Claims

1. An Unmanned Aerial Vehicle (UAV) detection system comprising:

a radio, a processor, a memory and instructions stored on the memory and executable by the processor to:

receive IQ data from the radio;

process the IQ data to form a spectrogram image in the following sequence:

apply a window function to the IQ data to filter out noise;

transform the IQ data into frequency-domain data forming a spectrogram data;

square the spectrogram data to ensure the data comprises of positive Real numbers;

apply averaging of the squared spectrogram data over several consecutive time blocks to form an initial spectrogram image; and

convert the initial spectrogram image to a logarithmic scale; and

analyse the spectrogram image to determine if the signal received belongs to a UAV

2. The UAV detection system according to claim 1 wherein the window function is Blackman-Harris window.

3. The UAV detection system according to claim 1 wherein the instruction to transform the IQ data into frequency-domain data comprises instructions to:

apply a Fast Fourier Transform (FFT) to convert the IQ data from time-domain signal to frequency-domain signal; and

stack the frequency-domain signals over several time blocks to form the spectrogram data.

4. The UAV detection system according to claim 3 wherein the spectrogram data is squared with the following expression:

$$|X[k]|^2 = |X_{re}[k]|^2 + |X_{im}[k]|^2$$

where *k* denotes the FFT subcarrier, X_{re} is the real (I) part of the frequency-domain signals and X_{im} is the imaginary (Q) part of the frequency-domain signals.

5. The UAV detection system according to claim 4 wherein the squared spectrogram data is averaged with the following expression:

$$Y[k] = \frac{1}{8}\sum_{i=0}^{7}|X[k]|_i^2$$

where *i* is the time block.

6. The UAV detection system according to claim 5 wherein the initial spectrogram image is converted to a logarithmic scale with the following expression $R[k] = \log_{10}(Y[k] + 1)$.

7. The UAV detection system according to claim 6 wherein the logarithmic scale is within 0 to 255.

8. The UAV detection system according to claim 1 wherein the instruction to analyse the spectrogram image to determine if the signal received belongs to a UAV comprises instructions to:

feed the spectrogram to a deep learning module to determine the presence of an uplink and/or downlink UAV signal.

9. A method of detecting an Unmanned Aerial Vehicle (UAV) comprising:

receiving IQ data from a radio;

processing the IQ data to form a spectrogram image in the following sequence:

applying a window function to the IQ data to filter out noise;

transforming the IQ data into frequency-domain data forming a spectrogram data;

squaring the spectrogram data to ensure the data comprises of positive Real numbers;

applying averaging of the squared spectrogram data over several consecutive time blocks to form an initial spectrogram image;

converting the initial spectrogram image to a logarithmic scale; and

analysing the spectrogram image to determine if the signal received belongs to a UAV.

10. The method according to claim 9 wherein the window function is Blackman-Harris window.

11. The method according to claim 9 wherein the step of transforming the IQ data into frequency-domain data comprises:

applying a Fast Fourier Transform (FFT) to convert the IQ data from time-domain signal to frequency-domain signal; and

stacking the frequency-domain signals over several time blocks to form the spectrogram data.

12. The method according to claim 11 wherein the spectrogram data is squared with the following expression:

$$|X[k]|^2 = |X_{re}[k]|^2 + |X_{im}[k]|^2$$

where *k* denotes the FFT subcarrier, X_{re} is the real (I) part of the frequency-domain signals and X_{im} is the imaginary (Q) part of the frequency-domain signals.

13. The method according to claim 12 wherein the squared spectrogram data is averaged with the following expression:

$$Y[k] = \frac{1}{8}\sum_{i=0}^{7}|X[k]|_i^2$$

where *i* is the time block.

14. The method according to claim 13 wherein the initial spectrogram image is converted to a logarithmic scale with the following expression $R[k] = \log_{10}(Y[k] + 1)$.

15. The method according to claim 14 wherein the logarithmic scale is within 0 to 255.

16. The method according to claim 9 wherein the step of analysing the spectrogram image to determine if the signal received belongs to a UAV comprises:

feeding the spectrogram to a deep learning module to determine the presence of an uplink and/or downlink UAV signal.