A Voice Initiated Smart Auto-Tracking Mobile Vehicle

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Abstract: This paper proposes a voice initiated smart auto-tracking mobile vehicle which can go start, stop, forward, backward, left turn and right turn automatically based on the received signal from a voice and the detected optical sensors. The proposed auto-tracking mobile vehicle is mainly constructed by AT89S51 based main control board and 8255 input/output peripheral board. Both commercial boards were built by Taiwan Embedded Microcontroller Development Institution (TEMI). In this paper, the AT89S51 microcontroller is used for software programming control and the 8255 parallel input/output extension chip is used for hardware peripheral control. According to the experimental results, the developed smart auto-tracking mobile vehicle can be initiated either by a voice or a push button as well as automatically terminated at the end of track with the 'T' mark, where the track is built by sticking the black tape on the ground. Conclusively, the designed smart auto-tracking mobile vehicle can provide students with brainstorm training opportunity in planning, designing and implementing the microcontroller based project.

1. Introduction

Over the past decade, microcontroller education is one of the most mainstream subjects in the fields of Computer, Electronic, Electrical, and Mechanical Engineering. In Taiwan, many universities view the programmable devices as the necessary education for present and future engineers. For example, at Kao Yuan University (KYU), it is a requirement in Electronic/Electrical Engineering curriculums and an elective course in Information Technology and Mechanical Engineering curriculums. The ultimate teaching goal is to train the students using a single chip to design a practical product. However, with the rapid growth of computer, electronic, and information technology in industries, most current related references and tools used for the μ-controller education are not good enough to achieve the teaching goal. In the reviewing some references related to μ-controller education, many universities, such as Uni. of South Carolina, USA (Giurgiutiu et al., 2005), Uni. of Penn State, USA (Mayer et al., 1995), Uni. of Zaragoza, Spanish (Martin-del-Brio and Bernal-Ruiz, 1998), Long-Hwa Uni., Taiwan (Lee et al., 2006), KYU Uni., Taiwan (Shih et al., 2012) etc., have shared their teaching experiences on μ-controller related courses. At Uni. of South Carolina and Penn State, the μ-controller courses adopted the available μ-controller evaluation board (EVB), Motorola MC68HC11 EVB, with LCD, keypad, a motor and digital thermometer interfaces for Mechanical Engineering and Electrical Engineering students, respectively. At Long-Hwa Uni., it applied the published book and the developed Intel AT89S51 teaching module board with the integrated development environment software for both Computer Science and Electronic Engineering students. At KYU Uni., the author constructed microcontroller-based 3 by 3 football team sets as an educational tool. However, using such commercial developed integrated modules as the teaching tool has one disadvantage: the tool is like a black box and it is too expensive for a student to buy it. Therefore, students need to rely on laboratory facilities for their works and cannot do the experiments at home. As for Uni. of Zaragoza, it only introduced the software tool of MC68HC11 in the μ-controller course.

Additionally, the literature (Athani, 1981), the study (Bray et al., 1981), and the research (Freedman et al., 1981) indicated that two-semester microcontroller courses are needed for students to learn well on both hardware and software design. One semester is for introductory course with conceptual design goals; the other semester is for project-oriented course with more hands-on experiences. Some references (Furman and Hayward, 2002; Jeon, 2000; Lee, 1976) also strongly suggested that the microcontroller course should emphasize more hands-on and use relatively inexpensive kits of components as teaching tools. The author (AI-Dhaher, 2001) pointed out that because of many kinds of microcontrollers available in the market, setting the "right" microcontroller teaching tool is a critical

decision because it may have impacts on students' reactions and learning effects in the class. In addition, the authors (Gupta and Moi-Tin, 2008) also indicated that the "right" microcontroller means the teacher needs to consider some factors, including popularity, availability, architecture, features, prices, tools, education supports, easy use, and so on. Specifically, the research (Schultz, 1991) suggested that teachers might consider 8051 or 68HC11 microcontroller as a teaching target because they are well supported and have matured to being readily available and reasonable alternative to the expensive high performance processors. Therefore, in order to achieve the goal of enhancing students' project planning, designing, and implementing capabilities, this paper aims to use Intel AT89S51 microcontroller as the major controller to develop a smart autonomous mobile vehicle system.

Autonomous mobile devices, one of the developed automatic control products, are designed, built, and experimented all over the world for the specific demands. Their applications are such as obstacle avoidance and response to light/sonar inputs in industry (Gopalakrishnan et al., 2004), assisting elderly individuals with mild cognitive and physical impairments in household (Pineau et al., 2003), multidirectional inspection under vehicles in military (Flann et al., 2002), and small robot helicopter's research platform in scientific laboratory (Helble and Cameron, 2007). In addition, some researchers have focused on a wide variety of multidisciplinary areas, including the decision making (Stone et al., 2006), data acquisition (Núñez et al., 2008), adaptive control system (Miura et al., 2006), sensory system (Martin et al., 2006) et al. However, despite their popularity and necessity in the modern society, these researches usually don't clearly illustrate exclusive structure, design, development, and practical implementation of an autonomous mobile device, thereby making the beginners having problems on learning, designing, and implementing an autonomous mobile device system. Specifically, building a working autonomous mobile device generally requires the knowledge of electronic, electrical, mechanical, and computer software technology. Therefore, opening an introductory autonomous mobile device course is necessary for undergraduate students majoring in Computer, Electronic, Electrical, and Mechanical Engineering.

Despite many kinds of autonomous mobile products being developed and proposed, it seems that finding the best driving mechanism with better efficiency is still much necessary. By considering the demands on developing autonomous mobile products with the specific function around the world, this study extends the author's previous research (Chao and Hsu, 2016) to develop a voice initiated smart auto-tracking mobile vehicle. The proposed technology could provide students for clarifying its fundamental structure, design, and implementation as well as brainstorming on learning project-based designing methodology and its extendibility.

2. Material and Methods

In this paper, the designed smart auto-tracking mobile vehicle mainly includes two parts: hardware circuitry design and auto-tracking software programming. The proposed hardware circuitry design applies AT89S51 microcontroller coupled with 8255 parallel input/output extension chip to control different peripheral devices such as LCM, keyboard, ultrasonic sensor, optical sensors, and DC motors, respectively. The auto-tracking software programming is functionally programmed with machine-based assembly language, which detects the signals from the ultrasonic sensor and optical sensors as well as drives the DC motors to control the mobile vehicle going forward, backward, left turn and right turn along with the tracks correctly. The design principles of the proposed hardware circuitry and the software auto-tracking flow control programming are described in detail as follows.

2.1. Hardware Circuitry Design

Figure 1 shows the hardware structure of the auto-tracking mobile vehicle. Figure 1(a) gives the block diagram of the proposed hardware structure; Figure 1(b) illustrates the driving circuitry of AT89S51 microcontroller; and Figure 1(c) presents the schematics of 8255 input/output control circuitry in which 8255 chip has three ports: PA0-PA7, PB0-PB7, and PC0-PC7. As shown in Figure 1(a), the hardware structure of the auto-tracking mobile vehicle contains three main parts, including AT89S51 central control unit, 8255 input/output interface control, and peripheral devices. The AT89S51 central control unit is connected to 8255 parallel input/output extension chip to control the LCM, keyboard and optical sensors. The DC motors are directly connected and controlled by Port2 (P2.4-P2.7) of AT89S51 microcontroller in order to control the autonomous mobile vehicle going forward, backward, left turn, or right turn. As shown in Figure 1(b), AT89S51 microcontroller is activated by four parts of basic circuitry connections: (1) connecting the 20th pin to ground and the 40th pin to power +5 Volts; (2) connecting the 31th pin to power +5 Volts; (3) the system resetting circuitry (pin 9); and (4) 12 MHz crystal oscillating circuitry (pin 18 and 19). As for Figure 1(c), 8-pin port 0 of AT89S51 microcontroller is connected to 8-pin data bus of 8255 input/output extension chip; the LCM display device is controlled by port A (PA0-PA7) and port C (PC0-PC2) of 8255

chip; the 4X4 keyboards of the peripheral device is controlled by port B (PB0-PB3) and port C (PC4-PC5) of 8255 chip; and four optical sensors are controlled by port C (PC6-PC7) of 8255 chip through 2X4 decoder of 74139 chip. Whenever one of the optical sensors is masked, the corresponding states of the detected sensors would be shown on the LCM display device.
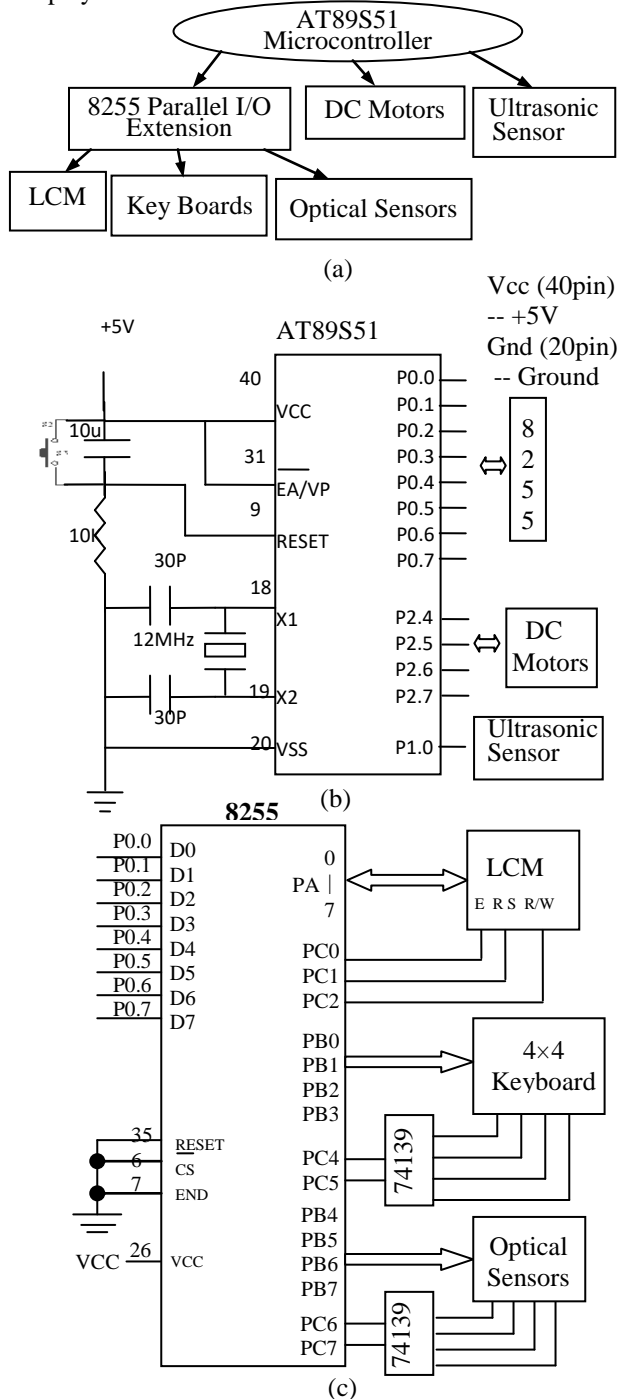

(a)

(b)

(c)

Figure 1. Hardware structure of the auto-tracking mobile vehicle; (a) block diagram, (b) driving AT89S51 central control circuitry, (c) 8255 input/output control circuitry.

2.2. Software Flow Control

Figure 2 shows the software flow chart of the auto-tracking mobile vehicle. As shown in Figure 2, the proposed software flow control mainly includes the display of the LCM, the trigger of the DC motors, and the detection of the ultrasonic sensor and optical sensors. The auto-tracking flow control process starts with powering the auto-tracking mobile device. When the power is at "on" status, the LCM will display the "Wait key – Candy!" on the first line and display the detected states of four optical sensors on the second line. The mobile vehicle then waits a user to whistle or push the "START" push button to trigger the autonomous mobile vehicle to move. As long as a user whistle or push the "START" button, the system will display the detected states of four optical sensors on the second line of the LCM device and move the mobile vehicle going forward, backward, left turn or right turn along with the tracks. Then, the mobile vehicle will be automatically terminated at the end of track with the 'T' mark, where the track is built by sticking the black tape on the ground
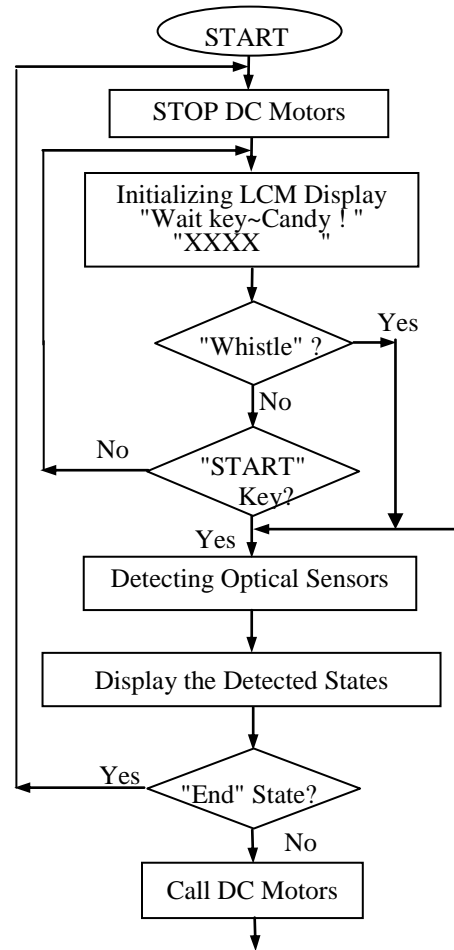

Figure 2. Flow chart of auto-tracking mobile robot.

Table 1 gives the analysis of the corresponding states from the LCM display, four optical sensors and DC motors. As shown in Table 1, there are 16 detected states from four optical sensors in which one state for stop, five states for going forward and three states for turning right, turning left and no actions, respectively.

Table 1. Analysis of corresponding states from the LCM display, four optical sensors and DC motors.
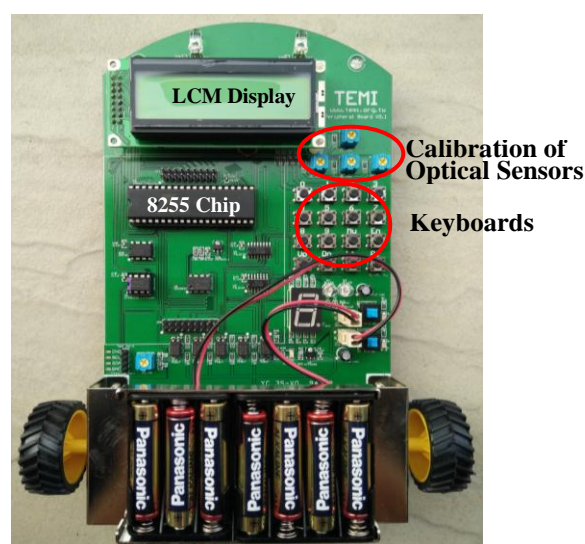
Mask: 0 ■   ;   Un-Mask: 1 □

LCM Display 1 2 3 4	Sensors (4 / 2 3 1)	DC Motors Movement
0 0 0 0	4:■ 2:■ 3:■ 1:■	Forward
0 0 0 1	4:□ 2:■ 3:■ 1:■	Stop
0 0 1 0	4:■ 2:■ 3:□ 1:■	No Action
0 0 1 1	4:□ 2:■ 3:□ 1:■	No Action
0 1 0 0	4:■ 2:□ 3:■ 1:■	Right
0 1 0 1	4:□ 2:□ 3:■ 1:■	Right
0 1 1 0	4:■ 2:□ 3:□ 1:■	Forward
0 1 1 1	4:□ 2:□ 3:□ 1:■	Right
1 0 0 0	4:■ 2:■ 3:■ 1:□	Left
1 0 0 1	4:□ 2:■ 3:■ 1:□	Forward
1 0 1 0	4:■ 2:■ 3:□ 1:□	Forward
1 0 1 1	4:□ 2:■ 3:□ 1:□	Left
1 1 0 0	4:■ 2:□ 3:■ 1:□	Forward
1 1 0 1	4:□ 2:□ 3:■ 1:□	Left
1 1 1 0	4:■ 2:□ 3:□ 1:□	No Action
1 1 1 1	4:□ 2:□ 3:□ 1:□	Left +Stop

3. Results

In this paper, the proposed voice initiated smart auto-tracking mobile vehicle is constructed by AT89S51 main control board and 8255 input/output extension board. Figure 3(a) is the 8255 input/output interface circuit board which mainly includes 8255 parallel I/O extension chip, LCM, keyboard, and optical sensors. Figure 3(b) shows the AT89S51 main control circuit board which basically contains initializing the system reset circuitry, enabling the internal ROM memory, connecting the 12 MHz crystal oscillation circuitry, 5-volt power and ground pins as well as peripheral devices such as the ultrasonic senor, and buzzer dip switches. Figure 3(c) illustrates the integrated hardware of the proposed auto-tracking mobile vehicle which combines both AT89S51 main control board and 8255 input/output extension board together. Both commercial peripheral boards are developed by Taiwan Embedded Microcontroller Development Institution (TEMI); a user can find the detail circuitry schematics and related references at the website of TEMI.

Figure 4 shows the autonomous mobile robot auto-tracking the black tap on the ground in which the wheels are improved and software control codes are embedded. Figure 4(a) and (b) present the pictures of the mobile robot which begins at starting point and passes through the tracks to the end point. Figure 4(c) gives the picture of the mobile robot which stops at the end point automatically. According to the experimental results, the improved mobile robot extends the wheels widely would support better stability by comparing the mobile robot using the original commercial wheels.

(a)

(a)

(b)

End point

(c)

Figure 4. Autonomous mobile vehicle auto-tracking the black tap on the ground; (a) mobile vehicle passing through start point and auto-tracking toward to the end point; (b) and (c) mobile vehicle stopping at the end point.
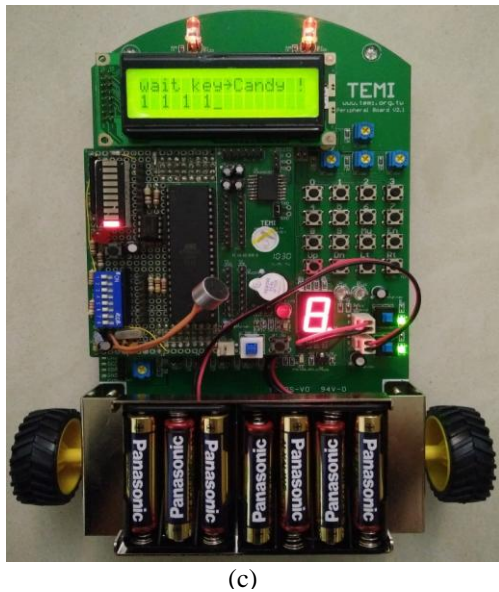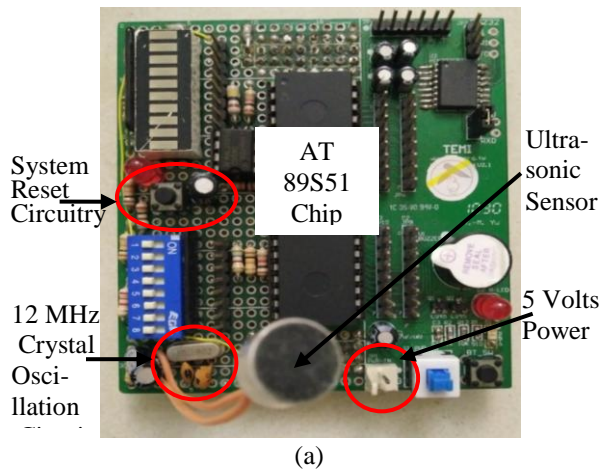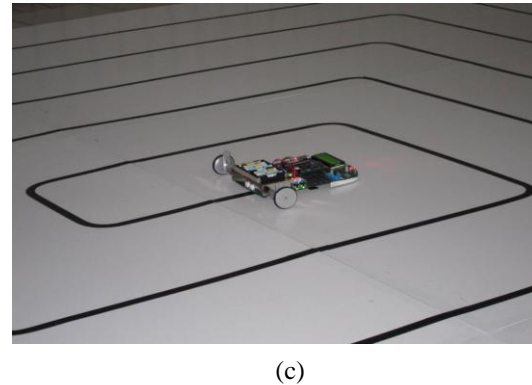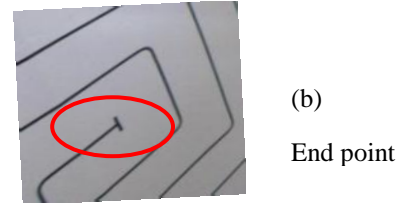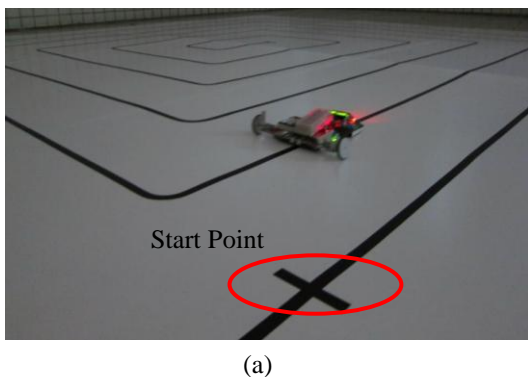

(c)

Figure 3. Hardware of the auto-tracking mobile vehicle; (a) 8255 input/output interface circuit board; (b) AT89S51 main control circuit board; (c) Integrated auto-tracking mobile vehicle.

Start Point

(a)

4. Conclusions

In this paper, a set of AT89S51 microcontroller based mobile vehicle has been constructed to train users learning both hardware and software technology skills, including exclusive structure design and practical implementation of an auto-tacking mobile vehicle. The proposed technology provides three distinctive advantages: (1) users not only learn the essential contents of μ-controller skills but also learn more peripheral interface control skills; (2) the proposed mobile vehicle built and tested by assembling the commercial boards would reduce the testing time, thereby enhancing brainstorming stimulation on designing an auto-tacking mobile vehicle; (3) users are allowed to construct their own main control board and peripheral board personally, thereby cultivating more qualified μ-controller hardware/software engineers.

According to the experimental results, this work can be extended to focus on applying the μ-controller to control different interface circuits, such as adding the driving circuitry for triggering DC motor fast in order to accelerate the velocity of the autonomous mobile vehicle. In addition, developing supplementary circuitry in modules would increase the design flexibility of an autonomous mobile vehicle in various applications.

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