

Implementation of master-slave method on multiprocessor-based embedded system: case study on mobile robot

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Abstract

In this research the master-slave method implemented on an embedded system using 3 processor applied to the mobile robot, to know the speed of program execution of robot. As a comparison is also used a robot with an embedded system based on single processor. From the experimental results, by applying the slave master method obtained the execution time of 546,5 μ s and the number of iteration 1079, while for single processor-based system obtained execution time average 67828 μ s and the amount of iteration average 147 times. Where the number of iterations is obtained by running the robot for 10 s. From this experiment, it can be concluded that there is a performance increase of 7.3% when compared to embedded systems based on single processor.

Keywords: multiprocessor; master-slave; time of program execution.

1. Introduction

The use of mobile robot looks increasing in industrial or household. In the industry many things can be done such as cleaning floors, loading and unloading in factories, transporting samples from one location to another and so forth. With various types of robot development, also used for domestic workers. This is done because of its flexibility, small size, and low cost. Whatever type of robot definitely needs a computer device that will run it. This computer is also called embedded system.

The mobile robot is a robot with the ability to move position in an environment using its own resources. One type of mobile robot is a wheeled robot. The wheeled robot is basically divided into two types, namely holonomic that can move all directions without changing the orientation and non-holonomic that moves in a direction by turning or changing orientation. Wheels on holonomic are mecanum wheel or Omni wheel and on non-holonomic using the conventional wheel. In a wheeled robot if using 2 wheels drive is called 2WD or using 4 wheels drive is called 4WD. To drive the robot, an embedded device system is designed specifically for the robot.

According to [1][10][11][12], embedded systems is a combination of hardware and software to respond to the surrounding events within the specified limits. Embedded systems can consist of a small computer with microprocessor or microcontroller and supporting devices. In the robot application, the microcontroller will perform the procedure in a sequential manner, i.e. from the process of acquiring and processing (perception) data from the sensor, run robot algorithm, and specify the action that must be done. From the procedure, the process of data acquisition of the sensor is time-consuming, how much time delay very greatly depending on the type of sensor used. For example, for distance sensor based on ultrasonic-wave with a maximum reading distance of 300 cm, a maximum delay of 17.4 ms. This can be a constraint, because

according to [1] an embedded system must react quickly to environmental changes and be able to respond to events in real time with small delay

One method that can be used to speed up the control process is by adding the number of processors. All processors on this system will communicate with the Master-Slave method. Master-slave is a communication model where one device or process has direct control over one or more other devices. Or in other words, there is only one device or process that is active, while others are passive. This method is commonly used as in [4][5][6][7].

According to [3] this is one method that can be used on multiprocessor systems.

2. Experimental Method

To support this research used tools such as a mobile robot with 4 wheels drive and equipped with 4 pieces of ultrasonic wave based distance sensors mounted on each side, and embedded system design using a microcontroller. The embedded systems for wheeled robots in this research are described in Figure 1 for systems using single processor and Figure 2 for systems using master-slave method.

The multiprocessor system used 3 pieces of microcontroller, one of them serves as a master which will run the main program for the robot system. Another microcontroller serves as a slave. Each slave serves as a data processor of the acquisition process and the actuator controller. This is shown in Figure 2. All microcontrollers work with clock speeds of 16 MHz and communicate using an I2C interface with a clock frequency of 100 KHz.

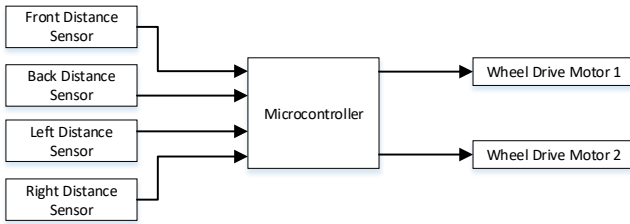


Fig. 1: Block Diagram of Embedded System on Mobile Robot using a single microcontroller

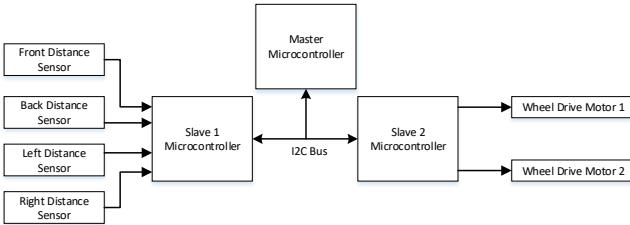


Fig. 2: Block Diagram of Embedded System on Mobile Robot using master-slave microcontroller.

There To interact between master and slave begins by master, which will start communication by sending a message to slave. When the slave receives the message, proceed with translating it. The result is an immediate task performed by the slave. Once completed the slave will inform the master again, or send the specified data if the message from the master is a data request. This interaction system is also known as inter-process communication. The Sequential process on master slaver as shown in Figure 4. From figure 4, 'motor control' is the main process run by slave 2. In this process will generate PWM signal which will be given to the motor driver. The PWM update value is given from the master through I2C communication. The process of receiving data using interrupt driven. When no data is sent then the microcontroller is idle.

While in slave 1 'acquisition and perception' is the main process. This process aims to acquire data from all sensors and perception them. The result will be stored in memory. This process runs with a time interval of 100ms, so the data in memory will be updated at that time interval. This data will be send when there is a request from the master. Receipt of requests and data sending is done by interrupt driven.

Figure 3 is a planned procedure for a single processor system. Figure 5 is a state diagram for the procedure on the slave with data processing function of the acquisition process, while on Figure 6 is the state diagram for the procedure on the slave that controls the actuator.

Acquisition And Perception	Robot Fuction algoritma	Action
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Fig. 3: Sequential process on single processor.

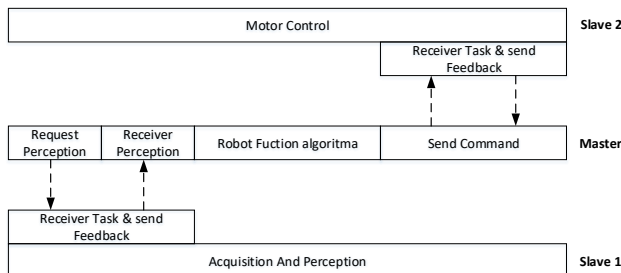


Fig. 4: Sequential process on master slaver.

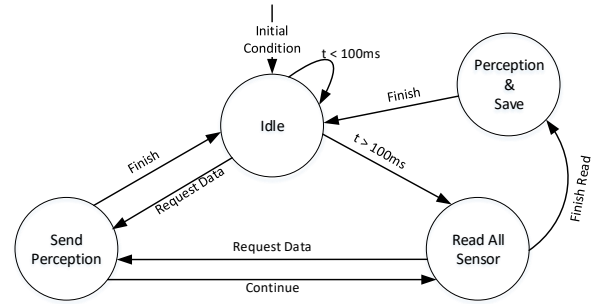


Fig. 5: State Machine Diagram of acquisition function Slave Processor

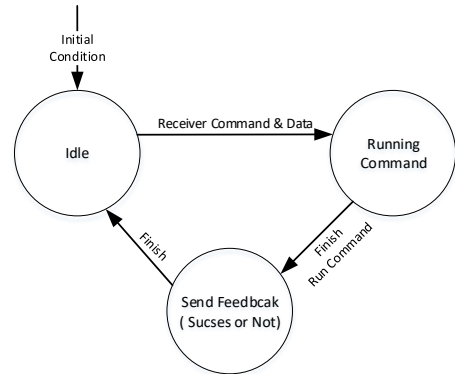


Fig. 6: State Machine Diagram of speed control functions of Slave Processor.

Both robots are tested by providing varying obstacles on two robot sensors. the maximum distance of each sensor is 90 cm. the result of this research is the speed in performing robotic functions performed on the two embedded system models, by measuring the time required for a single process, and the number of robot functions that can run for 10 seconds.

3. Result and Discussion

Master microcontroller using Arduino Nano Development board, as well as slave 1 and 2 microcontrollers. This is shown in Figure 7 and figure 8. The prototype robot has a dimension of 25cm length, 20cm width, and 17cm high. The robot has 4 wheels with a dc motor drive on each wheel. But on the left wheel (front and back) connected to the same a motor driving. Likewise with the wheel on the right side. Power source robot using Lipo Battery with voltage of 7.2Volt

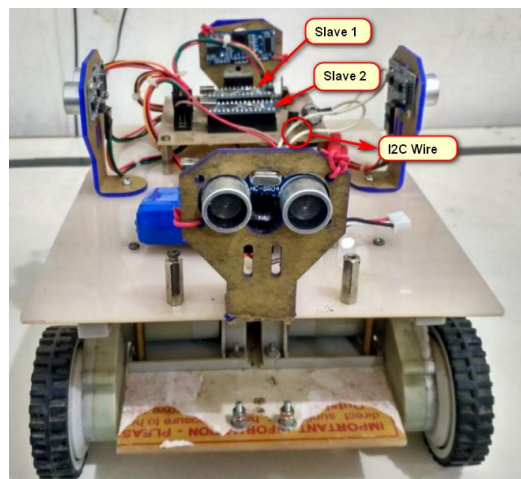


Fig. 7: Robot prototype, front view

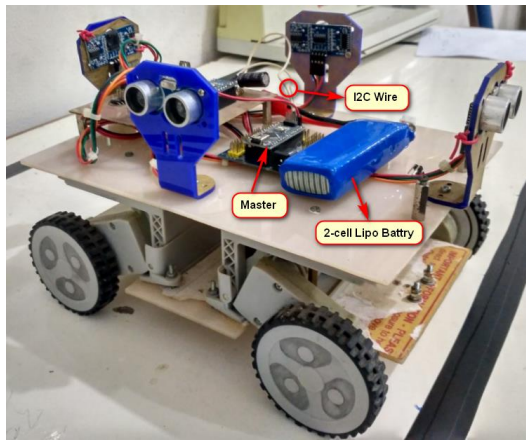


Fig. 8: Robot prototype, side view

An In the first experiment for single-processor-based systems, 2 data retrieval was performed. In the first data obtained program execution time average $66451.25\mu\text{s}$. The number of program execution iterations was obtained 150 iterations. In the second data obtained program execution time average $69204.72\mu\text{s}$. While the number of iterations 144. The data obtained by running the robot for 10 seconds. The results of the experiments are shown in figure 9.

From both graphs obtained a maximum time of $94752\mu\text{s}$ and a minimum time of $59856\mu\text{s}$. The oscillations on the graph show the difference in program execution time, this is caused by the delay that occurred during the acquisition of the sensor. Thus, the program execution time is affected by the distance between the sensor and the object

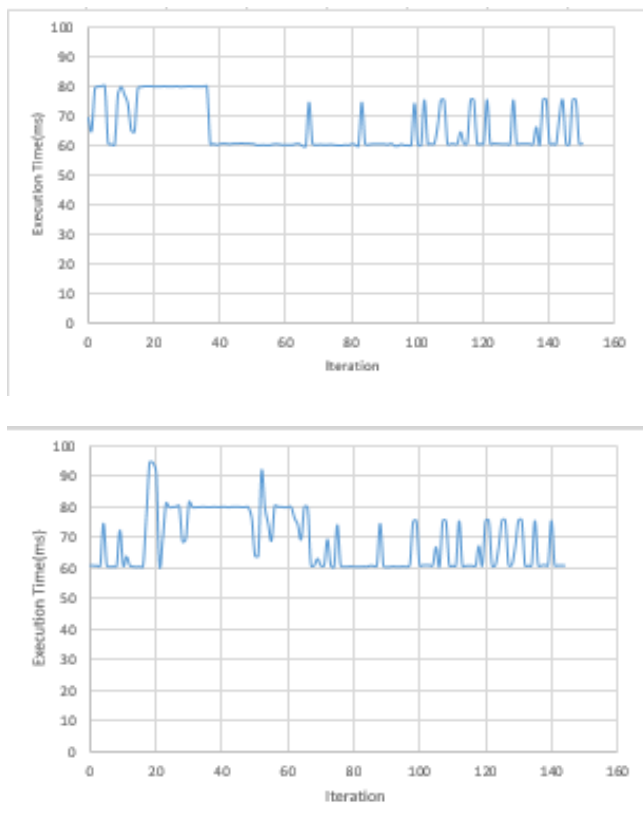


Fig. 9: Iteration and time execution in a 10s time interval on the single microcontroller, data first (top), second data (Bottom)

In the second experiment, the same way is applied to multiprocessor systems with the master-slave method. From both data got identical data. From the experimental results can be obtained the average program execution time of $546.5\mu\text{s}$, and the number of iterations obtained 1079. Experimental results are shown in Figure 10. Oscillation does not occur in this experiment, only in the itera-

tion of 0, 411 and 868 increased program execution time to $1068\mu\text{s}$. But overall there is an increase in execution time.

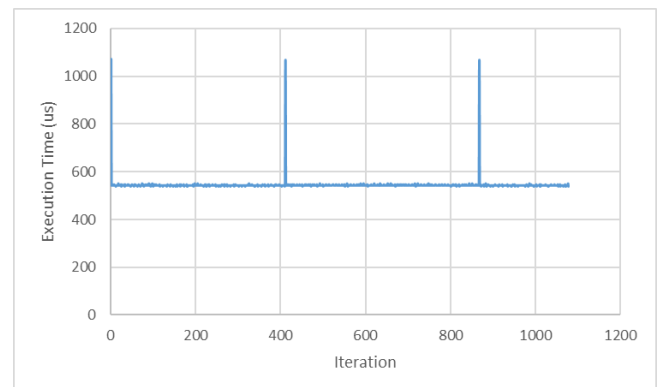


Fig. 10: Iteration and time execution in a 10s time interval on master-slave communication.

4. Conclusion

In From the research results can be concluded by applying multi-processor system with master-slave method for an embedded system in a robot, have better performance with speed improvement in program execution equal to 7.3 times compared with single micro-controller system

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