University of Canterbury Department of Electrical and Computer Engineering

Autonomous Go-Kart Specification Report

Final Year Project

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ABSTRACT

This project outlines the specifications and progress for the continuation in development of an Autonomous Go-Kart. The main goal of the project this year is to integrate the developed CANBus system onto the go-kart platform and obtain basic autonomous movements. A computer vision tracking component will also be added. Thus progress has been on familiarization with prior work and preparing the CANBus and actuator system for integration onto the kart platform.

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PROJECT OVERVIEW

The goal of this project is to integrate an existing CANBus drive-by-wire system onto an electrically powered go-kart, providing basic autonomous movement. This then allows the detailed development of autonomous movement and computer vision systems on an existing platform in future years.

Autonomous control is a modern technology becoming ever more popular in the engineering world. Autonomous control of ground vehicles in particular is rapidly developing with the push towards driverless motor vehicles for both passengers and goods. Driverless control or even computer aided driver assistance has the potential to be greatly advantageous in terms of public safety, reduced fuel costs, reduced emissions, reduced time costs and more efficient transportation in general. Significant developments are yet to be made in the autonomous vehicle technology itself as well as the infrastructure and policies required for the public integration of driverless cars. Events such as the DARPA Urban Challenge provide developers a chance to test their vehicles in mock situations. The motivation for this project comes from this global push towards autonomous navigation and movement. As inexpensive autonomous vehicles would be highly advantageous, this project focuses on a smaller, less complex scale, incorporating a go-kart platform.

PROJECT HISTORY

The project was first started in 2011, with the intention of transforming one of the University of Canterbury Electrical and Computer Engineering Department's go-karts into an autonomous vehicle. A team of four undertook the project and found it to be more work that appropriate for one final year project. The team therefore limited their work to choosing the steering and brake actuators and designing seven PCBs.

Five of the PCBs were for the CANBus control of the brake, steering, motor and sensor modules through a communications module connected to a laptop. These PCBs were all given the same layout to ease both development and manufacturing, however each board was only populated with components required for its individual function. All boards use AT91SAM7XC processors. There were several mistakes made in the designs however work-arounds were successfully implemented. Two motor driver PCBs were also designed for driving the steering and brake actuators. These were found to be inadequate and replaced the following year. The go-kart chassis was also modified by this team for the integration of the CANBus system with the required actuator attachments. The brake actuator bracket had been misplaced and needed to be redesigned and manufactured this year.

The 2011 team also looked into safety systems, software development practices and computer vision target tracking for the go-kart. Software development identified the use of unit tests and continuous integration; however the implementation of these methods in the project appeared minimal at most.

In 2012 work on the project was continued by a single person, similar to this year. The software side of the project developed in 2011 was deemed unsatisfactory for progression of the project and developing a new high-level software control API for the go-kart became the primary objective for that year. A bottom-up approach was implemented to accomplish the required control levels: peripheral control on each board; inter-board CANBus communication; laptop control via USB. All these levels of control were achieved thoroughly in most cases; however the system was only tested on bench-top and not tested on or calibrated for the go-kart platform.

The main remaining issues of 2012 work, other than lack go-kart testing, were the inadequate number of unit tests, need for new board connectors and testing of motor module communication with the Student Board. The Student Board is an intermediate PCB between the motor control module of the CANBus system and the motor drivers on the cart. The SPI commands send from the motor module to the Student Board were never verified to give correct PWM signals to the go-kart motor drivers.

SPECIFICATIONS

For a successful outcome from this project, basic autonomous motion control of the go-kart must be established. Navigation will be included in the form of target tracking through computer vision. To achieve this, the existing drive-by-wire CANBus control system must be successfully integrated and calibrated for the go-kart platform. These requirements and be roughly divided into three main categories: CANBus integration to achieve drive-by-wire control; programmable motion control; camera integration for target tracking navigation. It should be noted that the go-kart platform in its current state is incapable of reversing due to its motor drive configuration. This will not be changed under this project; however if the motor driver and/or Student Board are improved outside of this project an effort will be made to maintain compatibility.

CANBUS INTEGRATION

- Fit five CANBus modules, brake and steering actuators to go-kart
- Calibrate brake actuator position – identify brake application/withdrawal position sequences and update respective commands
- Calibrate steering servo – system should locate steering bounds and centre values at start-up with limit switches
- Motor module should communicate with Student Board to produce PWM waveforms with given duty cycle at the frequency accepted by the motor driver (2.5kHz)
- High level API commands (from Laptop) to be tested and corrected if needed:
    - Steering should be adjustable to within one degree within calibrated bounds and returned to centre steer and any point
    - Forward motion and brake can be enabled/disabled independently
    - Sensor module detects rear axle gear revolutions – this should be calibrated and converted to rpm
    - Speed can be set and checked – actual speed of and therefore accuracy of the speed measurement will be affected by wheel slip.
- Emergency stop button present on the go-kart to cut power supply to the system and shut down the motor
- Go-kart should be controllable by issuing successive commands from an on-board laptop

PROGRAMMABLE MOTION CONTROL

- System should go through initialisation, necessary calibration and testing routines on power-up
- Go-kart should be able to follow a control algorithm including forward motion, maintained speed, braking, stopping and turning.
- Speed should able to be maintained at $1ms^{-1}$

CAMERA INTEGRATION

- Fit camera to go-kart and extract checkerboard target position data from externally developed computer vision algorithm
- Integrate position data from vision algorithm with Python API commands
- Steering should adjust to ensure go-kart follows target – attempting to keep it in its direct path
- Speed and braking should be adjustable to maintain a set distance from the checkerboard target.
- Ultimately the go-kart should follow the checkerboard around maintaining a set following distance.

PROGRESS TO DATE

As this project is a continuation from development done over two previous years, researching and becoming familiar with previous work was a major component of the first two months.

The progress thus far has primarily been around becoming familiar with the project, including the work done in previous years. An assessment of the current state of the project was only able to be made after understanding what work had already been done.

- Installed Linux and necessary arm-none-eabi toolchain on laptop – had to find new guide as references provided from last year were now invalid.
- Examined go-kart to determined how the system fits together and any work needed
- Designed new brake bracket and got this manufactured.
- Setup CANBus system on bench and ran test progams written last year
- Tested current CANBus system from bench supply
- Located repaired Student Board and known information about it

PROJECT BUDGET AND TIMELINE

EXPECTED TIMELINE

Figure 1 shows the progression of the project thus far as well as the expected order of progression and duration of sections yet to be completed as at 6th May 2013.

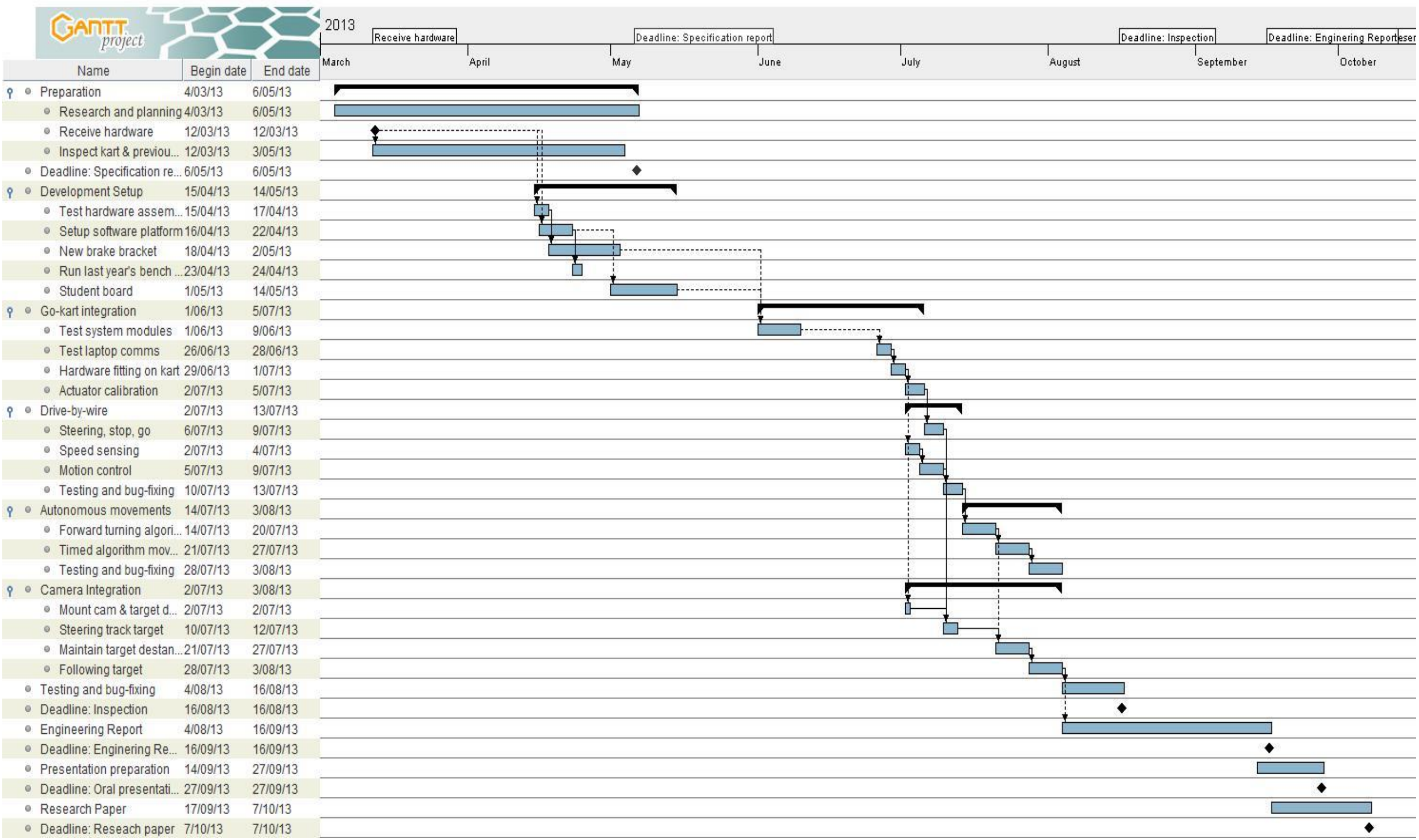

FIGURE 1: PROJECT TIMELINE GANTT CHART

BUDGET SUMMARY

As the majority of hardware has already been purchased and developed in previous years,

no major purchases should be required this year. The brake actuator bracket made in 2011 was lost in 2012, needing to be redesigned and manufactured in the ECE Department workhshop. Small cost items such as wires, ethernet cables and connectors will be used this year and should be available from ECE stock as well.

Item	**Cost**	**State**
Brake bracket	$25 (material) + 3hrs labour	Manufactured
Small electrical components	$80	Obtain from ECE stock as required
Webcam	$60	Received

SUSTAINABILITY ANALYSIS

The go kart in this case can be considered as a prototype on which other machinery might be modelled on. The go-kart is electrically powered and autonomous or laptop controlled. In terms of sustainability, the go-kart and possible future developments based on it are assed in terms of economic, social and environmental factors.

ECONOMIC

• Electrically powered vehicles do not depend on oil products to power the vehicle.
• Electric vehicles are expensive to buy but cheap to maintain, with the ever-increasing petrol prices, it eliminates the expense for individual consumers.
• Increased energy efficiency. They are able to convert 59- 62% of the energy to power the wheels, however traditional vehicles only convert 17-21% energy to power the wheels. (United States Department of Energy, 2013).
•Autonomous vehicles will save time, therefore money.

SOCIAL

• Benefits of future autonomous navigation maybe home/farm assistance vehicles therefore more time for people
• Saving money on running a vehicle can reduce financial stress on individuals and will enables people to use that money for other purposes.

ENVIRONMENTAL

• Electrical vehicles do not emit tailpipe pollutants thus increasing urban air quality (United States Department of Energy, 2013). .
• Electricity sourced from hydro, solar or wind powered plants will not emit pollutants into the air (United States Department of Energy, 2013).
• Overall, electric vehicles have less carbon emission than any other vehicle (New York City Government, 2013).
• No pounding pistons thus reducing the noise made by the vehicles.
• Electric vehicles utilise the energy in the batteries more efficient such that it releases less heat (New York City Government, 2013).

FUTURE IMPACTS

• Autonomous vehicles can be developed to transport disabled individuals that are unable to drive themselves.
• Exterior vehicle control will enable the use of heavy machinery in situations that would be too dangerous to have a driver in the vehicle e.g. autonomous control of army tanks/trucks and construction equipment.

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