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Research Article

Controllable and Observable Polynomial Description for 2D Noncausal Systems

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Two-dimensional state-space systems arise in applications such as image processing, iterative circuits, seismic data processing, or more generally systems described by partial differential equations. In this paper, a new direct method is presented for the polynomial realization of a class of noncausal 2D transfer functions. It is shown that the resulting realization is both controllable and observable.

1. INTRODUCTION

A 2D system is a system in which information propagates in two independent directions. Multidimensional (nD) systems have found many applications in areas such as image and video processing, geophysical exploration, linear multipass processes, iterative learning control systems, lumped and distributed networks [1]. In his pioneering work, Rosenbrock [2] has used polynomial matrices in a single variable to represent systems described by ordinary differential/difference equations. The success of his approach is mainly due to the computational aspects of the division ring involved. The polynomial matrix approach has been extended to the 2D case by a number of authors such as Bose [1], Frost and Boudellioua [3, 4], Johnson [5], Pugh et al. [6]. In the case of a 2D system, the resulting matrix is a two-variable polynomial matrix. Unfortunately, the polynomial ring in two variables is not an Euclidean division ring which makes extensions from 1D to 2D in most situations not possible.

2. CAUSAL 2D SYSTEMS

State-space models play an important role in the theory of 1D finite-dimensional linear systems. Several authors, for example, Attasi [7], Fornasini and Marchesini [8], and Roesser [9] have proposed different state-space models for 2D discrete systems or systems described by partial differential equations and have suggested some extensions of the usual 1D notions to the 2D case. However, it has been shown by Kung et al. [10] and other authors that Roesser's model is the most satisfactory and the most general since the other models can be embedded in it. Roesser's model is one in which the local state is divided into a horizontal state and a vertical state which are propagated, respectively, horizontally and vertically by first-order difference equations.

The model has the form

$$\begin{aligned} x^h(i+1, j) &= A_1 x^h(i, j) + A_2 x^v(i, j) + B_1 u(i, j), \\ x^v(i, j+1) &= A_3 x^h(i, j) + A_4 x^v(i, j) + B_2 u(i, j), \\ y(i, j) &= C_1 x^h(i, j) + C_2 x^v(i, j), \end{aligned} \tag{1}$$

where $x^h(i, j)$ is the horizontal state vector, $x^v(i, j)$ is the vertical state vector, $u(i, j)$ is the input vector, $y(i, j)$ is the output vector, and $A_1, A_2, A_3, A_4, B_1, B_2, C_1, C_2$ are real constant matrices of appropriate dimensions.

System (1) can be written in the polynomial form

$$\left[\begin{array}{cc|c} sI_n - A_1 & -A_2 & B_1 \\ -A_3 & zI_m - A_4 & B_2 \\ \hline -C_1 & -C_2 & 0 \end{array}\right] \left[\begin{array}{c} x^h(i,j) \\ x^v(i,j) \\ \hline -u(i,j) \end{array}\right] = \left[\begin{array}{c} 0 \\ 0 \\ \hline -y(i,j) \end{array}\right], \tag{2}$$

where s denotes an advance shift operator in the horizontal direction and z denotes an advance shift operator in the vertical direction. The polynomial matrix in s and z,

$$P(s,z) = \left[\begin{array}{cc|c} sI_n - A_1 & -A_2 & B_1 \\ -A_3 & zI_m - A_4 & B_2 \\ \hline -C_1 & -C_2 & 0 \end{array}\right], \tag{3}$$

is called a polynomial matrix description (PMD) associated with system (1). The order of $P(s,z)$ is given by $n+m$ and its rational transfer function is

$$G(s,z) = \begin{bmatrix} C_1 & C_2 \end{bmatrix} \begin{bmatrix} sI_n - A_1 & -A_2 \\ -A_3 & zI_m - A_4 \end{bmatrix}^{-1} \begin{bmatrix} B_1 \\ B_2 \end{bmatrix}. \quad (4)$$

Given the transfer function $G(s,z)$, the associated PMD, $P(s,z)$ that gives rise to $G(s,z)$ is called a realization of $G(s,z)$.

Using the definitions given by Zerz [11], system (1) is said to be strongly controllable if the matrix

$$\mathcal{C}(s,z) = \left[\begin{array}{cc|c} sI_n - A_1 & -A_2 & B_1 \\ -A_3 & zI_m - A_4 & B_2 \end{array}\right] \quad (5)$$

has full rank for all $(s,z) \in \mathbb{C}^2$ and canonical if furthermore it is observable, that is, the matrix

$$\mathcal{O}(s,z) = \left[\begin{array}{cc} sI_n - A_1 & -A_2 \\ -A_3 & zI_m - A_4 \\ \hline -C_1 & -C_2 \end{array}\right] \quad (6)$$

has no nontrivial factors in $\mathbb{R}[s,z]$, that is, any factorization $\mathcal{O}(s,z) = \overline{\mathcal{O}}(s,z)F(s,z)$, where $F(s,z)$ is square, implies that $F(s,z)$ is unimodular.

Another term used in the context of PMDs of the form (3) is that the PMD is said to be separable if the determinant

$$\begin{vmatrix} sI_n - A_1 & -A_2 \\ -A_3 & zI_m - A_4 \end{vmatrix} \quad (7)$$

can be written as a product of two polynomials, one in s, the other in z.

3. NONCAUSAL 2D SYSTEMS

One of the limitations of the model given in (1) is that it can only be used to describe causal 2D transfer functions. In other words, it is suitable only for the representation of northeast quarter plane 2D systems. Several authors have suggested a generalized state-space description for 2D systems. Zak [12] suggested a generalized model based on Roesser's model while Kaczorek [13, 14] proposed a model based on that of Fornasini and Marchesini. Noncausal 2D systems have been studied more recently by a number of authors such as Galkowski [15], Kaczorek [16], Zou and Campbell [17], and Xu et al. [18].

In the following, we will be concerned with PMDs of the type given by Zak [12], that is,

$$P(s,z) = \left[\begin{array}{cc|c} sE_1 - A_1 & -A_2 & B_1 \\ -A_3 & zE_2 - A_4 & B_2 \\ \hline -C_1 & -C_2 & 0 \end{array}\right], \quad (8)$$

where A_1, A_2, A_3, A_4 are, respectively, $n \times n$, $n \times m$, $m \times n$, $m \times m$ real constant matrices, E_1, E_2 are, respectively, $n \times n$ and $m \times m$ real constant matrices which may be singular, and B_1, B_2, C_1, C_2 are, respectively, $n \times l$, $m \times l$, $p \times n$, $p \times m$ real constant matrices.

The transfer function corresponding to the PMD (8) is the $p \times l$ rational matrix given by

$$G(s,z) = \begin{bmatrix} C_1 & C_2 \end{bmatrix} \begin{bmatrix} sE_1 - A_1 & -A_2 \\ -A_3 & zE_2 - A_4 \end{bmatrix}^{-1} \begin{bmatrix} B_1 \\ B_2 \end{bmatrix}. \quad (9)$$

PMDs of the form (8) can be regarded as extensions of the PMDs over $\mathbb{R}[s]$ of the form

$$P(s) = \left[\begin{array}{c|c} sE - A & B \\ \hline -C & 0 \end{array}\right], \quad (10)$$

which are often encountered in the study of the so-called generalized or descriptor state-space systems developed by Verghese et al. [19]. PMDs of the type (8) have been found to be useful by Zak [12] in the study of systems described by high-order partial differential equations.

One way to establish a connection between PMDs of the form (8) is via Rosenbrock's strict-system equivalence (SSE) defined by the following.

Definition 1. Two PMDs $P(s,z)$ and $Q(s,z)$ of the type (8) and having the same size are said to be SSE if they are related by a transformation of the form

$$\left[\begin{array}{c|c} M(s,z) & 0 \\ \hline X(s,z) & I_p \end{array}\right] \underbrace{\left[\begin{array}{cc|c} sE_1 - A_1 & -A_2 & B_1 \\ -A_3 & zE_2 - A_4 & B_2 \\ \hline -C_1 & -C_2 & 0 \end{array}\right]}_{P(s,z)} = \underbrace{\left[\begin{array}{cc|c} sF_1 - L_1 & -L_2 & R_1 \\ -L_3 & zF_2 - L_4 & R_2 \\ \hline -S_1 & -S_2 & 0 \end{array}\right]}_{Q(s,z)} \left[\begin{array}{c|c} N(s,z) & Y(s,z) \\ \hline 0 & I_l \end{array}\right], \quad (11)$$

where $M(s,z)$, $N(s,z)$ are $(n+m)\times(n+m)$ unimodular polynomial matrices and $X(s,z)$, $Y(s,z)$ are polynomial matrices of appropriate dimensions.

The transformation of SSE given in (11) preserves the transfer function and other system structural properties such as controllability and observability. However, the main disadvantage of using SSE in the context of PMDs of the type (8) is that it does not preserve the state space form (8). So in the case when two PMDs $P(s,z)$ and $Q(s,z)$ are in state-space form (8) and have the same dimensions, we introduce the following notion of restricted-system equivalence (RSE).

Definition 2. Two PMDs $P(s,z)$ and $Q(s,z)$ of the type (8) are said to be RSE if they are related by a transformation of the form

$$\left[\begin{array}{cc|c} M_1 & 0 & 0 \\ 0 & M_2 & 0 \\ \hline 0 & 0 & I_p \end{array}\right] \underbrace{\left[\begin{array}{cc|c} sE_1 - A_1 & -A_2 & B_1 \\ -A_3 & zE_2 - A_4 & B_2 \\ \hline -C_1 & -C_2 & 0 \end{array}\right]}_{P(s,z)} = \underbrace{\left[\begin{array}{cc|c} sF_1 - L_1 & -L_2 & R_1 \\ -L_3 & zF_2 - L_4 & R_2 \\ \hline -S_1 & -S_2 & 0 \end{array}\right]}_{Q(s,z)} \left[\begin{array}{cc|c} N_1 & 0 & 0 \\ 0 & N_2 & 0 \\ \hline 0 & 0 & I_l \end{array}\right], \quad (12)$$

where M_1, M_2, N_1, N_2 are nonsingular real constant matrices of appropriate dimensions.

The transformation of RSE in (12) is clearly a special case of the general SSE given in (11), and therefore preserves the transfer function matrix (9) and the controllability and observability properties of the original system. Note that when E_1 and E_2 are nonsingular, the PMD $P(s,z)$ is RSE to a PMD of the type (3), that is, with $F_1 = I_n$ and $F_2 = I_m$.

In the following, we will be concerned with PMDs having both E_1 and E_2 singular. First, we present a result for reducing a PMD of the type (8) to a canonical form using an RSE transformation.

Theorem 1. *Let $P(s,z)$ be an $(n+m+p)\times(n+m+l)$ PMD in state-space form* (8) *with $|sE_1 - A_1| \not\equiv 0$ and $|zE_2 - A_4| \not\equiv 0$. Then $P(s,z)$ is RSE to a PMD of the form*

$$\overline{P}(s,z) = \left[\begin{array}{cccc|c} sI_r - \overline{A}_1 & 0 & -\overline{A}_{21} & -\overline{A}_{22} & B_{1s} \\ 0 & I_{n-r} - sJ_1 & -\overline{A}_{23} & -\overline{A}_{24} & B_{1f} \\ -\overline{A}_{31} & -\overline{A}_{32} & zI_t - \overline{A}_4 & 0 & B_{2s} \\ -\overline{A}_{33} & -\overline{A}_{34} & 0 & I_{m-t} - zJ_2 & B_{2f} \\ \hline -C_{1s} & -C_{1f} & -C_{2s} & -C_{2f} & 0 \end{array}\right], \tag{13}$$

where $\overline{A}_1, \overline{A}_4$ are, respectively, $r\times r$, $t\times t$ matrices in first natural form ($r = \deg(|sE_1 - A_1|)$, $t = \deg(|zE_2 - A_4|)$) and J_1 and J_2 are in Jordan form.

Proof. This result follows from the theory of regular matrix pencils given by Gantmacher [20]. □

Example 1. Consider the PMD

$$P(s,z) = \left[\begin{array}{ccccc|c} s-1 & s-1 & 0 & -2 & -2 & 1 \\ -1 & s & s & -3 & 2 & 1 \\ -1 & 0 & 1 & 2 & -1 & 1 \\ -2 & -3 & 1 & z-2 & z-2 & 0 \\ -2 & -6 & 1 & z-2 & z-1 & 1 \\ \hline -2 & -1 & 0 & -3 & -1 & 0 \end{array}\right]. \tag{14}$$

Here, $n = 3$, $m = 2$, and $l = p = 1$. The matrices in (8) are given by

$$E_1 = \begin{bmatrix} 1 & 1 & 0 \\ 0 & 1 & 1 \\ 0 & 0 & 0 \end{bmatrix}, \quad A_1 = \begin{bmatrix} 1 & 1 & 0 \\ 1 & 0 & 0 \\ 1 & 0 & -1 \end{bmatrix}, \quad A_2 = \begin{bmatrix} 2 & 2 \\ 3 & -2 \\ -2 & 1 \end{bmatrix},$$
$$A_3 = \begin{bmatrix} 2 & 3 & -1 \\ 2 & 6 & -1 \end{bmatrix}, \quad E_2 = \begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix}, \quad A_4 = \begin{bmatrix} 2 & 2 \\ 2 & 1 \end{bmatrix}. \tag{15}$$

Then, clearly $|sE_1 - A_1| = s-1 \not\equiv 0$ and $|zE_2 - A_4| = z-2 \not\equiv 0$. It follows that the RSE transformation of the type (12) with

$$M_1 = \begin{bmatrix} 1 & 0 & 0 \\ -1 & 1 & 0 \\ 0 & 0 & -1 \end{bmatrix}, \quad M_2 = \begin{bmatrix} 1 & 0 \\ -1 & 1 \end{bmatrix},$$
$$N_1 = \begin{bmatrix} 1 & -1 & 0 \\ 0 & 1 & 0 \\ 1 & -1 & -1 \end{bmatrix}, \quad N_2 = \begin{bmatrix} 1 & -1 \\ 0 & 1 \end{bmatrix} \tag{16}$$

reduces $P(s,z)$ to the PMD in the form (13):

$$\overline{P}(s,z) = \left[\begin{array}{ccccc|c} s-1 & 0 & 0 & -2 & 0 & 1 \\ 0 & 1 & -s & -1 & 5 & 0 \\ 0 & 0 & 1 & -2 & 3 & -1 \\ -1 & -2 & -1 & z-2 & 0 & 0 \\ 0 & -3 & 0 & 0 & 1 & 1 \\ \hline -2 & 1 & 0 & -3 & 2 & 0 \end{array}\right] \tag{17}$$

4. CANONICAL PMD OF 2D NONCAUSAL SYSTEMS

The problem of finding a realization which is minimal in some sense is important in multidimensional systems theory. Zak [12] used a similar approach to that of Eising [21] for 2D causal systems to obtain a two-level algorithm for the realization of a class of noncausal 2D transfer functions. However, the method given by Zak does not result in a realization which is necessarily minimal. More recently, progress has been made for special classes of systems, see for example Galkowski [15] and Kaczorek [16]. In the following, we give a new direct method for a canonical realization of another class of SISO noncausal 2D transfer functions. Furthermore, the realization obtained is both controllable and observable.

Algorithm 1. *Consider the SISO noncausal 2D transfer function:*

$$g(s,z) = \frac{\widetilde{n}(s,z)}{d(s,z)}, \tag{18}$$

where

$$\begin{aligned} \widetilde{n}(s,z) &= r(s,z)d(s,z) + n(s), \\ n(s) &= e_n s^n + e_{n-1}s^{n-1} + \cdots + e_0, \\ d(s,z) &= k_0(s)z^m + k_1(s)z^{m-1} + \cdots + k_m(s), \end{aligned} \tag{19}$$

$k_0(s)$ is monic and has degree equal to n, and $k_j(s)$, $j = 1, 2, \ldots, m$ have degree less or equal to n, and $\widetilde{n}(s,z)$ and $d(s,z)$ are factor coprime. Furthermore,

$$r(s,z) = r_{q+1}(s)z^q + r_q(s)z^{q-1} + \cdots + r_1(s), \tag{20}$$

where

$$r_i(s) = \sum_{j=1}^{l+1} w_{ij}s^{l-j+1}, \quad i = 1, 2, \ldots, q+1, \tag{21}$$

where $l = \deg_s r(s,z)$. Then $g(s,z)$ can be decomposed as

$$g(s,z) = g_0(s,z) + r(s,z), \tag{22}$$

where

$$g_0(s,z) = \frac{n(s)}{d(s,z)}. \tag{23}$$

It follows using the algorithm given by Frost and Boudellioua [4] that $g_0(s,z)$ can be realized by a PMD of the form

$$P_0(s,z) = \left[\begin{array}{cc|c} sI_n - F_1 & -\overline{A}_2 & 0 \\ -\overline{A}_3 & zI_m - F_4 & E_m \\ \hline -C_1 & -C_2 & 0 \end{array}\right], \tag{24}$$

where F_1 and F_4 are $n \times n$ and $m \times m$ companion matrices and $\overline{A}_2 = [E_n \ \ 0]$. The elements of F_1, F_4, and $\overline{A}_3$ are uniquely determined from the characteristic polynomial

$$\begin{vmatrix} sI_n - F_1 & -\overline{A}_2 \\ -\overline{A}_3 & zI_m - F_4 \end{vmatrix}. \tag{25}$$

Furthermore, if $d(s,z)$ is separable, then $\overline{A}_3 = 0$.

On the other hand, it can be easily verified that the PMD

$$P_r(s,z) = \left[\begin{array}{cc|c} I_{l+1} - sJ_1 & 0 & E_{l+1} \\ -\overline{W} & I_{q+1} - zJ_2 & 0 \\ \hline 0 & -E_1^T & \end{array}\right] \tag{26}$$

is a realization of $r(s,z)$, where

$$\overline{W} = [w_{ij}], \quad i = 1,2,\ldots,q+1, \ j = 1,2,\ldots,l+1, \tag{27}$$

and E_{l+1} is the $(l+1)$th column of the identity matrix I_{l+1}.

Therefore, the PMD

$$P_1(s,z) = \left[\begin{array}{cccc|c} sI_n - F_1 & -\overline{A}_2 & 0 & 0 & 0 \\ -\overline{A}_3 & zI_m - F_4 & 0 & 0 & E_m \\ 0 & 0 & I_{l+1} - sJ_1 & 0 & E_{l+1} \\ 0 & 0 & -\overline{W} & I_{q+1} - zJ_2 & 0 \\ \hline -C_1 & -C_2 & 0 & -E_1^T & 0 \end{array}\right], \tag{28}$$

where F_1, F_4, $\overline{A}_2$, $\overline{A}_3$, $\overline{C}_1$, and $\overline{C}_2$ are the matrices which appear in the realization of $g_0(s,z)$, is a realization of $g(s,z)$.

$P_1(s,z)$ in (28) can be rearranged by elementary row and column operations to yield a PMD in the form (8)

$$\overline{P}(s,z)\left[\begin{array}{cccc|c} sI_n - F_1 & 0 & -\overline{A}_2 & 0 & 0 \\ 0 & I_{l+1} - sJ_1 & 0 & 0 & E_{l+1} \\ -\overline{A}_3 & 0 & zI_m - F_4 & 0 & E_m \\ 0 & -\overline{W} & 0 & I_{q+1} - zJ_2 & 0 \\ \hline -C_1 & 0 & -C_2 & -E_1^T & 0 \end{array}\right]. \tag{29}$$

Now it remains to show that the $\overline{P}(s,z)$ in (29) is canonical. The strong controllability of $\overline{P}(s,z)$ follows from the fact that $\overline{P}(s,z)$ can be reduced by SSE, in this case by elementary row and column operations, to the form

$$S(s,z) = \left[\begin{array}{cc|c} I_{n+m+l+q+1} & 0 & 0 \\ 0 & d(s,z) & 1 \\ \hline 0 & -\widetilde{n}(s,z) & 0 \end{array}\right], \tag{30}$$

where the PMD, $S(s,z)$, clearly satisfies the condition in (5) and since the polynomials $\widetilde{n}(s,z)$ and $d(s,z)$ are factor coprime, it follows that $S(s,z)$ and therefore $\overline{P}(s,z)$ are canonical.

Example 2. Consider the transfer function

$$g(s,z) = \frac{1}{d(s,z)}\left[(s^3+2s^2+2s+1)z^3 + (s^3+3s^2+5s+1)z^2 + 2(s^3+2s^2)z + 2s^3 - 2s^2 - 3\right], \tag{31}$$

where

$$d(s,z) = (s^2+s+1)z^2 + (3s+2)z + 2s^2 - s + 2. \tag{32}$$

Then

$$g(s,z) = g_0(s,z) + r(s,z), \tag{33}$$

where

$$g_0(s,z) = \frac{s^2 - 3s - 1}{(s^2+s+1)z^2 + (3s+2)z + 2s^2 - s + 2}, \quad r(s,z) = (s+1)z + s - 1. \tag{34}$$

Here $n = m = 2$ and $l = q = 1$. $g_0(s,z)$ can be realized by the PMD

$$P_0(s,z) = \left[\begin{array}{cccc|c} s & -1 & 0 & 0 & 0 \\ 1 & s+1 & -1 & 0 & 0 \\ 2 & 3 & z & -1 & 0 \\ 0 & -3 & 2 & z & 1 \\ \hline 2 & 4 & -1 & 0 & 0 \end{array}\right]. \tag{35}$$

It remains to find a realization for $r(s,z)$. Here $r_1(s) = s - 1$, $r_2(s) = s + 1$. Therefore,

$$\overline{W} = \begin{bmatrix} 1 & -1 \\ 1 & 1 \end{bmatrix}, \tag{36}$$

so that the PMD

$$P_r(s,z) = \left[\begin{array}{cccc|c} 1 & -s & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 1 \\ -1 & 1 & 1 & -z & 0 \\ -1 & -1 & 0 & 1 & 0 \\ \hline 0 & 0 & -1 & 0 & 0 \end{array}\right] \tag{37}$$

is a realization of $r(s,z)$.

Finally, it can be easily verified that the PMD

$$\overline{P}(s,z) = \left[\begin{array}{cccccccc|c} s & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & s+2 & 0 & 0 & -1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & -s & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 1 \\ 2 & 3 & 0 & 0 & z & -1 & 0 & 0 & 0 \\ 0 & -3 & 0 & 0 & 2 & z & 0 & 0 & 1 \\ 0 & 0 & -1 & 1 & 0 & 0 & 1 & -z & 0 \\ 0 & 0 & -1 & -1 & 0 & 0 & 0 & 1 & 0 \\ \hline 2 & 4 & 0 & 0 & -1 & 0 & -1 & 0 & 0 \end{array}\right] \tag{38}$$

is canonical and gives rise to $g(s,z)$.

5. CONCLUSIONS

A new method for the realization of a class of noncausal 2D transfer functions has been presented. The resulting polynomial description is canonical in the sense that it is both strongly controllable and observable.

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In conjunction with the IEEE International Conference on Communications (ICC) 2009 in Dresden, Germany, the International Workshop on Synergies in Communications and Localization (SyCoLo 2009) will be held.

The main objective of this workshop is to show how wireless communications and navigation/localization techniques can benefit from each other. With respect to these synergies the workshop aims at the following fundamental questions:

- How can navigation systems benefit from existing communications systems?
- How can communication systems benefit from positioning information of mobile terminals?

This workshop, whose proposal was jointly generated by the EU Research Projects WHERE and NEWCOM++, aims at inspiring the development of new position-aware procedures to enhance the efficiency of communication networks, and of new positioning algorithms based both on (outdoor or indoor) wireless communications and on satellite navigation systems.

The SyCoLo 2009 is, therefore, well in agreement with the new IJNO journal aims at promoting and diffusing the aims of joint communications and navigation among universities, research institutions, and industries.

This proposed IJNO Special Issue focuses all the research themes related to the timing aspects of joint communications and navigation, and starts from the SyCoLo 2009 where the Guest Editors will attend the different sessions and directly invite the authors of the most promising papers to submit an extended version of their papers to the journal.

The proposed Guest Editors are also part of the Scientific Committees of the SyCoLo 2009, therefore, directly involved in the evaluation of submitted papers.

Topics of interest will include, but are not limited to:

- Hybrid positioning using both wireless communications and satellite navigation systems
- Resource management with positioning information
- Location-aware PHY/MAC algorithms/procedures
- Indoor positioning combined with short-range communications
- Signal processing techniques for (seamless) indoor/outdoor localization

Before submission authors should carefully read over the journal's Author Guidelines, which are located at http://www.hindawi.com/journals/ijno/guidelines.html. Prospective authors should submit an electronic copy of their complete manuscript through the journal Manuscript Tracking System at http://mts.hindawi.com/ according to the following timetable:

Manuscript Due	October 1, 2009
First Round of Reviews	January 1, 2010
Publication Date	April 1, 2010

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Special Issue on Fuzzy Logic Techniques for Clean Environment

Call for Papers

The fuzzy technique for clean energy, solar and wind energy, is the most readily available source of energy, and one of the important sources of the renewable energy, because it is nonpolluting and, therefore, helps in lessening the greenhouse effect. The benefits arising from the utilization of solar and wind energy systems can be categorized into two sections: energy saving and the decrease of environmental pollution. The clean energy saving benefits come from the reduction in electricity consumption and from using any conventional energy supplier, which can avoid the expenditure of fuel supply. The other main benefit of the renewable energy is the decrease of environmental pollution, which can be achieved by the reduction of emissions due to the usage of electricity and conventional power stations. Electricity production using solar and wind energy is of the main research areas at present in the field of renewable energies, the significant price fluctuations are seen for the fossil fuel in one hand, and the trend toward privatization that dominates the power markets these days in the other hand, will drive the demand for solar technologies in the near term. The process of solar distillation is used worldwide for arid communities that do not have access to potable water. Also some solar technologies provide other benefits beside power generation, that is, fresh water (using desalination techniques).

The main focus of this special issue will be on the applications of fuzzy techniques for clean energy. We are particularly interested in manuscripts that report the fuzzy techniques applications of clean energy (solar, wind, desalination, etc.). Potential topics include, but are not limited to:

- Solar power station
- Wind power
- Photovoltaic and renewable energy engineering
- Renewable energy commercialization
- Solar cities
- Solar powered desalination unit
- Solar power
- Solar power plants
- Solar systems (company)
- World solar challenge
- Seawater desalination to produce fresh water
- Desalination for long-term water security

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Special Issue on
Machine Learning Paradigms for Modeling Spatial and Temporal Information in Multimedia Data Mining

Call for Papers

Multimedia data mining and knowledge discovery is a fast emerging interdisciplinary applied research area. There is tremendous potential for effective use of multimedia data mining (MDM) through *intelligent* analysis. Diverse application areas are increasingly relying on multimedia understanding systems. Advances in multimedia understanding are related directly to advances in signal processing, computer vision, machine learning, pattern recognition, multimedia databases, and smart sensors.

The main mission of this special issue is to identify state-of-the-art machine learning paradigms that are particularly powerful and effective for modeling and combining temporal and spatial media cues such as audio, visual, and face information and for accomplishing tasks of multimedia data mining and knowledge discovery. These models should be able to bridge the gap between low-level audiovisual features which require signal processing and high-level semantics. Original contributions, not currently under review or accepted by another journal, are solicited in relevant areas including (but not limited to) the following:

- Multiresolution-based video mining and features extraction
- Dimension reduction and unsupervised data clustering for multimedia content analysis tasks
- Mining methods and algorithms (classification, regression, clustering, probabilistic modelling), as well as association analysis
- Machine learning paradigms that perform spatial and temporal data mining
- Machine learning paradigms that allow for an effective learning of hidden patterns
- Object recognition and tracking using machine learning algorithms
- Interactive data exploration and machine learning discovery
- Mining of structured, textual, multimedia, spatiotemporal, and web data
- Application of MDM to contents-based image/video retrieval and medical data

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