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Microcontroller-based Smart Trolly Performance Analysis

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ABSTRACT

A shopping cart is an assisting tool in the commercial area where its function is as a temporary container for selected shopping items before the items are counted and billed. The cart becomes an indispensable tool in supermarkets. The more shopping items there are, the more energy is needed to manually push or pull the cart. This is considered not very effective in supporting consumer productivity in finding and fulfilling their needs. The aim of this research is to create a smart cart used in supermarkets, thus facilitating users in carrying shopping items. The design of the smart cart combines hardware and software. Arduino Uno serves as the main component with object detection around it using the HC-SR04 Ultrasonic Sensor and Bluetooth Module as the link between the cart and Smartphone. The cart is controlled by a smartphone using Bluetooth as the connection within a maximum range of 7m, powered by 4 DC motors and a 12V DC Battery. The maximum load capacity of this cart is 2,5 Kg. The cart's ability to detect objects is limited to a distance of <20 cm.

Keywords: *Arduino Uno, HC-SR04 Ultrasonic Sensor, HC-05 Bluetooth Module.*

1. INTRODUCTION

A cart is a human-assisting tool that is useful for carrying a quantity of items easily. With the existence of a cart, humans do not have to feel troubled and will not quickly get tired even when carrying a considerable number of items [1]. The use of carts in supermarkets is highly necessary. Manual carts are operated by being pushed or pulled by users. The more shopping items there are, the more energy is required to push or pull the cart, causing buyers to limit hand activities. Also, when focused on pushing the cart, buyers often overlook many items sold in the supermarket and only buy essential items. This can reduce the shopping volume of buyers [2][3].

From the above problems arises the idea to create a microcontroller-based device that can make the cart controllable by users holding a Smartphone. Using Arduino programming language and Ultrasonic HC-SR04 [4][5] as a distance controller so that the cart does not collide with surrounding objects. Therefore, users do not need to worry about the cart hitting objects around. The design of the smart cart combines hardware and software. Arduino Uno [6] as the main component and Ultrasonic HC-SR04 Sensor and Bluetooth Module [7] as the connection between the Cart and Smartphone [8]. The cart is automatically moved through the Smartphone device owned by the consumer.

The method used in this research is the Waterfall method, which depicts a systematic and sequential approach in software development, starting with user requirement specifications then progressing through planning, modeling, construction, and system delivery to users, culminating in support for the complete software produced [5][9][10]. Based on the background presented, the problem statement can be formulated as the need to analyze the performance of the smart trolley in facilitating buyers' shopping in a retail setting.

2. LITERATURE REVIEW

Research conducted by Faisal Irsan Pasaribu & Suthes Yogen (2019) found that the Cart prototype has the ability to detect the presence of users and follow the user's movements. The Cart prototype is controlled using a minimum system microcontroller Arduino Uno, which detects the user's position using Ultrasonic sensors. This Cart prototype is powered by 4 DC motors and a 9V DC battery power source [2].

Research conducted by Pratama Zanofa & Mico Fahrizal (2021) discusses an automatic gate prototype integrating software and hardware. Using an application controlled via Smartphone to operate the automatic system, Bluetooth signals activated by the user can open and close the gate, providing security by intercepting remote control signals [11].

Research by Irmawati Iskandar (2021) outlines the design of a device composed of two main components: hardware and software. Hardware is built using Ultrasonic sensors, DC Motor PG28 as a driver, Servo for collecting garbage, Li-Po Battery as a power source, and Arduino ATMega2560 [12] as the main microcontroller for the garbage collecting robot prototype. The software is built using Arduino IDE which includes libraries and programs to be uploaded to the microcontroller. Based on the test results, Ultrasonic sensors can detect garbage and obstacles at an optimal distance of 1 meter [13].

Research by Roy Sekaropa & Farid Thalib (2021) explains that the Arduino Uno microcontroller is a crucial component in the garbage collecting robot prototype as it processes and converts inputs into outputs. The garbage collecting robot is controlled using a Smartphone with the Arduino Bluetooth controller application, and DC motors are used as wheel drivers [14].

3. METHODS

3.1 Research Procedure

The research model utilized in this study employs the waterfall method [5][15], as depicted in Figure 1:

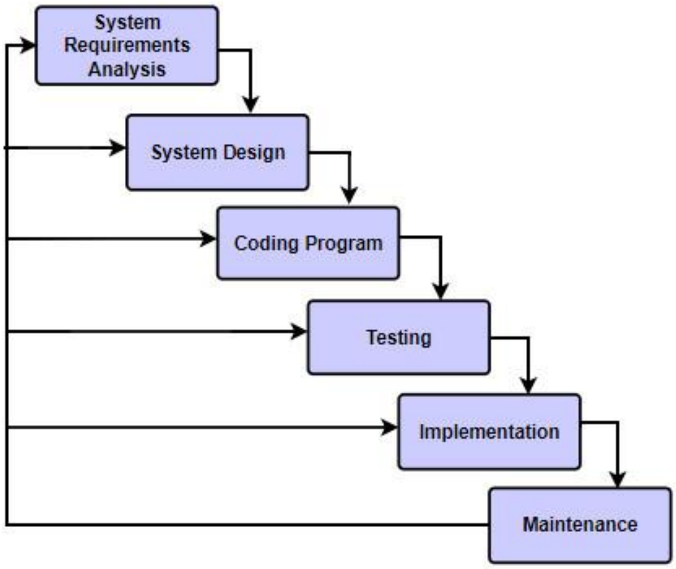

Figure 1. Waterfall Model System Development Method [5]

Where the steps of the method are as follows [16]:

1. Problem analysis explains what problems exist in the field related to the use of trolleys that need to be solved, then an analysis is carried out to find and create solutions.
2. Design aims to create a design used to address the problems that are occurring in the field, prioritizing ease of use of the system or designing it to be user-friendly.

3. Programming code aims to provide instructions in the form of program code written in the C++ programming language, utilizing its compilation application, Arduino IDE.
4. Testing is intended to evaluate the results of the design that has been programmed to find errors or deficiencies in the project being developed.
5. Implementation aims to directly operate the project to the users who are the object.
6. Maintenance aims to address issues that arise after the project has been implemented.

3.2 Data Collection Techniques

The data collection methods used in this research are [5]:

1. Observation Method
   In this research, observation was conducted at Jl. R.A. Kartini No.7, Mangkukusuman, Kec. Tegal Timur., Kota Tegal, Central Java 52131, to obtain the required data related to the control system on the smart trolley.
2. Interview Method
   An interview was conducted with Mr. Tri Yunanto, the Operational Supervisor at Sahabat Putra Tegal Store. The interview in this research was conducted to obtain information as supporting material in the making of the control system on the smart trolley.
3. Literature Review
   The literature review aims to search for reference sources related to the research object, where the sources vary greatly, including journals, proceedings, reports, books, and so on.

4. RESULTS AND DISCUSSION

After conducting the research methodology, an analysis of the hardware and software requirements used to create an Arduino Uno-based Smart Trolley was obtained. The next stage is the design stage. Designing the Smart Trolley using Arduino Uno includes hardware requirements such as Bluetooth, ultrasonic sensor, motor driver [17], DC motors needed using block diagram and flowchart design [16][18]. In making this Smart Trolley usable, it requires C, C++ programming languages with Arduino IDE tools [19][20].

1. Hardware Design

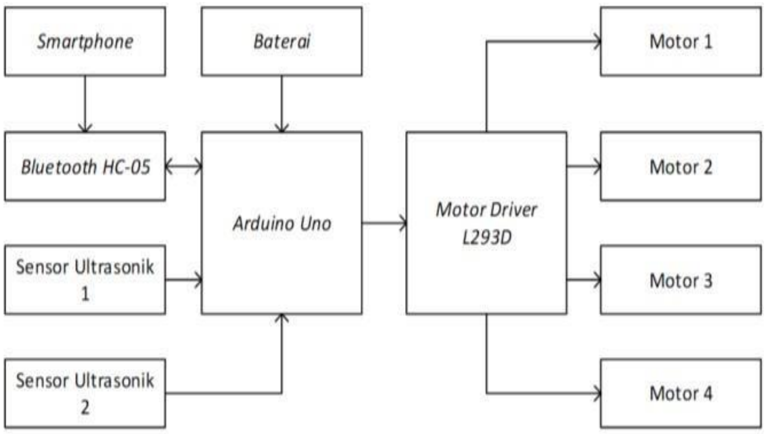

Figure 2. Smart Trolley Block Diagram

Each block has the following functions:

1. Arduino Uno [21], as the main component, data is sent to the Arduino Uno from the Arduino IDE software, which functions as a microcontroller so that the Arduino Uno will send commands to other components to perform their functions.
2. L293D motor driver [22] functions as a DC motor controller, so the motor can move clockwise or counterclockwise with a speed that can be adjusted using PWM (Pulse Width Modulation) system.
3. Ultrasonic sensors [4] used on the robot are two in number, placed on the front and back of the robot which will detect objects in front and behind.
4. Bluetooth Module [11] as a connection between the Smart Trolley and Smartphone.
5. DC Motors as the drive or wheels on the robot.
6. 12-Volt Li-Ion Battery [23] serves as the voltage source for the robot.

2. Overall Component Circuitry

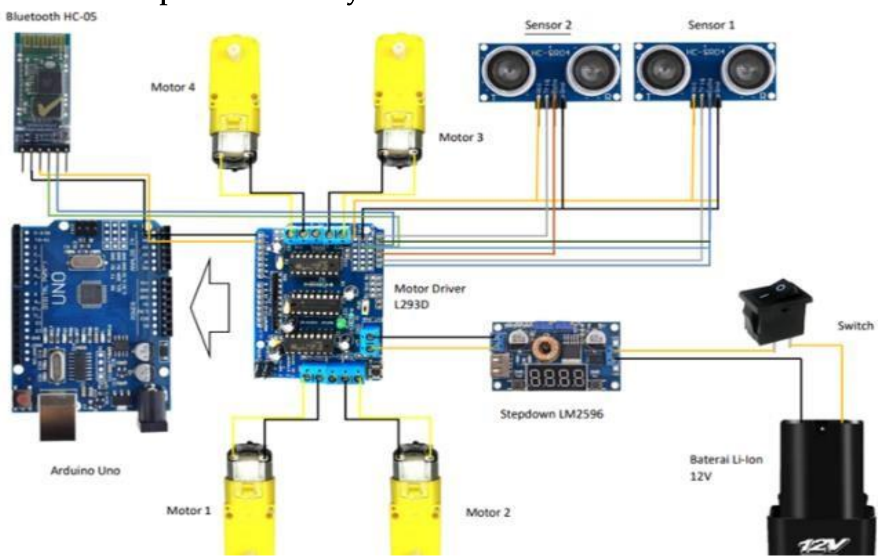

Figure 3. Overall Component Set [24]

3. Flowchart Design of Smart Trolley System

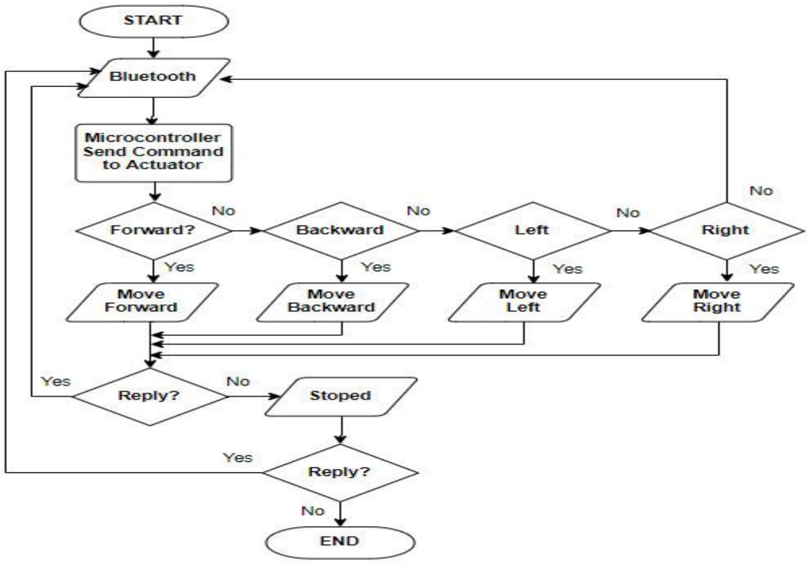

Figure 4. Flowchart Design [25] of Smart Trolley System

4. Smart Trolley Design Result

Figure 5. Smart Trolley Design Result

5. **Testing Results**
   1. Bluetooth Connection Distance Testing

Table 1. Bluetooth Distance Testing Results

No	Testing Distance (m)	Barrier	Description
1	1 to 2	No Barrier	Connected
2	3 to 4	No Barrier	Connected
3	5 to 6	No Barrier	Connected
4	7 to 8	No Barrier	Unstable Connection
5	9 to 10	No Barrier	No Connecton
6	1 to 2	there are barriers	Connected
7	3 to 4	there are barriers	Connected
8	5 to 6	there are barriers	Connected
9	7 to 8	there are barriers	No Connecton
10	9 to 10	there are barriers	No Connecton

   2. Ultrasonic Sensor Testing

Table 2. Ultrasonic Sensor Testing Results

No	Ultrasonic Sensor	Action at a distance (m)		
		15	20	25
1	Ultrasonic 1	Reverse	Reverse	Stop
2	Ultrasonic 2	Forward	Forward	Stop

   3. Trolley Load Testing

Table 3. Trolley Load Testing Results

No	Trolley Load (kg)	Description
1	0	The Trolley Can Walk
2	0,5	The Trolley Can Walk
3	1	The Trolley Can Walk
4	1,5	The Trolley Can Walk
5	2	The Trolley Runs Slowly
6	2,5	The Trolley Stalls

7	3	The Trolley Can't Run

6. Performance Analysis

From the test results that have been presented, it can be concluded that the smart trolley that has been designed and tested has successfully carried a load with a maximum load of 2.5 kg, where for the sensory capabilities of the smart trolley can sense objects around the smart trolley can work well so that the smart trolley does not hit the objects around it. Project optimization can be done by upgrading the motor that functions as a smart trolley driver so that it can carry loads weighing more than 2.5 kg.

CONCLUSION

Based on the research and implementation of the system that has been carried out, it is concluded that the trolley can be controlled by a Smartphone via Bluetooth when testing can be connected at a distance of 1 - 8 meters if there are no obstacles and when there are obstacles can only be connected at a distance of 1 - 6 meters, as well as ultrasonic sensors that detect objects at a distance of <20 cm, with a maximum trolley load of 2.5 kg. In the next development, it needs to be improved regarding the load that can be carried by the trolley.

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