International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Impact Factor (2012): 3.358

Identification of Gait Disorders Using Fuzzy Expert System

Dr. M. Pushparani[1], B. Kalaivani[2]

[1]Professor, Department of Computer Science, Mother Teresa Women's University, Madurai, Tamil Nadu, India

[2]Scholar, Department of Computer Science, Mother Teresa Women's University, Madurai, Tamil Nadu, India

Abstract: ***Gait analysis is one of the emerging techniques in security aspects as well as clinical aspects. Clinical aspects mainly consist of reading gait signals with a view to diagnose the movement related diseases. This paper discusses about identifying the movement disorders with particular reference to Parkinson's disease and Huntington's disease. It also attempts to differentiate between the above two apparently having similar disorders, so as to accurately diagnose the diseases. Mamdani fuzzy inference system is being used for diagnosing the diseases. Centroid method is used for defuzzification. This system gives better accuracy.***

Keywords: Parkinson's Disease, Huntington's Disease, Mamdani Fuzzy Inference System, Fuzzification, Defuzzification, Centroid.

1. Introduction

Biometrics has emerged as a reliable means of identifying a human subject based on the subject's distinctive biological features. Physiological biometrics such as face, fingerprints or iris pattern generally require the co-operation and presence of the subject person in proximity for recognition. Behavioral biometrics examines human behavior and the most promising one is **gait** which exploits a subject's distinctive **way of walking** for identification without the knowledge of subject and also without interfering the subject's activity. Gait analysis plays an important role in clinical field also. In clinical gait analysis plays a very significant role in the identification and classification of diseases. Clinical gait analysis is very useful in the identification of movement disorder diseases and cognitive disorder diseases and also neuropathology diseases.

2. Literature Review

A fuzzy expert system for heart disease diagnosis was developed by Ali Adeli and, MehdiNehar [1]. They explain about fuzzy Mamdani system clearly. In this paper, the author introduces the fuzzy system for diagnosing heart disease. The authors use 13 inputs and one output for diagnosing the diseases. This paper explains each input field, membership functions, output variables and rule base clearly. This approach gives 94% accuracy.

Introduction and application of an automatic gait recognition method to diagnose movement disorders that arose of similar causes are given by MasoodBanaie et.al [9].They explain different classifications for similar causes for movement disorders i.e. Parkinson's disease, Huntington's disease and ALS with healthy people.

Detection of movement disorders using Multi SVM has been proposed by Pushparani.M and Athisakthi.A [12]. This paper explains similar causes movement disorders using Multi SVM. It also explains about similar causes movement disorders i.e Parkinson's Disease, Huntington's Disease and ALS with healthy people using Multi SVM classification.

A Comprehensive assessment of gait accelerometry signals in time, frequency and tine-frequency domains are given by Ervin sejdle et. al. [5]. They explain about different gait signal features of healthy, Parkinson's disease and Peripheral neuropathy subject. It assesses the gait accelerometry signals in time, frequency and time-frequency.

3. Identification of Gait Disorders Using Fuzzy Expert System

Fuzzy logic is a suitable tool for dynamic classification. In this problem solution, fuzzy system deals that the identification of diseases. In this fuzzy system, 5 inputs and one output are used for identification and severity. The input and output variables and its membership functions are explained below and rule based systems are also explained.

3.1 Fuzzy Set and Membership Functions

1) Gait Speed (m/sec) : Gait speed depends on the subject. Each subject has different speeds. The gait speed input ranges are divided into three categories for identification (i.e.) control group ranges, Parkinson's disease group ranges and Huntington's disease group ranges. Membership function of this fuzzy set is trapezoidal and triangular. The table 1 shows the fuzzy set and ranges of gait speed and figure 1 shows the membership functions of that ranges.

Table 1: Fuzzy Set and Ranges of Gait Speed

Input Field	Classification of Diseases	
	Ranges	**Fuzzy Set**
Gait Speed (m/sec)	< 1.182	Low
	0.99 – 1.35	Mid
	> 1.182	High

Figure 1: Membership Functions of Gait Speed

2) Stride Interval (Sec) : Stride refers that the distance between two left steps. The time taken for the stride is called stride interval. This consists of three fuzzy sets for identification viz., control group ranges, Parkinson's disease group ranges, Huntington's disease group ranges. Membership function of this fuzzy set is trapezoidal and triangular. The table 2 shows the fuzzy set and ranges of stride interval and figure 2 shows the membership functions.

Table 2: Fuzzy Set and Ranges of Stride Interval

Input Field	*Classification of Diseases*	
	Ranges	*Fuzzy Set*
Stride Interval (sec)	< 1.146	Low
	1.08 – 1.22	Mid
	> 1.146	High

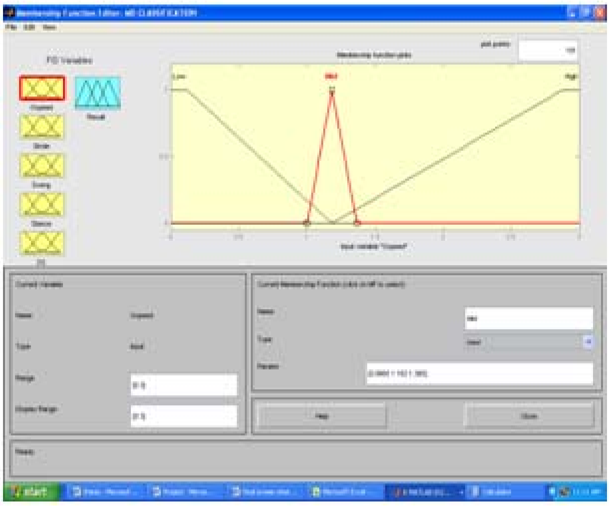

Figure 2: Membership Functions of Stride Interval

3) Swing Interval (%stride) *:* This is also similar to the swing interval. But, it is measured based on percentage of stride. This consists of three fuzzy sets for identification viz., control group ranges, Parkinson's disease group ranges, Huntington's disease group ranges. Membership function of this fuzzy set is triangular and trapezoidal. The table 3 shows the fuzzy set and ranges of swing interval and figure 3 shows the membership functions.

Table 3: Fuzzy Set and Ranges of Swing Interval

Input Field	*Classification of Diseases*	
	Ranges	*Fuzzy Set*
Swing Interval (% stride)	< 35.59	Low
	34.92 – 36.26	Mid
	> 35.59	High

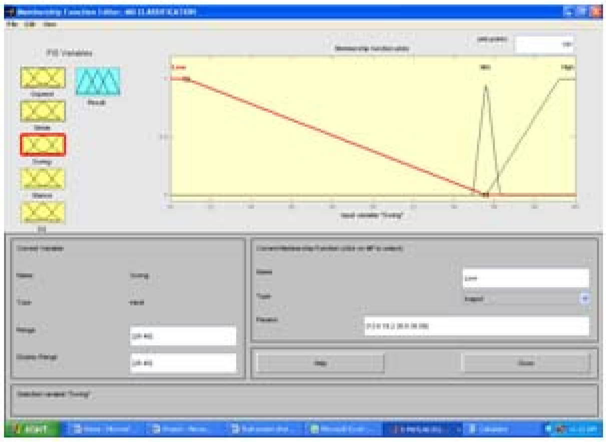

Figure 3: Membership Functions of Swing Interval

4) Stance interval (%stride)*:* This is also similar to the stance interval. But, it is measured based on percentage of stride. This consists of three fuzzy sets for identification viz., control group ranges, Parkinson's disease group ranges, and Huntington 's disease group ranges. Membership function of this fuzzy set is triangular and trapezoidal. The table 4 shows the fuzzy set and ranges of stance interval and figure 4 shows its membership functions.

Table 4: Fuzzy Set and Ranges of Stance Interval

Input Field	*Classification of Diseases*	
	Ranges	*Fuzzy Set*
Stance Interval (% stride)	< 65.78	Low
	63.74 – 67.52	Mid
	> 65.78	High

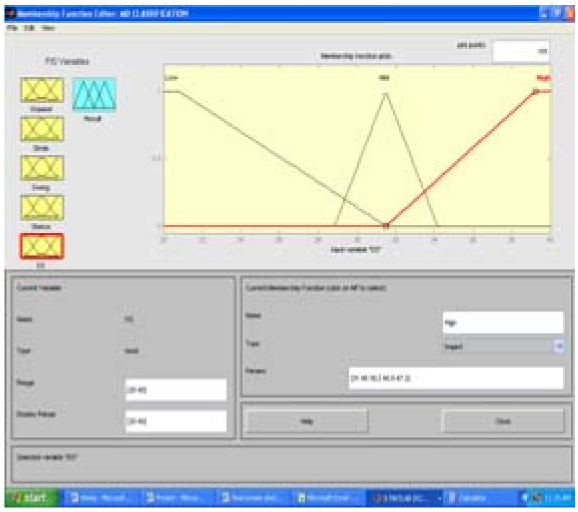

Figure 4: Membership Functions of Stance Interval

5) Double Support (DS) Interval (% Stride) *:* This is similar to the DS interval but it is based on percentage of stride. This consists of three fuzzy sets for identification viz., control group ranges, Parkinson's disease group ranges, Huntington's disease group ranges. Membership function of this fuzzy set is triangular and trapezoidal. The table 5 shows the fuzzy set and ranges of DS interval and figure 5 shows its membership functions.

Table 5: Fuzzy Set and Ranges of Double Support

Input Field	*Classification of Diseases*	
	Ranges	*Fuzzy Set*
Double Support Interval (% Stride)	< 31.48	Low
	28.82 – 34.15	Mid
	> 31.48	High

Figure 5: Membership Functions of DS

Output Variable:
It is the goal variable. This variable depicts wheather the subject suffers by Parkinson''s disease or Huntington's Disease or healthy subject. These ranges are also mentioned in the membership functions. Membership function of this fuzzy set is triangular and trapezoidal. The table 6 shows the fuzzy set and ranges of result field and figure 6 shows the membership functions.

Table 6: Fuzzy Set and Ranges of Result Field

Output Field	*Classification of Diseases*	
	Ranges	*Fuzzy Set*
Result	< 1	Healthy
	0 – 2	PD
	> 1	HD

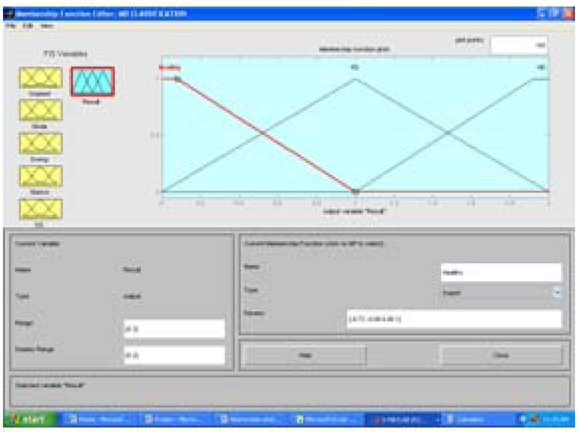

Figure 6: Membership Functions of Result

3.2 Fuzzy Rule Editor

Rule Editor is the important one in Fuzzy Inference System. The rules are set in the rule editor. The disease identification system has 8 rules. Figure 7 shows the rule editor. Some Fuzzy Rules are as follows:

1. If (Gspeed is high) and (Stride is low) and (Swing is high) and (Stance is low) and (DS is low) then the (Result is healthy (1))
2. If (Gspeed is low)and (Stride is high) and (Swing is low) and (Stance is high) and (DS is High) then the (Result is PD (1))
3. If (Gspeed is mid) and (Stride is mid) and (Swing is mid) and (Stance is mid) and (DS is mid) then the (Result is HD (1)) Figure 4.9Shows the rule editor.

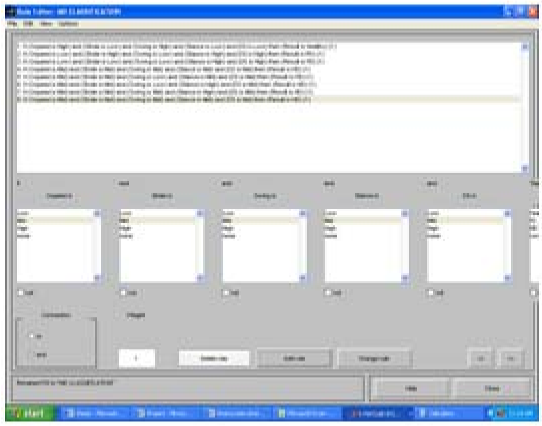

Figure 7: Rule Editor

3.3 Fuzzification and Defuzzification

This is the Mamdoni approach fuzzy system. In this system, the inputs are used AND operators. So, it gives the correct result. Hence, the antecedent section has combination of some inputs to form rules in the rule editor. For aggregation, the system is used maximum of validity degree. These maximum degrees is calculated as follows:
A=max (all rules)
For defuzzification, the system is used 'centroid' method.

$$z_{COA} = \frac{\int_Z \mu_A(z) z \, dz}{\int_Z \mu_A(z) \, dz},$$

Through this formula, the defuzzification is calculated.
It displays the answer.

4. Results

In the experiment, the following defuzzification values are derived to identify the diseases.

Table 7: Defuzzification Values

DefuzzificationValues	**Nature Of Disease**
<1	Control subject
=1	Parkinson's Disease
>1	Huntington's Disease

4.1 Experimental Result

Experiment No.1:

The data are extracted from physionet.org. The table 8 shows the inputs of the proposed system and its result.

Table 8: Gait Parameter Inputs for Experiment No.1

Gait Speed	*Stride*	*Swing*	*Stance*	*DS*	*Result*
0.98	1.134138	34.98461	65.01539	33.43861	1 (PD)

The proposed system gives the result is 1 based on the given inputs. So, that given subject is suffering from Parkinson's disease. Figure 8 shows the output of the above input parameters.

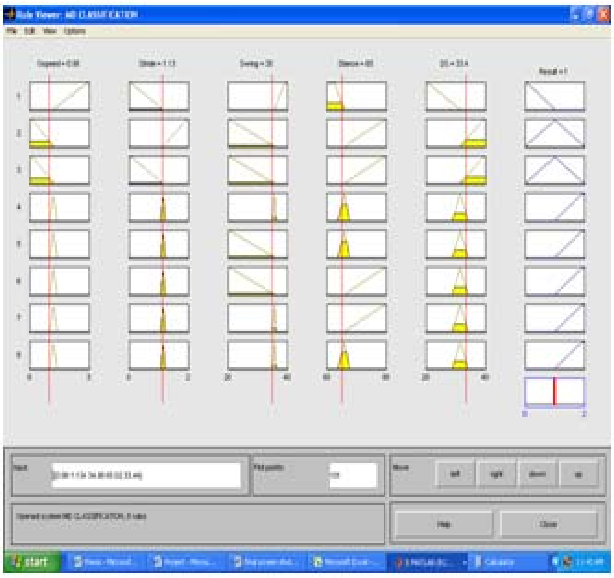

Figure 8: Output – PD people

4.2 Surface View of input vs output

This shows the graphical representation of different inputs and output. The following are some of the surface views.

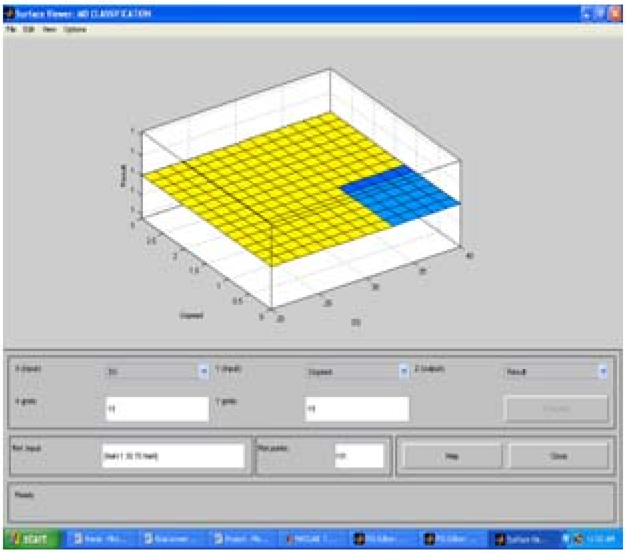

Figure 9: Surface view of DS and Gait speed vs Result

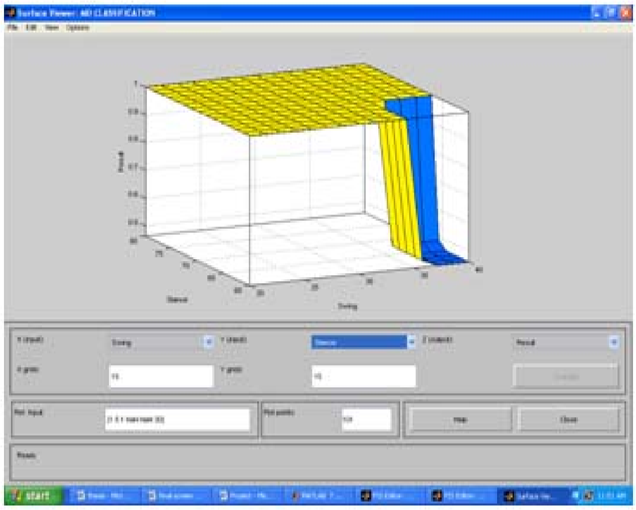

Figure 10: Surface view of Swing and Stride Interval vs Result

5. Analysis

The analysis covers 100 subject. The accuracy percentage is calculated as follows:

Table 9: Accuracy of Each Group

Subject	*Total Number In the group*	*Number of Positive Results*	*Number of Negative Results*	*Positive Results %*	*Negative Results %*
Control	30	26	4	86.67	13.33
PD	50	46	6	88.00	12.00
HD	20	17	3	85.00	15.00

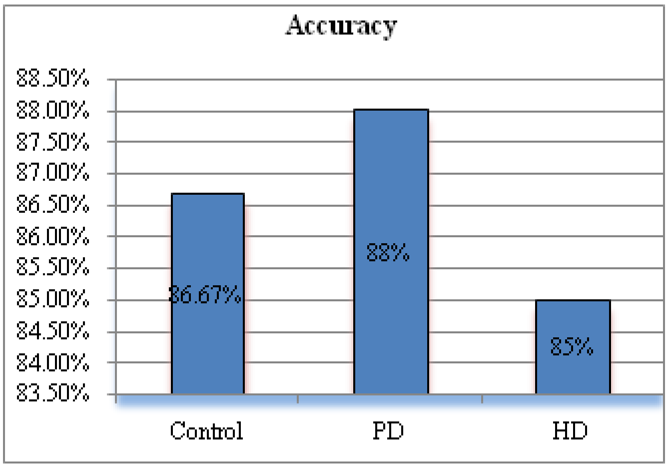

Figure 11: Each Group Accuracy

6. Conclusions and Scope for Future Work

Centroid method is used for defuzzification calculations. Testing data are also used to test the results. It gives the expected output. This system has been proved to give results with better accuracy. Again, the system is trained to identify only two similar disorders viz. PD and HD with similar symptoms. Hence, there is further scope to analyse some other similar movement disorders like Progressive Supranuclear Palsy, ALS, dementia.

References

[1] Ali.Adeli, Mdhdi.Ndshat, “A Fuzzy Expert System For Heart Disease Diagnosis”, International Multi Conference Of Engineers and Computer Scientists 2010 Vol 1, 2010.

[2] Aravind.S, Amit.R, and Rama.C, "A hidden Markov model based framework for recognition of humans from gait sequences," in Proceedings of the 2003 IEEE International Conference on Image Processing, 2003, pp. II-93-6 vol.3.

[3] Bobick A.F and Davis J.W, "The recognition of human movement using temporal templates," IEEE Transactionson Pattern Analysis and Machine Intelligence vol. 23, pp.257-267, 2001

[4] Chew-Yean Yam, Mark S.Nixon University of Southampton, Southampton, SO17 1BJ, UK. ‘Model based Gait Recognition’ In: Encyclopedia of Biometrics, pp1082-1088

[5] Ervin sejdic, Krisitn.A,Lowery, JennicaBellanca, Mark S.Refern and JeneffierS.Brach, ‘A Comprehensive \ assessment of gait accelerometry signal in time, frequency and time frequency domains’, IEEE transactions on Neural Systems and Rehabitation Engineering, 2013

[6] Han.J and Bhanu.B, "Individual recognition using gait energy image," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 28, pp. 316-322, 2006.

[7] Jianyi.L and Nanning.Z, "Gait History Image: A Novel Temporal Template for Gait Recognition," in 2007 IEEEInternational Conference on Multimedia and Expo, 2007, pp. 663-666.

[8] Jin Wang, Mary She, SaeidNahavandiA Review of Vision-based Gait Recognition Methods for Human Identification, 2010 Digital Image Computing: Techniques and Applications,

[9] MasoodBanaie, Mohammad Pooyan, Mohammad Mikaili, ‘Expert Systems With Application Introduction and application of an automatic gait recognition method to diagnose movement disorders that arose of similar causes’ Elsevier Ltd., Vol.38, pp-7539-7563,2011.

[10] Mehmet Fatih CAGLAR, Bayram CETISLI, InayetBurcu TOPRAK, ‘Automatic Recognition of Parkinson’s Disease from Sustained Phonation Tests Using ANN and Adaptive NeuroFuzzy Classifier’,

[11] Journal of Engineering Science and Design, Vol:1 No:2 pp.59-64, 2010

[12] NedeljkovicMapSoft Ltd, Zahumska 26 11000 Belgrade, Serbia and Montenegro,’ Image Classification Based On Fuzzy Logic’, The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Vol. 34, Part XXX

[13] Pushparani.M, Athisakthi.A, ‘Detection of Movement Disorders Using Multi SVM’, Global Journal of Computer Science and Technology Interdisciplinary, Vol 13, 2013

[14] Ravi. Jain1, Ajith. Abraham2,’A Comparative Study of Fuzzy Classification Methods on Breast Cancer Data’, 7th International Work Conference on Artificial and Natural Neural Networks, IWANN’03, Spain, 2003.

[15] Sarkar.S, Phillips P.J, Z. Liu, I. R. Vega, P. Grother, and K.W. Bowyer, "The humanID gait challenge problem: datasets, performance, and analysis," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 27, pp.162-177, 2005.

[16] Serge Guillaume, “Designing Fuzzy Inference Systems from Data:An Interpretability Oriented Review”, IEEE TRANSACTIONS ON FUZZY SYSTEMS, VOL. 9, NO. 3, JUNE 2001