บทความวิจัย –วิชาการ

การประชุมวิชาการ งานวิจัย และพัฒนาเชิงประยุกต์ ครั้งที่ 6 การพัฒนาเทคโนโลยีเพื่อให้โลกมีสันติสุข

ECTI-CARD Proceedings 2014, Chiang Mai, Thailand

Implementation of Autonomous parts (Brake, Gear, and Accelerator) of the AU Autonomous Caddy Car

Panuwat Janwattanapong[1], Narong Aphiratsakun[2]

Faculty of Engineering

Assumption University,

Ramkhamheng 24 Road, Huamark, Bangkapi, 10240, Thailand

jarrja@me.com[1], nott_abac@hotmail.com[2]

Abstract

This paper is focused on implementing an automatic system to AU Autonomous Caddy Car (AUAC) by introducing FiO Board controller to each system of AUAC, which includes Gear, Brake, and Accelerator systems. The mechanism designed to actuate each system is integrated with the controller and planted into different location to perform each function. The main objective of this project is to create a fully autonomous caddy car that can be programmed to replace the human interaction with the system. The program is written and compiled by using Simulink/MATLAB.

Keywords : AU Autonomous Caddy Car (AUAC), Autonomous System, FiO Board Controller.

I. INTRODUCTION

The AU Autonomous Caddy Car (AUAC) is a project from Assumption University and was first introduced in August 2011 by a group of senior students. The project was revealed with an automatic parking system, which the caddy car will be able to park into a parallel parking slot. The system uses an Ultrasonic sensor to detect the spot and then calculate the distance between it. The data is sent to a control system and calculate to provide signal to control the actuator located in the steering part. After the data is calculated and ready, the AUAC will automatically perform the parking itself. The system can be considered as only partial autonomous system due to the lack of other autonomous parts such as, brake, gear and accelerator systems. The old system still requires human interaction to the AUAC to successfully perform the task. So the new autonomous parts are introduced to the system to complete the AU Autonomous Caddy Car (AUAC).

The controlling parts of AUAC are similar to the Adaptive Cruise control for an intelligent vehicle by Worrawut [2]. The control system is developed and implemented onto each part of the AIT intelligent vehicle [2].

The concept applied onto AIT intelligence Vehicle by Nassaree [1] is the main purpose and motivation of this paper. The concept of autonomous and intelligent car is adapted and implemented onto the AUAC by using controller to control each system of the AUAC (Gear, Brake, and Accelerator parts).

FiO Board by aimagin [3] has been selected as a main controller for this project due to its performance and compatibility with RapidSTM32 Blockset of Simulink /MATLAB. FiO Board is user-friendly and is widely known and used among students and teachers in universities nowadays. FiO Board is capable of downloading a program compiled by using Simulink/MATLAB.

This paper shows the implementation and integration of both mechanism and control system to the AUAC system. Section II explains the autonomous parts added to the previous system; mechanical hardware and controller using to control the actuator. The programs of each system will be presented in section III. Section IV shows the results of each system controlled autonomously. The paper is concluded in section V.

II. AUTONOMOUS PARTS

The autonomous parts introduced to the system of the AUAC as shown in Fig.1 include Gear, Brake, and Accelerator systems. The selected actuator to this project is RC servo motors.

The RC Servo Motor 9850MG Servo shown in Fig.2 from Towerpro is selected as a main actuator in this project. This motor weights 180 g with the dimension of 67.9 x 30.2 x 56 mm. The operating voltage of this motor is between 4.8 – 6 V and the operating speed for 4.8V is 0.20sec/60degree and 0.16sec/60degree for 6V. It can produce the highest torque up to 25kg/cm by supplying maximum 6V to it.

The FiO Board controller is used as a main controller of each system, which the details of these are discussed briefly in the following sub-sections.

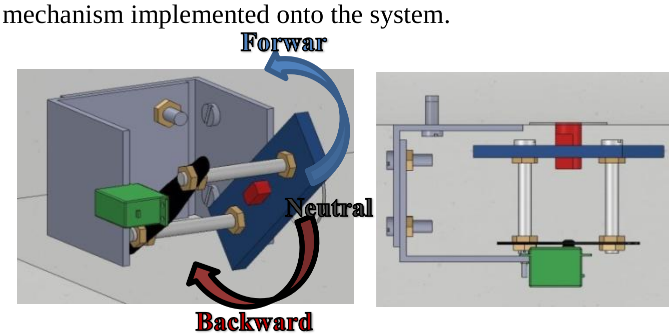
Fig.1: AUAC

Fig.2: 9850MG Servo Motor from Towerpro

A. Gear system: CAD and Mechanical Structure

The mechanical structure of Gear system consists of RC servo motor supported with an aluminum stand planted to the gear location. The shaft of the RC servo is mounted with a plastic hand and attached to the gear shaft to create a higher rotational force. The RC servo acts as an actuator, which receives an order from the controller, and controls the gear into the desire direction. There are 3 positions in the gear system, Neutral, Forward and Backward. These positions are located in different angles [65°, 90°, and 115°].

Fig.3 reviews the top view and the oblique view structure of the gear system implemented on to the shaft. The figure is shown in a CAD design format and Fig.4 shows a real mechanism implemented onto the system.



(a) *(b)*

Fig.3: CAD design of Gear System (a) Oblique view (b) Top view

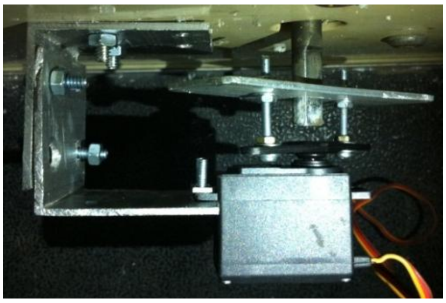


Fig.4: Mechanical part of gear system

B. Brake and Accelerator systems: CAD and Mechanical Structure

The mechanical structure of Brake and Accelerator systems share a common structure. Both of them consist of 2 RC servo motors located on the platform of the AUAC. The system requires 2 RC servo motors to generate enough force to successfully press the brake and accelerating pedal. Both shafts of RC servo motors are connected to 2 aluminum hands with flat surface at the end of the hands as shown in Fig.5 and exert force to push down the pedal in a desire angles. For the accelerating system, the moving speed of the AUAC depends on the angle of the accelerating pedal, which this mechanism is also similar to the brake system.

Fig.6 shows the real RC servo motors and arms mounted onto the accelerating and brake pedal of the AUAC.

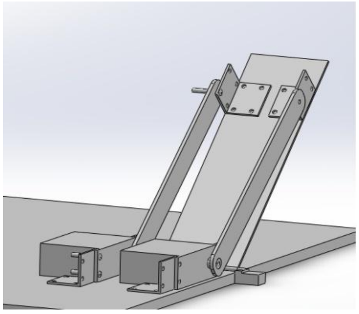


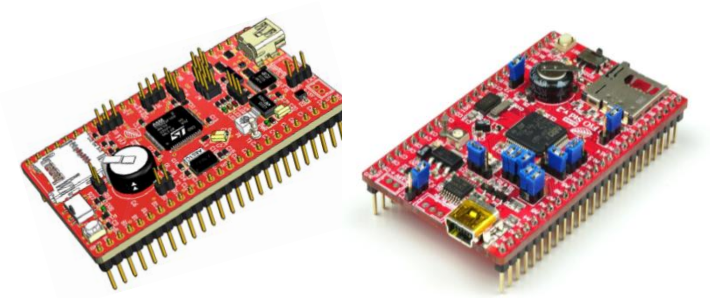
Fig.5: CAD design of Accelerator and brake systems

Fig.6: Mechanical part of accelerating system and brake

C. Controller: FiO Board

FiO Standard Board shown in Fig.7 is an evaluation board from FiO family which is based of STMicroelectronics STM32TM ARM 32 bits Cortex^{TM} – M3 processors.

Coding and programming are generally based on using Simulink/MATLAB program. Programs is written and compile by using embedded MATLAB function and Simulink to generate digital output and PWM to control the RC motor by using RapidSTM32 Block set which is already provided.



(a) *(b)*

Fig.7: (a) CAD design of FiO Board (b) FiO Board Controller

III. CONTROL SYSTEM AND PROGRAM

This section explains the program of each system implemented into AUAC, which includes Gear, Brake, and Accelerator systems.

Each program is written by using Simulink/MATLAB program and then downloaded to the FiO Board to directly control the RC servo motor. The controller generates a specific PWM signal and use to control the angle of rotation of each motor separately

The following sections explain the method and program of each autonomous system of AUAC

A. Gear System: Program Structure

The program of gear system is illustrated in Fig.8. The program is written in blockset. To be able to control the 3 positions of the gear, Neutral, Forward, and Backward, the program receives 2 signal inputs and generates a specific PWM signal and control the desire angle.

The program of gear controlling is briefly explained and summarized as flowchart shown in Fig.9.

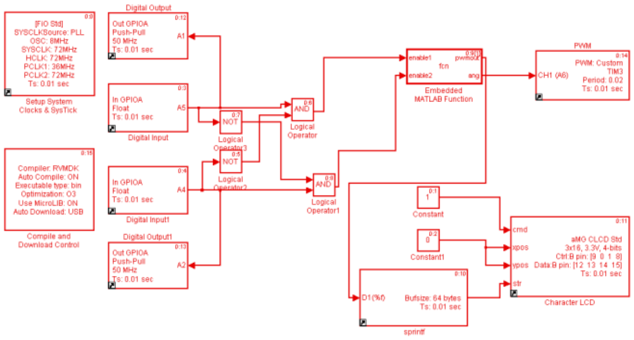


Fig.8: Simulink program of gear system

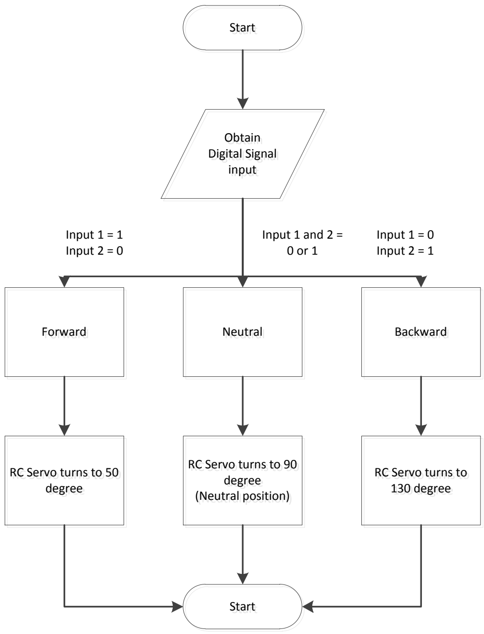


Fig.9: Overview of gear system program

B. Brake and Accelerator Systems: Program Structure

The brake and accelerator systems use the same program to operate. The program uses Simulink/MATLAB to compile similar to the gear system and then transfer the program to the FiO Board controller. The program of these systems is shown in Fig.10. The program receives the analog signal input and converts them to digital input for calculation and generates PWM signal to control the angle position. The angle position of the RC servo motors is determined by the analog signal compared to the thresholds in the program.

The program of brake and accelerator systems is similar and briefly explained and summarized as flowchart shown in Fig.11.

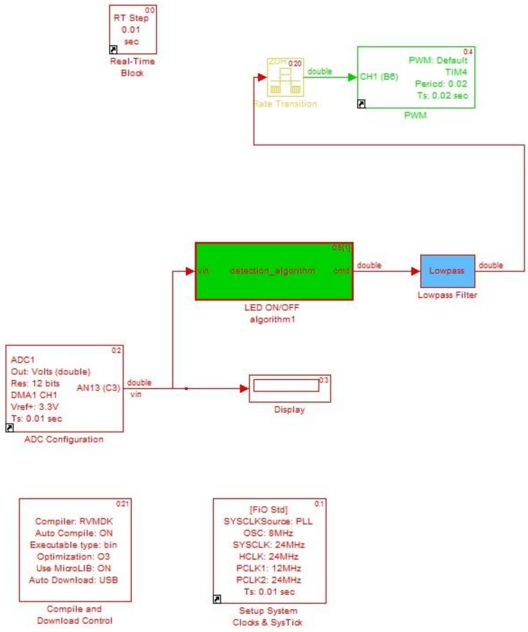


Fig.10: Simulink program of brake and accelerator systems

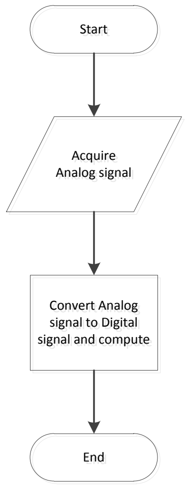


Fig.11: Overview of brake and accelerator systems program

IV. EXPERIMENTAL RESULT

The experiment and result is recorded while the AUAC was performing out at Basketball Court of Assumption University. The results of each system are promising and indicate that we are in the correct direction. The results of AUAC system are subdivided into following sections

A. Gear system: Result

The AUAC gear system contains 3 positions, Neutral, Forward and Backward. The AUAC started out in the Neutral position, which is selected by the default output of the program. When the forward signal is received, the RC servo motor successfully rotates the shaft of the gear to the forward position with precision and accuracy. As well as when the backward position is selected, the RC servo motor rotates to the given direction without error.

B. Brake system: Result

The AUAC brake system is tested when the AUAC is moving in a forward direction. When the controller receives the analog input, the RC servo motors rotate and press the brake pedal with an angle according to the input resulting in the AUAC stop moving. Also the brake system is tested when the AUAC is moving in a backward direction, which gives the exact motion of the previous test.

C. Accelerator system: Result

The AUAC Accelerating system is tested when the AUAC is stationary. When the controller receives the analog input, the RC servo motors rotate and press the gas pedal with an angle according to the input resulting in the AUAC starts moving forward. The speed of the AUAC is adjustable, which is adjusted by the input signal. The variation of speed is also tested and gives out the promising result.

D. Discussion

The whole system performs accurately and gives out a promising result. The only problem in is that, the torque generated from the RC servo in the Brake and Accelerator systems is not enough to push down the pedal to the desire angle, so the second RC servo is introduced to both of the systems to solve this problem. The FiO Board Controller performs efficiently to control each part of the AUAC and the programming code in MATLAB is simple and straightforward to understand and comprehend.

V. CONCLUSION

This paper describes the autonomous parts of the AUAC in detail of both mechanical and program design. This paper focuses on the autonomous parts added from the previous AUAC automatic parking system to fully complete the autonomous control of the AUAC system.

The AUAC system is introduced with the autonomous gear, brake and accelerator systems, which uses RC servo motors as the main actuator controlled by PWM signal generated from the main controller of this project, which is FiO Board. Each system is designed and modified to perform a specific purpose. The gear system uses RC servo motor to rotate the shaft of the gear to a different position, Neutral, Forward, and Backward. And for the brake and accelerator systems, use RC servo motors mounted with an aluminum arm to press down the pedal. The results of 3 systems are considered to be successful.

Integrating every autonomous parts existing in the AUAC system to perform autonomous parking system is a future work of this research.

ACKNOWLEDGMENT

This project is financially supported by Assumption University (ABAC), Thailand and is partially financially supported by AIMAGIN Co., LTD. We acknowledge the assistant and consultant from Asst. Prof. Dr. Kittiphan Techakittiroj. The authors acknowledge the help to render of Ms. Neeranut Ratchatanantakit, Mr. Padipat Pluemworasawat, and Mr. Supanut Vathunupracha.

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