WAVELET AND S-TRANSFORM BASED SPECTRUM SENSING IN COGNITIVE RADIO

S.Raghave[#1], R.Saravanan[*2] , R.Muthaiah[#3]
School of Computing, SASTRA University, Thanjavur-613402, India
[#1]raga.vanaj@gmail.com
[*2]saravanan_r@ict.sastra.edu
[#3]sjamuthaiah@core.sastra.edu

***Abstract*- Cognitive Radio is an intellectual radio having the ability of recognizing the vacant spectrum to transmit the data to avoid spectrum inefficiently usage problem. Here CR uses the spectrum policies technique, to spot the existence of user in particular frequency band. In this paper, for efficient spectrum sensing operation, a Wavelet and S-Transform based approach for the detection of sub band edges in wide spectrum band where primary users are available. Here the exact occupation of primary users and noise signal is calculated by S-Transform. The simulation result shows the frequency range which was occupied by primary user and its value is calculated by above two methods and plotted.**

Keywords: Cognitive Radio, Spectrum Sensing, Continuous Wavelets Transform, S-Transform.

I. INTRODUCTION

Cognitive Radio (CR) is a developing technology to overcome the problem of using the spectrum inefficiently by improving idle spectrum utilization in both temporally and spatially. CR having the ability to access the spectrum dynamically and it statistics out which frequencies are not used and elite them to transmit and receive data. When compare to traditional radio technique, Cognitive radio have many features like activating several licensed frequency bands to allow the unconstrained secondary user to communicate by another CR in some spectrum policy which defines some CR rules and limitations, it provide the capability of transmitting the data just by modifying the operating factor without any alteration in the hardware components and spectrum sensing technique. The fundamental step of evolving technology Cognitive Radio is spectrum sensing, in which the primary users is sensed in that spectrum band to detect the spectrum holes by avoiding unintentional interference. There are various methods in spectrum sensing. Based on primary user availability spectrum sensing technique mainly grouped into three:

1) Non Cooperative detection (Transmitter detection),2) Cooperative detection,3) Interference detection. In Transmitter detection, Wavelet based spectrum sensing techniques is used for signal edge detection where primary users present to detect the spectrum opportunities.

In this paper Continuous Wavelet technique is used to sense vacant spectrum and sub band edges with low computational complexity. To find the frequency resolution exactly at given frequency the S-Transform is used here since it is more fast in sensing time and flexibility and can effectively detect frequency boundaries accurately even at low Signal to Noise Ratio. Wavelets have two aspects: scale and time. To sense the spectrum at different frequency bands with less bandwidth this reduces hardware complexity and sensing time by using the wavelet properties. To overcome the loss of frequency resolution occur at certain frequency in wavelet based method here S-Transform is used to found the small variation and spike signal to differentiate the real and imaginary signal. The main advantage of above method is ability to detect the availability of primary user even at high frequency and high noise. Here average power spectrum density (PSD) within each sub-band is identified to determine the unoccupied band and to identify the frequency locations of the non-overlapping spectrum.

Continuous Wavelet Signal is simulated and given as input for S-Transform to measure the frequency resolution and from the corresponding result various thresholds are plotted for calculated power spectral density. In Sections II, we discuss about the Wavelet Transform and Continuous wavelet signal, and in section III Basics of S-Transform and how S-Transform detect the frequency resolution of frequently varying signal is explained. The simulation results are shown and evaluated in section IV and in the concluding section V, future work is proposed.

II. WAVELET TRANSFORM

The wavelet theory is used to analyze signals using their component and set of basic functions. Wavelet is a mathematical tool used for evaluating singularities and irregular structures and the wavelet transform can able to describe the local regularity of signals. So the wavelet transform approach for spectrum detection in CR is well motivated to investigate the primary users. Wavelets are described by both scale and position, so it is useful in analyzing variations in signals and spectrum. The feature of scale is denoting by the notion of local regularity and time aspects is describes by a list of domains. The Continuous Wavelet Transform (CWT) is a two-parameter expansion of a signal for a wavelet function.

Using this wavelet transform technique the sensing time that taken to detect whether primary user using the spectrum or not is very less when compare to other type of spectrum sensing technique. Here the disintegration is taken as a complete, when de-noising and compression processes are at center points. Because in every stage of decomposition of wavelet it denote only the available frequency i.e. spectrum holes in which the secondary user can communicate.

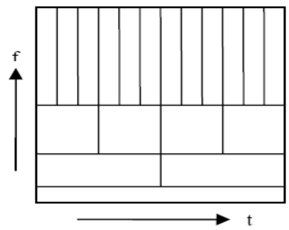

Fig.1. Two level decomposition using wavelet transform

In fig.1 at high frequencies the time resolution is good, while frequency resolution is low. At low frequency the frequency resolution is good while time resolution is bad. This also delivers required quality of time-frequency resolution compared to other transforms. Based on value of wavelet, the CWT is real or complex value function of frequency and time. In this paper, two level of decomposition is performed to generate CWT signal as mentioned in fig.1. At all scales, wavelet transforms keep dividing both low pass and high pass sub-bands. Consider low pass filter as an analyze filter and high pass as a simulation filter. From CWT signal the power is calculated from the amplitude of signal. Spectrum sensing is used to estimate the presence of user at power level in each band. In a wideband channel, for detecting edges in the power spectral density (PSD), wavelets are used.

III. S-TRANSFORM

The S-Transform (ST), is a hybrid of the Short Time Fourier Transform and Wavelet transform, has a time frequency resolution which is far from ideal. For time-frequency representation the ST is known for its local spectral phase properties. The Stransform is exclusively associates the time-frequency space of a frequency dependent resolution with fully referred data of local phase. From this we can easily describe the significance of phase in a local spectrum location. It also exhibits a frequency invariant amplitude response, which unable to display in the wavelet transform. The advantage of this ST approach is given and a comparison to wavelet transform is performed here. The S-transform is used to show referenced phase information absolutely, while the quality of the continuous wavelet transforms is lacking. Since CWT offsets high frequency signals relative to the low frequency signals.

A. Why S-Transform is combined with wavelet based spectrum detection:

The lack of phase data in the Wavelet transform led to the progress of the S transform, which sustains the total phase information and good time frequency resolution for all frequencies. In wavelet approach it only skilled to examine the local amplitude/power spectrum but in ST concurrently estimates local amplitude spectrum and local phase spectrum. The ST completely represents the amplitude of all signals, in difference to the CWT which diminishes high frequencies. It self-sufficiently reviews both the positive and negative frequency spectrum, whereas wavelet approaches are unqualified to a complex time series. The phase speed was deduced in S-transforms while evaluating the phase shifts between two time series. Such a candid analysis is impossible in wavelet based approach.

IV. RESULT

The Continous Wavelet signal is simulated for [0-1000MHz] frequency which given as input for S-Transform to detect the primary users as frequency resolution.

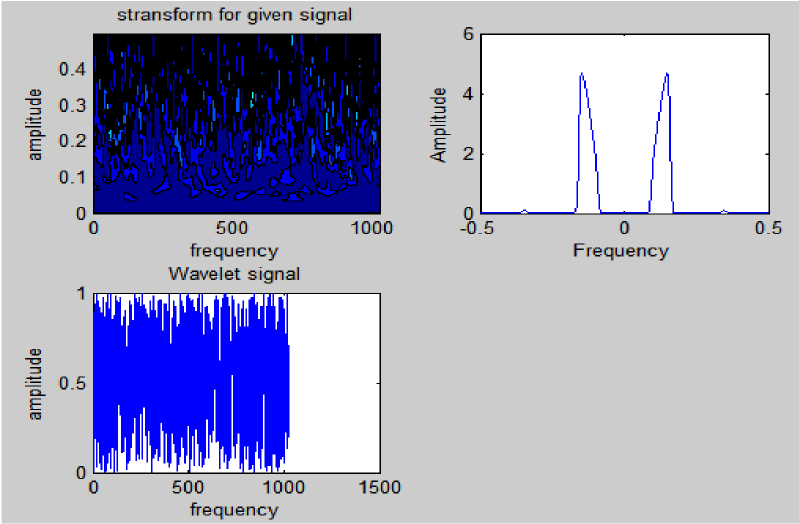

Fig.2. S-Transform signal is generated for the given Continuous Wavelet Signal

The above generated S-Transform signal is shown in 3D view which is easier to visualize the primary user in the specified frequency band to allocate the unoccupied frequency to the secondary users.

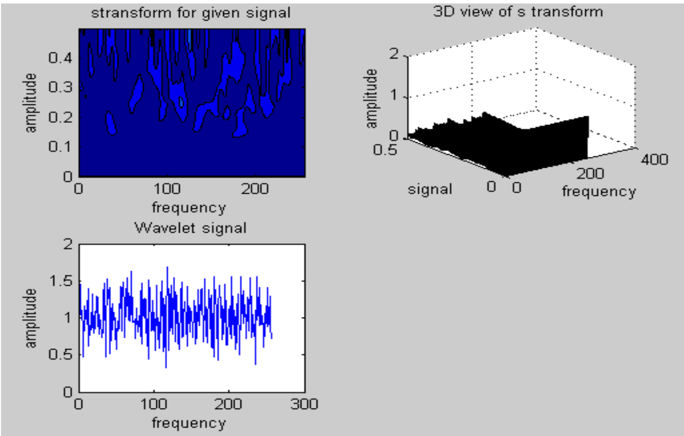

Fig. 3. 3D view of S-Transform for the given CWT signal

Here the simulation is taken as three steps. In first step the frequency range is divided into [0 – 300 MHz]. In that range many form of signal is generated and given as input in which the occupation is found in different form. The main advantage of using this S-Transform is can easily detect the small variation clearly and measure the peak value accurately.

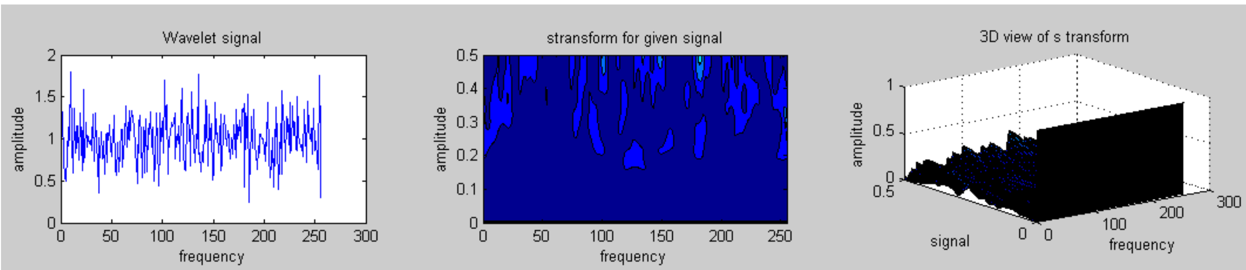

Fig. 4. No primary users are detected from simulated S-Transform signal

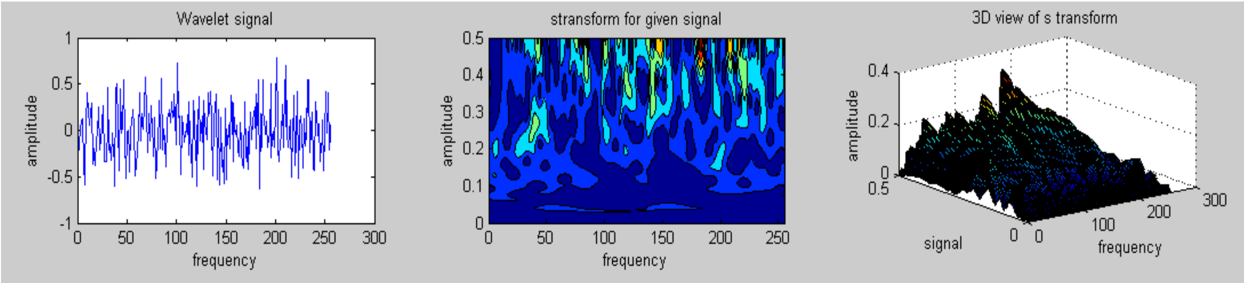

Fig. 5. Some primary users are detected near [150 – 200] frequency range.

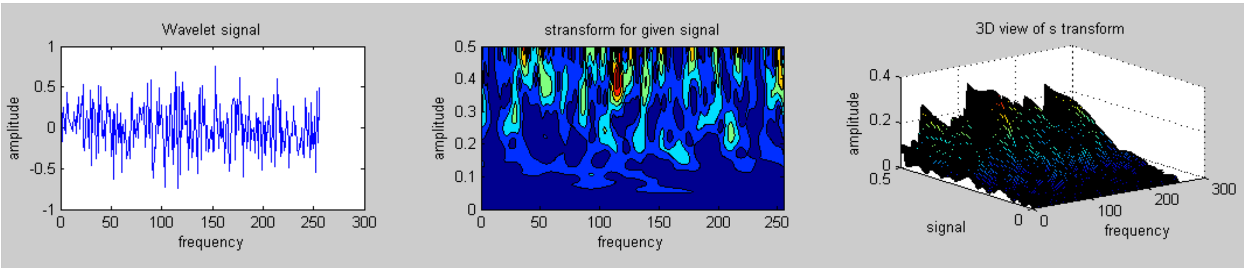

Fig. 6. Less no:of primary users are detected from simulated S-Transform signal

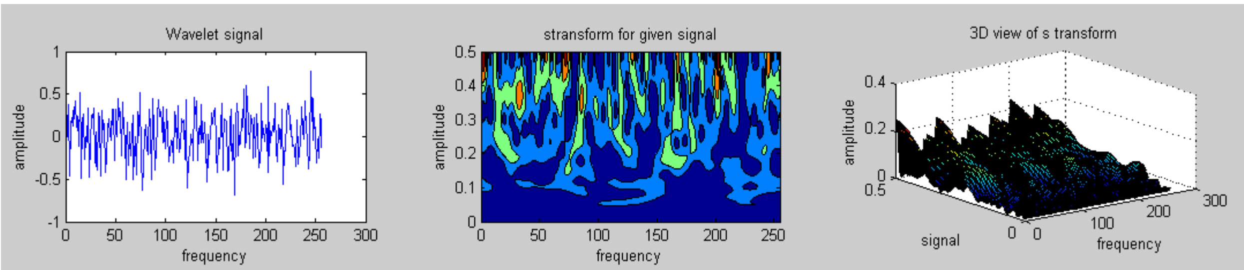

Fig. 7. More primary users are detected from simulated S-Transform signal

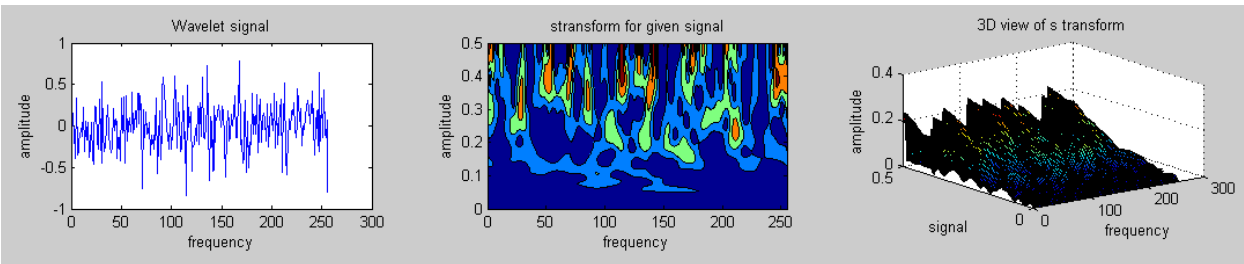

Fig. 8. Efficient primary users are detected from simulated S-Transform signal

In second step, the input signal is given in [0-150MHz] range to found whether the occupation area is licensed users or noises. Here the S-Transform is good to find the frequency resolution at low frequency. From the below simulated result the primary users are detected accurately by ignoring the false users and noise. In fig.9. there is no users are found in the given frequency band and in fig.10 by varying the signal only two users are found. In fig.11 only less no: of primary users are found but more noises are present in low frequency as earlier said S-Transform is good to find the frequency resolution at low frequency. In fig. 12 some users are found with noise which varies frequently so in next step by increasing the frequency range the S-Transform is simulate below.

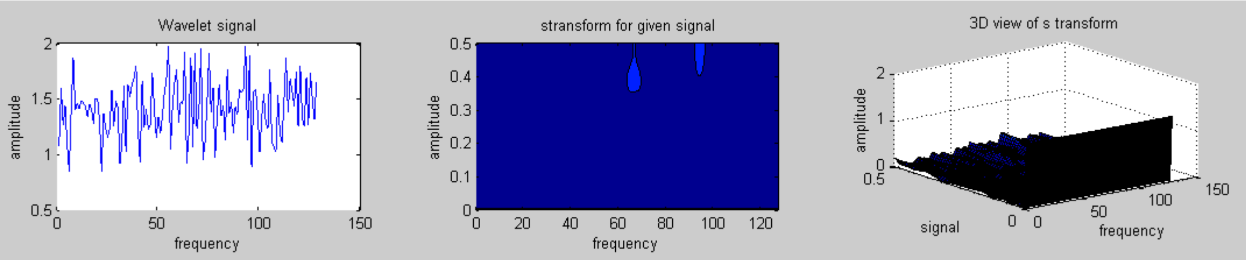

Fig. 9. No primary users are detected from simulated S-Transform signal

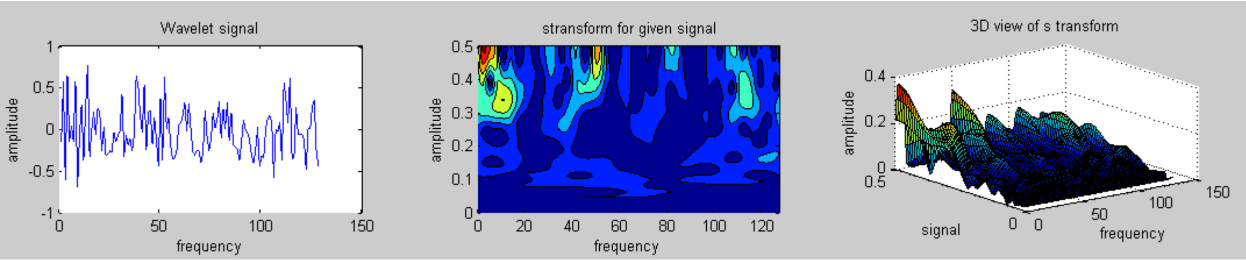

Fig. 10. Only two primary users are detected from simulated S-Transform signal

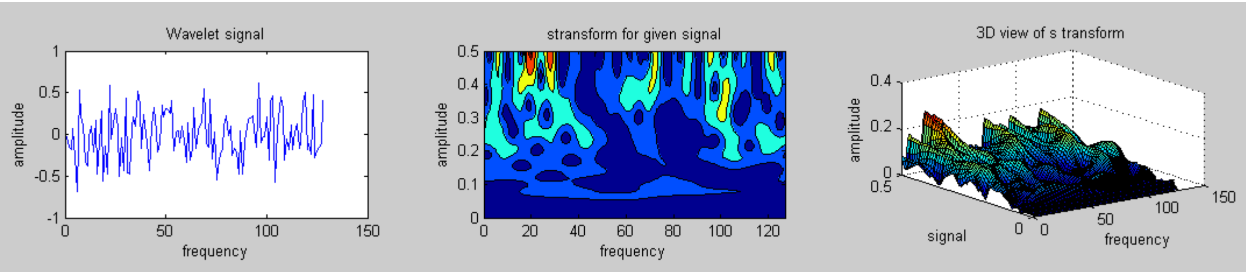

Fig. 11. Less primary users are detected and more noise found from simulated S-Transform signal

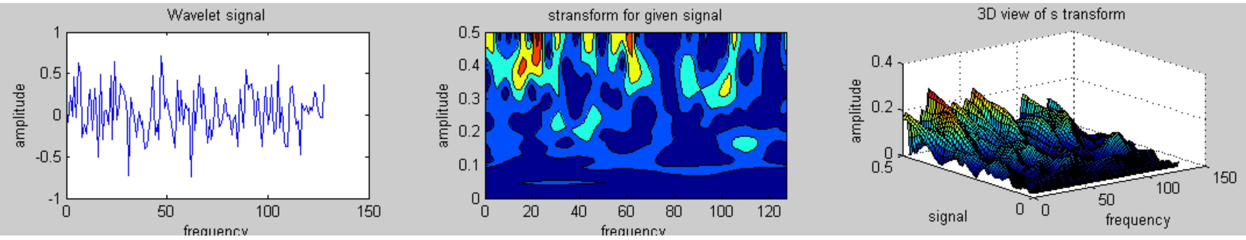

Fig. 12. Some primary users are detected with some noise

In third step, the input signal is given in [0-600MHz] range to found whether the occupation area is licensed users or noises. Here the S-Transform is good to find the frequency resolution at low frequency but it unable to detect the resolution at high frequency. From the below simulated result there is no primary users are detected. It shows only noise in the given frequency band.

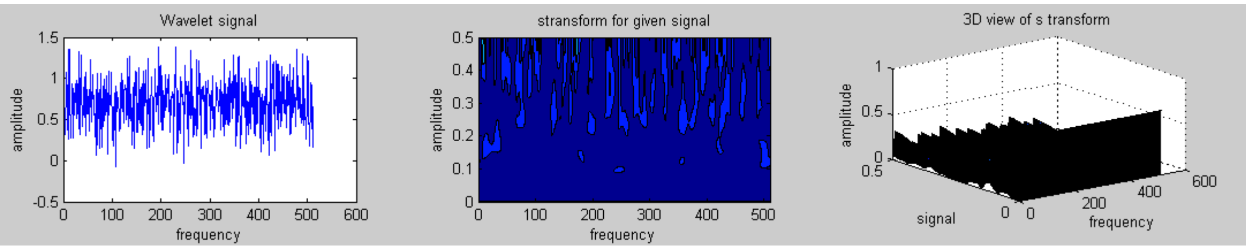

Fig. 13. No primary users are detected at high frequensy

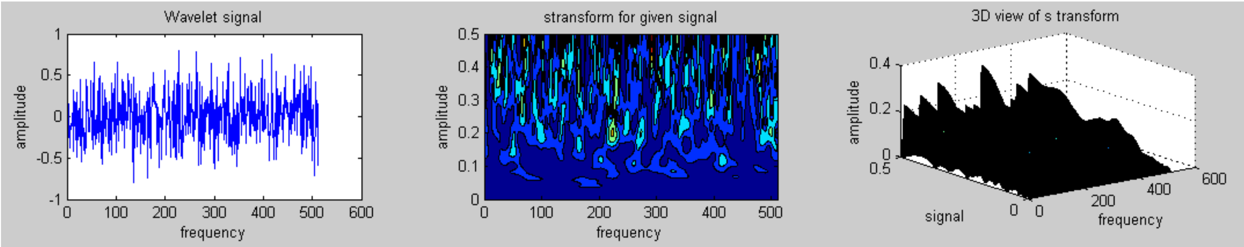

Fig. 14. Noises are detected from simulated S-Transform signal at high frequency

From the above simulated results many primary users are detected at various frequency range to find exactly where the primary user are present, Power spectral density is calculated and by fixing the threshold value the primary user found exactly by eliminating the noise and false or imaginary user occupation. In fig.15 the graph is plotted for PSD Vs power factor, which shows the presence of licensed user accurately for the given frequency band.

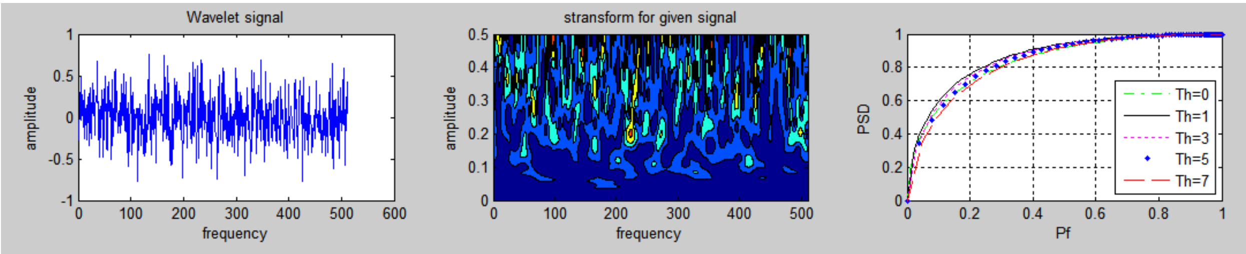

Fig. 15. Plotting Thershold value to detect the presence of primary users from Power spectral Value Vs Power factor for the given frequency band simulated by ST

V. CONCLUSION

In this paper, Continuous wavelet and S-Transform is used to sense the presence of primary users of cognitive radio. Thus the simulation shows the occupied frequency by measuring the PSD for various calculated threshold value. Here S-Transform is used to detect the small variation in the given frequency range. It found the availability of user even at low SNR level and give the accurate location of spectrum holes. The future work is to detect the user at high frequency using Modified S-Transform and M-Band Wavelet to overcome the loss of frequency resolution at high frequency.

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