Abstract—This study introduces a new coherent theoretical system that coordinates border patrol coverage. To implement the system, a hybrid global-local optimization algorithm for Elman-Recurrent networks, and dependent autoregressive (Elman-AR) models parameter estimation, are adapted in the processing stage using the topologic feature of a convex polygon. The proposed methodology promises a low O(log(n)) value of complexity and should be the first step towards solving the border patrol automatic system identification.

Keywords—Convex polygon, AR model, Elman neural network, border patrol security

I. INTRODUCTION

Interest in border patrol systems has recently grown in response to concerns regarding national security. Conventional border patrol systems suffer from intensive human involvement. However, newer unmanned border patrol systems employ high-tech devices: unmanned aerial vehicles, unattended ground sensors, and surveillance towers equipped with camera sensors [1, 2]. There has been increased emphasis on linking Wireless Sensor Networks (WSN) with military applications, particularly in the context of border safety [3, 4]. To achieve its full proposed functionality, researchers working on WSN used in border protection must resolve many interesting challenges, including energy efficiency [5, 6], communication and hardware consistency and security issues [7, 8].

Problems. Any single technique can encounter inextricable problems, such as high false alarm rates and line-of-sight constraints. There is no single coherent system able to coordinate border patrol. Border security systems cannot distinguish between a cow and a terrorist (biometric problems) [9]. Also, the high costs of tower and sensor locations create an additional problem. Finally, there is the issue of high costs associated with the computational complexity of scanning points on the border O(n3) [1].

Aims and Scopes. A new coherent system is proposed that coordinates border patrol coverage. It entails minimum tower locations and sensors, uses a low-complexity procedure based on a computational geometry algorithm and finally, and includes a biometric control that uses a neural network. A schematic of the proposed system is depicted in Figure 1.

The paper is organized in three stages, as follows: stage 1 provides the theoretical basis for the first two steps of the algorithm (convex sensor installation, and inside or outside identification). In the second stage, the biometric features extraction method is explained in two steps (gradient signal generation and AR model). Finally, in the third stage the connection between the algorithms with a biometric learning machine is described (decision part).

I. METHOD STAGE 1: THE BASIS OF THE ALGORITHM

A. Convex Sensor Installation

The basis of the proposed method is depicted by a unique convex polygon; a point is recognized as being either inside or outside the polygon [10]. A given set, Pi, is determined by convex polygon A of i vertexes (see Figure 2). Then, point C is inside the polygon if all Qi have the same sign with or in the counterclockwise case (see Figure 2a, 2b):

\[ Q_i = A \times B < 0 \quad C \in H(A) \]  

(1)
B. Identification Procedure

In a scenario that implements the above feature, a number of sensors (i) fit in the convex configuration polygon (Figure 3).

This scenario is based on the position of the unknown object being found by at least three (3) sensors. Then the sensors detect and produce coordinates for two possible positions (inside and outside) (Figures 4a, 4b).

II. METHOD STAGE 2: BIOMETRIC PROCEDURE

A. Gradient Signal Generation

It is known that it is possible to distinguish between the biometrical movements of humans, animals and cars. This paper introduces a new method using the previous algorithm may be considered in the same strategy.

Then if \( u \) represents the cross-product of equation (1).

Visualize a vector field: at a point in space, the field has a vector value. Let \( \mathbf{g} = \nabla u \) represent the gradient of \( u \) obtained when moving from a point \( x \) in space to a nearby point \( x + dx \) in the convex area \( d\mathbf{u} = g \left( d_x \right) \). Then, the signal received by the stable pair of sensors, I1 and I2, at time \( t_n \).

\[
s_m(n) = \sum_{x=1}^{n} d\mathbf{u}
\]

and is represented by a multichannel array.
B. AR Model

According to equation (2), a set of linear systems is adopted using the AR model [12], which is

\[ y_{i,n} = \sum_{i=1}^{p} a_i s(n) \]  
\[ y_{i,n} = \sum_{i=1}^{p} b_i s(n) \]  
\[ y_{i,n} = \sum_{i=1}^{p} c_i s(n) \]

Thus, the AR multidimensional (3xp) vector \( z \) is adopted and is depicted in equation (6)

\[ z = \begin{bmatrix} a_1 & b_1 & c_1 \\ a_p & b_p & c_p \end{bmatrix} \]  

Thus, the AR multidimensional (3xp) vector \( z \) is adopted and is depicted in equation (6)

III. DECISION STAGE

A. Elman Neural Network

The present study investigates the training of these vectors in the detection of three different objects (human, animal and car) whose movements are captured by sensors [13]. The Elman network is based on a two-layer network with feedback in the first (hidden recurrent) layer and a second output layer, and is considered ideal in this case. The recurrent connection permits the Elman network to detect and generate time-varying patterns. The hidden recurrent layer consists of neurons with a hyperbolic tangent activation function (tansig) as described in the application, and is represented by the following equation:

\[ \tan \sin(z) = \frac{1-e^{-2z}}{1+e^{-2z}} \]  

Thus, the function \( f(1) \) corresponds to class A, while the functions \( f(0) \) and \( f(-1) \) correspond to classes B and C respectively.

IV. CONCLUSION

This study introduces a new coherent theoretical system that coordinates the coverage of border patrol. To implement this system, a hybrid global-local optimization algorithm for Elman-Recurrent networks and dependent autoregressive (Elman-AR) model parameter estimation is adapted in the processing stage, using the topologic feature of a convex polygon. The proposed methodology promises a low \( \log(n) \) value of complexity. Future research should focus on testing the accuracy of this method using simulation data and video games, before being applied in a real environment. The next step for the proposed algorithm is to apply it using the real-time Neuro Evolution of Augmenting Topologies (rt-NEAT) method for developing increasingly complex artificial neural networks in real time, as a game is being played [14]. Finally, this method should be applied in RFID systems in order to direct the selection and testing of additional applications (e.g., airplane transponders, library security, etc.).

REFERENCES

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Activities

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Publications

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