DESIGNING AND IMPLEMENTATION OF A TACTILE RESPIRATORY MANAGEMENT SYSTEM

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Introduction

Currently the treatment of lung cancer patients may include a method known as respiratory gating, in which the tumor is targeted at a certain point in the breathing cycle [1]. By this method the overall radiation dose is decreased and the damage to healthy tissue is minimal. However, a difficulty arises in maintaining patients' ability to breathe consistently, as natural breathing patterns are inconsistent in both amplitude and frequency. Previous methods for management, including audio and visual cues, have proven relatively ineffective and produce a cognitive strain on the patient. Our goal is to provide patients' with tactile feedback for consistent and uniform breathing patterns. We propose a tactile Respiratory Management System (tRMS) to regulate patients' breathing motion in an instinctive manner, so that respiratory gating will be optimized to treat as much of the cancerous tissue and as little healthy tissue without causing cognitive strain.

Design

Our objective is to develop a system capable of managing patients' breathing cycles. We require that the design be portable and inexpensive, and provides an efficient and natural cues through the skin. In order to meet these requirements we designed a system comprised of small vibrating motors housed in small acrylic units, connected to a control box that could incorporate power for up to twelve motors. The input of the control box was connected to the parallel port of a personal computer. The accompanying circuitry included a high power Darlington transistor pair from Texas Instruments that worked as electrical switches for all motors. Each motor required 80 mA of current at 3 V to run at the speed of about 11000 RPM with perceivable amplitude levels. The encased motors were mounted inside of Velcro straps placed over an ace bandage. The motors are cued using binary logic owing to the transistor configuration of the control box.

Preliminary Testing

We have conducted a preliminary psychophysical study, in which three participants, ages 19, 22, and 32, were asked to identify which of the five motors were being cued for 200 msec along the array mounted on their forearm (Fig. 1). Participants underwent two sets of 100 trials each that lasted for about 3-5 minutes. The study resulted in participants being able to correctly identify the cues between 75.5% and 86.5% of the time and information transfer of 1.39-1.75 bits. This indicates that about three out of the five motors were reliably identified on the forearm. We hypothesize that this was due to asynchrony between physical distance and perceived distance on the forearm as well as due to low spatial acuity of the skin of the forearm. It is important to note that the most discrepancies were noted between adjacent motors.

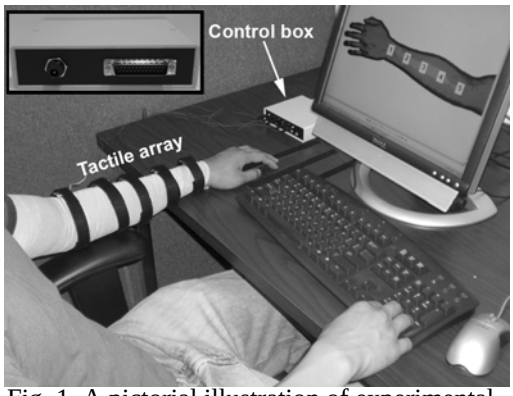

Fig. 1. A pictorial illustration of experimental setup

Future Work

In the future, we plan to quantify a relationship between perceived and actual distance of motors along the forearm and thigh. Using this function and the tRMS, we test actual cancer patients to breathe during gated-radiotherapy treatments using tactile alone and tactile combined with visual and auditory feedback.

References

[1] R. George, T. D. Chung, S. S. Vedam, V. Ramakrishnan, R. Mohan, E. Weiss, & P. J. Keall. Audio-visual biofeedback for respiratory-gated radiotherapy: Impact of audio instruction and audio-visual biofeedback on respiratory-gated radiotherapy. Int. J. Radiation Oncology Biol. Phys., 65:924–933, 2006.