ECE 445

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Senior Design Project Proposal

Smart Shopping Cart

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I. Introduction

Statement of Purpose:

As technology progressed, lives have been significantly improved due to the emergence of laborsaving and intelligent utilities. However, as we noticed, the shopping carts in major stores have experienced little changes and served only simple purposes ever since they were first manufactured. Pushing these carts around becomes noticeably painful when they carry heavy loads. Even though generally people are not moving fast in stores, there is a risk of collision if obstacles arise out of sight. Moreover, products can be extremely difficult to locate before people get familiar with the store layout. Considering all the disadvantages discussed above, we aim to implement a smart shopping cart that provides great convenience and efficiency to customers.

Objectives

Goals:

- Automatic customer tracing via communication between transmitter and receiver
- Avoid collisions with obstacles and detect accessible routes
- Optimize the path required to accommodate custom shopping list
- Alert system to warn customers on condition that carts fall behind

Benefits:

- Self-motion cart aiming to save human labor
- Optimal guiding system to reduce searching time
- Delicate user interface with multiple entering modes
- High-sensitivity sensors to minimize the possibility of collisions

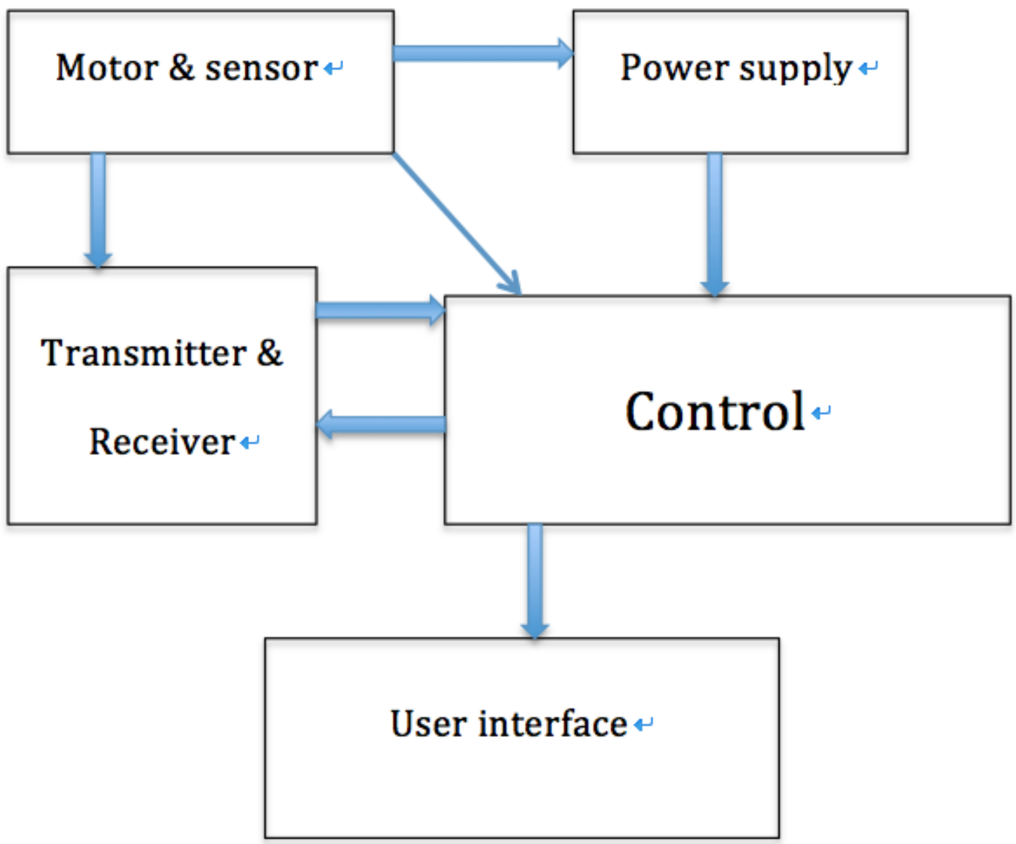
Features:

- Sensors with minimum detection radius of 0.5 m
- Signal transmitters installed in store for precise navigation
- High CPU calculation speed for rapid moving decision
- Keyboard and LCD display for convenient user input

- Enclosed store map and catalogs intended for search searching

II. Design

Block Diagram



Block Descriptions

1. Transmitter & Receiver: For instantaneous position update of customers, a GPS-like positioning system is embedded in the cart. Since commercial GPS may not provide enough precision, we will use transmitters and receivers to for accurate navigation. Four signal transmitters are installed in store attached on the ceiling, in order to cover the entire store. By receiving signals from transmitters, the receiver embedded in the shopping cart can determine the

customer's position easily so the cart is able to make automatic tracing. To improve signal reception, an antenna is assembled in each cart.

2. Motor & Sensor: Two DC motors are installed to drive the shopping cart and change its direction. Four sensors will be utilized to accomplish our obstacle-avoiding feature. When any sensor senses an obstacle within detection radius, it will send an alert to the microcontroller in order to adjust the direction of the cart, based on how far the obstacle is.

3. Power Supply: This unit is in charge of providing power to the motors, sensors, microcontroller and user interface. We will use 5V rechargeable batteries as power supply.

4. User Interface: We aim to provide a maneuverable and multi-functional user interface. A LCD display screen and a keypad are presented for customers to enter goods they wish to purchase. Goods are classified into different categories so that customers may narrow down the ranges for easier search. Customers can choose between two modes of navigation: item-by-item entry mode that leads customers to the product immediately after they finish entering one, or the multiple-item mode that determines the most efficient route covering all items entered.

5. Microcontroller: This is the most critical component in our design. An Arduino microcontroller is used to process all the data and calculations. The microcontroller is responsible to determine the shopping cart's speed and direction when tracing customers and avoiding obstacles via the receiver and sensor, respectively. It will also generate routes from the current position to places where desired goods are located. To implement this function, we need to enclose the store layout and catalogs within the microcontroller.

III. Requirements and Verification

<u>Requirements</u>

1. Transmitter & Receiver: In order to maintain frequent tracing of the customer's position, the transmitter carried by the customer and the receiver embedded in the cart must communicate at a minimum frequency of 100 Hz. In addition, the receiver should provide information to the

microcontroller at the same frequency (100$\pm$5 Hz) for immediate update of the customer's status. When the cart functions as a GPS, the receiver changes its channel to connect to the signal transmitters placed in the store. The same communication frequency (100 Hz) is desired.

2. Motor & Sensor: The shopping cart is equipped with two 12V DC motor to provide sufficient speed for a cart that weighs approximately 3 kg. The cart is supposed to accelerate to maximum speed in 3 sec and brake completely in 0.5 m. Two types of sensors are involved in this project: one is able to detect objects that are relatively distant (~2 m), for early avoidance decision; the other detects near obstacles within 0.5 m so the cart can slow down and recalculate its path.

3. Power Supply: In most times, the cart moves at average human walking speed. Even considering that the maximum speed is doubled (3$\pm$0.5 m/s), the power supply is not required to handle big currents. Adding up the power needed to provide to the other four modules, the total current will not exceed 3 A.

4. User Interface: The user interface consists of an alpha numeric keypad for customer input and a LCD display to show items entered. After sending the list to the microcontroller, the keypad is disabled until the cart visits all goods. Considering the complexity of solving for the most efficient path, at most 10 items are allowed to be entered at once.

5. Microcontroller: The fundamental task of the microcontroller is to determine the cart's speed and moving direction. It receives information from the receiver and sensors at a minimum frequency of 100 Hz and processes all the data at approximately 2 MHz CPU speed in order to directs the cart immediately, especially when calculating the most efficient path in GPS mode.

Verification

1. Transmitter & Receiver: Compare the distance calculated based on information from the transmitter & receiver with the actual distance. Present the results in a table and check whether the percentage errors are restricted within 5% at a range of 5 m. Intervals between signals should be less than 10 ms.

2. Motor & Sensor: Measure the outputs of the motors at various speeds and plot the results in a graph. Load test will be performed to determine whether the motors can achieve the maximum speed specified. The time required to fully stop from maximum speed and the time to reach maximum speed from rest will also be recorded. The sensors will be tested on their detection accuracy. The 0.5 m sensor can have a percentage error of no more than 3 % and the 2 m sensor with less than 5 %.

3. Power Supply: Measure the current of the power supply when the cart is moving at maximum speed and other units are also operating properly, and check if the power supply is able to handle that current (~ 3 A).

4. User Interface: We'll examine if the signals sent from the user interface accurately reach the microcontroller. Additionally, make sure the mode information, to search item by item or a list of items, is correctly submitted.

5. Microcontroller: The calculation speed will be measured to ensure that the microcontroller is able to send the results to other parts before it receives new data. In obstacle tests, we will examine the decisions of the microcontroller and record the success rate. When the cart works in the GPS mode, the microcontroller will be heavily tested on its ability to determine the most efficient path based on the shopping lists designed.

Tolerance Analysis

In this project, the microcontroller processes a larger amount of information than any other part of the cart and it communicates with all the rest components. Consequently, the microcontroller critically affects the performance of the entire project. A minor mistake in calculating the cart's speed and direction may result in significant inefficiency when trying to avoid an obstacle. And the cart fails to perform functionally if the microcontroller is not able to figure out the best route in GPS mode. Therefore, the moving decisions of the microcontroller demands great accuracy and its connections with the receiver, sensors and motors should be fast and reliable. The cart is expected to turn from 0 to 180 degrees both clockwise and counterclockwise and have a speed to sweep from 0 to 3 m/s. The turning angle is especially important so its tolerance is within $\pm$5%. More detailed requirements will be presented in later reports.

IV. Cost and Schedule

Cost Analysis

Labor:

Member	$/hour	Hours/week	Total hours	Subtotal	Subtotal * 2.5
Ying He	40	12	144	5760	14400
Di Fan	40	12	144	5760	14400
Xuyang Yao	40	12	144	5760	14400
				Total	43200

Parts:

Part name	Unit Price	Quantity	Total Price
Vehicle Frame set with motor	$40.67	1	$40.67
Object Detection Sensor	$9.99	4	$39.96
Arduino microcontroller	$25.99	1	$25.99
LCD screen	$19.95	1	$19.95
Keypad	$3.95	1	$3.95
SD Memory Card (16 GB)	$9.99	1	$9.99
On/Off Switch	$3.19	1	$3.19
Automotive Antenna	$15.95	1	$15.95
Signal Transmitter	$9.99	5	$49.95

Signal Receiver	$50	1	$50
		Total	$259.6

Grand Total = $36000 + $259.6 = $ 36259.6

Schedule

Week		Tasks	Assigned to
1	2/4/13	Finish primary proposal and mock DR sign-up	Collaborative
		Order vehicle frame, install motors, and assemble the vehicle	Collaborative
2	2/11/13	Learn Arduino software	Collaborative
		Install receiver and sensors to the vehicle	Collaborative
		Design store map and record into the memory of the controller	Collaborative
3	2/18/13	Finish the customer tracking unit	Collaborative
		Prepare for the Design Review	Collaborative
4	2/25/13	Finish the detection & decision unit for stationary obstacles	Collaborative
		Start the detection & decision unit for moving obstacles	Collaborative
5	3/4/13	Finish the detection & decision unit for moving obstacles	Collaborative
		Write individual progress report	Collaborative
6	3/11/13	Design the position system	Collaborative
		Create circuit board and order PCB	Collaborative
		LCD display and store catalog	Collaborative
7	3/18/13	Spring Break	Collaborative

8	3/25/13	Set up user interface	Collaborative
		Design one-by-one searching scheme	Collaborative
9	4/1/13	Design multiple-item searching scheme	Collaborative
		Finish the most-efficient-path determination unit	Collaborative
10	4/8/13	Assemble all components	Collaborative
		Finish PCB	Collaborative
		Debug and test	Collaborative
11	4/15/13	Prepare for demo and presentation	Collaborative
		Write final report	Collaborative
12	4/22/13	Demo and presentation	Collaborative
13	4/29/13	Final paper and lab notebook due	Collaborative
		Check out	