Soft Computing and Geometrical Control for Computer Aided Driving

Javier Alonso Ruiz, Teresa de Pedro, Carlos González y Ricardo García

Industrial Automation Institute, CSIC, La Poveda, Arganda del Rey.
28500 Madrid, Spain
{jalonso, ricardo, tere, gonzalez}@iai.csic.es

Abstract. After having completed the design of control systems for real autonomous cars in urban environment using straight lines as reference, we are now intending to build a fuzzy control system based in clothoids [2], the curve used in roads and train ways. This work proposes a method based on soft computing and upgraded via genetic algorithms. Both sets of simulations are shown, and compared.

Introduction

One of the big efforts in a control system is to reduce the force applied on the actuators. In autonomous vehicles the amount of electrical required is an important issue. Our goal is to reduce the electrical expense in the direction actuators. Moreover the reduction of excessive steering wheel movements increases the comfort feeling. We have proposed and tested a control method for vehicle navigation in curved sections. We have used a curvature control method based on fuzzy logic with genetic algorithms optimization over a geometric trajectory design. We have obtained impressive results on simulation and now we are testing these results on real autonomous vehicles.

Nowadays most roads are designed trying to maintain a progressive and smooth trajectory in its curved sections. This designing method is explained in “Carreteros” web page [4]. Each curve is divided into three parts, in the first one the curvature of the road increases, in the second one the curvature is maintained constant and in the last part the curvature is reduced to cero. Based on this idea we design a trajectory for each curve. Following this trajectory the vehicle smoothly changes its curvature from cero to a given number, and then from this number to cero.

To be more precise in [3] this differential equation system is shown relating the state and control variables and its integration equations for admissible paths:

$$\begin{pmatrix} x' & y' & \theta' & \kappa' \end{pmatrix} = v \cdot \begin{pmatrix} \cos\theta & \sin\theta & \kappa & 0 \end{pmatrix} + \sigma \cdot \begin{pmatrix} 0 & 0 & 0 & 1 \end{pmatrix} \quad \textbf{(1)}$$

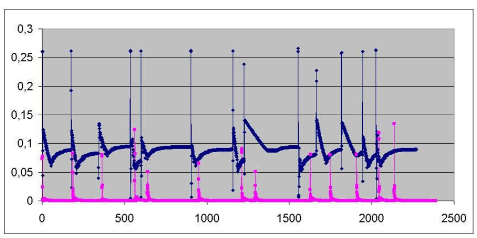
where (x y θ κ) stand for attitude and curvature, and σ is $\sigma = \kappa' = \Phi/\cos^2\Phi$. (Φ is the wheel angle).

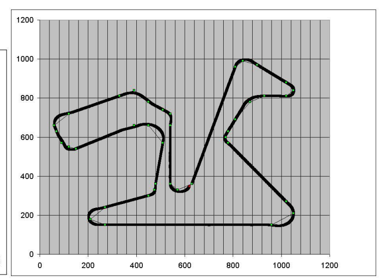
Our proposal is to express position of the car depending on its curvature, f(x,y,κ,v,t) related to steering angle and control the car using its usual inputs, acceleration and curvature (v', κ=1/r).

In order to obtain a solution as smother as possible we have used a fuzzy logic control system [1]. This control system must maintain the curvature goal that depends on the point of the curve where the car is. It will work on the curvature error, its first instant derivation and the error accumulated on that curve, just to minimize the curvature error. So we use a fuzzy PID fuzzy control.

The membership function parameters are improved with a genetic algorithm fitness function that combines the accumulated effort and the maximum error made on the circuit curves. We have obtained different optimized set values depending on the nature of the circuit curves (motorways with small curvature or race circuits).

The simulator uses detailed maps of competition circuits, mainly Xerez, with its real proportions. And it takes care of our cars, CITROËN, mechanical characteristics. We have carried out several simulations in this circuit, and the results show a drastic effort reduction after the genetic algorithm optimization.





Left fig. Differences between two consecutive steering wheel actuator goals. The blue one is the steering wheel actuation without optimization and the pink one is after application of genetic algorithm. **Right fig.** Drawing a course on Xerez circuit map

References

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