

## Multimedia Feedback for Improving Breathing Habit

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### Abstract

*Breathing is one of the most important functions in human body. Usually, people do not know enough about how to breathe. Therefore, we develop a system which can detect the user's breathing status and assist him by multimedia. Our system allows a user to know their body's physical conditions and, through the multimedia interactive feedback of the sense, the user can check whether their physical conditions are normal. This physiological biofeedback system provides users an effective way to learn efficient breathing and emotional control, and finally it helps, to improve physical and mental health. In this way, it can help the users to remain in relaxed condition most of the time. By combining smart clothing, interactive multimedia, and expert knowledge of medical research and clinics, we build a smart clothing system which can amend the user's breathing habit, strengthen his immunity and improve his physical and mental health in a friendly and natural way.*

**Keywords:** *Biofeedback, Multimedia, Interaction, Abdominal breathing, Respiratory Inductive Plethysmography*

### 1. Introduction

Although the traditional breathe-controlling exercise has excellent effects and has been popular for the past thousand years, rarely people

rarely analyzed how the exercise changes people's breathing habit with objective and clinical methods, nor did researchers discover how the breathe-controlling exercise produces effects on the treatment for thoracic-injured patients, on the change of immune function, and on the patient's recovery after an operation. Our system combines multimedia feedback and breathing habit tutorial from medical field, building a smart clothing system that has the ability to enhance the breathing habit, enhance the immune function, and improve people's health.

In our system, we use Respiratory Inductive Plethysmography (RIP) to detect the user's breathing status. It can adaptively detect the breathing condition according to a natural expansion or a natural shrinkage of the user's body. The breathing condition at least includes breathing mode (breast breathing or abdominal breathing), breathing rate, and breathing depth. The monitor displays a relative breathing condition picture according to the detected breathing condition. As such, the user can understand the practical breathing condition by viewing the breathing condition pictures or sounds, so as to be instructed to learn to use a breathing pattern suitable for him.

### 2. Motivation

Currently, office workers have to be used to take more responsibilities and bear heavier

burden than ever before. They are often surrounded by negative feelings, e.g., anger, fear, nervousness, which are usually caused by overpressure. Such negative feelings may distort human's autonomic nervous system, so that one's breathing may become fast-paced, short and hard to control, which often causes an oxygen-deficient and harms human's health.

Our breathing training system provides a method for improving a breathing pattern with an interactive multimedia approach. Our system detects user's breathing condition, and then gives a feedback with the data to the user. The feedback data, which can be easily understood, includes hearing adapted for sensing voice guidance, speech guidance, background voice, or affair sound effect, vision for sensing ambient light, or multimedia content. According to the interactive multimedia content, the user can learn how to improve the breathing pattern, so as to further alleviate emotional uncomfortableness, such as nervousness, awkwardness, anxiety, and heart throb, and thus reform the body condition and psychological health. Our system substantially eliminates the need for a professional clinical staff to explain complicated physiological data for the user to improve the breathing.

### 3. Related works

Through appropriate breathing exercise, the human body can inhale the oxygen and exhale the carbon dioxide, and regulate the acid-base balance and oxygen content in the body [7] [8]. These conditions might make the person be relaxed, reduces the blood pressure and promotes a healthy body. On the contrary, non-appropriate breathing exercise might cause anoxia, or unbalance of sour alkalinity and electrolyte. Therefore, the breathing method influences our body greatly.

There are several methods for monitoring respiration, but none of them have been proved to be satisfactory in all respects [10]. Optoelectronic Plethysmography (OEP) is a breathing detecting system, and it can measure the variety of thoracic and abdominal breathing volume. It makes use of an IR camera and a marking ball to record the

motion of user's thoracic and the abdominal breathing status (about 25-55 point). It measures the variety of the physical volume of user's thoracic and the abdominal, and then judges the pattern of user's breathing status [1]. But, it must work in the fixed location, and it is difficult to operate.

The SmartShirt System [12] is a unisex wearable wireless T-shirt designed to collect physiological signals and movement from the human body. The System collects bio-signals through conductive fiber sensors and passes them through a conductive fiber grid knitted. A textile connector passes the analog signals to a small personal controller held in the pocket of the shirt. The personal controller digitizes the signal and transmits the signal to a receiver connected to a base station where the information is collected, displayed and stored.

LifeShirt [15] is a lightweight thoracic strap with embedded sensors. These sensors monitor breath rate, heart rate, activity, posture and skin temperature in real-time and on a continuous basis. The thoracic strap is easy to put on and is machine washable. It can gather an athlete's pulmonary, cardiac, and other physiologic data before, during and after activity — whether a practice session or an actual competitive event.

With the progress of technology and multimedia, many systems make use of great deal of multimedia in human-computer interaction fields. Scarlatos [11] designed a multimedia system that teaches the child to learn Tangram through visual and sound guidance. The experiment results show that multimedia feedback provides more learning information and questions for children. The bedside wellness system [9] is effective for decreasing stress and improving mental well-being. It should relieve patients' side effects and mental disorders during cancer chemotherapy.

There are many smart clothing systems, and they can monitor user's conditions of physiological, emotional or sensorial reactions of human body [2]. And these systems could be used for citizen medicine, home healthcare, and disease prevention [3]. However, there are only a few systems using multimedia when it comes to

help the breathing-training. Teaching women abdominal breathing, can improve the premenstrual syndrome and, through biofeedback system, users can understand the breathing status by themselves, and moderate the breathing frequency and depth [5]. Therefore, we develop a multimedia system to guide the people and assist them in breathing training.

## 4. Methodology

### 4.1. Breathing methods

There are many ways in breathing learning, and it depends on the user's body condition. Through the different breathing frequency and the breathing exercise method, can reach different breath results. We developed a breathing training system based on standard breathing methods. The system adjusts the appropriate breath parameter according to the physiology appearance and learning appearance of the user. By this way, we can create a personalized breathing learning system to reach the best learning result.

### 4.2. Sensor description

Our smart clothing system detects user's breathing patterns with an interactive multimedia approach which mainly includes two breathing condition detectors (Respiratory Inductive Plethysmography, RIP) (Figure 1) and a processor, for guiding the user to learn a suitable breathing pattern. The breathing sensor is attached to the user, and can adaptively detect the breathing conditions according to a natural expansion or a natural shrinkage of a body of the user when breathing. The breathing condition at least includes a breathing mode (breast breathing or abdominal breathing), breathing rate, and breathing depth. The processor displays a relative breathing condition picture according to the detected breathing condition detected by the breathing condition detector on a monitor. As such, the user can understand the practical breathing condition by viewing the breathing condition picture, and gets instructed to learn to use a breathing pattern suitable for him.



Figure 1. Respiratory Inductive Plethysmography

We use the RIP to measure the dilation of thoracic and abdomen, and furthermore estimating the breathing status. When the user is wearing the smart clothing, the breathing sensor (RIP) is adapted to detect the breathing condition according to a natural expansion or shrinkage of the body of the user. Then, the processor receives the detected breathing conditions by either a wireless connection (Bluetooth) or a wired connection. When the processor receives the data, it will process the abdominal breathing and thoracic breathing's frequency, breathing depth, exhale time and inhale time. Figure 2 shows the interface of our detecting system. The green line shows the thoracic breathing curve, the blue line shows the abdominal breathing curve, and the black line shows the sum of abdominal breathing volume and thoracic breathing volume.

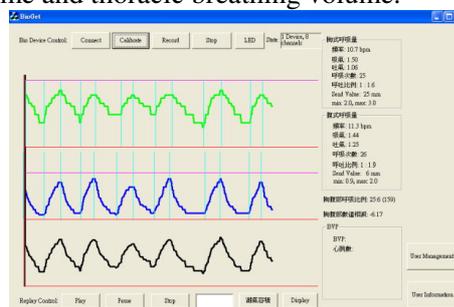


Figure 2. Bio-signal detecting system

Because the RIP tight degree differs from people to people when dressed, if we do not calibrate the volume, it will cause a disorder in breathing detection. Hence, we need a breathing volume calibration process. When the user wears the smart clothing, he will correct the thoracic expiration value when inhaling, thoracic shrinks value when exhaling, abdominal expiration value when inhale, abdominal expiration value when inhale separately. Though the correction setting step, the system will take these values and calibrate the personalized breathing value in real-time.

### 4.3. System description

In the past, people thought that a lot of physiology reactions, such as the heartbeat, breath, blood pressure etc., are controlled by the self-discipline nerve. It cannot be controlled by oneself. Health research and Psychology discovers that although we can't directly control the heartbeats, blood pressure and skin temperature, we can control respiration itself, and change the physiology responds and mood directly. The biggest difference between respiration function and liver and kidney is that, respiration functions can be changed by learning, but liver and kidney can't [4] [6] [13]. Traditional physical rehabilitation procedures are mostly guided by care workers. Tutorial videos and books are also involved in order to understand both, abdominal and thoracic breathing. Based on the breath-training procedures provided by professional breathing trainers, we developed a personal breath-training multimedia system. The system's flowchart is showed in Figure 3.

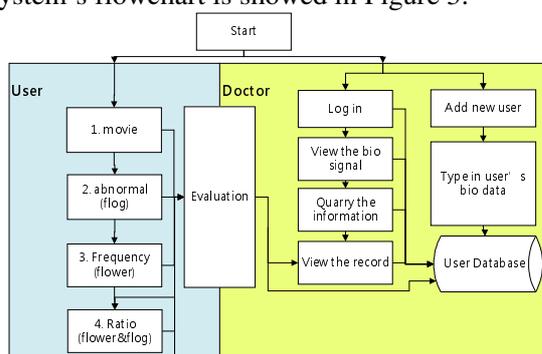


Figure 3. System description

Because of the dissimilarity of a user's body status (including height, weight, age, sex) and physiological condition (normal or recovered patient), user's breathing methods could be different. Hence, we should record user's basic data in the database, and provide the personalized evaluation.

In the part of multimedia breathe-training system, users may proceed the breath-training procedures under multimedia interactive environment. The training phases are (A) breath-training tutorial videos, (B) abdominal breathing

exercise, and (C) Training the frequency of breathing, described as following:

#### A. Breath-training tutorial videos

In order to provide the correct breathing method for the users, we recorded a series of breath-training tutorial videos. In the videos, doctors and physical therapists teach the patient how to proceed the abdominal breathing correctly and explain how correct breathing methods affect us, in both ways, physically and mentally. With the recorded videos, the patients may begin their breathing exercises without professional's attendance. The videos could be classified into three types of gestures: standing, sitting, and lying, with each type including two kinds of breathing exercises: (1) simple thoracic and abdominal breathing and (2) arm-assisted thoracic and abdominal breathing. Therefore, a total of six tutorial videos are provided (Figure 4) to adapt different patients' demands and as the foundation of designing a multimedia content.



Figure 4. Tutorial videos of breath-training

#### B. Training the abdominal breathing

Abdominal breathing is one of the most healthy and correct respiration methods. It does not only enlarge our breathing volume, but also makes it easy to adjust breathing speed. In this phase, the user may learn abdominal breathing from the interactive system. The animated frog reflects the user's breathing status. When the user inhales correctly using abdomen, the frog plumps its abdominal with its mouth slightly closed; when the user exhales, the frog shrinks its abdominal with its mouth opened (Figure 5). An indicator bar on the right side of the screen is also used to numerate the breathing amount. With the animated interaction, the user may learn the right way of abdominal breathing with the information provided.



(a) The interface



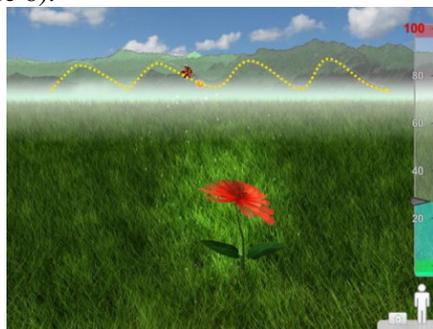
(b) Inhale

(c) Exhale

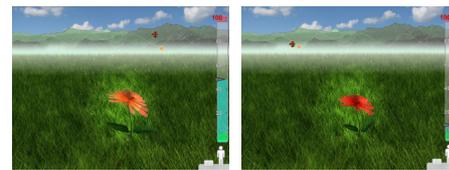
Figure 5. Training the abdominal breathing

### C. Training the frequency of breathing

In this phase, the user learns to breathe smoothly and cyclically in a proper way. We designed an interactive method that represents the user's breathing and guidance status. The user's breathing volume reflects on the ladybug's location, and it should follow the personalized breathing frequency (yellow curve). Thus the patient could learn the right way of breathing with the interaction. The preset yellow curve may be different according to various users and user's conditions. The system detects the user's current breathing status and provides an appropriate breathing frequency (yellow curve). Besides, the animated flower would also reflect the amount of breathing by blooming itself. When the user is inhaling, the flower blooms; otherwise it shrinks (Figure 6).



(a) The interface



(b) Inhale

(c) Exhale

Figure 6. Training the frequency of breathing

It should be noted that the aforementioned standard mode is based on a well-known concept that a deeper and slower breath is better. However, different individuals may be suitable for different standards according to the differences of their physiological conditions. For example, one may be suitable for a breathing frequency (such as inhaling for 2 second, and exhaling for 6 seconds). In this manner, the system may determine the standard mode according to the physiological data (including height, weight, age, sex), and physiological condition (normal or recovered patient), as well as previous learning scores, and thus finding out a most suitable breathing pattern for learning.

### 5. Experiment

We record the user's breathing status in general situation, and also record the user's breathing status after using our system. We detected the user's breathing value of thoracic and abdominal separately, and recorded them in real-time. Figure 7 shows user's breathing status in general, and we can observe that the tester used the thoracic breathing. The green line shows thoracic respiration volume, and the blue line shows abdominal respiration volume.



Figure 7. User's breathing status in general situation

We record the user's breathing status after using our breath-training system. The green line shows thoracic respiration value, and the blue line shows abdominal respiration. Figure 8 shows the user's breathing status after using our system. The result shows that the user is using abdominal

breathing.

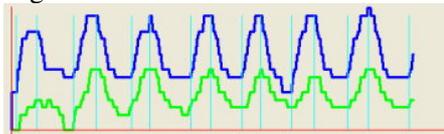


Figure 8. User's breathing status after using our system

The result shows that our system can teach users the abdominal breathing method, and guides them to breathe correctly. By using abdominal breathing, we can enlarge the respiration efficient, and then promote the health of the body.

## 6. Conclusion and future work

Our system provides a method for improving breathing pattern with an interactive multimedia approach. The system uses RIP to detect user's breathing status, and reflects the data with means of hearing and vision, and so instantly convert the physiological data and breathing learning data into multimedia feedback which is convenient to understand, thus facilitating the learning of suitable breathing pattern by the systematic feedback mechanism of reflection, guidance, and assessment. Through the experiment result, we find that a user can learn abdominal breathing easily, by following the guided breathing frequency correctly which is provided by our multimedia. The future works of our breathing training system include:

- **Portable devices:** users can use the breathing system anywhere. Thus, we can provide pervasive healthcare and health monitoring applications.
- **Multi-model biofeedback:** Provides more feedback, such as touch, vision, sounds, etc.
- **Interactive game:** Using playfulness factors to develop a breath-training game. The user could learn how to breathe correctly through interaction.

## 7. Acknowledgments

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