and sends them to a computer, and an "adaptive system" that performs self-tuning based on the input and output data of the sensing system. The calculated parameters are sent to the control controller. Data is transmitted over Wi-Fi between the three systems. ESP-WROOM-02 is used for data transfer. Fig.2 shows a conceptual diagram of the IoT system.

Used by connecting to Arduino to communicate with ESP-WROOM-02. Fig.3 shows the circuit configuration. Arduino works with 5V. ESP-WROOM-02 cannot be directly connected to Arduino because it operates at 3.3V. Therefore, different signal levels are switched by attaching a level conversion IC. The current consumption of ESP-WROOM-02 is about 80mA. Arduino 3.3V terminal can only output 50mA and cannot be used. Therefore, it is necessary to prepare a 5V power supply and a 3.3V power supply in separate systems.

Use the Arduino input port to capture the inputs, outputs, and deviations of your experimental setup. It also sends PI parameters to the controller through the output port. The controller only updates PI parameters. Calculation of PI parameters is performed on a computer via Wi-Fi.

Table 1 Specifications of ESP-WROOM-02.

Supply voltage	3.0-3.6V
Current Consumption	Average 80mA
Supported WiFi Protocols	802.11b/g/n (2.4GHz)
Size	18mm×20mm×3mm
Wi-Fi mode	station softAP SoftAP+station
Security	WPA/WPA2
Encryption	WEP/TKIP/AES

Fig.1 ESP-WROOM-02

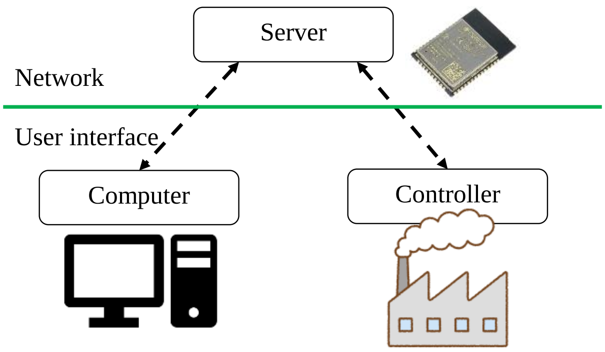

Fig.2 IoT IoT system conceptual diagram

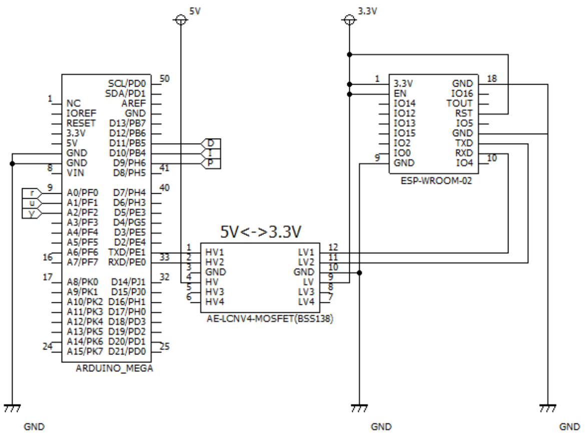

Fig.3 Circuit configuration

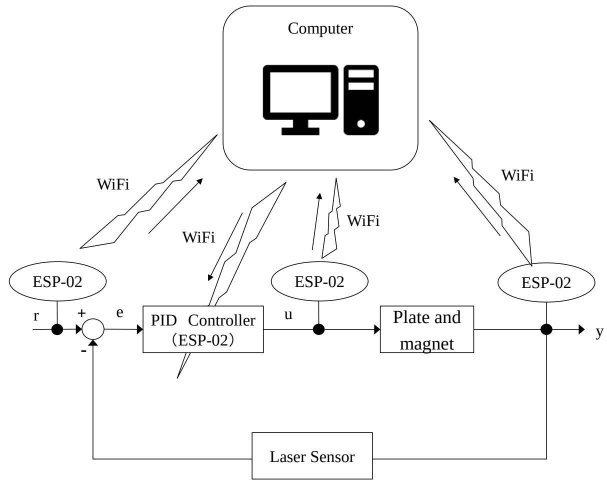

Fig.5 Block diagram

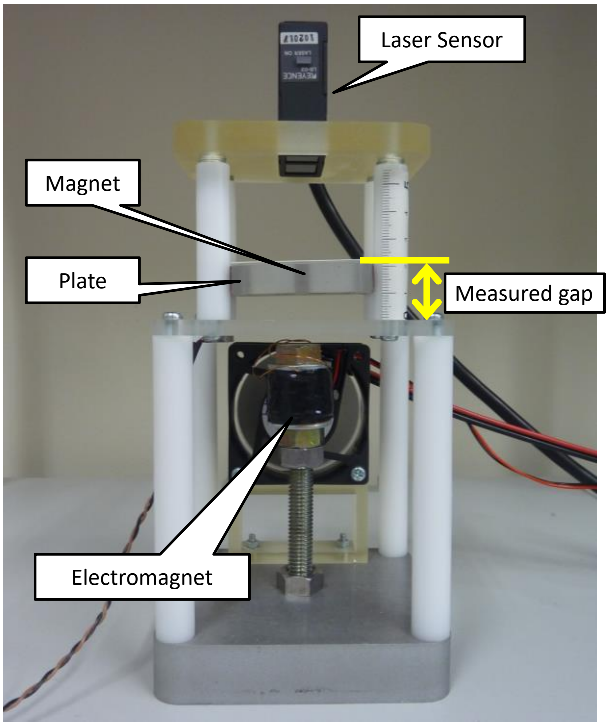

Fig.4 Experimental device

4. Simulation

A self-tuning control is used for the simulation. In addition, a magnetic levitation device is used in the experimental device. Fig.4 shows the magnetic levitation device. A magnetic levitation device levitates a magnetic body by controlling the current flowing through an electromagnet (coil) or the voltage across the coil. In the following, the magnetic body to be levitated is called the levitation body. This experimental device consists of a magnetic levitation device, an electromagnet amplifier, and a control device. Controller uses Arduino to send input/output data to another computer through ESP-WROOM-02. In addition, the displacement of the levitation body is measured using a laser displacement sensor. Fig.5 shows a block diagram of the magnetic levitation device.

Control input u(t) is the voltage applied to the coil, and control output y(t) is the gap length (the distance between the sensor and the upper surface of the levitation body). In addition, the coil voltage is controlled by a PWM (Pulse Width Modulation) signal with a duty ratio corresponding to the control input. Therefore, the control input u(t) in this experiment is assumed to be the duty ratio (0 to 100%) of the PWM signal. Also, this experimental device can only start from u(0)=100 due to its specifications. In addition, the vibration of about 17.6m/s^2 is given to the levitation body to prevent the levitation body from being caught by the effect of friction.

First, the target value r(t) is given as follows.

$$r(t) = \begin{cases} 11.5 \ (0 \le t < 100) \\ 8.0 \ (100 \le t < 200) \\ 10.0 \ (200 \le t < 300) \\ 7.0 \ (300 \le t < 400) \end{cases}$$

The parameters in the design polynomial and $P(z^{-1})$ re sigma=1, delta=0, and the sampling interval is Ts=0.1[sec].

At this time, $P(z^{-1})$ is obtained as the following equation.

$$P(z^{-1}) = 1 - 1.6375z^{-1} + 0.6703z^{-2}$$

Furthermore, let n_u=1 and k_m=0.

The experimental results are shown in Fig.6. Fig. 7 shows the temporal change of the PI parameter.

From the experimental results, the PI parameters change appropriately according to the characteristics of the system. From this, communication is properly performed through Wi-Fi.

4.1. *Conclusion*

In this paper, we developed an IoT self-tuning control device using Wi-Fi. As a result, he was able to connect the controller and computer with his IoT technology, perform the PID tuning calculations on the computer side, and send his calculated PID gains to the controller. The effect was verified by experiments. In the future, we plan to experiment with delays. We also plan to adapt it to systems with heavy memory loads.

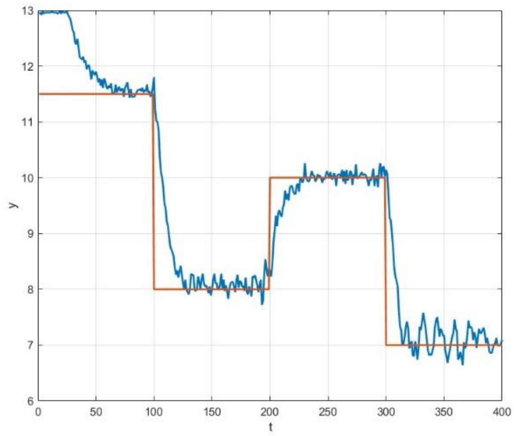

Fig.6 Experimental result

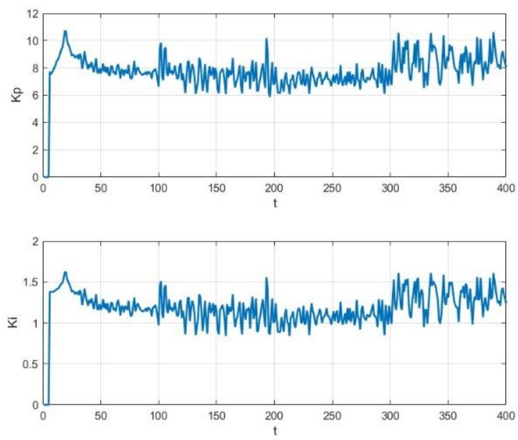

Fig.7 Changes in PI parameters

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Authors Introduction

Dr. Shinichi Imai

He graduated doctor course at department of engineering in Hiroshima University. He works at department of education in Tokyo Gakugei University. His research area is about control system design, educational engineering.