

Autonomous Car Driving using Neural Networks

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Abstract

The goal of this paper is to shape an utilitarian programming engineering for surely self-enough motors. Existing writing adopts a spellbinding method and famous beyond investigations with self-ruling riding or utilization specific to restricted regions (for instance winning a venture). The compositional preparations are regularly an after-math of building or advancing a self-sufficient vehicle and not the aftereffect of an unmistakable programming development lifecycle. A extraordinary hassle of this methodology is that requirements cannot be discovered as for utilitarian segments and a few components bunch most usefulness. Along the ones lines, it's far often tough to acquire the recommendations. In this paper we adopt a prescriptive approach starting with prerequisites from a automobile latest. We employ a NIST reference engineering for constant, smart, frameworks and settled compositional examples to help the plan requirements. We similarly take a look at the effects concerning the car programming improvement life cycle and consistence with vehicle safety ideas. In conclusion, we comparison our paintings and special proposition.

Keywords; *Intelligent vehicles, Autonomous vehicles, Software architecture.*

I. INTRODUCTION

"We are living in the time has many cars, many cars that's mean collision between them and sometimes leading to die of drivers so think to expert to find the idea and they found (car without driver) it is working according to the data that we will enter it. Autonomous driving systems have been actively researched. Several works have shown the possibility of autonomous driving in real life [1]. Google has been testing its autonomous vehicle in actual traffic conditions. In August 2012, Google announced that they have completed over 500,000 km autonomous driving without any accident [2]. Another research group in Italy, the VisLab in Parma University, did 13,000 km test run for autonomous vehicles from Italy to China [4].environment by camera sensors and fusion with other sensors. The VisLab also tested the autonomous vehicle in a real environment, together with real traffic on July 2013. In May 2014, Google presented a new concept for their driverless car that had neither a steering wheel nor pedals [5], and

unveiled a fully functioning prototype in December 2014 that they planned to test on San Francisco Bay Area roads beginning in 2015. Google plans to make these cars available to the public in 2020 [6]. The Computer Vision Center (CVC) is automat zing an electric car within the context of the project Automated and Cooperative Driving in the City. 2. System Architecture of the Autonomous Vehicle Figure 1 below shows the architecture of the project. In this paper, we focus on the design and implementation of such a vehicle low- level controller. This paper is focused on the low frame of the automatic control of the speed and the steering angle of the car following a predefined path with the best performances of stability and precision. Aware that a good automatic car control is the basis for achieving the other challenges of the autonomous driving systems. We propose two strategies of non-linear automatic low level control, based on the method of Lyapunov [12] and based on sliding mode, and a comparison of both has been made in a simple simulator (based on Simulink). Currently, it

is being tested in a complex simulator developed in unity 3D2 (see Figure 3)."

II. SYSTEM ARCHITECTURE OF THE AUTONOMOUS VEHICLE.

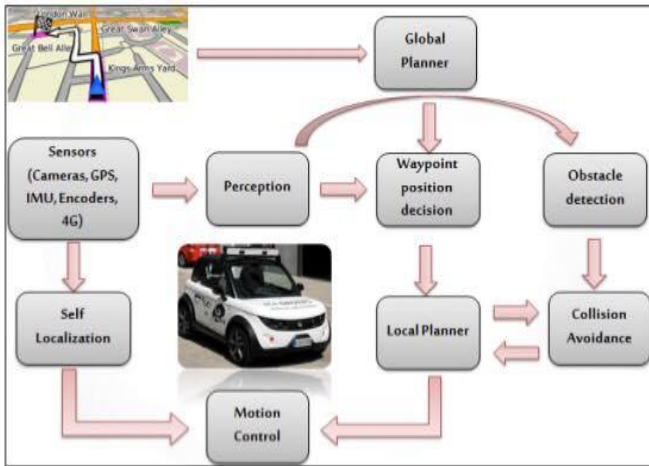


Fig. 1. System Architecture of the Autonomous Vehicle

III. MODEL OF CONTROL ORIENTED VEHICLE

For manipulate plan, the self-governing automobile has been considered as a motorbike like car ([7], [11]) situated at a nonzero separation concerning a dynamic waypoint (digital vehicle of reference), whose motion is restricted via the consolidated pastime of both the rakish speed $w_r(t)$ and the direct velocity $v_r(t)$ of the genuine vehicle (Figures 2 and three). This version anticipate that the automobile is symmetric, the directing point is the equivalent in each the front wheels, the roll and pitch development are disregarded, the instantly development in z hub is moreover omitted and edges like guiding and yaw are concept to be little. At that point, the association of kinematic situations of the cartesian position $(x_r; y_r)$ and direction (θ_r) of the real car is brought as follows:

$$\begin{aligned}
 X_r &= v_r \sin(\theta_r) \\
 Y_r &= v_r \cos(\theta_r) \dots\dots\dots(1) \\
 \theta_r &= v_r / I \tan(\phi_r)
 \end{aligned}$$

where v_r and ϕ_r represent the linear velocity and the steering angle respectively. Consequently, from Fig. 3, the kinematic equations for the virtual car can be defined as:

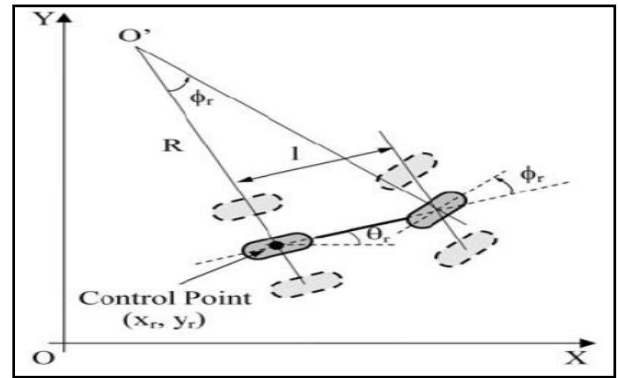


FIG. 2. BICYCLE MODEL

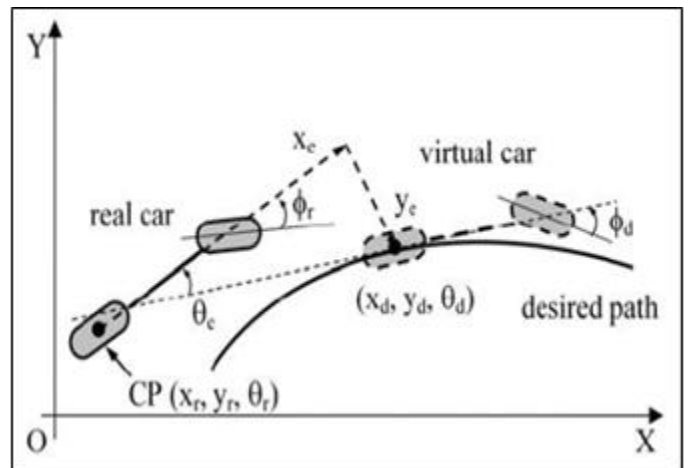


FIG. 3. VEHICLE'S POSITION AND ORIENTATION WITH RESPECT TO THE DYNAMIC TARGET FRAME (VIRTUAL CAR).

$$\begin{aligned}
 X_d &= v_d \sin(\theta_d) \\
 Y_d &= v_d \cos(\theta_d) \dots\dots\dots(2) \\
 \theta_d &= v_d / I \tan(\phi_d)
 \end{aligned}$$

"where x_d , y_d and ϕ_d are the position and orientation of the next way point generated by the trajectory planner. The error model (3) is defined as the difference between real vehicle position and the desired one multiplied by the rotation matrix over z axis which is the orthogonal to the road plane: That

after some algebraic manipulations lead to the following expression:"

$$x_e = v_r \cos(\theta_e) + y_e v_d / I \tan(\delta_d) - v_d \dots\dots(3)$$

$$y_e = v_r \sin(\theta_e) - x_e v_d / I \tan(\delta_d) \dots\dots\dots(4)$$

$$\theta_e = v_r / I \tan(\delta_r) - v_d / I \tan(\delta_d)$$

that can be expressed as follows taking into account the real and

reference vehicle models (1) - (2):

$$\dot{x}_e = v_r + w_r y_e - v_r \cos(\theta_e)$$

$$\dot{y}_e = -w_r x_e + v_d \cos(\theta_e) \dots\dots\dots(5)$$

$$\dot{\theta}_e = w_r - w_d$$

Where : $\theta_e = w_r - w_d$

IV. DESCRIPTION OF AUTOMATIC CONTROL STRATEGIES.

The Unbiased vehicle manipulate goal of way following via way directs contains inside the path of reach asymptotically to 0 the contrast most of the dynamic position and course of the real car regard to the dynamic way focuses (digital car) function and course.

In this paper, nonlinear programmed control tactics for self-sufficient automobiles for manner following and course direct method for Lyapunov [12] and the alternative dependent on sliding mode manage (SMC) [10]. The processes will endure in mind as beginning degree the mistake model had been given from the auto control-placed model introduced in beyond vicinity.

On one hand, the possibility of nonlinear manipulate depending on the direct Lyapunov technique is to signify a control law making certain the power and the asymptotic stop of the accompanying mistake. Then another time, the important notion of SMC is to reach at a sliding floor in limited time and live in this. In any case, this manage approach has a downside: the babbling, as an instance a course wavering over the sliding floor. There are

some distinctive approaches of coping with this trouble e.G., utilizing a higher request sliding surface or smoother works rather than the essential sign capability.

A. DIRECT LYAPUNOV APPROACH.

We are going to form a manipulate relying at the direct Lyapunov approach. This method sureties the asymptotic dependability of the vehicle manage given that:

$$\lim_{t \rightarrow \infty} \begin{bmatrix} X_e \\ Y_e \\ \theta_e \end{bmatrix} = 0 \dots\dots\dots(6)$$

which involves also:

$$\lim_{t \rightarrow \infty} \begin{bmatrix} \dot{x}_r - \dot{x}_d \\ \dot{y}_r - \dot{y}_d \\ \dot{\theta}_r - \dot{\theta}_d \end{bmatrix} = 0 \dots\dots\dots(7)$$

As control law we propose to use the non linear law from[12]:

$$\begin{bmatrix} V_r \\ W \end{bmatrix} = \begin{bmatrix} v_d \cos \theta_e - k_1 x_e \\ w_d - k_2 v_d \sin \theta_e \theta_e y_e - y_e \theta_e \end{bmatrix} \dots\dots(8)$$

Given the following Lyapunov function:

$$V = 1/2 X_e + 1/2 Y_e + 1/2 \theta_e \dots\dots\dots(9)$$

the steadiness condition is accomplished when $\dot{V} \leq 0$. In this manner, considering the blunder model (5), the proposed control law (8) and subbing in the subordinate of (9) and after certain improvements we acquire the accompanying articulation:

$$\dot{V} = -k_1 k_2 x_e - k_3 \theta_e \leq 0 \dots\dots\dots(10)$$

which implies that the control parameters k_1, k_2 and k_3 should be positive to assure the asymptotic stability of the closed-loop.

A. SLIDING MODE CONTROL.

The primary thought behind this methodology is to arrive at the sliding surface in a limited time and stay on such surfaces where the mistake is invalid.

From the numerical perspective a sliding surface is an articulation made by states out of the framework to be limited:

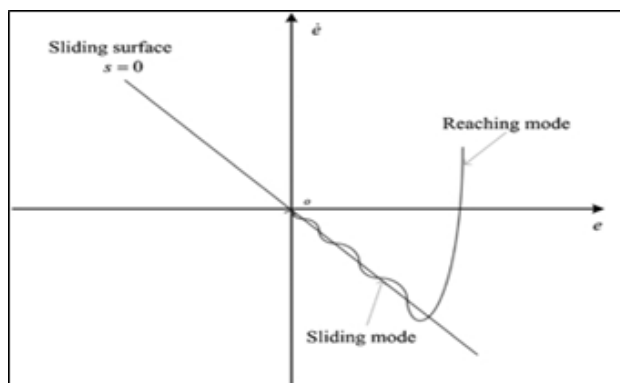


FIG. 4. SLIDING MODE BEHAVIOR

"Fig. 6 shows the basic principle of the method and it can be seen how the trajectory reaches the surface s and remains there. However, the trajectory presents some oscillations around the surface. This is known as the chattering phenomena. This drawback can be reduced by using a higher order sliding surfaces or using smooth functions instead of the common used sign function. In this paper, a stable SMC has been designed which has as inputs the errors (3), desired linear velocity (v_d), desired angular velocity (ω_d), desired linear acceleration (\dot{v}_d) and desired angular acceleration ($\dot{\omega}_d$), and as outputs the velocity (v_r) and the steering angle (θ_r). In order to implement it, a set of sliding surfaces are chosen. There is a surface s_i per control action. Given that there are three error variables (x_e , y_e and θ_e) and only two surfaces, one sliding surface have to contain two of such error variables. It has been decided to couple y_e and θ_e in the same sliding equation, therefore the resulting surfaces are the following:"

$$s_1 = \dot{x}_e + k_1 x_e \dots\dots\dots(11)$$

$$s_2 = \dot{y}_e + k_2 y_e + k_3 \theta_e \dots\dots\dots(12)$$

where k_1 , k_2 and k_3 are positive defined parameters. According to [9], the dynamics of the sliding surface is the following, which is called the reaching law:

$$\dot{s}_i = -Q_i s_i - P_i \text{sign}(s_i) \dots\dots\dots(13)$$

where Q and P are positive defined parameters and its stability can be proven using Lyapunov theorem [10]. A Lyapunov candidate function and its time derivative is defined as follows:

$$V = 1/2 s' s \dots\dots\dots(14)$$

Evaluating its derivative:

$$\dot{V} = s' \dot{s} \dots\dots\dots(15)$$

and considering the control law (13), it can be expressed as:

$$\dot{V} = s_1(-Q_1 s_1 - P_1 \text{sgn}(s_1)) + s_2(-Q_2 s_2 - P_2 \text{sgn}(s_2)) \dots\dots\dots(16)$$

We are developing them, the following control laws are obtained:

$$v_c = -v_r \theta_e \sin(\theta_e) - y_e \omega_d - \dot{y}_e \omega_d + v_d - k_1 x_e - Q_1 s_1 - P_1 \text{sgn}(s_1) / \cos(\theta_e) \dots\dots\dots(17)$$

We will take integration for the equation:

$$v_c = \dots\dots\dots(18)$$

$$\theta_c = \frac{\omega_d + \dots - P_2 s_2 - Q_2 \text{sign}(s_2) - k_2 y_e + \omega_d x_e + \dot{\omega}_d x_e - v_c \sin(\theta_e)}{v_r \sin(\theta_e) + k_3} \dots\dots\dots(19)$$

$$\theta_c = \text{atan}(1/v_r \theta_c) \dots\dots\dots(20)$$

The finally:

Equations (17) and (18) represent the velocity control law while (19) and (20) represent the steering control law.

IV. APPLICATION

In this location, the effects of the past control techniques are displayed in endeavor. The reenactment has been created in Matlab/Simulink and it's miles likewise at present created in the Unity stage.

In parallel with the usage of the controller, a route organizer has likewise been finished which offers the unique hints to the control region. The subsequent ranges are located to play out the direction following:

_ The GPS gives to the car an expansion of forward path focuses at every issue. The location amongst manner focuses is called fragment.

_ When a section completes, the organizer takes the following way factor and play out the right pace profile as in line with the best increasing pace authorized. From this issue pretty some sub manner focuses are decided with its specific position, route, right now velocity, particular tempo, direct growing pace and rakish quickening.

_ Once the type of fragment has been examined, at every example time ($T_s = 0.1s$) the manipulate area takes a sub way aspect consists of as an excellent setup and play out the manipulate.

Figure 6 demonstrates the all out way to be followed, wherein blue circles talk to the manner focuses and between them there are an expansion of sub way focuses. Figure five suggests an appropriate association of speeds for the complete way registered thru the organizer. Info aggravations had been remembered for the sensors information and in the model as Gaussian irregular clamors to make the replica increasingly low cost. Inside the car version, first request channels have been considered a good manner to moderate the excessive recurrence terms of the control flags if there ought to be an occurrence of the sliding version controller. In next subsections the aftereffects of the manipulate techniques are displayed.

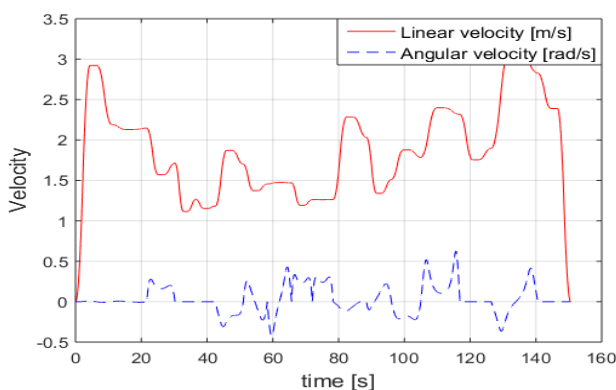


FIG. 6. PATH PROPOSED TO PROVE CONTROL TECHNIQUES

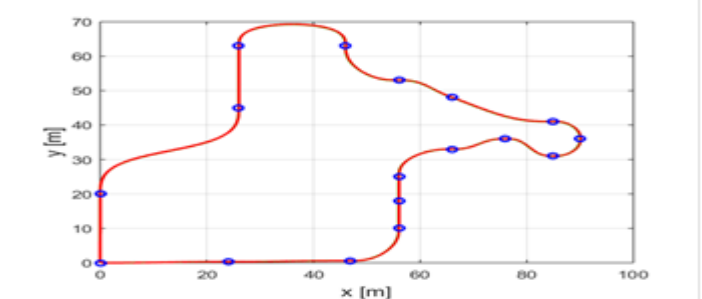


Fig. 5. Desired angular and linear velocities

A. DIRECT LYAPUNOV BASED CONTROLLER RESULTS

"The controller is designed according the procedure described in Section III.A. The design parameters are adjusted as follows: $k_1 = 0.9$, $k_2 = 1.1$ and $k_3 = 3$. They have been adjusted by trial and error. Fig. 6 presents the resulting path, the control actions and the errors. It can be seen that the errors are sufficiently small. For instance in the case of lateral vehicle error the maximum value reached when the car arrives to a curve is 5 cm."

B. SLIDING MODE CONTROL RESULTS

The controller is designed according the procedure describes in Section III.B. The set of sliding parameters are shown in Table I, which have been adjusted by trial and error too.

K1	0.22
K2	2
K3	2.55
P1	0.48
Q1	0.048
P2	3.7
Q2	0.3

TABLE. I SLIDING MODE CONTROL PARAMETERS

V. RESULT DISCUSSION

By looking the effects we are able to concede the 2 strategies supply comparative outcomes and they may be exceptional.

Note that the directing aspect manage interest of the Lyapunov method is cover. It is because of the way that the SMC approach play out the guiding signal

via the use of the 3 mistakes and the rushing up hobby, and each any such factors have commotion. Then again, Lyapunov method sincerely makes use of of the three mistakes to method the controlling factor.

Notice moreover that the sliding mode technique accomplishes littler mistakes albeit the sort of mistakes can be restrained with the aid of acquiring a superior affiliation of parameters inside the two techniques. Both control strategies have displayed to be powerful as for a few clamor and unsettling impacts, and the have been given consequences display the viability of such proposed manage.

CONCLUSIONS

This art work has introduced the exam of nonlinear model-primarily based totally control systems for self-ruling motors. The controllers have been planned making use of a manipulate located model of car dependent on a motorcycle model typically carried out within the writing for demonstrating self-ruling vehicles. The two control methodologies look at a model reference technique. Utilizing this gadget, the error elements version has been created. The controllers get as data the longitudinal, sidelong and course errors generating as manage yields the guiding factor and the fee of the car. The number one nonlinear manage technique has been planned with the aid of the usage of strategies for the Lyapunov direct methodology. The next approach has been hooked up making use of the sliding mode method. The controllers have been actualized, attempted and contrasted and wonderful manner following conditions in pastime. From the were given consequences, the 2 strategies provide comparable results being very sturdy to vulnerability and clamor. As of now remarked, as of now, each manipulate approaches are being tried on an augmented enjoy reenactment created in Unity in advance than being tried in a real car accessible on the Computer Vision Center.

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