HUMAN HEAD PHANTOM MATERIAL CHARACTERIZATION FOR MICROWAVE IMAGING SYSTEM

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Dedicated to my beloved family, mother and father

and

To my honourable supervisor, Dr Norhudah Binti Seman

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ABSTRAK

Barah payudara dan otak tersenarai sebagai barah yang menjadi penyebab utama kematian di seluruh dunia. Baru-baru ini, pengimejan gelombang mikro telah dicadangkan untuk pengimejan dan diagnosis barah payudara, dan boleh diteruskan untuk pengimejan barah otak. Walau bagaimanapun, tisu dan sel kepala manusia berbeza daripada tisu dan sel payudara manusia terutama daripada sifat-sifat dielektrik justeru itu penghasilan fantom kepala yang sesuai diperlukan. Fantom yang perlu bagi sistem pengesanan barah otak mesti mempunyai spesifikasi tertentu untuk menjadikannya sesuai dengan sistem pengimejan. Tesis ini membentangkan siasatan terhadap sifat-sifat dielektrik bahan fantom kepala manusia untuk sistem pengimejan gelombang mikro. Dalam penyiasatan, sampel-sampel fantom dibuat menggunakan air dan gelatin dalam menghasilkan fantom yang kos efektif. Skop penyiasatan adalah pada sifat air, tisu fantom, faktor perubahan dielektrik, pengawetan fantom dan jangka hayat fantom. Siasatan ini memberi tumpuan kepada sifat dielektrik yang terdiri daripada ketelusan relatif dan kekonduksian di seluruh frekuensi gelombang mikro daripada 1-6 GHz. Semua ukuran diperoleh menggunakan Rangkaian Penganalisis Vektor dengan prob dielektrik untuk mendapatkan ketelusan kompleks. Siasatan ke atas ciri-ciri air menunjukkan bahawa sebarang jenis air putih mempunyai sifat dielektrik yang hampir sama. Lima komposisi bahan berasaskan gelatin dibentangkan dalam siasatan ini menunjukkan ia mempunyai sifat dielektrik hampir sama dengan lima tisu kepala manusia iaitu perkara kelabu (kompososi 5g gelatin, 20g air dan 0.5 gula), perkara putih (kompososi 5g gelatin dan 14g air), cecair tulang belakang serebrum (kompososi 10g gelatin dan 50g air), darah (kompososi 10g gelatin dan 30g air) dan kulit (kompososi 10g gelatin dan 20g air). Selain nisbah antara air dan gelatin, tiga faktor-faktor lain iaitu suhu, garam dan gula mampu mengubah sifat dielektrik bahan. Pengawetan bahan berasaskan gelatin telah dicadangkan menggunakan cuka dan ia mampu memanjangkan jangka hayat fantom. Hasil dalam tesis ini berguna dalam meningkatkan pengetahuan mengenai sifat dielektrik bahan yang digunakan dalam fantom kepala manusia yang mana penting apabila menghasilkan, memperbaiki dan mengawal sifat dielektrik fantom.

ABSTRACT

Breast and brain cancers are stated as the most common causes of cancer-related deaths around the world. Recently, microwave imaging has been proposed for breast cancer imaging and diagnosis, and can be extended for brain cancer imaging. However, tissues and cells for human head are different from human breast especially in terms of dielectric properties thus requiring the development of an appropriate head phantom. The required phantom for brain cancer detection system must have particular specification to make it compatible with the imaging system. This thesis presents an investigation on dielectric properties of materials of human head phantom for microwave imaging system. In the investigation, samples of phantoms are made using water and gelatin in producing a cost effective phantom. The scopes of investigation are on the characteristics of water, tissues of phantom, dielectric variation factors, preservation of phantom and lifespan of phantom. This study focuses on dielectric properties consisting of relative permittivity and conductivity across microwave frequency from 1 to 6 GHz. All measurements are obtained using Vector Network Analyzer with a dielectric probe to obtain complex permittivity. Investigation on water characteristics indicate that almost any type of plain water has similar dielectric characteristics. Five compositions of gelatin-based materials presented in this investigation showed to have similar dielectric properties with five human head tissues, which are grey matter (composition of 5g gelatin, 20g water and 0.5g sugar), white matter (composition of 5g gelatin and 14g water), cerebral spinal fluid (composition of 10g gelatin and 50g water), blood (composition of 10g gelatin and 30g water), and skin (composition of 10g gelatin and 20g water). Besides the ratio between water and gelatin, three other factors of temperature, salt and sugar are discovered to be able to change the dielectric properties of the materials in the investigation. The preservation of gelatin-based material is proposed using vinegar and is able to prolong the lifespan of phantom. The outcome in this thesis is useful in gaining knowledge on dielectric characteristics of material used in human head phantom which is important in the stage of developing, tuning and controlling the dielectric properties of the phantom.