Non-contact breathing activity monitoring

Phuc Nguyen[1], Shane Transue[1], Ann Halbower[2], Min-Hyung Choi[1], and Tam Vu[1]

[1]University of Colorado, Denver, [2]University of Colorado School of Medicine and Children's Hospital Colorado

MOTIVATION

- Continuous and fine-grained breathing volume monitoring plays an important role in healthcare.
- Diseases such as asthma, chronic obstructive pulmonary disease (COPD), cystic fibrosis, tuberculosis could be detected.
- Existing approaches are **intrusive**, **expensive**, or **coarse-grained**. With the presence of patient body movement and posture changes, long-term monitoring of breathing volume at fine granularity is even more challenging.

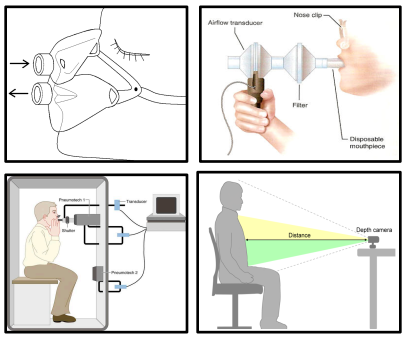


Fig. 1. Examples of existing respiratory signal monitoring systems that are using various kind of sensing technology including air pressure, wireless signal, etc.

CHALLENGES

- Respiration volume information is buried in the very minor phase shift of the reflected signal.
- Phase shift is fluctuated as the distance between the radar and subject is changed, or influenced by the imperfection of the hardware circuitry, or the non-linear/abnormal breathing behavior of the subjects.
- A minor non-respiratory movement could cause significant volume estimation error. That movement makes radar beam to new area on human's body, which leads the estimation inaccurate because different areas on the human chest move differently (while they reflect the same breathing volume).
- Posture change or body part's movements, e.g., subject's arms, also might block the chest movements to be seen by radar.

SYSTEM DESIGN

Basic principle. The principle relationship between the phase $\Phi(t)$ and traveling distance $d(t)$ of a wireless signal is formulated by $\Phi(t) = 2d(t)/\lambda$, with λ is the wavelength. Hence, by analyzing the phase change of the received signal, distance change between radar and chest surface can be inferred.

Our system is named by **WiSpiro**. In **WiSpiro**, the chest displacement is inferred to breathing volume through a neural network training technique.

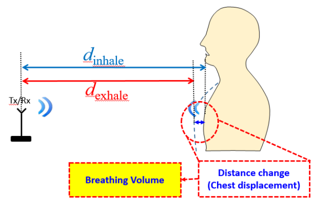


Fig. 2. Basic Principle

Objectives:

- Estimating volume in fine-grained, not the rate.
- Dealing with non-periodic or irregular body movement during sleep.

System Design:

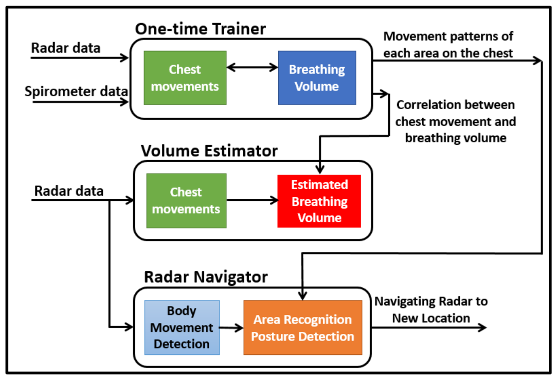


Fig. 2. WiSpiro design

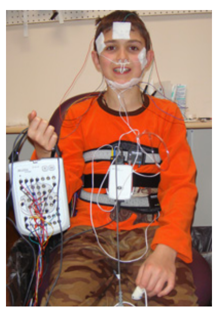


Fig 3. Current setup in hospital for breathing and sleeping monitoring

Fig 4. WiSpiro setup. The patient breathing volume during sleep is monitored from afar using wireless signals. The patient doesn't need to wear any device

ONE-TIME TRAINER

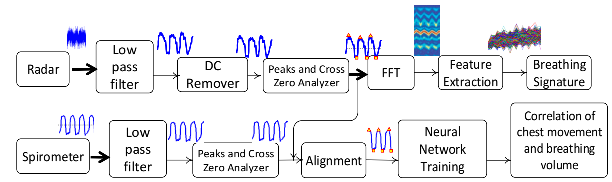


Fig. 5. One-time trainer component

VOLUME ESTIMATOR

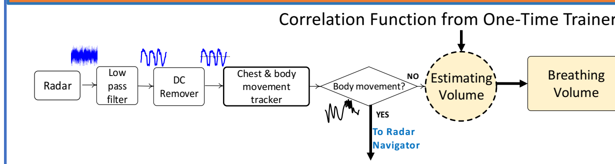


Fig. 6. Volume estimator component

RADAR NAVIGATOR

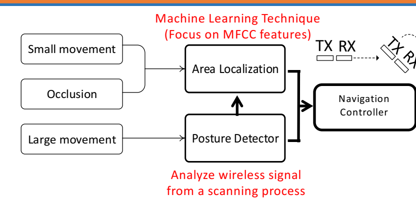
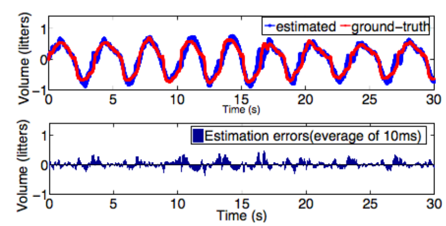


Fig. 7. Radar navigator component

SYSTEM PERFORMANCE



Volume estimated in stationary case vs. spirometer measurement. Mean error of 0.021l, max error of 0.051l

Fig. 8. Evaluation Results

CONTACT US

Phuc Nguyen - phuc.v.nguyen@ucdenver.edu