International Journal of Advance Research in Engineering, Science & Technology(IJAREST), ISSN(O):2393-9877, ISSN(P): 2394-2444,
Volume 2, Issue 8, August-2015, Impact Factor: 2.125

INVESTIGATIONS INTO THE EFFECT OF PROPOSED VQ TECHNIQUE ON ISOLATED HINDI SPEECH RECOGNITION USING DISCRETE HMM'S

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ABSTRACT

This paper describes the development of Front End for a Isolated Hindi speech recognizer which includes the digitization of raw speech and finding its Mel frequency cepstral coefficients (MFCC) which are subjected to a proposed Vector Quantization (VQ) technique. The Effect of proposed VQ technique is investigated through Proposed discrete Isolated Hindi speech recognizer. This includes a Front End along with a Statistical model such as HMM. The results of the experimentation have shown that Proposed VQ technique is more powerful and efficient as compared to existing K Means technique.

Keywords: VQ, Discrete HMM, Isolated Speech Recognizer.

INTRODUCTION

The principles of Markov Process are widely used in designing the automatic speech recognition system. The discrete HMM isolated Hindi Speech recognizer proposed in this paper makes use of the basic theory of hidden Markov Models (HMM's) [1,2,3]. The theory of hidden Markov Models was developed by Baum, Petrie & Egon in the year 1960 to 1970. The Rabiner, Wilpon, Jaung, Levinson and Sondhi applied this theory to speech recognition for designing isolated speech recognizer in the year 1980 to 1990 [4,5,6]. The proposed discrete Isolated Hindi speech recognizer involves capturing raw voice signal, its digitization and calculating the Mel frequency cepstral Coefficients (MFCC) followed by proposed VQ technique which goes through initialisation, sorting, partitioning quantization, cluster indexing & finally termination to get an observation sequence.

The VQ technique based on nearest neighbor search & distortion measure was proposed by Linde, Buzo & Gray in the year 1980 [7]. The set of codebooks were generated through the use of the spectral property of speaker by Soong & Rosenberg [8]. This paper is divided into six sections (i) Front End design (ii) Proposed VQ technique to get on observation sequence (iii) Block Diagram of proposed discrete Isolated Hindi Speech recognizer (iv) Results of the experimentation performed on proposed discrete Isolated Hindi Speech recognizer.(v) Discussion of results on comparison of Proposed Discrete Isolated Hindi Speech Recognizer with K-Means technique for male speaker (vi) Conclusions and future directions.

1. Front End design of proposed Isolated Hindi speech recognizer:

Front End Design:

The design of Front End involves the feature extraction that is to extract Mel frequency cepstral coefficients for every word recorded in the data base. The coefficients extraction or feature extraction is described here. The most popular parameter is the Mel frequency cepstral coefficients (MFCC) developed by Davis and Mermelstein. The idea of mapping an acoustic frequency to a perceptual frequency scale, the Mel scale permits one to obtain relevant coefficients . The Mel frequency cepstral coefficients represent the best approximation of human ear. The human ear is more sensitive to higher frequencies. A review on the speech recognition system concludes that the Mel frequency cepstral coefficients are widely used for developing the front end of a automatic speech recognizer [9, 10]. Figure 1 shows the block diagram of MFCC.

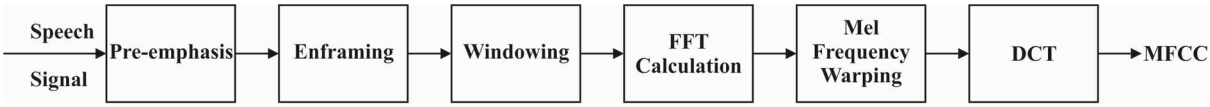

Figure 1: Block diagram of MFCC.

It includes recording , digitizing the speech signal and converting it into Mel frequency cepstral coefficients (MFCC). The Mel scale is having linear frequency spacing below 1 KH_Z and has logarithmic spacing above $1KH_Z$. Because of this property these parameters finds application in the speech recognition. The MFCC algorithm has various steps such as pre-emphasizing speech signal, Enframing , windowing , FFT calculation , Mel frequency transformation and finally Discrete cosine transformation (DCT) is performed to get MFCC parameters.. The 12 dimensional MFCC vectors are passed through a proposed vector quantizer for the purpose of reducing the data and designing different codebooks described in next Para. The detailed steps of development of front end for Hindi speech recognizer have been described in [11]. The Proposed VQ technique has been described in next section.

2 Proposed Vector Quantization technique to get an observation sequence

The proposed VQ technique is used to find a discrete symbol sequence known as observation sequence which may further be used to develop a statistical model. The codebook used here is of size 32 discrete symbols.The proposed algorithm for designing a Codebook is described below [12].

Algorithm

*Step 1***:** *Initialization*

Raw Speech is digitized and large number of voice samples are obtained to get Mel frequency cepstral coefficients (MFCC) to get initial Data Set.

Step 2: Sorting

The member components of the Data Set are arranged in the ascending order of their magnitude value to get a New Data Set.

Step 3: Partitioning

The small number of groups or cells are obtained from the New Data Set through the process of partitioning. The number of cells or groups depend upon the size of the codebook.

Step 4: Quantization

A quantized value or amplitude value is assigned to every partition.

Step 5: Cluster Indexing

The cluster Index value is assigned to every member of New Data Set to obtain a symbol sequence known as observation sequence.

Step 6: Termination

Finally a sequence of symbols called observation sequence is obtained after completion of step 5 and the process is stopped. The block diagram of proposed Vector quantizer is shown in the figure2.

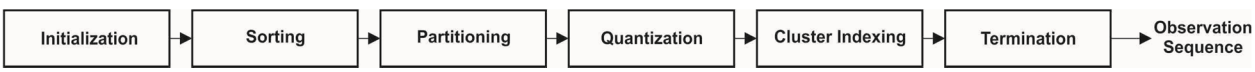

Figure 2 : Block diagram of Proposed Vector Quantizer [12]

3. Block Diagram of proposed Discrete Isolated Hindi Speech Recognizer:

A effective investigation into Hindi Speech recognition (Words) is to be achieved by using different techniques like Mel Frequency Cepstral Coefficients (MFCC) Technique and Hidden Markov Modeling (HMM) . For achieving this goal the following tasks has to be done:

1. Data Acquisition: It includes the capture of speech utterance.
2. Feature Extraction: It includes the analysis of the raw speech into suitable set of parameters.
3. Statistical Model: The statistical models to be prepared. Here HMM models are prepared.
4. Probability computation: The computation of probabilities is done and similar words have maximum probability.

Block diagram of proposed Isolated Hindi Speech Recognizer is shown in figure 3. Here the input speech signal is the 'word' that is to be recognized. The system is trained for number of words say W=10 each with K=5 utterances. As the input signal is applied to the proposed Isolated Hindi Speech Recognizer. It is passed through a preprocessing stage that consist of digitization, extraction of Mel frequency cepstral co-efficient from the digitized voice samples through a process of MFCC algorithm described in earlier section [11]. The Mel frequency cepstral coefficients are used because they best represent the approximation of human ear. After the cepstral coefficients are obtained these are subjected to the proposed VQ technique which is described in the earlier section. The net result of passing the speech signal through a pre-processing stage is to get an observation symbol sequence for every word (training as well as testing word) which is to be used further to develop a statistical model such as HMM model. After the observation symbol sequence is obtained a statistical model such as HMM model is prepared for every word. HMM model for word 1, HMM model for word 2 and so on. The number of HMM's are prepared for every word and are stored in the data base.

In testing mode the word which is to be recognized is applied to Isolated Hindi Speech Recognizer and an HMM model is prepared for that word, its transition matrix 'A' is also obtained which is applied to every word in the data base & probability is calculated for every word. It will be maximum for the similar word & the index of the maximum probability will give the recognized utterance. The parameter discrete symbol probability distribution (Emission matrix) and how a discrete symbol moves from one state to another (Transition matrix) are estimated by Baum Welch algorithm which makes use of Forward and Backward variables, Viterbi algorithm is used to find the correct state sequence[12][13].

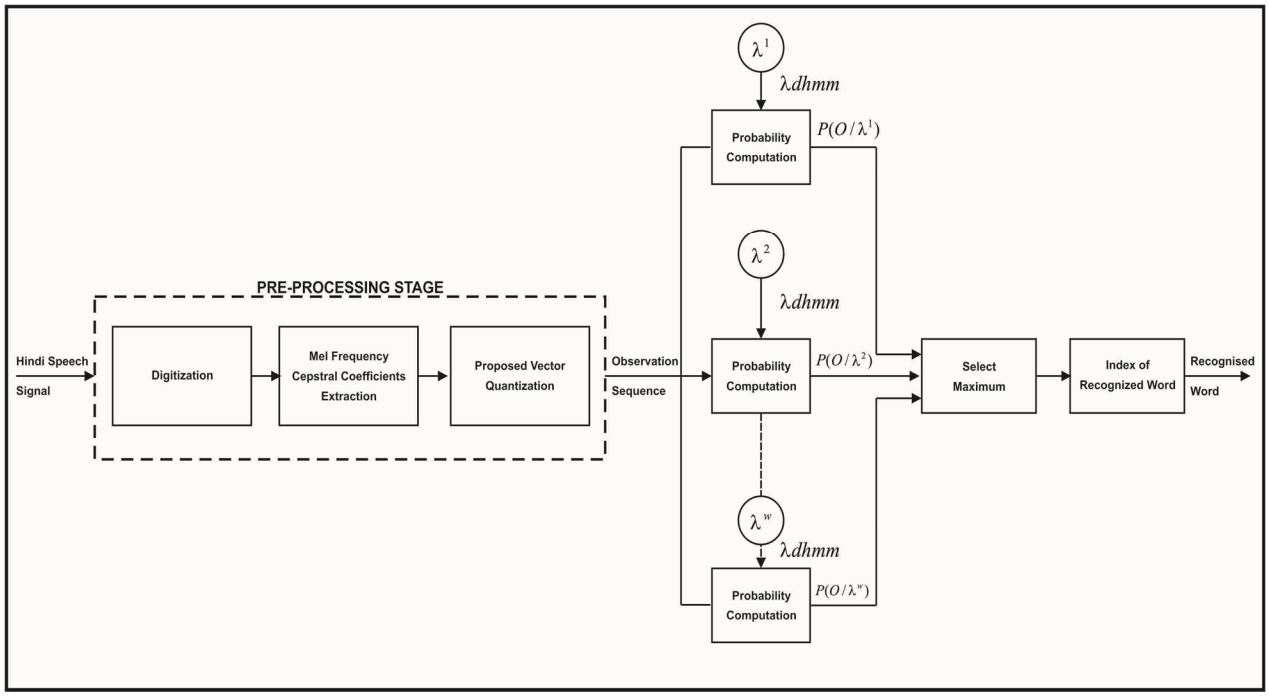

Figure 3: Proposed Discrete Isolated Hindi Speech Recognizer

Following steps are required to complete the process of Hindi speech recognition of different words.

1. A discrete HMM model for W words of the vocabulary is prepared. The model parameters $\lambda = (A, B, \pi)$ are calculated and are used to optimize the probability of the training set observation vectors for W^{th} word.

2. For the recognition of every unknown word the pre-processing as shown in the figure 3 is carried out. The first step is the digitization of raw speech and second step is the feature extraction of the speech signal of every word. Here we use the Mel frequency cepstral coefficients. The third step is vector quantization of the speech vectors to get observation sequence $O = (O_1\ O_2\ O_3 \ldots\ O_N)$. Finally is the calculation of probability of observation sequence for every word. i.e. $P(O / \lambda s)$, $1 \le w \le W$ followed by the selection of the word whose model probability is maximum [12,13,14]. Recognized utterance will be given by the index $w^* = \arg\max[P(O / \lambda w)]$. Generally

$1 \le w \le W$

The Probability computation is done through Viterbi algorithm. A software in MATLAB has been designed using proposed VQ techniques and algorithms such as Forward, Backward, Viterbi and Baum –Welch .

4. Results of the experimentation performed on Proposed Discrete Isolated Hindi Speech Recognizer (for male speaker)

Table 1: Showing results of experimentation performed on Discrete Isolated Hindi speech recognizer for male speaker (Test word 1&2).

	Existing Method (*using k means of VQ*)				Proposed Method (*using proposed VQ*)			
Words in Data	Unknown Word 1 (*Maa)*		Unknown Word 2 (*Pitaji*)		Unknown Word 1 *(Maa)*		Unknown Word 2 (*Pitaji*)	
	Probability Computation		Probability Computation		Probability Computation		Probability Computation	
(Index j)	Iteration 1	Iteration 2	Iteration 1	Iteration 2	Iteration 1	Iteration 2	Iteration 1	Iteration 2
	1.0e+003*	1.0e+003*	1.0e+004 *	1.0e+004*	1.0e+003*	1.0e+003*	1.0e+004*	1.0e+004*
Word1(*Maa*)	-8.9704	-8.9076	-1.8260	-1.8119	**-8.5615**	**-8.5615**	-1.7864	-1.7864
Word 2(*Pitaji*)	-8.8577	-8.8492	-1.8093	-1.8243	-8.5958	-8.5958	**-1.7329**	**-1.7329**
Word 3(*Putra*)	**-8.720**	-8.9321	**-1.7727**	-1.8101	-8.6267	-8.6267	-1.7562	-1.7562
Word 4(*Pati)*	- 9.0426	**-8.773**	-1.8025	-1.8221	-8.6067	-8.6067	-1.7387	-1.7387
Word 5(*Patni*)	-8.8084	-9.0448	-1.8170	-1.8179	-8.5833	-8.5833	-1.7385	-1.7385
Word 6(*Putri*)	-8.9999	-8.7887	-1.8187	-1.8125	-8.6036	-8.6036	-1.7424	-1.7424
Word 7(*Bhai*)	-8.8654	-8.7759	-1.8035	-1.8148	-8.5885	-8.5885	-1.7629	-1.7629
Word 8(*Bahan*)	-8.8539	-9.1163	-1.7947	**-1.7976**	-8.5992	-8.5992	-1.7841	-1.7841
Word 9(*Dadaji*)	-8.8886	-8.8904	-1.7756	-1.8060	-8.6044	-8.6044	-1.7517	-1.7517
Word 10(*Dadiji*)	-8.9197	-9.0136	-1.7874	-1.7977	-8.6711	-8.6711	-1.7795	-1.7795
Max Probability index 'j'	**j=3**	**j=4**	**j=3**	**j=8**	**j=1**	**j=1**	**j=2**	**j=2**
	*The maximum probability is selected which gives the index of the recognized utterance. The proposed DHMM is trained with 5 utterances of each word and sixth utterance of every word is used as an unknown word during the testing phase**.**							
Unknown Test Word	*Maa*	*Maa*	*Pitaji*	*Pitaji*	*Maa*	*Maa*	*Pitaji*	*Pitaji*
Recognised word	*Putra*	*Pati*	*Putra*	*Bahan*	*Maa*	*Maa*	*Pitaji*	*Pitaji*
Status of Recognition	*Incorrect*		*Incorrect*		*Correct*		*Correct*	

Table 2: Showing results of experimentation performed on Discrete Isolated Hindi speech Recognizer for male speaker (Test word 3&4).

	Existing Method (*using k means of VQ*)				Proposed Method (*using proposed VQ*)			
Words in Data	Unknown Word 3 (*Putra)*		Unknown Word 4 (*Pati*)		Unknown Word 3 *(Putra)*		Unknown Word 4 (*Pati*)	
	Probability Computation		Probability Computation		Probability Computation		Probability Computation	
(Index j)	Iteration 1	Iteration 2	Iteration 1	Iteration 2	Iteration 1	Iteration 2	Iteration 1	Iteration 2
	1.0e+004*	1.0e+004*	1.0e+004*	1.0e+004*	1.0e+00*	1.0e+004*	1.0e+004*	1.0e+004*
Word1(*Maa*)	**-1.8071**	-1.8146	-1.6543	-1.701	-1.8274	-1.8274	-1.6735	-1.6735
Word 2(*Pitaji*)	-1.8570	-1.8102	-1.6904	**-1.6592**	-1.8112	-1.8112	-1.6469	-1.6469
Word 3(*Putra*)	-1.8491	**-1.7959**	-1.6853	-1.6951	**-1.7823**	**-1.7823**	-1.6421	-1.6421
Word 4(*Pati)*	-1.8128	-1.8021	-1.6876	-1.6989	-1.7968	-1.7968	**-1.6374**	**-1.6374**
Word 5(*Patni*)	-1.8072	-1.7969	-1.7076	-1.6963	-1.8086	-1.8086	-1.6475	-1.6475
Word 6(*Putri*)	-1.8758	-1.8309	**-1.6365**	-1.7234	-1.8066	-1.8066	-1.6418	-1.6418
Word 7(*Bhai*)	-1.8195	-1.8311	-1.7063	-1.7164	-1.8037	-1.8037	-1.6532	-1.6532
Word 8(*Bahan*)	-1.8332	-1.8094	-1.6790	-1.6804	-1.8157	-1.8157	-1.6699	-1.6699
Word 9(*Dadaji*)	-1.8403	-8.8904	-1.6910	-1.6753	-1.8072	-1.8072	-1.6518	-1.6518
Word 10(*Dadiji*)	-1.8228	-1.7978	-1.6585	-1.7129	-1.8293	-1.8293	-1.7795	-1.6733
Max Probability index 'j'	**j=1**	**j=3**	**j=6**	**j=2**	**j=3**	**j=3**	**j=4**	**j=4**
	*The maximum probability is selected which gives the index of the recognized utterance. The proposed DHMM is trained with 5 utterances of each word and sixth utterance of every word is used as an unknown word during the testing phase**.**							
Unknown Test Word	*Putra*	*Putra*	*Pati*	*Pati*	*Putra*	*Putra*	*Pati*	*Pati*
Recognised word	*Maa*	*Putra*	*Putri*	*Pitaji*	*Putra*	*Putra*	*Pati*	*Pati*
Status of Recognition	*Incorrect*	*Correct*	*Incorrect*		*Correct*		*Correct*	

Table 3: Showing results of experimentation performed on Discrete Isolated Hindi speech Recognizer for male speaker (Test word 5&6).

	Existing Method (*using k means of VQ*)				Proposed Method (*using proposed VQ*)			
Words in Data	Unknown Word 5 (*Patni)*		Unknown Word 6 (*Putri*)		Unknown Word 5 *(Patni)*		Unknown Word 6 (*Putri)*	
	Probability Computation		Probability Computation		Probability Computation		Probability Computation	
(Index j)	Iteration 1	Iteration 2	Iteration 1	Iteration 2	Iteration 1	Iteration 2	Iteration 1	Iteration 2
	1.0e+004*	1.0e+004*	1.0e+004 *	1.0e+004*	1.0e+00*	1.0e+004*	1.0e+004*	1.0e+004*
Word1(*Maa*)	-1.6433	-1.6168	-1.6514	-1.6367	-1.6198	-1.6198	-1.6361	-1.6361
Word 2(*Pitaji*)	-1.6437	**-1.6013**	-1.6246	-1.6395	-1.576	-1.5760	-1.5984	-1.5984
Word 3(*Putra*)	-1.6559	-1.6576	-1.6643	**-1.6219**	-1.5895	-1.5895	-1.6048	-1.6048
Word 4(*Pati)*	-1.6195	-1.6518	-1.663	-1.6364	-1.5798	-1.5798	-1.6012	-1.6012
Word 5(*Patni*)	-1.6486	-1.6447	-1.6713	-1.6283	**-1.5753**	**-1.5753**	-1.5986	-1.5986
Word 6(*Putri*)	-1.6383	-1.6286	-1.6677	-1.6482	-1.5813	-1.5813	**-1.5968**	**-1.5968**
Word 7(*Bhai*)	-1.6425	-1.6493	-1.6791	-1.6583	-1.6007	-1.6007	-1.6172	-1.6172
Word 8(*Bahan*)	-1.6564	-1.6629	-1.6371	-1.6319	-1.6194	-1.6194	-1.6335	-1.6335
Word 9(*Dadaji*)	**-1.6134**	-1.6543	-1.6430	-1.6420	-1.5834	-1.5834	-1.6101	-1.6101
Word 10(*Dadiji*)	-1.6345	-1.6374	**-1.6246**	-1.6756	-1.6185	-1.6185	-1.6356	-1.6356
Max Probability index 'j'	**j=9**	**j=2**	**j=10**	**j=3**	**j=5**	**j=5**	**j=6**	**j=6**
	*The maximum probability is selected which gives the index of the recognized utterance. The proposed DHMM is trained with 5 utterances of each word and sixth utterance of every word is used as an unknown word during the testing phase**.**							
Unknown Test Word	*Patni*	*Patni*	*Putri*	*Putri*	*Patni*	*Patni*	*Putri*	*Putri*
Recognised word	*Dadaji*	*Pitaji*	*Dadiji*	*Putra*	*Patni*	*Patni*	*Putri*	*Putri*
Status of Recognition	*Incorrect*		*Incorrect*		*Correct*		*Correct*	

Table 4: Showing results of experimentation performed on Discrete Isolated Hindi speech Recognizer for male speaker (Test word 7&8).

	Existing Method (*using k means of VQ*)				Proposed Method (*using proposed VQ*)			
Words in Data	Unknown Word 7 (*Bhai)*		Unknown Word 8 (*Bahan*)		Unknown Word 7 *(Bhai)*		Unknown Word 8 (*Bahan*)	
	Probability Computation		Probability Computation		Probability Computation		Probability Computation	
(Index j)	Iteration 1	Iteration 2	Iteration 1	Iteration 2	Iteration 1	Iteration 2	Iteration 1	Iteration 2
	1.0e+003*	1.0e+003*	1.0e+003 *	1.0e+003*	1.0e+00*	1.0e+003*	1.0e+003*	1.0e+003*
Word1(*Maa*)	-8.6142	-8.5697	-9.2143	**-8.9576**	-8.3019	-8.3019	-8.9434	-8.9434
Word 2(*Pitaji*)	-8.6908	-8.627	-9.0850	-8.9852	-8.3003	-8.3003	-8.9201	-8.9201
Word 3(*Putra*)	-8.7182	-8.6369	-9.3011	-9.0928	-8.3474	-8.3474	-8.8910	-8.8910
Word 4(*Pati)*	-8.6153	-8.5182	-8.9458	-8.9753	-8.3148	-8.3148	-8.9020	-8.9020
Word 5(*Patni*)	-8.544	-8.7407	-9.1086	-9.0910	-8.2943	-8.2943	-8.9164	-8.9164
Word 6(*Putri*)	-8.5158	-8.6470	-9.0810	-9.2884	-8.2980	-8.2980	-8.8993	-8.8993
Word 7(*Bhai*)	-8.4954	-8.6635	-9.1254	-9.0920	**-8.2909**	**-8.2909**	-8.8965	-8.8965
Word 8(*Bahan*)	**-8.4175**	-8.5658	-9.2463	-9.2088	-8.3238	-8.3238	**-8.8759**	**-8.8759**
Word 9(*Dadaji*)	-8.4865	-8.5527	**-8.9139**	-8.9981	-8.354	-8.354	-8.9824	-8.9824
Word 10(*Dadiji*)	-8.6667	**-8.5099**	-9.0733	-9.1187	-8.3282	-8.3282	-8.9843	-8.9843
Max Probability index 'j'	**j=8**	**j=10**	**j=9**	**j=1**	**j=7**	**j=7**	**j=8**	**j=8**
	*The maximum probability is selected which gives the index of the recognized utterance. The proposed DHMM is trained with 5 utterances of each word and sixth utterance of every word is used as an unknown word during the testing phase**.**							
Unknown Test Word	*Bhai*	*Bhai*	*Bahan*	*Bahan*	*Bhai*	*Bhai*	*Bahan*	*Bahan*
Recognised word	*Bahan*	*Dadiji*	*Dadaji*	*Maa*	*Bhai*	*Bhai*	*Bahan*	*Bahan*
Status of Recognition	*Incorrect*		*Incorrect*		*Correct*		*Correct*	

Table 5: Showing results of experimentation performed on Discrete Isolated Hindi speech Recognizer for male speaker (Test word 9&10).

	Existing Method (*using k means of VQ*)				Proposed Method (*using proposed VQ*)			
Words in Data	Unknown Word 9 (*Dadaji)*		Unknown Word 10 (*Dadiji*)		Unknown Word 9 *(Dadaji)*		Unknown Word 10 *(Dadiji)*	
	Probability Computation		Probability Computation		Probability Computation		Probability Computation	
(Index j)	Iteration 1	Iteration 2	Iteration 1	Iteration 2	Iteration 1	Iteration 2	Iteration 1	Iteration 2
	1.0e+004*	1.0e+004*	1.0e+004 *	1.0e+004*	1.0e+00*	1.0e+004*	1.0e+004*	1.0e+004*
Word1(*Maa*)	-1.7973	-1.7441	-1.0832	-1.1146	-1.7553	-1.7553	-1.0722	-1.0722
Word 2(*Pitaji*)	-1.7988	-1.7964	-1.1247	-1.1017	-1.7178	-1.7178	-1.0723	-1.0723
Word 3(*Putra*)	-1.7378	-1.7936	-1.1252	-1.1013	-1.7244	-1.7244	-1.0720	-1.072
Word 4(*Pati)*	-1.8251	-1.7832	-1.1117	-1.0859	-1.7215	-1.7215	-1.0736	-1.0736
Word 5(*Patani*)	-1.7963	-1.7710	-1.1411	-1.0992	-1.7160	-1.7160	-1.0727	-1.0727
Word 6(*Putri*)	-1.7567	-1.7768	-1.0969	-1.0951	-1.7164	-1.7164	-1.0710	-1.0710
Word 7(*Bhai*)	-1.7449	-1.7858	-1.0913	-1.0985	-1.7396	-1.7396	-1.0722	-1.0722
Word 8(*Bahan*)	**-1.6995**	-1.7440	**-1.0756**	**-1.0850**	-1.7607	-1.7607	-1.0721	-1.0721
Word 9(*Dadaji*)	-1.7278	-1.7995	-1.1021	-1.1094	**-1.7110**	**-1.7110**	-1.0789	-1.0789
Word 10(*Dadiji*)	-1.7754	**-1.7092**	-1.1030	-1.0938	-1.7557	-1.7557	**-1.0675**	**-1.0675**
Max Probability index 'j'	**j=8**	**j=10**	**j=8**	**j=8**	**j=9**	**j=9**	**j=10**	**j=10**
	*The maximum probability is selected which gives the index of the recognized utterance. The proposed DHMM is trained with 5 utterances of each word and sixth utterance of every word is used as an unknown word during the testing phase**.**							
Unknown Test Word	*Dadaji*	*Dadaji*	*Dadiji*	*Dadiji*	*Dadaji*	*Dadaji*	*Dadiji*	*Dadiji*
Recognised word	*Bahanm*	*Dadiji*	*Bahan*	*Bahan*	*Dadaji*	*Dadaji*	*Dadiji*	*Dadiji*
Status of Recognition	*Incorrect*		*Incorrect*		*Correct*		*Correct*	

5. Discussion of results on comparison of Proposed Discrete Isolated Hindi Speech Recognizer with K-Means technique for male speaker

With reference to Table 1 showing the results of experimentation performed on proposed DHMM for Unknown Test Words 1 to Unknown Test word 10 the column 1 & column2 of Existing method that is K-Means for unknown word /Test Utterance *Maa* the maximum Probabilities(represented as negative logarithm) are -8.7200 and -8.7730 for iteration 1 & iteration 2 respectively. The recognized word corresponding to these probabilities are *Putra* & *Pati* which is a incorrect recognition result since the test word/Unknown word was *Maa*. But if we take the case of Proposed VQ technique the column 1 & column 2 of proposed VQ technique the maximum probabilities are -8.5615 & -8.5615 for iteration 1 & iteration 2 respectively. The recognized word corresponding to maximum probability is *Maa* which is a correct recognition result.

Similarly for Unknown word/ Test Utterance *Pitaji* the maximum probabilities for K-Means case is -1.7727 & -1.7976 for iteration 1 & iteration 2 respectively. The recognized word corresponding to these probabilities is *Putra* & *Bahan* which is incorrect recognition result while for the proposed VQ technique in column 1 & column 2 the maximum probabilities are -1.7329 & -1.7329 for iteration 1 & iteration 2 respectively. The recognized word corresponding to these probabilities is *Pitaji* which is correct recognition result.

The interpretation of the above results (refer table 1) concludes that the proposed technique of Speech recognition is superior and the accuracy is extremely high as compared to K-Means of VQ technique although the data length used is small. All the test utterances were recognized correctly through proposed method as compared to K-Means method for same speaker that is we can say that the system has been designed Speaker dependent. It can be made Speaker independent by training the system by large number of speaker. The proposed technique of speech recognition is superior as compared to K Means technique. Here the number of words for which the system is trained is 10 such as *Putra* , *Pati, Patni, Putri, Bhai, Bahan, Dadaji and Dadiji* and all the 10 words were recognized correctly as is clear from the tables 2, Table 3,Table 4,Table 5 which is self explainatory.

6. Conclusions and future directions

The efficiency of the proposed Discrete Isolated Hindi speech recognizer is better as compared to older method of VQ such as K-mean technique. The proposed Discrete Isolated Hindi Speech recognizer is speaker dependent it can be made speaker independent by training the system by large number of speaker. All the test utterances were recognized correctly through proposed method. Although the number of words for which the system was trained is 10 and all the 10 words were correctly recognized. The future work may be carried out by using the amplitude of the test word to be of different values for investigating its effect on the overall accuracy of speech recognition.

REFERENCES:

1. Buam, L. E.,1972, "*An Inequality and Associated Maximisation Technique in Stastical Estimation of Probabilistic Function of Markov Process, Inequalities*", 3, 1-8.

2. Buam, L. E. and Egon, J.A.,1967, "*An Inequality with Applications to Statstical Estimation for Probabiistic Functions of a Markov Process and to a Model for Ecology*", Bull. Amer. Meterorol. Soc., 73, 360-363.

3. Buam,L. E. and Petrie, T., 1966, "*Statstical Inference for Probabilistic Functions of Finite State Markov Chains*", Ann. Math. Stat., 37, 1554-1563.

4. Rabiner,L. R. and Wilpon, J. G., 1979, "*Speaker Independent, Isolated Word Recognition for a Moderate Size (54 word) Vocabulary*", IEEE Trans. on Acoustics, Speech, and Signal Processing, ASSP-27,. 6, 583-587

5. Juang, B. H. and Rabiner, L. R., 1985, "*A Probabilistic Distance Measure for Hidden*

Markov Models", AT&T Technical Journal, 64(2), 391-408.

6. Rabiner, L. R., Levinson, S. E. and Sondhi, M. M., 1983, "*On The Application of Vector Quantication and Hidden Markov Models to Speaker Independent Isolated Word Recognition*", Bell Syst. Tech., 62 (4), 1075-1105.

7. Yoseph Linde, Andres Buzo,Robert M Gray" *An Algorithm for Vector Quantizer Design*",IEEE Transactions. Vol.COM-28, No.1, January 1980.

8. F. K. Soong, A. E. Rosenberg, L. R. Rabiner , B. H. Juang "A Vector Quantization Approach to Speaker Recognition".AT&T Technical Journal, Volume 66, Issue 2, 1987.

9 S .K. Gaikwad,"A Review on Speech Recognition Techniques", I. J.of Computer Applications",Vol.10, November, 2010

.

10 Joseph W Picone,"Signal Modeling Technique in Speech Recognition",Proceedings of the IEEE,vol 81,No.9, September, 1993.

11 Satish kumar, Prof Jai Prakash "Developement of Front End and Statistical Model for Hindi Speech Recognizer: A Practical Approach" Journal of Indian Research, Vol. 2, Issue-3, July- September , 2014.

12 Satish kumar, Prof Jai Prakash "Design & Development of Discrete HMM (DHMM) Isolated Hindi Speech Recognizer" Journal of Indian Research, Vol. 2, No. 4,October-December , 2014.

13 L.R.Rabiner & B.H. Juang, "An introduction to Hiden Markov Models", IEEE ASSP Magazine, Pg 4-16, January.1986.

14 Lawrence Rabiner and B. H. Juang, "Fundamentals of Speech Recognition'', Prentice Hall, Englewood clliffs,NJ,1993.