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Anfis for Noise Suppression in Voice Communication

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Abstract- **The paper contains about voice communication and different types of noise interference in voice communication. The paper proposed the adaptive noise suppression technique for noise suppression in voice communication. There were different techniques earlier used for adaptive filtration like LEAST MEAN SQUARE, KALMAN'S FILTER etc.**

In the paper we used "FUZZY LOGIC" technique for adaptive filteration. It also shows how fuzzy is advantageous than other techniques. We study the theory of adaptive filtration of noise and application of fuzzy logic. How fuzzy can be related to this topic. This paper proposes adaptive nonlinear noise cancellation using the Fuzzy Logic functions ANFIS and GENFIS1 by MATLAB. ANFIS is the Adaptive Neuro-Fuzzy training of Sugeno-type Fuzzy Inference Systems. ANFIS uses a hybrid learning algorithm to identify the membership function parameters of single-output, Sugeno type fuzzy inference systems (FIS)

INTRODUCTION

It is well known that background noise reduces the intelligibility of speech and that the greater the level of background noise the greater the reduction in intelligibility. We are able to understand speech in a moderately noisy environment because speech is a highly redundant signal and thus even if part of the speech signal is masked by noise, other parts of the speech signal will convey sufficient information to make the speech intelligible, or at least sufficiently intelligible to allow for effective speech communication. There is less redundancy in the speech signal for a person with hearing loss since part of the speech is either not audible or is severely distorted because of the hearing loss.

Background noise that masks even a small portion of the remaining, impoverished speech signal will degrade intelligibility significantly because there is less redundancy available to compensate for the masking effects of the noise.

As a consequence, people with hearing loss have much greater difficulty than normally hearing people in understanding speech in noise.

a)Voice communication
b)Noises in voice communication
c)Adaptive filter
d)Fuzzy logic

a).Voice communication

Voice communication is essential part of human life.With the development of modern man voice communication has become very important. The communication occur directly earlier after the invent of Telephone it become communication between man-machine. First telephone was developed by "ALAXANDER GRAHM BELL" in 1876. After that lots of development done in man to machine communication. The era of 1990s was the era when voice processing, image processing, wireless communication. The field of voice communication in composes these broad technology areas,

Voice coding: The process of compressing the information in a voice signal as to either transmit it or store it economically over a channel whose bandwidth is significantly smaller than that of uncompressed signal.

In cellular system with advent of the European GSM standard at 13.2kbps, the North American standard IS-54 at 8kbps, the promises of the so-called half rate standards. Some coding technique used are At 64kbps - μ-law pulse code modulation-G.711 32kbps- adaptive differential pulse code modulation G.721 16kbps low delay code excited linear prediction-G.728

The most important application is in the storage, the most important application is in the storage of voice massage in voice-mail boxes. Another application is digital telephone answering machine.

Voice synthesis:- The process of creating a synthetic replica of a voice signal so as to transmit from a machine to a person, with the purpose of conveying the information in the message.

Voice synthesis has advances to the point where virtually any ASCII text message can be converted into speech. One such application is a voice server for accessing e-mail message remotely over a dialled-up telephone line. Other application are automated order inquiry, remote student registration, proofing of text document.

Speech Recognition:- The process of extracting the message information in a voice signal so as to control the action of a machine in response to spoken command.

Its application are automation of the billing function of operator services where by all calls that are not dialled directly.

Recent application is cellular voice dialogs for automobiles voice routing of calls, Automatic creation of medical reports form entry.

Speaker Recognition:- The process of either identifying or verifying a speaker by extracting individual voice characteristic, primarily for the purpose of restricting access to information.

The ability of a computer to either identify a speaker from a given population or to verify an identity from a name speaker. Speaker verification is required for a wide variety of applications entrée to ATMs, PBXs, BANKING SERVICES.

Spoken language translation:- The process of recognition, the speech of a person talking in one language, translation the message content to a second language , and synthesizing an appropriate message in the second language ,for providing two-way communication between people who do not speak the same language.

Its application is VEST (Voice English to Spanish translator) developed by AT&T and Telefonica.

Another one by ATR "interpreting technology".

NOISE IN VOICE COMMUNICATION

Types of noises in voice communication

1. External noise
2. Internal noise

External Noise:- The external noise in communication occur outside the circuit and includes

Erratic Natural Disturbances:-This type of noise does not occur regularly cause by lightining, electrical stroms, and intergalactic or other atmospheric disturbances. The atmospheric noise is less severe above 30MHZ.

Man Made noise:- Because of the undesired pick-ups from electrical appliances, such as motors switch gears, automobiles and aircraft ignition, etc. the frequency range is 1MHZ-500MHZ.

Internal noise:- This type of noise caused due to fluctuation in internal circuit. Important type of fluctuation noise is

a)Shot noise:- This type of noise appears due to random behaviour of charges carriers(electrons and holes). In electron tubes shot noise generated, due to yhe random emission of electrons from cathodes Power spectrum density of shot noise is Gaussian distributed with zero mean value.

$$S_i(\omega)=qI_o$$

b) Thermal noise:- Also called as Johnson noise caused by thermal random motion of charged carriers. The noise amplitude has Gaussian distribution. In this case, using Carson's theorem we can get

Si(f)=2NT =2NT = = ,where the rate of events, = , V is the volume of resistor and n the electron density

$$S_v(f)=4kTR$$

C) FLICKER NOISE

In semiconductors this noise is mostly due to random trapping and detrapping of charges at the Si-SiO2 interface and associated changes in carrier mobility due to Coulombic scattering. Also, there's a limited distribution of the time constants associated with the trapping and detrapping.

The noise (amplitude) is often non-Gaussian. Carbon resistor and MOSFET have Flicker noise. Metal-film resistor doesn't have it. Theoretically, 1/f noise comes from a distribution of τ so approximately

$$S_v(f)= Kf$$

ADAPTIVE FILTER

An adaptive filter is a computational device that attempts to model the relationship between two signals in real time in an iterative manner. The development of adaptive filter based on Estimation theory. The origin of Linear Estimation theory is credited to Gauss who on the age of 18 in 1795 invented the method of least square estimator.

The first studies of minimum mean-square estimation in stochastic process were made by Kolmogorov, Krein and Weiner during the late 1930s &1940s .

Weiner formulated the continues-time linear prediction problems and deprived an explicit formula for the optimum prediction. The explicit formula for the optimum estimate required the solution of an integral equation known as the Weiner-Hopf equation.

In 1947 Levison formulated the Weiner filtering problem in discrete time. In the case of discrete-time signals.

The earliest work on Adaptive filter may be traced back to the late 1950s. From early work LMS algorihm emerged as a simple yet effecive algorithm for the operation of adaptive transvered filter.

LMS ALGORITHM

The LMS algorithm was devised by Wisdrow and Hopf in 1959 in their study of pattern recognition scheme known as adaptive linear element.

This algorithm is a member of the stochastic gradient algorithms, e.g. [Poularikas(2006)]. There are many iterative search algorithms derived for minimizing the underlying cost function with the true statistics replaced by their estimate obtained in some manner

Gradient-based iterative methods

(1) Method of Steepest Descent

(2) Newton’s Method

The LMS algorithm is a linear adaptive filtering algorithm, which, in general, consists of two basic processes:

The filtering process,

which involves computing the output y(n) of the adaptive filter in response to the vector input signal x(n), generating an estimation the error e(n), e.g. Fig.8 by comparing this output y(n) with the desired response d(n)

An adaptive process

which involves the automatic adjustment of the parameters w(n+1) of the filter in accordance with the estimation error e(n),

y(n)=wT(n)x(n) ……………………(1)

w(n) the tap – weight vector,

w(n+1)=w(n)+2μe(n)x(n)……………(2)

w(n)[w0(n)w1(n)w2(n)w3(n)………………

wm-(n)]T

w(n+1) is tape vector update.

μ is stepsize.

The LMS algorithm adapts the filter tap weights so that e(n) is minimized in the mean-square sense. When the processes x(n) and d(n) are jointly stationary, this algorithm converges to a set of tap weights which, on average, are equal to the Wiener-Hopf solution.

W0=R-1P

Where P is the cross- correlation vector Mx1 of input x(n) and desired signal d(n).

Advantages & disadvantages of LMS algorithm :

(1) Simplicity in implementation

(2) Stable and robust performance against different signal conditions

(3) slow convergence (due to eigenvalue spread)

after lms kalman designed filter for called kalman estimator for continuous and discrete estimation problem.

In 1960, R.E. Kalman published his famous paper describing a recursive solution to the discrete data linear filtering problem . Since that time, due in large part to advances in digital computing, the Kalman filter has been the subject of extensive research and application, particularly in the area of autonomous or assisted navigation. The recent development in the field of adaptive noise cancelling was by DM Chabrise ,RW Christiansen in “digital signl processing to speech enhancement for the hearing impaired”.

FUZZY LOGIC

Intelligent systems need the application of both old type (mathematics based) and new type (fuzzy, neural and genetic algorithm based) computational methods. Fuzzy systems (FS), neural networks (NN) and genetic algorithms (GA) are relatively new methods in computational intelligence.

Fuzzy systems are defined by membership functions of the linguistic variables, the relations describing the system behavior in fuzzy sense, the fuzzification rule, the inference rule and the defuzzification rule. Since the relations normally use standardized variables, input and output normalizing gains belong also to the system parameters. If the consequent parts of the relations are deterministic functions the fuzzy system is of Takagi-Sugeno-Kong (TSK) type.

Especially if the deterministic functions are linear (or constant linear) then the FS is of Sugeno type. It is known that every continuous function over a compact interval can be approximated by Sugeno type FS with constant output deterministic functions. For increasing number of variables it is impossible to find a priori the relations of the FS, hence adaptive tuning is necessary. Sugeno type FS can be rewritten to a feedforward NN, thus the gradient method of optimization in the form of backpropagation (BP) can also be used.

A feedforward NN consists of one input, some hidden and one output layer. A neuron is characterized by the weights for the input signals and the transition function mapping the net input (weighted sum of the input signals) into the output of the neuron. Several type of transition functions can be used (sigmoid, hard limits, linear etc.). The feedforward NN has also function approximation properties. Both FS and feedforward NN can be converted into feedforward adaptive networks (AN). AN's are similar to NN's with the only difference that the weights of the NN are removed into the arguments of the functions placed in the nodes of the NN.

If the node does not contain any parameters it is a fixed node, otherwise it is an adaptive node. If some of the parameters appear linear in the functions then linear parameter estimation can be applied for them, while gradient method etc. for the remaining parameters in the actual step of the tuning (hybrid optimization). Since gradient, conjugate gradient and quasi-Newton methods are usually convergent to local optimum only, methods are needed for finding the global optimum. Since genetic and evolutionary algorithms are stochastic optimization methods they have the chance to find the global optimum (minimum) of a scalar-valued function. The input variables of the objective function can be coded in standard binary or Gray-code (binary GA) or remain real encoded (real GA).

In order to improve the stochastic property the value of the objective function will be mapped into a bounded domain by using a fitness function (linear ranking, nonlinear ranking). The population consists of individuals (input vectors). Parents will be selected from the population using roulette-wheel selection, stochastic universal sampling etc. Between the pairs of parents recombination (crossover) will be performed and with small probability mutation is applied. The children will be replaced into the population based on the fitness of the new individuals but saving the best ones in the old population (elitist strategy).

In many cases if the optimal FS, NN or AN has to be found for given input-output samples, the best strategy is to start with optimization using GA. Unfortunately by using genetic operators of the GA, enormly large number of steps are needed to reach the global optimum because stochastic optimization is time consuming. Hence the GA will often be used to come near to the global optimum, and the optimization will be continued using gradient (BP), conjugate gradient, quasi-Newton optimum seeking methods or linear parameter estimation (LS), nonlinear LS or extended Kalman filter techniques. Intelligent systems have the fundamental function of sensing, perception, knowledge acquisition, learning, inference, decision making and acting abilities. Soft computing (FS,NN, AN, GA) methods can help to realize these functions. They can deal as alternative methods in system modelling, optimal and robust control design, nonlinear and adaptive control too. They can support the design and realization of autonomous (wheeled or legged) mobile robots, service robots, cooperating robots, robotized production systems, aircraft and satellite control systems, and the modelling of complex (technical and nontechnical)processes.

Theoretical and Numerical Analysis

Noise in communication system is multiscattering effect, i.e., in the presence of fog, hail, heavy rain, etc. in the atmosphere causes serious signal degradation in the propagation path Under clear sky condition, the optical wireless communication system has very less attenuation and scattering effects, but in the fog or snow form condition, the attenuation and scattering effects are very high. This effect limits the maximum system bandwidth and increases bit error rate . The use of optical wireless communication can be improved only when the environmental effects are controlled or overcome by system performance. In the impulse response function of atmospheric clouds for optical pulses is derived and modeled the optical wireless communication system and used only for earth to low earth orbit(LEO) satellites, geo synchronous orbit(GEO) satellites and downwards. But, this paper proposes an optical wireless communication system for worst climatic condition, is considered as atmospheric turbulence channel, on the Earth's surface between tower to tower or high building to building. By analyzing these effects by extension search of the literature survey and propose a novel approach of using an intelligent method called Fuzzy Logic concept to overcome.

The changes in the parameters of the optical channels, like atmospheric attenuation coefficient, radius of the scattering particle, visibility, the size distribution of the scattering particles etc.can be measured and the optical receiver can be adapted to these changes. The front end of intelligent optical receiver will consists, the fuzzy logic unit performs adaptive nonlinear noise cancellation upto -40dB SNR level and able to extract the signal upto The link equation for optical wireless communication system using Beers-Lambert law is given by, Pr =Pt[Ar / (D.R)2]exp(-σR) where, Pr is the received power at the optical receiver in Watts, Pt is the transmitted power at the optical transmitter in Watts, Ar is the receiver aperture area in cm2 with the radius of r = 20cm, the transmit beam divergence D = 2mrad, the distance between the optical transmitter and receiver(range) R=2km and σ is the atmospheric attenuation coefficient in km-1 is given by, σ = [3.91/V] (λ /550 nm)-q where, V is visibility in the atmosphere in km and q is the size distribution of the scattering particles depends on visibilities, and given by,

q = 1.6 ,for V>50km
= 1.3 ,for 6km<V<50km
= 0.16V+0.34 ,for km<V<6km
= V-0.5 ,for 0.5km<V<1km
= 0 ,for V<0.5km (4)

The data rate is taken as 20Gbps and range is restricted to 2km under this worst climatic condition, but for clear sky. This paper proposes adaptive nonlinear noise cancellation using the Fuzzy Logic functions ANFIS and GENFIS1 by MATLAB. ANFIS is the Adaptive Neuro-Fuzzy training of Sugeno-type Fuzzy Inference Systems. ANFIS uses a hybrid learning algorithm to identify the membership function parameters of single-output, Sugeno type fuzzy inference systems (FIS). A combination of leastsquares and back propagation gradient descent methods are used for training FIS membership function parameters to model a given set of input/output data. Defined below is an optical pulse information signal (x) sampled at 1550nm (≈194THz) over 6*10-13 seconds.

Regrettably, the information signal (x) cannot be measured without an interference signal (n2), which is generated from another noise source (n1) through unknown nonlinear process. The interference signal (n2) that appears in the measured signal (m) is generated by means of an unknown nonlinear equation,

n2(k) =

Fuzzy logic control Scheme

Although tunable or matched optical filter based on fiber Bragg gratings are a flexible and promising solution for dispersion compensation, but still have the problem of variable optical communication path characteristics, environmental fluctuations, and the indifference of applications that are themselves in a constant state of change and requires re-design and re-fabrication of an appropriate fiber Bragg grating for each case. Therefore an alternative novel technique of signal detection based on adaptive, intelligent optical scheme would overcome these problems. In such a scheme the pulse profile is continuously monitored for any distortion caused by atmospheric turbulence effects, and the adaptive tuning parameters together with the control strategy are updated continuously in order to compensate for dispersion - regardless of the data rate or range. Figure (3) is showing the model of the proposed real time intelligent optical scheme, which comprises Fuzzy logic control. Fuzzy Logic has emerged as a profitable tool for the controlling of complex processes, it is a problem-solving control system methodology that lends itself to implementation in systems ranging from simple, small, embedded micro-controllers to large systems. It provides a simple way to arrive at a definite conclusion based upon vague, ambiguous, imprecise, noisy, or missing input information. Fuzzy Logic incorporates a simple, rule-based IF X AND Y THEN Z approach to a solving control problem rather than attempting to model a system mathematically. The reasons for selecting fuzzy logic control in this paper are:

(i)relatively easy implementation,

(ii) can manage with different initial conditions

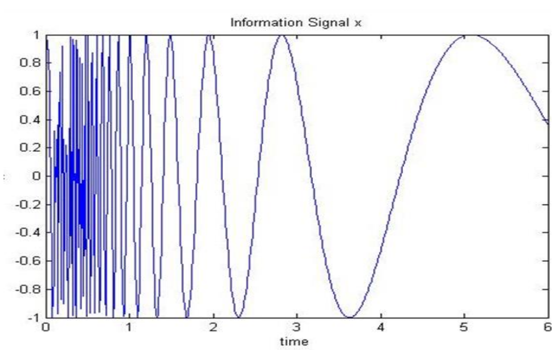
(iii) the Fuzzy Logic control model is empirically-based, relying on a knowledge base system, where all operating parameters and optical filter tuning optimization constraints can be stored, with a self learning algorithm it has the ability to adapt itself and update its knowledge base, (iv) the ability to respond to random changes in the atmosphere, so that the light signal detection process can be further extended, that may arise from other environmental effects. The outputs of the Fuzzy Logic controller are used to control the fluctuations in the optical signal, (v) the Fuzzy Logic control is the main intelligence that provides the adaptability of the entire schemes. The purpose of the error signal in this case is to drive the firing of the fuzzy logic control rules, which is different to that of the error signal in a feedback control system where the aim is to reduce the error signal to zero if possible. Fuzzy logic algebra is used to improve the detection of signals in an optical wireless communication system where signals are modulated by intensity modulation scheme. New fuzzy signal detection techniques are proposed based on the application of fuzzy operations such as multiplication, addition, and integration mixed with ordinary algebraic operations. Because the task of fuzzy detector has to decide which signal is present in a waveform out of M possible reference signals, the concept of the classical cross-correlator detector is being extended. The fuzzy Hamacher product, the fuzzy algebraic sum, and the new combined fuzzy product are deployed to detect the presence of signals in a noisy received waveform. The feasibility of employing the fuzzy detector in an Intensity Modulated (IM)-Coherent Detection optical communication system is investigated.

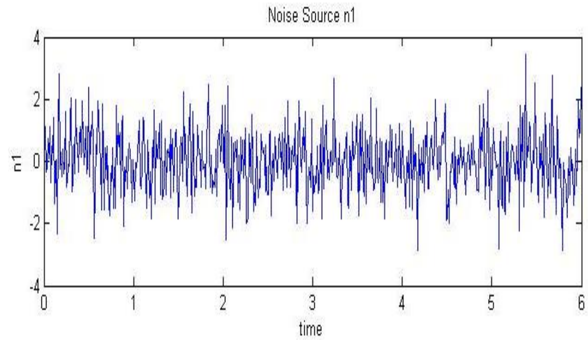
In order to maintain the sensitivity of the receiver above 0.1 µw, the coherent optical receiver with 20 Gbps was implemented. So that the adaptive filter is designed by the function as,

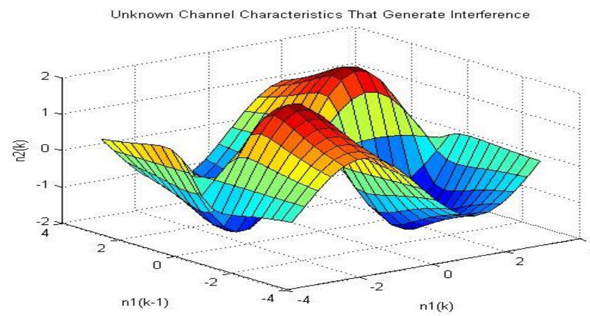
$$F(f) = [(Y1-Y0) / (Z2+2Z+1)G1] * [\{k1/(k2-j2\pi f)2\}+ \{k3/(k4-j2\pi f)2\} + \{k5/(k6-j2\pi f)2\} + ...+\{kn-1/(kn-j2\pi f)2\}]exp(-j2\pi ftd) \quad (1)$$

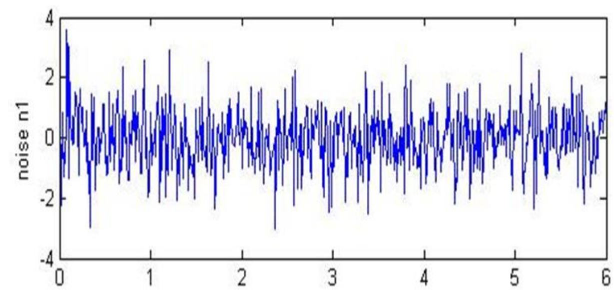
where, F(f) is the adaptive filter transfer function, Y1 & Y0 are functions of receiver parameters and transmitter power for receiving 1 and 0 respectively, k1,k2 …… kn are n-gamma function constants depends upon the visibilities, f is the operating frequency, and td is the time at which signal is at the filter output, and Z2 = (G0/G1), where G0&G1 are the noise spectral densities of the receiver for receiving 0 and 1 respectively.

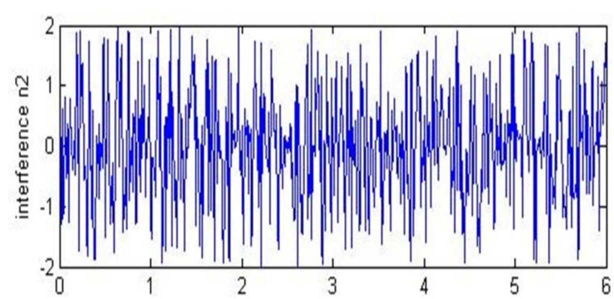
RESULT

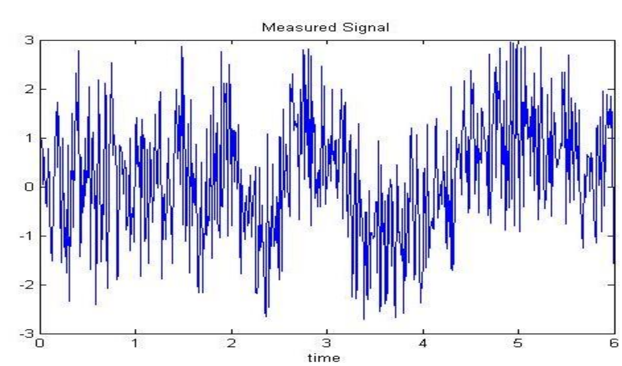


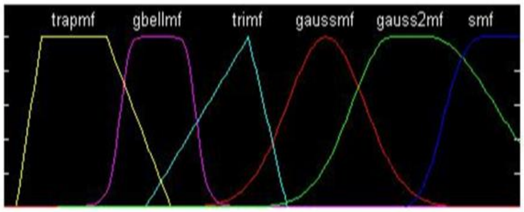


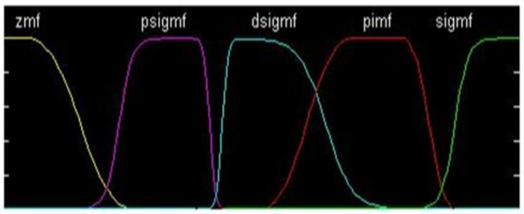












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