ISSN:0975-9646

Cini Kurian / (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 5 (5) , 2014, 6169-6175

A Survey on Speech Recogntion in Indian Languages

Cini Kurian

Department of Computer Science , Al-Ameen College, Edathala, Aluva, Kerala-683561

Abstract— **Speech recognition applications are becoming common and useful in this day and age as many of the modern devices are designed and produced user-friendly for the convenience of general public. Speaking/communicating directly with the machine to achieve desired objectives make usage of modern devices easier and convenient. Although many interactive software applications are available, the uses of these applications are limited due to language barriers. Hence development of speech recognition systems in local languages will help anyone to make use of this technological advancement. In India, speech recognition systems have been developed for many indigenous languages. In this paper , we present the survey of major research works in the development of automatic speech recognition in Indian language.**

Keywords— **Speech Recognition, Indian languages**

I. INTRODUCTION

Speech is the vocalized form of human communication. Speech is natural, easy, fast, hands-free and do not require technical knowledge. Human beings are comfortable with speaking directly with computers rather than depending on primitive interfaces such as keyboards and pointing devices. The primitive interfaces like keyboard and pointing devices require certain amount of skill for effective usage. Use of mouse requires a good hand-eye coordination. Physically challenged people find it difficult to use computer. It is difficult for blind people to read from monitor. Moreover current computer interface assumes a certain level of literacy from the user. It expects the user to have certain level of proficiency in English apart from typing skill. Speech interface [1] helps to resolve these issues.

Interaction with computer through a convenient and user-friendly interface has always been an important technological issue. Machine-oriented interfaces [2] restrict the computer usage to a minuscule fraction of the population, who are both computer literate and conversant with written English. Computers which can recognize speech in native languages enable common man to make use of the benefits of information technology.

Speech recognition system keeps elderly, physically challenged especially blind people closer to the Information technology revolution. Speech recognition benefits a lot in manufacturing and control applications where hands or eyes are otherwise occupied. It has large application for use over telephone, including automated dialing, telephone directory assistance, spoken database querying for novice users, voice dictation systems like medical transcription applications, automatic voice translation into foreign languages etc. Speech enabled applications in public areas such as; railways, airport and tourist information centers might serve customers with answers to their spoken query. Such tantalizing applications have motivated research in automatic speech recognition (ASR) since 1950's. Great progress has been made so far, especially since 1970's, using a series of engineered approaches that include template matching, knowledge engineering, and statistical modeling [3]. Yet computers are still nowhere near the level of human performance at speech recognition, and it appears that further significant innovation requires serious research/studies.

Automatic speech recognition has tremendous potential in Indian scenario. Although literacy rate of India is above 65%, less than 6% of India's total population uses English for communication. Since the internet has become universal, common man now mainly depend, the same for any sort of information and communication. Therefore it is imperative that the about 95% of our population cannot enjoy the benefits of this internet revolution. If this information is available in local languages, India could also be benefited by this technology revolution and could stand along with developed countries.

It would be a vital step in bridging the digital divide [4] between non English speaking people and others. Since there is no standard input for Indian languages, it eliminates the key board mapping of different fonts. In Indian scenario, where there are about 1670 dialects of spoken form, speech recognition technology has wider scope and application [5]. A survey on major research works in the development of automatic speech recognition in Indian language is being presented in this paper.

II. REVIEW OF MAJOR SPEECH RECOGNITION WORKS IN HINDI LANGUAGE

Samudravijaya [6] came up with the development of a speaker independent, continuous speech recognition system for Hindi. Their system recognized spoken queries in Hindi in the context of railway reservation enquiry task. The sentence corpus contained 320 sentences and the size of the vocabulary was 161 words.

HMM tool kit was used by Gupta [7] to develop a speaker independent isolated Hindi word speech recognizer for recognizing the ten digits in Hindi, using continuous HMM. Venkataramani [8] has worked on the development of an on-line "speech to text engine" for isolated word

recognition on a vocabulary of 10 words (digits 0-9) which was implemented as a system on a programmable chip (SOPC). Speech was acquired at run time through a microphone and processes the sampled speech to recognize the uttered text.

N. Rajput M. Kumar and A. Verma [9] of IBM research lab, has developed a large-vocabulary continuous speech recognition system for Hindi. They developed a Hindi Speech Recognition system which has been trained on 40 hours of audio data and has a trigram language model that is trained with 3 million words. For a vocabulary size of 65000 words, the system gives a word accuracy of 75% to 95%.

Mathur et al. [10] used Julius (a software tool) to develop a domain specific speaker independent continuous speech recognizer for Hindi. Kumar and Aggarwal [11] have developed a Hindi isolated word speech recognizer using HTK on Linux platform which recognizes isolated words using acoustic word model. Vocabulary used for this system was just 30 words. HMM was used to train and recognize the speech. 39 MFCCs (12 Mel Cepstrum + Log energy + 1st and 2nd Order derivatives) features were extracted.

Aggarwal and Dave [12] have proposed an approach to speed up the statistical pattern classification by reducing the time consumed in the likelihood evaluation of feature vectors with the help of optimal number of Gaussian mixture components. They applied extended MFCC procedure by extracting 52 MFCC features (39 MFCC + 13 triple delta features) and then reducing them to 39 by using HLDA – Hetroscedastic linear discriminant analysis technique.

Mishra et al. [13] have developed a connected Hindi digits recognition system using robust feature extraction techniques and HTK (a soft ware tool using HMM) recognition engine. In spite of creating just a base line recognizer, the results were encouraging. Sivaram and Samudravijaya [14] have made an attempt to compensate the mismatch between training and testing conditions with the help of unsupervised Speaker adaptation. MLLR - Maximum Likelihood Linear Regression, a speaker adaptation technique requiring small amount of data, has been used

III. REVIEW OF SPEECH RECOGNITION RESEARCH IN PUNJABI LANGUAGE

Ravinder et al. [15] developed a speaker dependent, real time, Isolated and connected word recognition systems for Punjabi language using acoustic template matching technique. It was designed for medium sized dictionary. Vector quantization was used to transform signal parameters to codebook indices and Dynamic time warping techniques was used for finding the lowest distance path through the matrix, with some modification to noise and word detection algorithms. Accuracy of this ASR was just 61%.

Kumar [16] also compared the performance of DTW based speech recognition and HMM based speech recognition for Punjabi isolated words. Performance was in favor of DTW based recognizer but that is just because of insufficiency of HMM training data. Time and space complexity has been found to be less in HMM based recognizer for same size of code book.

IV. A SURVEY ON TAMIL AUTOMATIC SPEECH RECOGNITION

Nayeemulla et al [17] have developed speech recognition system for some specific domains of Tamil language. In 2004, Sararwathi et al.[18] have build a language model for Tamil speech recognition system. Lakshmi et al [19] present a novel technique for building a syllable based continuous speech recognizer when un annotated transcribed train data is available. Two different segmentation algorithms to segment the speech and the corresponding text into comparable syllable like unit have been presented. A group delay based two level segmentation algorithm is proposed to extract accurate syllable units from the speech data. A rule based text segmentation algorithm is used to automatically annotate the text corresponding to the speech into syllable units. Isolated style syllable models are built using multiple frame size (MFS) and multiple frame rate (MFR) for all unique syllables by collecting examples from annotated speech. Experiments performed on Tamil language show that the recognition performance is comparable to recognizers built using manually segmented train data. These experiments suggest that system development cost can be reduced by using minimum manual effort if sentence level transcription of the speech data is available.

Thangarajan et al. [20] have developed a small vocabulary word-based and medium vocabulary triphone based continuous speech recognizer for Tamil language. Larger memory requirement is a limitation of triphone sub-word model approach. Thangarajan et al. [21] have worked for developing a continuous speech recognizer for Tamil language using syllable as a sub-word unit for building acoustic model. Initially, a small vocabulary context independent word model and a medium vocabulary context dependent phone model have been developed. Subsequently, an algorithm based on prosodic syllable is proposed and two experiments have been conducted. First, syllable based context independent models have been trained and tested. Despite large number of syllables, this system has performed reasonably well compared to context independent word models in terms of word error rate and out of vocabulary words. Subsequently, in the second experiment, syllable information is integrated in conventional triphone modeling wherein cross-syllable triphones are replaced with monophones and the number of context dependent phone models is reduced by 22.76% in untied units. In spite of reduction in the number of models, the accuracy of the proposed system is comparable to that of the baseline triphone system.

Dharun and Karnan, 2012 [22] developed a system for voice recognition in Tamil word and numeral using Mel-Frequency Cepstral Coefficients (MFCC) and Dynamic Time Warping (DTW). Vimala and Krishnaveni [23] present a Continuous Speech Recognition (CSR) system for Tamil language using Hidden Markov Model (HMM) approach. The most powerful and widely used MFCC feature extraction is used as a front-end for the proposed system. The monophone based acoustic model is chosen to recognize the given set of sentences from medium vocabulary. The results are found to be satisfactory with 92% of word recognition accuracy and 81% of sentence accuracy for the developed system.

Vimala C. and V. Radha [24] present a speaker independent isolated speech recognition system for Tamil language. The experiments furnish high-quality word accuracy of 88% for trained and test utterances spoken by the speakers. The performance evaluation of the system is done based on the Word Error Rate (WER) which gives 0.88 WER for the above research work. DTW based Speech Recognition System has a good accuracy for isolated Tamil Digits [25]. An Isolated Tamil word Recognizer was built using the HTK tool [26] by A. Akila et. al. The recognizer was trained with the grain names in Tamil spoken by 2 female speakers. The result obtained from the recognizer was having good accuracy rate for isolated Tamil words.

V. REVIEW OF DEVELOPMENTS IN ASSAMESE AND BANGALI

In 2010, M. P. Sarma and K.K Sarma [27] worked for the development of numeral speech recognition system for Assamese language. Gender and mood variations were given consideration during the recording of speech signals of 10 numeral digits at 8 KHz in mono channel mode. In 2011, M. P. Sarma and K.K Sarma [28] have proposed the design of an optimal feature extraction block and ANN based architecture for speech recognition.

Neural network approach has been proposed by M. R. Hassan et.al [29] for Bengali phoneme recognition. A Bengali speech recognizer is built by training the HTK toolkit that can recognize any word in the dictionary [30]. After acoustic analysis of speech signal, the words are recognized. Technically this work presents training the toolkit and builds a segmented speech recognizer of Bengali. The paper contains the training procedure of the toolkit along with different steps of building a recognizer with the HTK toolkit.

Banerjee et.al [31] worked to study the effect of triphone based acoustic modeling over monophone based acoustic models in the context of continuous speech recognition in Bengali. Triphone clusters have been generated using decision tree based techniques. These triphone clusters have then been used to generate tied-state triphone based acoustic models to be used in a continuous speech recognizer.

Mandal, S et.al [32] in their paper introduce the SPHINX3-based Bengali Automatic Speech Recognition (ASR) system Shruti-II and an E-mail application based on it. This ASR system converts standard Bengali continuous speech to Bengali Unicode. Due to the limited availability of access to computer, visually impaired community can use speech as an input method for various computer-based applications. This paper also demonstrates an application based on Shruti-II which is made for the visually challenged people. Those people can send E-mail by using this system.

VI. REVIEW OF DEVELOPMENTS IN ASSAMESE AND BANGALI

Gawali et al. [33] worked to develop a speech database and speech recognition system for isolated words of Marati language. CSL lab (Computer Speech Laboratory) has been used for collecting speech data. Broadening the scope of Marathi speech recognition to the benefit for society, Gaikwad et al. [34] developed a Polly clinic inquiry system using IVR, which can respond to wide range of health care services. It is a commendable effort which can help the patients to interact for their health related queries.

VII. SPEECH RECOGNITION RESEARCH IN ORIYA AND URDU LANGUAGES

Oriya Automatic recognition of continuously spoken digits is one area where speech recognition can serve the speakers of any language and thereby help them to exploit the benefits of modern technology. Mohanty and Swain [35] have made such effort for Oriya language. Mohanty and Swain [36] have come forward to apply the benefit of automatic speech recognition systems to society by developing an isolated speech recognizer for Oriya language so that visually impaired students can attempt the closed ended questions such as fill-in-blanks, dichotomous, ranking scale, multiple choice and rating scale questions, well during their exams.

Raza et al. [37] worked for the development of a HMM based Large Vocabulary Automatic Spontaneous Urdu speech recognition system with the help of Sphinx 3 trainer and decoder. Sarfraz et al. [38] have worked on the development of LVCSR for Urdu language using CMU Sphinx Open Source Toolkit. They used a corpus of training data recorded in noisy environment so as to improve the robustness of speech recognition

VIII. MAJOR RESEARCH WORKS IN KANNADA LANGUAGES

M. A. Anusuya and K.K Katti [39] proposed a new scheme for recognition of isolated words in Kannada Language speech, based on the Discrete Wavelet Transform (DWT) and Principal component Analysis (PCA). Initially the Discrete wavelet transform of a speech signal is computed and then LPC coefficients are calculated. Sarika Hegde et.al, 2012 [40] have developed an Isolated Word Recognition (IWR) system for identification of spoken words for the database created by recording the words in

Kannada language. The developed system is tested and evaluated with a performance of 79% accuracy.

In 2012, M. A. Anusuya and K.K Katti [41] used statistical method to remove the silence from the speech signal. This method is applied on vector quantization technique to identify the minimum speech patterns that are required while creating the training set of the speech samples. This paper also discusses the importance and efficiency of the algorithms used in vector quantization for the clustering purpose. Also speech recognition accuracies for speaker dependent and speaker independent methods have been evaluated and tabulated in the tables given below. The paper shows the importance of the statistical method analysis of the signal than the normal analysis.

Shiva Kumar C [42] worked to provide a low cost alternative for the literate deaf people. The project describes Isolated Word Recognition of Kannada Digits. The system reads the spoken speech signal. Wavelet transform of the speech signal is taken and MFCC (Mel Frequency Cepstral Coefficients) are calculated followed by Vector Quantization. Euclidean Distance measure is used to correlate the test speech signal with pre recorded speech signals from the speech database. The nearest match is identified and its respective text equivalent is displayed. The project is carried out for Kannada digits, which can be extended to words later. The programming is done using Matlab.

Sarika Hegde et.al, 2013 [43] developed an Isolated Word Recognizer for identification of spoken words for the database created by recording the words in Kannada Language. Support Vector Machine (SVM) algorithm is used for designing the classifier model. They have analyzed the variation in the performance of classification for words ending with same phonetics and found that the classification accuracy using SVM with Mel-Frequency Cesptrum Coefficients (MFCC) is good and accuracy has an affect due to the similar phonetic sounds in different words.

IX. TELEGU SPEECH RECOGNITION WORKS

In 2003, Sai Prasad and Girija [44] have used Neural Networks for speech Recognition of Isolated Telugu Vowels. Hegde, R.M. et.al, 2004 [45] have used joint features derived from the modified group delay function and MFCC for Continuous speech recognition. Hegde, R.M. et,al 2005 [46] have worked to develop continuous speech recognizer for Telugu using modified group delay function. In 2009 ,Sunitha .K.V.N and Kalyani .N. [47] have build a dictation system in Telugu language using phoneme as a basic unit of recognition.

In 2012, Sunitha .K.V.N and Kalyani .N [48] have build a speech recognition system that uses syllable as the basic unit. The experiment is conducted on CIIL Telugu corpus and achieved good results in recognizing the words that were not used for training. For training they have used 300 words and for testing they recorded 100 new words and 80% of the words were recognized correctly. Vijai Bhaskar P et.al [49] have used the HTK toolkit for building a speech recognizer for Telugu language.

In the proposed Telugu speech recognition system Usha Rani N and Girija P.N [50] have analyzed, errors obtained from decoder to improve the performance of the speech recognition system. Static pronunciation dictionary plays a key role in the speech recognition accuracy. Modification has been done in the dictionary, which is used in the decoder of the speech recognition system. This modification reduces the number of the confusion pairs which improves the performance of the speech recognition system. Language model scores are also varied with this modification. Hit rate is considerably increased during this modification and false alarms have been changed during the modification of the pronunciation dictionary. Variations are observed in different error measures such as F-measures, error-rate and Word Error Rate (WER) by application of the proposed method.

X. GUJARATI AND BODO LANGUAGES FOR SPEECH RECOGNITION RESEARCH

A technique for fast bootstrapping of initial phone models of a Gujarati language is presented by Himanshu N. Patel [51]. The training data for the Gujarati language is aligned using an existing speech recognition engine for English language. This aligned data is used to obtain the initial acoustic models for the phones of the Gujarati language. Speech recognition of Gujarati Language is presented by Patel Pravin and Harikrishna Jethva [52]. Neural network was used for developing the system.

M.K.Deka et.al [53] have proposed an approach for Speech Recognition using LPCC (Linear Predictive Cepstral Coefficient) and MLP (Multilayer Perceptron) based Artificial Neural Network with respect to Assamese and Bodo Language. A new simplified approach has been made for the design and implementation of a noise robust speech recognition using Multilayer Perceptron (MLP) based Artificial Neural Network and LPC-Cepstral Coefficient. Cepstral matrices obtained via Linear Prediction Coefficient are chosen as the eligible features. Here, MLP neural network based transformation method is studied for environmental mismatch compensation.

The paper by Utpal Bhattacharjee [54] investigates the problems faced by tonal languages like bodo during recognition process. The performance of speech recognition system degrades considerably when the recognizers are used to recognize the tonal words. Two approaches have been investigated in this paper for this purpose. In the first approach attempt has been made to develop a feature level solution to the problem of tonal word recognition. In the second approach, a model level solution has been suggested. Experiments were carried out to find the relative merits and demerits of both the methods.

Table 1.1: Survey of Indian Efforts in ASR

Language	Author	year	Task/Name of recognizer and techniques/approaches
Hindi	1) Samudravijaya	2000	S.I continuous speech recogntizer
	2) Gupta	2006	Digit recognizer
	3) Venkitaramani	2006	Digit recognizer
	4) N.Rajput M et.al	2010	Large vocabulary continuous speech recognizer
	5) Mathur et.al	2010	S.I continuous speech recognnizer
	6) Kumar and Agarwal	2011	Isolated word speech recognizer
	7) Agarwal and Dave	2011	statistical pattern classification
	8) Mishra	2011	Connected digit recognizer
	9) Sivaram et.al	2011	MLLR for unsupervised speaker adaptation
Punjabi	1) Kumar et.al	2004	Isolated and connected word recognizer
	2) Kumar	2010	DTW and HMM for speech recognizer
Tamil	1) Nayeenmulla et.al	2001	speech recognizer for specific domain
	2) Saraswathy et.al	2004	Language model for speech recognizer
	3) Lakshmi A et.al	2006	A Syllable based continuous speech recognizer
	4) R. Thangarajan et.al	2008	Word and Triphone Based Approaches in Continuous Speech Recognition
	5) R. Thangarajan et.al	2009	Syllable modeling in continuous speech recognition
	6) V.S.Dharun et.al	2012	Voice and Speech Recognition for Tamil Words and Numerals
	7) V. Radha et.al	2012	Continuous Speech Recognition system using monophone-based HMM
	8) Vimala C. et.al	2012	Speaker Independent Isolated Speech Recognition System using HMM
	9) S. Karpagavalli et. Al	2012	Isolated Tamil Digits Speech Recognition using Vector Quantization
	10) A. Akila et. Al	2013	Tamil Word Speech Recognition System Using HTK-
Assameese	1) M. P. Sarma et.al	2010	Speech Recognition of Assamese Numerals - LPC-features and heterogenous ANNs
	2) M. P. Sarma et.al	2011	Numeral Speech Recognition - Multiple Features and Cooperative LVQ – Architectures
Bangali	1) M. R. Hassan	2003	Bengali Phoneme Recognition -New Approach
	2) Mahmudul Hoque et.al	2006	Bengali Segmented Speech Recognition System
	3) Banerjee et.al	2008	triphone based clustering in acoustic modeling for continuous speech recognition
	4) Mandal, et.al	2010	A vernacular speech recognition system
Marati	1) Gawali et. Al	2010	isolated word recognizer
	2) Gaikwad et.al	2011	Polly clinic inquiry system using IVR
Oriya	1) Mohanty and Swain	2010	Continuous digit recognizer
	2) Mohanty and Swain	2011	Markov Model Isolated Speech Recognizer
Urdu	1) Raza et.al	2009	Large vocabulary continuous speech recognizer
	2) Sarfraz, H	2010	Large vocabulary continuous speech recognizer
Kannada	1) M. A. Anusuya et.al	2010	Kannada speech Recognition using Discrete wavelet Transform-PCA
	2) Sarika Hegde et.al	2012	Isolated Word Recognition for Kannada Language Using Support Vector Machine
	3) M A Anusuya et.al	2012	Speaker Independent Kannada Speech Recognition using Vector quantization
	4) Shiva Kumar	2013	Digits Speech Recognition for Permanent Deaf Patients
	5) Sarika Hegde	2013	Isolated Word Recognition using Pattern Recognition Approach
Telugu	1) Sai Prasad P. S. V. S et.al	2003	Speech Recognition of Isolated Telugu Vowels Using Neural Networks.
	2) Hegde, R.M et.al	2004	speech recognition - modified group delay function and MFCC
	3) Hegde, R.M et.al	2005	Continuous speech recognition from the modified group delay function
	4) Sunitha .K.V.N et.al	2009	Syllable analysis to build a dictation system in Telugu language
	5) Sunitha .K.V.N et.al	2012	Isolated Word Recognition using Morph Knowledge for Telugu
	6) Vijai Bhaskar P et.al	2012	HTK Based Telugu Speech Recognition
	7) Usha Rani N et.al	2012	Error analysis to improve the speech recognition accuracy on Telugu language
Gujarati	1) Himanshu N. Patel et.al	2011	A Small Vocabulary Speech Recognition for Gujarati
	2) Patel Pravin et.al	2013	Neural Network Based Gujarati Language Speech Recognition
Bodo	1) M.K.Deka et.al	2011	Noise Robust Speech Recognition- LPC-and MLP based AI
	2) Utpal Bhattacharjee	2013	Recognition of the Tonal Words of BODO Language

XI. MALAYALAM SPEECH RECOGNITION RESEARCH

Syama R. and Suma Mary Idikkula built an isolated word and speaker independent speech recognition system for Malayalam [55]. Microsoft Visual Studio was used for compiling HTK and Active Perl as interpreter. Accuracy of this system was just 62%. Vimal Krishnan et.al [56] developed a small vocabulary (5 words) speech recognition using 4 types of wavelet for feature extraction and Artificial neural network technique (ANN) is used for classification and recognition purpose. By using this method they have achieved a recognition rate of 89%. Raji kumar et.al have presented recognition of the isolated question words from Malayalam speech query using DWT and ANN [57]. A recognition accuracy of 80% has been reported. A small vocabulary speech recognizer has been developed by Anuj Mohamed and K.N Ramachandran Nair [58] using Hidden Markov Models and MFCC. The system has produced 94.67% word accuracy. Sonia Sunny et.al worked on the speech recognition of isolated 20 words of Malayalam language and reported results in three papers [59,60,61] i.e. comparative study of two wavelet based feature extraction methods; comparison of LPC and DWT for speech recognition; and the accuracy of the speech recognizer with DWT and ANN.

REFERENCES

[1] Sorin Dusan and Larry R. Rabiner, "On integrating insights from human speech perception into automatic speech recognition," in Proceedings of INTERSPEECH 2005, Lisbon, 2005.

[2] HILL, D. R. (1971). Man-machine interaction using speech. In Advances in Computers, 11. Eds

[3] F. L. Alt, M. Rubinoff & M. C. Yovitts, pp. 165-230. New York: Academic Press.

[4] Furui, S., "50 Years of Progress in Speech and Speaker Recognition Research Identification", In ECTI Transformations on Computer and Information Technology, vol. 1, no. 2, 2003.

[5] Balaji. V., K. Rajamohan, R. Rajasekarapandy, S. Senthilkumaran," Towards a knowledge system for sustainable food security: The information village experiment in Pondicherry," in IT Experience in India : Bridging the Digital Divide, Kenneth Keniston and Deepak Kumar, eds., New Delhi, Sage,2004.

[6] Madhuresh Singhal et al. 'Developing Information Technology Solutions in Indian Languages: Pros and Cons'. At 1st International CALIBER: Mapping Technology on Libraries and People, 13-15 Feb. Ahmadabad, India, pages 655-666, 2003.

[7] Samudravijaya, K.,―Computer Recognition of Spoken Hindil. Proceeding of International Conference of Speech, Music and Allied Signal Processing, Triruvananthapuram, pages 8-13, 2000.

[8] Gupta, R., and Sivakumar, G., "Speech Recognition for Hindi Language", IIT BOMBAY, 2006.

[9] Venkataramani, B., "SOPC-Based Speech-to-Text Conversion", Nios II Embedded Processor Design Contest—Outstanding Designs 2006.

[10] N. Rajput M. Kumar and A. Verma. A large-vocabulary continuous speech recognition system for Hindi. IBM Journal for Research and Development 2004.

[11] Mathur, R., Babita, Kansal, A., "Domain specific speaker independent continuous speech recognizer using Julius", Proceedings of ASCNT – 2010, CDAC, Noida, India, pp. 55 – 60.

[12] Kumar, K. and Aggarwal, R. K., "Hindi Speech Recognition System Using HTK", International Journal of Computing and Business Research, ISSN (Online): 2229-6166, Volume 2 Issue 2 May 2011.

[13] Aggarwal, R.K. and Dave, M., -Using Gaussian Mixtures for Hindi Speech Recognition Systeml, International Journal of Signal Processing, Image Processing and Pattern Recognition, Vol. 2, No. 4, December 2011.

[14] Mishra, A. N., Biswas, A., Chandra, M., Sharan, S. N., "Robust Hindi connected digits recognition", International Journal of Signal Processing, Image Processing and Pattern Recognition Vol. 4, No. 2, June, 2011.

[15] Sivaraman. G.; Samudravijaya, K., Hindi Speech Recognition and Online Speaker Adaptation, International Conference on Technology Systems and Management: ICTSM-2011, IJCA.

[16] Kumar, R., Singh, C., Kaushik, S., -Isolated and Connected Word Recognition for Punjabi Language using Acoustic Template Matching Technique, 2004.

[17] Kumar, R., Comparison of HMM and DTW for Isolated Word Recognition System for Punjabi Language, International Journal of Soft Computing 5(3):88-92, 2010.

[18] A. Nayeemulla Khan and B. Yegnanarayana, Development of Speech Recognition System for Tamil for Small Restricted Task, Proceedings of National Conference on Communication, India, 2001.

[19] Saraswathi, S. and T. V. Geetha, "Building language models for Tamil speech recognition system." Proceedings ofAACC 2004.

[20] Lakshmi.A and Hema A Murthy, 2006, A Syllable Based Continuous Speech Recognition for Tamil, INTERSPEECH -ICSLP, Pennsylvania, pp 1878-1881.

[21] R. Thangarajan, A.M. Natarajan, M. Selvam, "Word and Triphone Based Approaches in Continuous Speech Recognition for Tamil Language", Wseas Transactions on Signal Processing, Issue 3, Volume 4, March 2008.

[22] R. Thangarajan , A. M. Natarajan and M. Selvam "Syllable modeling in continuous speech recognition for Tamil language", Int. J. Speech Technol., vol. 12, pp.47 -57 2009.

[23] V.S.Dharun, M.Karnan, 2012, Voice and Speech Recognition for Tamil Words and Numerals, IJMER, Vol. 2, 5, pp 3406-3414.

[24] C.Vimala, M.Krishnaveni , 2012, Continuous Speech Recognition system for Tamil language using monophone-based Hidden Markov Model , Proceedings of the Second International Conference on Computational Science, Engineering and Information Technology CCSEIT '12 , pp 227-231.

[25] Ms. Vimala C., V. Radha, Speaker Independent Isolated Speech Recognition System for Tamil Language using HMM, Procedia Engineering, Volume 30, 2012, Pages 1097-1102,

[26] S. Karpagavalli et. al , 2012 , Isolated Tamil Digits Speech Recognition using Vector Quantization, IJERT, Vol.1, 4, pp 1-9.

[27] A. Akila1, E. Chandra, Isolated Tamil Word Speech Recognition System Using HTK- International Journal of Computer Science Research and Application 2013, Vol. 03, Issue. 02, pp. 30-38

[28] M. P. Sarma and K. K. Sarma, "Speech Recognition of Assamese Numerals using combinations of LPC-features and heterogenous ANNs", Proceedings of International Conference on Advances in Information and Communication Technologies (ICT 2010), Kochi, Kerala, India (V. V. Das and R. Vijaykumar (Eds.): ICT2010, CCIS 101, pp.8-11,2010, Springer-verlag, 2010.

[29] Sarma, M. P.; Sarma, K. K.,Assamese Numeral Speech Recognition using Multiple Features and Cooperative LVQ – Architectures, International Journal of Electrical and Electronics 5:1, 2011.

[30] M. R. Hassan, B. Nath and M. Ala Uddin Bhuiyan, "Bengali Phoneme Recognition: A New Approach", Proc. 6th ICCIT, Dhaka, 2003.

[31] A. K. M. Mahmudul Hoque, "Bengali Segmented Speech Recognition System", Undergraduate Thesis Report, Computer Science and Engineering, BRAC University, May, 2006.

[32] Banerjee, G. Garg, P. Mitra, and A. Basu, "Application of triphone clustering in acoustic modeling for continuous speech recognition in Bengali," in International Conference on Pattern Recognition, ICPR.,Dec. 2008, pp. 1–4.

[33] Mandal, S , Das, B , Mitra, P. "Shruti-II: A vernacular speech recognition system in Bengali and an application for visually impaired community" Students' Technology Symposium (TechSym), 2010 IEEE.

[34] Gawali, Bharti W., Gaikwad, S., Yannawar, P., Mehrotra Suresh C., ―Marathi Isolated Word Recognition System using MFCC and DTW Features (2010), Int. Conf. on Advances in Computer Science 2010, DOI: 02.ACS.2010. 01.73.

[35] Gaikwad, S.; Gawali, B.; Mehrotra, S. C.; ―POLLY CLINIC INQUIRY SYSTEM USING IVR IN MARATHI LANGUAGEl, International Journal of Machine Intelligence, ISSN: 0975–2927 & E-ISSN: 0975–9166, Volume 3, Issue 3, 2011, pp-142-145.

[36] Mohanty, S.; Swain, B. K., ―Continuous Oriya Digit Recognition using Bakis Model of HMM, International Journal of Computer Information Systems, Vol. 2, No. 1, 2011.

[37] Mohanty, S.; Swain, B. K., ―Markov Model Based Oriya Isolated Speech Recognizer-An Emerging Solution for Visually Impaired Students in School and Public Examination, Special Issue of IJCCT Vol. 2 Issue 2, 3, 4; International Conference On Communication Technology-2010.

[38] Raza, A., Hussain, S., Sarfraz, H., Ullah, I., and Sarfraz, Z., An ASR System for Spontaneous Urdu Speech, Proceedings of O-COCOSDA'09 and IEEE Xplore, 2009.

[39] Sarfraz, H.; Hussain, S.; Bokhari, R.; Raza, A. A.; Ullah, I.; Sarfraz, Z.; Pervez, S.; Mustafa, A.; Javed, I.; Parveen, R., ―Large Vocabulary Continuous Speech Recognition for Urdu, International Conference on Frontiers of Information Technology, Islamabad, 2010.

[40] M. A. Anusuya, S. K. Katti " Kannada speech Recognition using Discrete wavelet Transform-PCA" international conference on computer applications --24-27 - December 2010 - Pondicherry – India.

[41] Sarika Hegde, Achary K.K., Surendra Shetty " Isolated Word Recognition for Kannada Language Using Support Vector Machine" Wireless Networks and Computational Intelligence Communications in Computer and Information Science Volume 292, 2012, pp 262-269.

[42] M A Anusuya and S K Katti. "Speaker Independent Kannada Speech Recognition using Vector quantization." IJCA Proceedings on National Conference on Advancement in Electronics and Telecommunication Engineering NCAETE(1):32-35, May 2012. Published by Foundation of Computer Science, New York, USA.

[43] Shiva Kumar C. *A Simple approach for Speech Recognition: "Kannada Digits Speech Recognition for Permanent Deaf Patients"* Lap Lambert Academic Publishing Sep 2012, 2012. Taschenbuch.

[44] Sarika Hegde ,K K Achary,Surendra Shetty- Analysis of Isolated Word Recognition for Kannada Language using Pattern Recognition Approach-International Journal of Information Processing , 7(1), 73 - 80. -2013.

[45] Sai Prasad P. S. V. S, . Girija P. N Speech Recognition of Isolated Telugu Vowels Using Neural Networks. Proceedings of the 1st Indian International Conference on Artificial Intelligence, IICAI 2003, Hyderabad, India, 28-34 December 18-20, 2003.

[46] Hegde, R.M., Murthy, H.A., Gadde, V.R.R., 2004. Continuous speech recognition using joint features derived from the modified group delay function and MFCC. In: Proceedings of ICSLP, Jeju, Korea, pp. 905–908.

[47] Hegde, R.M., Murthy, H.A., Rao, G.V.R., 2005. Speech processing using joint features derived from the modified group delay function. In:Proceedings of ICASSP, vol. I. Philadelphia, PA, pp. 541–544.

[48] Sunitha .K.V.N & Kalyani.N (2009). Syllable analysis to build a dictation system in Telugu language. International Journal of Computer Science and Information Security. Vol 30. No 30.

[49] Sunitha K V N, Kalyani N. Isolated Word Recognition using Morph Knowledge for Telugu Language. International Journal of Computer Applications 38(12):47-54, February 2012. Published by Foundation of Computer Science, New York, USA.

[50] Vijai Bhaskar P , Rama Mohan Rao S , Gopi A - "HTK Based Telugu Speech Recognition" International Journal of Advanced Research in Computer Science and Software Engineering - Volume 2, Issue 12, December 2012.

[51] Usha Rani N, Girija P N "Error analysis to improve the speech recognition accuracy on Telugu language" Sadhana Vol. 37, Part 6, December 2012, pp. 747–761. Indian Academy of Sciences.

[52] Himanshu N. Patel, P.V. Virparia - "A Small Vocabulary Speech Recognition for Gujarati"- International Journal of Advanced Research in Computer Science Volume 2, Issue 1, Jan-Feb 2011. ISSN 0976-5697.

[53] Patel Pravin, Harikrishna Jethva -" Neural Network Based Gujarati Language Speech Recognition " International Journal of Computer Science and Management Research Vol 2 Issue 5 May 2013.

[54] M.K.Deka , C.K.Nath , S.K.Sarma , P.H. Talukdar - "An Approach to Noise Robust Speech Recognition using LPC-Cepstral Coefficient and MLP based Artificial Neural Network with respect to Assamese and Bodo Language" International Symposium on Devices MEMS, Intelligent Systems & Communication (ISDMISC) 2011.

[55] Utpal Bhattacharjee-"Recognition of the Tonal Words of BODO Language"- International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Volume-1, Issue-6, January 2013.

[56] Syama R, Suma Mary Idikkula (2008) “HMM Based Speech Recognition System for Malayalam”, ICAI’08 – The 2008 International Conference on Artificial Intelligence, Monte Carlo Resort, Las Vegas, Nevada, USA (July 14-17, 2008) .

[57] Krishnan, V.R.V. Jayakumar A, Anto P B (2008) , “Speech Recognition of isolated Malayalam Words Using Wavlet features and Artificial Neural Network”. DELTA2008. 4th IEEE International Symposium on Electronic Design, Test and Applications, 2008.Volume,Issue, 23-25 Jan. 2008 Page(s):240 – 243.

[58] A.R. Sukumar, A.F. Shah, and P.B. Anto, “Isolated question words recognition from speech queries by using Artificial Neural Networks”, in proc. of IEEE 2nd International conference on Computing, Communication and Networking Technologies(ICCCNT), Karur, India, 2010, pp. 1-4.

[59] Anuj Mohamed, K. N. Ramachandran Nair-Continuous Malayalam speech recognition using Hidden Markov Models. Proceedings of the 1st Amrita ACM-W Celebration on Women in Computing in India, September 16-17, 2010, Tamilnadu, India; 01/2010.

[60] Sonia Sunny, David Peter S , and K Poulose Jacob -A Comparative Study of Wavelet Based Feature Extraction Techniques in Recognizing Isolated Spoken Words," International Journal of Signal Processing Systems, Vol.1, No.1, pp.49-53,June 2013.

[61] Sunny, Sonia; David Peter, S.; Poulose Jacob, K. "Recognition of speech signals: an experimental comparison of linear predictive coding and discrete wavelet transforms" International Journal of Engineering Science & Technology; Apr 2012, Vol. 4 Issue 4, p1594.