CLAIMS

1. A system for monitoring a health condition of a user, comprising:

a sensor configured to receive a sound from the user;

an analogue-to-digital converter configured to convert the received sound into a digital signal, wherein the analogue-to-digital converter is configured to sample the received sound at below the Nyquist's sampling rate;

a selection circuit configured to select a predetermined number of samples from the digital signal;

an entropy determination circuit configured to determine at least one entropy-based parameter value based on the selected samples; and

an entropy comparator circuit configured to compare the at least one entropy-based parameter value with a predetermined threshold value to detect a health signal for monitoring the health condition.

2. The system as claimed in claim 1, further comprising a filter and amplifier module configured to amplify the received signal.

3. The system as claimed in claim 1 or 2, further comprising a segmentation circuit configured to segment the digital signal into a plurality of segments of a first time duration; and wherein the selection circuit is configured to select the samples from the plurality of segments.

4. The system as claimed in claim 3, wherein the first time duration is one of between about 10 ms to about 1 s and about 64 ms.

5. The system as claimed in claim 3 or 4, wherein the selected predetermined number of samples comprise samples corresponding to one of a segment and an overlap between two adjacent segments of the plurality of segments.

6. The system as claimed in claim 5, wherein the overlap is one of between about 0% to about 100% and about 50%.

7. The system as claimed in any one of claims 1 to 6, further comprising a transformation circuit configured to transform the selected predetermined number of samples into a plurality of frequency components.

8. The system as claimed in claim 7, wherein the transformation circuit is configured to perform a Short Time Fourier Transform.

9. The system as claimed in claim 7 or 8, further comprising an averaging filtering circuit configured to determine a plurality of dominant frequency components.

10. The system as claimed in claim 9, wherein the averaging filtering circuit is configured to determine the plurality of dominant frequency components from the plurality of frequency components.

11. The system as claimed in claim 9 or 10, wherein the averaging filtering circuit comprises:

a comparator circuit configured to compare a respective magnitude of each of the plurality of frequency components with a threshold point; and

an identification circuit configured to identify at least one of a dominant frequency component when the respective magnitude is above the threshold point and a non-dominant frequency component when the respective magnitude is below the threshold point.

12. The system as claimed in claim 11, further comprising a threshold determination circuit configured to determine the threshold point by averaging magnitudes of a predetermined number of neighbouring components of the plurality of frequency components.

13. The system as claimed in claim 12, wherein the predetermined number of neighbouring components is one of between about 0 to about the predetermined number of samples and about a quarter of the predetermined number of samples.

14. The system as claimed in claim 9 or 10, wherein the averaging filtering circuit comprises:

a comparator circuit configured to compare a respective magnitude of each of a plurality of power components in a power spectrum corresponding to the plurality of frequency components with a threshold point;

an identification circuit configured to identify at least one of a dominant frequency component when the respective magnitude of the corresponding power component in the power spectrum is above the threshold point and a non-dominant frequency component when the respective magnitude of the corresponding power component in the power spectrum is below the threshold point.

15. The system as claimed in claim 14, further comprising a threshold determination circuit configured to determine the threshold point by averaging magnitudes of a predetermined number of neighbouring power components in the power spectrum.

16. The system as claimed in claim 15, wherein the predetermined number of neighbouring power components is one of between about 0 to about the predetermined number of samples and about a quarter of the predetermined number of samples.

17. The system as claimed in any one of claims 11 to 16, wherein the non-dominant frequency components are discarded.

18. The system as claimed in any one of claims 11 to 16, further comprising a substitution circuit configured to replace a respective magnitude of each of the non-dominant frequency components with one of about 0.01 and a numeral between about 0 to a value corresponding to a smallest value of the non-dominant frequency components.

19. The system as claimed in any one of claims 11 to 18, further comprising a power determination circuit configured to determine a plurality of normalized power of the dominant frequency components.

20. The system as claimed in claim 19, wherein the entropy determination circuit is configured to determine a plurality of entropy values from the plurality of normalized power.

21. The system as claimed in claim 20, wherein the entropy determination circuit is further configured to determine a maximum entropy value and a minimum entropy value from the plurality of entropy values after a second time duration.

22. The system as claimed in claim 21, wherein the second time duration is one of about 3 s and greater than the first time duration.

23. The system as claimed in claim 21 or 22, wherein the at least one entropy-based parameter value comprises at least one of an entropy difference between the maximum entropy value and the minimum entropy value and an entropy ratio of the maximum entropy value to the minimum entropy value.

24. The system as claimed in claim 23, wherein the entropy comparator circuit is further configured to subtract the at least one of the entropy difference and the entropy ratio from the predetermined threshold value to produce a result; and identify that the health signal is present when the result is a positive value or identify that the health signal is absent when the result is a negative value.

25. The system as claimed in claim 24, wherein the predetermined threshold value is one of a fixed threshold value and an adaptive threshold value.

26. The system as claimed in claim 25, further comprising an adaptive threshold determination circuit configured to determine the adaptive threshold value.

27. The system as claimed in claim 26, wherein the adaptive threshold determination circuit comprises:

a noise power determination circuit configured to determine a noise power from the non-dominant frequency components; and

a look-up comparator circuit configured to determine the adaptive threshold value based on the noise power and a look-up table comprising a plurality of predetermined threshold values at different noise powers.

28. The system as claimed in any one of claims 1 to 27, further comprising a sample selection circuit configured to reduce the number of samples from the selected predetermined number of samples.

~~29. The system as claimed in any one of claims 1 to 28, wherein the analogue-to-digital converter is configured to sample the received sound at below the Nyquist's sampling rate.~~

~~30~~29. The system as claimed in any one of claims 1 to ~~29~~28, wherein the sensor comprises a sound-based sensor.

~~31~~30. The system as claimed in any one of claims 1 to ~~30~~29, wherein the sensor comprises one of an air conduction sensor, a microphone, a stethoscope, a piezo-electric sensor and a pressure sensor.

~~32~~31. The system as claimed in any one of claims 1 to ~~31~~30, wherein the health condition comprises at least one of a respiratory condition and a cardiac condition.

~~33~~32. The system as claimed in any one of claims 1 to ~~32~~31, wherein the health condition comprises a condition selected from a group consisting of wheezing, asthma, chronic obstructive pulmonary disease, obstructive sleep apnea syndrome, stridor, crackles, coughing and any combination thereof.

~~34~~33. A method for monitoring a health condition of a user, comprising:

receiving a sound from the user;

converting the received sound into a digital signal;

selecting a predetermined number of samples from the digital signal;

determining at least one entropy-based parameter value based on the selected samples; and

comparing the at least one entropy-based parameter value with a predetermined threshold value to detect a health signal for monitoring the health condition,

wherein converting the received sound into a digital signal comprises sampling the received sound at below the Nyquist's sampling rate.

~~35~~34. The method as claimed in claim ~~34~~33, further comprising:

filtering and amplifying the received sound.

~~36~~35. The method of as claimed in claim ~~34~~33 or ~~35~~34, further comprising:

segmenting the digital signal into a plurality of segments of a first time duration; and

wherein selecting the samples comprises selecting from the plurality of segments.

~~37~~36. The method as claimed in claim ~~36~~35, wherein the first time duration is one of between about 10 ms to about 1 s and about 64 ms.

~~38~~37. The method as claimed in claim ~~36~~35 or ~~37~~36, wherein the predetermined number of selected samples comprise samples corresponding to one of a segment and an overlap between two adjacent segments of the plurality of segments.

~~39~~38. The method as claimed in claim ~~38~~37, wherein the overlap is one of between about 0% to about 100% and about 50%.

4039. The method as claimed in any one of claims 34-33 to 3938, further comprising transforming the predetermined number of selected samples into a plurality of frequency components.

4140. The method as claimed in claim 4039, wherein transforming the selected samples into the plurality of frequency components comprises performing a Short Time Fourier Transform.

4241. The method as claimed in claim 40-39 or 4140, further comprising determining a plurality of dominant frequency components from the plurality of frequency components.

4342. The method as claimed in claim 4241, wherein determining the plurality of dominant frequency components comprises performing an averaging filtering process.

4443. The method as claimed in claim 4342, wherein performing the averaging filtering process comprises:

comparing a respective magnitude of each of the plurality of frequency components with a threshold point;

identifying at least one of a dominant frequency component when the respective magnitude is above the threshold point, and

a non-dominant frequency component when the respective magnitude is below the threshold point.

4544. The method as claimed in claim 4443, further comprising determining the threshold point by averaging magnitudes of a predetermined number of neighbouring components of the plurality of frequency components.

4645. The method as claimed in claim 4544, wherein the predetermined number of neighbouring components is one of between about 0 to about the predetermined number of samples and about a quarter of the predetermined number of samples.

4746. The method as claimed in claim 4342, wherein performing the averaging filtering process comprises:

comparing a respective magnitude of each of a plurality of power components in a power spectrum corresponding to the plurality of frequency components with a threshold point;

identifying at least one of a dominant frequency component when the respective magnitude of the corresponding power component in the power spectrum is above the threshold point, and a non-dominant frequency component when the respective magnitude of the corresponding power component in the power spectrum is below the threshold point.

4847. The method as claimed in claim 4746, further comprising determining the threshold point by averaging magnitudes of a predetermined number of neighbouring power components in the power spectrum.

4948. The method as claimed in claim 4847, wherein the predetermined number of neighbouring power components is one of between about 0 to about the predetermined number of samples and about a quarter of the predetermined number of samples.

5049. The method as claimed in any one of claims 44-43 to 4948, further comprising discarding the non-dominant frequency components.

5150. The method as claimed in any one of claims 44-43 to 4948, further comprising replacing a respective magnitude of each of the non-dominant frequency components with one of about 0.01 and a numeral between about 0 to a value corresponding to a smallest value of the non-dominant frequency components.

5251. The method as claimed in any one of claims 44-43 to 5150, further comprising determining a plurality of normalized power of the dominant frequency components.

~~53~~52. The method as claimed in claim ~~52~~51, further comprising determining a plurality of entropy values from the plurality of normalized power.

~~54~~53. The method as claimed in claim ~~53~~52, further comprising determining a maximum entropy value and a minimum entropy value from the plurality of entropy values after a second time duration.

~~55~~54. The method as claimed in claim ~~54~~53, wherein the second time duration is one of about 3 s and greater than the first time duration.

~~56~~55. The method as claimed in claim ~~54~~53 or ~~55~~54, wherein determining at least one entropy-based parameter value comprises determining at least one of an entropy difference E_d between the maximum entropy value and the minimum entropy value from the equation:

$$E_d = E_{max} - E_{min}$$

and an entropy ratio E_r of the maximum entropy value to the minimum entropy value from the equation:

$$E_r = \frac{E_{max}}{E_{min}}$$

where E_{max} is the maximum entropy value and E_{min} is the minimum entropy value.

~~57~~56. The method as claimed in claim ~~56~~55, wherein comparing the at least one entropy-based parameter value with the predetermined threshold value to detect the health signal related to the health condition comprises:

subtracting at least one of the entropy difference and the entropy ratio from the predetermined threshold value to produce a result; and

identifying that the health signal is present when the result is a positive value or

identifying that the health signal is absent when the result is a negative value.

~~58~~57. The method as claimed in claim ~~57~~56, wherein the predetermined threshold value is one of a fixed threshold value and an adaptive threshold value.

5958. The method as claimed in claim 5857, further comprising determining the adaptive threshold value, comprising:

determining a noise power from the non-dominant frequency components; and

determining the adaptive threshold value based on the noise power and a look-up table comprising a plurality of predetermined threshold values at different noise powers.

6059. The method as claimed in any one of claims 34-33 to 5958, further comprising reducing the number of samples from the selected predetermined number of samples.

~~61. The method as claimed in any one of claims 34 to 60, wherein converting the received sound into digital signals comprises sampling the received sound at below the Nyquist's sampling rate.~~

6260. The method as claimed in any one of claims 34-33 to 6159, wherein the health condition comprises at least one of a respiratory condition and a cardiac condition.

6361. The method as claimed in any one of claims 34-33 to 6260, wherein the health condition comprises a condition selected from a group consisting of wheezing, asthma, chronic obstructive pulmonary disease, obstructive sleep apnea syndrome, stridor, crackles, coughing and any combination thereof.

CLAIMS

1. A system for monitoring a health condition of a user, comprising:

a sensor configured to receive a sound from the user;

an analogue-to-digital converter configured to convert the received sound into a digital signal, wherein the analogue-to-digital converter is configured to sample the received sound at below the Nyquist's sampling rate;

a selection circuit configured to select a predetermined number of samples from the digital signal;

an entropy determination circuit configured to determine at least one entropy-based parameter value based on the selected samples; and

an entropy comparator circuit configured to compare the at least one entropy-based parameter value with a predetermined threshold value to detect a health signal for monitoring the health condition.

2. The system as claimed in claim 1, further comprising a filter and amplifier module configured to amplify the received signal.

3. The system as claimed in claim 1 or 2, further comprising a segmentation circuit configured to segment the digital signal into a plurality of segments of a first time duration; and wherein the selection circuit is configured to select the samples from the plurality of segments.

4. The system as claimed in claim 3, wherein the first time duration is one of between about 10 ms to about 1 s and about 64 ms.

5. The system as claimed in claim 3 or 4, wherein the selected predetermined number of samples comprise samples corresponding to one of a segment and an overlap between two adjacent segments of the plurality of segments.

6. The system as claimed in claim 5, wherein the overlap is one of between about 0% to about 100% and about 50%.

7. The system as claimed in any one of claims 1 to 6, further comprising a transformation circuit configured to transform the selected predetermined number of samples into a plurality of frequency components.

8. The system as claimed in claim 7, wherein the transformation circuit is configured to perform a Short Time Fourier Transform.

9. The system as claimed in claim 7 or 8, further comprising an averaging filtering circuit configured to determine a plurality of dominant frequency components.

10. The system as claimed in claim 9, wherein the averaging filtering circuit is configured to determine the plurality of dominant frequency components from the plurality of frequency components.

11. The system as claimed in claim 9 or 10, wherein the averaging filtering circuit comprises:

a comparator circuit configured to compare a respective magnitude of each of the plurality of frequency components with a threshold point; and

an identification circuit configured to identify at least one of a dominant frequency component when the respective magnitude is above the threshold point and a non-dominant frequency component when the respective magnitude is below the threshold point.

12. The system as claimed in claim 11, further comprising a threshold determination circuit configured to determine the threshold point by averaging magnitudes of a predetermined number of neighbouring components of the plurality of frequency components.

13. The system as claimed in claim 12, wherein the predetermined number of neighbouring components is one of between about 0 to about the predetermined number of samples and about a quarter of the predetermined number of samples.

14. The system as claimed in claim 9 or 10, wherein the averaging filtering circuit comprises:

a comparator circuit configured to compare a respective magnitude of each of a plurality of power components in a power spectrum corresponding to the plurality of frequency components with a threshold point;

an identification circuit configured to identify at least one of a dominant frequency component when the respective magnitude of the corresponding power component in the power spectrum is above the threshold point and a non-dominant frequency component when the respective magnitude of the corresponding power component in the power spectrum is below the threshold point.

15. The system as claimed in claim 14, further comprising a threshold determination circuit configured to determine the threshold point by averaging magnitudes of a predetermined number of neighbouring power components in the power spectrum.

16. The system as claimed in claim 15, wherein the predetermined number of neighbouring power components is one of between about 0 to about the predetermined number of samples and about a quarter of the predetermined number of samples.

17. The system as claimed in any one of claims 11 to 16, wherein the non-dominant frequency components are discarded.

18. The system as claimed in any one of claims 11 to 16, further comprising a substitution circuit configured to replace a respective magnitude of each of the non-dominant frequency components with one of about 0.01 and a numeral between about 0 to a value corresponding to a smallest value of the non-dominant frequency components.

19. The system as claimed in any one of claims 11 to 18, further comprising a power determination circuit configured to determine a plurality of normalized power of the dominant frequency components.

20. The system as claimed in claim 19, wherein the entropy determination circuit is configured to determine a plurality of entropy values from the plurality of normalized power.

21. The system as claimed in claim 20, wherein the entropy determination circuit is further configured to determine a maximum entropy value and a minimum entropy value from the plurality of entropy values after a second time duration.

22. The system as claimed in claim 21, wherein the second time duration is one of about 3 s and greater than the first time duration.

23. The system as claimed in claim 21 or 22, wherein the at least one entropy-based parameter value comprises at least one of an entropy difference between the maximum entropy value and the minimum entropy value and an entropy ratio of the maximum entropy value to the minimum entropy value.

24. The system as claimed in claim 23, wherein the entropy comparator circuit is further configured to subtract the at least one of the entropy difference and the entropy ratio from the predetermined threshold value to produce a result; and identify that the health signal is present when the result is a positive value or identify that the health signal is absent when the result is a negative value.

25. The system as claimed in claim 24, wherein the predetermined threshold value is one of a fixed threshold value and an adaptive threshold value.

26. The system as claimed in claim 25, further comprising an adaptive threshold determination circuit configured to determine the adaptive threshold value.

27. The system as claimed in claim 26, wherein the adaptive threshold determination circuit comprises:

a noise power determination circuit configured to determine a noise power from the non-dominant frequency components; and

a look-up comparator circuit configured to determine the adaptive threshold value based on the noise power and a look-up table comprising a plurality of predetermined threshold values at different noise powers.

28. The system as claimed in any one of claims 1 to 27, further comprising a sample selection circuit configured to reduce the number of samples from the selected predetermined number of samples.

29. The system as claimed in any one of claims 1 to 28, wherein the sensor comprises a sound-based sensor.

30. The system as claimed in any one of claims 1 to 29, wherein the sensor comprises one of an air conduction sensor, a microphone, a stethoscope, a piezo-electric sensor and a pressure sensor.

31. The system as claimed in any one of claims 1 to 30, wherein the health condition comprises at least one of a respiratory condition and a cardiac condition.

32. The system as claimed in any one of claims 1 to 31, wherein the health condition comprises a condition selected from a group consisting of wheezing, asthma, chronic obstructive pulmonary disease, obstructive sleep apnea syndrome, stridor, crackles, coughing and any combination thereof.

33. A method for monitoring a health condition of a user, comprising:

receiving a sound from the user;

converting the received sound into a digital signal;

selecting a predetermined number of samples from the digital signal;

determining at least one entropy-based parameter value based on the selected samples; and

comparing the at least one entropy-based parameter value with a predetermined threshold value to detect a health signal for monitoring the health condition,

wherein converting the received sound into a digital signal comprises sampling the received sound at below the Nyquist's sampling rate.

34. The method as claimed in claim 33, further comprising:

filtering and amplifying the received sound.

35. The method of as claimed in claim 33 or 34, further comprising:

segmenting the digital signal into a plurality of segments of a first time duration; and

wherein selecting the samples comprises selecting from the plurality of segments.

36. The method as claimed in claim 35, wherein the first time duration is one of between about 10 ms to about 1 s and about 64 ms.

37. The method as claimed in claim 35 or 36, wherein the predetermined number of selected samples comprise samples corresponding to one of a segment and an overlap between two adjacent segments of the plurality of segments.

38. The method as claimed in claim 37, wherein the overlap is one of between about 0% to about 100% and about 50%.

39. The method as claimed in any one of claims 33 to 38, further comprising transforming the predetermined number of selected samples into a plurality of frequency components.

40. The method as claimed in claim 39, wherein transforming the selected samples into the plurality of frequency components comprises performing a Short Time Fourier Transform.

41. The method as claimed in claim 39 or 40, further comprising determining a plurality of dominant frequency components from the plurality of frequency components.

42. The method as claimed in claim 41, wherein determining the plurality of dominant frequency components comprises performing an averaging filtering process.

43. The method as claimed in claim 42, wherein performing the averaging filtering process comprises:

comparing a respective magnitude of each of the plurality of frequency components with a threshold point;

identifying at least one of a dominant frequency component when the respective magnitude is above the threshold point, and

a non-dominant frequency component when the respective magnitude is below the threshold point.

44. The method as claimed in claim 43, further comprising determining the threshold point by averaging magnitudes of a predetermined number of neighbouring components of the plurality of frequency components.

45. The method as claimed in claim 44, wherein the predetermined number of neighbouring components is one of between about 0 to about the predetermined number of samples and about a quarter of the predetermined number of samples.

46. The method as claimed in claim 42, wherein performing the averaging filtering process comprises:

comparing a respective magnitude of each of a plurality of power components in a power spectrum corresponding to the plurality of frequency components with a threshold point;

identifying at least one of a dominant frequency component when the respective magnitude of the corresponding power component in the power spectrum is above the threshold point, and a non-dominant frequency component when the respective magnitude of the corresponding power component in the power spectrum is below the threshold point.

47. The method as claimed in claim 46, further comprising determining the threshold point by averaging magnitudes of a predetermined number of neighbouring power components in the power spectrum.

48. The method as claimed in claim 47, wherein the predetermined number of neighbouring power components is one of between about 0 to about the predetermined number of samples and about a quarter of the predetermined number of samples.

49. The method as claimed in any one of claims 43 to 48, further comprising discarding the non-dominant frequency components.

50. The method as claimed in any one of claims 43 to 48, further comprising replacing a respective magnitude of each of the non-dominant frequency components with one of about 0.01 and a numeral between about 0 to a value corresponding to a smallest value of the non-dominant frequency components.

51. The method as claimed in any one of claims 43 to 50, further comprising determining a plurality of normalized power of the dominant frequency components.

52. The method as claimed in claim 51, further comprising determining a plurality of entropy values from the plurality of normalized power.

53. The method as claimed in claim 52, further comprising determining a maximum entropy value and a minimum entropy value from the plurality of entropy values after a second time duration.

54. The method as claimed in claim 53, wherein the second time duration is one of about 3 s and greater than the first time duration.

55. The method as claimed in claim 53 or 54, wherein determining at least one entropy-based parameter value comprises determining at least one of an entropy difference E_d between the maximum entropy value and the minimum entropy value from the equation:

$$E_d = E_{max} - E_{min}$$

and an entropy ratio E_r of the maximum entropy value to the minimum entropy value from the equation:

$$E_r = \frac{E_{max}}{E_{min}}$$

where E_{max} is the maximum entropy value and E_{min} is the minimum entropy value.

56. The method as claimed in claim 55, wherein comparing the at least one entropy-based parameter value with the predetermined threshold value to detect the health signal related to the health condition comprises:

subtracting at least one of the entropy difference and the entropy ratio from the predetermined threshold value to produce a result; and

identifying that the health signal is present when the result is a positive value or

identifying that the health signal is absent when the result is a negative value.

57. The method as claimed in claim 56, wherein the predetermined threshold value is one of a fixed threshold value and an adaptive threshold value.

58. The method as claimed in claim 57, further comprising determining the adaptive threshold value, comprising:

determining a noise power from the non-dominant frequency components; and

determining the adaptive threshold value based on the noise power and a look-up table comprising a plurality of predetermined threshold values at different noise powers.

59. The method as claimed in any one of claims 33 to 58, further comprising reducing the number of samples from the selected predetermined number of samples.

60. The method as claimed in any one of claims 33 to 59, wherein the health condition comprises at least one of a respiratory condition and a cardiac condition.

61. The method as claimed in any one of claims 33 to 60, wherein the health condition comprises a condition selected from a group consisting of wheezing, asthma, chronic obstructive pulmonary disease, obstructive sleep apnea syndrome, stridor, crackles, coughing and any combination thereof.