WHAT IS CLAIMED IS:

1. A system for health condition monitoring comprising a wearable device, a portable device and a server, the portable device being capable of communicating between the wearable device and the server, the system for health condition monitoring further comprising:

a non-contact ECG acquisition module embedded in the wearable device for capturing ECG signals from a user wearing the wearable device;

a non-contact audio acquisition module embedded in the wearable device for capturing a respiratory sound signal and a heart sound signal from the user wearing the wearable device;

a first signal processing and analysis module embedded in the wearable device and connected with the non-contact ECG acquisition module for receiving and processing the ECG signals, wherein QRS detection, HR (heart rate) calculation and ECG derived RR (respiratory rate) determination are performed in the first signal processing and analysis module, and the first signal processing and analysis module is connected with the non-contact audio acquisition module for receiving and processing the respiratory sound signal and the heart sound signal; and

a second signal processing and analysis module provided on the server for receiving and processing the ECG signals, the respiratory sound signal and the heart sound signal uploaded by the portable device, wherein heart sound localization, heart sound cancellation, respiratory sound restoration, and sound based RR determination are performed in the second signal processing and analysis module, so as to obtain information for health condition monitoring.

2. The system for health condition monitoring according to claim 1, wherein the wearable device is a wearable vest, and the portable device is a smart phone or a tablet.

3. The system for health condition monitoring according to claim 1, wherein the non-contact ECG acquisition module and the non-contact audio acquisition module do not directly contact the skin of the user.

4. The system for health condition monitoring according to claim 1, wherein the non-contact ECG acquisition module comprises three or more non-contact ECG sensors.

5. The system for health condition monitoring according to claim 4, wherein the non-contact ECG sensors are located at a top of the manubrium, a left side of the ninth rib, and a right side of the ninth rib when the user is wearing the wearable device.

6. The system for health condition monitoring according to claim 1, wherein the non-contact audio acquisition module comprises two or more non-contact audio sensors for capturing the respiratory sound signal and the heart sound signal.

7. The system for health condition monitoring according to claim 6, wherein the non-contact audio sensor is a MEMS (microelectro-mechanical system) microphone sensor.

8. The system for health condition monitoring according to claim 6, wherein the non-contact audio sensor comprises a bell-shaped acoustic chamber to optimize transfer of sound from the user's body and block external soundwave.

9. The system for health condition monitoring according to claim 1, wherein the wearable device further comprises:

a microcontroller connected with and managing operations of the non-contact ECG acquisition module, the non-contact audio acquisition module, and the first signal processing and analysis module;

a data storage connected with the microcontroller for storing the captured signals and processed data; and

a first transceiver connected with the microcontroller.

10. The system for health condition monitoring according to claim 9, wherein the portable device comprises a second transceiver capable of communicating with the first transceiver of the wearable device.

11. The system for health condition monitoring according to claim 10, wherein the first transceiver and the second transceiver communicate with each other through a Bluetooth protocol.

12. The system for health condition monitoring according to claim 1, wherein the portable device comprises an application capable of communicating with the wearable device and the server for their operations and data transmissions.

13. The system for health condition monitoring according to claim 1, wherein the wearable device comprises an outer layer and an inner layer, and the non-contact ECG acquisition module and the non-contact audio acquisition module are attached to the inner layer and deployed between the outer layer and the inner layer.

14. The system for health condition monitoring according to claim 1, wherein the wearable device comprises a two-section strip made of conductive clothing to ensure secure grounding.

15. The system for health condition monitoring according to claim 1, wherein the ECG signal obtained by the non-contact ECG acquisition module is first filtered to remove the baseline wandering and other noise out of the desired band, and a bandwidth used in filtering the ECG signal is 0.67-150 Hz.

16. The system for health condition monitoring according to claim 1, wherein the QRS detection is performed in the first signal processing and analysis module by a derivative processing based technique.

17. The system for health condition monitoring according to claim 1,

wherein another QRS detection is performed in the second signal processing and analysis module by a template matching based technique.

18. The system for health condition monitoring according to claim 1, wherein the first signal processing and analysis module comprises an adaptive filter with ANC (adaptive noise cancellation) configuration, which is applied to the respiratory sound signal and the heart sound signal to suppress both ambient noise and heart sound simultaneously.

19. The system for health condition monitoring according to claim 1, wherein multiband products based on FFT (fast Fourier transform) coefficients are used for the heart sound localization, the heart sound cancellation, and the respiratory sound restoration.

20. The system for health condition monitoring according to claim 19, wherein the multiband products are calculated by multiplying the FFT coefficients of the desired sub-bands as the following formula:

$$P_{j,k}(\tau) = \prod_{i=j}^{k} |S(\tau, i)|$$

where j is a positive number equal to or greater than 0 which corresponds to the lower bound of the desired sub-band of the heart sound, k is a positive number greater than or equal to j and corresponds to the upper bound of the desired sub-band of the heart sound, $P_{j,k}$ is the multiband product of FFT coefficients from the jth sub-band to the kth sub-band, and $S(\tau, i)$ is the FFT coefficient.

21. The system for health condition monitoring according to claim 19, wherein the respiratory sound restoration is performed by linear prediction using FFT coefficients.

22. The system for health condition monitoring according to claim 19, wherein the sound based RR is estimated from a cleaned respiratory signal after heart sound cancellation by multiplying the squared frequency with

the power of its FFT coefficients as the following formulas:

$$Q(\tau, f_n) = \left|S_{ANC,r}(\tau, f_n)\right|^2 \cdot f_n^2 \quad (n = n_1, n_1 + 1, \mathrm{L}\ n_2)$$

$$P(\tau) = \sum_{n=n_1}^{n_2} Q(\tau, f_n)$$

where τ is the shift in time, f is the frequency, n_1 is a positive number equal to or greater than 0 which corresponds to the lower bound of the desired sub-band of the respiratory sound, n_2 is a positive number greater than or equal to n_1 and corresponds to the upper bound of the desired sub-band of the respiratory sound, and $S_{ANC,r}(\tau, f)$ is the refurbished FFT coefficient.

23. The system for health condition monitoring according to claim 19, wherein a final result of RR is obtained from the ECG derived RR and the sound based RR by a weighted method, where the RR from better signal quality is assigned a heavier weight.

24. A method for health condition monitoring, comprising steps of:

(a) providing a wearable device, a portable device and a server, the wearable device comprising an embedded non-contact ECG acquisition module, an embedded non-contact audio acquisition module and an embedded first signal processing and analysis module, the portable device being capable of communicating between the wearable device and the server, the server comprising a second signal processing and analysis module;

(b) capturing ECG signals by the non-contact ECG acquisition module and capturing a respiratory sound signal and a heart sound signal by the non-contact audio acquisition module from the user wearing the wearable device;

(c) processing the ECG signals, the respiratory sound signal and the heart sound signal by the first signal processing and analysis module to

perform QRS detection, HR (heart rate) calculation and ECG derived RR (respiratory rate) determination; and

(d) processing the ECG signals, the respiratory sound signal and the heart sound signal by the second signal processing and analysis module to perform heart sound localization, heart sound cancellation, respiratory sound restoration, and sound based RR determination, and thus obtaining information for health condition monitoring.

25. The method for health condition monitoring according to claim 24, further comprising a step of obtaining a final result of RR from the ECG derived RR and the sound based RR by a weighted method, where the RR from better signal quality is assigned a heavier weight.

26. The method for health condition monitoring according to claim 24, wherein the ECG signal obtained by the non-contact ECG acquisition module is first filtered to remove the baseline wandering and other noise out of the desired band, and a bandwidth used in filtering the ECG signal is 0.67-150 Hz.

27. The method for health condition monitoring according to claim 24, wherein the QRS detection is performed in the first signal processing and analysis module by a derivative processing based technique.

28. The method for health condition monitoring according to claim 24, wherein another QRS detection is performed in the second signal processing and analysis module by a template matching based technique.

29. The method for health condition monitoring according to claim 24, wherein the first signal processing and analysis module comprises an adaptive filter with ANC (adaptive noise cancellation) configuration, which is applied to the respiratory sound signal and the heart sound signal to suppress both ambient noise and heart sound simultaneously.

30. The method for health condition monitoring according to claim 24,

wherein multiband products based on FFT (fast Fourier transform) coefficients are used for the heart sound localization and the heart sound cancellation.

31. The method for health condition monitoring according to claim 30, wherein the multiband products are calculated by multiplying the FFT coefficients of the desired sub-bands as the following formula:

$$P_{j,k}(\tau) = \prod_{i=j}^{k} |S(\tau, i)|$$

where j is a positive number equal to or greater than 0 which corresponds to the lower bound of the desired sub-band of the heart sound, k is a positive number greater than or equal to j and corresponds to the upper bound of the desired sub-band of the heart sound, $P_{j,k}$ is the multiband product of FFT coefficients from the jth sub-band to the kth sub-band, and $S(\tau, i)$ is the FFT coefficient.

32. The method for health condition monitoring according to claim 30, wherein the respiratory sound restoration is performed by linear prediction using FFT coefficients.

33. The method for health condition monitoring according to claim 30, wherein the sound based RR is estimated from a cleaned respiratory signal after heart sound cancellation by multiplying the squared frequency with the power of its FFT coefficients as the following formulas:

$$Q(\tau, f_n) = \left|S_{ANC,r}(\tau, f_n)\right|^2 \cdot f_n^2 \quad (n = n_1, n_1 + 1, \mathrm{L}\ n_2)$$

$$P(\tau) = \sum_{n=n_1}^{n_2} Q(\tau, f_n)$$

where τ is the shift in time, f is the frequency, n_1 is a positive number equal to or greater than 0 which corresponds to the lower bound of the desired sub-band of the respiratory sound, n_2 is a positive number greater than or equal to n_1 and corresponds to the upper bound of the desired sub-band of

the respiratory sound, and $S_{ANC,r}(\tau, f)$ is the refurbished FFT coefficient.