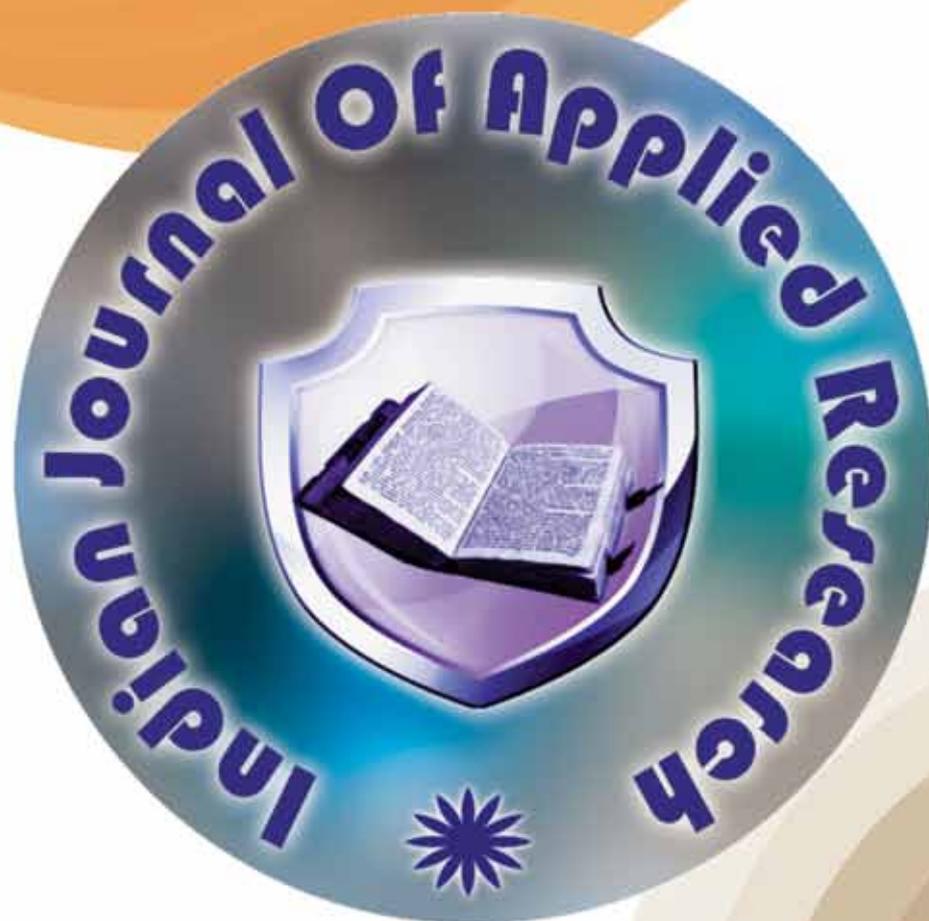


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INDEX

Sr. No.	Title	Author	Subject	Page No.
1	Impact of Liquid biofertilizers, Chemical fertilizers and Vermicompost on the Growth and Yield of <i>Chenopodium album</i> (L.)	Dr. Sivgami Srinivasan, A. Sabitha	Biochemistry	1-3
2	Production Of Biodiesel From Microalgae Using Sodium Methoxide	M. R. Ananadhi Padmanabhan, Dr. Shaleesha A.Stanley	Biotechnology	4-6
3	Profitability Analysis Of Bharath Sanchar Nigam Limited (Bsnl)	Dr. M.Dhanabhakyaam, Swapna Kurain	Commerce	7-9
4	Water Resource Management Through Community Initiatives	Dr. Mahalaxmi Krishnan	Commerce	10-11
5	IPO Grading – An Insight	Dr. Bheemanagouda	Commerce	12-14
6	Public Private Partnership (PPP) in West Bengal: A Study	Suvarun Goswami	Commerce	15-17
7	Factors Influencing Impulse Buying of Personal Care Products in Salem City	Dr. A. Vinayagamoorthy, P. kannan	Commerce	18-21
8	Employees Savings and Investment Behaviour of Selected Chemical Industries in Cuddalore District	Dr. G. Sasikumar, R. Punniyaseelan	Commerce	22-28
9	Object Oriented Mutation Applied to Java platform and C++ classes	Ravindra K. Gupta, Dr. Shailendra Singh, Titu Singh Arora	Computer Science	29-32
10	Estimating The Intravenous Fluid Resuscitation In Patients In The Intensive Care Units (A Fuzzy Logic Based Expert Advisory System)	Kamal Kumari Dadhirao, M. Surendra Prasad Babu, Mr. Suresh Kumar Maddila	Computer Science	33-36
11	An Evaluation of Women Construction Workers	T. Christy Chanchu, T. Christy Cresida	Economics	37-39
12	Carlson's Tropic State Index(CTSI) Used in Mandya Lakes	Nagarathna, Hosmani S P	Economics	40-42
13	A water pollution of metropolitan cities in India	Dr. Pawar A.S.	Economics	43-44
14	Urbanization & Pollution in India	Dr. Pawar Ashok Shankarrao	Economics	45-46
15	Motivational Strategies on Enhancing Competencies of LIC Professionals	Dr. K. Gunasekaran	Education	47-49
16	Awareness On Socio - Educational Rights Among Students Studying in Secondary School	Dr. A. Selvan, Dr. P. Paul Devanesan	Education	50-52
17	Major Approaches in Instilling Values Related to Human Rights	Dr. A. Selvan, P. Paul Devanesan	Education	53-54
18	A Study On Achievement In Mathematics of IXth Standard Students in Relation to Locus of Control and Test Anxiety	Dr. N .Rajashekara, Prathima .H.P, Narayana Swamy.Y.R	Education	55-58
19	Impact of value-orientation on Leadership Behaviour of Secondary School Teachers in Tumkur District	Dr. Umme kulsum, G.P.Nagaraja	Education	59-62
20	Performance Comparison between LMS and NLMS Algorithm	Baljit Kaur	Engineering	63-65
21	Overview of Speech Enhancement Techniques for Various Applications	N B Umashankar, Anand Jatti	Engineering	66-67

22	Hanford and Radioactive Tumbleweeds: A Case Study	Rajesh Gopinath	Engineering	68-69
23	Construction of a Knowledge Test for Tennis Players	Sanjay Singh, Sani Kumar Verma	Engineering	70-72
24	A Noval Switch Mode Power Supply for Flash Lamp Pumped Nd: Yag Laser	Kireet Semwal, S. C. Bhatt	Engineering	73-75
25	Uniform Price Electricity Market Model in Deregulated Power System	T. Nireekshana, Dr. G. Kesava Rao, Dr. S. Siva Naga Raju	Engineering	76-79
26	Effect of Notch Orientation, Temperature and Filler Material on Impact Toughness of GFRP Composites	M.C.Muruges, Dr. K. Sadashivappa	Engineering	80-83
27	Prediction of Heat transfer rate for Indian coal slurry based on regression analysis	C.M. Raguraman, A. Ragupathy, L. Sivakumar	Engineering	84-86
28	A study of antimicrobial activity of the flavonoid- Kaempferol-3-rutinoside- from <i>Gliricidia sepium</i> (Jacq.) kunth.ex.Walp.	Anandhi, B., Sukumar. D, Arivudainambi. R	Engineering	87-88
29	Amitav Ghosh: Transfiguration of Memory and Imagination in the Shadow Lines	S.Kokila	English	89-90
30	Shareholder Activism in the U.S. and India	Ch. Chaitanya	Finance	91-93
31	Growth and Trends of Population in Nanded City, Maharashtra	Dr. Rathod S. B.	Geography	94-96
32	Regional Disparities of Ground water irrigation in Solapur District: A Geographical Analysis	Dr. G.U.Todkari, Shri B.D. Patil	Geography	97-99
33	Women and Employment in Textile Industries	Dr. S. S. Vijayanchali, Dr. E. Arumuga Gandhi	Home Science	100-102
34	Transition in Nutrition and Marketing of Agro Products	Dr. Anjali Rajwade	Home Science	103-104
35	Assessment of Knowledge About Effects of Inadequate Dietary Pattern on Mother and Child Health	Dr. Anjali Rajwade, Dr. Charuta Rajwade	Home Science	105-106
36	Job Enrichment	Kapil Dev Upadhyay, Dr. (Prof.) Vijay Kumar Soni	Human Resource Management	107-108
37	Quality of Work Life	Himani Avasthi, Dr. (Prof.) Vijay Kumar Soni	Human Resource Management	109-110
38	Understanding Security Requirement Engineering	Velayutham Pavanasam, Chandrasekaran Subramaniam	Information Technology	111-112
39	GENE Prediction	Er. Pankaj Bhambri, Dr. O.P. Gupta, Er. Meenakshi	Information Technology	113-114
40	Predictive Analysis In Data Mining Using Weighted Associative Classifier	Suwarna Gothane	Information Technology	115-119
41	Exchange Rate Forecasting	Dr. T. Koti Reddy	International Trade	120-124
42	Mass Media in India – New Trends	J. Ramanjaneyulu	Law	125-127
43	Right to Education Under the Indian Constitution	Mannava Muni Hemachand	Law	128-130
44	Criminal Law: A Tool for Consumer Protection in India	Aneesh V. Pillai	Law	131-132

45	Public Trust Doctrine: A Repository of Governmental Obligations to Protect the Environment	Dr. Kaumudhi Challa	Law	133-134
46	Application of Biometrics in the Investigation of Crime	Dr. R. Thilagaraj, Mr. G. Deepak Raj Rao	Law	135-137
47	Factors and Situations of Language Change	Dr. Syed Mohammed Haseebuddin Quadri	Literature	138-139
48	Omprakash Valmiki ke kahanio me chitrit dalitoki samajik stithi	Dr. V. P. Mahalinge	Literature	140-141
49	Fund Management in Pharmaceutical Industry in India	Dr. R. Perumal	Management	142-145
50	A study of Relationship management with customers in hospitality sector	Afreen Nishat A. Nasabi	Management	146-147
51	Outsourcing of Geriatric Services	Dr. V. Sreedevi	Management	148-150
52	Factor Analysis and Business Research	Dr. Kakali Majumdar	Management	151-154
53	Faculty Turnover Intention in Educational Institutions	K. R. Sowmya, Dr. N. Panchanatham	Management	155-156
54	Corporate Governance	Kalola Rimaben A., Chauhan Lalit R.	Management	157-159
55	Investment Avenues and Tax Implications for Small Investors	P. Menakadevi, Dr. V. Kumaravel	Management	160-163
56	Analyzing the IT Industry Progressions and Comprehensive Market Downfall Consciences through Deliberate Thinking	Dr. Venkatesh. J, Ms. Aarthy. C	Management	164-166
57	A Study On Problems and Prospects of Farmers in Cultivation of Paddy in Mahabubnagar District, A.P	Mr. M. Madhu Mohan	Management	167-170
58	An Analytical Study of Cash Management of IT Industries in Global Era	Bhaves P Chadamiya, Mital R Menapara	Management	171-173
59	The Status & Performance of Registered Small Enterprises; A Study in Karnataka	Dr. D. Kumuda	Management	174-179
60	Malnutrition – A Business Opportunity for State Cooperative Dairy Federations (Scdfs)	Dr. N. Ramanjaneyalu	Management	180-181
61	Financial Performance of Indian Corporate Sectors During Pre and Post Mergers and Acquisitions	Dr. Shailesh N. Ransariya, Dr. Butalal C. Ajmera	Management	182-184
62	A Study on Influence of Pedagogical Effectiveness on Academic Achievement of Students of B Schools	Dr. Viral Shilu	Management	185-186
63	Stimulation of Entrepreneurship through Venture Capital in India	Vijayakumar, Subrahmanya K C	Management	187-189
64	Performance Analysis of Indian Banks	Ajay K. Shah	Management	190-192
65	An Emprical Study on Effect of Combination of Sun with Different Zodiac Signs on Return of it Sector of Indian Stock Market	Dr. Jaydip Chaudhari, Pinkal Shah	Management	193-197
66	Internet Banking Customer Satisfaction and Online Banking Service Attributes	Md. Mahtab Alam, Dr. Umesh R. Dangarwala	Management	198-199
67	Changing Customer expectations & preferences in Indian Banking	Ms. Smita S. Shetty	Management	200-202
68	Current e-Governance Scenario in Healthcare sector in India	Samir Roy	Management	203-204

69	Liver function abnormality & Vestibular symptoms with Azithromycin	Dr. Parveen Kumar Sharma, Dr. Rekha Bansal	Medical Science	205-206
70	Unicornuate Uterus with Functional Noncommunicating Rudimentary Horn - A Rare Mullerian Anomaly	Anju Kumari Rani, Anand Prakash, Deepa Kapoor	Medical Science	207-208
71	Antenatal Diagnosis and Successful Delivery of a Fetus with Complete Heart Block	Anju Kumari Rani, Aditya Kapoor, Deepa Kapoor	Medical Science	209-210
72	Kangaroo mother care diminishes pain from heel lance in preterm neonates:	Dr.S.Valliammal, Dr. Ramachandra, Mr. Raja Sudhakar	Nursing	211-213
73	Experiential Domain and Extentionalistic Vocabulary : A Critical Consideration of Behaviourism	Dr. Jatinder Kumar Sharma	Philosophy	214-215
74	The Effect of a Mindfulness-Based Stress Reduction (MBSR) Program on Stress and Well-Being in Adolescents: A Pilot Study	Urvashi Anand, Dr. Mahendra P. Sharma	Psychology	216-218
75	Personality Profile of Patients with Somatic Complaints at a Rural Health Centre	Dr. Mahendra P. Sharma, B. Padmasri and, Dr. Ramchandra	Psychology	219-220
76	Psychological Well-being: A study of the institutionalized aged	Dr. Pankaj S. Suvera	Psychology	221-223
77	Crystal Growth, Thermal and Optical Studies on L-arginine Based Nonlinear Optical Material	J. Ramajothi	Science	224-226
78	Encapsulation of Lactic Acid Bacteria in Calcium Alginate Beads for Bacteriocin Production	Vijay S. Wadhai, Shweta G. Kayarkar, Archana N. Dixit	Science	227-229
79	Synthesis Of Nonatitnate Based Dielectric Ceramic Using Various Grain Size of Starting Materials	Parul, Anand K Tyagi	Science	230-232
80	Separate Telangana Movement and Related Literary Works: A Study In Sociology of Literature	Dr. M. Sreedevi Xavier	Sociology	233-234
81	Changing Interests In Fine Arts as a Profession: A Study In Sociology of Art	Dr. Poonam Gandhi-Moirangthem	Sociology	235-236
82	Modeling Fertility and Growth of Mising Community of Assam, India	Deba Kr. Baruah, S. C. Kakaty	Statistics	237-239
83	Fort Vasota an Adventure Tourism Destination in Satara District	Dr. Ananadrao S. Patil	Tourism	240-242



Overview of Speech Enhancement Techniques for Various Applications

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ABSTRACT

The problem of enhancing speech degraded by uncorrelated additive noise, has recently achieved much attention. Speech enhancement is a long standing problem with numerous applications ranging from hearing aids, to coding and automatic recognition. Recently many speech enhancement algorithms are developed to deal to with noises from different environment. Powerful tools like MATLAB has made way for implementation of various complex algorithms. Various transform domain techniques like Wavelet transform, DCT etc has helped in designing of more powerful enhancement techniques. The advent of VLSI and DSPs has made speech enhancement techniques to be applied on portable devices like mobile phones etc. In this paper some software and hardware based techniques are discussed.

Keywords : speech Enhancement, Wavelet Transform , Automatic Recognition

1. INTRODUCTION

In modern hands free speech communication environments often occurs the situation that the speech signal is superposed by background noise (Figure 1). This is particular the case if the speaker is not located as close as possible to the microphone. The speech signal intensity decreases with growing distance to the microphone. It is even possible that background noise sources are captured at a higher level than the speech signal. The noise distorts the speech and words are hardly intelligible. In order to improve the intelligibility and reduce the listeners (FES) stress by increasing the signal to noise ratio a noise reduction procedure also called speech enhancement algorithm is applied.

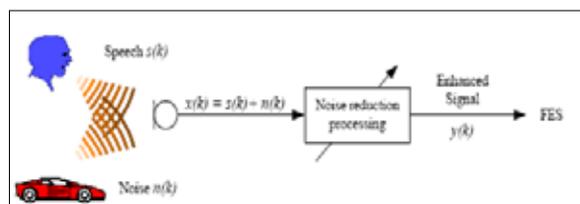


Figure 1 Enhancement of Speech Signal

Speech enhancement aims to improve speech quality in terms of clarity, intelligibility ,pleasantness or compatibility with some other method in speech processing. The requirements of noise reduction system for speech enhancement are intelligibility and naturalness of the enhanced signal, improvement of signal to noise ratio, short signal delay and computational simplicity.

We live in noisy world! Enhancing of speech degraded by noise or noise reduction is used for many applications such as mobile phones , VoIP ,teleconferencing systems , speech recognition systems , hearing aids, Bio telemetry , Avionics: voice activated systems in cockpit , speech to text conversion, for performance enhancement of speech codec and many more.

The algorithms of speech enhancement for noise reduction can be categorized into three fundamental classes: Filtering techniques, Spectral Restoration and Model based methods.

The techniques can be classified as single channel and multi channel algorithms. The former technique apply to situation in which a unique acquisition channel is available as telephone based applications or prerecorded applications. The later technique is employed when multiple sources of signal are present.

2. SPEECH ENHANCEMENT METHODS

The central methods for enhancing speech are the removal of background noise, echo suppression and the process of artificially bringing certain frequencies into the speech signal.

First of all, every speech measurement performed in a natural environment contains some amount of echo. Echo suppression is needed in big halls to enhance the quality of the speech signal, especially if the distance between the microphone and the speaker is large. The background noise suppression is well known speech enhancement technique.

2.1 SOFTWARE BASED METHODS

The spectral subtractive algorithm is historically one of the first algorithms proposed for noise reduction. It is based on the principle that one can obtain an estimate of the clean signal spectrum by subtracting an estimate of the noise spectrum from the noisy speech spectrum. The performance of this technique depends on the correct estimation of noise.

The noise estimation even during speech activity is a challenging task. Many noise estimation algorithms are developed. Voice activity detection (VAD), it typically extract some type of feature (example short time energy, zero crossing etc..) from the input signal and compared against threshold value, usually determined during speech absent period, Martin's noise estimation algorithm is based on tracing the minimum of noisy speech power spectrum. MCRA-2 noise estimation algorithm is based on the observation that the noise signal has non uniform effect on the spectrum of the speech [2][3]. Another class of speech enhancement techniques is signal subspace filtering. Here, a non parametric linear estimate of the unknown clean speech signal is obtained, based on a decomposition of the observed noisy signal into mutually orthogonal speech and noise subspaces. Noise reduction is then obtained by nullifying the noise subspace.

Modified Speech Enhancement (MSE), is a type of spectral subtraction method which includes the advantages of both parametric spectral subtraction (PSS) and relative spectral processing (RASTA) and it achieves improved quality and intelligibility in presence of simultaneous broad band and total noise [4].

Neural network and wavelet transform based speech enhancement techniques are developed. A method including adaptive linear neuron (ADALINE) to perform the task of noise cancellation is discussed using the LMS learning rule to adjust the synaptic weights to deal with different environment noises. This neural network in combination with wavelet transform also was studied [5].

The conventional power spectral subtraction method substantially reduces the noise levels in the noisy speech. But it also introduces an annoying distortion in the speech signal called musical noise. A time recursive estimation of the noise PSD is used to compare the multiband over subtraction factor in a nonlinear frequency spacing approach. This method achieved a very good speech quality with less musical noise and with minimal speech distortion [6].

2.2 HARDWARE BASED METHODS

The speech enhancement implementations should preferably be robust to the rough environment in which they are intended and versatility and flexibility are key features for speech enhancement devices. Example the ability to adapt to changing environment and fit into a variety of applications.

When the enhancement is to be applied in system which is not stationary, power consumption is a major factor to consider. Design considering this factor is discussed in [7], which is a straight forward, robust and flexible, light weight and stand alone. This adaptive gain enhancement (AGE) algorithm was implemented on analog hardware using custom electronic components as shown in figure 2 The benefits of this algorithm includes the data is neither quantized or digitalized, also it was a better solution for battery powered applications compared to corresponding DSP based solutions.

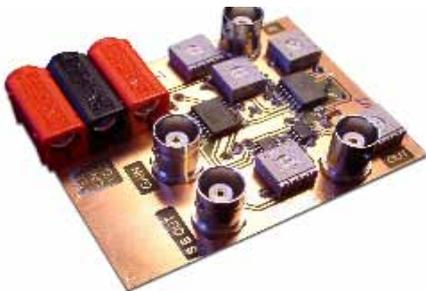


Fig 2 Printed circuit board of the Adaptive Gain

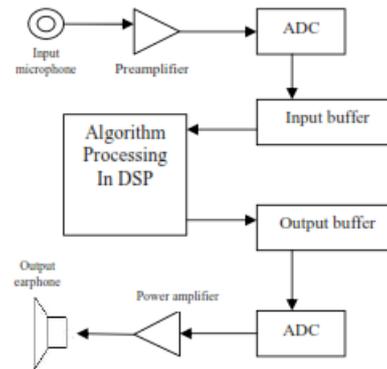


Fig 3 Implementation process of speech enhancement system Equalizer analog circuit implementation.

An embedded speech enhancement system is proposed in [8], a practical real time speech enhancement system. It is based on the TI TMS3205509A IC23B as the analog interface and EEPROM for program and data storage. Low power consumption and high efficiency make this system suitable for portable devices. Figure shows the implementation

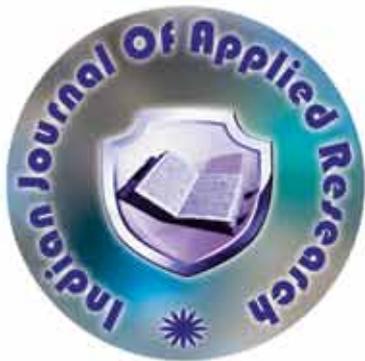
With the development of VLSI techniques and DSP, many practical speech enhancements are evolved. A fixed point design of the frequencies domain spectral subtraction enhancement was implemented on a Xilinx Spartan-3A DSP FPGA. This fixed point FPGA implementation matched that of an equivalent floating point of an equivalent floating point version running on a PC.

3.CONCLUSION

There are different speech enhancement techniques proposed for different environment conditions and various applications. Depending on the computational complexity achievable and power consumption considerations the techniques are chosen and implemented. The use of DSPs make real time implementations more effective. Thus speech enhancement is a great area to explore especially designing algorithms for portable applications.

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