

Internet of Things Technology Applies to Two Wheeled Guard Robot with Visual Ability

Chih-Hui Chiu and Yu-shiou Huang

Abstract In this study, a two wheeled guard robot (TWGR) system with visual ability is realized. The hardware of the TWGR includes a chassis carrying dc motors for wheels, the input/output (I/O) board connects the TWGR system to a personal computer (PC) and Personal Digital Assistant (PDA), driver circuits for the motors, the necessary sensors and filter circuit needed to measure system states. Moreover, camera system and image transmission module are also connected to the chassis. Moreover, based on Internet of Things (IoT) technology, all system state and real-time image from the visual system can be transmitted to the cloud server through the Internet. Administrator is able to access the cloud server to monitor each TWGR immediately. Finally, TWGRs can be controlled remotely to deal with any emergency situation.

Keywords Inverted pendulum · Fuzzy control · System integration · Internet of things (IoT)

1 Introduction

In recent years, the rapid development of semiconductor industry speeds up the robot development. To satisfy the needs of human, the various functions of the robot is be designed. Many mobile robot studies have received many attentions. The ball robot has been constructed in 1994 [1]. The similarity of this wheel-based mobile robot likes unicycle-type mobile robot [2], two-wheeled inverted pendulum

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L. Yao et al. (eds.), *Advanced Mechanical Science and Technology for the Industrial Revolution 4.0*, https://doi.org/10.1007/978-981-10-4109-9_2

[3], mobile wheeled inverted pendulum [4], and intelligent omnidirectional mobile robots. [5] ...etc.

Recently, technology of the Internet of things (IoT) has been developed rapidly [6–8]. In general, connect all the things to the Internet, it is called IoT. IoT has a wide range of applications, from wearable devices, smart cars, smart home, intelligent transportation, smart city, to the industrial networking and so on. IoT can make the real world digitization, so it has a very wide range of uses. Through the Internet of things, machines, equipment or personnel can be managed by a remote control center. Moreover, it can also be used to the family device control, car remote control, as well as the search location for stolen items, etc.

In this study, a two wheeled guard robot (TWGR) system with visual ability is designed. A TWGR can be modelled as an inverted pendulum on two coaxial wheels that have independent drives. This system is composed of a chassis carrying a DC motor coupled to a gearbox for each wheel. The image transmission system with the camera is also added. Clearly, a transmission loss exists with this configuration. Obviously, the mathematical model for a TWGR system is complex and inexact. From a control perspective, the conventional control technologies always require a good understanding of the plant. Because an exact dynamic TWGR model is difficult to obtain, controlling such a system using conventional control technologies is also difficult. Therefore, this study applies a Mamdani-type fuzzy control strategy for angle and position control of a TWGR system. Moreover, based on above IoT technology, the TWGR system can send the images back to the control center or other devices for watching wirelessly. By this way, through the Internet of things, the TWGA can be managed by a remote control center.

2 Design Method

A TWGR can be considered an inverted pendulum and is a physically unstable system. This system mainly consists of a platform, pose sensors, and a controller. The platform includes the robot body, the left and right wheels with encoders, and the electronic circuits. The TWGR in this work consists of a base that carries a DC motor, which is connected to a reduction gear for each wheel. The control algorithms are executed using a microprocessor, W78E058B40DL, which is produced by Winbond company. W78E058B40DL is an 8-bit microcontroller, which has a programmable, flash-erasable read-only memory to refresh the firmware. W78E058B40DL has 32 kilobytes of main read-only memory, 4 kilobytes of auxiliary read-only memory, 512 bytes of random access memory, four bi-directional and bit-addressable input/output (I/O) ports, one 4-bit multipurpose programmable port, three timers/counters, and one full-duplex serial port. Moreover, several self-created circuits are used in the TWGR system. The I/O circuits connect the TWGR to the microcontroller, the driver circuits for the motors, and the sensors and filter circuits that are required to measure the rider states.

In the following, the fuzzy controller of the TWGR is described. First, The TWGR can be simply considered as an inverted pendulum on a two coaxial wheels (Fig. 1). By moving the two coaxial wheels back and forth, the body of the two-wheel robot will keep balance. Therefore, we assume two dc motors will receive the same force command in balance control.

The following is a review of fuzzy inference systems. Generically, a fuzzy model is a collection of fuzzy rules $Rule^j, j = 1, \dots, m$, where m is the number of the fuzzy rules. Each rule is expressed in the following form:

$$Rule^j : \text{If } y_1 \text{ is } \mu_{A_1}^j, \dots, y_n \text{ is } \mu_{A_n}^j, \text{ then } u_j \text{ is } \mu_{B_j}$$

where u_j is the output variable, $y_i, i = 1, \dots, n$ are the input variables, n is the number of inputs, $\mu_{A_1}, \dots, \mu_{A_n}$ are standard fuzzy sets, and $\mu_{B_1}, \dots, \mu_{B_m}$ are fuzzy singletons.

In this study, the center-of-gravity method and the *product-sum* operation were used for defuzzification. Specifically, the output, U_{Fuzzy} , of the fuzzy system can be obtained as

$$U_{Fuzzy} = \frac{\sum_{j=1}^m w_j \prod_{i=1}^n \mu_{A_i}^j(y_i)}{\sum_{j=1}^m \prod_{i=1}^n \mu_{A_i}^j(y_i)} \quad (1)$$

where w_j is the point where $\mu_{B_j} = 1$.

3 Results

This work uses a fuzzy theory to design a vision based security robot. Through the Internet of things, the TWGR can be controlled by a remote control center. Moreover, it can also send remote image back by the camera on the TWGR. In this

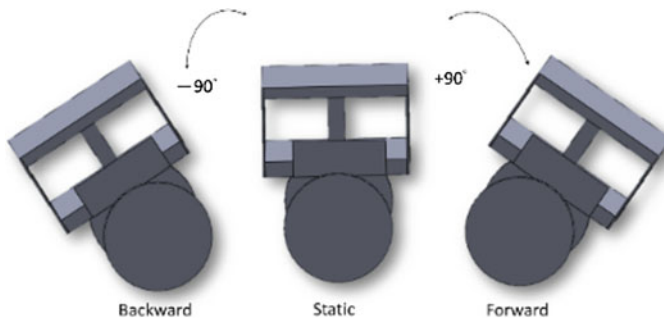


Fig. 1 The scope of the body

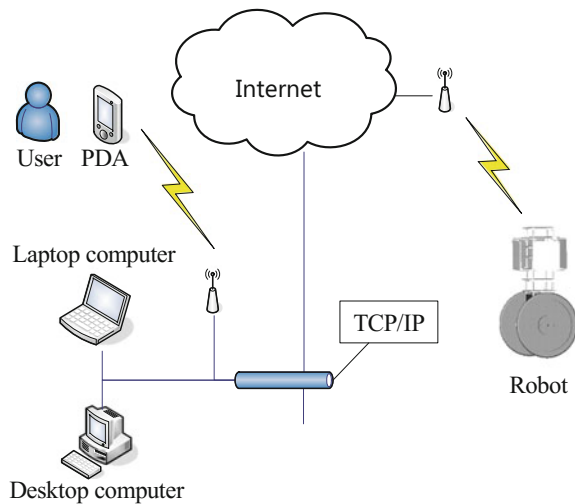


Fig. 2 User schematic

study, the notebook and the PDA are used to monitor the robot through the Internet network. According to IoT technology, it can connect all TWGRs to the Internet (shown in Figs. 2 and 3). Then, the control center can control several robots at the same time. It also can use PDA or other terminals to monitor multiple images from TWGRs. Figure 4 is the experimental system. The TWGR states can use a PDA to monitor. This experimental result is shown in Fig. 5. Figure 6 shows the remote image send by the TWGR.

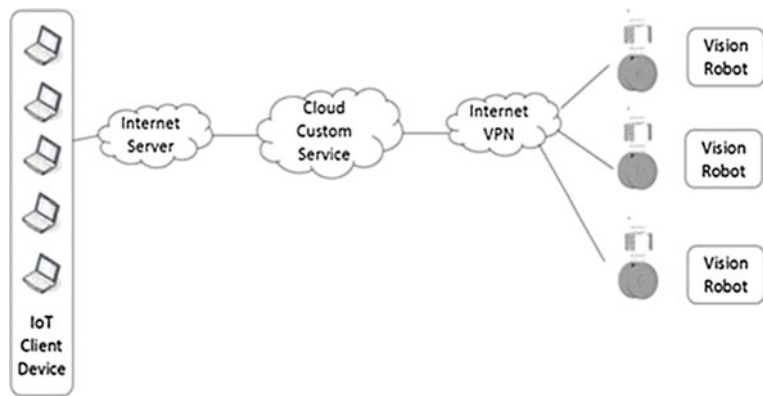
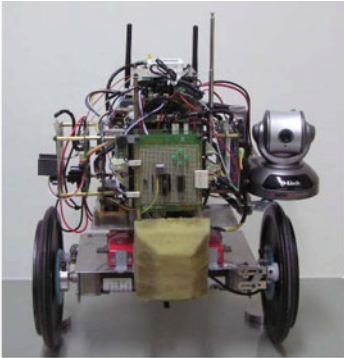


Fig. 3 Iot System block diagram

Fig. 4 TWGR experimental system



(a) TWGR



(b) PDA and control center

Fig. 5 PDA control center

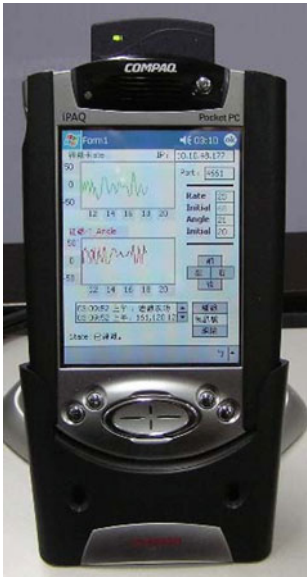




Fig. 6 Remote image monitor interface

4 Conclusions

In this study, the model-free fuzzy control strategy for a TWGR with visual ability has been proposed. Based on basic fuzzy theory, all the simple structure controllers are designed. Finally, 8-bit microprocessors are used to implement this fuzzy controller in this robot. Based on Internet of Things (IoT) technology, all system state and real-time remote image from the visual system can be transmitted to the cloud server through the Internet. Administrator is able to access the cloud server to monitor each TWGR immediately. Experimental results have shown that the proposed control strategy has very good efficiency.

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Advanced Mechanical Science and Technology for the
Industrial Revolution 4.0

Yao, L.; Zhong, S.; Kikuta, H.; Juang, J.-G.; Anpo, M.
(Eds.)

2018, X, 344 p. 209 illus., 172 illus. in color., Hardcover
ISBN: 978-981-10-4108-2