Claims

1. A method of detecting a level of fluid accumulation in a lung of a subject, comprising:

providing at least one classifier trained to distinguish between two or more levels of fluid accumulation, the two or more levels comprising a level corresponding to a presence of fluid and a level of corresponding to an absence of fluid;

acquiring an audio signal generated by the lung;

processing said audio signal by:

segmenting the audio signal into consecutive time windows;

performing feature extraction to generate at least one feature vector for each time window; and

assigning a level of fluid accumulation from the two or more levels to the audio signal by:

passing at least one component of each feature vector to the at least one classifier to generate a plurality of tentative fluid levels for the audio signal; and

selecting a most frequent occurring level from amongst the plurality of tentative fluid levels; and

providing an indication to a user that the subject has lung fluid accumulation if the most frequent occurring level is the level corresponding to the presence of fluid.

2. A method according to claim 1, wherein said consecutive time windows at least partially overlap.

3. A method according to claim 1, wherein the passing at least one component of each feature vector to the at least one classifier comprises passing selected components of each feature vector to the at least one classifier.

4. A method according to claim 3, wherein performing the feature extraction comprises determining mel-frequency cepstral coefficients or determining perceptual linear prediction coefficients, or both.

5. A method according to claim 1, wherein the at least one classifier comprises at least one linear classifier.

6. A method according to claim 1, wherein the at least one classifier comprises at least one non-linear classifier.

7. A method according to claim 1, further comprising training the at least one classifier.

8. A method according to claim 7, wherein said training comprises:

acquiring audio signals from a plurality of subjects having known levels of fluid accumulation;

performing feature extraction on the audio signals acquired from a plurality of subjects having known levels of fluid accumulation to generate a plurality of candidate feature vectors; and

performing feature selection on the plurality of candidate feature vectors to identify one or more components of the candidate feature vectors which are useful for discriminating between the two or more levels.

9. A method according to claim 8, wherein the feature selection is performed by identifying *N* features having greatest importance, from the plurality of candidate feature vectors and wherein the importance of a feature is calculated according to:

$$I\left(x_i\right)=\frac{\sum_{j\neq k}\left(m_{i,c(j)}-m_{i,c(k)}\right)^2}{\sum_{c(j)}\sigma^2_{i,c(j)}},$$

where i =1, …, M; M is the dimension of each feature vector; and

$m_{i,c(j)}$ and $\sigma^2_{i,c(j)}$ are a sample mean and variance, respectively, of a feature x_i for a class $c(j)$; $c(j), j=1,2,...N_c$ is a j^{th} class; and N_c is a number of levels of fluid accumulation.

10. A method according to claim 1, wherein said acquiring comprises positioning at least one sensor on the subject in proximity to the lung such that the sensor is acoustically coupled to the lung.

11. A system for detecting a level of fluid accumulation in a lung of a subject, comprising:

at least one sensor positionable on the subject adjacent to the lung to measure an audio signal generated by the lung;

a memory configured to store data representing the audio signal; and

at least one processor in communication with the memory and being configured to:

retrieve, from said memory, data representing at least one classifier trained to distinguish between two or more levels of fluid accumulation, the two or more levels comprising a level corresponding to a presence of fluid and a level corresponding to an absence of fluid;

process said audio signal by segmenting the audio signal into consecutive time windows, and performing feature extraction to generate at least one feature vector for each time window;

assign a level of fluid acumulation from the two or more levels to the audio signal by:

passing at least one component of each feature vector to the at least one classifier to generate a plurality of tentative fluid levels for the audio signal; and

selecting a most frequent occurring level from amongst the plurality of tentative fluid levels; and

provide an indication to a user that the subject has lung fluid accumulation if the most frequent occurring level is the level corresponding to the presence of fluid.

12. A system for detecting a level of fluid accumulation in a lung of a subject, comprising:

at least one sensor positionable on the subject adjacent the lung to measure an audio signal generated by the lung; and

at least one processor configured to:

segment the audio signal into consecutive time windows;

perform feature extraction to generate at least one feature vector for each time window;

assign to each time window a fluid level which is one of a set of two or more levels of fluid accumulation by passing at least one component of the at least one feature vector for each time window to at least one classifier trained to distinguish between the two or more levels of fluid accumulation to generate a plurality of tentative fluid levels for the audio signal, wherein the two or more levels comprises a level corresponding to a presence of fluid and a level corresponding to an absence of fluid;

select a most frequent occurring level from amongst the plurality of tentative fluid levels and

provide an indication to user that the subject has lung fluid accumulation if the most frequent occurring level is the level corresponding to the presence of fluid.

13. A method according to claim 1, wherein the indication comprises an alarm signal.

14. A system according to claim 11 wherein the indication comprises an alarm signal.

15. A system according to claim 12 wherein the indication comprises an alarm signal.

16. A method according to claim 4, wherein determining the mel-frequency cepstral coefficients comprises selecting between 4 to 8 components.

17. A method according to claim 4, wherein determining the perceptual linear prediction coefficients comprises selecting between 7 to 11 components.

18. A method according to claim 1, wherein said acquiring comprises acquiring the audio signals using a plurality of audio sensors.

19. A method according to claim 18, wherein said acquiring comprises positioning the plurality of audio sensors on the subject in proximity to the lung such that each of the sensors is coupled to the lung.

20. A method according to claim 9, wherein *M* ranges from 10 to 15.