AN INTELLIGENT TRACTION CONTROL FOR MOTORCYCLES

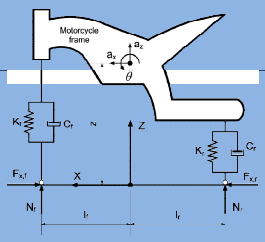
P. Urda, J.A. Cabrera, J.J. Castillo, A.J. Guerra
Department of Mechanical Engineering
University of Málaga

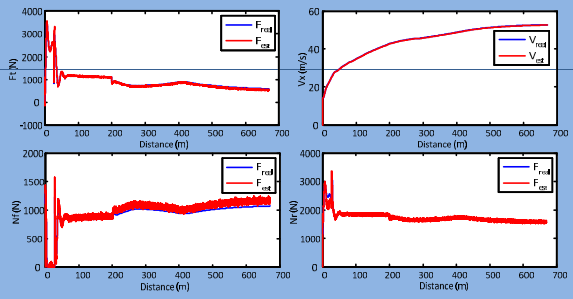
1. Introduction

In terms of traction and brake control systems, four-wheel vehicles have a clear advantage with regards to motorcycles. The present trend is that most car manufacturers are incorporating, together with ABS, additional systems such as ESP (Electronic Stability Program), CWS (Collision Warning System), CAS (Collision Avoidance System) or AHS (Automated Highway System). The main problem of two-wheel vehicles comes from the fact that these vehicles require more complex modeling with respect to automobiles whose performance is easier than the first ones. However, there is a strong interest in the development and implementation of these systems in motorcycles, especially to improve active safety in these vehicles. As expected, the control algorithm is the main part of any traction control system. It is the one that decides how to perform in the system. This paper presents a novel traction control algorithm based on the use of Artificial Neural Networks (ANN) and Fuzzy Logic. An ANN is used to estimate the optimal slip of the surface the vehicle is moving on. A fuzzy logic control block, which makes use of the optimal slip provided by the ANN, is developed to control the throttle position.

2. Parameters estimation

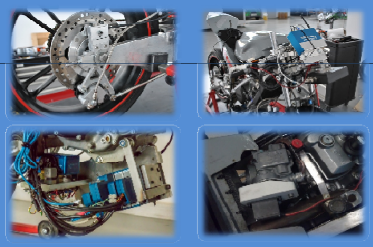
For this work, the longitudinal and vertical acceleration and pitch rate are used to obtain the slip and friction coefficient using an extended Kalman filter (EKF) and a three-degree-of-freedom longitudinal-vertical motorcycle model to simulate the vehicle when moving in a straight line. Several simulations have been done with BikeSim® and Matlab® to test the accuracy of the model.



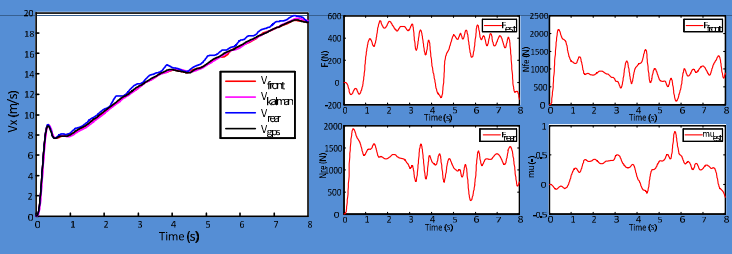


3. Road tests

Using the IMMa experimental motorcycle, several tests have been carried out on road.

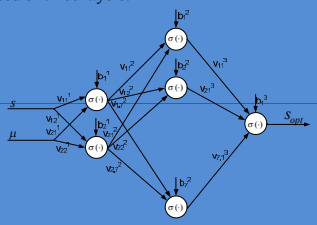


As shown in the figure below, the EKF implemented in the real-time computer, estimates the velocity of the vehicle during accelerations perfectly. The traction force, wheel vertical forces and slip coefficient are also estimated by the EKF.

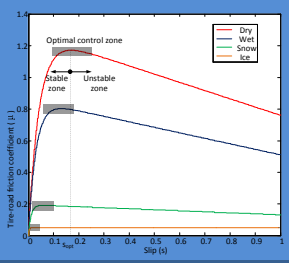


4. Road type estimation

The knowledge of the type of contact between tire and road is fundamental. In this work, the estimation is carried out using artificial neural networks. The network that we proposed is a feed forward neural network composed of three layers.



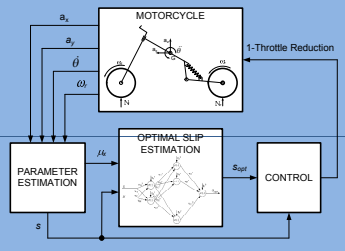
The ANN. inputs are the adhesion coefficient (μ) and the slip (s), and the output the optimum slip (s_{opt}) for the type of surface on which the motorcycle is circulating.



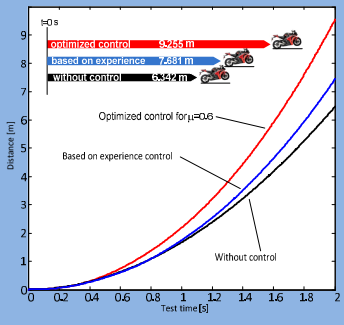
5. Traction Control System

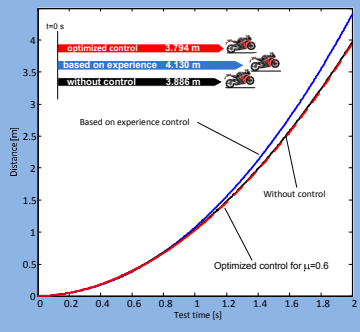
A fuzzy-logic based traction control system has been implemented. Its goal is to maintain the rear wheel slip ratio as near as possible from its optimal value according to the Burckhardt model. For this purpose, the control performs on the servo-assisted carburator installed on the motorcycle and hence modifying the torque on the rear wheel.

Two control blocks have been tuned. The first control block has been tuned according to the experience of an expert operator while the second one has been optimized using Evolutionary Computation (EC).



Simulation shows the use of EC can improve the fuzzy logic based control algorithm, obtaining better results than those produced with the control tuned only by experience.





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iMMa Ingeniería Mecánica Málaga

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OBJECTIVES OF MOTORBIKE TRACTION CONTROL SYSTEMS:

- Prevent rear wheel from slipping
- Prevents uplift of the front wheel
- Improve safety while leaning over (no oversteering)
- Competition: enhance acceleration and cornering capabilities

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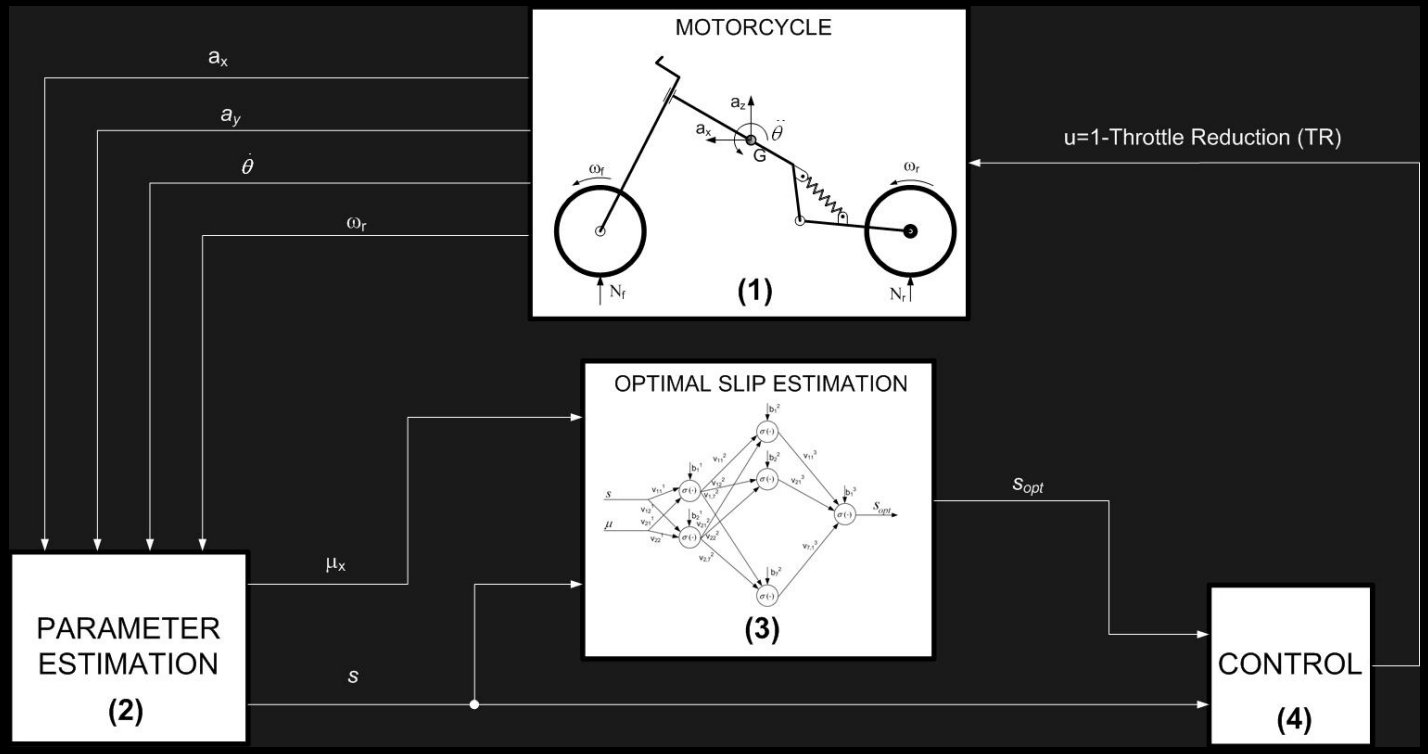
INTRODUCTION:

This paper presents a novel traction control algorithm based on the use of Artificial Neural Networks (ANN) and Fuzzy Logic. An ANN is used to estimate the optimal slip of the surface the vehicle is moving on. A fuzzy logic control block, which makes use of the optimal slip provided by the ANN, is developed to control the throttle position.



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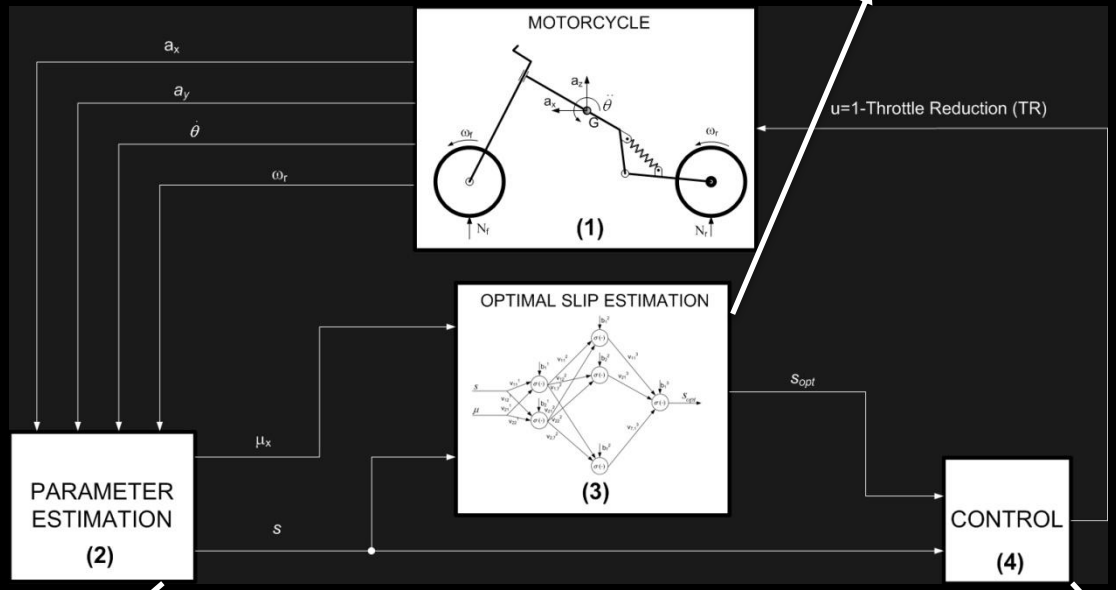
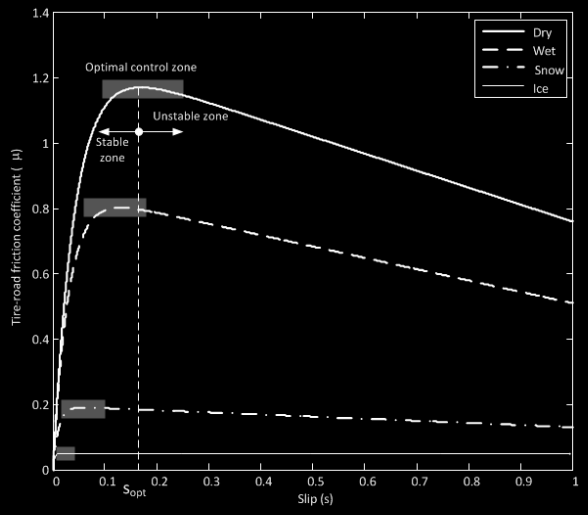
ROAD TYPE ESTIMATION BLOCK:

- **Artificial Neural Network**
- **Estimation of optimal slip**





PARAMETER ESTIMATION BLOCK:

- **Standard sensors**
- **Extended Kalman Filter**
- **Estimation of slip and adhesion coefficient**

TRACTION CONTROL BLOCK:

- **Fuzzy Logic**
- **Maintain the rear wheel slip ratio as near as possible from its optimal value**

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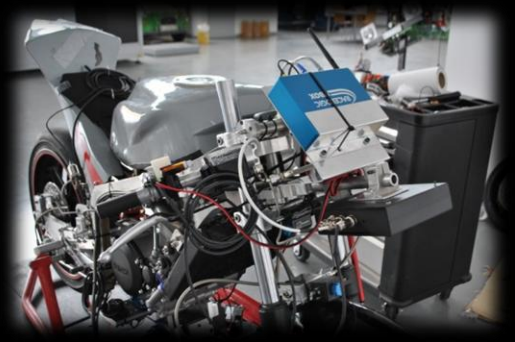
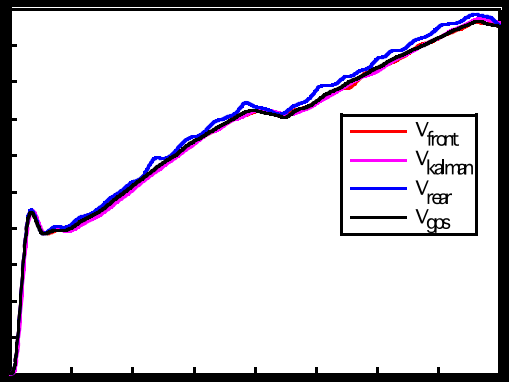
RESULTS:

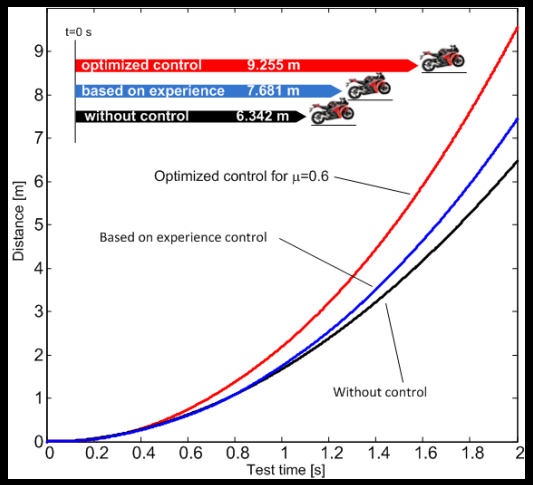
Exprimental motorcycle:

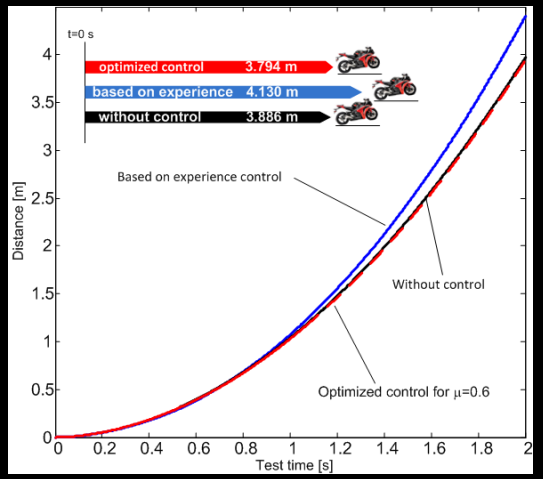


Longitudinal velocity estimation:



Traction control comparative:





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CONCLUSIONS:

- **A new intelligent traction control system has been developed**
- **The system allows predicting the type of surface the vehicle is moving on**
- **An EKF is used to estimate the traction force, vertical forces and the velocity of the center of mass of the motorbike**
- **The traction control has been implemented in a real-time computer installed on the IMMa motorbike.**
- **Simulations and experimental tests confim the accuracy of the parameter estimation method and the performance of the proposed T.C.S.**

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