

An open source self-driving podcar platform for automation research

Chris Waltham[†], F. Camara^{*†}, C. W. Fox^{*†}

^{*}Institute for Transport Studies, University of Leeds, UK

[†] School of Computer Science, University of Lincoln, UK

Abstract—Open source autonomous vehicle full stack software is now available (cite AUTOWARE) but there is a need for a corresponding open-source hardware platform to enable researchers to build standard setups and share research. This paper’s aim is to show a process of modifying an electric pod car into a fully open-source hardware and open-source software self-driving system.

Index Terms—Autonomous Vehicles, Pedestrian - Vehicle Interaction [3 maximum]

I. REQUIREMENTS

Specific requirements for such a platform are that it needs to be as low cost as possible, and easy to build. This is to enable the community to reproduce and use it. Consumer levels of safety and reliability are not required, preferring to minimise cost, through research standards of safety and reliability are required.

II. DONOR VEHICLE

A PIHSIANG TE-889XLSN hard-canopy scooter (branded in UK as Shoprider Traverso) is used as the pod car platform. It is an electric car powered by two 12V batteries connected in series to provide 24V operating voltage and containing 75Ah. Its steering is controlled by human operated loop handle bar. Speeding and braking system are both powered by an electric motor and an electric brake via the trans-axle assembly, controlled by AC2 digital controller receiving different voltage signals to drive forward or brake. The manual speeding and braking systems were controlled by three buttons connected in series on the handle bar: A toggle switch in parallel with a resistor (10k) to choose speed mode high or low; A speed dial knob via a variable resistor (20k) to choose a maximum speed value; A throttle lever connected with a potentiometer (5k), 2.5k to 2.6k for each side to speed or brake.

III. MECHANICAL MODIFICATION

A. Steering

To automate steering, a GLA750-P 12V DC linear actuator with position feedback is mounted under the chassis to car’s front axle via bearings. This actuator has a 8mm/s full load (750N) speed and 250mm stroke length (installation length is 390mm).

This project has received funding from EU H2020 interACT: Designing cooperative interaction of automated vehicles with other road users in mixed traffic environments under grant agreement No 723395. Thanks to Yao Chen for making figures X and Y, and Gabriel Walton for scoping simulation tools.

To access the underside of the vehicle, use two axle stands TODO photo.

There is an existing hole in the right front wheel axle. Mount the linear actuator via rear hole to the left side of front chassis and connect it through the front hole of the actuator with the hole in the car’s right front wheel axle via bearings as shown in Fig. 1.

B. Sensors

1) *Lidar*: Velodyne16 lidar sensor. Mounted on the vehicle roof using a small optical tripod (TODO give model). Note that optical devices have unusual physical mounting standards which use Imperial rather than metrics units. This system is used by optics research based on optical table sizing. The lidar screws onto the tripod. The tripod is cabled-tied to the vehicle roof via drilled holes at locations in fig. TODO. It is mounted at a 10 degree tilt downwards (to allow pedestrians to be most clearly seen in the 16 scan lines).

2) *Odometry*: TODO – we need some hall effect or other shaft encoders to measure odometry.

IV. ELECTRONIC MODIFICATION

A. Steering

The front wheels are steered by a Pololu (TODO give model number) PID controller, which takes serial port desired positions as input. It also takes feedback position information as an analog voltage from the linear actuator as an input. It outputs analog high-power voltages to the linear actuator.

TODO give PID settings. Windows app is needed to set them once only.

The relationship between the required central turning angle θ of the pair of front wheels and extending length l of linear actuator is,

$$\theta = \alpha - \arctan\left(\frac{W}{2H}\right) \quad (1)$$

$$\beta = \alpha - \frac{\pi}{2} \quad (2)$$

$$x = r_1 * \cos(\beta) \quad (3)$$

$$y = r_1 * \sin(\beta) \quad (4)$$

$$l = \sqrt{(x_0 - x)^2 + (y_0 - y)^2} - L + l_0 \quad (5)$$

Where r_1 , x_0 , y_0 , W , H and L are the geometric coefficients shown in Fig.1. Among them, the value of y_0 is negative. l_0 is the initial value of the linear actuator position feedback.

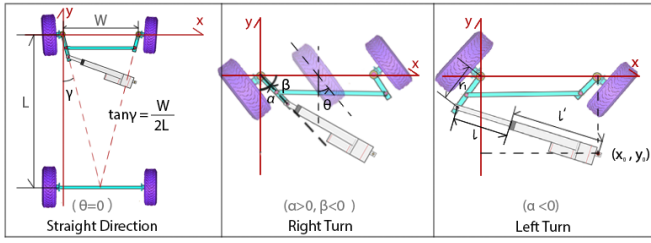


Fig. 1: The bottom view of front wheels steering relationship including geometric coefficients

Test commands can be passed to the Pololu using the commands in /tools/cmdSteer ****DO NOT GIVE COMMANDS OUTSIDE RANGE 1000-25000 AS THEY HAVE DAMAGED THE VEHICLE****. TODO – WRITE SAFETY WRAPPER FOR THIS.

A non-ROS test of the C API for the Pololu is in /tools/pololuTestCSerial.

B. Speed

1) *Dead mans handle*: Deadmans handle to ignition. Replace key with relay (TODO model) and dead-mans-handle button switch (TODO model) on a 10m, 2-core cable. TODO: are any other console functions changed?

TODO edited version of wiring from shoprider manual. And photo of the real wires.

2) *Speed control*: Arduino UNO is used to send electric signals to vehicle's motor controller instead of using speed buttons. TODO DAC model and wiring. TODO arduino wiring.

Arduino code is supplied in the distribution (/Arduino/ThrottleControlSerial.ino). When uploaded to the Arduino (using the standard Arduino IDE running on the laptop), it provides a simple serial port API running at 112000baud (TODO other erial options.) It receives commands of the form FA:210 as speed commands. The test scripts /tools/zeroSpeed.py and /tools/testSpeed.py can be used to send example commands for debugging.

The ranges of voltage in different speed mode were measured shown in Table 1. Thus, the range of electric signal provided by Arduino UNO is 2.54V-3.59V for forward speed from 0mph to 4mph, and 1.03V-0V for back speed with a negative correlation. It was also found 1.74V was the stop voltage for vehicle to work when starting, corresponding the speed throttle lever in the neutral position. Otherwise a bleep error would come out for safety reason and fail to start the car.

Speed mode		Forward	Back
Low	min	2.54	1.03
	max	3.08	0.50
High	min	2.69	0.89
	max	3.59	0

- insert Figure 2 about the wiring diagram of speed buttons and micro-controller.

- talk about safety (dead-man button). And speed code part with details.

V. ROS INTERFACE

TODO fig showing low level nodes

VI. SIMULATION

TODO gazebo physics numbers

VII. ROS CONTROL AND PLANNING STACK

TODO ackerman_msgsmove_{base}implementation

VIII. LOCALISATION AND MAPPING SYSTEM

TODO

IX. USER GUIDE

A. Power up

Check that the vehicles original lever for auto-manual is set to auto (DOWN). It is on the main motor, under the vehicle at the rear left, colored red. Requires some force to move it.

Power on the vehicle using the original on-off switch located under the seat on the left. It is marked ON-OFF.

Power on the modified electronics using the new toggle switch. (This lights LEDs on the DCDCs and Pololu, and the lidar makes a whirring sound).

Check that the batteries are charged (use a multimeter across one of the DCDC converters, need to see 24V or over. DO NOT USE THE VEHICLE IF IT IS UNDERCHARGED, THIS IS DANGEROUS.

Power on the laptop using the slider switch on its front right. Login as user podcar, password TODO.

Type: roscd podcar

Type: roslaunch podcar podcar.launch

Use the joystick to control steering and speed.

B. Usage

X. TROUBLESHOOTING GUIDE

A. *vehicle beeps continuous when press DMH and rear wheels do not move*

This is due to a safety mode preventing ignition.

Check: is the manual-auto switch under the rear motor on auto?

Check: is the 4 voltage is the dead zone, it should be

XI. RELATED WORK

About 20 references or more if you can (at least one page) about similar work, SLAM, vehicle control and simulation, open source projects.... Cite this project from UC berkeley: <http://www.barc-project.com/>

XII. DISCUSSION

We hope that the platform will be useful...