ALEXANDRIA UNIVERSITY

Faculty of Engineering
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OPTIMIZATION OF ANTENNA EXCITATIONS FOR BREAST CANCER TREATMENTS

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Abstract

Noninvasive microwave hyperthermia could be a promising standalone technique for breast cancer treatment. Compared to the existing therapeutic treatments it is non-ionized and noninvasive. In this modality, the temperature at the tumor is raised above 42°C noninvasively using phased array antenna while maintaining healthy tissue at normal temperature for a sufficient amount of time to kill cancer cells.

The technique has focusing challenges, which is to achieve localized heating at the tumor position and to avoid hot spots in healthy tissues. Several effective methods for targeting cancerous tissue with microwave hyperthermia have been proposed. The accuracy of the excitation signals used for each antenna element is critical to the success of microwave hyperthermia in treating breast cancer. Therefore, using a global optimization algorithm, the correct excitations parameters for each antenna are calculated so that the microwave power is delivered only to the tumor position, while the healthy tissue is kept safe.

The success of hyperthermia treatment appears to be strongly related to the capability of the antenna to focus energy effectively into a tumor. Using microstrip patch antenna in array configuration, the microwave energy is considered to be the most powerful way to cause hyperthermia noninvasively in the treatment of malignant tumors.

The goal of this thesis is to efficiently focus microwaves for noninvasive hyperthermia treatment of breast tumor at early stages where the tumor has not yet spread to lymph nodes or other parts of the body. Two evolutionary optimization techniques, particle swarm optimization and genetic algorithm, are applied and compared in order to select the algorithm which will be used in the study. The technique is put to the test on a difficult scenario involving a 3D realistic breast model with a tumor radius of 5 mm (less than 1cm^3 volume) embedded in various locations deep within the glandular tissue of a dense breast. The results confirmed the focusing technique's capability in tumors located away from the antenna array's center plane. Then, the same focusing technique is used to collect data of accurate antenna excitations (amplitudes and phases) for tumor having a radius of 2.5 mm embedded in every possible position in the glandular tissue in the center plane of the antenna array. Further validation that shows the effectiveness of the proposed 3D microwave focusing technique is introduced by obtaining the temperature distribution at the tumor center position and compared with other healthy locations.

At the end of the research, a proposed noninvasive hyperthermia system for breast cancer treatment is presented. In this system, the collected data of antenna excitations with respect to the tumor position is stored in a database, where clinical doctors input the coordinates of the tumor and obtain the optimum amplitudes and phases of each antenna to achieve the goal of the hyperthermia treatment.