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EDITORIAL PREFACE

This is third issue of volume three of International Journal of Human Computer Interaction (IJHCI). IJHCI is an International refereed journal for publication of current research in Human Computer Interaction. Publications of IJHCI are beneficial for researchers, academics, scholars, advanced students, practitioners, and those seeking an update on current experience, state of the art research theories and future prospects in relation to applied science. Some important topics covers by IJHCI are affective computing, agent models co-ordination and communication, computer mediated communication, innovative interaction techniques and user interface prototyping for interactive systems etc.

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Image Quality Assessment using Elman Neural Network Model and Interleaving Method

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Abstract

Imaging systems introduce distortions and artifacts to the image. It is crucial to know the quality of the image before processing. In any image processing application it is important to know reliability of the imaging system and the quality metrics of the image acquired using the imaging system. This research aims to develop, reference image quality measurement algorithms for JPEG images. A JPEG image database was created and subjective experiments were conducted on the database. A newly proposed image pixel reduction technique was applied to the image to reduce its size. An attempt to design a computationally inexpensive and memory efficient feature extraction method has been developed along with the interleaving method. Subjective test results are used to train the neural network model, which achieves good quality prediction performance without any reference image. In particular the Elman neural network model predicts the mean opinion score of the human observer. The system has been implemented and tested for its validity. Experimental results show that the proposed algorithms have an accuracy rate of 90.23% for image quality recognition.

Keywords: Image Quality Assessment, Vertical Interleaving, Feature Extraction, Neural Network.

1. INTRODUCTION

Over the years, many researchers have taken different approaches to the problem of image quality assessment and have contributed significant research in the area with claims to have made progress in their respective domains. The topic of image quality assessment has been around for more than four decades, but the last few years have seen a sudden acceleration in progress and interest in this area. This corresponds with the rapid rise in interest in digital imaging in general, driven by technological advances and by the ubiquity of digital images and videos on the Internet. Image quality assessment plays an important role in various image processing applications. The field of image and video processing generally deals with signals that are meant for human consumption, such as images or videos over the Internet [1]. An image or video may go through many stages of processing before being presented to a human observer and each stage of processing may introduce distortions that could reduce the quality of the final display. For example, images and videos are acquired by camera devices that may introduce distortions due to optics, sensor noise, color calibration, exposure control, camera motion etc [2]. After acquisition, the image or video may further be processed by a compression algorithm that reduces the bandwidth requirements for storage or transmission. Such compression algorithms are generally designed to achieve greater savings in bandwidth by letting certain distortions happen to the signal. Similarly, bit errors, which occur while an image is being transmitted over a channel or (rarely) when it is stored, also tend to introduce distortions. Finally, the display device used to render the final output may introduce some of its own distortion, such as low reproduction resolution, bad calibration etc. The amount of distortion that each of these stages could add depend mostly on economics and/or physical limitations of the devices [3].

One is obviously interested in being able to measure the quality of an image or video, and to gauge the distortion that has been added to it during different stages. One obvious way of determining the quality of an image or video is to obtain opinion from human observers as these signals are meant for human consumption [4]. However, such a method is not feasible not only due to the sheer number of images and videos that are available, but also because quality measurement techniques have to be embedded into the very algorithms that process images and videos, so that their output quality may be maximized for a given set of resources.

The goal of research in objective image quality assessment is to develop quantitative measures that can automatically predict perceived image quality [5]. Generally speaking, an objective image quality metric can play an important role in a broad range of applications, such as image acquisition, compression, communication, displaying, printing, restoration, enhancement, analysis and watermarking [5]. First, it can be used to dynamically monitor and adjust image quality. Second, it can be used to optimize algorithms and parameter settings of image processing systems. Third, it can be used to benchmark image processing systems and algorithms. In short, objective quality measurement (as opposed to subjective quality assessment by human observers) seeks to determine the quality of images or videos algorithmically. The goal of objective quality assessment (QA) research is to design algorithms whose quality prediction is in good agreement with subjective scores from human observers [7]. From the previous researches on image quality assessment it was observed that only few researchers have used the neural network to predict the quality of the image [8, 9]. In this paper, the various camera setting parameters and the feature extracted from the image database are used as the input to the neural network and the mean opinion score obtained from the subjects is used as the output to train the neural network model.

2. METHODOLOGY

An image acquisition process is subjected to many environmental concerns such as the position of the camera, number of cameras used, lighting sensitivity and background condition due to which the quality of the image is affected. The proposed system will predict the quality of the image using neural network models. The data are collected in three different locations with different environmental. Figure 1 shows the 3 different locations where the data collection were carried out .The images are captured using Sony DSR camera. While collecting the data the aperture diameter (f1.0-f14), shutter speed (8-2000), ISO (160-3200) [8], light illumination and Pixel values are noted and used as features for the network model. Human observers can easily assess the quality of distorted images without using any reference image, for this reason the subjective evaluation of the image database is carried out [10]. There are 467 test images in the database, for collecting the mean opinion score 16 subjects were used and the pictures in the database are shown to them one by one. The subjects were asked to assign each image a quality score between 1 and 10 (10 represents the best quality and 1 the worst). The 16 scores of each image were averaged to a final Mean Opinion Score (MOS) of the image. Subjective experimental results on JPEG compressed images are used to train the network model. The proposed system has three processing stages namely preprocessing, feature extraction and classification. Figure 2 shows the block diagram of the proposed system. In the preprocessing stage the image is resized to reduce the computational time using interleaving method.

FIGURE 1: Three different Data collection locations

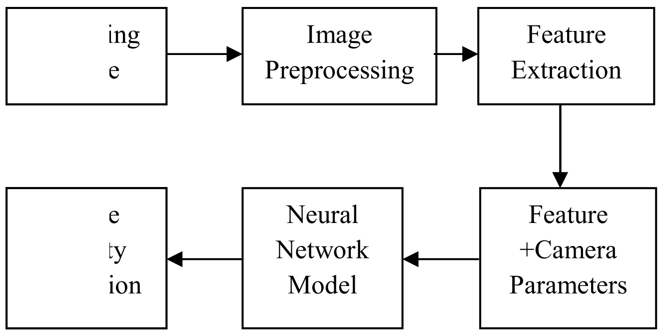

FIGURE 2: Block Diagram of Proposed System

3. VERTICAL INTERLEAVING METHOD

Interleave is a pixel reduction technique where interleave method interleaves the image pixel either row-by-row or column-by-column. In this research a simple interleave method is proposed and carried out by comparing the pixel values either row-by-row or column-by-column. During the comparison the maximum pixel value will be taken and the minimum value is discarded. If the pixel value is equal then any one pixel value is taken. The pixel values are compared column by column in this research and hence the proposed method is called vertical maximum interleaving. Figure.3 shows the image before interleaving and after interleaving. The vertical maximum interleaving method algorithm is as follows.

Vertical Maximum Interleaving method Algorithm:

Step 1: Acquire the segmented region
Step 2: Compare the pixel value of each alternative columns with the corresponding adjacent column and find the maximum value.

Step 3: If both the pixel value are same then take any one value.
Step 4: Acquire the new vertical interleaved image using Step 2 and Step 3
After applying interleaving method on the image and the features are extracted from the input images.

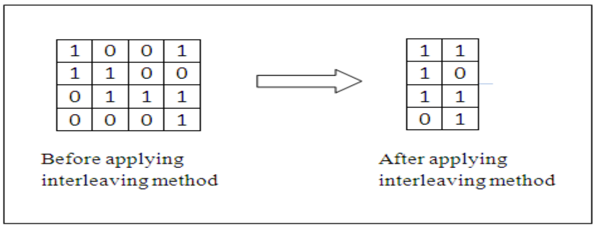

FIGURE 3: Vertical Maximum Interleaving method

4. FEATURE EXTRACTION

JPEG is a block DCT-based lossy image coding technique. It is lossy because of the quantization operation applied to the DCT coefficients in each 8×8 coding block. Both blurring and blocking artifacts may be created during quantization. The blurring effect is mainly due to the loss of high frequency DCT coefficients, which smoothes the image signal within each block. Blocking effect occurs due to the discontinuity at block boundaries, which is generated because the quantization in JPEG is block-based and the blocks are quantized independently. Blurring and blocking are the most significant artifacts generated during the JPEG compression process [11]. We denote the test image signal as $x(m,n)$ for $m \in [1,M]$ and $n \in [1,N]$, Calculating the differencing signal along each horizontal axis:

$$d_h(m,n)=x(m,n+1)-x(m,n), n\in[1,N-1]) \qquad (1)$$

First, the blocking estimated as the average differences across block boundaries:

$$B_h=\frac{1}{M\left(\left[\frac{N}{8}\right]-1\right)}\sum_{i=1}^{M}\sum_{j=1}^{\left[\frac{N}{8}\right]-1}|d_h(i,8j)| \qquad (2)$$

Secondly, the blurring in the image is evaluated using two activity measures. The first activity measure is the average absolute difference between in-block image samples and is calculated as:

$$A_h=\frac{1}{7}\left[\frac{8}{M(N-1)}\sum_{i=1}^{M}\sum_{j=1}^{N-1}|d_h(i,j)|-B_h\right] \qquad (3)$$

The second activity measure is the zero-crossing (ZC) rate. Define $n\in[1,N-2]$,

$$z_h(m,n)=\begin{cases}1 & \text{horizontal ZC at } d_h(m,n)\\ 0 & \text{otherwise}\end{cases} \qquad (4)$$

Then the horizontal *ZC* rate can be calculated from the below equation

$$Z_h=\frac{1}{M(N-2)}\sum_{i=1}^{M}\sum_{j=1}^{N-2}z_h(m,n) \qquad (5)$$

Using similar methods, we calculate the vertical features of *Bv*, *Av*, and *Zv*. Finally, the overall features are given by:

$$B=\frac{B_h+B_v}{2}, A=\frac{A_h+A_v}{2}, Z=\frac{Z_h+Z_v}{2}. \tag{6}$$

These feature extraction methods are computationally inexpensive and memory efficient [12].

5. NEURAL NETWORK MODELING

Artificial Neural Network (ANN) provides alternative form of computing that attempts to mimic the functionality of the brain [13].To classify the image based on its quality an Elman neural network has been developed. Typical Elman network has one hidden layer with delayed feedback. The Elman neural network is capable of providing the standard state-space representation for dynamic systems [14]. The neural network architecture has three layers consisting of an input layer, one hidden layer and an output layer. To predict the quality of the image a simple neural network model using error back propagation was developed. The network model has 8 input neurons representing the features (aperture diameter, shutter speed, pixel value, ISO, light illumination, *B*, *A* and *Z*), 3 hidden neurons and 4 output neurons. The network initial weights are chosen randomly between 0 to 1. The network is trained with 60 % of samples i.e., 281 samples and tested with the remaining 40 % i.e., 186 samples. For each trail, the network is trained for five times (with five different initial weights) and the mean classification rate, minimum and maximum epochs are recorded. In the experimental analysis, five such trails were made and the results are tabulated in Table 1.

Number of Input neurons:8				Number of hidden neurons:6		
Number of output neurons:4				Momentum Factor: 0.9		
Activation Function: Binary sigmoid				Training Tolerance: 0.001		
Learning Rate: 0.5				Testing Tolerance: 0.1		
Number of samples used for training: 281						
No. samples used for testing:186						
Total Samples:467						
	No of Epoch:			Classification Rate:		
Trail	Minimum Epoch for Training	Maximum Epoch for Training	Mean Epoch for Training	Minimum Classification Rate (%)	Maximum Classification Rate (%)	Mean Classification Rate (%)
1	5697	7006	6723	88.62	91.32	89.12
2	6135	6690	6340	88.33	92.24	89.33
3	6211	7836	6915	89.19	91.91	89.16
4	6172	6862	6435	89.32	90.33	88.91
5	5015	8466	8156	88.74	92.46	89.62
Average	6846	7172	8713	88.64	91.05	90.23

TABLE 1: Network architecture for image quality prediction

6. RESULTS AND DISCUSSION

The learning rate, momentum factor, training and testing tolerance for the image quality prediction network are also shown in Table 1.From Table 1 it is observed that the maximum classification accuracy for the developed network model is 92.46% and the minimum classification rate is 89.19%. The maximum epoch value obtained for the developed network model is 8466 and the minimum epoch value is 5015. The mean epoch value for the developed network model is 8713. The interleaving method showed improvements in reducing the processing time. Experimental results shows that the neural network model correlates highly with the mean opinion scores based on the classification results obtained.

7. CONCLUSION

The current research in image quality assessment has come a long way from its beginning few decades ago. This work presented an automated system for objective assessment of image quality a new approach for image quality assessment using neural network model was proposed. Using the Elman neural network model the quality of the images where obtained. A new image interleaving algorithm was proposed in this paper. The image interleaving method reduces the pixel values and hence the processing time was reduced. The proposed system has a mean classification accuracy of 90.23%. The experimental results confirm that the developed system can recognize the quality metrics of the image correctly. In future a neural network based controller is proposed to be used to control the camera parameters to obtain good quality image.

8. ACKNOWLEDGMENT

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9. REFERENCES

[1] Zhou Wang, Alan C. Bovik,"Modern Image Quality Assessment", Synthesis Lectures on Image, Video, and Multimedia Processing, 2006, Vol. 2, No. 1, pp 1-156.

[2] Kalpana Seshadrinathan, Thrasyvoulos N. Pappas, Robert J. Safranek, Junqing Chen, Zhou Wang, Hamid R. Sheikh, and Alan C. Bovik, " Image Quality Assessment", http://www.downloadit.org/free_files/Pages%20from%20Chapter%2021 a083d09ec93486e5de61a062d13060cb.pdf.

[3] Alan Chalmers, Ann McNamara, Scott Daly, Karol Myszkowski, Tom Troscianko, "Image Quality Metrics", http://www.cs.bris.ac.uk/ Publications/pub_master.jsp?id=1 00473.

[4] "Small survey of Objective Image Quality metrics",http://www .mvkonnik.info/2009/03/small-survey-of objective- image-quality. html.

[5] Jia Gu and Wenjing Li, "Automatic Image Quality Assessment for Uterine Cervical Imagery", Proc. of SPIE Vol. 6146 61461B-1

[6] J. Ahumada, Jr., "COMPUTATIONAL IMAGE QUALITY METRICS: A REVIEW",http://vision.arc.nasa.gov/personnel/al/ papers/93sidaja/93s d.htm.

[7] Zhou Wang,Alan C. Bovik and Ligang Lu,"WHY IS IMAGE QUALITY ASSESSMENT SO DIFFICULT?", http:// **Error! Hyperlink reference not valid.** ~zwang/files/papers.

[8] Bouzerdoum, A, Havstad, A & Beghdadi, A, Image quality assessment using a neural network approach, Proceedings of the Fourth IEEE International Symposium on Signal Processing and Information Technology, 18-21 December 2004, 330-333. Copyright IEEE 2004.

[9] P. Carrai, et al., "Image quality assessment by using neural networks," in Circuits and Systems, 2002. ISCAS 2002. IEEE International Symposium on, 2002, pp. V-253-V-256 vol.5.

[10] Bryan F Peterson, "Basic Photo Tips: Aperture, Shutter Speed, and ISO", http://photo.net/learn/basic-photo-tips/aperture-shutterspeed-iso/

[11] M. Pinson and S. Wolf, “Comparing subjective video quality testing methodologies”, Proceedings of the SPIE, Vol. 5150, pp. 573-582, 2003.

[12] Zhou Wang, Hamid R. Sheikh and Alan C. Bovik “NO-REFERENCE PERCEPTUAL QUALITY ASSESSMENT OF JPEG COMPRESSED IMAGES ”

[13] S.N Sivanandam and Paulraj M, “An Introduction to Artificial Neural Networks”, Vikhas Publication, India 2003.

[14] L. Whei-Min and H. Chih-Ming, "A New Elman Neural Network-Based Control Algorithm for Adjustable-Pitch Variable-Speed Wind-Energy Conversion Systems," Power Electronics, IEEE Transactions on, vol. 26, pp. 473-481, 2011.

Parameters Optimization for Improving ASR Performance in Adverse Real World Noisy Environmental Conditions

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Abstract

From the existing research it has been observed that many techniques and methodologies are available for performing every step of Automatic Speech Recognition (ASR) system, but the performance (Minimization of Word Error Recognition-WER and Maximization of Word Accuracy Rate- WAR) of the methodology is not dependent on the only technique applied in that method. The research work indicates that, performance mainly depends on the category of the noise, the level of the noise and the variable size of the window, frame, frame overlap etc is considered in the existing methods.

The main aim of the work presented in this paper is to use variable size of parameters like window size, frame size and frame overlap percentage to observe the performance of algorithms for various categories of noise with different levels and also train the system for all size of parameters and category of real world noisy environment to improve the performance of the speech recognition system.

This paper presents the results of Signal-to-Noise Ratio (SNR) and Accuracy test by applying variable size of parameters. It is observed that, it is really very hard to evaluate test results and decide parameter size for ASR performance improvement for its resultant optimization.
Hence, this study further suggests the feasible and optimum parameter size using Fuzzy Inference System (FIS) for enhancing resultant accuracy in adverse real world noisy environmental conditions.

This work will be helpful to give discriminative training of ubiquitous ASR system for better Human Computer Interaction (HCI).

Keywords: ASR Performance, ASR Parameters Optimization, Multi-Environmental Training, Fuzzy Inference System for ASR, Ubiquitous ASR System, Human Computer Interaction (HCI).

1. INTRODUCTION

Many Speech User Interface (SUI) based applications are now a part of daily life. However, a number of hurdles remain to making these technologies ubiquitous [1]. In light of the increasingly mobile and socially connected population, core challenges include robustness to additive background noise, convolutional channel noise, room reverberation and microphone mismatch [2, 3]. Other challenges include the ability to support the world’s range of speakers, languages and dialects in speech technology.

Automated speech recognition (ASR) is the foundation of many speech and language processing applications. ASR technology includes signal processing, optimization, machine learning, and statistical techniques to model human speech and understanding.
This complete work focuses on following major issues for ASR performance improvement,

- Methodologies at pre-processing i.e. back-end level;
- Techniques at signal processing front-end for feature parameter extractions;
- Multi-environment training for Environment Adaptation and reducing the difference between training and testing environment;
- Variable parameter optimization using Fuzzy logic that is similar to the way of human thinking. Fuzzy sets are successfully applied for speech recognition due to their ability to deal with uncertainty.

This paper focuses on the last issue, as first three issues are already analyzed and results are submitted for publication.
This work may be extended to train the system for multi-user and English language speakers from various countries.

2. FUZZY LOGIC AND FUZZY INFERENCE METHODOLOGY

The concept of fuzzy logic [4] to present vagueness in linguistics, and further implement and express human knowledge and inference capability in a natural way. Fuzzy logic starts with the concept of a fuzzy set.

A fuzzy set is a set without a crisp, clearly defined boundary. It can contain elements with only a partial degree of membership. A Membership Function (MF) is a curve that defines how each point in the input space is mapped to a membership value (or degree of membership) between 0 and 1. The input space is sometimes referred to as the universe of discourse. Let X be the universe of discourse and x be a generic element of X. A classical set A is defined as a collection of elements or objects x Є X, such that each x can either belong to or not belong to the set A, $A \sqsubseteq X$. By defining a characteristic function (or membership function) on each element x in X, a classical set A can be represented by a set of ordered pairs (x, 0) or (x, 1), where 1 indicates membership and 0 non-membership. Unlike conventional set mentioned above fuzzy set expresses the degree to which an element belongs to a set. Hence the characteristic function of a fuzzy set is allowed to have value between 0 and 1, denoting the degree of membership of an element in a given set. If X is a collection of objects denoted generically by x, then a fuzzy set A in X is defined as a set of ordered pairs.

The Fuzzy System has Five Parts of the Fuzzy Inference System

- Fuzzification of the given set of variables
- Application of the fuzzy operator (AND or OR) in the antecedent
- Implication from the antecedent to the consequent
- Aggregation of the consequents across the rules
- Defuzzification

Fuzzy Inference System

In this context, Fuzzy Inference Systems (FIS), also known as fuzzy rule-based systems, are well-known tools for the simulation of nonlinear behaviors with the help of fuzzy logic and linguistic fuzzy rules. There are some popular inference techniques developed for fuzzy systems, such as Mamdani [5], Sugeno [6], Tsukamoto [6]. Mamdani FIS is selected to use in this experimental study.

3. PROPOSED METHODOLOGY

From the literature study and analysis of speech processing methods it is observed that performance of the speech processing technique and the word recognition accuracy of a speech recognition system is dependent on windowing and frame size frame overlap size of a speech sample [7], recoding – training – testing environment, technique/s used at front-end and back-end of a system.

Therefore this work uses variable size of windowing, framing and frame overlap size, and the performance evaluation is done on every step of a system model from front-end and back-end techniques.

- Speech samples of digits, zero to nine are recorded from different ten Indian English speaking persons (five males and five females) and multiple utterances, in real world noisy environment with sampling frequency 8 kHz and time duration 3 sec.
- First, these samples are checked for whether voiced / invoiced / or silence [8]. Only voiced samples are considered and others are discarded.
- In the pre-processing steps, noise is removed using filters and enhanced [9,10] using Wiener-Type Filter algorithm [11]. This algorithm is tested on different window size, frame size frame overlap size and for different category of noisy environment (Back-end level).
- SNR improvement test is performed. Results are given in Table: 1-5.
- Features are extracted using MFCC front-end technique [12, 13]. Features are extracted using different window and frame size.
- Further these feature parameters are passed to Hidden Markov Model (HMM) for training and followed by recognition [14]. Here the aim is to train the system for all types of environment (Multi-environment training) to improve the word recognition accuracy therefore, system is trained for all variety of samples like samples recorded at clean environment (inside glass cabin), samples recorded at all category of real world noise (out-side of room and at crowded places), samples after applying traditional noise removal filters, samples after applying speech enhancement algorithms etc.
- Accuracy is computed using Word recognition rate separately for different window and frame size. Results are given in Table: 1-5.
- This experiment is performed adjusting variable parameters like window, frame and frame overlap size manually (using computer program) to find out improvement in word recognition accuracy using iterative method. Please refer Table: 1-5
- The aim of this experiment is to find-out variable parameters size to optimized accuracy therefore a ruled base Fuzzy Inference System (FIS) from MatLab [15] is used.
- Window size and Frame overlap size in % and SNR as an environment are sent to the FIS as input parameters and Word recognition accuracy is computed as output. Rules are framed to compute the output.

4. EMPIRICAL PROCESS FOR FUZZY INFERENCE SYSTEM (FIS)

FIS uses following parameters,

4.1 Parameter List:

1. Hamming Window Size: 240-270 step size 10 (240, 250, 260, 270)

2. Frame Overlap percentage: 20-60 % Step size 5% (20, 25, 30, 35, 40, 45, 50, 55, 60)

3. Window Size is calculated using following equation:

Window Size = Window length * Sampling Frequency (Window length is 20 ms)

4. Variable Frame Size is obtained using equation:

$$\text{Frame Size} = \frac{\text{Speech Sample Length}}{\text{Size of Hamming Window}} * \text{Frame Overlap \%}$$

5. Word Recognition Accuracy is computed using equation:

$$\text{Word Recognition Accuracy} = \frac{\text{Number of Words Recognised}}{\text{Number of Words Tested}} \%$$

4.2 Fuzzy Inference System (FIS) :
FIS is set using following parameters:

[System]
Name='SpeechAccuracy'
Type='mamdani'
Version=2.0
NumInputs=3
NumOutputs=1
NumRules=5
AndMethod='min'
OrMethod='max'
ImpMethod='min'
AggMethod='max'
DefuzzMethod='centroid'

Three inputs are selected in the system, SNR value is passed for the Environment, Hamming windows size as WinSz and Frame overlap percentages as FrOver.
Input parameters, their membership function and ranges as follow.

[Input1]
Name='Environment'
Range=[10 50]
NumMFs=3
MF1='VNoisy':'trimf',[-6 10 20]
MF2='Noisy':'trimf',[20 30 35]
MF3='Clean':'trimf',[35 50 66]
Environment is defined as the value based on SNR, 10-20 dB is Very Noisy, 20-35 dB is Noisy and 35-50 dB is assumed for clean environment.

[Input2]
Name='WinSz'
Range=[240 270]
NumMFs=3
MF1='Small':'trimf',[225 240 250]
MF2='Medium':'trimf',[250 255 260]
MF3='Large':'trimf',[260 270 282]
Window size is considered in three ranges Small, Medium and Large with ranges 240-250, 255-260 and 260-270 respectively.

[Input3]
Name='FrOver'
Range=[20 60]
NumMFs=3
MF1='Small':'trimf',[4 20 40]
MF2='Medium':'trimf',[40 50 55]
MF3='Large':'trimf',[50 60 76]
Frame overlap percentage is considered in three ranges Small, Medium and Large with ranges 20-40, 40-50 and 50-60 respectively.

[Output1]
Name='Accuracy'
Range=[95 100]
NumMFs=3
MF1='Good':'gaussmf',[0.8493 95]
MF2='Better':'gaussmf',[0.8493 97.5]
MF3='Best':'gaussmf',[0.8493 100]

The Word recognition Accuracy is the final output. It is considered as Good, Better and Best in the expected range of 95 to 100 %,

After defining input, output and their membership functions, rules are framed and weights are assigned as given below

[Rules]
3 0 0, 2 (0.5) : 1
3 0 2, 3 (0.75) : 1
3 2 2, 3 (1) : 1
0 0 2, 2 (0.5) : 1
0 2 0, 2 (0.5) : 1

- If (Environment is Clean) then (Accuracy is Better) (0.5)
- If (Environment is Clean) and (FrOver is Medium) then (Accuracy is Best) (0.75)
- If (Environment is Clean) and (WinSz is Medium) and (FrOver is Medium) then (Accuracy is Best) (1)
- If (FrOver is Medium) then (Accuracy is Better) (0.5)
- If (WinSz is Medium) then (Accuracy is Better) (0.5)

Final step is defuzzification, output accuracy is observed for different rules and crisp value is obtained using centroid - DefuzzMethod,

Observations and output results are given in Results and Discussion section.

5. RESULTS AND DISCUSSION

Frame size, SNR and accuracy results for different Hamming window and frame overlap % are given in table 1-5. Tables are given at the end of paper.

Table 1: SNR & Accuracy Test results for different Hamming Window Size, Frame Size and Frame Overlap % for same sample recorded at Real World Environment Noise

Table 2: SNR & Accuracy Test results for different frame size and frame overlap % and Window Size 240 for different samples at Real World Environment Noise

Table 3: SNR & Accuracy Test results for different frame size and frame overlap % and Window Size 250 for different samples at Real World Environment Noise

Table 4: SNR & Accuracy Test results for different frame size and frame overlap % and Window Size 260 for different samples at Real World Environment Noise

Table 5: SNR & Accuracy Test results for different frame size and frame overlap % and Window Size 270 for different samples at Real World Environment Noise

FIS Results

- Five rules are set to compute the Accuracy as an output as shown in fig: 1.
- Using the default values output of rules are viewed as shown in fig: 2 and crisp value of accuracy is observed.

Output of rules are viewed and crisp value of accuracy is observed by changing input values as shown in fig: 3

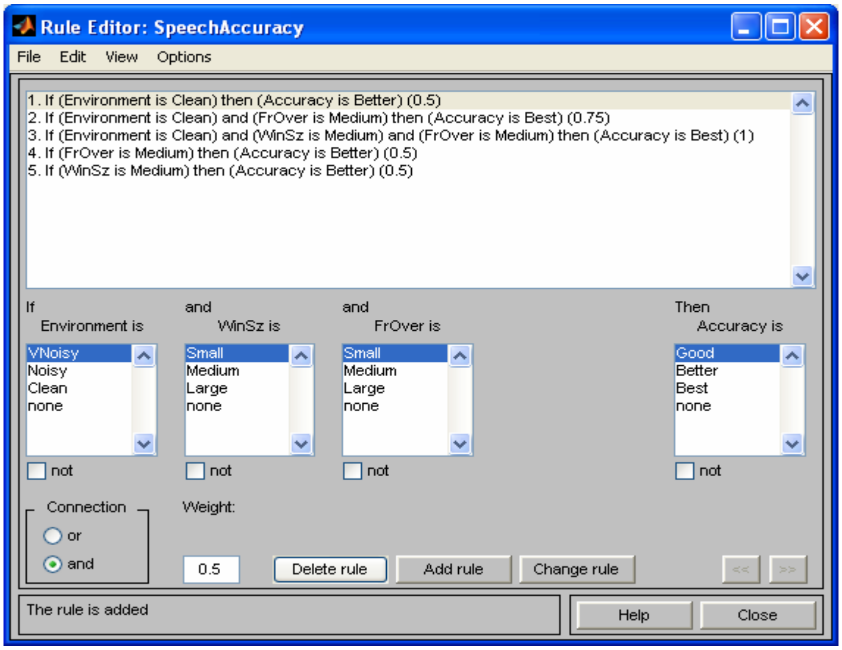

Fig 1: Rules sets for Accuracy Optimization

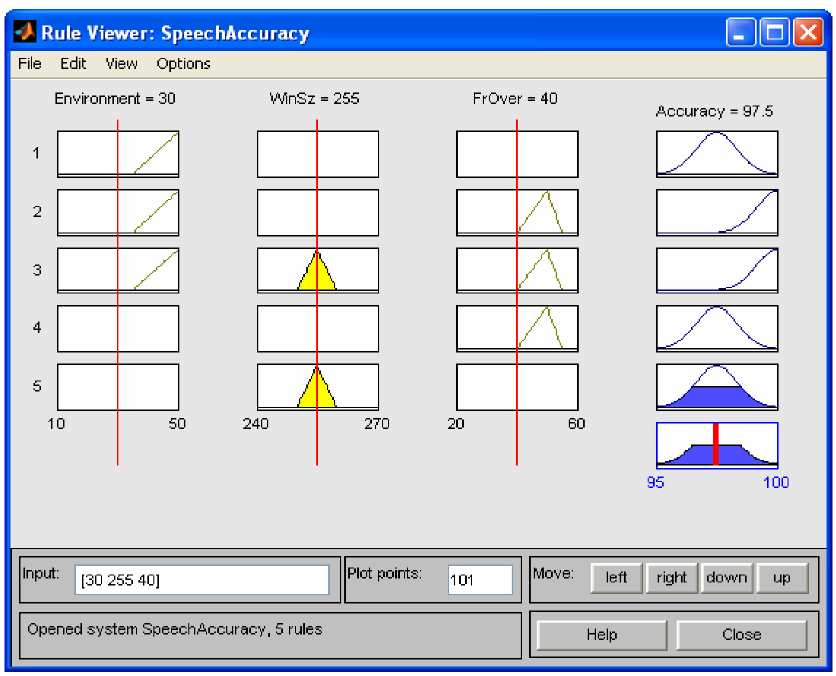

Fig 2: Output of Rules and Defuzzification (Parameter Set 1)

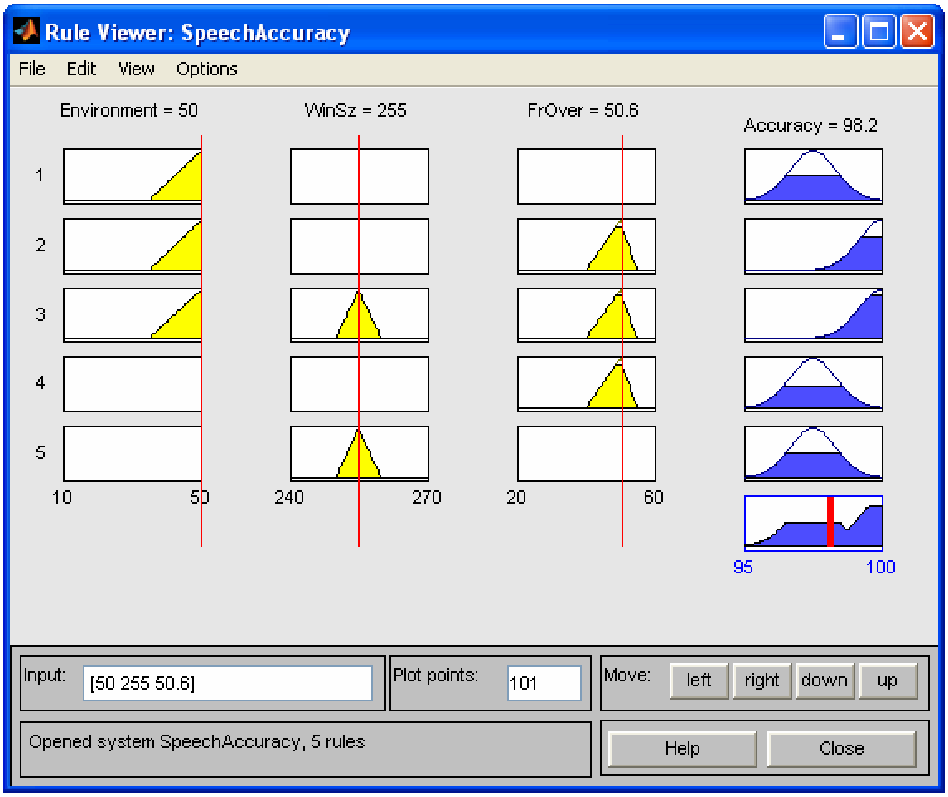

Fig 3: Output of Rules and Defuzzification (Parameter Set 2)

6. CONCLUSION

The assumption for this study was that the word recognition accuracy not only depends on the adverse environment conditions but variable size of hamming window, frame overlap and frame length also. It is proved by using traditional algorithm methods and calculations using different size of parameters as well as fuzzy system.

The improved word recognition accuracy is observed using hybrid signal enhancement method as compared to results shown in previous literature.

From the tabular data, for all hamming window size, SNR gradually improved till 50 % frame overlap but after going down. There is variation in word recognition accuracy calculated for different hamming window size and frame size. The better accuracy is observed in between 45-55 % frame overlap.

From FIS simulation results, the feasible parameter size for accuracy improvement is found in ranges, that clean environment SNR between 40-50 dB, Hamming window size should be medium 250-260 ms and frame overlap percentage between 40-55 %.

The optimized parameter size for best accuracy is observed by clean environment SNR above 45 db, hamming window size 255 ms and frame overlap percentage 50.6

7. REFERENCES

[1] "LOOKING AHEAD: Grand Challenges In Speech And Language Processing", *IEEE Signal Processing Magazine* [179] January 2012

[2] B.-H.Juang, "Speech Recognition in Adverse Environments," *Computer Speech and Language*, pp. 275--294, 5, 1991.

[3] Y.Gong, "Speech Recognition in Noisy Environments: A Survey," *Speech Communication*, Vol. 12, No. 3, pp. 231--239, June, 1995.

[4] L. A. Zadeh, “Fuzzy sets,” *Inform. Control*, vol. 8, pp. 338–353, 1965

[5] J. C. Bezdek and S. K. Pal, Eds., “Fuzzy Models for Pattern Recognition Methods That Search for Structures in Data”. *New York: IEEE Press*, 1992.

[6] T. Takagi and M. Sugeno, “Fuzzy identification of systems and its applications to modeling and control,” *IEEE Trans. Syst., Man, Cybern*., vol. SMC-15, no. 1, pp. 116–132, Jan. 1985.

[7] Qifeng Zhu and Abeer Alwan, “On The Use Of Variable Frame Rate Analysis In Speech Recognition”, *ICASSP*, 2000

[8] J. Ramírez, J. M. Górriz and J. C. Segura, “Voice Activity Detection. Fundamentals and Speech Recognition System Robustness”, *I-Tech*, Vienna, Austria, June 2007

[9] Loizou, P., Kim, G., “Reasons why current speech-enhancement algorithms do not improve speech intelligibility and suggested solutions”. *IEEE Trans. Acoust. Speech Signal Process*. 19, 47–56., 2011

[10] Loizou, P., “Speech Enhancement: Theory and Practice”. CRC *Press LLC, Boca Raton*, Florida.,2007

[11] Suhadi Suhadi, Carsten Last, and Tim Fingscheidt, “A Data-Driven Approach to A Priori SNR Estimation”, IEEE Transactions On Audio, Speech, And Language Processing, Vol. 19, No. 1, January 2011, pg 186- 195

[12] Motlíček P.: “Feature Extraction in Speech Coding and Recognition”, *Report, Portland, US, Oregon Graduate Institute of Science and Technology,* pp. 1-50, 2002

[13] I Mporas, T Ganchev, M Siafarikas, N Fakotakis, “Comparison of Speech Features on the Speech Recognition Task”, *Journal of Computer Science* Vol 3 (8): pp 608-616, 2007

[14] L R Rabiner, “A Tutorial on Hidden Markov Models and Selected Application in Speech Recognition”, *proceedings of the IEEE*, Vol. 77, No. 2, Feb 1989.

[15] MathWorks - MATLAB and Simulink for Technical Computing, www.mathworks.com/

Result Tables

Hamm Win Size	Variables	Frame Overlap 20 %	Frame Overlap 25 %	Frame Overlap 30 %	Frame Overlap 35 %	Frame Overlap 40 %	Frame Overlap 45 %	Frame Overlap 50 %	Frame Overlap 55 %	Frame Overlap 60 %
240	FrSz	11.0000	11.0000	12.0000	13.0000	13.0000	13.0000	14.0000	15.0000	15.0000
	SNR	10.6244	13.9512	18.1852	21.9053	29.0342	37.6815	42.9845	33.3873	25.5868
	Accuracy	95.6196	97.6584	96.3816	92.0023	95.8129	96.0878	97.1450	96.8232	97.2298
245	FrSz	11.0000	11.0000	12.0000	12.0000	13.0000	13.0000	14.0000	14.0000	15.0000
	SNR	09.6427	13.1146	17.7529	22.2198	29.5783	39.1633	43.8332	33.0721	23.8667
	Accuracy	86.7843	91.8022	94.0904	93.3232	97.6084	99.8664	99.0630	95.9091	90.6935
250	FrSz	11.0000	11.0000	12.0000	12.0000	13.0000	13.0000	14.0000	14.0000	15.0000
	SNR	10.1832	13.9075	17.6812	23.4952	29.5787	38.8426	43.4540	33.3081	23.5664
	Accuracy	91.6488	97.3525	93.7104	98.6798	97.6097	99.0486	98.2060	96.5935	89.5523
255	FrSz	10.0000	11.0000	11.0000	12.0000	12.0000	13.0000	13.0000	14.0000	14.0000
	SNR	10.0862	13.9694	16.9383	22.2111	29.0016	36.1081	39.3579	30.8962	23.6862
	Accuracy	90.7758	97.7858	89.7730	93.2866	95.7053	92.0757	98.9489	98.5990	90.0076
260	FrSz	10.0000	11.0000	11.0000	12.0000	12.0000	13.0000	13.0000	13.0000	14.0000
	SNR	10.7480	13.5735	18.0468	22.0750	29.0213	38.0217	43.3384	33.5192	25.9135
	Accuracy	96.7320	95.0145	95.6480	92.7150	95.7703	96.9553	97.9448	97.2057	98.4713
265	FrSz	10.0000	11.0000	11.0000	11.0000	12.0000	12.0000	13.0000	13.0000	14.0000
	SNR	10.3382	13.7806	16.8835	21.9894	28.9723	37.2079	41.9009	33.2083	25.5744
	Accuracy	93.0438	96.4642	89.4826	92.3555	95.6086	97.8801	98.6960	96.3041	97.1827
270	FrSz	10.0000	10.0000	11.0000	11.0000	12.0000	12.0000	13.0000	13.0000	14.0000
	SNR	10.2738	13.6145	16.8504	22.0041	28.3733	36.2857	40.0923	32.2709	24.3966
	Accuracy	92.4642	95.3015	89.3071	92.4172	93.6319	98.5285	98.6086	98.5856	92.7071

TABLE 1: SNR & Accuracy Test results for different Hamming Window Size, Frame Size and Frame Overlap % for same sample recorded at Real World Environment Noise

Digit & SNR	Frame Overlap %	20	25	30	35	40	45	50	55	60
Zero 2.1552	Fr Size	13.1950	13.7708	14.4029	14.8725	15.5108	16.1554	16.6812	17.1727	17.7267
	SNR	10.3807	14.1610	17.6800	23.0630	30.9840	38.9664	39.5634	29.5456	23.0126
	Accuracy	83.0456	86.3821	86.6320	92.2520	98.2193	98.6227	99.1268	97.7731	82.8454
One 2.532	Fr Size	11.4950	11.9479	12.4529	13.1006	13.6442	13.9804	14.4937	15.0415	15.3267
	SNR	10.6244	13.9512	18.1852	21.9053	29.0342	37.6815	42.9845	33.3873	25.5868
	Accuracy	84.9952	85.1023	89.1075	87.6212	92.0384	98.6675	98.9690	97.1457	92.1125
Two 7.1607	Fr Size	12.2950	12.8594	13.4279	14.0850	14.3442	15.0679	15.7438	18.2383	18.9267
	SNR	10.9099	14.9720	18.8613	22.4832	28.8421	37.4938	39.5090	31.8631	24.0928
	Accuracy	87.2792	91.3292	92.4204	89.9328	91.4295	98.2357	99.0180	98.0304	86.7341
Three 5.1581	Fr Size	11.6950	12.0781	12.6154	13.2975	13.6442	14.2523	16.6812	17.1727	18.1267
	SNR	11.0012	14.1745	17.6697	22.8366	29.3103	39.6793	37.2644	30.2142	21.6886
	Accuracy	88.0096	86.4645	86.5815	91.3464	92.9137	97.2624	99.5288	98.5783	78.0790
Four 3.3196	Fr Size	8.8950	9.3438	9.6904	10.1475	13.1775	12.3492	13.2438	13.9758	14.5267
	SNR	10.8110	13.6829	17.4169	22.2642	29.6222	41.9072	48.0202	33.8526	25.2955
	Accuracy	86.4880	83.4657	85.3428	89.0568	93.9024	96.3866	99.0404	98.4020	91.0638
Five 2.9423	Fr Size	11.7950	12.4688	12.7779	13.4944	13.8775	14.5242	16.9938	17.5279	18.1267
	SNR	11.2457	14.5056	20.0666	22.6091	28.5618	37.8589	42.8678	33.9163	25.3535
	Accuracy	89.9656	88.4842	98.3263	90.4364	90.5409	97.0755	98.7356	96.5740	91.2726
Six 2.9731	Fr Size	7.5950	7.9115	8.3904	9.9506	10.3775	10.7179	11.0563	11.1342	12.1267
	SNR	9.8293	13.1812	17.1789	22.1467	29.4873	41.3465	48.7289	32.2793	24.2792
	Accuracy	78.6344	80.4053	84.1766	88.5868	93.4747	98.0970	99.4578	98.1541	87.4051
Seven 3.963	Fr Size	14.8950	15.5938	16.1904	16.8412	17.6108	18.0585	18.8688	19.6592	20.1267
	SNR	10.5861	14.1139	17.9920	22.6423	29.5017	41.1010	45.9814	35.6063	27.6307
	Accuracy	84.6888	86.0948	88.1608	90.5692	93.5204	97.5323	98.9628	96.1370	91.4705
Eight 4.0143	Fr Size	8.6723	8.9856	9.3950	9.7304	12.3792	12.1521	12.8019	13.2287	14.1477
	SNR	10.5210	13.5585	17.4763	21.1063	26.8338	31.0465	30.3656	23.1879	22.1511
	Accuracy	94.1680	92.7069	95.6339	94.4252	95.0631	97.4070	98.7312	96.6073	97.7440
Nine 5.2752	Fr Size	13.8950	14.4219	15.2154	15.8569	16.4442	16.9710	17.3062	18.2383	21.3267
	SNR	9.9747	13.9209	17.3987	22.2017	28.8799	36.1080	35.2710	28.7752	18.3880
	Accuracy	97.7976	94.9175	95.2536	98.8068	93.5493	98.0484	99.5420	97.6930	96.1968

TABLE 2: SNR & Accuracy Test results for different frame size and frame overlap % and Window Size 240 for different samples at Real World Environment Noise

Digit & SNR	Frame Overlap %	20	25	30	35	40	45	50	55	60
Zero 2.1552	Fr Size	12.7632	13.3450	13.8268	14.4666	14.8904	15.7702	16.0140	16.4858	17.0176
	SNR	10.4638	14.8782	18.4936	23.4261	30.2385	40.6107	42.3616	28.6485	23.1388
	Accuracy	83.7104	92.2448	90.6186	93.7044	95.8560	96.4046	98.3483	97.3510	83.2997
One 2.532	Fr Size	11.1312	11.5950	12.1108	12.5766	13.0984	13.6822	14.2140	14.4398	15.0976
	SNR	10.1832	13.9075	17.6812	23.4952	29.5787	38.8426	43.4540	33.3081	23.5664
	Accuracy	81.4656	86.2265	86.6379	93.9808	93.7645	98.3380	99.7297	98.9319	84.8390
Two 7.1607	Fr Size	11.8992	12.4700	12.8908	13.5216	13.9944	14.4652	15.1140	17.5088	18.1696
	SNR	11.4743	14.8349	18.9242	22.7534	29.0030	40.5465	41.8622	33.1496	24.3065
	Accuracy	91.7944	91.9764	92.7286	91.0136	91.9395	97.2570	98.2596	98.5039	87.5034
Three 5.1581	Fr Size	11.2272	11.8450	12.2668	12.7656	13.0984	13.6822	16.0140	16.8268	17.4016
	SNR	11.5551	13.4172	18.0454	22.9101	29.3780	40.4492	35.3010	28.0499	21.1498
	Accuracy	92.4408	83.1866	88.4225	91.6404	93.1283	97.0332	98.9562	97.7347	76.1393
Four 3.3196	Fr Size	8.8272	9.2200	9.6148	9.9306	12.6504	12.1162	13.0140	13.7578	14.3296
	SNR	9.8627	13.5182	17.7196	22.7193	29.6216	42.1054	44.2421	33.4859	24.3936
	Accuracy	78.9016	83.8128	86.8260	90.8772	93.9005	96.8424	98.4478	97.4119	87.8170
Five 2.9423	Fr Size	11.5152	11.9700	12.5788	12.9546	13.5464	13.9432	16.3140	17.1678	18.1696
	SNR	11.3458	14.4631	18.7603	23.4329	29.5343	39.1727	35.4104	32.8159	25.1857
	Accuracy	90.7664	89.6712	91.9255	93.7316	93.6237	97.0972	98.1947	97.6029	90.6685
Six 2.9731	Fr Size	7.4832	7.8450	8.0548	9.5526	10.1864	10.5502	10.9140	11.0298	11.6416
	SNR	10.1006	14.4536	18.7031	22.5996	29.3225	39.6375	40.2627	31.3231	22.4486
	Accuracy	80.8048	89.6123	91.6452	90.3984	92.9523	97.1663	98.7727	98.5724	80.8150
Seven 3.963	Fr Size	14.4912	15.0950	15.6988	16.3566	16.9064	17.5972	18.1140	18.8728	19.7056
	SNR	9.7025	12.8357	17.2056	22.5191	29.3951	41.3525	45.8197	36.3344	26.8617
	Accuracy	77.6200	79.5813	84.3074	90.0764	93.1825	95.1108	99.8869	98.1029	96.7021
Eight 7.5287	Fr Size	4.8912	5.8450	6.1828	6.5286	7.2744	6.1132	6.4140	12.3938	8.9536
	SNR	10.3578	13.3700	17.4085	20.1015	23.0182	20.6113	17.3084	26.2883	20.3808
	Accuracy	92.8624	92.8940	95.3017	90.4060	92.9677	97.4060	98.7323	97.9784	93.3709
Nine 5.2752	Fr Size	13.4352	14.0950	14.6068	15.2226	15.7864	16.2922	17.2140	17.5088	20.4736
	SNR	10.0927	13.7013	17.3809	22.7023	28.8386	38.8475	33.3886	26.0706	20.1303
	Accuracy	90.7416	94.9481	85.1664	90.8092	91.4184	98.3493	98.7871	98.3906	92.4691

TABLE 3: SNR & Accuracy Test results for different frame size and frame overlap % and Window Size 250 for different samples at Real World Environment Noise

Digit & SNR	Frame Overlap %	20	25	30	35	40	45	50	55	60
Zero 2.1552	Fr Size	12.2723	12.8317	13.2950	13.9102	14.3177	15.1637	15.3981	16.1796	16.3631
	SNR	13.0516	16.1677	17.3721	22.8980	30.9635	40.0116	35.2423	28.8058	22.6986
	Accuracy	91.3612	98.6230	85.1233	91.5920	98.1543	98.4274	98.9604	98.6562	81.7150
One 2.532	Fr Size	10.7031	11.2692	11.6450	12.0929	12.5946	13.1560	13.6673	13.8844	14.5169
	SNR	10.7480	13.5735	18.0468	22.0750	29.0213	38.0217	43.3384	33.5192	25.9135
	Accuracy	75.2360	82.7984	88.4293	88.3000	91.9975	98.7312	99.3430	97.8538	93.2886
Two 7.1607	Fr Size	11.4415	11.9904	12.3950	13.0015	13.4562	13.9088	14.5327	16.8354	17.4708
	SNR	10.1636	13.7098	17.8231	22.2122	28.9391	39.4509	42.9588	32.2936	24.8644
	Accuracy	71.1452	83.6298	87.3332	88.8488	91.7369	98.1041	98.6217	97.4221	89.5118
Three 5.1581	Fr Size	10.8877	11.3894	11.7950	12.2746	12.8100	13.1560	15.3981	16.1796	16.7323
	SNR	11.6689	14.4418	18.0843	22.5843	28.9631	40.5176	42.4350	30.1566	22.5473
	Accuracy	81.6823	88.0950	88.6131	90.3372	91.8130	97.6215	98.6265	98.4385	81.1703
Four 3.3196	Fr Size	8.6723	8.9856	9.3950	9.7304	12.3792	12.1521	12.8019	13.2287	14.1477
	SNR	10.5212	14.7670	19.1109	22.0829	29.9058	42.1800	51.0734	34.4307	24.6275
	Accuracy	73.6484	90.0787	93.6434	88.3316	94.8014	99.5448	99.0395	98.4060	88.6590
Five 2.9423	Fr Size	11.1646	11.6298	12.0950	12.6381	13.0254	13.6579	15.9750	16.8354	17.4708
	SNR	10.0491	14.4815	18.1763	22.1886	28.4045	38.1060	46.0153	31.8556	23.7583
	Accuracy	70.3437	88.3372	89.0639	88.7544	90.0423	98.9302	98.4291	98.1957	85.5299
Six 2.9731	Fr Size	7.1954	7.5433	7.8950	9.1852	9.7946	10.1444	10.4942	10.6056	11.1938
	SNR	10.0934	13.4992	17.5608	22.2304	29.4272	40.7459	46.3925	32.2664	23.7353
	Accuracy	70.6538	82.3451	86.0479	88.9216	93.2842	97.1603	98.1458	98.3459	85.4471
Seven 3.963	Fr Size	14.0262	14.6346	15.2450	15.9092	16.4715	17.1713	17.7058	18.1469	18.9477
	SNR	10.4811	14.4564	18.0680	22.3551	29.4636	39.1440	42.7104	35.0012	26.0217
	Accuracy	73.3677	88.1840	88.5332	89.4204	93.3996	99.3798	98.1498	98.0034	93.6781
Eight 7.5287	Fr Size	4.7031	5.7404	6.0950	6.4592	6.9946	5.8781	6.1673	12.2450	13.4092
	SNR	10.2369	15.4974	16.5973	21.9644	25.2904	26.2734	21.8446	30.0355	20.0605
	Accuracy	71.6583	94.5341	81.3268	87.8576	80.1706	96.0052	98.5047	98.0994	92.2178
Nine 5.2752	Fr Size	12.9185	13.5529	14.0450	14.6371	15.1792	15.9165	16.5519	16.8354	19.6862
	SNR	11.5170	14.6621	19.1623	22.4067	29.4844	37.5927	38.1018	27.7750	22.9560
	Accuracy	80.6190	89.4388	93.8953	89.6268	93.4655	98.7188	97.3934	97.7700	82.6416

TABLE 4: SNR & Accuracy Test results for different frame size and frame overlap % and Window Size 260 for different samples at Real World Environment Noise

Digit & SNR	Frame Overlap %	20	25	30	35	40	45	50	55	60
Zero 4.6704	Fr Size	7.7289	7.9583	8.3248	8.8450	9.0170	9.5270	9.8278	10.2128	10.4237
	SNR	10.5210	13.5585	17.4763	21.1063	26.8338	31.0465	30.3656	23.1879	22.1511
	Accuracy	84.1680	92.7069	85.6339	84.4252	85.0631	97.4070	96.1970	96.6073	79.7440
One 2.532	Fr Size	10.3956	10.8519	11.3581	11.8200	12.1281	12.6687	13.1611	13.3702	14.3348
	SNR	10.2738	13.6145	16.8504	22.0041	28.3733	36.2857	40.0923	32.2709	24.3966
	Accuracy	82.1904	83.0485	92.5670	88.0164	89.9434	98.4571	97.4012	98.1314	87.8278
Two 7.1607	Fr Size	11.1067	11.5463	12.0804	12.5200	12.9578	13.6354	3.9944	16.2119	7.1793
	SNR	10.8361	13.5814	18.6875	22.4416	29.9386	38.8200	41.9225	30.6552	24.8186
	Accuracy	86.6888	82.8465	91.5688	89.7664	94.9054	98.2860	99.3911	98.7690	89.3470
Three 5.1581	Fr Size	10.4844	10.9676	11.3581	11.8200	12.3356	12.6687	4.8278	15.8961	6.1126
	SNR	10.0660	13.4298	17.6323	22.2393	29.4800	40.5937	25.0868	28.2966	22.0612
	Accuracy	80.5280	81.9218	86.3983	88.9572	93.4516	93.3655	98.6892	97.4008	79.4203
Four 3.3196	Fr Size	8.4400	8.7685	9.1915	9.5450	11.2985	11.7020	2.3278	12.7387	3.6237
	SNR	10.5104	14.4805	18.0018	23.3613	29.5838	1.8883	9.7839	34.0240	44.8241
	Accuracy	84.0832	88.3311	88.2088	93.4452	93.7806	94.3431	97.3289	96.8648	96.3668
Five 2.9423	Fr Size	10.8400	11.3148	11.6470	12.3450	12.7504	13.1520	15.3833	16.2119	16.8237
	SNR	10.4099	14.6564	19.1060	23.1816	28.4106	38.4336	44.6465	34.5082	26.6326
	Accuracy	83.2792	89.4040	93.6194	92.7264	90.0616	98.3973	97.3294	96.1721	95.8774
Six 2.9423	Fr Size	10.8400	11.3148	11.6470	12.3450	12.7504	13.1520	15.3833	16.2119	16.8237
	SNR	10.4099	14.6564	19.1060	23.1816	28.4106	38.4336	44.6465	34.5082	26.6326
	Accuracy	83.2792	89.4040	93.6194	92.7264	90.0616	98.3973	97.3294	97.1721	95.8774
Seven 3.963	Fr Size	13.6844	14.2083	14.8248	15.3200	16.0689	16.5354	17.3278	17.7906	18.6015
	SNR	11.4981	15.9106	17.2896	22.6451	28.7847	38.0097	41.0257	33.8041	23.9987
	Accuracy	91.9848	97.0547	84.7190	90.5804	91.2475	98.4223	99.4360	98.2711	86.3953
Eight 7.5287	Fr Size	4.6178	5.5278	5.8693	6.3950	6.7356	5.6604	5.9389	11.7915	12.9126
	SNR	12.1827	16.1518	16.4825	20.9298	24.2040	26.6296	22.2510	26.2754	21.5904
	Accuracy	97.4616	98.5260	80.7643	83.7192	86.7267	96.2481	98.5072	97.9436	87.7254
Nine 5.2752	Fr Size	12.6178	13.0509	13.6693	14.0950	14.8244	15.3270	15.9389	16.5276	19.3126
	SNR	9.6448	12.9770	17.0795	22.1698	29.4271	37.7130	38.8767	29.3890	20.1720
	Accuracy	87.1584	89.1597	83.6896	88.6792	93.2839	96.7399	98.7512	97.3503	82.6192

TABLE 5: SNR & Accuracy Test results for different frame size and frame overlap % and Window Size 270 for different samples at Real World Environment Noise

An Improved Approach for Word Ambiguity Removal

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Abstract

Word ambiguity removal is a task of removing ambiguity from a word, i.e. correct sense of word is identified from ambiguous sentences. This paper describes a model that uses Part of Speech tagger and three categories for word sense disambiguation (WSD). Human Computer Interaction is very needful to improve interactions between users and computers. For this, the Supervised and Unsupervised methods are combined. The WSD algorithm is used to find the efficient and accurate sense of a word based on domain information. The accuracy of this work is evaluated with the aim of finding best suitable domain of word.

Keywords: Human Computer Interaction, Supervised Training, Unsupervised Learning, Word Ambiguity, Word sense disambiguation.

1. INTRODUCTION

Sometimes people are facing problems in understanding correct meaning of the sentence. Since, sentence comprised of ambiguous words. In such case, correct meaning is taken by the context of the sentence. Usually, it is found in English language. In other words, we can say that context uniquely identifies meaning of the sentence. Based on this interpretation the ambiguity of word, known as lexical ambiguity is disambiguated; which is called as a process of WSD. Manual method of meaning extraction uses approach of searching words correct meaning in typical or online dictionaries which had several drawbacks.

To resolve an ambiguity in a sentence, natural language processing provides word sense disambiguation which governs a sentence in which the sense of a word or meaning is used, when the word has multiple meanings (polysemy). WSD is a process which identifies the correct sense of a word with the help of surrounding words in a sentence. The correct sense of a word is obtained from the context of the sentence. a different meaning of the single word is associated in each sentence based on the context, the remaining sentence gives us. Thus, if the word imagination appears near the word play, we can say that it is related to free_time and not related to a sport which is known as local context. Computers that read words, one at a time must use word sense disambiguation process for finding the correct meaning (sense) of a word. A disambiguation process requires a dictionary in which senses are to be specified and disambiguated. For identifying the correct sense of the word the ‘WordNet’ domain is used. A domain consists of different syntactic categories of synsets. It groups senses of the same word into uniform clusters, with the effect of reducing word polysemy in WordNet. WordNet domain provides semantic domain as a natural way to establish semantic relations among word senses. This functionality is used in creation of MySQL database. The system for disambiguation of ambiguity in a sentence aims to identify domain of intended sense of word. Basically, input provided to the system is a sentence with ambiguous words and the output is identified as domain of word.

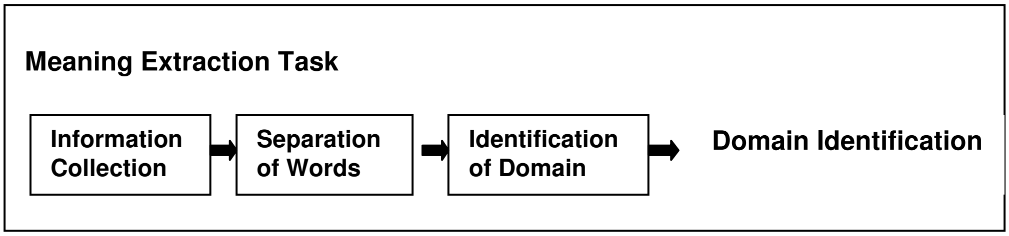

FIGURE 1 Context based meaning extraction task

2. LITERATURE SURVEY

For Word sense disambiguation, the first attempt effectively used by Michael E. Lesk was based on the Dictionary approach [1]. The problem with this algorithm is that, it defines context in a more complex way which is overcome by Simplified Lesk algorithm [2]. It can be effectively used with the WordNet lexical database. Such an attempt is made at Indian Institute of Technology, Bombay [3] and the results are promising. Navigili [4] had found that the right sense for a given word amounts to identifying the most “important” node among the set of graph nodes representing its senses. Ling Che Yangsen and Zhang [5] described a general framework for domain adaptation which contained instance pruning and weighting and the training instance augmentation. Agirre [6] described a thorough overview of the current WSD techniques and performance of systems on data sets, as well as a brief history of the field and some truly insightful discussions on potential developments. In [7] we find the most general and well-known attempt to utilize information in machine-readable dictionaries for WSD, that of Lesk , which computes a degree of overlap—that is, number of shared words--in definition texts of words that appear in a ten-word window of context.

3. SYSTEM MODEL

The system model has five stages:

POS Tagger

An English sentence with ambiguous words is given as an input to the project. From the sentence, content words are extracted and tagged by POS tagger [6, 7, 8] [22].

Distribute Domain

Then domains are distributed to Content words from the WordNet Domains which maintains domain distribution table [3, 4, 5] [22].

Pick the Target Word

The target word is selected by comparing WordNet, available domain and the domain of target word is displayed.

Identification of Domain

The accurate domain of the target word is identified by supervised and unsupervised training [1] [2] [22].

Obtain Sense of Word

The sense of target word belonging to the domain is obtained which is added to the domain distribution table i.e. the table is updated using supervised and unsupervised training [4].

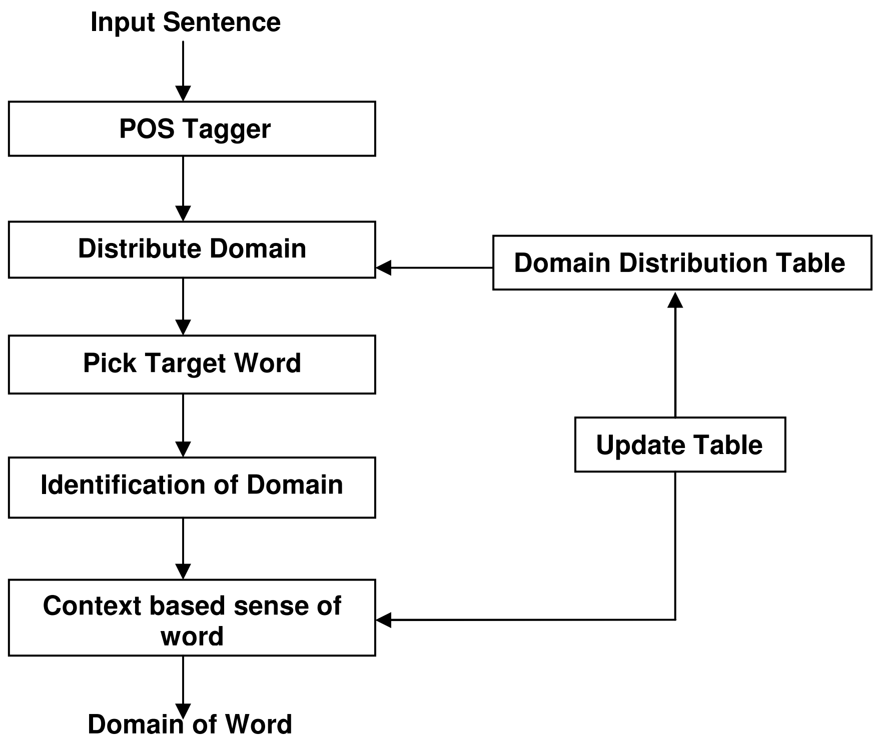

FIGURE 2 System Model

4. WSD ALGORITHM

This algorithm is used in supervised and unsupervised training method and gives better performance than graph based algorithm. [13].It has following steps:
Step1: Create a database which can store the words and their meanings.

ID	field	ID	Word	ID	Word	FieldID
1	Computer	70	is	441	diving	2
2	Sports	71	the	442	racing	2
3	Medical	72	was	443	athletics	2
4	Engineering	73	that	444	wrestling	2
5	Factotum	74	on	445	boxing	2
6	History	75	of	446	fencing	2
7	Geography	76	for	447	archery	2
8	Games	77	where	448	fishing	2
9	Law	78	how	449	hunting	2
10	Biomedical	79	when	450	bowling	2

TABLE 1: Fields Table **TABLE 2:** General Words Table **TABLE 3:** Meanings Table

The three tables are created as fields, general words and meanings. TABLE 1 shows fields table in which ID and Domain name is stored. An ID is assigned to respective domain name. TABLE 2 shows General words table in which ID and general words are stored after separation of words. TABLE 3 shows Meanings table in which ID, words and respective domain ID assigned to words are stored. A unique ID and FieldID are assigned to the word which belonging to correct domain name.

Step 2: Separate the content words from the sentence using Part -of- Speech tagging (POS) process. This process is used for identification of words as nouns, verbs, adjectives, adverbs, etc, since it is used to tag or mark the text [11]. FIGURE 3 shows tags which are used to mark the content words and their separation. The separation is done with the help of Penn Treebank Tagset of Part of Speech tagging process which is shown in FIGURE 3 and FIGURE 4.

Example:

Play the stock market.

Tag	Description(Penn Treebank Tagset)
DTR	Determiner
NN	Noun,Singular or mass
VBD	Verb,Past tense
VBG	Verb present participle
NNS	Noun,plural

FIGURE 3 Penn Treebank Tagset

The |DTR fisherman |VBD went |VBG to |the |NN bank |NN.|.

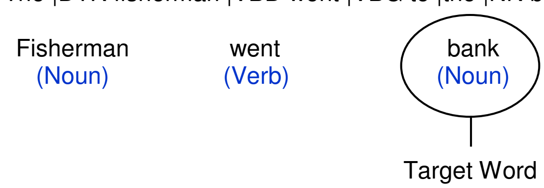

FIGURE 4 Example of POS Tagger Process

Step 3: Decompose the separation of sentence into three categories as C1, C2 and C3 for finding results i.e. displaying correct domain of word. In step 3, various comparisons are performed to find correct domain of words. It is required to detect correct sense of word with the help of most suitable domain for a word using various algorithms and finally the meaning of a sentence.

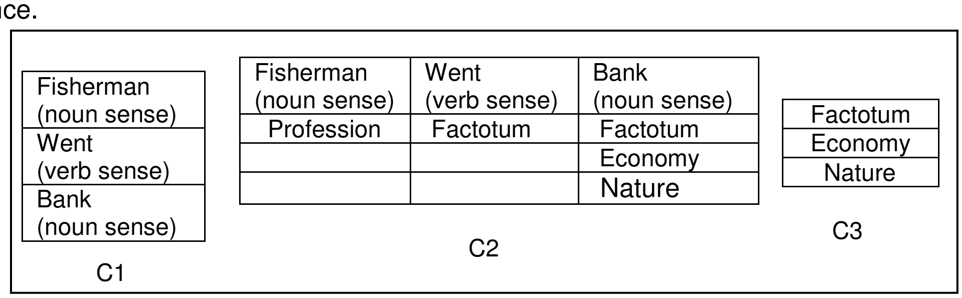

FIGURE 5 Contents of Category C1, C2 and C3

Step 4: Supervised training module to check if the given category of words are properly processed or not. In step 2, if the inputted sentence domain displayed by the system is free_time. But this may be a wrong domain if the context based meaning is considered. According to the context, domain of play is Commerce. Since stock market is whose work is related to Commerce.

In this case, supervised training is required to train the system to pick the correct domain as Commerce. Let us assume that the sentence is

The play of the imagination.

The correct domain for the word play is Free_time. Since maximum count of comparison is 2 for domain free_time (ID 4).Suppose the next sentence is entered by user is

Play the drama.

Here, the domain of the word play and drama is Entertainment. Previously, the same word has domain related to free_time [10, 12]. It is shown in TABLE 4 below.

FieldID	Word	Domain
4	Play	Free_time
5	play	commerce
4	imagination	Free_time

TABLE 4 Domain Comparisons

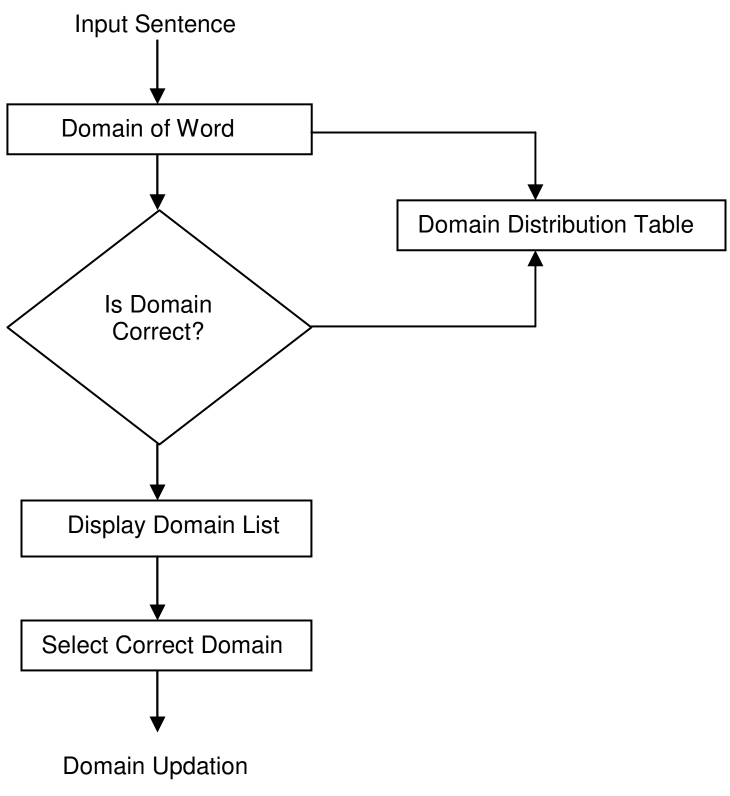

FIGURE 6 Supervised Training Flow

Step 5: Unsupervised learning module to auto update the database with the selected sentences and word-meaning pairs. The flow is shown in fig. 7. If it is correct that is considered as correct domain of word (disambiguation) and this entry is updated in the database. Else, user has given the chance to input the sentence again. This flow is shown in Fig. 7. The knowledge acquisition bottleneck problem is overcome by unsupervised learning, since it is independent of manual work.

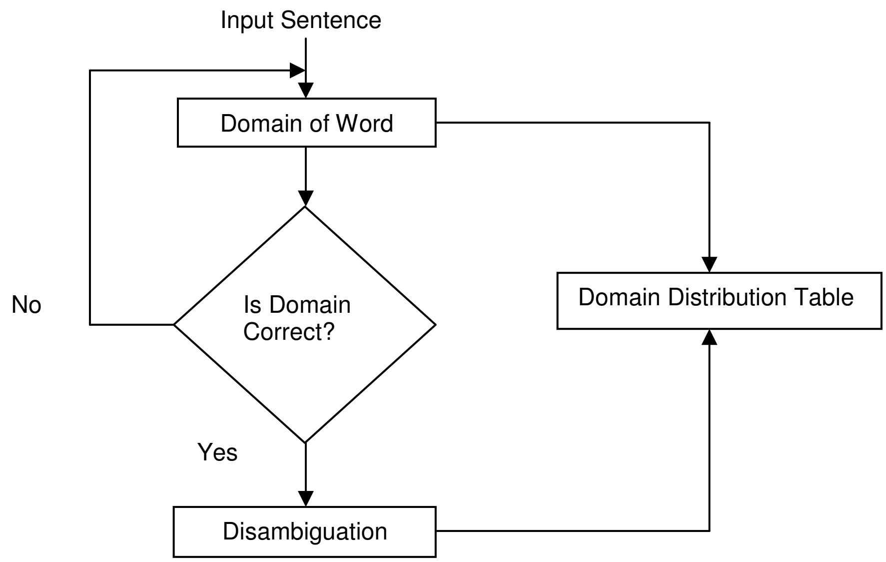

FIGURE 7 Unsupervised Learning Flow

The experimental setup is done by following steps and accuracy of Unsupervised, Supervised and Hybrid method is evaluated using mathematical formula as

$$\frac{\sum_t \textit{Number of Correct terms}}{\sum_i \textit{Number of Input}}$$

Where, t =correct terms (Correctly disambiguated)
& i = input (Number of sentences)

Repeat the below steps for:
i=1…number of sentences (n), n=1….15
Where, i indicate sentence and n indicates number of sentences.

Step 6: Finally, display the **correct** domain of the word. The correct domain of the word for given example is Commerce.

5. RESULTS

Stage 1: Part of Speech Tagger

The first stage “POS Tagger” of the system model is implemented. FIGURE 9 shows the snapshot of POS Tagger process. This stage is used to separate the content words and general words like noun, verb, adjective etc. from the sentence in step1 and Classification of separated words in three categories c1, c2, and c3.

Sentence- Play the stock market.
Separation-
Play
The
Stock
Market
Match: play: play clustered under – Commerce
Match: play: play clustered under – Free_time
Match: play: play clustered under – Entertainment
Match: stock: stock clustered under – Commerce
Match: market: market clustered under - Commerce

FIGURE 9 Result of POS Tagger Process

Stage 2: Unsupervised Learning
There are five steps to process the system. When the domain of word is identified; it is checked by the system for correctness if the identified domain is correct then out of five steps only four steps are processed to get the output. This is shown in FIGURE 10 with example.

Sentence: The play of the imagination.

Step 1: Separating All Words
Word: The
Word: play
Word: of
Word: the
Word: imagination.

Step 2: Finding Matching Domain
Match – play: play
Match – play: play
Match – play: play
Match – play: play
Match – play: play
Match – imagination: imagination
Match – imagination: imagination

Step 3: Checking for Best Probable Field
Field 11 found 2 times
Field 2 found 2 times
Max Value: 9 For field ID: 69
The Domain is Free_time

Step 4: Checking for Correctness
Is this the type of the sentence at input? Y/N
The new elements with selected domains have been updated…

FIGURE 10 Result of Unsupervised Learning of Implemented System

Sentence: Play the stock market.
Step 1: Separating All Words
Word: Play
Word: the
Word: stock
Word: market.
Step 2: Finding Matching Domain
Match – play: Play
Match – play: Play
Match – play: Play
Match – play: Play
Match – play: Play
Match – stock: stock
Match – stock: stock
Match – market: market
Match – market: market
Step 3: Checking for Best Probable Field
Field 11 found 1 times
Field 17 found 3 times
Field 2 found 2 times
Field 69 found 9 times
Max value: 9 for field ID: 69
The Domain is Free_time
Step 4: Checking for Correctness
Is this the type of the sentence at input? Y/N
Step 5: Supervised Learning
Your choice is: **Commerce**
So the new field of this sentence is set to: Commerce
Words to be updated:

FIGURE 11 Result of Supervised Learning of Implemented System

Stage 3: Supervised Learning
In stage 3, when the domain of word is identified; it is checked by the system for correctness if the identified domain is incorrect then all five steps of system are processed to get the output. This is shown in FIGURE 11 with example.
Stage 4: Spell Checker Utility
Sometimes, the sentence entered by the user will be incorrect or correct. So, here apart from above results one additional step as spell checker utility is implemented. In stage 4, the corrections in spellings of the entered sentence are corrected using online spell checker concept which requires internet connection before executing the system. The result of this utility is shown below in FIGURE 12.

Pla the stk makt.

Probable Spelling Matches found...

Play Ply Plum

stuck stock stick wore worm

marketing market making

Do you wish to change the input(y/n): y

FIGURE 12 Result of Spell Checker utility

Stage 5: Final Result of the System

The system is used for determining correct domain of word. First part of this system is sentence collection. It is required by the user to enter the sentence after that sentence is separated by POS tagger. Once the sentence is separated out, it will be processed through various steps like domain distribution, supervised learning, unsupervised learning, WSD algorithm. The final result for the implemented system is shown below in TABLE 5:

Sentence	Separation of Words	Target Word	Domain Identification	Comparison	Final Domain
Play the stock market	Play the stock market	Match – play: play Clustered under Match –stock: stock Clustered under Match – market: market Clustered under Match –play: play	Entertainment Commerce Commerce Commerce	Max Value :03 For field ID: 05	Commerce

TABLE 5 Final Result of Implemented System

Stage 6: Results of Accuracy of the System

Firstly, the unsupervised learning, supervised learning and hybrid training accuracy is evaluated shown in TABLE 6 and FIGURE 13.Then comparison of all learning approaches are done and observed that these approaches gives 63%,76% and 80% of accuracy respectively. Hence, the accuracy is improved using Hybrid training method shown in TABLE 7 and FIGURE 14.

Sentence	Target word	Disambiguated	Correctly Disambiguated	Accuracy (%)
1	2	2	2	100
2	3	3	2	66.67
3	1	1	1	100
4	1	1	1	100
5	2	2	1	50
6	2	2	2	100
7	2	2	1	50
8	1	1	1	100
9	1	1	1	100
10	2	1	1	100
11	3	3	2	66.67
12	1	1	1	100
13	3	3	2	66.67
14	1	1	1	100
15	2	1	1	50
Total	27	25	20	80.00

TABLE 6 Results of Hybrid Learning Method Accuracy of 15 Sentences

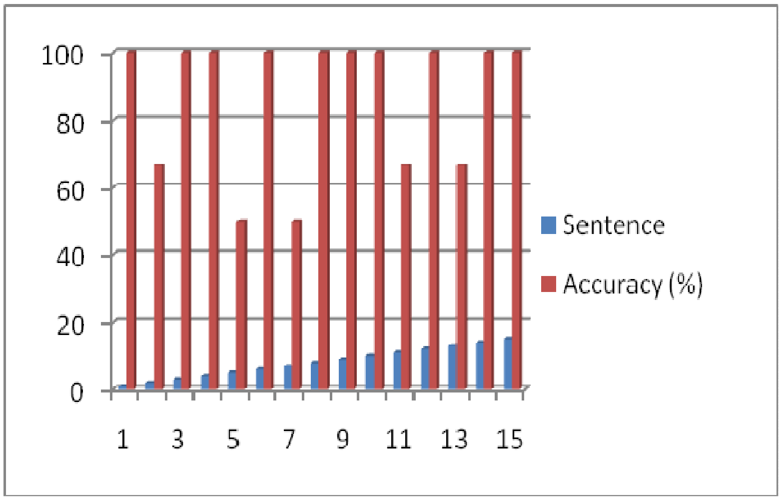

FIGURE13 Hybrid Learning Method Accuracy

Sentence	Target word	Disambi-guated	Correctly disambiguated	Supervised Accuracy (%)	Unsupervised Accuracy (%)	Hybrid Accuracy (%)
1	2	2	1	50	100	100
2	3	3	2	67	67	67
3	1	1	1	100	100	100
4	1	1	1	100	100	100
5	2	2	1	50	50	50
6	2	2	2	100	100	100
7	2	2	1	50	50	50
8	1	1	1	100	100	100
9	1	1	1	100	100	100
10	3	3	1	33	50	50
11	3	3	2	67	67	67
12	2	2	1	50	100	100
13	3	3	2	67	67	67
14	3	2	1	50	100	100
15	2	2	1	50	50	50
Total	31	30	19	63	76	80

TABLE 7 Results of Comparison of Unsupervised, Supervised and Hybrid Learning

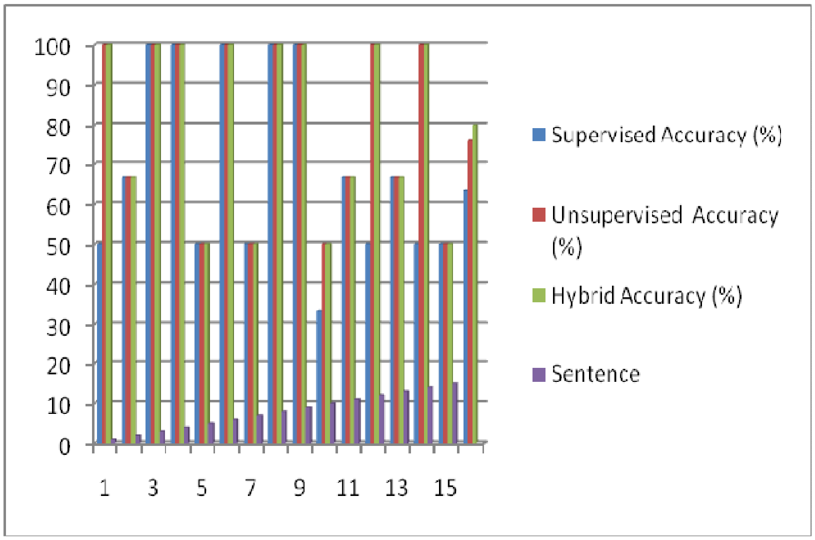

FIGURE 14 Comparison of Unsupervised, Supervised, Hybrid Accuracy

CONCLUSIONS

The system improves the self-learning process by obtaining correct sense of a sentence by resolving ambiguity from a word with full automation. The system requires correct domain of word identification from the sentence. Hence, sentence comprised of various content words like nouns, verbs, adjectives, adverb etc. Firstly, it is required to separate out content words from a sentence. By applying POS tagger process and WSD algorithm, domain is allotted to each word and each domain of word is compared to get correct domain of word. A count of comparisons is calculated, the domain which has the maximum count is assumed as correct domain. Also, this system improves the accuracy of identifying the correct domain of word. As per the Table 8 it shows that self learning language is improved by obtaining correct sense of a word by removing ambiguity from a sentence with full automation. Also, improves disambiguation process by obtaining appropriate sense of a word. The synonym relationship approach is used to identify intended domain of word. The system is trained using supervised training to check correctness of domain which gives 76% of accuracy; an unsupervised learning is used to update the database with the selected sentences and word-meaning pairs automatically. It gives 63% of accuracy. The hybrid method improves this accuracy up to 80% from Table 7. In this system, when the number of target word is correctly disambiguated system gives 100% accuracy. Else, the accuracy may be 66% or 50%. Hence, the overall 80% accuracy is evaluated. These results generated by the system are beneficial for Human Computer Interaction as it is motivating people to learn the language by themselves using computer in the absence of teacher. Additionally, the spell checker utility is implemented to avoid mistakes in words.

REFERENCES

[1] Roberto Navigli, Mirella Lapata (2010), "An Experimental Study of graph connectivity for unsupervised word sense disambiguation", IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 32, No. 4.

[2] Myunggwon Hwang, Chang Choi (2011)," Automatic Enrichment of Semantic Relation Network and Its application to Word sense Disambiguation",IEEE transaction on knowledge and data engineering, vol. 23, no. 6.

[3] Francisco Tacoa, Hiroshi Uchida (2010),”A Word Sense Disambiguation approach for converting Natural Language Text into a Common Semantic Description", Fourth International Conference on Semantic Computing, IEEE.
[4] Ping Chen, Wei Ding (2010), “Word Sense Disambiguation with Automatically Acquired Knowledge”, IEEE Intelligent Systems.
[5] Ling Che Yangsen Zhang (2011),”Study on Word Sense Disambiguation Knowledge base based on Multi-Sources”, IEEE.
[6] Alex Roney Mathew; Al Hajj (2011), “Human-Computer Interaction (HCI): An overview”, IEEE International Conference on Computer Science and Automation Engineering (CSAE).
[7] E. Agirre and P. Edmonds (2006),” Word sense Disambiguation: Algorithms and Applications”, Springer.
[8] Johan Bos and Malvina Nissim (2009),” From shallow to deep Natural language processing: A hands-on tutorial”, Springer.
[9] Leung (2006),“Learners as users, and users as learners”, 7th International Conference on Information Technology Based Higher Education and Training, ITHET '06.
[10] Yousif, J.H. Sembok, T.(2008),”Arabic part-of-speech tagger based Support Vectors Machines”, Information Technology,2008. ITSim 2008. International Symposium.
[11] Diana McCarthy, Rob Koaling (2007),”Unsupervised Acquisition of Predominant Word Senses,” Computational Linguistics, Vol.33, No.4.
[12] Andrei Mincă, Stefan Diaconescu (2011),”An Approach to Knowledge-Based Word Sense Disambiguation Using Semantic Trees Built on a WordNet Lexicon Network”,IEEE.
[13] Priti Saktel,Urmila Shrawankar(2012),”Context based Meaning Extraction for HCI Using WSD Algorithm:A Review”, IEEE-International Conference on Advances in Engineering, Science and Management,pp. 208-212.
[14] Jerome R. Bellegarda, Fellow (2010),” Part-of-Speech Tagging by Latent Analogy”, IEEE Journal of Selected Topics In Signal Processing, Vol. 4, No. 6, Dec. 2010.

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