

# CIÊNCIAS SOCIALMENTE APLICÁVEIS:

INTEGRANDO SABERES E  
ABRINDO CAMINHOS

JORGE JOSÉ MARTINS RODRIGUES  
MARIA AMÉLIA MARQUES

(Organizadores)

VOL VIII



EDITORIA  
ARTEMIS

2023

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## APRESENTAÇÃO

O oitavo volume desta coleção segue a lógica dos livros anteriores. Procura apresentar ao leitor uma coletânea de artigos sobre problemáticas que são transversais ao campo das ciências sociais aplicadas.

Sendo discutível, na metodologia seguida na organização dos vários volumes procurou-se privilegiar artigos que abordassem novas tendências e/ou problemáticas transversais relevantes, adotassem metodologias mais holísticas e/ou modelos de investigação aplicada, apresentassem estudos de caso nacionais e/ou internacionais e procurassem ser reflexivos. Nesse contexto, o presente volume está organizado em três grandes eixos – Programação, Sustentabilidade, Educação e redes sociais.

Na construção da estrutura de cada eixo procurou-se seguir uma lógica em que cada artigo possa contribuir para uma melhor compreensão do artigo seguinte, gerando-se um fluxo de conhecimento acumulado que se pretende fluido e em espiral crescente.

Assim, o eixo Programação é constituído por um conjunto de oito artigos. A programação pode ser entendida como um conjunto de actividades que visam transformar tarefas repetitivas e monótonas em rotinas cooperativas e colaborativas. Estas rotinas são algoritmos e modelos matemáticos geradores de informação estruturada e eficiente que, apesar da sua racionalidade limitada, é útil para a tomada de decisões, sejam individuais ou de grupo.

O eixo Sustentabilidade junta um conjunto de sete artigos que, em comum, contribuem para a construção da responsabilidade social. As mudanças climáticas estão a perturbar a vida de milhões de pessoas no planeta, com especial ênfase nas regiões rurais mais pobres e com impacto negativo na economia. Assim, exigem-se políticas públicas inclusivas que incentivem o uso de materiais multíusos, amigos do ambiente. Os resíduos sólidos urbanos necessitam de ser melhor geridos e as empresas deverão ser incentivadas a incorporar aquelas políticas nas suas estratégias, para reforço dos seus valores, conforto e bem-estar dos seus constituintes.

O eixo Educação e redes sociais tem seis artigos. As principais teorias de liderança parecem apontar para que esta seja contingencial, podendo ser ensinada e as respectivas competências treinadas e melhoradas. Todo o ensino, presencial ou a distância, tem os seus pontos fortes e pontos fracos. Exigem-se comportamentos éticos, nomeadamente em ambiente de redes sociais, para evitar fraudes quer com os conteúdos quer com a respectiva avaliação, com eventuais traumas psicológicos em quem é visado.

Com a disponibilização deste livro e seus artigos esperamos que os mesmos gerem inquietude intelectual e curiosidade científica, procurando a satisfação de novas necessidades e descobertas, motor de todas as fontes de inovação.

Jorge Rodrigues, ISCAL/IPL, Portugal  
Maria Amélia Marques, IPS/ESCE, Portugal

## SUMÁRIO

### PROGRAMAÇÃO

#### **CAPÍTULO 1..... 1**

NUMERICAL CALCULATION BASED ON AGILE PROGRAMMING DEVELOPMENT TRAINING

Ángel Rubén Barberis

Lorena Elizabeth Del Moral Sachetti

Jorge Alberto Silvera

 [https://doi.org/10.37572/EdArt\\_3005238111](https://doi.org/10.37572/EdArt_3005238111)

#### **CAPÍTULO 2..... 11**

DISEÑO DE UN ROBOT MÓVIL PARA LA VALIDACION EXPERIMENTAL DE CONTROLADORES EN EL SEGUIMIENTO DE PARED

Jaime Franco Gutiérrez

Moisés García Villanueva

Salvador Ramírez Zavala

 [https://doi.org/10.37572/EdArt\\_3005238112](https://doi.org/10.37572/EdArt_3005238112)

#### **CAPÍTULO 3..... 23**

FAMÍLIAS ESTRUTURADAS DE MATRIZES ESTOCÁSTICAS SIMÉTRICAS

Cristina Paula da Silva Dias

Carla Maria Lopes da Silva Afonso dos Santos

João Tiago Praça Nunes Mexia

 [https://doi.org/10.37572/EdArt\\_3005238113](https://doi.org/10.37572/EdArt_3005238113)

#### **CAPÍTULO 4..... 35**

ANÁLISIS DE LA EFICIENCIA DE LOS ALGORITMOS MEDIANTE EL USO DE LAS FUNCIONES DE LANDAU

José Francisco Villalpando Becerra

María José Aceves Sepúlveda

 [https://doi.org/10.37572/EdArt\\_3005238114](https://doi.org/10.37572/EdArt_3005238114)

#### **CAPÍTULO 5..... 46**

ANÁLISIS DE FTIR EN BREAS DE ALQUITRÁN DE HULLA

Juanita Yazmín Guevara Chávez

Fátima Pamela Lara Castillo

Griselda Berenice Escalante Ibarra

 [https://doi.org/10.37572/EdArt\\_3005238115](https://doi.org/10.37572/EdArt_3005238115)

**CAPÍTULO 6.....52**

DE LA RACIONALIDAD LIMITADA A LA RACIONALIDAD FINANCIERA EN LOS ESTUDIANTES DE LA UAEMEX (UNIDAD ACADÉMICA PROFESIONAL CUAUTITLÁN IZCALLI)

Marco Antonio Piña Sandoval

Fermin Leonel Reyes

Montserrat Piña Cárdenas

Jorge Rogelio Zenteno Domínguez

 [https://doi.org/10.37572/EdArt\\_3005238116](https://doi.org/10.37572/EdArt_3005238116)

**CAPÍTULO 7..... 63**

SLIDING MODE CONTROLLER-OBSERVER EXPERIMENTAL DESIGN FOR THE TWO-TANK HYDRAULIC SYSTEM TAKAGI-SUGENO MODELING

Ángel Garibo

Marco A. Rodríguez

Juan M. de la Torre

Marisela Y. Hernández

Juan Anzures Marín

Salvador Ramírez Zavala

 [https://doi.org/10.37572/EdArt\\_3005238117](https://doi.org/10.37572/EdArt_3005238117)

**CAPÍTULO 8.....77**

ESTUDO DE TERMINOLOGIA CONTROLADA PARA TRADUÇÃO AUTOMÁTICA COM BASE EM CORPORA DE MANUAIS DE INSTRUÇÕES DE ELECTRODOMÉSTICOS

尹雪璐 Xuelu Yin

甄钊 Zhao Zhen

 [https://doi.org/10.37572/EdArt\\_3005238118](https://doi.org/10.37572/EdArt_3005238118)

**SUSTENTABILIDADE**

**CAPÍTULO 9.....92**

CLIMATE SHOCKS AND THE US ECONOMY

Dejan Romih

Arne Baruca

 [https://doi.org/10.37572/EdArt\\_3005238119](https://doi.org/10.37572/EdArt_3005238119)



**CAPÍTULO 10.....107**

EMPODERAMIENTO DETONADOR DE CRECIMIENTO ECONÓMICO ANTE  
LOS PROBLEMAS SOCIALES QUE ENFRENTAN LAS MUJERES RURALES  
EMPREENDEDORAS QUE VENDEN PESCADO EN LA PERIFERIA DEL MERCADO  
PÚBLICO MANUEL LARRAINZAR EN TONALÁ, CHIAPAS

Isabel Pérez Pérez

Graciela de Paz

 [https://doi.org/10.37572/EdArt\\_30052381110](https://doi.org/10.37572/EdArt_30052381110)

**CAPÍTULO 11..... 120**

PERSONAL FACTORS INFLUENCING SINGLE-USE PLASTIC PACKAGING  
CONSUMPTION: A QUALITATIVE APPROACH

María del Carmen Franco Gómez

Kristel Rojas Campoverde

Javier Solano Solano

 [https://doi.org/10.37572/EdArt\\_30052381111](https://doi.org/10.37572/EdArt_30052381111)

**CAPÍTULO 12 ..... 141**

LA GESTIÓN DE RESIDUOS SÓLIDOS URBANOS: UNA VISIÓN DE ESTUDIANTES Y  
CIUDADANOS DE CHILPANCINGO, GUERRERO, MÉXICO

Ciro Andraca Sánchez

Justiniano González González

Alejandra Hitahii Muñoz García

María Cristina Santiago Dionisio

Paulino Bueno Domínguez

Manuel Mendoza Mojica

 [https://doi.org/10.37572/EdArt\\_30052381112](https://doi.org/10.37572/EdArt_30052381112)

**CAPÍTULO 13.....152**

LA RESPONSABILIDAD SOCIAL CORPORATIVA EN LAS EMPRESAS ECUATORIANAS

Alexandra Auxiliadora Mendoza Vera

Pablo Edison Ávila Ramírez

Angélica María Indacochea Vásquez

Martha Margarita Minaya Macías

Gina Gabriela Loor Moreira

Janeth Virginia Intriago Vera

Jorge Luis Loor Tello

Fernando José Veloz Párraga

Maritza Alexandra Ávila Ramírez

Jhonny Antonio Ávila Ramírez

 [https://doi.org/10.37572/EdArt\\_30052381113](https://doi.org/10.37572/EdArt_30052381113)

**CAPÍTULO 14..... 167**

LAS EMPRESAS FAMILIARES DEL MEDIO RURAL Y SU FORTALEZA EN LA RELACIÓN CON SUS EMPLEADOS

Alma Delia Inda

Gloria Muñoz del Real

Jackeline Hernández Bejarano

Olga Lidia Gutiérrez Gutiérrez

 [https://doi.org/10.37572/EdArt\\_30052381114](https://doi.org/10.37572/EdArt_30052381114)

**CAPÍTULO 15..... 178**

HUARACHES KWARACHI-INNOVA: CAMINANDO HACIA UN FUTURO ECO-AMIGABLE

Adriana Calderón Gutiérrez

José Roberto Jiménez Echeverría

Liliana Venegas Michel

Armando García Echeverría

Alejandra Delgado Urbina

 [https://doi.org/10.37572/EdArt\\_30052381115](https://doi.org/10.37572/EdArt_30052381115)

**EDUCAÇÃO E REDES SOCIAIS**

**CAPÍTULO 16..... 189**

MODELO DE CARACTERIZACIÓN DE LIDERAZGO

Omar Alejandro Guirette Barbosa

Claudia Guadalupe Lara Torres

Emanuel Magallanes Ulloa

Beatriz Adriana Rodríguez González

Selene Castañeda Burciaga

 [https://doi.org/10.37572/EdArt\\_30052381116](https://doi.org/10.37572/EdArt_30052381116)

**CAPÍTULO 17 ..... 200**

CHIAKI ISHII – UMA PESQUISA NARRATIVA SOBRE O ATLETA QUE ALAVANCOU O JUDÔ NO BRASIL A PARTIR DAS COMPETÊNCIAS DO ESPORTISMO

Rodrigo Guimarães Motta

Neusa Maria Bastos Fernandes dos Santos

Wagner Castropil

 [https://doi.org/10.37572/EdArt\\_30052381117](https://doi.org/10.37572/EdArt_30052381117)

**CAPÍTULO 18 .....219**

TRANSFORMING TRADITIONAL PROFESSIONAL DEVELOPMENT INTO BLENDED LEARNING COMMUNITIES

Cristo Ernesto Yáñez León

James M. Lipuma

 [https://doi.org/10.37572/EdArt\\_30052381118](https://doi.org/10.37572/EdArt_30052381118)

**CAPÍTULO 19 .....230**

IMPACTO FINANCIERO Y PSICOLÓGICO DEL FRAUDE INFORMÁTICO EN LOS MIEMBROS DE LAS COMUNIDADES EDUCATIVAS DE GUAYAQUIL

Yesenia Karina Alcívar Rendón

Diana Carolina Arriaga León

Damián Enrique Dattus Torres

Douglas Daniel Díaz Torres

Susana Mirella Gómez Cabrera

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 [https://doi.org/10.37572/EdArt\\_30052381119](https://doi.org/10.37572/EdArt_30052381119)

**CAPÍTULO 20 .....249**

LAS REDES SOCIALES COMO MEDIO DE DIFUSIÓN DE LA COMUNIDAD LGBTQ+ EN VERACRUZ

Rossy Lorena Laurencio Meza

María del Pilar Anaya Avila

Carlos Eduardo Anaya Avila

Kevin Eloy Cué Rosales

 [https://doi.org/10.37572/EdArt\\_30052381120](https://doi.org/10.37572/EdArt_30052381120)

**CAPÍTULO 21 .....261**

A TEORIA HIPODÉRMICA E A OPERACIONALIDADE DO MODELO DE COMUNICAÇÃO DE LASSWELL EM TEMPO DE REDES SOCIAIS: O CASO DE CHARLOTTESVILLE (EUA, 2017)

Paulo Bruno Alves

 [https://doi.org/10.37572/EdArt\\_30052381121](https://doi.org/10.37572/EdArt_30052381121)

**SOBRE OS ORGANIZADORES .....296**

**ÍNDICE REMISSIVO ..... 297**

# CAPÍTULO 7

## SLIDING MODE CONTROLLER-OBSERVER EXPERIMENTAL DESIGN FOR THE TWO-TANK HYDRAULIC SYSTEM TAKAGI-SUGENO MODELING

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**ABSTRACT:** In this document, we present the design and results of a Takagi-Sugeno fuzzy compensator and observer as sliding modes for a non-linear system. The control is designed for a non-linear liquid level system consisting of: two-tank, two valves for fluid control in the system, as well as two ultrasonic sensors for reading the liquid level. For the optimization of the compensations of the compensator and the observer linear matrix inequalities (LMI) are used, which in addition to optimizing these gains make the control have a better response in stable state. The implementation of the control is carried out with the help of software and NI-LabVIEW hardware, which provide us with a programming environment for the control algorithm, as well as a data acquisition card to carry out the communication of the control with the system dynamic.

**KEYWORDS:** Fuzzy logic control. Takagi Sugeno fuzzy model. LMI sliding modes observer.

## DISEÑO EXPERIMENTAL DE UN CONTROLADOR-OBSERVADOR DE MODO DESLIZANTE PARA EL SISTEMA HIDRÁULICO DE DOS TANQUES MODELADO TAKAGI-SUGENO

**RESUMEN:** En este documento, se presenta el diseño y los resultados de un compensador difuso Takagi-Sugeno y un observador como modos deslizantes para un sistema no lineal. El control está diseñado para un sistema de nivel de líquido no lineal que consta de: dos tanques, dos válvulas para control de fluido en el sistema, así como dos sensores ultrasónicos para leer el nivel de líquido. Para la optimización de las compensaciones del compensador y del observador se utilizan desigualdades matriciales lineales (LMI), que además de optimizar estas ganancias hacen que el control tenga una mejor respuesta en estado estable. La implementación del control se realiza con la ayuda del software y hardware de NI\_LabVIEW, los cuales brindan un entorno de programación para el algoritmo de control, así como una tarjeta de adquisición de datos para realizar la comunicación del control con el sistema dinámico.

**PALABRAS CLAVE:** Control con lógica difusa. Modelo difuso Takagi Sugeno. Observador de modos deslizantes LMI.

### 1 INTRODUCTION

In industrial processes it is required to control or maintain constant variables some variables such as: pressure, flow, level, temperature, pH, speed, etc. for which automatic control is used keeping those variables in the most suitable conditions, that is, at a control point called “set point”. The control system performs these actions comparing the value of the variable or condition with the set point and takes a correction action according to the existing deviation without the intervention of the system operator at all (C.T.Chen, 1999).

Fuzzy logic systems provide a simple and direct way to break down the modeling and control design task into a group of local tasks, which tend to be handled more easily. Fuzzy logic also provides the mechanism to link these local tasks to deliver modeling and complete control design (K. Tanaka, H.O. Wang, 2001).

The fuzzy model consists of decomposing the non-linear system in a simple way, which takes linear local dynamics of the system to handle it more easily. With fuzzy logic we can interpolate all the local models in order to have the best response and complete design of the system (C.T. Chen, 1999).

At present there is a great variety of control techniques which make the design and modeling of a system either linear or non-linear more favorable. These techniques range from classical control, control in the state space, optimal and adaptive control and even robust control.

The Takagi-Sugeno model, which consists of the interpolation of local models, which are given by a set of rules which depend on membership functions which evaluate compliance with the rules.

The tool used in this work for compensator design is linear matrix inequalities (LMI) with which multiple conditions have been solved for analysis and design of control systems, which facilitates the criteria of asymptotic stability, minimization of response times (L. Fortuna, et al. 2012), (S. Boyd, et al., 1994).

Systems with sliding modes have proven to be an efficient technique to control complex high-order nonlinear dynamic plants operating under uncertainty conditions, a common problem for many processes of modern technology. This explains the high level of research and publication activity in the area and unremitting interest of practicing engineers in sliding mode control during the past two decades (B. Castillo-Toledo, J. Anzurez-Marin, 2005).

So in this paper we present the design and results of a Takagi-Sugeno fuzzy controller-observer sliding modes observer for a non-linear liquid level system.

## 2 METHOD DESCRIPTION

### 2.1 TAKAGI-SUGENO FUZZY MODEL

The model proposed by Takagi and Sugeno (TS) is described by a fuzzy set rules of the form IF-THEN, which represent linear input-output relationships of a non-linear system. The main characteristic of a Takagi-Sugeno Fuzzy Model (TSFM) is the ability to express the local dynamics of each fuzzy implication (rule) by means of a linear subsystem. The complete fuzzy model of the system is obtained from the fuzzy “combination” of the linear models.

The  $i$ -th rule of the TSFM for a continuous System is given by (1).

Rule Model  $i$ :

$$\begin{aligned} &\text{IF } z_1(t) \text{ es } M_{i1} \text{ y } \dots \text{ y } z_p(t) \text{ es } M_{ip}, \\ &\text{THEN } \begin{cases} \dot{x}(t) = A_i x(t) + B_i u(t), \\ y(t) = C_i x(t), \end{cases} \quad i = 1, 2, \dots, r. \end{aligned} \tag{1}$$

where,  $M_{ij}$  is the fuzzy set and  $r$  is the number of rules;  $x(t) \in \mathbf{R}^n$  it is the state vector,  $A_i \in \mathbf{R}^{n \times n}$ ,  $B_i \in \mathbf{R}^{n \times m}$ , and  $C_i \in \mathbf{R}^{q \times n}$  are known matrices;  $z_1(t), \dots, z_p(t)$  they are known premise variables that can be functions of state variables, disturbances or time. We will use  $z(t)$  to denote the vector that contains the individual elements  $z_1(t), \dots, z_p(t)$ . It is assumed

that the premise variables are not functions of the estimated variables. Each linear equation represented by  $A_i x(t) + B_i u(t)$  it is called a subsystem. The final outputs of the Fuzzy System are expressed as (2) y (3).

$$\dot{x} = \sum_{i=1}^r h_i(z)(A_i x + B_i u), \quad (2)$$

$$y = \sum_{i=1}^r h_i(z)C_i x, \quad (3)$$

where

$$z = [z_1 \ z_2 \ \dots \ z_p], \quad h_i(z) = \frac{w_i(z)}{\sum_{i=1}^r w_i(z)}, \quad w_i(z) = \prod_{j=1}^p M_{ij}(z_j). \quad (4)$$

The fuzzy controller is described as (5)

$$u = - \sum_{i=1}^r h_i(z)F_i x. \quad (5)$$

The fuzzy observer, for the case in which the variables  $z(t)$  do not depend on the estimated variables, it takes the following form (6) y (7).

$$\dot{\hat{x}} = \sum_{i=1}^r h_i(z)\{A_i \hat{x} + B_i u + K_i(y - \hat{y})\}, \quad (6)$$

$$\hat{y} = \sum_{i=1}^r h_i(z)C_i \hat{x}. \quad (7)$$

If the observed states are feedback, the controller is represented as (8).

$$u = - \sum_{i=1}^r h_i(z)F_i \hat{x}. \quad (8)$$

Combining the controller and fuzzy observer is obtained (9) y (10).

$$\dot{x} = \sum_{i=1}^r \sum_{j=1}^r h_i(z)h_j(z)\{(A_i - B_i F_j)x + B_i F_j e\}, \quad (9)$$

$$\dot{e} = \sum_{i=1}^r \sum_{j=1}^r h_i(z)h_j(z)(A_i - K_i C_j)e, \quad (10)$$

where  $e$  is the error vector between the state and the estimated state.

The augmented system can be written as (11).



$$\dot{x}_a = \sum_{i=1}^r h_i(z)h_i(z)G_{ii}x_a + 2 \sum_{i=1}^r \sum_{i<j} h_i(z)h_j(z) \frac{G_{ij} + G_{ji}}{2} x, \quad (11)$$

where:

$$x_a = \begin{bmatrix} x \\ e \end{bmatrix}, \quad G_{ij} = \begin{bmatrix} A_i - B_i F_j & B_i F_j \\ 0 & A_i - K_i C_j \end{bmatrix}. \quad (12)$$

## 2.2 LINEAR MATRIX INEQUALITIES (LMI)

The Linear Matrix Inequalities (LMI) give rise to an important problem of optimization, these constitute a special and wide class of problems of convex optimization that attracts researchers in control. Two reasons that explain this interest are the great variety of specifications and design restrictions that can be expressed through LMI, once the LMI is correctly formulated, a problem can be solved by very efficient algorithms of convex optimization, especially based on internal point methods. Using numerical methods can solve a variety of problems in automatic control whose solution is unknown or do not. The field of application extends to various techniques, such as robust control, optimal control and fuzzy control (K. Tanaka, H.O. Wang, 2001, M. Junca, 2005).

A LMI has the form (13).

$$F(x) = F_0 + \sum_{i=1}^m x_i F_i > 0 \quad (13)$$

where:  $x^T = (x_1, x_2, \dots, x_m)$ ,  $F_i$  they are symmetric matrices given, and  $F(x) > 0$  it is positive defined.

LMI's are matrices, Lyapunov inequality is used to meet the stability criteria.

The LMI means that  $F(x)$  is a positive definite matrix. It can also be given in the form  $F(x) \geq 0$  it is easy to see that an LMI defines a convex set; that is, the set of  $X$  is convex, in addition it does not necessarily have a smooth boundary.

The type of mathematical program that minimizes a linear function with LMI constraints is called a semi-definite program. Inequalities in which variables are matrices with common problems that come from control theory, such is the case of Lyapunov's inequality.

$$A^T P + P A < 0 \quad (14)$$

where  $P$  are  $n \times n$  symmetric matrices, which is the variable.

$A$  it is a matrix of  $n \times n$  and  $P = P^T$  It is the variable. The previous inequality can be expressed as  $P_1, P_2, \dots, P_m$ .

### 2.3 SLIDING MODE OBSERVER APPLIED TO THE SYSTEM WITH DISTURBANCE

For the linear system with disturbance as (15) y (16).

$$\dot{x} = Ax + Bu + Ed, \quad (15)$$

$$y = Cx, \quad (16)$$

where,  $d \in \mathbb{R}^p$  is the unknown inputs vector and  $E$  is the disturbance distribution matrix.

The sliding mode observer we proposed as (17) y (18).

$$\dot{\xi} = A\xi + Bu + K(\hat{y} - y) + \varphi, \quad (17)$$

$$\hat{y} = C\xi, \quad (18)$$

where,  $\varphi$  is the discontinuous vector of sliding mode.

The error is defined as (19).

$$e = x - \xi. \quad (19)$$

The dynamics of the error is (20).

$$\dot{e} = \bar{A}e + Ed - \varphi, \quad (20)$$

where:

$$\bar{A} = A - KC \quad (21)$$

Using the sliding mode fuzzy observer on T-S model.

The dynamics of the error is (23).

$$\dot{e} = \sum_{i=1}^r \sum_{j=1}^r h_i(z)h_j(z) [(A_i - K_i C_j)e + E_i d + \varphi_i], \quad (23)$$

It is possible to demonstrate by Lyapunov's stability that the system is stable if

$$\varphi^T = k \operatorname{sgn}(e^T P) \quad (22)$$

where,  $k > 0$  and  $P > 0$  a symmetric matrix such that  $A^T P + P A < 0$  (V. Utkin, et. at. 2009, K. Tanaka, H.O. Wang, 2001, B. Castillo-Toledo, J. Anzures, 2005).

### 3 DESCRIPTION OF THE LIQUID LEVEL SYSTEM

The liquid level system consists of two tanks, two electro valves, a pump and a cistern. The system's dynamics are described in general: the pump takes the water from the cistern and carries it to the tank 1, this is connected to the tank 2 and the flow between them is regulated by the electro-valves 1; the electro-valves 2 controls the flow between tank 2 and the cistern.

The electro-valves are controlled by means of a voltage signal. A value of 0 volts causes the valve to close, while a value of 5 volts causes the valve to be open. Intermediate voltage values allow partial openings. Ultrasonic sensors located at the top of each tank are used to measure the liquid level.

The actual system to be controlled is shown in Figure 1. We can see both tanks and their respective sensor located on the top of each, the electro-valves and the cisterns, located in the lower right.

Figure 1. Schematic diagram of the liquid level system.



The dynamics of the system can be described in the space of states through matrices (14).

$$A = \begin{bmatrix} -\frac{R_1}{2C_t\sqrt{h_1}} & -\frac{\sqrt{h_1}}{C_t} & 0 & 0 \\ 0 & -\frac{1}{T_1} & 0 & 0 \\ \frac{R_1}{2C_t\sqrt{h_1}} & \frac{\sqrt{h_1}}{C_t} & -\frac{R_2}{2C_t\sqrt{h_2}} & -\frac{\sqrt{h_2}}{C_t} \\ 0 & 0 & 0 & -\frac{1}{T_2} \end{bmatrix} \quad (24)$$

$$B^T = \begin{bmatrix} 0 & \frac{l_{e1}}{T_1} & 0 & 0 \\ 0 & 0 & 0 & \frac{l_{e2}}{T_1} \end{bmatrix}, \quad C = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

where:

$R_1$  y  $R_2$  are the opening factors of the electro-valves.

$h_1$  y  $h_2$  are the desired liquid heights in the tanks.

$T_1$  y  $T_2$  are the opening time constants of the electro-valves.

$L_{e1}$  y  $L_{e2}$  are the constants of proportionality of the electro-valves.

$C_t$  is the transverse area of each tank (both have the same cross-sectional area).

#### 4 THE FUZZY SLIDING MODE COMPENSATOR DESING

The membership functions were chosen as (25) to (28).

$$M_1(x_1) = \left[ 1 - \frac{1}{1 + e^{-35(x_1 - \pi/12.5)}} \right] \left[ \frac{1}{1 + e^{-35(x_1 + \pi/12.5)}} \right], \quad (25)$$

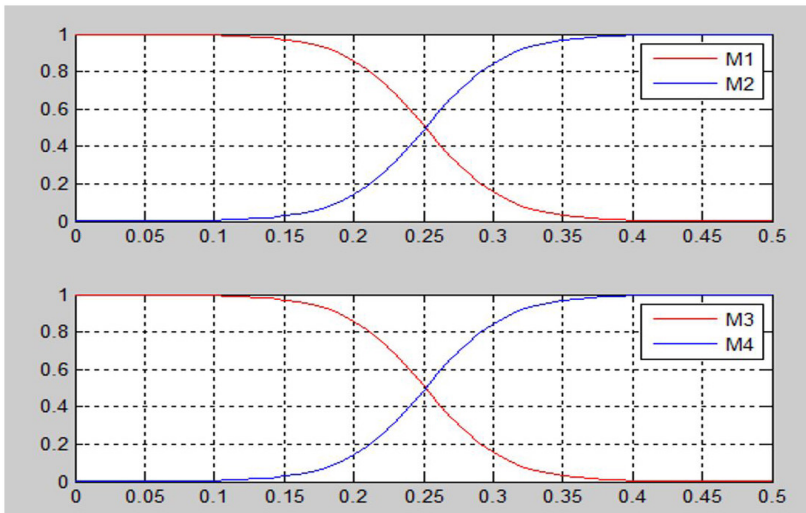
$$M_2(x_1) = 1 - M_1(x_1), \quad (26)$$

$$M_3(x_3) = \left[ 1 - \frac{1}{1 + e^{-35(x_3 - \pi/12.5)}} \right] \left[ \frac{1}{1 + e^{-35(x_3 + \pi/12.5)}} \right], \quad (27)$$

$$M_4(x_3) = 1 - M_3(x_3). \quad (28)$$

The membership functions are shown in Figure 2

Figure 2. Membership functions.



Using these fuzzy sets, the nonlinear system may be represented according to the fuzzy model Takagi-Sugeno as:

Rule Model 1:

IF  $x_1$  es  $M_1$  y  $x_3(t)$  es  $M_3$ ,

$$\text{THEN } \begin{cases} \dot{x}(t) = A_1x(t) + B_1u(t), \\ y(t) = C_1x(t). \end{cases} \quad (29)$$

Rule Model 2:

IF  $x_1$  es  $M_1$  y  $x_3(t)$  es  $M_4$ ,

$$\text{THEN } \begin{cases} \dot{x}(t) = A_2x(t) + B_2u(t), \\ y(t) = C_2x(t). \end{cases} \quad (30)$$

Rule Model 3:

IF  $x_1$  es  $M_2$  y  $x_3(t)$  es  $M_3$ ,

$$\text{THEN } \begin{cases} \dot{x}(t) = A_3x(t) + B_3u(t), \\ y(t) = C_3x(t). \end{cases} \quad (31)$$

Rule Model 4:

IF  $x_1$  es  $M_2$  y  $x_3(t)$  es  $M_4$ , d

$$\text{THEN } \begin{cases} \dot{x}(t) = A_4x(t) + B_4u(t), \\ y(t) = C_4x(t). \end{cases} \quad (32)$$

Where  $A_i, B_i, C_i$  are known dimensions matrices of the subsystems at local region.

Table 1, Table 2, Table 3 and Table 4 show the respective values of each subsystem.

Table 1. Operation point of subsystem 1.

$C_t = 0.1482m^2$	
$h_1 = 0.06 m$	$h_2 = 0.12 m$
$T_1 = 8.41 s$	$T_2 = 12.2 s$
$R_1 = 0.01643$	$R_2 = 0.02213$
$l_{e1} = -0.0022$	$l_{e2} = -0.0022$

Table 2. Operation point of subsystem 2.

$C_t = 0.1482m^2$	
$h_1 = 0.13 m$	$h_2 = 0.25 m$
$T_1 = 8.41 s$	$T_2 = 8.99 s$
$R_1 = 0.01643$	$R_2 = 0.01643$
$l_{e1} = -0.0021$	$l_{e2} = -0.0021$

Table 3. Operation point of subsystem 3.

$C_t = 0.1482m^2$	
$h_1 = 0.47 m$	$h_2 = 0.13 m$
$T_1 = 7.25 s$	$T_2 = 8.68 s$
$R_1 = 0.01472$	$R_2 = 0.02213$
$l_{e1} = -0.0021$	$l_{e2} = -0.0023$

Table 4. Operation point of subsystem 4.

$C_t = 0.1482m^2$	
$h_1 = 0.39 m$	$h_2 = 0.37 m$
$T_1 = 7.54 s$	$T_2 = 12.2 s$
$R_1 = 0.01415$	$R_2 = 0.01586$
$l_{e1} = -0.0021$	$l_{e2} = -0.0021$

Linear Matrix Inequalities (LMIs) that must be resolved to determine the gains  $F_i$  and  $K_i$  of the fuzzy compensator are:

$$P_1, P_2 > 0,$$

$$P_1 A_i^T - M_{1i}^T B_i^T + A_i P_1 - B_i M_{1i} < 0,$$

$$A_i^T P_2 - C_i^T N_{2i}^T + P_2 A_i - N_{2i} C_i < 0,$$

$$P_1 A_i^T - M_{1j}^T B_i^T + A_i P_1 - B_i M_{1j} + P_1 A_j^T - M_{1i}^T B_j^T + A_j P_1 - \quad (33)$$

$$B_j M_{1i} < 0, \quad i < j \text{ s.t. } h_i \cap h_j \neq \emptyset,$$

$$A_i^T P_2 - C_j^T N_{2i}^T + P_2 A_i - N_{2i} C_j + A_j^T P_2 - C_i^T N_{2j}^T + P_2 A_j -$$

$$N_{2j} C_i < 0, \quad i < j \text{ s.t. } h_i \cap h_j \neq \emptyset.$$

Thus the gains can be calculated as:

$$F_i = M_{1i} P_1^{-1}, \quad (34)$$

$$K_i = P_2^{-1} N_{2i}.$$

For the sliding mode vector ( $\varphi$ ), the positive definite P matrices were obtained for each subsystem such that it is fulfilled  $(P\bar{A} + \bar{A}^T P) < 0$

To reach a constant reference a constant term is introduced in the control, as (35).

$$u = - \sum_{i=1}^r h_i(z) * (F_i \hat{x} + v). \quad (35)$$

Which is calculated as:

$$v = H(0)^{-1} * y_d \quad (36)$$

Where:  $H(0)$  is the transfer function evaluated in 0 of the system with feedback and  $y_d$  is the desired output vector.

Thus, the system with fuzzy compensator that reaches a constant reference and observer with sliding modes can be described as (37) and (38).

$$\dot{x} = \sum_{i=1}^r \sum_{j=1}^r h_i(z) h_j(z) [(A_i - B_i F_j) x + B_i F_j e + B_i v_i], \quad (37)$$

$$\dot{e} = \sum_{i=1}^r \sum_{j=1}^r h_i(z) h_j(z) [(A_i - K_i C_j) e + E_i d + \varphi_i]. \quad (38)$$

## 5 RESULT

The first part of the experiment it was determined to use a reference of 20 cm of liquid level for each of the tanks and after some time we changed the reference of both tanks to 10 cm, the control responded of tank 1 and 2 can be seen in Figure 3 and 4. We can see that the observer converges to the 20 cm reference and then responds to the reference change. The same way we can observe a similar behavior in tank 2 (Figure 4). So, we can observe that the state error converge to zero, Figure 5 y 6.

It is important to show the sliding mode signal that adds strength to the fuzzy observer, in Figure 7 we can observe a high frequency signal once the output reaches the reference.

Figure 3. Response of tank 1 with fuzzy controller and observer.

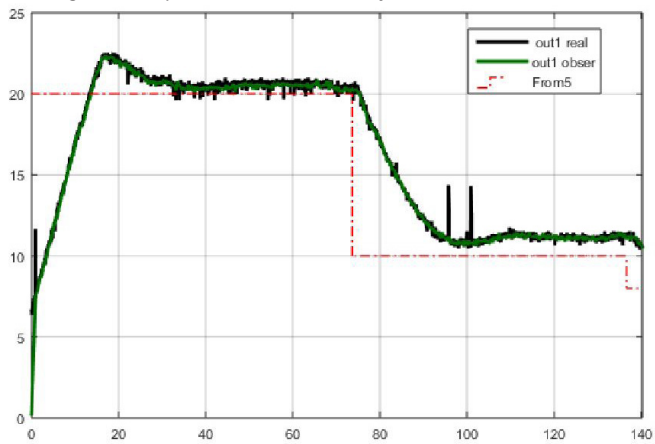


Figure 4. Tank 2 response with fuzzy controller and observer.

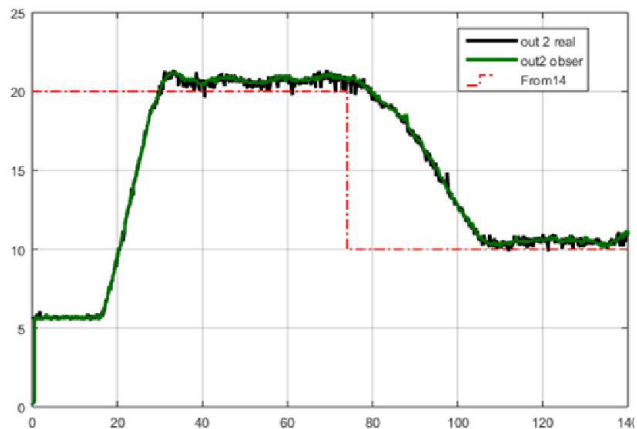


Figure 5. Error of the outputs and observed outputs corresponding to the state  $x_1$  and  $x_3$  respectively.

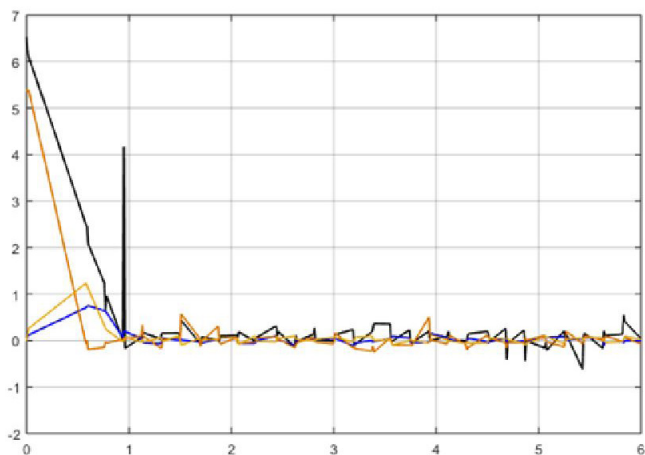




Figure 6. State's error.

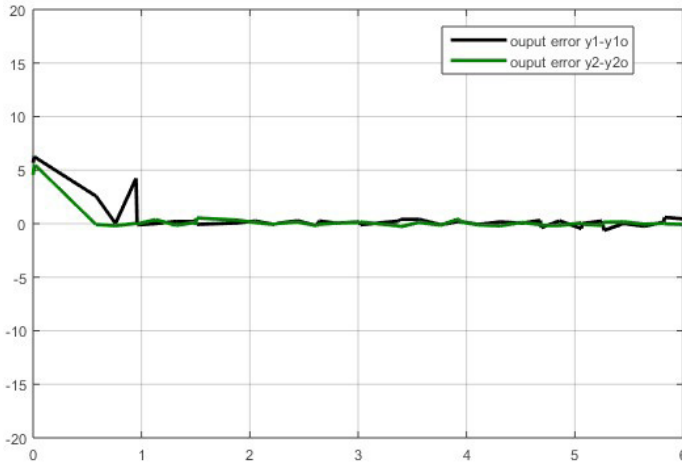
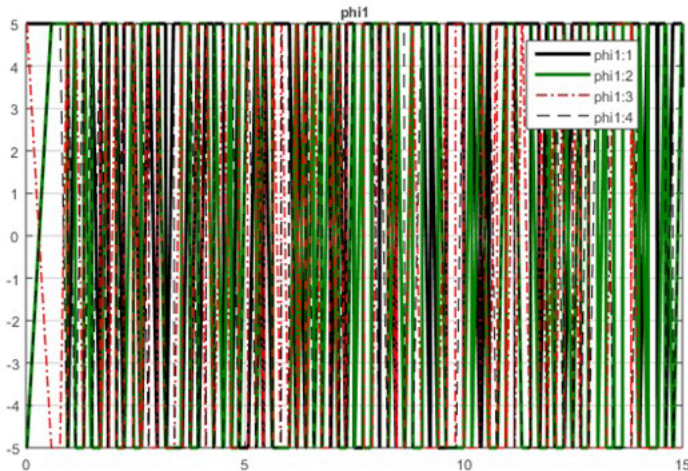


Figure 7. Sliding mode action (Chattering).



## 4 CONCLUSIONS

In this paper we performed the design and implementation in Real Time of a Takagi-Sugeno fuzzy sliding mode compensator for a second order two tanks liquid level system. In general, it is not easy to determine a control law using classical control to stabilize a nonlinear system. The fuzzy compensator achieved the objective of estimating and control with which the output reaches a constant reference, while the sliding mode fuzzy observer accelerated the process of convergence with the states.

The LMI tools allows to perform a stability analysis and at the same time obtain the compensator's gains.

## REFERENCES

- B. Castillo-Toledo, J. Anzures-Marin, "Model-based fault diagnosis using sliding mode observers to Takagi-Sugeno fuzzy model", Proceedings of the 2005 IEEE International Symposium on Intelligent Control.
- C.-T. Chen, Linear System Theory and Design, New York, EEUU: Oxford University Press, 1999.
- K. Tanaka y H. O. Wang, Fuzzy Control Systems Design and Analysis, New York: John Wiley & Sons, Inc., 2001.
- M. Junca, V. Grisales, A.Gauthier, "Introducción a las desigualdades lineales matriciales y su aplicación en el control automatico", Ciencia Investigación Academia Desarrollo, Octubre 2005.
- L. Fortuna, M Frasca, Optimal and Robust Control Advanced topics with Matlab, London and New York: Taylor & Francis Group, Inc., 2012.
- O. Perez, W. Colmenares, "desigualdades lineales matriciales en el diseño integrado de procesos", unpublished.
- S. Boyd, L. Ghaoui, E. Feron, V. Balakrishnan, "Linear Matrix Inequalities in System and Control Theory", Philadelphia: Society for Industrial and Applied Mathematics, Ind., 1994.
- V. Utkin, J. Guldner, J. Shi, "Sliding Mode Control in Electro-Mechanical Systems", New York: Taylor & Francis Group, 2009.

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## ÍNDICE REMISSIVO

### A

Agile programming 1, 6  
Agile training 1, 6  
Alquitrán 46, 47, 48, 49, 50, 51  
Alternatives to plastic 120, 132, 133, 135  
Análisis de algoritmos 35, 36, 37, 38, 40, 42, 45

### B

Base design 23, 24  
Blended Learning 219, 220, 222, 223, 224, 226, 227, 228

### C

Caracterización 51, 147, 189, 192, 193  
Charlottesville 261, 262, 263, 273, 277, 278, 279, 281, 282, 283, 284, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295  
Ciber espacio 231  
Climate 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 226  
Climate change 92, 93, 94, 95, 98, 99, 100, 101, 102, 103  
Climate crisis 92, 98  
Climate shock 92, 93, 94, 95, 98, 99, 100, 101, 102  
Competências 61, 176, 194, 200, 201, 202, 203, 205, 206, 207, 210, 215, 216, 217, 218  
Complejidad computacional 35, 37, 42, 43, 44  
Compuestos aromáticos 46, 49  
Comunicación 15, 64, 93, 158, 160, 169, 171, 175, 184, 190, 193, 194, 231, 232, 235, 248, 249, 252, 254, 255, 256, 257, 259, 260  
Comunidad LGBTTTTIQ+ 249, 251, 252, 255, 258  
Consumer behavior 120, 124, 125, 126, 127, 128, 129, 136, 137, 140  
Control clásico 11, 18  
Control difuso 11, 16, 17  
Convivencia 167, 172, 173, 175, 231, 232, 245, 259  
Corpora 77, 78, 80, 81, 82, 83, 84, 85, 86, 87, 88

### E

Eco-amigables 179, 180, 185, 186

Economía 53, 54, 61, 62, 89, 92, 93, 107, 136, 164, 186, 206  
Economy 92, 93, 94, 95, 96, 98, 99, 100, 101, 108, 124, 128, 132, 136, 138  
Education 10, 122, 124, 126, 139, 151, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229  
Effective instruction 219, 225  
Eficiencia computacional 35  
Empoderamiento 107, 112, 113, 114, 115, 117, 118, 119, 256  
Empresa familiar 167, 168, 169, 170, 172, 173, 174, 175, 177  
Empresas ecuatorianas 152, 153, 154, 163, 164  
Entrevista focalizada 249, 252, 255  
Esportismo 200, 201, 202, 203, 204, 205, 206, 207, 210, 216, 217, 218  
Estándares internacionales 153, 158

## F

Famílias estruturadas 23, 25, 28, 32  
Fraude 195, 230, 231, 232, 233, 234, 235, 237, 238, 240, 241, 244, 245  
Funciones de Landau 35, 37, 40, 41, 43, 44, 45  
Fuzzy logic control 22, 64

## G

Grupos de intereses 153

## H

Huaraches cómodos 178, 179, 182, 186, 187  
Hulla 46, 47, 48, 49, 50, 51

## I

Incertidumbre 52, 53, 55, 58, 60  
Infrarojo 46  
Instrumento 53, 107, 146, 172, 189, 193, 205, 217, 233, 263, 264, 265

## J

Jornalismo 261, 262, 292, 293  
Judô 200, 201, 202, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 218

## K

K-12 219, 225  
Kwarachi-Innova 178, 179, 180, 186, 187

## L

Lasswell 261, 262, 263, 264, 265, 266, 268, 269, 270, 271, 272, 273, 274, 277, 281, 282, 284, 285, 288, 289, 292, 293, 294, 295

Liderazgo 112, 176, 189, 190, 191, 192, 193, 194, 195, 196

LMI sliding modes observer 64

## M

Manuais de instruções dos eletrodomésticos 77, 80, 81

Materiales sustentables 178, 179, 182, 184, 186, 187

Matrizes estocásticas simétricas 23, 25, 29, 32

Mercados públicos 107, 108, 113

Modelo 16, 23, 25, 28, 32, 56, 57, 64, 139, 144, 151, 160, 164, 167, 168, 169, 172, 173, 175, 188, 189, 190, 191, 192, 193, 213, 216, 217, 218, 261, 262, 263, 264, 267, 268, 269, 270, 271, 272, 273, 274, 277, 278, 281, 282, 284, 285, 288, 289, 292, 293, 294

Modelos 23, 25, 28, 29, 32, 33, 173, 174, 189, 190, 191, 259, 265, 294

Mujeres rurales 107, 109, 110, 111, 113, 114, 117, 118, 119

## O

Online learning 219, 220, 222, 226, 227, 228

Online professional learning community 219, 221, 222, 228

Operaciones 36, 37, 38, 39, 40, 43, 44, 108, 154, 165, 167, 168, 171, 172, 173, 174, 175

## P

Perspectiva de género 113, 118, 249, 252, 253, 255, 257, 259

Pesquisa narrativa 200, 201, 205, 216, 217

Phishing 231, 234, 235, 236, 237, 238, 241, 245, 246, 247

Población 53, 54, 109, 110, 111, 141, 142, 143, 145, 146, 147, 148, 150, 163, 236, 240, 246, 258, 260

Professional development 219, 220, 221, 222, 228, 229

Professional learning and training methods 219

Programming training 1, 6

Programming with scrum 1

Propiedad 15, 43, 161, 167, 168, 169, 170, 171, 172, 173, 174, 175

## Q

Qualitative approach 120, 122, 153

## R

Racionalidade financeira 52, 55

Racionalidade limitada 52, 53, 55, 56, 57, 60, 61

Redes sociais 239, 243, 244, 249, 251, 254, 255, 256, 257, 258, 259, 260

Relleno sanitario 141, 142, 144, 145, 148, 149

Resíduos sólidos urbanos 141, 142, 144, 147, 149, 150, 151

Responsabilidade social 152, 153, 154, 156, 158, 159, 160, 161, 163, 164, 165, 166

Robot móvel 11, 13, 14, 18, 22

## S

Satisfação de gostos y necesidades 179

Scrum 1, 2, 5, 6, 7, 8, 9, 10

Single-use plastic packaging 120, 122, 123, 124, 125, 126, 127, 128, 129, 130, 133, 134, 135, 136

Sistemas de control 11, 12, 13, 22

Subproduto 46, 47, 50, 143

Sustainable consumption 120, 125, 126, 129, 130, 136

## T

Takagi Sugeno fuzzy model 64, 65, 76

Teoria hipodérmica 261, 262, 263, 267, 268, 271, 272, 273, 293

Terminologia controlada 77

Toma de decisiones 15, 52, 53, 55, 56, 57, 59, 60, 115, 157, 169, 172, 192, 196

Tradução automática 77, 78, 79, 80, 82, 83, 85, 88, 89

## U

United States 22, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 143, 151, 219, 262, 275, 286, 294

## V

Variables 17, 33, 64, 65, 66, 67, 141, 142, 144, 146, 147, 148, 149, 163, 172, 173, 177

Virtualidade 231, 255