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A new approach to fuzzy logic analysis of Indian currency recognition

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Abstract

In the modern society the advancement and development in the field of scanning and printing technology is rapidly increasing day by day. This gives rise to the generation of counterfeit currency notes in the economy. The goal of this present investigation is to limit the circulation of fake currency notes using logic that can be also referred as fuzzy logic. This paper deals with the utility of fuzzy logic in the domain of Indian currency notes. An integrated banknote detection system implementing a fuzzy-based security features classifier has been developed. The important security features that have been considered are on the basis of the Indian denominations used as well as present in foreign currency notes. The rules that have been developed are formulated upon logic, observation, people's feedback and experiences while dealing with currency notes. With the help of the Surface Viewer several output surfaces have been generated upon varying the security features with each other. This gives an evaluation approach to the existing security features for controlling banknote forgery.

Keywords: security features, fuzzy inference system, membership functions, IF-THEN rules, Surface Viewer

1. Introduction

For any country worldwide money is an economic unit that functions as a generally accepted medium of exchange for transactional purposes in an economy. Counterfeit currency refers to a currency that closely resembles the original currency of a country, but that is produced without the legal approval of the government, which creates a negative impact on the overall economy. The expansion of latest banking services necessitates the requirement for automatic currency recognition and authentication system; hence it is the need of the hour to design a system that is helpful in recognition of paper currency notes correctly. Therefore, in this work, a system of logic has been incorporated for addressing banking crises or as an alternate to verify the resolvability of banks while minimizing the impact on the important economy. An integrated system for a quantitative approach has been made for the evaluation of security features present in the Indian banknotes. This framework is based on the fuzzy logic architecture that explains with a flow diagram to describe the methodology. Seven important security features have been considered which are already present in the denominations used in this study as well as present in foreign currency notes.

Among all the security features present in the currency notes, seven security features are applied to the inference system to get the desired output based on a decision-making process. The condition of a security feature is classified in terms of its linguistic variables as 'poor', 'fair' or 'excellent' using a 3-point Likert scale. The output gives the result based upon the conditions of the security features. According to people's feedback and experiences on banknotes, analysis has been done in order to formulate human thinking by using fuzzy IF-THEN rules. The rules determine the actual process in the system and consequently give an evaluation based on that. The evaluated results at the output determine whether a currency note is genuine, worn, or counterfeit considering the condition of its security features that are present at the input. The 3D graphs are generated based on the rules and their characteristics show the curve of a genuine, worn, or counterfeit currency by considering variations of the security features. Seven security features considered in the present study are watermark, security thread, hologram, intaglio printing, latent image, micro-lettering and see-through register. The security features of Indian currency notes are explained in detail by various researchers (Ali, Gogoi and Mukherjee, 2014; Mann, Shukla and Gupta, 2015).

In the field of fuzzy logic in banking and financial applications Seung Yong Kwon with his colleagues (Kwon, et al., 2016) proposed a fuzzy-based classifier based on heuristic design of fuzzy rules and membership functions that could determine the fitness of banknotes through an objective, systematic method rather than subjective judgment. Mohammad Saber Iraji and Saeid Anjakani Moghadam (Iraji and Moghadam, 2016) also presented an approach known as Adaptive Neuro Fuzzy System (ANFIS) method based on wavelet features with vision sensing, which indicated better and more accurate results. Nagy Ramadan Darwish and Ashraf M. El Nour (Darwish and El Nour, 2018) aimed to propose an intelligent fuzzy-based framework for evaluating the most important security features of Egyptian banknotes. Their proposed framework depended on the Likert scales and the utilization of fuzzy logic for classification of banknotes that were genuine or counterfeit. Rodel Emille T. Bae with other researchers (Bae, et al., 2019) presented a study that had been divided into two parts: a template matching technique for feature extraction and comparison of accuracy between fuzzy logic algorithms and K-Channel Nearest Neighbour (KNN) based on the information they gathered. Revati and Somashekhar Dhanyal (Revati and Dhanyal, 2019) proposed a work that was to provide an easy and efficient system for the detection of fake and original notes based on the input image features. In this work they used a feature based Fuzzy classifier along with some digital image processing methods to extract the features of currency images for recognition as well as for verification. Marc Sanchez-Roger and colleagues (Sanchez-Roger, Oliver-Alfonso and Sanchís-Pedregosa, 2019) attempted a study to critically examine fuzzy logic as an effective, useful method to be applied to financial research and, particularly, to the management of banking crises by using artificial intelligence techniques. In the present investigation a new methodology has been developed on the basis of the operation of fuzzy logic for the recognition of Indian currency notes by obtaining several output surfaces of the seven security features considered.

2. Proposed methodology

The proposed methodology depends upon the operation of fuzzy logic for the categorization of Indian currency notes as counterfeit, worn and genuine. The first step deals with using the triangular membership function where the inputs are fuzzified to acquire fuzzy sets. Conversion of crisp values into linguistic variables is performed in the second step. The transformation of the values of each crisp input into the grades of its membership function is done for linguistic terms of fuzzy sets. Later in the testing phase to fuzzify the security features these membership functions are considered. The third step is known as fuzzy inference system that is used in a fuzzy rule to decide outcome of the rule based upon the given input rule information. Fuzzy rules signify experience, survey, feedback or modelling knowledge. In the rule consequence, to calculate the outcome for the output variables fuzzy inference is needed when particular information is assigned to the input variables.

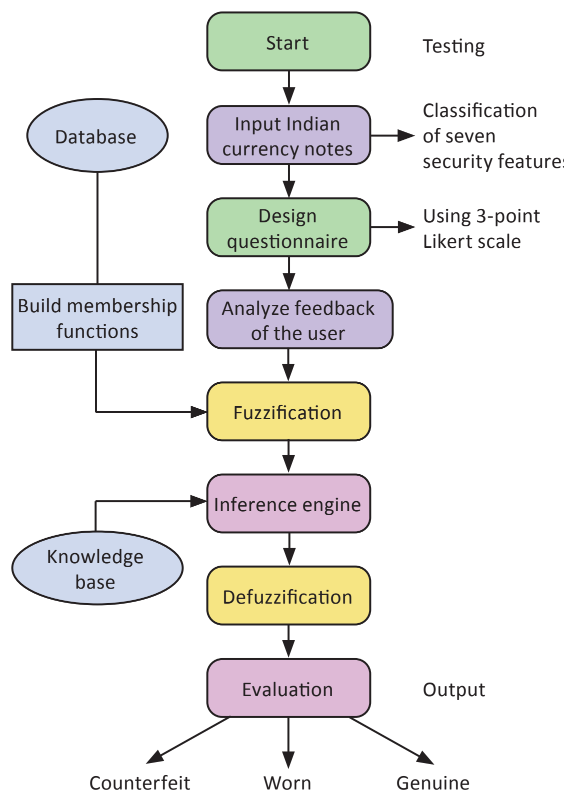

Figure 1: Framework of the proposed methodology

The proposed framework takes into account the Mamdani fuzzy rules (Mamdani and Assilian, 1975). Three fuzzy variables, namely 'poor', 'fair' and 'excellent', are used to describe the feature variations at the input side and 'counterfeit', 'worn' and 'genuine' are the variations present at the output. Since the fuzzy inference system processes all of the cases in a parallel approach therefore it makes the decision more logical and reasonable. The outputs of fuzzy values are defuzzified in order to generate a crisp value for the given variables. To choose a single output based on the suggested fuzzy sets there are numerous defuzzification methods provided. But from them the most frequently used defuzzification strategies are: the maximizing decision, the mean of maximum method and the centres of gravity method.

In the present investigation, the defuzzification strategy used is known as the centre of gravity method. After the evaluation phase specific graphs are generated in the Surface Wiewer, which depicts the output according to the given input. The flowchart in Figure 1 represents the proposed framework.

3. Fuzzy inference system

A fuzzy inference system is the fundamental unit of a fuzzy logic system. It is a type of computer prototype which is supported by fuzzy set theory, fuzzy IF-THEN rules, and fuzzy reasoning (Chen and Pham, 2000). Different functional blocks constitute its structure. Fuzzy set theory is used by a fuzzy inference system to map inputs to its outputs. It is generally based upon a nonlinear mapping that derives its output from a group of fuzzy IF-THEN rules. The range and domain of non-linear mapping can be fuzzy points or sets that are multidimensional in nature (Tsatiris and Kitikidou, 2018). It takes into account novel methods to solve day to day problems.

The characteristics of a fuzzy inference system consist of conversion of fuzzy variable into a crisp variable using a defuzzification unit that accompanies the system. Regardless of the input which can be in the form of fuzzy or crisp, the result from a fuzzy inference system is always a fuzzy set. When the system is used as a controller it is essential to have a fuzzy output.

The essential structure of a fuzzy inference system consists of three entities such as a database or dictionary that contains the participation functions, which are applied in the fuzzy rules. Rule base accommodates all the required fuzzy rules. A reasoning mechanism is performed made upon the guiding principle and the facts given to understand a reasonable conclusion or outcome.

All the necessary information regarding a fuzzy inference system is displayed by the MATLAB applicaton Fuzzy Logic Designer. It comprises the information about the most recent operation that is displayed at the bottom by the status line. The name of an input or output variable, its type, and its default range is presented by the Current Variable area. And to let the user modify the different fuzzy inference functions, drop-down lists are present. At the MATLAB prompt the command "Fuzzy" needs to be typed to open the Fuzzy Logic Designer. The fuzzy inference system consists of the names of the variables at the input side as well as at the output side. The input variables are always present at the left-hand side whereas the output variables are present at the right-hand side. In the present study, Mamdani-type inference has been used. A seven-input, one-output system has been constructed here. The seven inputs are watermark, security thread, hologram, intaglio printing, latent image, micro-lettering and see-through register. As soon as the new names of the input and output variables are assigned the diagram becomes updated to reflect the changes as shown in Figure 2. There is now a new variable in the workspace called Currency that contains all the information about this system.

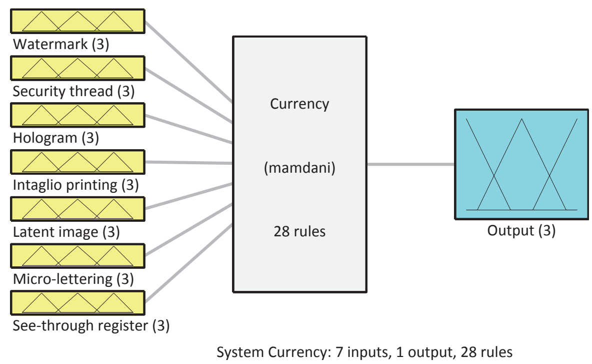

Figure 2: Mapping of all the security features to the output

3.1 Triangular membership function

Membership functions illustrate fuzziness that is all the information that is present within a fuzzy set whether the elements are continuous or discrete in those fuzzy sets (Sivanandam, Sumathi and Deepa, 2007). To solve practical problems, membership functions can be expressed as a technique that focuses upon experience rather than knowledge. It is always represented in graphical forms. Triangular membership function explains how each point in the input space is mapped to its membership value in the range of 0 and 1. The membership function editor lets the user edit as well as display all the membership functions which are connected with all the variables present at the input and output for the entire fuzzy inference system.

The different linguistic variables 'poor', 'fair' and 'excellent' and their associated membership functions at the input for security feature 'watermark' are shown in Figure 3. Each of the remaining security features 'security thread', 'hologram', 'intaglio printing', 'latent image', 'micro-lettering' and 'see-through register' are having the same membership functions. The separate three triangles denote that each of the security features may have varying conditions hence separate categories known as 'poor' 'fair' and 'excellent' are chosen under the corresponding security features.

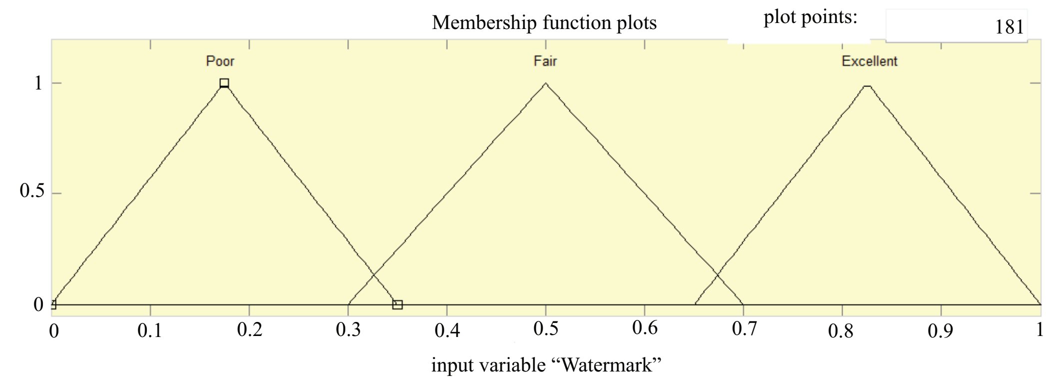

Figure 3: Triangular membership functions for input variable 'Watermark'

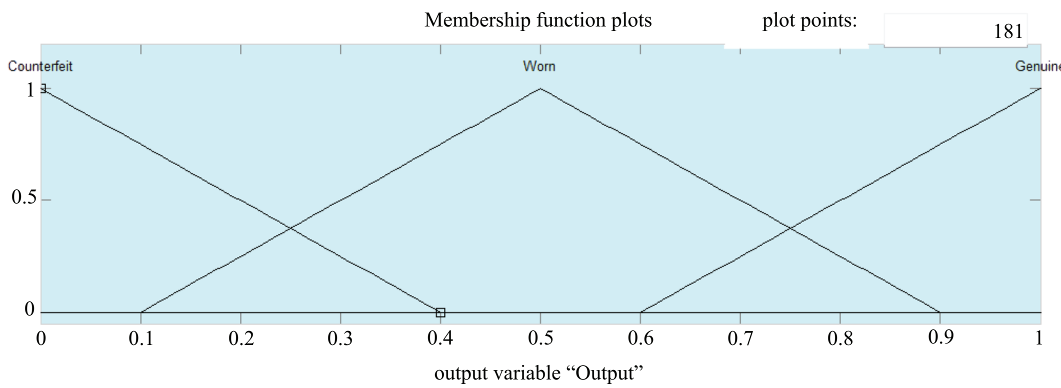

Figure 4: Triangular membership functions for variable 'Output'

The different linguistic variables 'counterfeit', 'worn' and 'genuine' and their associated membership functions at the output are shown in Figure 4. The shape of the membership function is such that the currency notes in our day to day lives are mostly worn since it gets circulated from one hand to another. Hence the two categories 'counterfeit' and 'genuine' take a certain part under the triangular curve 'worn'. This in turn states that a currency note can be worn as well as counterfeit and also a genuine currency note can be worn.

3.2 Fuzzy IF-THEN rules

The graphical Rule Editor interface helps the user to develop fuzzy IF-THEN rules. The Rule Editor takes into consideration the number of input and output variables as well as their corresponding membership functions that are already defined in the Fuzzy Logic Designer. The construction of the rule statements takes place automatically by using the Rule Editor.

The first 16 rules are based upon the experiences of the experts of the departments of forgery and counterfeiting (Darwish and El Nour, 2018). These sixteen rules altogether also deal with the feedback of the public about banknotes. It has been observed that these rules contain three sets of repetitive conditions. Therefore, in the present study these rules are further modified on the basis of fuzzy reasoning formulated by a group of fuzzy IF-THEN rules. Fuzzy logic mainly focuses upon different types of surveys and experiences from human thinking, so rather than knowledge it concentrates upon overall experiences.

Similarly, more rules can also be developed depending upon logic and observations of the conditions of currency notes. Here in the present study additional 12 rules are developed for further evaluation of security features. The modified 16 IF-THEN rules along with the presently developed 12 rules are given in Appendix in tabular form including their numbers.

3.3 The Surface Viewer

Once the Surface Viewer is opened, the mapping from the seven security features to the output result can be obtained from a three-dimensional curve. The Surface Viewer is prepared with drop-down menus having X (input), Y (input) and Z (output) that lets the user select any two inputs and any one output at a time for plotting the curve. There are grid lines present the number of which the user can specify in the two input fields, X grids and Y grids, respectively. For complex problems this option of facility permits the user to keep the time rea-

Table 1: Groupings of variations among different security features

Security feature	Group 1	Group 2	Group 3
Watermark	Security thread	Hologram, intaglio printing	Latent image, micro-lettering, see-through register
Security thread	Watermark	Hologram, intaglio printing	Latent image, micro-lettering, see-through register
Hologram	Watermark	Security thread, intaglio printing	Latent image, micro-lettering, see-through register
Intaglio printing	Watermark	Security thread, hologram	Latent image, micro-lettering, see-through register
Latent image	Watermark	Security thread, hologram, intaglio printing	Micro-lettering, see-through register
Micro-lettering	Watermark	Security thread, hologram, intaglio printing	Latent image, see-through register
See-through register	Watermark	Security thread, hologram, intaglio printing	Latent image, micro-lettering

sonable for any sort of calculation. When the selections of input or output variables are changed, by default, the surface plot, as well as the number of grid points, update automatically. Plot points help if the user wants to create a smoother plot in the input or output range where the field needs to be specified to the number of points on which the membership functions are evaluated. By default, this field is set to the minimum number of plot points which is 101. If the user wants to specify fewer plot points, then automatically the field value resets to 101 along with updating the output surface curve. Also, if the user wants to manipulate the surface to get the view from different angles, then by dragging the mouse and clicking on the plot axes the 3D curves can be seen. In some scenarios there are more inputs that are required by the system than the surface is mapping. In such situations the function Ref. Input is helpful as it allows the user to edit and explicitly set inputs that are not specified in the surface.

Suppose there is a five-input one-output system and the user would like to see the output surface. A three-dimensional output surface is generated by using the Surface Viewer where there is a variation between any two inputs, but the remaining three inputs must be assigned as constant since a computer monitor is unable to display a six-dimensional shape. When such case occurs, the input becomes a five-dimensional vector with undefined numeric data type Not a Number (NaN) being assigned to the place of the varying inputs while those input values that remain fixed are indicated with numerical values. Also, in the present study since it is a seven-input one-output system, the input is a seven-dimensional vector with NaNs holding the place of the varying inputs while the rest of the five numerical values indicate those inputs that remain fixed. The groupings of variations among different security features are stated in Table 1.

4. Results and discussions

The classification of the variations between different security features with one another is determined which generates different types of graphs as described in Table 2.

Table 2: Variations of individual security features under the different types of graphs

Type of graph	Variation of security features present under the graph
Type 1	Varies with watermark and security thread
Type 2	Varies with watermark, hologram and intaglio printing
Type 3	Varies with watermark, latent image, micro-lettering and see-through register
Type 4	Varies with security thread, watermark, hologram and intaglio printing
Type 5	Varies with security thread, hologram and intaglio printing
Type 6	Varies with security thread, hologram, intaglio printing, latent image, micro-lettering and see-through register
Type 7	Varies with latent image, watermark, micro-lettering and see-through register
Type 8	Varies with latent image, hologram, intaglio printing, security thread, micro-lettering and see-through register
Type 9	Varies with latent image, micro-lettering and see-through register

Among the seven security features, two features are taken simultaneously as input variables in the present study. Though this Table 2 depicts nine types of graphs but actually the variations among seven security features can generate forty-two numbers of graphs of which some of the output surfaces for different input variables are similar in nature due to membership functions. Among these forty-two graphs only nine types of graphs are randomly selected for the purpose of analysis.

From the Surface Viewer, various graphs have been resulted with respect to the different security features. It is a 7-input 1-output system so to evaluate the security features, 2 inputs are taken at a time and its corresponding output is shown in a 3D curve. Since the output is generated based on IF-THEN rules as created from people's feedback and experiences while handling banknotes, the fuzzy inference system gives the desired results.

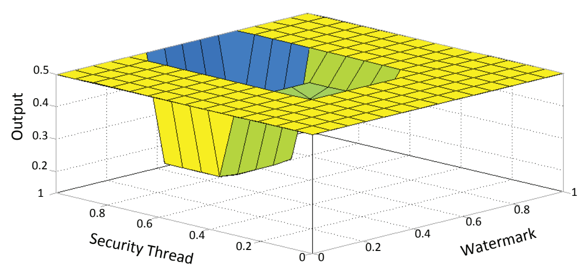

Figure 5: Type 1 graph

In Type 1 graph (Figure 5) it can be seen that the X input is assigned the variable watermark and the Y input is assigned the variable security thread, so the output curve is represented with a 3D curve. These two security features together can detect whether a note is counterfeit, worn or genuine. In this case variable watermark (*x*-axis) can only be varied with the variable security thread (*y*-axis) as output surfaces cannot be generated with other variables (shown in Table 2).

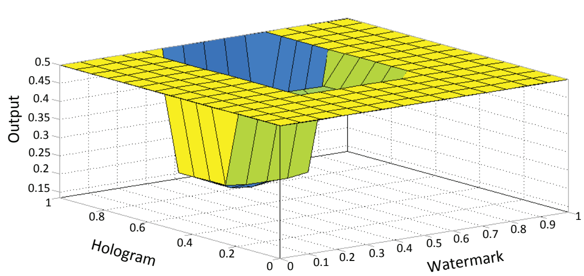

Figure 6: Type 2 graph

There comes a separate variation of graph in the Type 2 graph (Figure 6) in case of hologram and intaglio printing when varied with watermark. Thus, it can be predicted that watermark together with hologram and intaglio printing forms another unit for the detection of a fake note and also whether that particular fake note is worn or not.

In Type 3 graph (Figure 7) it can be seen that watermark varies with latent image of a banknote. Also, the same variation takes place in case of micro-lettering and see-through register when varied with watermark. So, it can be predicted that watermark together with latent image, micro-lettering and see-through register form another group for further detection in counterfeiting of currency notes.

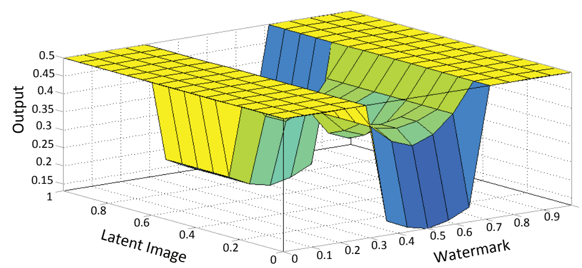

Figure 7: Type 3 graph

In Type 4 graph (Figure 8) it can be seen that the X input is assigned the variable security thread and the Y input is assigned the variable watermark, so the output curve is represented with a 3D curve. In this case it is seen that scaling in *x*-axis and *z*-axis is different as compared with Figure 5 (Type 1 graph) because two input variables are interchanged with *x*-axis and *y*-axis. These two security features together can detect whether a note is counterfeit, worn or genuine. Again, it can be analyzed that if watermark varies with security thread then the output is predicted to be a worn but genuine currency note since the output is shown by the value 0.5. While considering membership function 0.5 is taken under the category of worn, the output tends to be worn. So, the output is predicted to be a worn but genuine currency note. Moreover, if the variable security thread is varied with the variables hologram and intaglio printing (as given in Table 2), it is observed that same nature of 3D curves can be obtained.

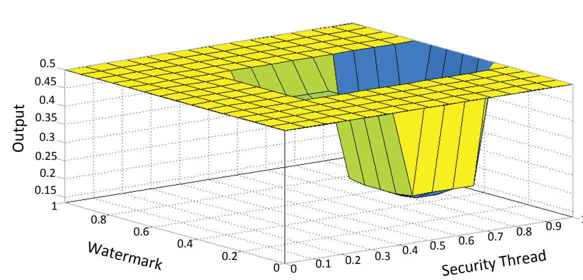

Figure 8: Type 4 graph

There comes a separate variation of graph in the Type 5 graph (Figure 9) in case of hologram and intaglio printing when varied with security thread. Thus, it can be predicted that security thread together with hologram and intaglio printing form another unit for the detection of a fake note and also whether that particular fake note is worn or not.

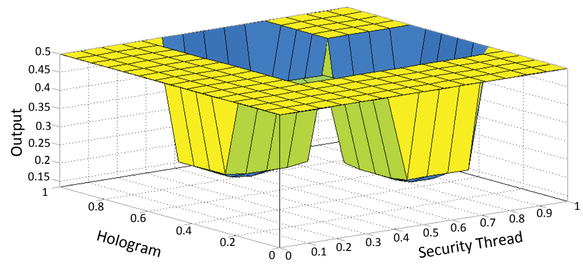

Figure 9: Type 5 graph

In Type 6 graph (Figure 10) it can be seen that security thread varies with latent image of a banknote. Also, the same variation takes place in case of micro-lettering and see-through register when varied with security thread. So, it can be predicted that security thread together with latent image, micro-lettering and see-through register form another group for further detection in counterfeiting of currency notes.

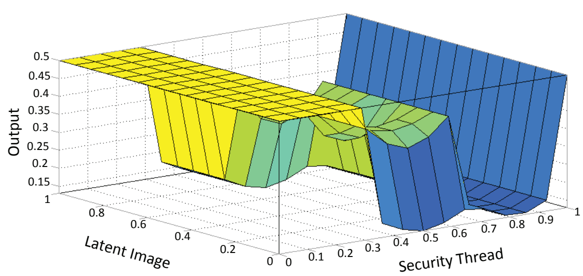

Figure 10: Type 6 graph

In Type 7 graph (Figure 11) it can be seen that the X input is assigned the variable latent image and the Y input is assigned the variable watermark, so the output curve is represented with the 3D curve.

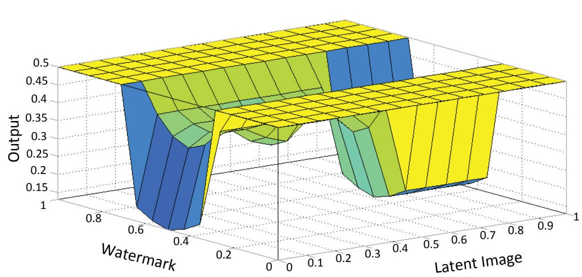

Figure 11: Type 7 graph

Here, the output surface is generated by interchanging the two input variables of Type 3 graph (Figure 7) in *x*- and *y*-axes. The same variation is observed in case of micro-lettering and see-through register when varied with latent image. So, it can be postulated that latent image together with watermark, micro-lettering and see-through register together can detect whether a note is counterfeit, worn or genuine.

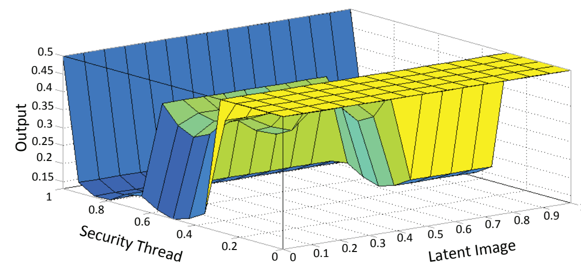

Figure 12: Type 8 graph

There comes a separate variation of graph in Type 8 graph (Figure 12) in case of security thread, hologram and intaglio printing when varied with latent image. Here, the output surface is generated by switching the two input variables of Type 6 graph (Figure 10) in *x*- and *y*-axes. The same variation is observed in case of micro-lettering and see-through register. Thus, it can be predicted that latent image together with security thread, hologram and intaglio printing forms another unit for the detection of a fake note and also whether that particular fake note is worn or not.

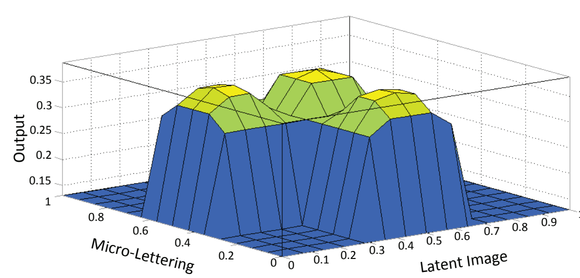

Figure 13: Type 9 graph

In Type 9 graph (Figure 13) it can be seen that latent image varies with micro-lettering of a banknote. It can be analyzed that if latent image varies with micro-lettering, then the output is predicted to be a counterfeit currency note since the output is shown by the value 0.3. While considering membership functions 0.3 is taken under the category of worn and counterfeit, the output is predicted to be a worn but counterfeit note. Also, the same variation takes place in case of see-through register when varied with latent image.

So, it can be predicted that latent image together with micro-lettering and see-through register form another group for further detection in counterfeiting of currency notes.

5. Conclusion

An integrated banknote detection system implementing a fuzzy-based security features classifier has been developed. The fuzzy inference system has been established which primarily consists of the membership functions that help to form linguistic variables that are applied at the input and output, fuzzy IF-THEN rules and fuzzy Surface Viewer. The security features such as watermark, security thread, hologram, intaglio printing, latent image, micro-lettering and see-through register present in the denominations used in this study as well as considering the important security features, which are accepted globally, to the input side with corresponding output gives the cluster of graphs that predicts the tendency of a currency note being counterfeit, worn or genuine relying upon the conditions of its security features. The fuzzy IF-THEN rules are based upon logic, observation, people's feedback and experiences while dealing with currency notes. Finally, the Surface Viewer concentrates upon the decision making process and gives the outcome as a characteristic 3D curve by varying the input. Several graphs that have been generated by the Surface Viewer varying the security features with each other gives an evaluation approach to the existing security features for controlling banknote forgery. This research work may be expanded to a web-based design system to be implemented in the domain of evaluation of security features based on fuzzy logic. Moreover, increase in the number of security features may be considered to build an advanced fuzzy system for every type of currencies across the globe.

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Appendix: IF-THEN rules

Rule No.	IF	THEN
1	(watermark is fair) and (security thread is fair) and (hologram is fair) and (intaglio printing is fair)	(output is Counterfeit)
2	(watermark is excellent) and (security thread is excellent) and (hologram is poor) and (intaglio printing is fair)	(output is Worn)
3	(watermark is fair) and (security thread is excellent) and (hologram is fair) and (intaglio printing is fair)	(output is Counterfeit)
4	(watermark is fair) and (security thread is fair) and (hologram is excellent) and (intaglio printing is fair)	(output is Counterfeit)
5	(watermark is fair) and (security thread is fair) and (hologram is fair) and (intaglio printing is excellent)	(output is Counterfeit)
6	(watermark is fair) and (security thread is fair) and (hologram is excellent) and (intaglio printing is excellent)	(output is Worn)
7	(watermark is fair) and (security thread is excellent) and (hologram is fair) and (intaglio printing is excellent)	(output is Worn)
8	(watermark is excellent) and (security thread is fair) and (hologram is excellent) and (intaglio printing is fair)	(output is Worn)
9	(watermark is excellent) and (security thread is excellent) and (hologram is fair) and (intaglio printing is fair)	(output is Worn)
10	(watermark is excellent) and (security thread is excellent) and (hologram is excellent) and (intaglio printing is fair)	(output is Genuine)
11	(watermark is excellent) and (security thread is excellent) and (hologram is poor) and (intaglio printing is excellent)	(output is Genuine)
12	(watermark is excellent) and (security thread is poor) and (hologram is excellent) and (intaglio printing is excellent)	(output is Genuine)
13	(watermark is fair) and (security thread is excellent) and (hologram is excellent) and (intaglio printing is excellent)	(output is Genuine)
14	(watermark is excellent) and (security thread is fair) and (hologram is excellent) and (intaglio printing is excellent)	(output is Genuine)
15	(watermark is excellent) and (security thread is excellent) and (hologram is fair) and (intaglio printing is excellent)	(output is Genuine)
16	(watermark is excellent) and (security thread is excellent) and (hologram is excellent) and (intaglio printing is excellent)	(output is Genuine)
17	(watermark is poor) and (security thread is poor) and (hologram is poor) and (intaglio printing is poor) and (latent image is poor) and (micro-lettering is poor) and (see-through register is poor)	(output is Counterfeit)
18	(watermark is fair) and (security thread is fair) and (hologram is fair) and (intaglio printing is fair) and (latent image is fair) and (micro-lettering is fair) and (see-through register is fair)	(output is Worn)
19	(watermark is excellent) and (security thread is excellent) and (hologram is excellent) and (intaglio printing is excellent) and (latent image is excellent) and (micro-lettering is excellent) and (see-through register is excellent)	(output is Genuine)
20	(watermark is poor) and (security thread is poor) and (hologram is poor) and (intaglio printing is poor) and (latent image is fair) and (micro-lettering is poor) and (see-through register is fair)	(output is Counterfeit)
21	(watermark is poor) and (security thread is poor) and (hologram is poor) and (intaglio printing is poor) and (latent image is poor) and (micro-lettering is fair) and (see-through register is fair)	(output is Counterfeit)
22	(watermark is poor) and (security thread is poor) and (hologram is poor) and (intaglio printing is poor) and (latent image is fair) and (micro-lettering is fair) and (see-through register is poor)	(output is Counterfeit)
23	(watermark is fair) and (security thread is fair) and (hologram is fair) and (intaglio printing is fair) and (latent image is fair) and (micro-lettering is fair) and (see-through register is poor)	(output is Worn)

Rule No.	IF	THEN
24	(watermark is fair) and (security thread is fair) and (hologram is fair) and (intaglio printing is fair) and (latent image is fair) and (micro-lettering is poor) and (see-through register is fair)	(output is Worn)
25	(watermark is fair) and (security thread is fair) and (hologram is fair) and (intaglio printing is fair) and (latent image is poor) and (micro-lettering is fair) and (see-through register is fair)	(output is Worn)
26	(watermark is excellent) and (security thread is excellent) and (hologram is excellent) and (intaglio printing is excellent) and (latent image is fair) and (micro-lettering is excellent) and (see-through register is excellent)	(output is Genuine)
27	(watermark is excellent) and (security thread is excellent) and (hologram is excellent) and (intaglio printing is excellent) and (latent image is excellent) and (micro-lettering is fair) and (see-through register is excellent)	(output is Genuine)
28	(watermark is excellent) and (security thread is excellent) and (hologram is excellent) and (intaglio printing is excellent) and (latent image is excellent) and (micro-lettering is excellent) and (see-through register is fair)	(output is Genuine)