Communication and Navigation Ability for Cooperative Automatic Guided Vehicle (CO-AGV)

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Abstract. Communication is a very well-known area of research in Cooperative Automatic Guided Vehicle (CO-AGV), especially since techniques for communication are changing rapidly. This study is to investigate communication between Automated Guided Vehicles (AGVs) to complete common task. This idea came from ROBOCON competition 2009 (Theme - Travel Together for the Victory Drums). The concept of navigation is using line and CO-AGV is physically connected. Communication between master and slave AGV during navigation is a concept of controlling this Co-AGV. Several experiments by varying the number of load and robot speed were designed to test the communication and navigation between Kogas-1 (Master) and Kogas-2 (Slave) especially the movement at a curve point.

Introduction

The overall focus point of this study is to investigate communication Cooperative behavior, a subclass of collective behavior that is characterized by cooperation. Cooperative behavior is defined as "Given some task specified by a designer; a multiple-robot system displays cooperative behaviour if; due to some underlying mechanism (i.e.; the "mechanism of cooperation"); there is an increase in the total utility of the system" [1]. Cooperative robotic systems couple computational intelligence to the physical world. These systems consist of multiple homogenous or heterogeneous robots that perceive the environment, make decisions, and carry out commands to affect the environment [2]. Communication and cooperation is important for these systems since their robots work as a collective team to finish common tasks. Cooperative Automated Guided Vehicle System (Co-AGV) as two AGV joint collaborative behaviour that is directed toward some goal in which there is a common interest or reward and a form of interaction, usually based on communication that moves along defined pathways between delivery points or stations. It may be easier and cheaper to design cooperative teams of robots to perform the same tasks than it would be to use a single robot. Then, it is difficult to build teams of heterogeneous robots that can work together to accomplish a mission, where each robot has different architecture performing different task in a collaborative manner. Any of this group of robots needs reliable communication among them, in such way that the robots will be able to accomplish their mission even when no robot failures occur. The multi robot system required some knowledge of capabilities of its team-mates, before the start of the mission. This

communication may take place directly via an explicit communication channel or robots or its environment.

The main objective of this study is:

1. To develop AGV controller for smooth navigation occasion through communication between two AGVs.
2. To analyze the communication ability of between two AGVs through a line following task.

Problem Statement

This cooperation AGV (Co-AGV) is to overcome a single AGV limitation on handle load capacity such as cannot handle heavy load and long size load.Problem statement for this project is how to control the communication between the two AGVs (Kogas 1-Master.& Kogas2-Slave) are connected together physically and navigated through a line. The challenge on this communication is competency of the slave to follow the leader robot in line following task, especially during a movement at curve point.

Literature Review

Communication is a very important area of research in cooperative robotics; especially since techniques methods for communication are changing fast., according to [3]. Bluetooth (over IEEE 802.15.1), ultra-wideband (UWB, over IEEE 802.15.3), ZigBee (over IEEE 802.15.4), and Wi-Fi (over IEEE 802.11) are four protocol standards for short range wireless communications with low power consumption. From an application point of view, Bluetooth is intended for a cordless mouse, keyboard, and hands-free headset, UWB is oriented to high-bandwidth multimedia links, ZigBee is designed for reliable wirelessly networked monitoring and control networks, while Wi-Fi is directed at computer-to-computer connections as an extension or substitution of cabled networks.

Bluetooth, also known as the IEEE 802.15.1 standard is based on a wireless radio system designed for short-range and cheap devices to replace cables for computer peripherals, such as mice, keyboards, joysticks, and printers. This range of applications is known as wireless personal area network (WPAN). Two connectivity topologies are defined in Bluetooth: the piconet and scatternet. A piconet is a WPAN formed by a Bluetooth device serving as a master in the piconet and one or more Bluetooth devices serving as slaves. A frequency-hopping channel based on the address of the master defines each piconet. All devices participating in communications in a given piconet are synchronized using the clock of the master. Slaves communicate only with their master in a point-to-point fashion under the control of the master.

ZigBee over IEEE 802.15.4 defines specifications for lowrate WPAN (LR-WPAN) for supporting simple devices that consume minimal power and typically operate in the personal operating space (POS) of 10m. ZigBee provides self-organized, multi-hop, and reliable mesh networking with long battery lifetime. Two different device types can participate in an LR-WPAN network: a full-function device (FFD) and a reduced-function device (RFD). The FFD can operate in three modes serving as a PAN coordinator, a coordinator, or a device. An FFD can talk to RFDs or other FFDs, while an RFD can talk only to an FFD. An RFD is intended for applications that are extremely simple, such as a light switch or a passive infrared sensor.

Zigbee wireless communication technology has advantages of low cost, low power dissipation, high-capacity networks, safe and reliable data transmission. It could be applied in remote control, measure, data acquisition, etc. Recently, there were few companies like this, but it has already been applied in products of many abroad. With the ceaseless upgrade of Zigbee protocol and the improvement of performance of Zigbee development tool, it is possible to design high-performance Zigbee wireless communication network.

Navigation is important to many applications of automatic guided vehicle (AGV) or mobile robots. The variety of navigation technique from expensive high accuracy tools to cheap low accuracy tools. The complexity the requirement, the more expensive the tools required. A cheap and simple navigation tool would be line following sensor. The line follower robot is a mobile machine that can detect and follow the line drawn on the floor [4]. Generally, the path is predefined and can be either visible like a black line on a white surface with a high contrasted color it can be invisible like a magnetic field. In order to detect these specific markers or lines, various sensing schemes can be employed [5]. These schemes may vary from simple low cost line sensing circuit to expensive vision system. The choice of these schemes would be depend on upon the sensing accuracy and flexibility required.

Methodology

This idea came from ROBOCON competition 2009 (Theme - Travel Together for the victory Drums). The AGVs (Kogas 1 - Master. & Kogas 2 - Slave) are connected together physically and navigated through a line. The challenge on this communication is ability of the slave to follow the leader robot in line following task, especially during a movement at curve point. This cooperation AGV (Co-AGV) is to overcome a single AGV limitation on handle load capacity such as cannot handle heavy load and long size load.

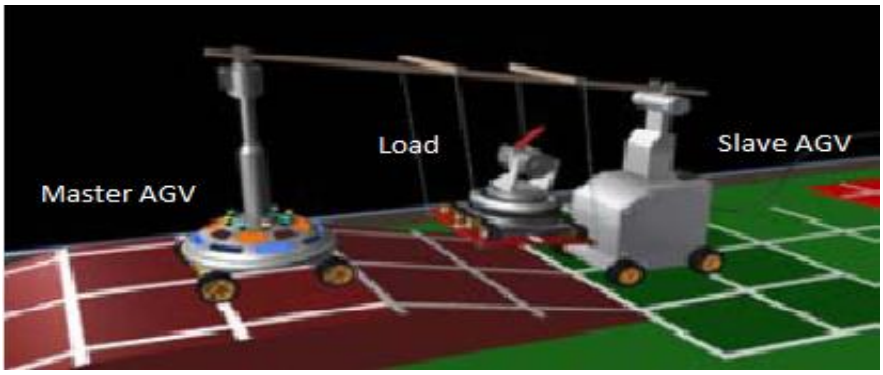

Figure 1: Master and Slave AGV. Source (Robocon rules 2009)

This Co-AGV will be driven by PIC16F877A controller and powered by batteries. It is a four wheels vehicle. The front wheel is used for driving and steering the AGV and the two rear wheels are free. The steering and driving are using VEXTA brushless DC motor. This development consists several blocks as shown in Figure 2.

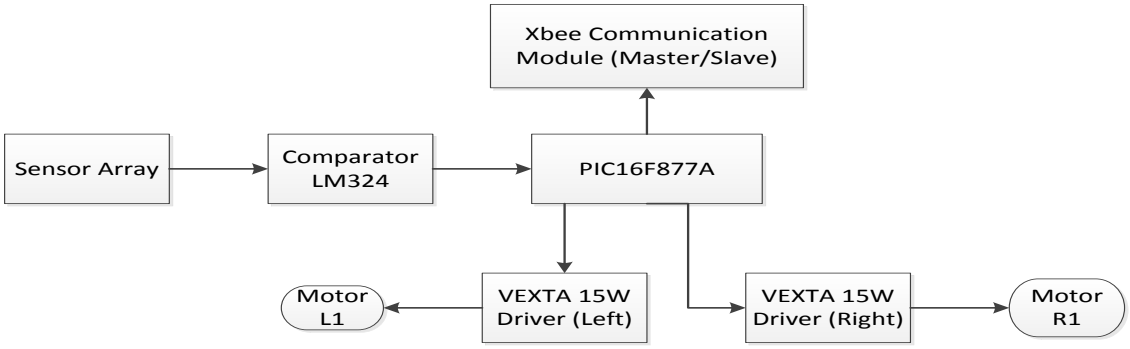

Figure 2: Block Diagram of Development of Controller System

The microcontroller acts like the brain of the Co-AGV. The microcontroller chip that has been selected is PIC16F877A, manufactured by Microchip. This controller is the most famous PIC microcontroller that had been used by many hobbyists and developers due to its high-performance RISC CPU and various peripheral features. There are a few types of packaging for PIC 16F877A, such as 44-Pin QFN, 40-Pin PDIP, 44-Pin PLCC and 44-Pin TQFP. However, 40 pins package (PDIP) is more convenience for hobbyists and students to use due to it compatible pin out. Different PICs have different on-board peripherals, as for the PIC16F877A common peripherals are digital I/O pins, Analog to Digital Converters (ADC) (10bit), serial communications: UART (RS-232), SPI, I2C, Pulse Width Modulation (PWM) (10bit), Timers and counters (8 and 16bit), Watchdog timers and Brown out detect.

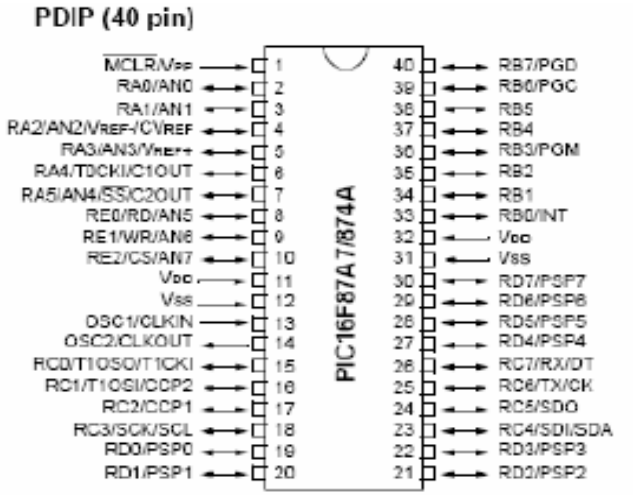

Figure 3: PIC 16F877A Microcontroller

Microchip IDE (Integrated Development Environment) is integrated source code development software. It is a free product of Microchip Inc. and is an effort to make source code development as smooth and comprehensive as possible. It is the best development tool since it is produced by Microchip Inc. Integrated development, means that Microchip IDE is a combination of the source code editor, assembler, linker, simulator, debugger and even programmer all together. The MPLAB IDE is use to write the source code and assemble/compile it into the machine code (hex file) since it is one-stop software for all source code development needs. Besides this, it also

supports third party add-on to extend its compiler capabilities. The PICC Lite is one of the add-on that will be used together. Every microcontroller has own special compiler which can write program with the language C after compiling, the compiled program will be sent to the microcontroller with programmer. A programmer is a device that can be connected with a computer and the microcontroller will be placed on the programmer to send the program into the microcontroller's ROM.

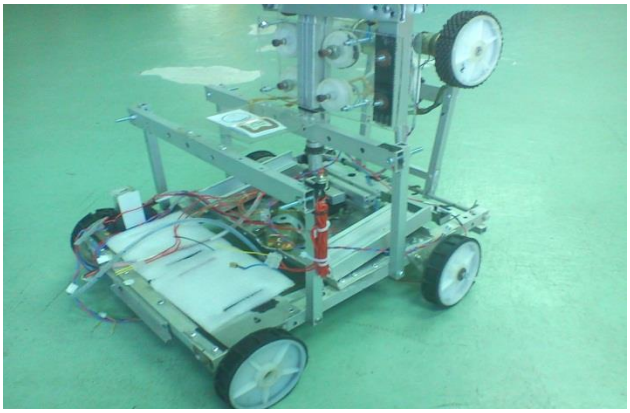

Figure 4: Automatic Guided Vehicle (KOGAS 1)

This robot is used during the competition ROBOCON 2012, all experiment were carried out using this robot. This robot has two wheels with a motor and sensor mounted on it. The selected motor for this robot is the VEXTA 15W DC Motors with motor driver cards. This motor operates at 24V DC. The master controller functions as the main controller which oversees the general function of the robot. By having a master controller instead of a conventional single controller would increase the master controller availability to cater for any robot functionalities.

In this project the sensor will work as an input to microcontroller and the data will be processed before microcontroller send it to the output part which is motor driver that will drive the dc motor. Infra-red sensor (IR sensor) is a sensor that is compatible with the concept of mobile robots. This sensor is used to make sure that the robot will move in its own path by detect the line. If it can receive the reflection ray, it means that the robot is on white and if it cannot receive it, so the robot is on black. These devices work by measuring the amount of light that is reflected into the receiver. IR reflectance sensors contain a matched infrared transmitter and infrared receiver pair as shown in Figure 5.

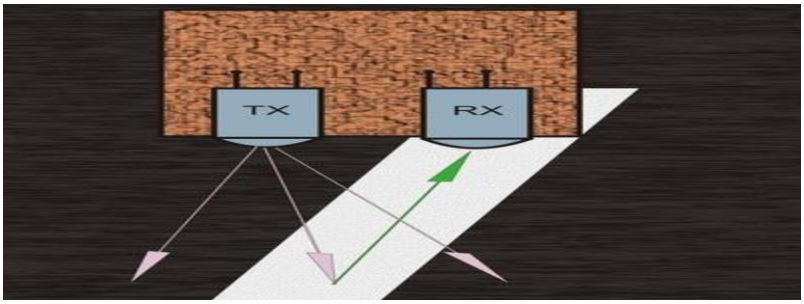

Figure 5: Infrared Reflection (Source : S.F.Mansour, 2011)

ZigBee is the name of a specification for a suite of high level communication protocols using small, low-power digital radio based on the IEEE 802.15.4 standard for wireless personal area networks (WPANs), such as wireless headphones connecting with cell phones via short-range radio. The technology is intended to be simpler and cheaper than other WPANs, such as Bluetooth. ZigBee is targeted at radio-frequency (RF) applications that require a low data rate, long battery life, and secure networking ZigBee is a low-cost, low-power, wireless mesh networking standard. The low cost allows the technology to be widely deployed in wireless control and monitoring applications, the low power-usage allows longer life with smaller batteries, and the mesh networking provides high reliability and larger range

Expected Result

The experiment will seek solution to the scope of the project. A test pitch for experiment referring is shown in figure 6.

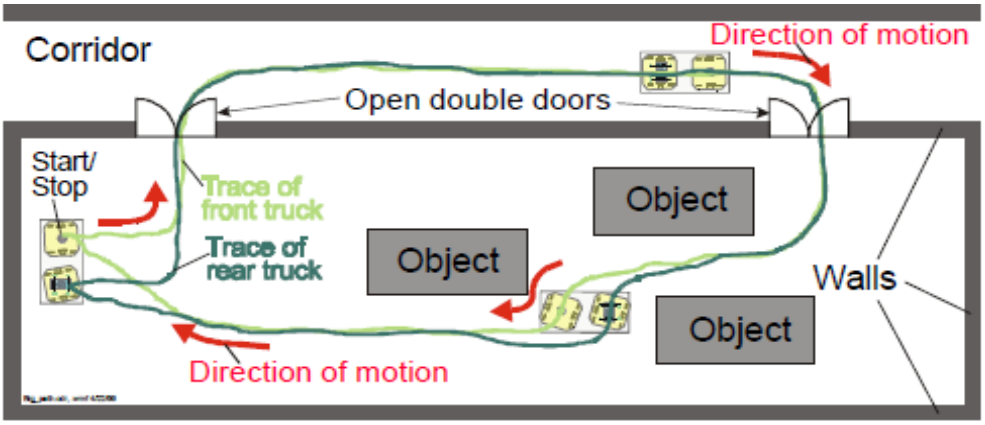

Figure 6: A Test Pitch for Experiment

Discussion

The circuit in Figure 6 will be used to identify the communication between the two robots that are linked together to work. The communication ability between the two Agvs will be determined in terms of competency of the slave to follow the leader robot in line following task, especially during a movement at curve point.

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