FH Signal Interception Based on the Time-Frequency Spectrogram by Image Enhancement Techniques

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Abstract—**In the recent days new methods based on image processing are evolving for FH signal interception. In this project a method is proposed to extract the parameters of frequency hopping (FH) signals based on the spectrogram obtained by short-time Fourier transform (STFT). The spectrogram analysis will be investigated to detect and extract FH parameters by useful image processing techniques. After getting the STFT of received signal, we process the time frequency spectrogram in terms of image operations, where noise can be reduced by image enhancements and extract multiple image features. By this performance we can extract the FH parameters.**

MATLAB will be used for simulating the algorithm.

Keywords- **Contrast Stretching, Frequency-Hopping Spread Spectrum, Morphological Operations, STFT, Spectrogram.**

I. INTRODUCTION

Frequency hopping (FH) one of the spread spectrum (SS) technique which has good immunity to channel noise and can provide security to the communication link by employing pseudo random selected carriers. In military and police search operations there is great requirement of intercepting such signal and identifying the parameters of the FH communication link.

Even today not proven systems are developed which can detect the FH signals with a reasonable success rate. With the development of low cost FH wireless embedded modules the need for developing the effective interception algorithms is increasing.

Introducing image processing into the FH detection, this kind of methods can eliminate some kinds of interferences effectively, but they didn't give out explicit ways to verify the existence of FH signals, and they cannot detect the hops jammed with fixed-frequency interferences.

II. Frequency-Hopping Spread Spectrum

Frequency hopping signal changes the carrier with high rate hence the effective signal spectrum is much wider than the normal signal bandwidth. Frequency-hopping spread spectrum (FHSS) is a method of transmitting radio signals by rapidly switching a carrier among many frequency channels, using a pseudorandom sequence known to both transmitter and receiver. It is utilized as a multiple access method in the frequency-hopping code division multiple access (FH-CDMA) scheme. A spread-spectrum transmission offers three main advantages over a fixed-frequency transmission:

1.Spread-spectrum signals are highly resistant to narrowband interference. The process of re-collecting a spread signal spreads out the interfering signal, causing it to recede into the background.

2.Spread-spectrum signals are difficult to intercept. An FHSS signal simply appears as an increase in the background noise to a narrowband receiver. An eavesdropper would only be able to intercept the transmission if they knew the pseudorandom sequence.

3.Spread-spectrum transmissions can share a frequency band with many types of conventional transmissions with minimal interference. The spread-spectrum signals add minimal noise to the narrow-frequency communications, and vice versa. As a result, bandwidth can be utilized more efficiently.

FH communication has received ever increasing attention as numerous applications have adopted this scheme. With this increased use of FH communications, naturally, came the question of detection. This question has given rise to a considerable amount research. Many new detection methods are proposed in recently years.

III. PROPOSED ALGORITHM

The parameters explained here are mentioned in the below block diagram as in fig 4.2

1. Time Frequency Analysis

1.1 Short-term FT(STFT)

The STFT is chosen to preprocess the broadband received signal. The time-frequency spectrum of the signal can be obtained:

$$stft(m,k) = \sum_{n=0}^{N-1} r(n)\omega*(n-m)e - j2\pi kn/N$$

In order to achieve reliable processing, proper time-frequency resolution and window function $w(m)$ should be chosen according to the range of hop rate. The amplitude of time-frequency spectrum can be regarded as an image; therefore, image processing methods can be adopted to acquire image features. The operations of image processing are orderly introduced as follow. The signal existence area of the image in our analysis focus, which can be obtained by image segmentation.

$$Sbin(m,k)=\begin{cases}1, & |Stft(m,k)|^2 \geq \mu \\ 0, & |Stft(m,k)|^2 < \mu\end{cases} \quad ,\mu = -ln(\alpha_0)\lambda_{m,k}$$

where *Sbin*(*m*, *k*) expresses the binary image after segmentation, $\alpha 0$ is the given false alarm probability, $\lambda m,k$ represents the power of noise, it can be obtained by averaging the power of a certain region whose center is point (m, k).

1.2 Spectrogram

It is a time-varying spectral representation (forming an image) that shows how the spectral density of a signal varies with time. Spectrogram of a signal s(t) is the squared magnitude of the STFT of the signal .

Spectrogram{x(t)} = |X(T,W)|2

2. Image Processing

Time-frequency spectrum is obtained from time-frequency analysis, which is regarded as an image of special contents. The noise in the image is removed by contrast stretching, and by morphological operations.

2.1 Contrast Stretching

Contrast stretching is a simple image enhancement technique that improves the contrast in an image by'stretching' the range of intensity values it contains to span a desired range of values. This involves identifying lower and upper bounds from the histogram (usually the minimum and maximum brightness values in the image) and applying a transformation to stretch this range to fill the full range. It is the basic form of contrast stretching which involves the mapping of pixel values observed (m,M) to the full dynamic range(n,N). The output value

Where $g(x,y) = (N-n)\left[\frac{f(x,y)-m}{M-m}\right]+n$ g(x,y) output grey level.

f(x,y) input grey level.

m minimum of observed data range.

M maximum of observed data range.

n minimum for available grey level scale(n,N).

N maximum for available grey level scale(n,N)

2.2 Morphological Operations

Four basic morphological operations are used in the processing of binary images: erosion, dilation, opening, and closing.

Erosion makes the objects smaller, and can break a single object into multiple objects.

Dilation makes the objects larger, and can merge multiple objects into one.

Opening removes small islands and thin filaments of object pixels.

Likewise, closing removes islands and thin filaments of background pixels. These techniques are useful for handling noisy images where some pixels have the wrong binary value. Introducing image processing into the FH detection, this kind of methods can eliminate some kinds of interferences effectively, but they didn't give out explicit ways to verify the existence of FH signals.

IV. BLOCK DIAGRAMS

In the project as the input must be created (dummy input) to see the code is working and can detect the hop frequency, this work is carried out by a program called frequency hopping parameters print.

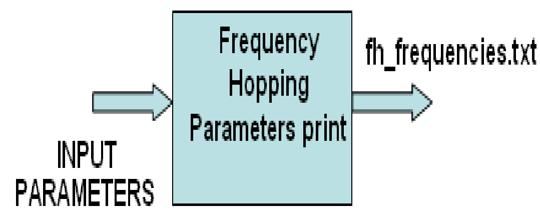

Fig: 4.1.Block diagram of frequency hopping transmission parameters

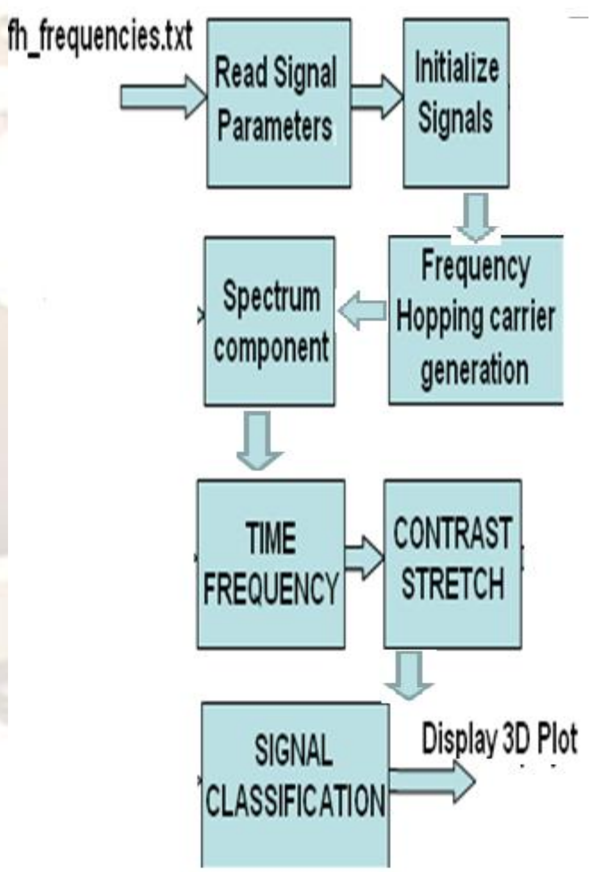

Fig: 4.2.Block diagram of frequency hopping detection

V. SIMULATION RESULTS

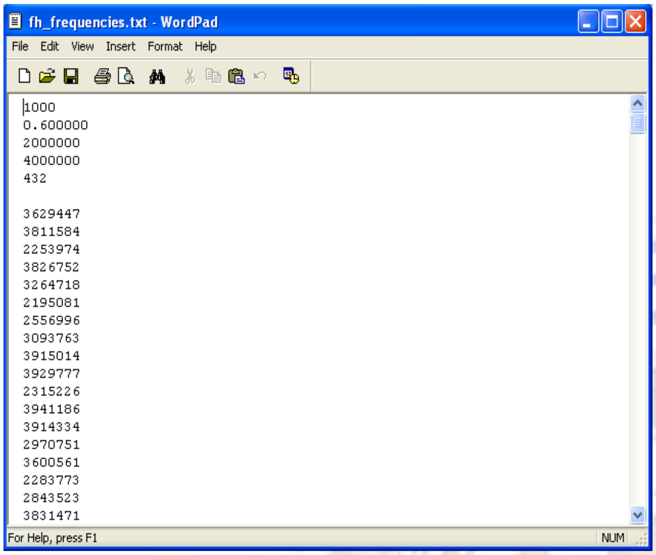

Fig: 5.1.FH parameters print

The above fig shows the output of program will be saved in the file that contains the values of hop frequency.

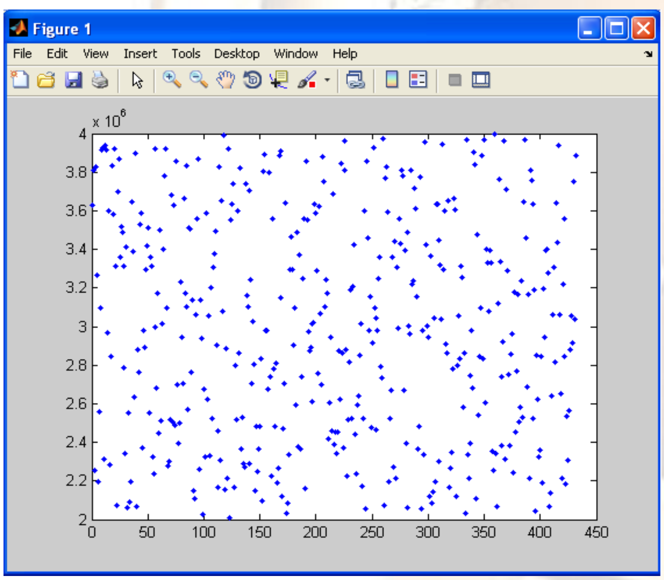

Fig: 5.2. Frequency parameters are converted

The above hop frequencies will be converted into image by using the plot command then resultant image is shown below.

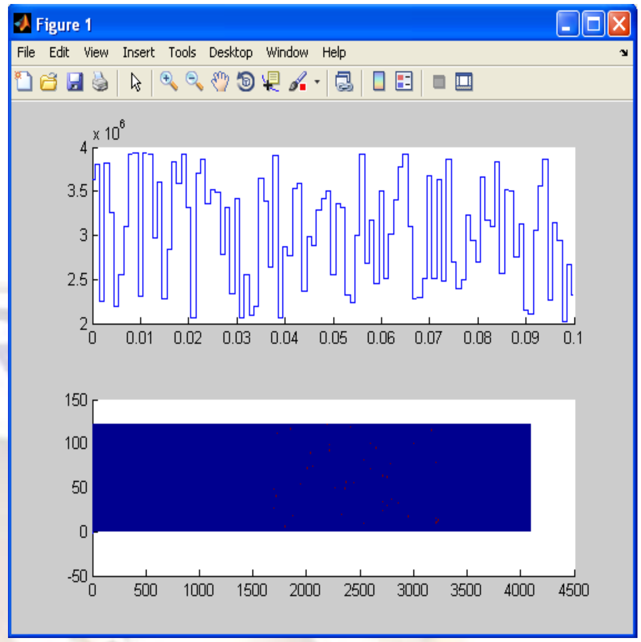

Fig: 5.3. Initialisation of FH signal

The above fig shows in plot upper subplot consists of 'x' axis showing time at and 'y' axis showing frequency in MHz by seeing the waveform it display at particular time what frequency is been utilized to transmit message in frequency hopping technique. In downward subplot red dots in the figure shows frequency has been hopped from one frequency to another frequency.

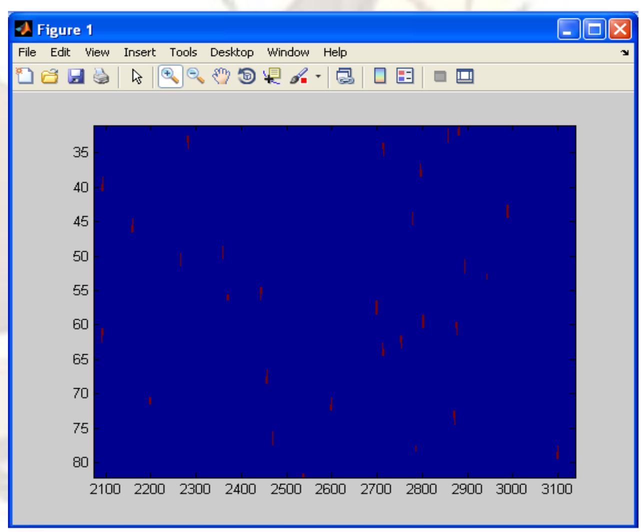

Fig: 5.4.Image of frequency vs time

The above fig shows the zoomed image of fig:5.3. downward plot with red dots as noise .

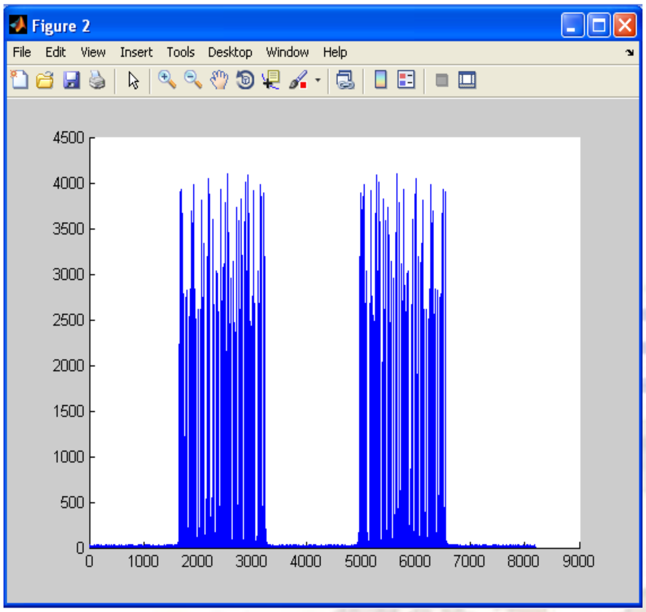

Fig: 5.5.Output of waterfall wave form

The above fig shows the water fall waveform of STFT output of the image signals processed

Fig: 5.6.Image converted to grayscale

The above fig represents that the process zoomed image of fig:5.4.with morphological image processing, it is converted to gray scale image in this 'x' axis as frequency and 'y' is represented with time.

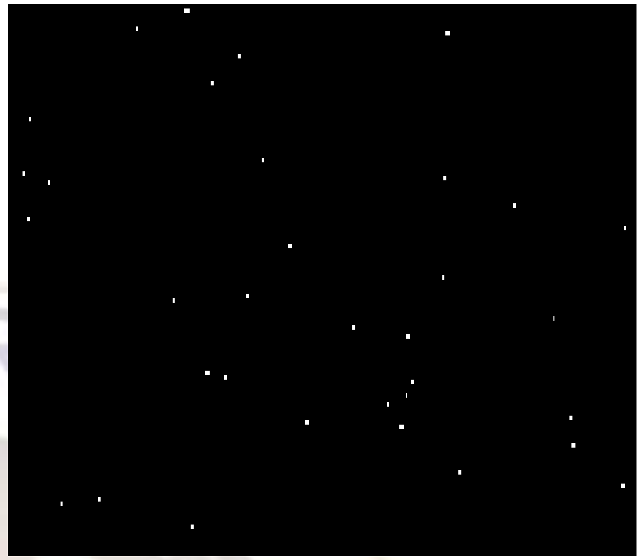

Fig: 5.7. Output image after contrast stretching

The above fig represents that by using contrast stretching of image, noise is eliminated from the image

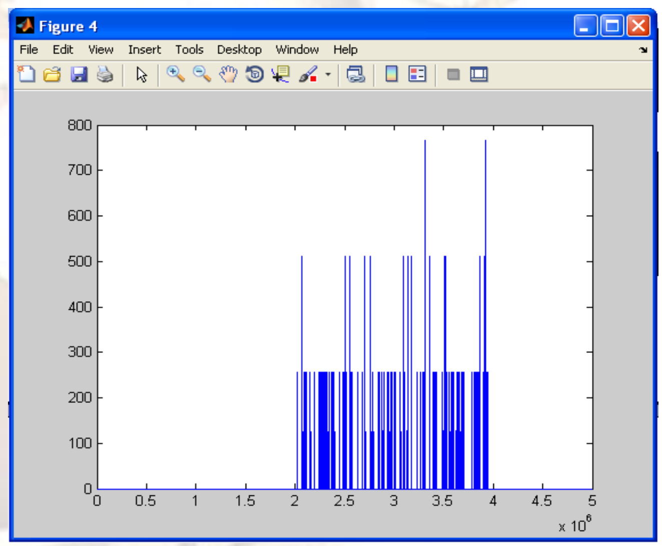

Fig: 5.8. Frequency hoped signal

The above fig represents the frequency hoping signal in blue color wherever same frequency is reputed then amplitude will be doubled i.e. same frequency is hoped.

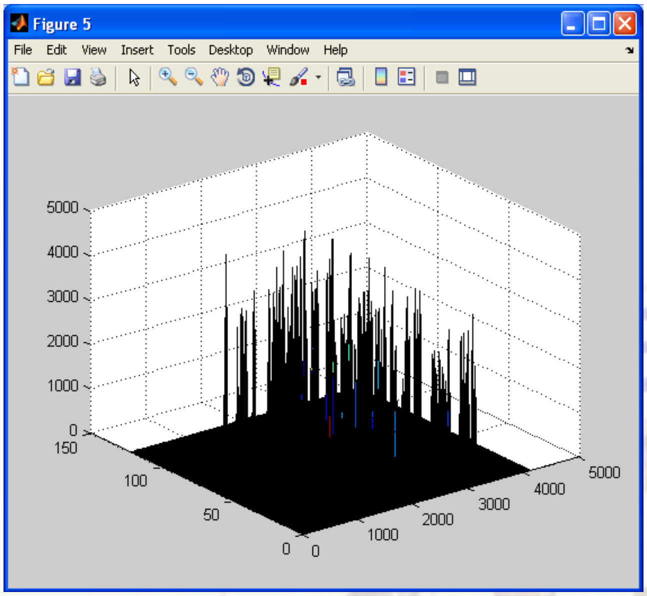

Fig: 5.9. Frequency hoped signal in 3D view

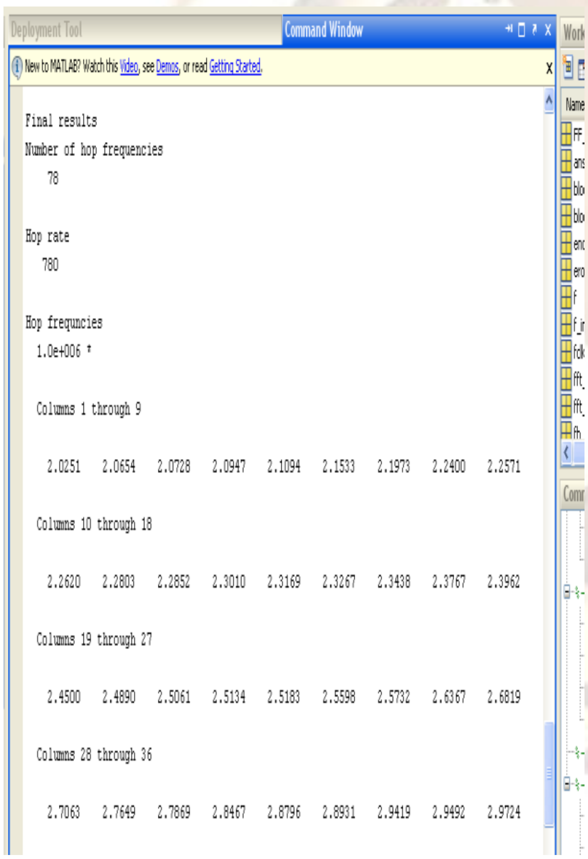

Fig: 5.10.Output of final result

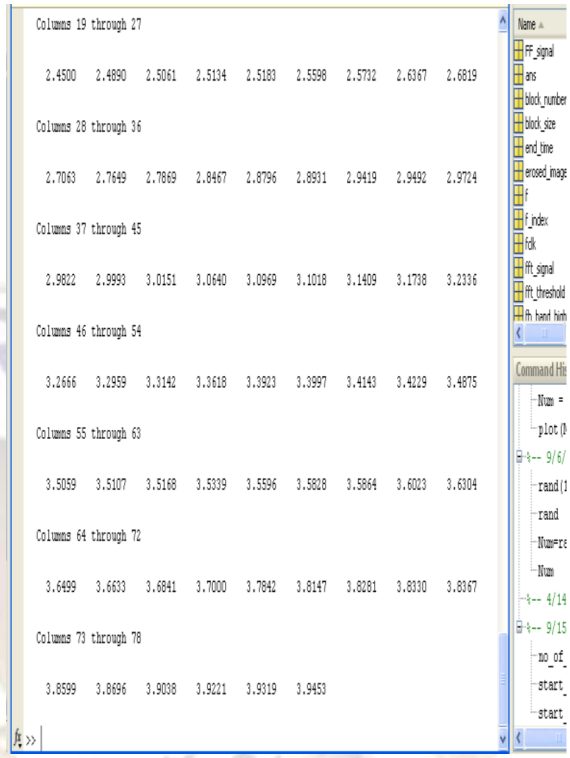

Fig: 5.11. Continuation of final result

The above figs:5.10,5.11 represents the results of parameters i.e.no of the hoping frequencies, hop rate.

VI. CONCLUSION

In this paper a technique for detecting unknown FH signals in complicated environment was described. The proposed method can be processed in real-time FH signals at high wide-band sampling rate. Algorithm implementation and simulation results will show that, this detection algorithm is feasible to implement in hardware and efficient. It is low complex algorithm compared to Wavelet transform based techniques. In military and police search operations there is a great requirement.

REFERENCES

[1] Mei Wenhua, Wang Shubo,Qiu Yonghong and Du Xingmin, Frequency Hopping Communications, National Defence Industry Press,China,2005.

[2] R.C. Gonzalez, and R.E.Woods, Digital Image Processing (2^{nd} edition).

[3] Cui Yi, Image Processing and Analysis-Mathematical Morphological Methods and Applications, Science Press, China,2000.

[4] MATLAB 7 Desktop Tools and Development Environment, The MathWorks, Inc., 2004.

[5] Wang Zhong, Zhou Li. Simulation and analysis of the frequency hopping signal by

MATLAB. Computer Simulation,20 (11), pp: 131-134,2003.

[6] Xu Mankun, Ping Xijian, Li Tianyun, Xu Mantian. A new time-frequency spectrogram analysis of FH signals by image enhancement and mathematical morphology. Fourth International Conference on Image and Graphics, 2007. ICIG 2007. pp:610-615, 2007.

[7] Hu Xiaofeng, Zhao Hui. Practical cases of Visual C++/MATLAB Image Processing and Identification. Posts & Telecom Press, Beijing, 2004.

[8] He Dongjian. Digital Image Processing. Xidain University Press, Xi'an, 2003.

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