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Spectrogram Enhanced Pitch Period Tracking using MWSG Filter in Noisy Environments

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Abstract*: Speech Processing is the study of speech signals which carry individual information such as speaker characteristics, acoustic environment, etc due to which the parameters defining the signal are unique. Pitch Period, Duration, Intensity are the parameters that play the main role in coding speech applications such as authentication, surveillance, speaker recognition. As the conventional filters are static in nature, for non-linear and non-stationary variations of signal parameters adaptive filtering models which are robust are required. Hence the tracking and estimation of the parameters can be done by using Particle-Kalman Filter. It is very important that the signal has to track perfectly even in the presence of noise, by removing the noise and thereby enhancing the output. The approach in this paper is to propose a method for enhancing the performance, using multiple window Savitzky-Golay Filter (MWSG Filter). The performance of filter is measured by parameters Viz., SNR and PSNR.

Index Terms*: Kalman Filter, MWSG Filter, Particle Filter, Pitch Period

I. INTRODUCTION

Sound is generated by the vocal tract through the creation of pressure waves. If we measure this pressure at a point of space then we have a description of the phenomenon of sound which is defined as a speech signal. The speech signal is analyzed to understand certain parameters, mainly in this paper we analyzed the pitch period which is necessary for many speech processing applications. Earlier algorithms for tracking are of mostly time domain and frequency domain approaches [1]. Recently most of the tracking based applications use Kalman based filters and Particle filters [2][5-7].

The Kalman filters are applicable for linear applications, the extended versions of Kalman Filters and Particle filters[6] are applicable to the nonlinear and non-stationary applications. The approach in this paper is to use the Particle Kalman filter to estimate the Pitch period in speech processing applications.

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The proposed algorithm is discussed in the forthcoming Section. This followed by simulations in section 3, and a conclusion in Section 4.

II. SPECTROGRAM ENHANCEMENT USING MWSG FILTER

2.1 Flow Chart

The pitch period tracking is done using Particle-Kalman filter which is described in the forthcoming section. Due to the presence of noise the efficiency of tracking is reduced. In order to enhance the output and increase the efficiency we use multiple window Savitzky-Golay Filter. Due to the usage of multiple window Savitzky-Golay filter the noise is removed perfectly as there are different windows to eliminate different levels of noises. The output spectrogram if noise free and enhanced as the signal to noise ratio gets improved.

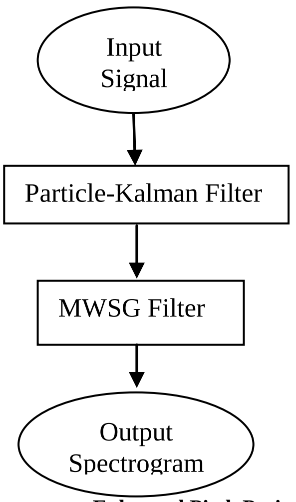

Fig. 2.1. Spectrogram Enhanced Pitch Period Tracking

2.2 The Tracking of Pitch Period

In the initial stage input signal is expressed as state-space and observation equations.

$$p_t = x(p_{t-1}) + a_t, \qquad (1)$$

$$q_t = y(p_t) + b_t, \qquad (2)$$

q_t and p_t denote observation and state vectors while a_t and b_t denote noise vectors. The main aim is to find state vector. The earliest and succeeding equations symbolize the prior and likelihood which are extracted from [3].

Consider s_t as a set of samples of an audio signal x(t) at a time t. Voiced segments of audio signal are quasi-periodic hence the signal can be recreated with unknown delay t1.

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$$s_t \sim s_{t-t1} \qquad (3)$$

Keeping the prior equation in mind rephrasing the observation equation as

$$s_t = g_t s_{t-t1} + b_t \qquad (4)$$

Where g_t is the gain of rearranging, the main intension of this model is to estimate two state variables g_t and t1.

To track the pitch period of the signal an algorithm is set which is divided in to five stages. In the first stage the initialization takes place in which we give input and consider samples and have peak estimate. In the second stage sequential importance sampling is done in which the computation of state variables in which one state variable is computed using kalman filter equations [6] and upgrading the weights [3] and the normalization of weights takes place.

In next stage octave error correction is done by means of simple algorithm in which the particles accord with octave error will be decreased and particles which accord with actual pitch will be increased.

In the last stage resampling is done on particles if the estimated particle weight is not compatible with the observed one then after some iterations we get the compatible output. The resampling methodology used here is multinomial resampling.

Now we have certain tracked path and to evaluate in noisy environments we added a noise to the output then pass it through the MWSG Filter whose output is more efficient in all the ways [4].

The estimation of pitch period is done by weighted sum of particles with certain exponential gain. In this for accurate estimation of pitch period we used improved particle-kalman filter in which piggybacked the error obtained as another observation which has produced better results.

III. SIMULATION RESULTS

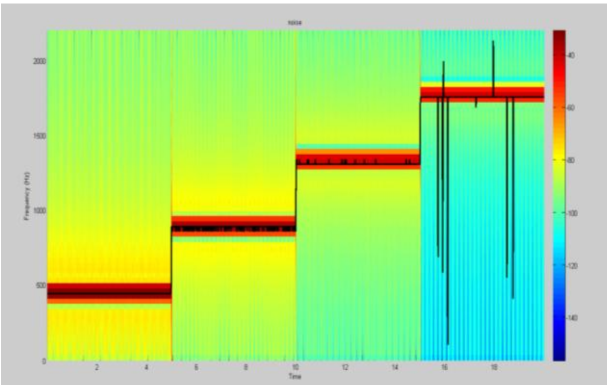

Fig. 3.1. The input of MWSG Filter

The above figure represents the spectrogram of tracked output affected with noise which should be eliminated. The added is Gaussian noise with normal distribution as probability density function. The noise is removed using the median filter and then compared with the proposed MWSG filter. The below figure represents the spectrogram of output of MWSG Filter which is noise free.

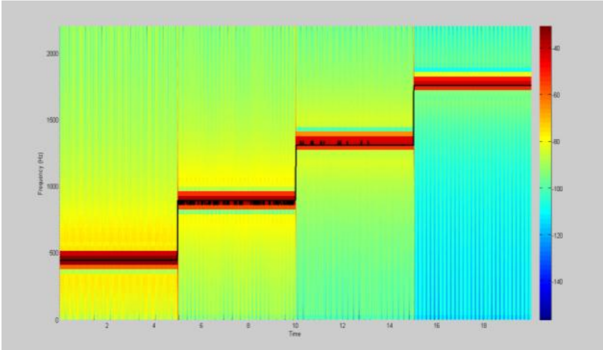

Fig. 3.2. The output of proposed algorithm

The random signal (defined in certain manner) is taken and given as input and in both figure represents the output in which the background is the spectrogram is input signal and the foreground (black line) represents the tracked output.

Table. 3.1. Comparison of Proposed methodology

Algorithm Used	PSNR	SNR
Median Filter	2.1894	2.987
MWSG Filter	10.527	9.8186

The above table represents signal to noise ratio and peak signal to noise ratio values of both the filters. The below shown are pitch period estimation results and their performance parameter fine pitch error.

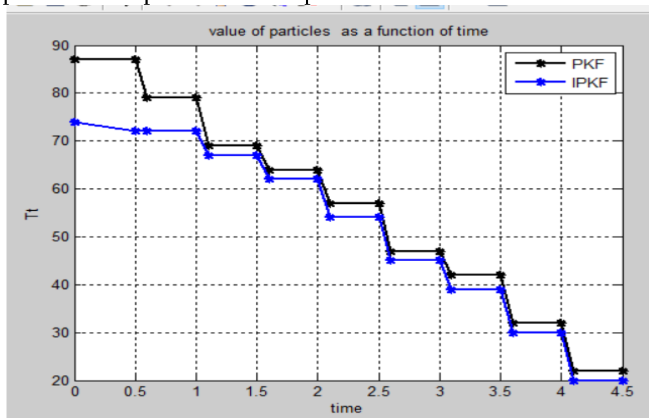

Fig. 3.3. Pitch Period Estimation

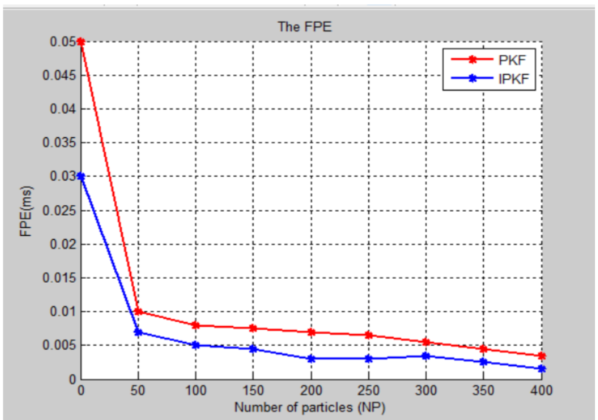

Fig. 3.4. Fine Pitch Error

IV. LIMITATIONS

The noise frequencies range should be known prior. While trying to remove noise there is chance of misleading signal as noise which gets eliminated.

V. CONCLUSION

The approach in this paper is to estimate and track the pitch period efficiently even in noisy environments which is done using Particle Kalman filter with the help of MWSG Filter. The performance of Spectrogram Enhanced Pitch Period Tracking using Median Filter and MWSG Filter is analyzed using Signal to Noise ratio and Peak Signal to Noise ratio as shown in table 3.1. From the results it is ensured that the Particle - Kalman Filter gives better results with MWSG Filter when compared to Median Filter for pitch period tracking in the noisy environments.

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