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Optimization of Mel Cepstral Coefficient by Flower Pollination Algorithm for Speech Enhancement

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ABSTRACT
This paper describes the speech intelligibility enhancement by extracting the speech features. A method is introduced for modifying the speech features i.e. Mel frequency cepstral coefficient from a fusion of noise and speech signal and then these features are optimized by Flower pollination algorithm (FPA) which is a nature-inspired algorithm and is based on the process called pollination. Different results shows each and every step, extracting the speech features and optimized by flower pollination algorithm and by taking same speech signal and different noises FPA signal-to-noise ratio (SNR) gives better results and when different speech signals and different noisy signals have been compared still the FPA SNR perform better than the existing technique. Thus, proposed method gives reliable and effective results.
Keywords: Denoising, Feature extraction, Flower pollination, Levy flights, Mel cepstral coefficients.

I. INTRODUCTION

Speech signal is an important medium for communication between humans and it is extremely non-stationary and when investigated closely i.e. divide it into frames it seems to be stationary for few milliseconds. Speech signal is degraded by various types of noises. It's quite difficult to interpret the speech signal for humans. Phonetic feature mapping eliminate imperceptible components, and modify frequency and magnitude scales of speech [1]. When automatic speech recognition system is applied to real surroundings, it is essential to minimize the noise components to enhance the recognition rate. Various methods existing in literature presents how to increase the signal-to-noise ratio of automatic speech recognition system at input [2]. Several types of noises like white noise, musical noise etc corrupt the speech signal and for reducing the noise several noise reduction techniques for example decision-directed approach excessively limit the level of musical noise and approximated a priori SNR [3]. Basically, Speech enhancement is related with enhancing some visceral conditions of speech signal that has been corrupted by additive noise and suppression of background noise can be done through noise suppression algorithms. For, hearing impaired listeners wearing cochlear implant devices struggle intense difficulty while communicating in noisy environment so, there is highly need to improve the quality and intelligibility of speech [4]. Improving quality, might not accordingly lead to improvement in intelligibility. Some algorithms perform best in terms of overall quality but not same in terms of speech intelligibility [5]. The performance of various objective measures for predicting the quality of enhanced speech signal enhanced by different algorithms. Various speech enhancement algorithms like Subspace, Wiener algorithm, Spectral subtraction algorithm are employed to improve quality of speech [6]. Reverberant speech can be enhanced spectro-temporal processing and this processing involves high signal-to reverberation (SRR) ratio [7], [8]. It is difficult for normal listeners and hearing impaired listeners to interpret the speech signals in the presence of surroundings noise. Various speech enhancement algorithms are used for the reduction of noise to improve intelligibility and quality of speech signal [9]. Most of the actual speech enhancement intelligibility measures do not solve the distortion problem so new objective intelligibility measures are needs to be proposed to predict the intelligibility of speech in noisy conditions [10]. One reason is the fact that we do not have a good estimate of the background noise spectrum that is needed for the implementation of better algorithms and second attenuation distortion and amplification distortion. Both these distortion should be separately solved because there perceptual effects are different [11].

II. MEL CEPSTRAL COEFFICIENT

With the help of new techniques it is now desirable to enhance speech intelligibility degraded by noise by improving clean speech signal. For this, effects of adjusting or reshaping the spectral envelope or Mel cepstral features can be taken into account. Mel cepstral coefficients are modified by

Glimpse proportion measure [12]. To enhance the intelligibility of synthetic speech mixture of noise-independent and noise-dependent algorithms were developed. Noise-independent approach outperforms better as compared to noise-dependent because it suppresses the noise with dynamic range compression [13]. Optimization techniques are used to reduce background or additive noise from speech and language processing. With help of parameters, observed data and priors function by optimization speech can be enhanced [14]. Speech signal corrupted by noise can be estimated by power spectral density (PSD). Short-time Fourier Transform (STFT) established on power spectral density yield better tracking performance even in detrimental noise conditions [15]. In this, Noise suppression algorithm for example spectral subtraction algorithm reduces the noise level and Hidden Markov Model based on speech absence and presence states [15]. Mel cepstral coefficients are the features of speech recognition and they are copied or derived from a type of cepstral illustration of the audio clip. Speech features are extracted by pre-emphasis the noisy speech signal because it advances the energy at higher frequencies and then windowing the signal because speech signal is non-stationary so it is quite difficult to reduce noise from it [16]. Speech signal is divided into smaller frames so that it can be considered as stationary signal and noise removal mechanism can be employed on it. Then, Discrete Fourier Transform (DFT) or Fast Fourier Transform (FFT) of a signal is taken to convert it from time domain into frequency domain [16].

$$H(e^{jw}) = \exp \sum_{m=0}^{M} c_m e^{-jm\omega} \qquad \text{……. (1)}$$

After that, Mel filter bank is employed, because it applies Mel-scale frequency which helps to simulate in a way human ear works and it gives better resolution at low frequencies and by applying log it compresses the dynamic range of values i.e. volume of sound developing from an musical instrument [16].

III. FLOWER POLLINATION ALGORITHM

Flower pollination is an interesting mechanism in the natural world and its natural evolutionary components or characteristics can be used to construct an advanced optimization algorithms. Many nature-inspired algorithms are bat algorithm works on the echolocation of bats [17], [18], particle swarm intelligence based on schooling of fish or flocking of birds [19] and firefly algorithm was established on flashing light patterns [20]. It approximates the concept of random walks. By physicists, such random walks are referred to as motions or Levy flights. This is used to model financial data and for improved adjustment to real world data various modified levy flights have been introduced such as exponentially damped, gradually truncated or truncated. On the other hand, random walks on scaled transformation possess levy scaled distribution [21], [22].All these arrangements have been practiced or applied to immense range of applications. The main function of a flower is basically reproduction which is done by pollination. Flower pollination is correlate with the transfer of pollen gamete from one flower to another flower and such transfer is done with the help of honeybees, insects, bats, birds etc which are known as pollinators [23].

Pollination can be of two types: Biotic and Abiotic. Biotic pollination includes 90% of the flowering plants in which pollen is transmitted from one flower to another flower with the help of pollinators and Abiotic pollination includes about 10% of the flowering plants which does not depend upon pollinators. Abiotic pollination takes place with the help of wind or diffusion in water like grass. Insects, honeybees, bats, birds etc are also called as pollen vectors. These pollen vectors fly over a long distance and perform levy flights means random distribution of pollen gametes.

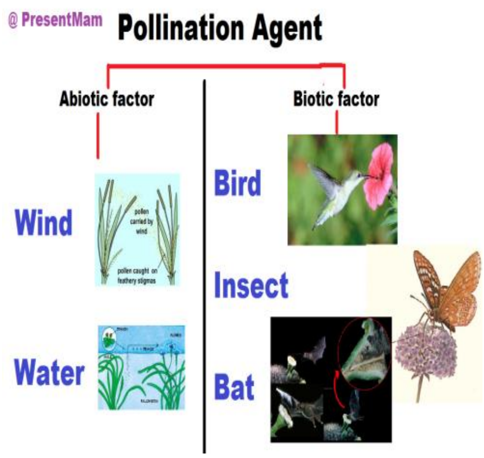


Fig 1: Types of Pollination

Pollination can be accomplished by cross pollination and self pollination. Cross pollination is a process in which pollen gamete is transferred from a flower of a different plant whereas Self pollination is the process which includes pollen transferred from a different flower or from a same flower of same plant like peach flower and this is done without the help of any pollinator. Self pollination is basically the process of fertilization of a flower [23].

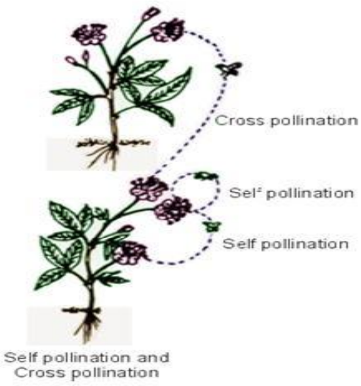


Fig 2: Cross pollination and Self pollination

Flower constancy is a feature of Pollination in which some pollinators are influenced to visit some exclusionary flowers while neglecting other flowers category. This feature is advantageous by virtue of maximizing the transfer rate of flower pollen and thus reproduction rate also increases and this is favorable for pollinators also in a way that pollinators also get nectar in return [23].

Flower pollination algorithm follows some basic rules:

1. Self pollination and abiotic pollination are treated as local pollination because it does not involve any pollinator in its mechanism.

2. Cross pollination and biotic pollination can be assumed as global pollination because it involves pollinators such as bats, insects, birds etc travel over a long distance carrying pollen and performing a function called levy flights.

3. Flower constancy can be assumed as probability of reproduction and is proportional to analogy of two flowers tangled.

4. Global and local pollination is restrained by switch probability $p \in [0, 1]$ and due to natural proximity or other factors; local pollination can acquire an important fraction *p* in overall pollination movements.

Flower Pollination Algorithm (or simply Flower Algorithm)
Objective min or max $f(x)$, $x = (x_1, x_2, \ldots\ldots, x_d)$
Initialize a population of n flowers/pollen gametes with random solutions
Find the best solution **g∗** *in the initial population*
Define a switch probability $p \in [0, 1]$
while *(t < MaxGeneration)*
for *i = 1:n (all n flowers in the population)*
if *rand < p,*
Draw a (d-dimensional) step vector L which obeys a Levy distribution
Global pollination via $x_i^{t+1} = x_i^{t} + L(g_* - x_i^{t})$
else
Draw $\in$ from a uniform distribution in [0, 1]
Randomly choose j and k among all the solutions
Do local pollination via $x_i^{t+1} = x_i^{t} + \in (x_j^{t} - x_k^{t})$
end if
Evaluate new solutions
If new solutions are better, update them in the population
end for
Find the current best solution **g∗**
end while

Pseudo code of Flower Pollination Algorithm (FPA)

There are two important steps in this algorithm named as global pollination and local pollination. In global pollination, pollen gametes are transferred through insects, honeybees, bats etc and pollens can fly over a long distance with the help of these pollinators. This mechanism gives confirmation of reproduction and pollination of the fittest and it gives the best solution denoted by **g***. This can be expressed as:-

$$x_i^{t+1} = x_i^{t} + L(x_i^{t} - g^*) \quad \ldots\ldots\ldots (2)$$

where x_i^t is pollen and solution x_i, g* is the best solution at iterations t and parameter l is step size or strength of pollination.

In local pollination, it imitates the flower constancy feature in a limited area and this equation is represented as:

$$x_i^{t} + \in (x_j^{t} - x_k^{t}) \quad \ldots\ldots\ldots (3)$$

where x_j^t and x_k^t are pollen gamete from different flowers of same plant category [23].

There is also extension of flower pollination algorithm to solve extended problems in engineering called as Multi-objective flower algorithm. The elementary way is to use mask or weighted sum to incorporate all multiple objectives into a single objective [24].

Multi-objective flower algorithm is represented as:

$$f = \sum_{i=1}^{m} w_i f_i \; , \quad \sum_{i-1}^{m} w_i = 1, \quad w_i > 0 \;\ldots\ldots (4)$$

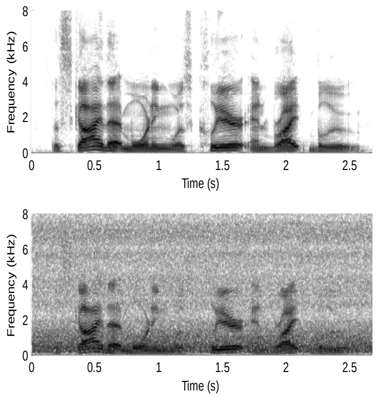
where m is the number of objectives and w_i are non-negative mask or weight functions. This is used to get pareto front uniformly and precisely distributed on front [24].

Flower pollination algorithm is used to solve Sudoku puzzles and is used to improve the search accuracy. Flower pollination algorithm is a technique to improve fractal image compression and is used to access high-quality images [25].

IV. FIGURES

In this section, figures shows that the fusion of speech signals with noise result in noisy speech signal. Then, by applying various steps speech features are extracted from the signal known as Mel frequency cepstral coefficients. These features are then optimized by Flower pollination algorithm to enhance the speech signal and for noise removal.

(a)



(b)

Fig 3: (a) indicate the clean speech signal and **(b)** shows the fusion of clean speech signal with the noise shows noisy speech signal.

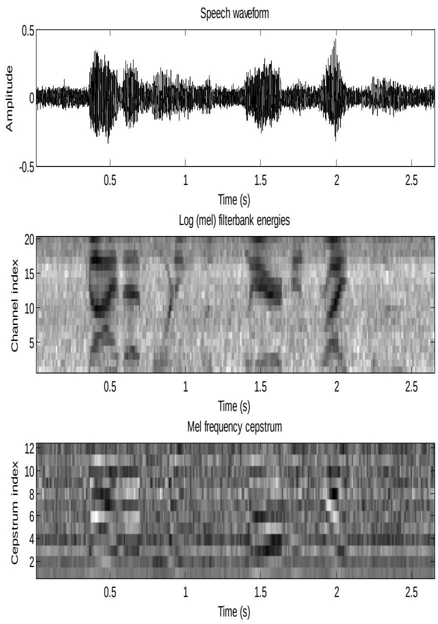
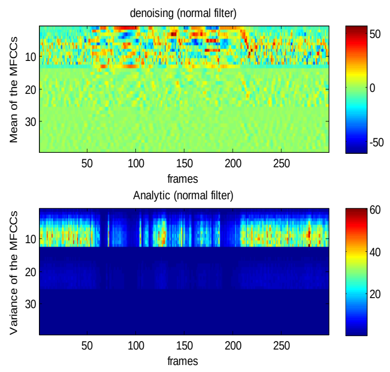


Fig 4: First part depicts a noisy speech signal; second display log Mel filter bank energies and third displays the Mel frequency cepstral coefficients.

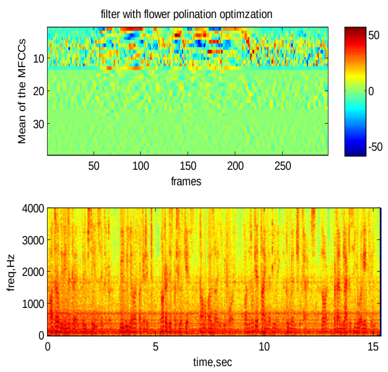
(a)



(b)

Fig 5: (a) Shows denoising of the normal filter by taking Mean of MFCCs as a parameter **(b)** Shows the analytic view of denoising filter by taking Variance of MFCCs as a parameter

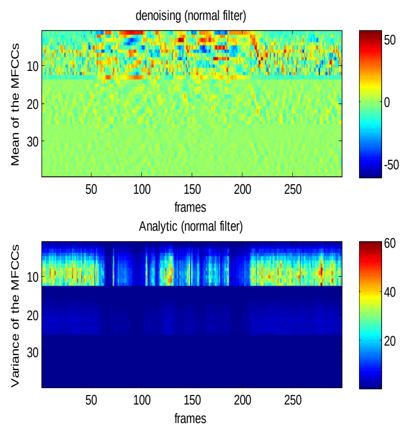
(a)



(b)

Fig 6: (a) shows the filter optimized by flower pollination algorithm taking Mean of MFCCs as a parameter **(b)** shows less traces of noise by applying flower pollination

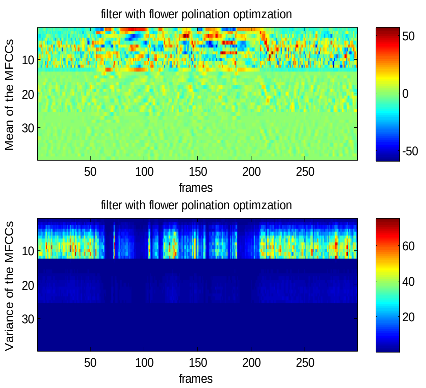
(a)



(b)

Fig 7: (a) shows denoising and analytic view of speech signal and traces of noise and **(b)** shows analytic view of noise traces

(a)



(b)

Fig 8: (a) Shows the signal optimized by Flower pollination algorithm and **(b**) shows less traces of noise

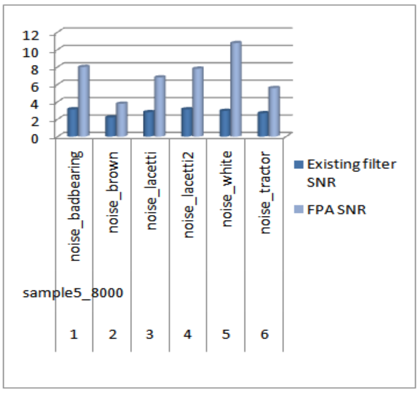


Fig 9: Shows the graph between existing filter SNR and FPA SNR taking same signal with different noises and it is clearly shown that the FPA SNR is better than the existing SNR

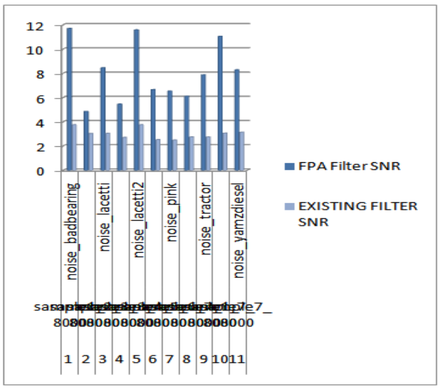


Fig 10: shows the variations between FPA SNR and Existing filter SNR taking different speech signals and different noise signals and it shown clearly that the proposed technique gives better results

V. CONCLUSION

The proposed method has been implemented on different samples to check variations in the experimental results. The Existing filter SNR and Flower pollination optimization SNR are then calculated to check the performance of proposed algorithm. The proposed algorithm outperformed as compared to existing algorithm and it is observed from the experimental results that the proposed algorithm reduces noise and enhance speech intelligibility. Thus FPA optimization method is very efficient and reliable and is better than the existing technique. Flower pollination algorithm is used in cloud computing, enhance search accuracy; solve Sudoku puzzles, wireless sensor networks, clustering, web mining etc and in many other field to get fast, effective results.

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