iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 **Issue:** IV **Month of publication:** April 2018

DOI: http://doi.org/10.22214/ijraset.2018.4504

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue IV, April 2018- Available at www.ijraset.com

Galois Homomorphic Fractal Approach for the Recognition of Emotion

T. G. Grace Elizabeth Rani[1], G. Jayalalitha[2]
[1]*Research Scholar, Bharathiar University, India,*
[2] *Associate Professor, Department of Mathematics, Vels University, India,*

Abstract: A novel approach is employed in the recognition of emotions conveyed through speech. Galois field is constructed for various segments of the signal. This is used as input for homomorphic filtering. The signal obtained by filtering is used to evaluate Higuchi's Fractal Dimension. These results derived in the frequency domain are compared with results from time domain analysis of the signal, where the signal is initially filtered using a median filter, and then its Higuchi's Fractal Dimension is evaluated. As Galois field is capable of computing convolution without round off error, it is employed in our paper. The results indicate that the voice of male is coarser in happy and angry moods than in neutral mood, which is the reverse for females.
Keywords: Galois field, Homomorphic filtering, emotion, fractals, Higuchi's fractal dimension, median filter.

I. INTRODUCTION

Speech can be defined as waves of air pressure created by air flow pressed out of lungs and going out through the mouth and nasal cavities. The resonant frequencies of the vocal tract are called formants[1]. Formants carry information about emotional content [6]. Vowels and consonants characterize speech. As a result speech signal shows both periodicity and self-similarity. The measure that is most commonly associated with self-similar objects is its Fractal Dimension. Emotions are cognitive processes related to the architecture of the human mind, such as decision making, memory or attention. Emotions use components such as subjective, cultural, physiological and behavioral that individual's perception expresses with regard to the mental state, the body and how it interacts with the environment [5]. Classical Mathematics and signal processing techniques have played a major role in the development of speech recognition systems. The kernel of fractal geometry is the notion of self similarity. A self-similar object appears similar at different scales. The work by Pickover [7] is supposed to have been the first paper on the application of fractals in speech processing. Several research is on , since then in speech and emotion analyses using fractal dimension. The application of fractal geometry to speech signals and speech recognition systems is now receiving serious attention. A very important characteristic of fractals, useful for their description and classification is their fractal dimension *D*. The fractal dimension provides an objective means of quantifying the fractal property of an object and comparing objects observed in natural world. Fractals provide a simple description of many natural forms. Intuitively *D* measures the degree of irregularity over multiple scales. The application of fractal geometry depends on the accurate measurement of *D*, which is very much essential in fractal based speech recognition[1]. Speech recognition can generally be defined as the process of transforming continuous speech signals into a discrete representation. The problem of speech analysis is a deconvolution process where the components in convolution are to be separated. This paper focuses on applying a novel approach in the recognition of emotions conveyed through speech. Two schemes of analyses are adopted. The first scheme uses the property of Galois field that there is no round off error in obtaining the convolution and hence Fast Fourier Transform. Initially Galois field is constructed for various segments of the signal, which is the input to homomorphic filtering. The filtered signal is used to find Higuchi's Fractal Dimension(HFD). In the second scheme, the signal is filtered using median filter and then its HFD is evaluated. The rest of the paper is organized as follows: In section 2, the methodologies are presented. Section 3 presents the schemes of analyses, section 4 discusses the results and the last section gives the conclusions of the paper.

II. DESCRIPTION OF METHODS

The fractal dimension is one of the most commonly used measures to characterize the complexity of a system. Fractal Dimension of natural phenomena is only measurable using statistical approaches. For non-stationary waveforms such as speech waveforms, it is intelligible to segment the signal into various frames and then extract the information contained in each segment [3].

A. Higuchi's Fractal Dimension

When a time series changes its structure in time domain across a certain frequency it is difficult to determine the power law indices and a characteristic time scale from the power spectrum. Higuchi developed a technique which gives stable indices and time scale corresponding to a characteristic frequency even for a small number of data. Consider a finite set of time series observations taken at regular intervals: $X(1), X(2), X(3), \cdots X(N)$. From the given time series the following new time series $X_i(m)$ is constructed:

$$X_i(m): X(m), X(m+i), X(m+2i), \cdots X\left(m+\left\lfloor \frac{N-m}{i} \right\rfloor i\right), \text{ with } m = 1, 2 \ldots i \qquad (1)$$

Here $\lfloor \; \rfloor$ denotes Gauss' notation and both '*i*', '*m*' are integers. They represent the interval time and initial time respectively. For a time interval '*i*', a total of ' *i* ' new sets of time series are obtained. The series is so constructed that there are no overlaps. If ' *i* ' = 4 and *N* =100, the four time series obtained for Higuchi's[4] procedure is:

$$\begin{aligned} X_4^1 &: X(1), X(5), X(9), \cdots\cdots\cdots, X(97) \\ X_4^2 &: X(2), X(6), X(10), \cdots\cdots\cdots, X(98) \\ X_4^3 &: X(3), X(7), X(11), \cdots\cdots\cdots, X(99) \\ X_4^4 &: X(4), X(8), X(12), \cdots\cdots\cdots, X(100) \end{aligned} \qquad (2)$$

The length of the curve $X_i(m)$ is defined as follows:

$$L_m(i) = \left\{ \left(\sum_{l=1}^{\left\lfloor \frac{N-m}{i} \right\rfloor} \left| X(m+l\,i) - X(m+(l-1)\,i) \right| \right) * \frac{N-1}{\left\lfloor \frac{N-m}{i} \right\rfloor i} \right\} * \frac{1}{i} \qquad (3)$$

The term $\frac{N-1}{\left\lfloor \frac{N-m}{i} \right\rfloor i}$ represents the normalization factor for the curve length of subset time series. Let $\langle L(i) \rangle$ be the average value over '*i* ' sets of $L_m(i)$. If

$$\langle L(i) \rangle \;\alpha\; i^{-D} \qquad (4)$$

then the curve is fractal with the dimension *D*. Using the method of least squares a straight line is fitted. The maximum value of '*i*' is eight.

B. Galois Field

A finite field or Galois field must contain p^m elements, where p is prime and *m* is a positive integer[9]. The Galois field $GF(2^m)$ contains 2^m elements. $GF(2^m)$ is an extension field of $GF(2) = \{0,1\}$,with two elements. Arithmetic operations are performed by taking the results modulo 2. Non-zero elements of $GF(2^m)$ are generated by a primitive element α, where α is a root of the primitive irreducible polynomial $F(x) = x^m + f_{m-1}x^{m-1} + \cdots + f_1 x + f_0$, over $GF(2^m)$. The non-zero elements of $GF(2^m)$ can be represented in powers of α. i.e., $GF(2^m) = \{0, \alpha, \alpha^2, \ldots \alpha^{2m-2}, \alpha^{2m-1} = 1\}$. Since $F(\alpha) = 0$, $\alpha^m = f_{m-1}\alpha^{m-1} + \cdots + f_1\alpha + f_0$. The reason for positive sign is that the operation of subtraction is regarded as the inverse of addition. Therefore an element of $GF(2^m)$ can also be represented as a polynomial in α with degree less than *m*. i.e.,

$$GF(2^m) = \left\{ a_{m-1}\alpha^{m-1} + \ldots + a_1\alpha + a_0 \mid a_i \in GF(2), 0 \le i \le m-1 \right\}.$$

C. Homomorphic Filtering

A homomorphic filter is simply a homomorphic system having the property that the desired component in a signal passes unaltered through the system, while the undesired component is removed. An important aspect in the theory of homomorphic system is that any homomorphic system can be represented as a cascade of three systems. The first system takes inputs combined by convolution and transforms them into an additive combination of corresponding outputs . The second system is a conventional linear system obeying the principle of superposition[8]. The third system is the inverse of the first system i.e., it transforms the signals combined by addition back into signals combined by convolution. Homomorphic systems for convolution obey the principle of superposition, which for conventional linear system is given by

$$L(x(n)) = L(x_1(n)) + L(x_2(n))$$
$$L(ax(n)) = aL(x(n)) \qquad (5)$$

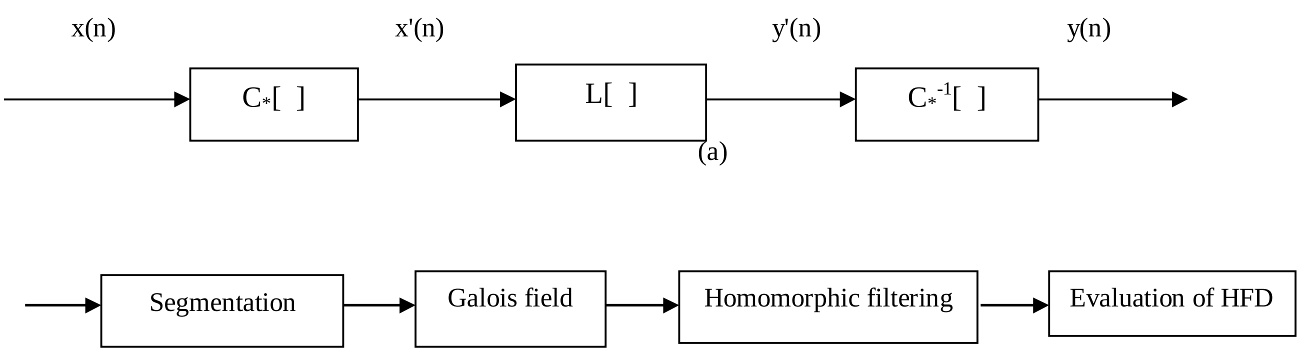
Homomorphism property can be stated as

$$\begin{aligned} H(x(n)) &= H(x_1(n) * x_2(n)) \\ &= H(x_1(n)) * H(x_2(n)) \end{aligned} \qquad (6)$$

III. SCHEMES OF ANALYSES

A. Galois Homomorphic Fractal Approach

We present below pictorially, the existing scheme for homomorphic deconvolution and the proposed scheme based on Galois fields. The proposed scheme is termed as Galois Homomorphic Fractal Approach(GHFA).



(b)

Fig.1 Scheme of analysis (a) existing (b) proposed

The scheme presented in Fig.1 (a), is as in [8]. C*[ ], C_*^{-1}[ ] are called the characteristic system for convolution and inverse characteristic system for convolution respectively and L represents a linear system. Figure 1(b) depicts the proposed scheme, where the input signal is first segmented. Construction of its Galois field is the next step, followed by homomorphic filtering. The final stage is evaluation of HFD.

B. Time Domain Analysis Using Hfd

The signal is filtered using a 10^{th} order median filter. Its HFD is then evaluated by segmenting the signal into various windows. Noise reduction algorithms aim to reduce noise while attempting to preserve the information content of the signal. Median filter is used here, as it is a superior noise reducing filter especially in the removal of isolated noise spikes [1].

The selected database consists of a male and female speaker both aged 31. Two emotion states, anger, happiness and a neutral state are chosen. Three texts common to the speakers are identified and used for analysis. A collective of 14 utterances are used[2].

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue IV, April 2018- Available at www.ijraset.com

IV. RESULTS AND DISCUSSION

Galois field with 2^6 elements viz $GF(2^6)$ is chosen for study. The primitive irreducible polynomial obtained for a specific segment of the signal is $F(x) = x^6 + x + 1$. $F(x)$ is used to generate the Galois field elements, corresponding to the appropriate segment. The result is taken as input to homomorphic filtering. The filtered result is the input to HFD. The value obtained for Text 1 in neutral mood is 1.9626, for Text 2 in angry mood is 2.04 and for Text 3 in angry mood is 2.002. As homomorphic filtering involves convolution and deconvolution, Galois Field which is capable of producing results with nil round off error is a sensible application. In the second scheme of analysis, fractal dimension for various segments ranges between 1 and 1.9. It is inferred from the analyses that voice of male is coarser in happy and angry moods than in neutral mood, which is the reverse for females. The values obtained in the former phase of analysis for a chosen fragment of the signal resemble the maximum values of HFD obtained in the latter scheme of analysis. Thus Fractal dimension demarcates major peaks. Higuchi's Fractal Dimension of male in happy mood is greater than in neutral mood. At the same time for female the value is less than in neutral mood. In case of angry mood, the Higuchi's Fractal Dimension of male is much greater than in neutral mood. But for female, when compared with angry mood, Higuchi's Fractal Dimension is higher for happy mood. In both male and female Higuchi's Fractal Dimension of neutral mood is less in comparison to the other moods, namely angry and happiness. It is also interesting to note that for male HFD is higher in angry mood and for female it is higher in happy mood (Table 1). This demonstrates that HFD is capable of differentiating emotions, which is a special case of speech. The original speech waveform for a text spoken by male in happy mood and the corresponding HFD values in various segments are presented in Figure.2, Figure.3 respectively.

Table 1 Higuchi's Fractal Dimension(HFD) Values*

		Male	Female
Text 1	Happy	1.151 ± 0.202	1.229 ± 0.238
	Neutral	1.110 ± 0.190	1.167 ± 0.220
Text 2	Happy	1.149 ± 0.208	1.162 ± 0.165
	Angry	1.149 ± 0.196	1.178 ± 0.224
	Neutral	1.103 ± 0.147	1.118 ± 0.167
Text 3	Happy	1.170 ± 0.266	1.181 ± 0.167
	Neutral	1.121 ± 0.215	1.161 ± 0.220

*expressed as mean ± standard deviation

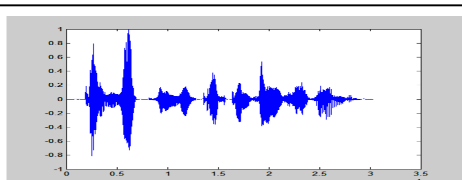


Fig.2 Actual waveform for a text spoken by male in happy mood

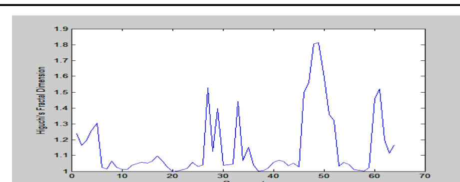


Fig.3 Higuchi's Fractal Dimension values of various segments for a text spoken by male in happy mood

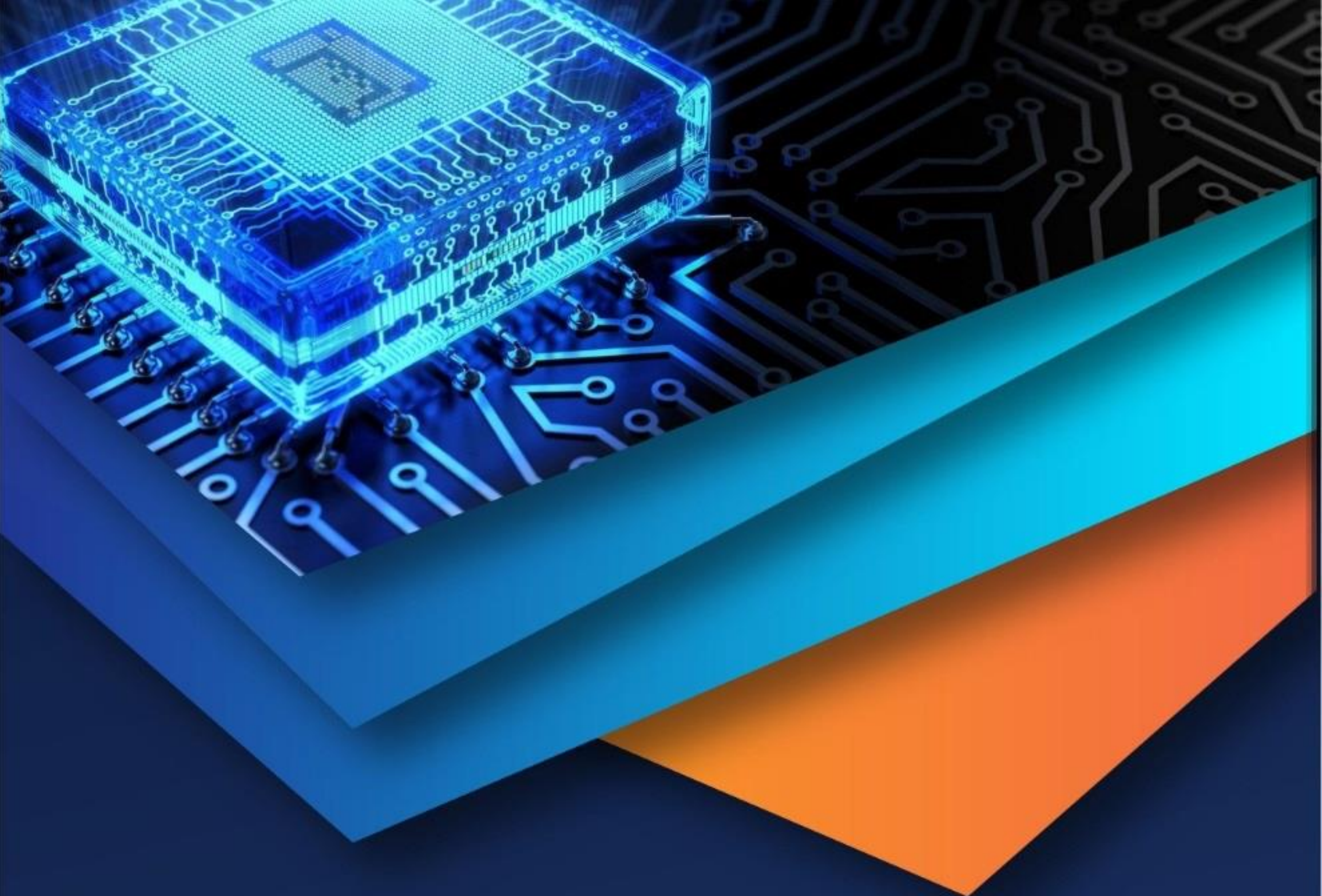
V. CONCLUSIONS

A novel approach based on finite field namely Galois field is employed in the fractal analysis of emotion recognition. Speech signals are finite by nature, which justifies the choice of Galois field. As the operations of addition and multiplication are based on 'modulo' in finite field, the input of Galois field elements to HFD is routed through homomorphic filtering. The process of constructing fast Fourier transform in homomorphic filtering resolves this issue. Value of *m* in Galois field construction may vary between 1 and 16. The results from GHFA suggest that it is a replica of the dominant characteristic of the signal considered. Signals of emotions carry erratic ups and downs. These are to be filtered properly for effective segmentation. Median filter is used in the second scheme of analysis, which is a superior noise reducing filter. The value of fractal dimension varies for each segment. It reflects on the complexity of the signal and also on the multi fractal nature of speech signal, in particular on signals of emotions. To compare the results obtained in the first phase of analysis, window size has been chosen as 2^6. This may be varied, which might yield different fractal dimension value. However this would not much affect the inferences of the work. Future work may be aimed at using different values of *m* in the Galois field construction to excavate more intrinsic details of emotions.

REFERENCES

[1] Al-Akaidi, M. (2004), Fractal speech processing, Cambridge University Press
[2] Burkhardt, F., Paeschke, A., Rolfes, M., Sendlmeier, W. F., & Weiss, B. A database of German emotional speech, in Interspeech, 5, 2005, September,m1517-1520
[3] Ezeiza, A., de Ipiña, K. L., Hernández, C., et.al., Enhancing the feature extraction process for automatic speech recognition with fractal dimensions, Cognitive Computation, 5(4), (2013), 545-550
[4] Higuchi, T. Approach to an irregular time series on the basis of the fractal theory, Physica D: Nonlinear Phenomena, 31(2), (1988),277-283
[5] López-de-Ipiña, K., Alonso, J. B., Travieso, C. M., et.al., On the selection of non-invasive methods based on speech analysis oriented to automatic Alzheimer disease diagnosis, Sensors, 13(5), (2013),6730-6745
[6] V. A. Emotion recognition in speech signal: experimental study, development, and application, Studies, 3, (2000):4
[7] Pickover, C. A., and Khorasani, A. L. Fractal characterization of speech waveform graphs, Computers and graphics, 10 (1), (1986), 51-61
[8] Rabiner, L. R., and Schafer R.W. (1978), Digital processing of speech signals. Prentice Hall
[9] Yeh, C. S., Reed, I. S., and Truong, T. K. Systolic multipliers for finite fields GF (2^m). IEEE Transactions on Computers, 100(4), 1984, 357-360.

3027



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY