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Novel TDOA Technique for Speaker Localization using MATLAB

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Abstract: Source localization has always been a challenging problem wherein the main focus is to give an estimate about the coordinates of different sound sources that generates a signal which is then received by a pair of microphones. In this process we have considered a Time Delay of Arrival based source localization which uses a wireless sensor network. In this we show that the association ambiguity of TDOAs can be effectively resolved using the concept of an inverse delay interval region (IDIR). — Multiple source localization (MSL) using time differences of arrival (TDOAs) is challenging because of the ambiguity involved in associating the TDOAs computed across microphone pairs to the sources.

We show that the association ambiguity of TDOAs can be effectively resolved using the concept of an inverse delay interval region (IDIR), which we introduce in this paper.

By examining the association between a spatial domain and the TDOAs, we define IDIR as an inter-hyper boloidal spatial region corresponding to an interval of delays for a given pair of microphones. The proposed system for localizing multiple sources of sound involves two stages that is in the first stage, the given waves is partitioned into non-overlapping elemental regions and which contains a source are then detected by measure based on the generalized cross-correlation with phase transform (GCC-PHAT), and the IDIRs. In the second stage, we see that the sources are finely localized within each of the detected regions by identifying .

Keywords: Time delay of arrival(TDOA), Inverse delay interval region(IDIR), MATLAB, Generalized cross-correlation with phase transform (GCC-PHAT),SSL(Single Source Localization), Room Impulse Response (RIR), Localization.

I. INTRODUCTION

Of the several research efforts that have been directed towards single source localization, a significant number are based on estimating the time differences of arrival (TDOAs) between pairs of microphones. TDOA based SSL is attractive because it offers an elegant geometric interpretation and is computationally inexpensive.

By examining the association between a spatial domain and the TDOAs, we define IDIR as an inter-hyperboloidal spatial region corresponding to an interval of delays for a given pair of microphones. The proposed scheme for localizing multiple sources involves two stages.

In the first stage, the given enclosure is partitioned into non-overlapping elemental regions and the ones that contain a source are detected using a measure based on the generalized cross-correlation with phase transform (GCC-PHAT), and the IDIRs.

In the second stage, the sources are finely localized within each of the detected elemental regions by identifying IDIR containing a single source and an oval region-constrained localization approach. Lathoud et al. proposed a method to detect sources within sector-like regions using beam-steering.

They calculate the steered response power and carry out coarse identification of potential source regions. In the second pass, they repeat the procedure with a narrower beam to perform fine localization. Using SRP in the fine localization stage is computationally expensive as shown in.

Brutti et al. compute a spatial acoustic map called the global coherence field (GCF), starting from the generalized cross-correlation with phase transform (GCC-PHAT) functions of several distributed pairs of microphones. The strongest GCF peak is associated with a source. Subsequently, a de-emphasis is applied to each GCC-PHAT function and the GCF is recomputed, and the peak now corresponds to the next source. Brutti et al. showed that the approach becomes less reliable when there are more than two sources.

II. LITERATURE SURVEY[1-49]

Sl No.	Title of the Paper	Authors	Month & Year	Observations
1	Speaker localization using the TDOA-based feature matrix for a humanoid robot	Ui-Hyun Kim , Jinsung Kim, Doik Kim	15 August 2008	In this paper, we report on a speaker localization system with six microphones for a humanoid robot called MAHRU of KIST and propose a time delay of arrival (TDOA)-based feature matrix
2	An improved combination of Directional BSS and a source localizer for robust source separation in rapidly time-varying acoustic scenarios	Anthony Lombard, Yuanhang Zheng, Herbert Buchne	07 July 2011	A variety of successful ICA (Independent Component Analysis) methods have been developed for dealing with gradually moving sources
3	Localization of multiple simultaneously active sources in acoustic sensor networks using ADP	Andreas Brendel, Walter Kellermann	10-13 Dec. 2017	In this context direction of arrival (DOA) estimation is an important step for many signal processing applications, like speaker position estimation and tracking
4	Multi-source localization based on approximated kernel density estimator and spatial likelihood function in near-field reverberant environment	Yu-Zhuo Fang, Xu Zhi-Yong, Zhao Zhao	09 February 2017	In order to cope with the multi-source localization in near-field reverberant environment, approximated kernel density estimator (KDE) algorithm is introduced
5	A learning-based approach to direction of arrival estimation in noisy and reverberant environments	Xiong Xiao , Shengkui Zhao	06 August 2015	Used extract features from the generalised cross correlation (GCC) vectors and use a multilayer perceptron neural network to learn the nonlinear mapping from such features to the DOA
6	A neural network based algorithm for speaker localization in a multi-room environment	Fabio Vesperini, Paolo Vecchiotti	10 November 2016	The approach is fully data-driven and employs a Neural Network fed by GCC-PHAT Patterns, calculated by means of the microphone signals, to determine the speaker position in the room under analysis
7	A real-life experimental study on semi-supervised source localization based on manifold regularization	Bracha Laufer-Goldshtein, Ronen Talmon	05 January 2017	The idea is to estimate the function that maps each relative transfer function (RTF) to its corresponding position
8	Semi-Supervised Source Localization on Multiple Manifolds With Distributed Microphones	Bracha Laufer-Goldshtein, Ronen Talmon	24 April 2017	Introduction Acoustic source localization is an essential component in various audio applications, such as automated camera steering and teleconferencing systems ,speaker separation and robot audition
9	Multitask Learning of Time-Frequency CNN for Sound Source Localization	Hong Liu, Xiaofei Li	18 March 2019	In this paper, a novel binaural SSL method based on time–frequency convolutional neural network (TF-CNN) with multitask learning is proposed to simultaneously localize azimuth and elevation under unknown acoustic conditions
10	Coherent SVR Learning for Wideband Direction-of-Arrival Estimation	Zhi-Tao Huang	25 February 2019	In this letter, we propose a coherent support vector regression (SVR) scheme to address the wideband direction of arrival (DOA) estimation problem
11	Detection Sound Source Direction in 3D Space Using Convolutional Neural Networks	Xiao Yue, Guangzhi Qu	14 March 2019	In this work, we propose to use convolutional neural networks to detect the sound source direction in a 3D space. This algorithm is based on the generalized cross correlation method with phase transform (GCC-PHAT)

12	Multi-Channel Overlapped Speech Recognition with Location Guided Speech Extraction Network	Zhuo Chen, Xiong Xiao, Jinyu Li	14 February 2019	In this work, we propose a simple yet effective method for multi-channel far-field overlapped speech recognition.
13	Direction-of-Arrival Estimation Based on Deep Neural Networks With Robustness to Array Imperfections	Zhang-Meng Liu, Chenwei Zhang	08 October 2018	The framework consists of a multitask autoencoder and a series of parallel multilayer classifiers.
14	Direction of Arrival Estimation of Acoustic Echoes Using Source Elimination Method	Marc-André Guérard, Dominic Grenier	28 September 2017	The source elimination method (SEM), based on the elimination of the contribution of each source to improve the DOA estimation, is developed
15	Direction of Arrival Estimation with Microphone Arrays Using SRP-PHAT and Neural Networks	David Diaz-Guerra, Jose R. Beltran	30 August 2018	we propose the use of Neural Networks (NN) to obtain the DOA as a regression problem from a low resolution SRP-PHAT power map.
16	CRNN-based Joint Azimuth and Elevation Localization with the Ambisonics Intensity Vector	Lauréline Perotin, Romain Serizel	05 November 2018	We propose to use as input to the CRNN the FOA acoustic intensity vector, which is easy to compute and closely linked to the sound direction of arrival (DoA)
17	Speaker localization using stereo-based sound source localization	Halim Sayoud, Siham Ouamour	27 June 2011	In this approach, two-channel-based (stereo) estimation of the speaker position is achieved by comparing the signals received by two cardioids microphones that are placed the one against the other and separated by a fixed distance.
18	A high performance sound source localization system based on macro-pipelined architecture	Qing Sun, Yuzhuo Fu, Wenqi Bao	25-28 Oct. 2011	This paper presents a novel macro-pipelined sound source localization system . The system employs a small 4-microphone array and uses the time-delay estimation method.
19	Tracking an unknown time-varying number of speakers using TDOA measurements	Wing-Kin Ma , Ba-Ngu Vo	21 August 2006	In this paper, we focus on a more realistic assumption that the number of active speakers is unknown and time-varying. Such an assumption results in a more complex localization problem, and we employ the random finite set (RFS) theory to deal with that problem
20	Multiple acoustic sources localization using incident Signal Power comparison	Daniele Salvati, Antonio Rodà	26 September 2011	This approach aims at finding a solution to the ambiguities in Direction Of Arrivals (DOAs) combination caused by simultaneous multiple sources.

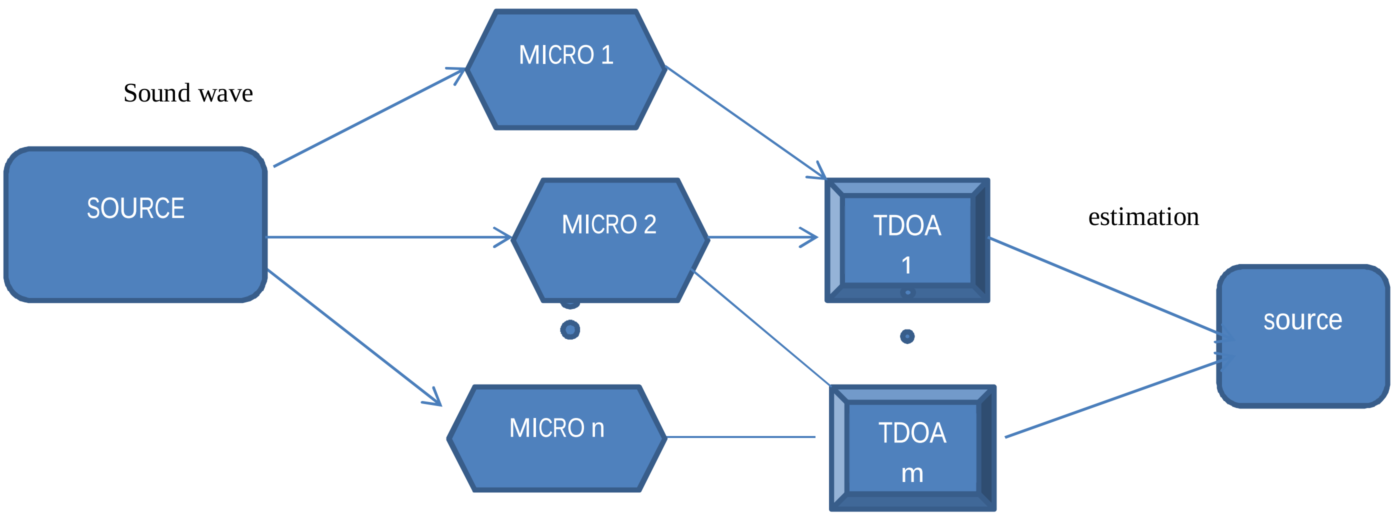
A. Problem Statement

This definition is applied for a probabilistic interpretation as mutually exclusive IDIRs correspond to mutually exclusive delay-intervals. Thereafter, all standard probabilistic rules apply. In many of the methodology that is being proposed in other papers shows the use of neural netwoks, Direction of arrival(DOAs), RFS theory, SRP-PHAT and also time–frequency convolutional neural network. In many of these methodology basically deals with the approach of sound interacts with the device and the use of these approach to visualize them.

B. Objective of Proposed Work

Multi-speaker localization methods using voice signal are proposed. Sound source localization systems consisting of many microphones have been widely researched. In our laboratory, we have researched sound source localization of persons based on TDOA (Time Difference of Arrival) between distributed microphones for the purpose of efficient use of air conditioner and lighting in the office . Localization systems based on sound such as footsteps or voice are superior to those based on image data in terms of privacy-consciousness and utility in the dark. As sound source localization methods, beamforming, subspace methods and TDOA-based methods are widely used. CSP (Cross-power Spectrum Phase) analysis is one of the most famous method to estimate TDOA.

C. Proposed Work Flow



As seen in the block diagram, the signal sent by the source (speaker) is received by the microphones. It is then checked for synchrony on each of the pairs of microphones. For this purpose cross-correlation methods are used which gives an estimation of the time differences between the signals. One of the most commonly used cross-correlation methods is generalized cross-correlation with phase transform (GCC-PHAT).

The dataset for the project is obtained through the use of a Room Impulse Response (RIR) generator. With this, it is possible to simulate a room with a set of of desired characteristic for the experiment. RIR generators help in coming up with a set of desired attributes for the localization problem, such as the number of microphones, sources, the distance between the sources and microphones etc.

In this project the source location is found in two steps. In the first step, an indicator is obtained which gives a region in which the source can be lying based on some probabilistic measure. This kind of a likelihood estimation is going to give rise to a coarse acoustic map. In the second step, the system refines the localization estimate in the previously obtained active spatial regions.

III. METHODOLOGY

Localization of source from the audio signal is a challenging problem where the goal of the system is to estimate the coordinates of a speaker with the help of an array of microphones. Many of the most effective techniques for the speaker localization are based on the Time Difference of Arrival estimates (TDOAs).

The key advantages of using TDOA are its elegant geometric interpretation and computationally inexpensive implementations. To perform a localization in 2D, a minimum of 3 microphones is needed. For localization in 3D, 4 microphones are necessary. For single source localizations, time difference of arrival for each pair of microphone is computed.

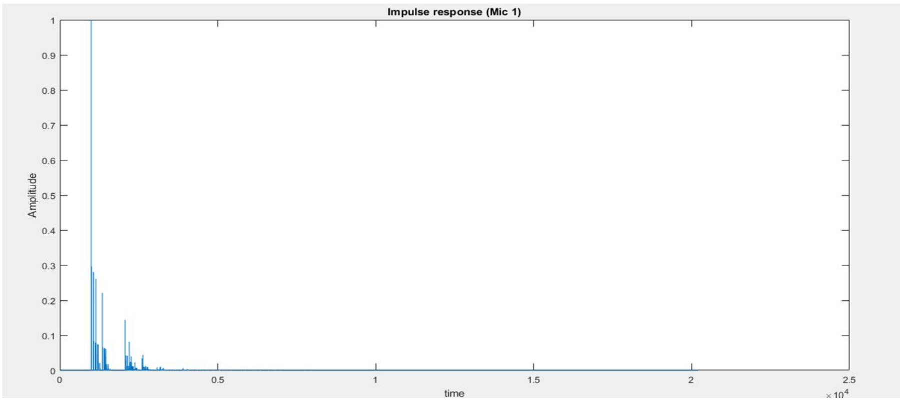
The mapping between source location and the TDOAs are represented by a quadratic equation describing a hyperbolic branch. Intersection of such hyperbolic branches is going to yield the source location. This involves solving a system of nonlinear equations.

IV. RESULT AND DISCUSSION

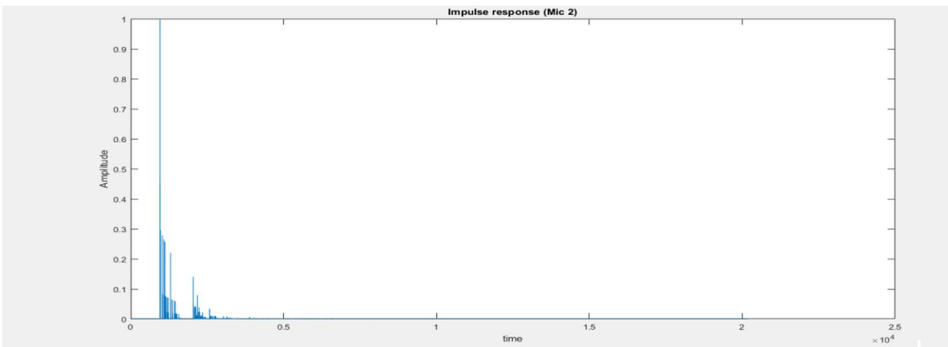
```
clear all;
close all;
fs= 16000;
mic1= [19 2 1.6];
mic2= [18 2.1 1.6];
n=12;
r=0.3;
rm=[20 19 21
```

```
src=[5 18 1.6];
nsrc=1;
d = norm(mic1-mic2);
h1= rir(fs, mic1, n, r, rm, src);
h2= rir(fs, mic2, n, r, rm, src);
figure; plot(h1); xlabel('time'); ylabel('Amplitude');
title('Impulse response (Mic 1)');
figure; plot(h2); xlabel('time'); ylabel('Amplitude');
title('Impulse response (Mic 2)');
[x, Fs1] = audioread('female.wav');
y1 = conv(x,h1);
y2 = conv(x,h2);
y=[y1(1:200000) y2(1:200000)];
 [estimated_tau_gcc_nonlinear, spec_gcc_nonlinear] = bss_locate_spec(y, fs, d, nsrc, ...
                                          'GCC-NONLIN','max');
actual_tau = (norm(src-mic2) - norm(src-mic1))/343;
display(actual_tau);
display(estimated_tau_gcc_nonlinear);
 [estimated_tau_gcc_phat, spec_gcc_phat] = bss_locate_spec(y, fs, d, nsrc, ...
                                          'GCC-PHAT','max');
display(estimated_tau_gcc_phat);
```

A. Screen Shots



The wave generated with respect to the audio that is being given. A particular graph is generated from the given amplitude and time which shows the impulse response that is received in micropone 1



Here, another impulse is generated with respect to the surrounding sound. The response is take by another set of microphone.

V. CONCLUSION

In this we have developed a two-stage approach for localizing multiple sources using TDOA technique. First stage involves performing a coarse localization of the source which lie in a certain elemental regions and in the second stage, we perform fine localization in the active regions. In future the work mainly would be to derive bounds on the number of microphones that is required to approximate specific convex regions using random configurations of microphone arrays, and to explore the theoretical limits of the approximation for non-convex regions.

REFERENCE

[1] Y. Huang, J. Benesty, and G. W. Elko, "Passive acoustic source localization for video camera steering," in Proc. IEEE Intl. Conf. Acoust Speech and Signal Process., vol. 2, 2000, pp. 909–912.

[2] M. S. Brand stein and H. Silverman, "A practical methodology for speech source localization with microphone arrays," Comp. Speech and Lang., vol. 11, no. 2, pp. 91–126, 1997.

[3] A. Canclini, F. Antonacci , A. Sarti , and S. Tubaro, "Acoustic source localization with distributed asynchronous microphone networks," IEEE/ACM Trans. Audio, Speech, and Lang. Process., vol. 21, no. 2, pp. 439–443, Feb. 2013.

[4] Y. T. Chan and K. C. Ho, "A simple and efficient estimator for hyperbolic location," IEEE Trans. Signal Process., vol. 42, no. 8, pp. 1905–1915, 1994. Shwetak N. Patel , Location in Pervasive Computing, University of Washington. http://www.ekahau.com/

[5] J. H. DiBiase, "A high-accuracy, low-latency technique for talker localization in reverberant environments using microphone arrays," Ph.D. dissertation, Brown Univ., 2000.

[6] J. Dmochowski, J. Benesty, and S. Affes, "Direction of arrival estimation using the parameterized spatial correlation matrix," IEEE Trans. Audio, Speech, and Lang. Process.,, vol. 15, no. 4, pp. 1327 – 1339, May 2007.

[7] Dr. Mohan Kumar S & Dr. Balakrishnan, Classification Of Breast Mass Classification – CAD System And Performance Evaluation Using SSNE, IJISET – International Journal of Innovative Science, Engineering & Technology, Vol. 2, Issue 9, 417-425, ISSN 2348 – 7968

[8] Dr. Mohan Kumar S, Dr. Balakrishnan, Classification Of Breast Mass Classification – CAD System With Performance Evaluation, International Journal of Engineering And Computer Science, Volume 4, Issue 09, 14187-14193, ISSN 2319-7242, September, 2015

[9] Dr. Mohan Kumar S, Dr. Balakrishnan, Classification Of Breast Microcalcification- CAD System And Performance Evaluation Using SSNE, International Journal of Advanced Research in Computer Science and Software Engineering, Volume 5 , Issue 9, 824-830, ISSN: 2277 128X, Sep- 2015

[10] Dr. Mohan Kumar S, Karthikayini, Essential Best Practices And Processes In Higher Educational Technical Institutions, International Journal Of Engineering Research And General Science, Volume 3, Issue 6, 231-236, ISSN 2091-2730 231, December, 2015

[11] Dr. Mohan Kumar S, Karthikayini, LNW-A System Model For A High Quality Effective E-Learning Using Cloud Environs, International Journal of Current Research and Review, Volume 7, Issue 23, 21-25, ISSN: 0975-5241, December, 2015

[12] Dr. Mohan Kumar S, Ayurveda Medicine Roles In Healthcare Medicine, And Ayurveda Towards Ayurinformatics, International Journal of Computer Science and Mobile Computing, Volume 4, Issue 12, 35-43, ISSN 2320-088X, December, 2015

[13] Dr. Mohan Kumar S, Muralidhara, Importance Of Accreditation And Autonomous Status In HEI – An Assessment With Special Orientation To Karnataka State, International Journal of Engineering Sciences & Research Technology, Volume 5, , Issue 1, 472-479, ISSN : 2277-9655, January, 2016

[14] Dr. Mohan Kumar S , Interrelated Research Works And Importance Of Object Oriented Analysis And Modeling, International Journal of Engineering Sciences & Research Technology, Volume 5, Issue 1, Page Numbers:59-62, ISSN : 2277-9655, January, 2016

[15] Dr.S Mohan Kumar, R.Jaya, A Survey On Medical Data Mining – Health Care Related Research And Challenges, International Journal of Current Research, Volume 8, Issue 01, Page Numbers; 25170-25173, ISSN:0975-833X, January, 2016

[16] R.Jaya, Dr S Mohan Kumar, A Study On Data Mining Techniques, Methods, Tools And Applications In Various Industries, International Journal of Current Research & Review, Volume 8, Issue 04, Page Numbers:35-43, ISSN:0975-5241, January, 2016

[17] Clara K, Dr S Mohan Kumar, Cyber Crime Varient Activities And Network Forensic Investigation, International Journal of Emerging Technology and Advanced Engineering, Volume 6, Issue 04, Page Numbers: April 2016, ISSN:2250-2459, March, 2016,

[18] Clara.K, Dr S Mohan Kumar,Exploratory Study Of Cyber Crimes, Digital Forensics And Its Tools, International Journal of Emerging Technology and Advanced Engineering, Volume 6, Issue 04, Page Numbers: April 2016, ISSN:2250-2459, March, 2016

[19] Revathi Y, Dr S Mohan Kumar, Efficient Implementation Using RM Method For Detecting Sensitive Data Leakage In Public Network International Journal of Modern Trends in Engineering and Research, Volume 3, Issue 04, Page Numbers: 515-518, ISSN (Online):2349–9745 ISSN (Print):2393-8161 , April, 2016

[20] Revathi Y , Dr S Mohan Kumar, Review On Importance And Advancement In Detecting Sensitive Data Leakage In Public Network, International Journal Of Engineering Research And General Science, Volume 4, Issue 02, Page Numbers:263-265, ISSN:2091-2730, April, 2016

[21] Revathi Y, Dr S Mohan Kumar, A Survey On Detecting The Leakage Of Sensitive Data In Public Network International Journal of Emerging Technology and Advanced Engineering, Volume 6, Issue 03, Page Numbers:234-236, January, 2016

[22] Mr.Dilish Babu.J, Dr.S Mohan Kumar, A Survey On Secure Communication In Public Network During Disaster , IJESRT -International Journal Of Engineering Sciences & Research Technology, Volume 5, Issue 3, Page Numbers:430-434, ISSN: 2277-9655, March 2016

[23] Mr.Dilish Babu.J, Dr.S Mohan Kumar, Survey On Routing Algorithms During Emergency Crisis Based On MANET, IJETAE, International Journal of Emerging Technology and Advanced Engineering, Volume 6, Issue 3, Page Numbers: 278-281, ISSN: 2250–2459, Mar-16

[24] Mr.Dilish Babu.J, Dr.S Mohan Kumar, Emergency Communication Sysytem For Natural Disaster Using MANET, IJRDO, International Journal of Research and Development Organization, Volume 2, Issue 5, Page Numbers:01 to 10, ISSN:2456-1843, May, 2016

[25] Ms.Sulochana Panigrahi, Dr S Mohan Kumar, Social Data Analysis Using Big-Data Analytic Technologies- Apache Flume, HDFS, HIVE, IJRDO, International Journal of Research and Development Organization, Volume 2, Issue 5, Page Numbers:16 to 21, ISSN:2456-1843, May, 2016

[26] Ms.Sulochana Panigrahi, Dr S Mohan Kumar, Social Media Analysis Using Apache Flume, Hdfs, Hive, International Journal of Current Trends in Engineering & Technology, Volume 2, , Issue 2, Page Numbers:282 to 285, ISSN:2395-3152, March, 2016

[27] Dr. V. ILANGO and Dr. S. Mohan Kumar, Factors For Improving The Research Publicatons And Quality Metrics International Journal of Civil Engineering & Technology (IJCIET) ISSN 0976-6308 and 0976-6316(Print&Online) Volume 8, Issue 4, 04-17,

[28] Naga Raju Hari Manikyam and Dr. S .Mohan Kumar, Methods And Techniques To Deal With Big Data Analytics And Challenges In Cloud Computing Environment, International Journal of Civil Engineering & Technology (IJCIET), ISSN 0976-6308 and 0976-6316(Print&Online), Volume 8, Issue 4, 04-17,

[29] V Karthik, Dr.S . Mohan Kumar and Ms. Karthikayini, A Novel Survey On Location Based Node Detection And Identifying The Malicious Activity Of Nodes In Sensor Networks International Journal of Civil Engineering & Technology, (IJCIET), ISSN 0976-6367 and 0976-6375(Print & Online), Volume 8,

[30] Karthik V, Ms.Karthikayini, Dr S Mohan Kumar, Ms Gayathri T, Geocentric Based Node Detection And Revoking Malicious Node In WSN, International Journal for Science and Advance Research in Technology (IJSART), ISSN 2395-1052 (Print&Online), Volume 3, Issue 4, 04-17
[31] Dr.S. Mohan Kumar and Dr G. Balakrishnan, Wavelet And Symmetric Stochastic Neighbor Embedding Based Computer Aided Analysis For Breast Cancer, Indian Journal of Science and Technology ISSN 0974-6846 and 0974-5645(Print&Online), Volume 9, Issue 47, 12-16
[32] Sruthi Hiremath, Sheba Pari N and Dr.S. Mohan Kumar, Booster in High Dimensional Data Classification, (DOI: 10.15680/IJIRCCE.2017. 0503349), International Journal of Innovative Research in Computer and Communication Engineering, Vol. 5, Issue 3, March 2017, 5984-5989.
[33] Dr S. Mohan Kumar & Dr.T.Kumanan, Skin Lesion Classification System and Dermoscopic Feature Analysis for Melanoma Recognition and Prevention, IJETAE, International Journal of Emerging Technology and Advanced Engineering, ISSN: 2250–2459 and Volume 7, Issue 7, July 2017,
[34] Dr S. Mohan Kumar & DrJitendranathMungara, J. Karthikayini, Design and implementation of CNN for detecting Melanoma through image processing, International Journal for Research in Applied Science and Engineering Technology, ISSN : 2321 – 9653, Volume 6, Issue - 3, March – 2018 in (DOI : 10.22214) pp. No.: 2249-2253
[35] Dr S. Mohan Kumar & J. Karthikayini, Surveys on Detection of Melanoma through image processing Techniques, International Journal for Research in applied science and Engineering Technology (IJRASET), ISSN : 2321 – 9653, volume 6, Issue III, March 2018 in IJRASET, DOI: 10.22214, pp. no.: 1699-1704
[36] Dr S. Mohan Kumar, Automated Segmentation of retinal images, International Journal of Engineering and Technology, UAE, July 2018, International Journal of Engineering and Technology, UAE
[37] Dr. S. Mohan Kumar & Anisha Rebinth, Automated detection of Retinal Defects using image mining, A review, European Journal of Biomedical and Pharmatical Sciences, European ISSN : 2349 – 8870, Volume 5 , Issue : 01 year : 2018, pp No.: 189 – 194
[38] Dr. S. Mohan Kumar& Dr.T.Kumanan, Analysis on skin Lesion classification systems and Dermoscopic Feature Analysis for Melanoma International Journal for Research in Applied Science and Engineering Technology (IJRASET), ISSN : 2321 – 9653, Volume 6, Issue - 3, March – 2018 in (DOI : 10.22214), pp. no.:1971-78
[39] Dr. S. Mohan Kumar & Dr.T.Kumanan, Study on skin Lesion Classifications system and Dermoscopic Feature Analysis for Melanoma, International journal of Creative Research Thoughts (IJCRT), IJCRT1802680, ISSN : 2320 – 2882, Volume 6, issue-1, March 2018, Page No . 1863 – 1873
[40] Dr. S. Mohan Kumar & Dr.T.Kumanan, Classification System and Dermoscopic Features Analysis for Melanoma recognition and Prevention, International journal of Creative Research Thoughts (IJCRT), IJCRT1802680, ISSN : 2250 – 2459 , Volume 7 , Issue 8, August 2017 , pp no: 351 – 357
[41] Dr. S. Mohan Kumar& Darpan Majumder, Healthcare Solution based on Machine Learning Applications in IOT and Edge Computing, International Journal of Pure and Applied Mathematics, ISSN: 1311-8080 (printed version) ISSN: 1314-3395 (on-line version) Jul 2018 issue.
[42] Dr. S. Mohan Kumar, Ashika.A, A Survey on Big Data Analysis, Approaches and its Applications in the real World, Journal of Emerging Technologies and Innovative Research, ISSN: 2349-5162, May 2018 , Volume 5, Issue 5, pp. no.: 93-100
[43] Shreya R, Sri Lakshmi Chandru, Vivek Kumar, Shwetha M, Dr. S. Mohan Kumar, Classification of Skin Cancer through image processing and implementating CAD System International journal of Creative Research Thoughts (IJCRT)IJCRT1802680m, ISSN : 2320 – 2882, Volume 6, issue-2 , April 2018 Page No . 1863 – 1873
[44] S Mohan Kumar & Dr. Balakrishnan, Statistical Features Based Classification of Micro calcification in Digital Mammogram using Stocastic Neighbour Embedding, International Journal of Advanced Information Science and Technology, 2012, ISSN:2319-2682 Volume 07, Issue 07 , November 2012, Page Numbers: 20-26
[45] S Mohan Kumar & Dr. Balakrishnan ,Breast Cancer Diagnostic system based on Discrete Wavelet Transformation and stochastic neighbour Embedding, European Journal of Scientific Research, 2012, ISSN:1450-216X ,Volume 87, Issue 03 , October 2012, Page Numbers: 301-310
[46] S Mohan Kumar & Dr. Balakrishnan, Classification of Microclacification in digital mammogram using SNE and KNN classifier, International Journal of Computer Applications - Conference Proceedings published in IJCA, 2013 ISBN: 973-93-80872-00-6, ICETT proceedings with IJCA on January 03,2013, Page Numbers: 05-09
[47] S Mohan Kumar & Dr. Balakrishnan, Mutiresolution analysis for mass classification in Digital Mammogram using SNE, IEEE international Conference-ICCSP-13 organized by Athiparasakthi Engineering College, Chennai , 2013, ISBN:978-1-4673-4864-5, Page Numbers: 2041-2045.
[48] S Mohan Kumar & Dr. Balakrishnan, Categorization of Benign And Malignant Digital Mammograms Using Mass Classification – SNE and DWT, Karpagam Journal of Computer Science, 2013, ISSN No: 0973-2926, Volume-07, Issue-04, June-July-2013, Numbers: 237-243.
[49] S Mohan Kumar & Dr. Balakrishnan, Classification of Micro Calcification And Categorization Of Breast Abnormalities - Benign and Malignant In Digital Mammograms Using SNE And DWT, Karpagam Journal of Computer Science 2013, ISSN No: 0973-2926, Volume-07, Issue-05, July-Aug, 2013. Page Numbers: 253 to 259
[50] S Mohan Kumar & Dr. Balakrishnan, The Performance Evaluation of the Breast Mass classification CAD System Based on DWT, SNE AND SVM , International Journal of Emerging Technology and Advanced Engineering, 2013, ISSN 2250–2459, Volume 3, Issue 10, October 2013, Page Numbers: 581-587
[51] S Mohan Kumar & Dr. Balakrishnan ,The Performance Evaluation of the Breast Microcalcification CAD System Based on DWT, SNE AND SVM, CiiT International Journal of [49] Digital Image Processing, 2013, Print: ISSN 0974 – 9691 & Online: ISSN 0974 – 9586, Issue-November 2013, Page Numbers / DOI: DIP112013005.