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Fuzzy Tracking Control Design Using Observer-based Stabilizing Compensator for Nonlinear Systems

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Abstract— This paper presents fuzzy tracking control design for nonlinear systems. The design methodology is a synthesis of the tracking control theory of linear multivariable control and the Takagi–Sugeno fuzzy model. The observer-based stabilizing compensator type from multivariable tracking control theory is used, because not all states of the nonlinear system are fully available or measured while Takagi–Sugeno (T–S) fuzzy model is used to represent the dynamic of nonlinear system. The concept of parallel distributed compensation is employed to design fuzzy tracker and fuzzy observer from the T–S fuzzy model. The stability analysis of the designed system is derived via the Lyapunov function. Numerical simulation and real-time experiment are provided to illustrate the tracking control design procedure and performance of the proposed methods for practical application.

Keywords— Fuzzy tracking control, Takagi-Sugeno fuzzy model, observer-based stabilizing compensator

I. INTRODUCTION

The tasks of regulation (stabilization) and tracking are two typical control problems. In general, tracking problems are more difficult than regulation especially for nonlinear systems. In linear multivariable control theory, the tracking problem has been treated by several researchers, for instance, Davison [1], Davison and Patel [2], and Wonham [3]. Despite the fact that much progress has been made in studying the tracking problem of nonlinear systems, it is difficult to apply the theory and techniques to practical engineering problems. How to utilize clear concepts and simple methods of linear multivariable control theory in solving this problem is still very interesting.

Recently, Takagi–Sugeno (T–S) type fuzzy controllers have been successfully applied to regulation and tracking control design of nonlinear systems [4–12]. The T–S fuzzy model has been proved to be a very good representation for a nonlinear dynamic system [4]. In T–S fuzzy model, local dynamics in different state space regions are represented by linear models. The overall model of the system is achieved by fuzzy blending of these linear models. The control design is carried out based on the fuzzy model via Parallel Distributed Compensation (PDC) scheme [6]. In the PDC design, each control rule is designed from the corresponding rule of a T–S fuzzy model. The designed fuzzy controller shares the same fuzzy sets with the fuzzy model in the premise parts [13].

Applications of such a fuzzy control scheme can be found in [5], [12–13].

In this paper, a tracking control design based on the T–S fuzzy model is presented. First, T–S fuzzy model is used to represent a nonlinear system. This fuzzy model is a piecewise interpolation of several linear models through membership functions. Then, we use a stabilizing compensator based on observer to solve the tracking problem [14]. This type of stabilizing compensator is chosen because the states of nonlinear system are not all directly measurable. If the T–S fuzzy model can accurately approximate the original nonlinear system, the fuzzy controller and observer can be designed independently using the separation property [10]. For the proposed method, the stability analysis is derived for the designed system using Lyapunov theory. The LMI convex programming technique is used to solve this problem.

The paper is organized as follows. Section 2 addresses the synthesis of fuzzy tracking control system for nonlinear plant. The stability analysis of the closed-loop T–S fuzzy systems and the design of fuzzy observer are also discussed in this section. In Section 3, the application of the proposed method in pendulum-cart system is derived. Also, the simulation and experiment results are provided in Section 3. Finally, Section 4 concludes this paper.

II. FUZZY TRACKING CONTROL

A. T-S fuzzy model and compensator model

A fuzzy dynamic model has been proposed by Takagi and Sugeno [4] to represent a nonlinear system. The T–S fuzzy model is described by fuzzy *If-Then* rules and employed to deal with the control design problem for the nonlinear systems. The i th rule of the fuzzy model is of the following form [5]:

Plant Rule i :

If $z_1(t)$ is F_{i1} and $\dots$ and $z_g(t)$ is F_{ig}

Then $\dot{x}(t) = A_i x(t) + B_i u(t)$

$$y(t) = C_i x(t) \quad i = 1, 2, \dots, r \quad (1)$$

where $x(t) \in R^n$ denotes the state vector, $u(t) \in R^m$ denotes the control input, $y(t) \in R^q$ denotes output of the system, F_{ij} ($j=1, 2, \dots, g$) is the fuzzy set, r is the number of *IF-THEN*

rules, $z_1(t) \sim z_g(t)$ are the premise variables, and A_i , B_i , and C_i are state, input, and output matrix respectively.

Using singleton fuzzifier, max-product inference and center average defuzzifier, we can write the aggregated fuzzy model as [5, 6]:

$$\begin{aligned}\dot{x}(t) &= \frac{\sum_{i=1}^r \mu_i(z(t)) [A_i x(t) + B_i u(t)]}{\sum_{i=1}^r \mu_i(z(t))} \\ &= \sum_{i=1}^r h_i(z(t)) [A_i x(t) + B_i u(t)] \\ y(t) &= \frac{\sum_{i=1}^r \mu_i(z(t)) [C_i x(t)]}{\sum_{i=1}^r \mu_i(z(t))} \\ &= \sum_{i=1}^r h_i(z(t)) [C_i x(t)]\end{aligned}\quad (2)$$

where μ_i satisfies

$$\begin{aligned}\mu_i(z(t)) &= \prod_{j=1}^g F_{ij}(z_j(t)) \\ h_i(z(t)) &= \mu_i(z(t)) / \sum_{i=1}^r \mu_i(z(t)) \\ z(t) &= [z_1(t), z_2(t), \dots, z_g(t)]\end{aligned}$$

with $z_j(t)$ is the grade of membership of $z_j(t)$ in F_{ij} . We assume

$$\mu_i(z(t)) \geq 0 \quad \text{and} \quad \sum_{i=1}^r \mu_i(z(t)) > 0 \quad \text{for all } t.$$

Therefore, we get [5]

$$h_i(z(t)) \geq 0, \quad \text{for } i = 1, 2, \dots, r$$

$$\text{and } \sum_{i=1}^r h_i(z(t)) = 1.$$

Consider a servo-compensator model as follows [15]:

$$\begin{aligned}\dot{x}_c(t) &= A_c x_c(t) + B_c e(t) \\ y_c(t) &= x_c(t) \\ e(t) &= y_r(t) - y(t)\end{aligned}\quad (3)$$

where $x_c(t) \in R^{n_c}$ are the compensator states, $y_r(t) \in R^q$ are the reference input signals, $e(t) \in R^q$ are the tracking error in the system, and

$$\begin{aligned}A_c &= \text{block diag} \{ \underbrace{A \ A \ \dots \ A}_q \} \\ B_c &= \text{block diag} \{ \underbrace{B \ B \ \dots \ B}_q \}.\end{aligned}$$

A is the companion matrix of the characteristic polynomial of the (reference) signal, i.e. $\phi(s) = s^l + \alpha_{l-1}s^{l-1} + \dots + \alpha_1s + \alpha_0$, so that

$$A = \begin{bmatrix} 0 & & & \\ \vdots & & I_{l-1} & \\ 0 & & & \\ -\alpha_0 & -\alpha_1 & \dots & -\alpha_{l-1} \end{bmatrix}; \quad B = \begin{bmatrix} 0 \\ \vdots \\ 0 \\ 1 \end{bmatrix}.$$

The synthesis of the plant model (1) and the compensator model (3), the following augmented system:

$$\begin{bmatrix} \dot{x}(t) \\ \dot{x}_c(t) \end{bmatrix} = \begin{bmatrix} A_i & 0 \\ -B_c C_i & A_c \end{bmatrix} \begin{bmatrix} x(t) \\ x_c(t) \end{bmatrix} + \begin{bmatrix} B_i \\ 0 \end{bmatrix} u(t) + \begin{bmatrix} 0 \\ B_c \end{bmatrix} y_r(t) \quad (4)$$

is obtained. The final controlled system (2) is sequentially connected with the servo-compensator model (3); we obtain the following system

$$\begin{aligned}\begin{bmatrix} \dot{x}(t) \\ \dot{x}_c(t) \end{bmatrix} &= \sum_{i=1}^r h_i(z(t)) \begin{bmatrix} A_i & 0 \\ -B_c C_i & A_c \end{bmatrix} \begin{bmatrix} x(t) \\ x_c(t) \end{bmatrix} \\ &+ \sum_{i=1}^r h_i(z(t)) \begin{bmatrix} B_i \\ 0 \end{bmatrix} u(t) + \begin{bmatrix} 0 \\ B_c \end{bmatrix} y_r(t).\end{aligned}\quad (5)$$

B. Fuzzy Controller

The fuzzy controller is designed via the PDC scheme, where each control rule is designed from corresponding rule of a T-S fuzzy model. These rules share the same fuzzy sets with the fuzzy model in the premise parts [13]. For the local model (4), the controller rules are given as follows:

Controller Rule i :

If $z_1(t)$ is F_{i1} and $\dots$ and $z_g(t)$ is F_{ig} ,

$$\text{Then } u(t) = -[K_i \ K_{ci}] \begin{bmatrix} x(t) \\ x_c(t) \end{bmatrix}; \quad i = 1, 2, \dots, r \quad (6)$$

Then, the final output of the controller is

$$\begin{aligned}u(t) &= -\sum_{i=1}^r \mu_i(z(t)) [K_i \ K_{ci}] \begin{bmatrix} x(t) \\ x_c(t) \end{bmatrix} / \sum_{i=1}^r \mu_i(z(t)) \\ &= -\sum_{i=1}^r h_i(z(t)) [K_i \ K_{ci}] \begin{bmatrix} x(t) \\ x_c(t) \end{bmatrix}; \quad i = 1, 2, \dots, r\end{aligned}\quad (7)$$

where the weight $h_i(z(t))$ is the same as the weight of i th rule of the fuzzy system (2).

A sufficient condition that guarantees the stability of the fuzzy system is obtained in terms of Lyapunov's direct method. Using the following theorem, the stability conditions for the fuzzy system can be derived.

Theorem 1 [5]: The equilibrium of the continuous fuzzy control system is globally asymptotically stable if there exists a common positive definite matrix P such that

$$G_{ii}^T P + P G_{ii} < 0 \quad i=1, 2, \dots, r$$

$$\left(\frac{G_{ij} + G_{ji}}{2} \right)^T P + P \left(\frac{G_{ij} + G_{ji}}{2} \right) \leq 0 \quad i < j \leq r \quad (8)$$

where G_{ij} is defined as:

$$G_{ij} = \begin{bmatrix} A_i - B_i K_j & -B_i K_j \\ -B_c C_i & A_c \end{bmatrix} \quad i, j=1, 2, \dots, r$$

These inequalities can be efficiently solved numerically through a linear matrix inequality (LMI) framework.

C. Fuzzy Observer

The fuzzy tracking controller has the local linear state feedback laws in the consequent parts. In a real problem, not all states are measurable; hence it is necessary to design a fuzzy observer to estimate the states.

Suppose the following fuzzy linear observer is proposed to deal with the state estimation of local linear model (1).

Observer Rule i :

If $z_1(t)$ is F_{i1} and ... and $z_g(t)$ is F_{ig} ,

Then $\dot{\hat{x}}(t) = A_i \hat{x}(t) + B_i u(t) + L_i (y(t) - \hat{y}(t))$

$$\hat{y}(t) = C_i \hat{x}(t) \quad (9)$$

where $L_i \in R^{n \times q}$ is the observer gain, $y(t)$ and $\hat{y}(t)$ are the final output of the fuzzy system and the fuzzy observer. Then, the final estimated state of the fuzzy observer is

$$\hat{\hat{x}}(t) = \frac{\sum_{i=1}^r \mu_i(z(t)) [A_i \hat{x}(t) + B_i u(t) + L_i (y(t) - \hat{y}(t))]}{\sum_{i=1}^r \mu_i(z(t))}$$

$$= \sum_{i=1}^r h_i(z(t)) [A_i \hat{x}(t) + B_i u(t) + L_i (y(t) - \hat{y}(t))]$$

and the final output of the fuzzy observer is

$$\hat{\hat{y}}(t) = \sum_{i=1}^r \mu_i(z(t)) C_i \hat{x}(t) / \sum_{i=1}^r \mu_i(z(t)) = \sum_{i=1}^r h_i(z(t)) C_i \hat{x}(t) \quad (10)$$

where the weight $h_i(z(t))$ is the same as the weight of i th rule of the fuzzy system (2). Utilizing the final estimated states $\hat{\hat{x}}(t)$, (5), and (7), we obtain the following fuzzy controller.

Controller Rule i :

If $z_1(t)$ is F_{i1} and ... and $z_g(t)$ is F_{ig} ,

$$\text{Then } u(t) = -[K_i \quad K_{ci}] \begin{bmatrix} \hat{\hat{x}}(t) \\ x_c(t) \end{bmatrix} \quad (11)$$

Hence, the overall fuzzy controller is given by

$$u(t) = - \sum_{i=1}^r \mu_i(z(t)) [K_i \quad K_{ci}] \begin{bmatrix} \hat{\hat{x}}(t) \\ x_c(t) \end{bmatrix} / \sum_{i=1}^r \mu_i(z(t))$$

$$= - \sum_{i=1}^r h_i(z(t)) [K_i \quad K_{ci}] \begin{bmatrix} \hat{\hat{x}}(t) \\ x_c(t) \end{bmatrix} \quad (12)$$

Because the observer can be designed accurately to approximate the dynamic of nonlinear system, the estimated states represent the original states of the system. Hence, this tracking control system can be considered as a common state feedback problem.

III. APPLICATION IN PENDULUM-CART SYSTEM

In this section, we will apply the proposed approach to design a fuzzy tracking control system to control the pendulum-cart system. Our goal is making the output of the system to track a sinusoidal reference signal and to stabilize the pendulum in upright position.

The state equations of the pendulum-cart system are [16]

$$\dot{x}_1 = x_3$$

$$\dot{x}_2 = x_4$$

$$\dot{x}_3 = \frac{a(F - T_c - \mu x_4^2 \sin x_2) + l \cos x_2 (\mu g \sin x_2 - f_p x_4)}{J + \mu l \sin^2 x_2}$$

$$\dot{x}_4 = \frac{l \cos x_2 (F - T_c - \mu x_4^2 \sin x_2) + \mu g \sin x_2 - f_p x_4}{J + \mu l \sin^2 x_2} \quad (13)$$

where $a = l^2 + (J/(m_c + m_p))$, $\mu = (m_c + m_p)l$, x_1 denotes the cart position (m) or distance from the centre of the rail, x_2 denotes the angle (rad) of the pendulum from the vertical, x_3 is the cart velocity (m/s), and x_4 is the pendulum angular velocity (rad/s). g is the gravity constant, m_p is the mass (kg) of the pendulum, m_c is the mass (kg) of the cart, l is the distance from the axis of rotation to the centre of mass of the pendulum-cart system, J is the moment of inertia of the pendulum-cart system with respect to the centre of mass, F is the force (N) applied to the cart, T_c is the friction force, and f_p is the pendulum friction constant (kg·m²/s). The system parameters used for simulation and experiment are $m_c = 1.12$ kg, $m_p = 0.025$ kg, $J = 0.0135735$ kgm², $g = 9.8$ m/s², $l = 0.0167903$ m, and $f_p = 0.000107$ kg·m/s [16].

The T-S fuzzy model for the system in (13) is given by the three-rule fuzzy model:

R₁: If $x_2(t)$ is F_1 (about 0)

Then $\dot{x}(t) = A_1 x(t) + B_1 u(t)$; $y(t) = C_1 x(t)$

R₂: If $x_2(t)$ is F_2 (about $\pm\pi/15$)

Then $\dot{x}(t) = A_2 x(t) + B_2 u(t)$; $y(t) = C_2 x(t)$

R₃: If $x_2(t)$ is F_3 (about $\pm\pi/7.5$)

Then $\dot{x}(t) = A_3 x(t) + B_3 u(t)$; $y(t) = C_3 x(t)$

where

$$A_1 = \begin{bmatrix} 0.0 & 0.0 & 1.0 & 0.0 \\ 0.0 & 0.0 & 0.0 & 1.0 \\ 0.0 & 0.2524 & 0.0 & -0.0001 \\ 0.0 & 15.0319 & 0.0 & -0.0079 \end{bmatrix}; B_1 = \begin{bmatrix} 0.0 \\ 0.0 \\ 0.8272 \\ 1.2370 \end{bmatrix}$$

$$A_2 = \begin{bmatrix} 0.0 & 0.0 & 1.0 & 0.0 \\ 0.0 & 0.0 & 0.0 & 1.0 \\ 0.0 & 0.2298 & 0.0 & -0.0001 \\ 0.0 & 14.6546 & 0.0 & -0.0079 \end{bmatrix}; B_2 = \begin{bmatrix} 0.0 \\ 0.0 \\ 0.8263 \\ 1.2086 \end{bmatrix}$$

$$A_3 = \begin{bmatrix} 0.0 & 0.0 & 1.0 & 0.0 \\ 0.0 & 0.0 & 0.0 & 1.0 \\ 0.0 & 0.2366 & 0.0 & -0.0001 \\ 0.0 & 14.7691 & 0.0 & -0.0079 \end{bmatrix}; B_3 = \begin{bmatrix} 0.0 \\ 0.0 \\ 0.8266 \\ 1.2173 \end{bmatrix}$$

$$C_i = [1 \ 0 \ 0 \ 0] \text{ for } i=1,2,3$$

These matrices are obtained from linearization of (13) for three operating point, i.e. $x^1=(0,0,0,0)$, $x^2=(0,\pi/15,0,0)$, and $x^3=(0,\pi/7.5,0,0)$. We use the angle of pendulum (x_2) as the premise variable and the cart position as the system output to track the reference signal.

Membership function for Plant Rule 1, 2 and 3 are

$$F_1(x_2(t)) = (1 - (1/(1 + \exp[-90(x_2(t) - \pi/30)]))) \cdot (1/(1 + \exp[-90(x_2(t) + \pi/30)]))$$

$$F_2(x_2(t)) = (1 - (1/(1 + \exp[-90(x_2(t) - \pi/15) - \pi/30]))) \cdot (1/(1 + \exp[-90(x_2(t) - \pi/15) + \pi/30]))$$

$$F_3(x_2(t)) = 1/(1 + \exp[-90(x_2(t) - \pi/7.5 + \pi/30)]).$$

The Laplace transformation of the reference signal $y_r(t)=0.1\sin(0.2\pi t)$ is $Y_r(s)=0.0628/(s^2+0.3948)$. It can be seen that the characteristic polynomial of the signal is $\phi(s)=s^2+0.3948$. Therefore, the compensator model of $y_r(t)$ is

$$\dot{x}_c(t) = \begin{bmatrix} 0 & 1 \\ -0.3948 & 0 \end{bmatrix} x_c(t) + \begin{bmatrix} 0 \\ 1 \end{bmatrix} e(t)$$

where $e(t) = y_r(t) - x_1(t)$.

Using the augmented system (4), and choose the closed loop eigenvalues of $[-3.1 \ -2.5 \ -2.3 \ -2.1 \ -1.9 \ -1.6]$ by trial and error, we obtain the controller and the compensator gain matrices using pole placement method

$$K_1 = [-24.3632 \ 86.1710 \ -17.5418 \ 22.3955]$$

$$K_2 = [-26.4568 \ 91.0714 \ -18.8395 \ 23.9604]$$

$$K_3 = [-29.9548 \ 101.1890 \ -21.2378 \ 27.6260]$$

$$K_{cl} = [-1.6545 \ 25.6296]$$

$$K_{c2} = [-2.0053 \ 17.0378]$$

$$K_{c3} = [-2.1457 \ 19.4999]$$

In order to check the stability of a fuzzy system with a fuzzy tracking control system, one must find a common positive definite matrices P such that the equation (8) is satisfied. LMI optimization algorithm can be used to find the following matrix.

$$P = \begin{bmatrix} 0.104 & -0.363 & 0.084 & -0.095 & 0.009 & -0.055 \\ -0.363 & 1.462 & -0.309 & 0.360 & -0.038 & 0.189 \\ 0.084 & -0.309 & 0.082 & -0.089 & 0.008 & -0.050 \\ -0.095 & 0.360 & -0.089 & 0.104 & -0.009 & 0.055 \\ 0.009 & -0.038 & 0.008 & -0.009 & 0.004 & -0.005 \\ -0.055 & 0.189 & -0.050 & 0.055 & -0.005 & 0.039 \end{bmatrix}$$

To design the fuzzy observer, choosing the closed-loop eigenvalues $[-27.5+27i \ -27.5-27i \ -18.9+1.9i \ -18.9-1.9i]$ for the observer system (9), we obtain the observer gain matrices

$$L_1 = \begin{bmatrix} 48.42 & 18.62 \\ -28.03 & 44.31 \\ 762.63 & 304.99 \\ -523.68 & 508.52 \end{bmatrix}; L_2 = \begin{bmatrix} 49.34 & 31.86 \\ -18.29 & 47.39 \\ 728.16 & 625.65 \\ -377.85 & 588.62 \end{bmatrix}$$

$$L_3 = \begin{bmatrix} 52.04 & 24.77 \\ -22.25 & 48.70 \\ 822.30 & 465.23 \\ -459.54 & 610.23 \end{bmatrix}$$

In the simulation, to assess the effectiveness of the control law, we apply the designed control system to the original system (13). The simulation program is realized by MATLAB/Simulink. Simulations results are depicted in Figures 1–2. These figures show the comparative results of using the robust servomechanism problem (RSP) method and using the fuzzy tracking control proposed in this paper under the identical initial conditions. The results indicate that the output (cart position) of the tracking control system can follow the reference signal $y_r(t)$. The system can also stabilize the pendulum in the upright position.

The simulation results show that the fuzzy tracking controller has much better performance than the RSP controller. The time response of the cart required to follow the reference signal for the system with the fuzzy tracking controller is shorter than that of the RSP controller. The overshoot and settling time of the response of pendulum position converging back to the equilibrium for the system with the proposed controller are better than those of the RSP controller.

A real-time experiment on the pendulum-cart system from The Feedback Instrument Ltd. is conducted to verify the performance of the designed fuzzy tracking control system. The control system is performed using Matlab 6.5 version with Real-Time Workshop and Simulink Toolbox from The MathWorks, Inc.

Figure 1. Closed-loop response of the cart position (x_1), and the angle of the pendulum (x_2) for initial condition $x = [0, 0.3 \text{ rad}, 0, 0]$.

Figure 2. Closed-loop response of the cart position (x_1), and the angle of the pendulum (x_2) for initial condition $x = [0, 0.5 \text{ rad}, 0, 0]$.

Experiment results indicate the response of the system with the proposed fuzzy tracking controller has an excellent performance. Figure 3 shows the behavior of the system for initial conditions $x_2(0)$ is about 0.3 rad, and $x_1(0)=x_3(0)=x_4(0)=0$; the reference signal is $y_r(t)=0.1 \sin(0.2\pi t)$. This result shows that the performance of the fuzzy tracking control system does not have much difference comparing with the simulation result. It can be concluded that the responses of the designed control system met the designed criteria, i.e. the cart can follow the sinusoidal reference signal and the pendulum is stable in upright position.

IV. CONCLUSION

In this paper we have presented a systematic design method of fuzzy tracking control using observer-based compensator for nonlinear systems. The methodology is a synthesis of multivariable control and fuzzy control using Takagi-Sugeno fuzzy model. Based on the numerical simulations and the experiment, it can be concluded that the control performances of the proposed fuzzy tracking control system designed in this paper can meet the design objectives. Furthermore, the controller is able to give better performance than that of the original robust servomechanism problem (RSP) technique. Hence, the proposed fuzzy tracking control can improve the performance specifications of the multivariable tracking control.

Figure 3. Real-time experiment response of the cart position (x_1), and the angle of the pendulum (x_2).

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Fuzzy tracking control design using

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Electr. Eng. Dept., Inst. Teknol. Sepuluh Nopember, Surab

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ABSTRACT

This paper presents fuzzy tracking control design for multivariable control and the Takagi-Sugeno fuzzy model is used, because not all states of the nonlinear system dynamic of nonlinear system. The concept of parallel fuzzy model. The stability analysis of the designed system is provided to illustrate the tracking control design procedure.

INDEX TERMS

- **INSPEC**

- **Controlled Indexing**

- Lyapunov methods , control system synthesis , disturbance rejection , stability

- **Non Controlled Indexing**

- Lyapunov function , Takagi-Sugeno fuzzy model , compensator , parallel distributed compensation control

- **Author Keywords**

- Fuzzy tracking control , Takagi-Sugeno fuzzy model ,

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2010 International Conference on System Science and Engineering

July 1-3, 2010, Taipei, Taiwan

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Welcome to ICSSE 2010

On behalf of the Taiwan Association of System Science and Engineering (TASSE), and the Organizing and Program Committees, it is our greatest pleasure to welcome you to the conference: the International Conference on System Science and Engineering (ICSSE 2010), held here at National Taipei University of Technology (NTUT) in Taipei, Taiwan during July 1-3, 2010. As we all agree upon, technology advancements provide opportunities not only for improving system capabilities, but also for introducing development risks that must be weighed and managed. Thus, it is our goal to bring together scholars from all areas to have a forum to discuss, demonstrate and exchange research ideas in the scope of system science and engineering. This event will definitely provide a great opportunity for scientists, engineers, and practitioners from all over the world to present the latest system design concepts, research results, developments, and applications, as well as to facilitate interactions between scholars and practitioners.

Although it is the first time for TASSE to host such an international event in Taiwan, we received 156 submissions including special sessions and contributed papers, from which the committee selected 124 papers for presentation at the conference. Program Committee for ICSSE 2010 have assembled a comprehensive technical program that covers a broad spectrum of topics in System Science and Engineering, which comprises 24 sessions spanning a period of three days. To provide better opportunities to disseminate the research results presented at the Conference, accepted papers published in the proceedings of ICSSE 2010 will also be included in the IEEE Xplore digital library.

The highlights of the conference include plenary speeches given by distinguished individuals. In line with the themes of ICSSE 2010, we have the following four plenary speeches, including "To Study the Success of Mayo Clinic by Use of Systems Ethics" by Professor Kuang-Wei Han, the Honorary Prof. of National Chiao-Tung University, Academician, and Academia Sinica, R.O.C., "Finding the Right Genes for Disease and Prognosis Prediction" by Prof. Lawrence O. Hall, from the University of South Florida, "Towards An Integrative and Adaptive Service System" by Prof. James M. Tien from the College of Engineering University of Miami, and "Adaptive Sensor Fault Detection and Identification and Life Extending in Health Monitoring Systems" by Prof. C. L. Philip Chen from The University of Texas. We believe their speeches will definitely be informative and entertaining.

Last, but definitely not least, we would like to express our sincere gratitude to everyone involved in making the conference a success. Many thanks go to the organizing committee, the plenary speakers, the special session organizers, the program committees and reviewers, the conference participants, and of course, to all the contributing authors who will be sharing the results of their research.

Again, it is our great pleasure to have you with us at the conference, where we hope new ties will be made and existing ones renewed and strengthened. Please accept our best wishes for a wonderful and stimulating stay in Taipei.

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