

Anomally Detection of Airways Transportation using Deep Neural Networks and Feature Selection Based Particle Swarm Optimization Algorithem

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Abstract: Aviation industry is an important part of transportation system in any country. Damage to this industry cussed expensive and sometimes Irrecoverable problems for governments, so for scientist in various field is attractive for research in aviation. There are several unpleasant events in aviation that can be due to a variety of human error, unwanted defect hardware or terroristic and criminal actions that happen eventually with change in the behavior of a normal airplane. Often new method of detecting anomalies in finding these events leading to useful result for this industry. There are many limitations for diagnosing abnormalities based on human supervision. One of these limitations is human error. This problem after long working hours is more prevalent. Greatest limitations of using manpower is that simultaneous checking of all the flights according to the high density transportation in main airports is not possible. Proposed methods for automatically detecting anomalies in this paper is based on using one of the powerful tools in artificial intelligence and computer science called neural networks. The method proposed in this paper used neural networks for create an efficient model for all data. Sure using feature selection based particle swarm optimization helped us to achieve best result. In this paper for evaluate method we use data from three major airports including Tehran's Mehrabad airport, Mashhad's Hasheminejad airport and yazd's Shahid Sadoughi airport. Simulation results shows proposed method is reliable and can help us for reduce accidents caused by human errors, which achieving 99.78 percent accuracy rate clearly shows this fact.

Keywords: Aviation industry, aviation transportation anomaly detection, particle swarm optimization, Feature selection, feed forward multilayer neural networks.

1. Introduction

One of the problems that most countries and governments are involved with problems related to cross and Mrvrhvayy can be. For an example of these problems can be heavy casualties in the event of a collision because The planes pointed at each other or things like airport walls and things like that. One solution to this problem using the technique of automatic anomaly detection on track planes in order to find unusual items and use it to control and prevent crime and accidents can be [1].

The basis of work in an anomaly detection system is based on educational data that is collected from the behavior of the subject in a specific period of time [2, 3]. Using this data, the training algorithm has been trained and finally the system can be've found that a new path as input and check its status, in terms of normality or abnormality in the output of the normal or abnormal the subject to the application of our aircraft under review is the show .

In the meantime, there are several possible problems . The first problem is that the process is more desirable because the need to have a lot of label for its training process . To solve the first problem can be subject to route data over time and the fact that this data can be used during long periods of time are available first problem ironed out to be . For the latter also be offered the use of neural networks .

Among the different methods that can be adopted for this purpose using machine learning deficiencies that are fully optimized to use them for the intended use does not effect them [4, 5]. Among the shortcomings can be noted that due to the use of single data training in the design process method based on machine learning, system design flexibility with limited exposure to the event that you need to understand due process are , will be faced with the demands of our intended use of the highest quality should not satisfy them . For this purpose, several conventional methods in this field have been added to this article for comparison . With regard to the issues raised by the ability to solve problems can be neural networks for applications to be used . Neural networks in applications varied such as information technology, biology , computer vision , speech recognition Speech in data mining of , information retrieval, pattern recognition and so on used and this is saying this is the network of nerve powerful tools for different applications is not .

Including research in the field has been an indicator that can be used to study [6] noted that the use of Gaussian mixture models and practices of conventional clusters-Classification using data related to the behavior of the aircraft into the airport's category and detecting anomalous routes . The advantage of the proposed method is its compactness and high speed in detecting abnormal paths .

In [7] using independent component analysis of applied behavior analysis plane took sit down and get up from the runway at the airport has been implemented . The advantage of this method is the use of components effective in detecting abnormal process that eventually will achieve an effective system for detecting anomalies in the process . In the study [8] also uses the network of nerve encoded a process anomaly detection efficiency and optimization is designed to addition in the education system will run faster even higher accuracy also for process anomaly detection will follow Had .

In this article, first in the second part , the proposed method will be presented and then in the next step, the simulation of the proposed method on the data set used in this research will be examined and finally in the fourth part, the results obtained in the simulation section will be evaluated. Will be located . In the last section, a summary of the research conducted in this article and the achievements and results will be presented

2. basics

In this paper, the basis of the proposed method is based on the use of feed forward neural networks, and PSO algorithm so in this section first we will present the structures of neural networks and its generalities then PSO details presented.

3. Proposed method

In this section, the proposed method for implementing the anomaly detection process will be discussed and its various parts will be examined in detail .

The proposed method consists of two main parts: training and testing . In the education sector with the training of the education system, and the next step is to categorize data using the model in other words, we will process anomaly detection .

In Figure 1, below the block diagram, the proposed method can be seen .

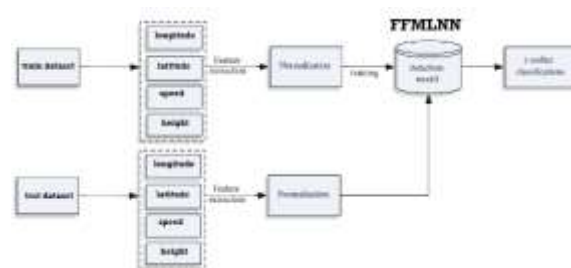


Figure 1. Block diagram of the proposed method.

The first step in the training phase extraction of data on latitude, speed and altitude data in the database is used to process anomaly detection .

The second step is to extract the feature from the mentioned data and the third step will be dedicated to the normalization of the extracted feature . In the next step, with the help of normalized features, the classifier will be taught and finally, in the final step, the classification results on the test data will be evaluated .

In this section, the desired sections will be further evaluated and examined .

2-1 Collection of data

Data set used in this article is derived from data relating to the aircraft fleet President of Iran is that hides the period of one month has been registered [9].

The M c Mvh data include but are not as instantaneous fuel consumption of the total weight of the moment, latitude, speed and altitude, and so on . Of these contracts, only four sets during the geography of the Yi , speed and altitude of the land to be used and the feature extraction process is described in the next section to apply them be .

2-2 Feature Extraction

This is one of the most significant parts of the research and extraction of features with the ability to characterize the input data can be .

To extract the mentioned feature, first some basic components are extracted from the data set related to longitude, latitude, speed and altitude of the aircraft, which will be examined in the following .

The first extraction component of the displacement [1] is calculated by the following equation can be .

$$(1) \quad D = \sqrt{(y_i - y_{i+1})^2 + (x_i - x_{i+1})^2}$$

In the above relationship and Represents latitude and longitude at the moment i Is .

The second basic component is related to the speed of the split relation 1 on the period between the two samples are created to be . The third component is acceleration, which is obtained by dividing the velocity by the time between two samples . The next component is related to the angle of the path, which shows the relationship between the two ways of calculating it .

$$(2) \quad A = \arctan\left(\frac{y_{i+1} - y_i}{x_{i+1} - x_i}\right)$$

The fifth base deals with height changes [6] is assigned by the following relation .

$$(3) \quad H = y_i - y_{i+1}$$

The next component is the difference when the distance between the two samples . Name another angle with respect basic component 4 Word was calculated to be .

$$(4) \quad OA = \arctan\left(\frac{y_i}{x_i}\right)$$

The last basic component is related to the length of the path that has been traveled from the sum of the path to the moment i At the moment the calculated path can be . The total flight time as other basic features that are calculated to be .

These features include changes in each of the inputs in two consecutive times and dynamic speed and acceleration and angle and dynamic displacement and changes in time and dynamic angle and total distance traveled and flight time , time interval component of different parts of the inputs , the time of landing and the rise of the first plane and the length of time the airplanes of the uncut (continuity) , maximum speed, average speed and standard deviation of velocity component and the absolute value of the average acceleration and standard deviation of the

absolute value of the acceleration and maximum acceleration and maximum loss acceleration and horizontal velocity and the average time that the plane into the airport is the standard deviation and maximum and minimum path is .

After calculating the features that their total number to 73 numbers can be implemented next process .

2-3 Normalization of features

This step is very effective in creating robustness and flexibility to build a powerful model . To soften the transferred average algorithm [7] used to be . Nexus 5 indicates how to calculate this is the way [10] :

$$(y_k)_s = \sum_{i=-n}^{i=n} y_{k+i} / (2n+1) \quad (5)$$

In this regard n The component determines the averaging window and $(y_k)_s$ And y_{k+i} Represents softened data and previous data, respectively .

Another process that takes place on the raw data normalization has a relationship 6 under implementation are [11] :

$$Y = \frac{X - X_{\min}}{X_{\max} - X_{\min}} \quad (6)$$

In this regard, the normalized value is determined using the maximum and minimum values, which is called the minimum - maximum normalization method. [8] is famous .

2-4 Select features

In this paper the method of filtering based on solidarity fast [9] It is the speed and efficiency better than the method of feature selection And based on solidarity show up . As a result, it leads to the features to better help with your data with dimensions up matches will feature far better to pick up . In this method, first the asymmetric uncertainty criterion value [10] on all the features calculated to be . This value, through the calculation of information interest x with condition y Divided by the total entropy of all the features of the product can be . In the end the values of certainty asymmetric, sort of , and characteristics of waste [11] remove F can be [12].

The result of using this process is selecting the top 15 features from among the 73 defined features .

2-4 Features classification

The most important part of pattern recognition methods is its classification . In this section, a multi-layered frontal neural network classifier is used, which will be examined in full detail .

Multilayer anterior neural network

Network Perceptron neural as one of the common types of neural networks, is a process that usually neural network MLP layers , including full use of the these networks nerve is . These networks are able to perform a nonlinear mapping with desired accuracy by selecting the appropriate number of layers and neural cells, which are often not large. . This is what a lot of things in technical and engineering as the main solution proposed logged in .

Optimal selection of the structure of this type of neural networks is one of the most important and practical cases that should be considered in using them and determined according to the dimensions of educational data, because using a network with high dimensions. And limited data lead to over-fitting [12] and the use of high-dimensional network and limited data leads to low fit [13] The system will not perform well in either case . After selecting optimum neural network type of the network that in them a number of layers with the use of principles and rules consistent training , you see , can be used in automatic sorting data properly . So take advantage of this network is very common that and in many areas of machine vision wide range of applications is . In general , a network

Multilayer nerve The three main layers formed is that the layer of input , layer or hidden layers and layers of output can be . Each layer of the above are in charge of .

The input layer is responsible for receiving data and transmitting it into the neural network. The point of note about this layer is that the number of neurons in this layer is equal, which must be equal to the dimensions of the input .

The next layer is for hidden layers . The number of these layers and the number of neurons present in it is determined arbitrarily according to the input data . Usually this works correctly if the error is of course to pay attention to two things should be considered more fit and less fit .

Finally, the output layer, which usually produces a number as output, this number is the amount of probability received at the input to the desired class, and by rounding it, the result of the classification can be determined [13].

In this study, in addition to the above classification, there are four categories of support vector machines [14] Classification of the decision tree [15] Classification of the nearest neighbor [16] And Bayesian simplified [17] The proposed method has been used to compare the results and ensure the performance .

In this paper for a better evaluation of the method than the mutual evaluation method KFOLD Has been taken advantage of .

The method used in evaluating this article is the method of mutual validation10 fold You have to explain more to say, if the data set of the education system at random by thek Or the layer of of a size equal division now the AD of the power we each stage of learning the process validators of the cross, the number of k-1 The use of the layer of the display as a training dataset of and the one of a data collection pilot intends to take . Image of each of the R, the late Methodsk-Fold As well the show of shows . It is clear that by choicek = 10Number of repetitions In the process of Ned CV Equal to 1 will be 0 and the water of a suitable model as fast as acceptance of any of the lead .

4. Simulation

To simulate the hardware features ofCPU: I7 4500U 2.4GHz And RAM: 8GB And graphics card with specifications NVIDIA GeForce 820M And dedicated memory 6GB With a special amount2GB DDR3 Used for graphics card . For simulation of softwareMATLAB R2020a Has been taken advantage of in this section simulation of the proposed ways to step forward and evaluated in detail to be .

4.1. Input data

The first thing to consider in this section will be the input data used to train and test the system . Since the appropriate assessment of the proposed method by applying it only the selected database appears to be . Proper selection of the database is very important . Database used Based on data collected from the country's airports company . And includes 6 months of air data from the Persian date Farvardin 1398 is . The data from the three airports Tehran's Mehrabad airport Hashemi Nejad Airport Yazd and Mashhad have been collected . In this article , data related to three airports have been used, which can be seen in the following image of the location of Hasheminejad Airport in Mashhad along with Yazd Airport and Mehrabad Airport in Tehran along with its entrance and exit runways .

Routes used in this article all directions on the rise and landing airport in the Eastern Band Hasheminejad and Yazd to Mehrabad Airport with Western bands can be . The total number of routes is equal In 1200 the route is .



Figure 2. View of Hasheminejad Airport in Mashhad.



Figure 3. View of Mehrabad Airport in Tehran



Figure 4. View of Yazd Airport

The data are normal because there was no abnormal event in the flight process at the time of data registration. However, to evaluate the method, 300 routes were added to the data set by making changes in speed and altitude position to improve the performance of the case method. Be evaluated . As much as possible, the added data has been completely varied to provide a better view of the performance of the method .

4-2 Feature Extraction

At this stage, the individual paths 73 features have been extracted . These features are described in the relevant section and selected in such a way as to best describe the route . After that comes the process of career] feature can be .

In this process, 73 attributes have led to the selection of the top 15 attributes .

4-3 Classification

In this study, Perceptron Network Jlvsv Tuesday layers have been used for classification . The network can be said that each neuron in each layer of the all neurons in layer to connect is . Complete networks are connected to such networks [14] say . The network, the network used in this article, in fact, formed from a merger of two networks Perceptron single- layer form is . One of the layers, output layer and two of the layers between them are

not . The output of the first layer , the input vector layer II forms, and so the output layer, the second the input layer, the third up to , and ultimately output obtained by layering Third, the real answer to constitute the network . For education or of the right of neural network training process consists of two stages . First the forward stage [15] And then the post-release phase of the error [16]. The Jlvsv input to layer the primary network is and the dot product between the input and the components of each neuron and end the process of convolution in each layer takes place . The output is calculated to be . In this paper, in order to adjust the components of the network including the weight of the different neurons of the output result obtained for the size of network error used to be . For this purpose the network output uses an error function [17] The error rate is determined by calculating the correct answer after calculating the distance between the two results . In the next step based on the calculated error of the step So publish the error Begins . At this point derive each parameter according to the law Chain of [18] The calculation and all parameters change according to the effect they have on the error created in the network . After the update of parameter stage Crush Jlvsv start and finally after repeated an appropriate number of network training process is completed there .

In this paper, for better comparison of results in addition to the classification neural network classifiers such other because four classification vector machine backup , classification decision tree , classification iTunes Dyktryn neighbor and Bayesian simplified to compare the results and ensure the functioning of the proposed method used Has been . In the section, the results obtained for each section are compared .

5.results

At this stage to assess the proposed method, the results obtained by other conventional methods of machine vision first two components detection rate of true positive class ([19] T P) And the correct detection rate of negative class ([20] T N) According to equation below is calculated .

$$(7) \quad TP(TD, GT) = \frac{\#(TD \cap ED)}{\#(ED)}$$

In the above relationship TD Specifies the number of anomalies that obtained with the proposed method andED As well as the number of disorders that can be diagnosed by a professional in the database . In addition, the component that the calculation is made,FPR According to equation 5 can be .

$$(8) \quad TN(TD, GT) = \frac{\#(TD \cap \overline{ED})}{\#(ED)}$$

Finally, using these two components as well as two criteria FP [21] That complementary mode TP ·FN [22] That complementary mode TN Is, the percentage of accuracy [4], using Equation 9 calculated to be . In this paper currency or without the proposed method compared to other methods of this criterion is used .

$$(9) \quad Accuracy = \frac{TN + TP}{TN + TP + FN + FP}$$

In addition to using this criterion in the proposed process of cross-evaluation method10fold Has been taken advantage of . For the sake of brevity, one of these 10 performances will be presented along with the average of these performances .

The graph shown in Figure 5 illustrates the results obtained in Section 10 for each classifier .

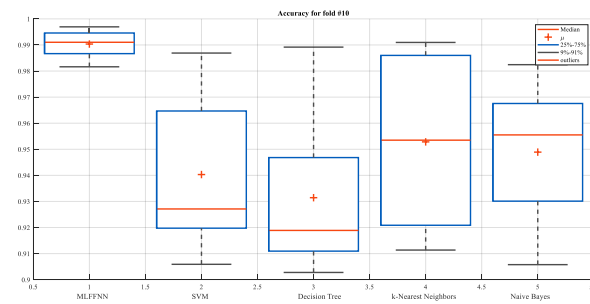


Figure 5 : Results for percentage accuracy in Section 10

In addition to the above graph percent accuracy achieved on average over the 10 repetitions in Figure 6 are visible

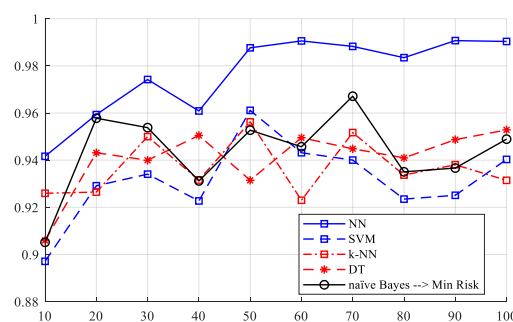


Figure 6 : Mean percentage of accuracy obtained for 10 replications obtained in Section 10 for each classifier .

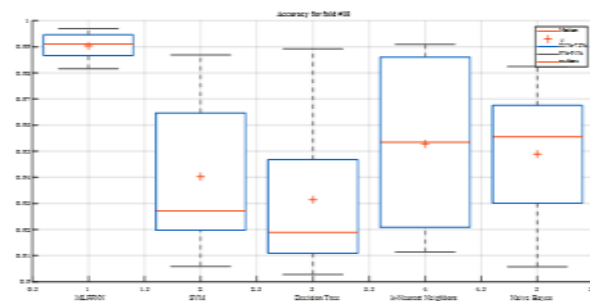


Figure 7 : Results for percentage accuracy in Section 10

In addition to the above graph percent accuracy achieved on average over the 10 repetitions in Figure 6 are visible

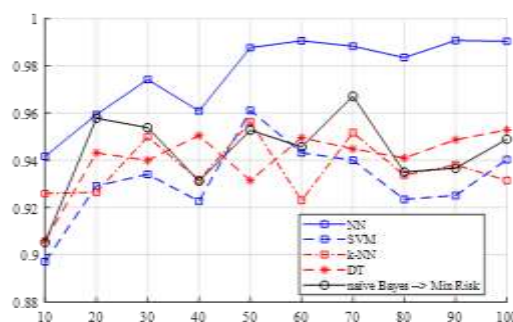


Figure 8 : Mean percentage of accuracy obtained for 10 replications

In Table 1, the final results for 5 categories will be visible in an average of 10 repetitions.

NB	DT	KNN	SVM	NN	Classifier
94.34%	94.08	93.68%	93.16%	97.67%	Average of accuracy on test data
3.02×10^{-4}	1.88×10^{-4}	1.39×10^{-4}	2.82×10^{-4}	2.95×10^{-4}	Average of accuracy on train data

By evaluating the charts and the above table can be clearly seen that taking advantage of the proposed method in the diagnosis of routes abnormal functioning very well. In comparison with other classifiers results are a testament to the good performance of the new data will be Which is entered into the system for evaluation .

6- Conclusion

In this paper, using the network of nerve and pretty good, they complex processes manner of new anomaly detection path of the air we present the implementation of the database on Tuesday airport in the country and compare it with the four- way Conventional pattern recognition we evaluated its performance . The results of the simulations indicate that the proposed method has a better performance in the process of detecting airway abnormalities . Achieving a 97.67% accuracy rate is a testament to this Manuscripts should be typed with a font Times New Roman of 11 pt. in the MS-Word format, double spacing. Table 1 provides samples of the appropriate type sizes and styles to use.

4.2. Title and author details

Title must be in 15 pt Regular font. Author name must be in 12 pt Regular font. Author affiliation must be in 8 pt Italic. Email address must be in 7.5 pt Courier Regular font. All title and author details must be in single-column format and must be centered.

Author details must not show any professional title (e.g. Managing Director), any academic title (e.g. Prof.) or any membership of any professional organization (e.g. Senior Member JAIDM).

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Divide your article into clearly defined and numbered sections. Subsections should be numbered 1.1 (then 1.1.1, 1.1.2.), 1.2, etc. No more than 3 levels of headings should be used. The abstract is not included in section numbering. All headings must be in 11pt font.

Table 1. Results of the separation of normal and abnormal behaviors of the individual

Font	Appearance (in Time New Roman)		
size	Regular	Bold	Italic
15	Title		
12	Author name		
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10	Reference item		
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Depending on the word count, Articles may have up to 10 display items (figures and/or tables). In addition, a limited number of uncaptioned molecular structure graphics and numbered mathematical equations may be included if necessary. To enable typesetting of papers, the number of display items should be commensurate with the word length — those with word counts less than 2,000 should have no more than 4 figures/tables. Please note that schemes are not used; these should be presented as figures.

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Use the abbreviation “Figure 1” and “Table 1”, even at the beginning of a sentence and in parentheses. In the middle of sentence use the abbreviation “figure 1”, “table 1” and do not use abbreviation “fig. 1” or “Fig. 1” nowhere in the text. The same data should not be presented simultaneously in tables and figures.

Figure axis labels are often a source of confusion. Please use words rather than symbols. As an example, write the quantity “Time,” or “Time, s,” not just “T.” Put units in parentheses.

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Captions of a single line must be centered whereas multi-line captions must be justified (e.g. Figure 1). Captions with figure and table numbers must be placed after their associated figures.

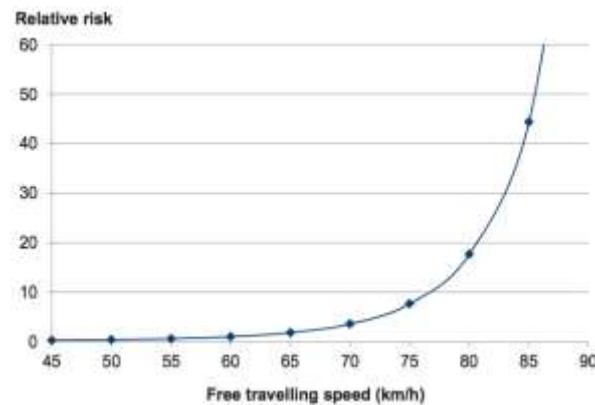


Figure 2. The free travelling speed and the risk of involvement in a crash resulting.

4.5. Numbering

Number reference citations consecutively in square brackets [1]. Multiple references are each numbered with one bracket, for example use [1,2,3] instead of [1],[2],[3] and [1,2-4,5] instead of [1],[2]-[4],[5]. Refer simply to the reference number, as in [3]. Do not use "Ref. [3]" or "reference [3]" except at the beginning of a sentence: "Reference [3] shows...."

Some examples of correct refer:

1. The theory was first put forward in 1987 [1].
2. Scholtz [2] has argued that... .
3. Several recent studies [3,4,15,16] have suggested that...
4. For example, see [7].
5. Smith [4] and Brown [5]...
6. ... as shown by Brown [4,5].
7. ... as mentioned earlier [2,6-9,11].
8. ... as demonstrated in [3].
9. ... according to [4, 6–9].
10. ...Wood et al. [7].

Use Arabic numerals for figures and Roman numerals for tables. Appendix figures and tables should be numbered consecutively with the figures and tables appearing in the rest of the paper. They should not have their own numbering system.

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Number equations consecutively. Equation numbers, within parentheses, are to position flush right margin of the column, as in (1), using a right tab stop. To make your equations more compact, you may use the solidus (/), the exp function, or appropriate exponents. Italicize Roman symbols for quantities and variables, but not Greek

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$$\mathbf{R}\mathbf{I}_a + \mathbf{L}\dot{\mathbf{I}}_a + \mathbf{K}_b \mathbf{r}^{-1} \dot{\mathbf{q}} + \boldsymbol{\varphi} = \mathbf{v} \quad (1)$$

where, $\mathbf{v} \in R^n$ is the vector of motor voltages, $\mathbf{I}_a \in R^n$ is the vector of motor currents and $\boldsymbol{\varphi} \in R^n$ is a vector of external disturbances.

Be sure that the symbols in your equation have been defined before or immediately following the equation. Refer to “(1),” not “Eq. (1)” or “equation (1),” except at the beginning of a sentence: “Equation (1) is ...”.

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- Reference to a journal publication [1,2]:
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6. Submitting the paper

Submit the paper to the Journal of Artificial Intelligence & Data Mining (JAIDM) via the website <http://jad.shahroodut.ac.ir/>.

7. Acknowledgment

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