DEVELOPMENT OF VOXEL MALE AND FEMALE WHOLE-BODY MODELS AND DOSIMETRY

Soichi Watanabe[(1)], **Tomoaki Nagaoka**[(2)], **Kiyoko Sakurai**[(3)], **Satoshi Watanabe**[(4)], **Etsuo Kunieda**[(5)], **Masao Taki**[(6)], **and Yukio Yamanaka**[(7)]

[(1)]***Communications Research Laboratory, Independent Administrative Institution,***
Nukuikitamachi 4-2-1, Koganei, Tokyo 184-8795, Japan, E-mail: wata@crl.go.jp
[(2)]***Department of Medical Engineering, Graduate School of Kitasato University,***
Kitasato 1-15-1, Sagamihara, Kanagawa 228-8555, Japan, E-mail: nagaoka@rtpc2.ahs.kitasato-u.ac.jp
[(3)]***As (2) above, but E-mail: sakurai@nc.kitasato-u.ac.jp***
[(4)]***As (2) above, but E-mail: swat@medcc.kitasato-u.ac.jp***
[(5)]***Department of Radiology, School of Medicine, Keio University,***
Shinanomachi 35, Shinjuku, Tokyo 160-8582, Japan, E-mail: kunieda@sc.itc.keio.ac.jp
[(6)]***Graduate School of Engineering, Tokyo Metropolitan University,***
Minami-Osawa 1-1, Hachioji, Tokyo 192-0397, Japan, E-mail: taki@eei.metro-u.ac.jp
[(7)]***As (1) above, but E-mail: yama@crl.go.jp***

ABSTRACT

In order to obtain detail dosimetry for near-field exposure by wearable wireless devices or far-field exposure by VHF-UHF broadcast towers, various whole-body human models are needed. Numerical (voxel) male and female whole-body models have been developed from MRI data of Japanese male and female volunteers whose figures are close to Japanese average ones, respectively. These models constitute of over 50 types of tissues and their spatial resolutions are $2 \times 2 \times 2$-[mm]. Homogeneous whole-body models with various figures and postures have also been developed. Preliminary calculation (FDTD) results are presented in this paper.

INTRODUCTION

Rapid progress of computer facilities allows detailed and realistic dosimetry of a human body exposed to electromagnetic fields [1]. From 70 to 80s, for example, only human models with over 1-cm dimension cells could be treated even if super computer systems were used [2, 3], while recent high-end WS or PC systems can treat numerical human models with mm-resolution.

Because such high-resolution numerical human bodies with heterogeneous tissue structures cannot be developed manually, they were developed by transforming MRI data of human bodies to the numerical voxel data which are tagged with corresponding tissue types. Many detailed head models have particularly been developed for estimation of specific absorption rate (SAR) in a human head exposed to near-field of cellular telephone devices [4–7].

In near future, on the other hand, mobile telecommunication devices are going to be used not only at temporal side of a user's head but also at wearable position, e.g., wrists, waist, or even inside of the body. The head models without other parts are therefore not appropriate to simulate various exposure positions.

Furthermore, digital TV systems are going to be introduced in a few years. It requires additional broadcast towers operated at VHF and UHF bands and may cause public concerns on health effects at these frequency bands. The whole-body resonance is one of the most important phenomena to determine the human-body energy absorption in these frequency bands [8]. Many dosimetric studies on the whole-body resonance have been reported although most models were based on adult male bodies and their postures were always in upright standing [8]. It can be however expected that the characteristics of energy absorption depends on the sexuality, age (children and adult), and posture.

We therefore have developed detail numerical male and female whole-body models based on MRI data of volunteers whose figures are close to Japanese average ones. We also developed a software to produce homogeneous-tissue human-body models with various figures and postures.

DEVELOPMENT OF HETEROGENEOUS-TISSUES WHOLE-BODY MODELS

Male and female models are based on the MRI data of volunteers whose figures are close to Japanese average male body (171-cm tall and 63-kg weight) and female body (159-cm tall and 53-kg weight), respectively. Parameters of MRI scans were optimized for the head region and the body region in order to get enough spatial resolution and to save data acquisition time. MRI scanning with 2-mm slice of the whole body however required several hours intermittently. In MRI

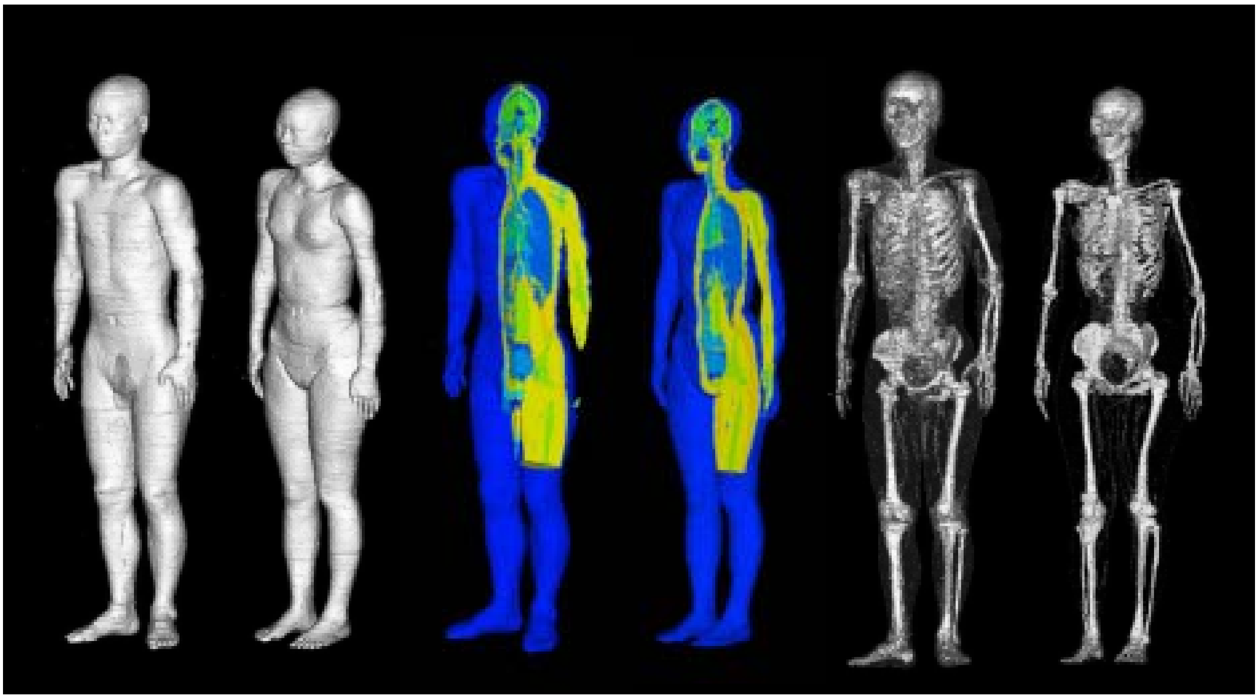

Figure 1: Numerical whole-body human models based on MRI data of volunteers whose figures are close to Japanese average ones. The spatial resolutions are 2-mm and over 50 types of tissues are identified.

scanning, orthopedics forms were used to keep the position of the volunteers' body and fix his/her ankles like as standing on the ground plane. Finally, male and female models were constructed with 866 and 804 slices, respectively.

MRI data (DICOM format) were transformed to TIFF format, then the continuities between different scan data were corrected. Furthermore, the resolution of the TIFF data was shrunk to be 2-mm pixel size. It is noted that these high-resolution section data were obtained without any interpolation or extrapolation procedures to improve spatial resolution. Identification of tissue types was done manually by medical staffs because any automatic identification softwares were not available with enough accuracy.

The tissue identification took over three years. The views of the developed models and preliminary calculation results are shown in Figs. 1 and 2, respectively. It is noted that higher frequency (1 GHz) than VHF and UHF bands is assumed in the preliminary calculations in order to save computation time.

DEVELOPMENT OF WHOLE-BODY MODELS WITH VARIOUS FIGURES AND POSTURES

In order to develop whole-body human models with various figures and postures, we have improved a software (Quete, OGIS-RI Co. Ltd.) which can manipulate various parts of Japanese average human-body CAD data. We added some modules to convert from CAD data to homogeneous voxel data with any spatial resolution. Some example of model data and calculated results are shown in Figs. 3 and 4.

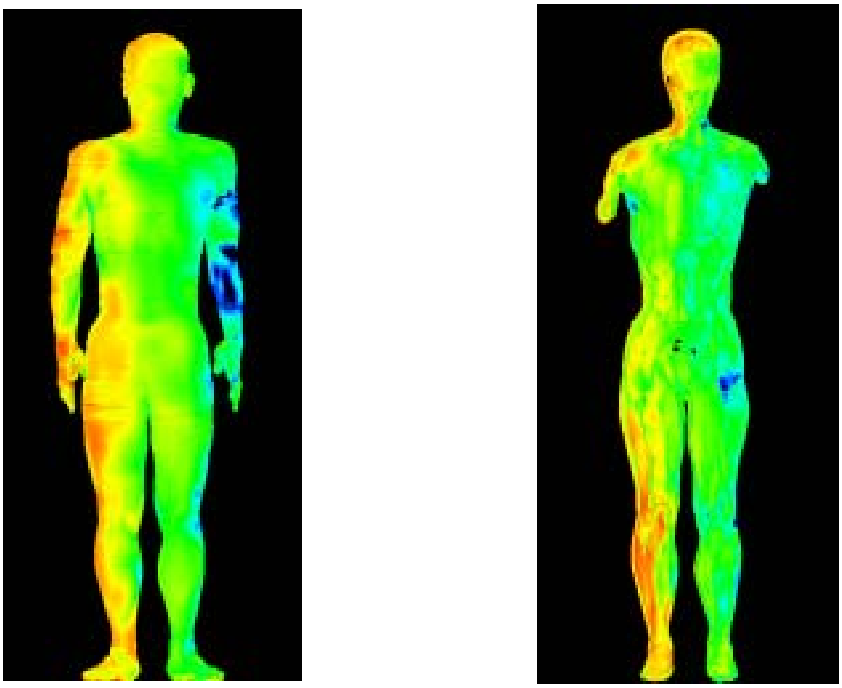

Figure 2: SAR distributions of the whole-body male model exposed to 1-GHz E-polarized plane wave propagating from left to right. The left view shows the SAR distribution on the surface of the model and the right one shows the SAR distribution in the vertical section of the model.

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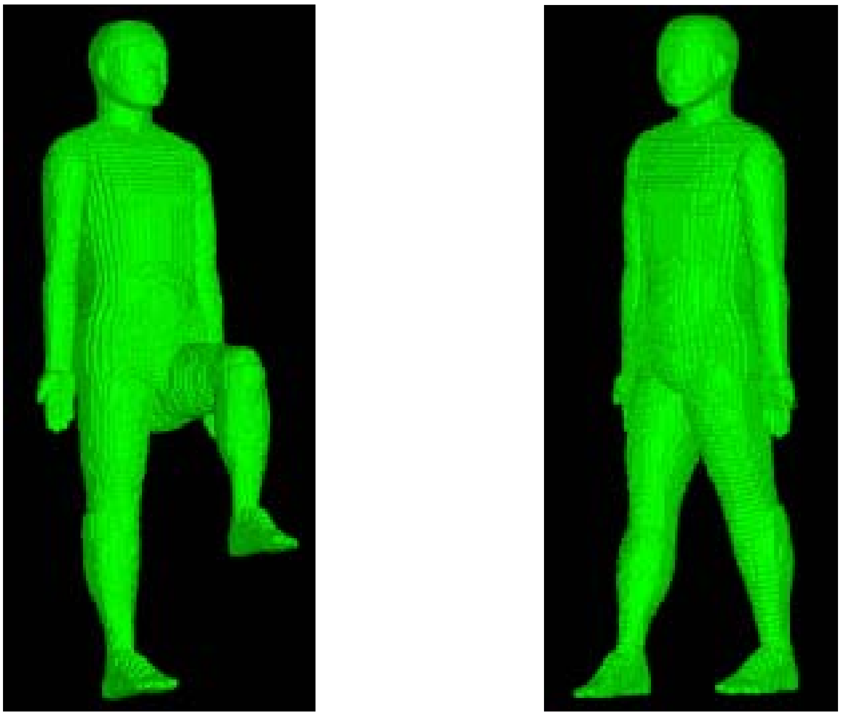

Figure 3: Any-posture whole-body human models (walking). The size of voxel is 4 mm and the homogeneous tissue (2/3-muscle) is assumed.

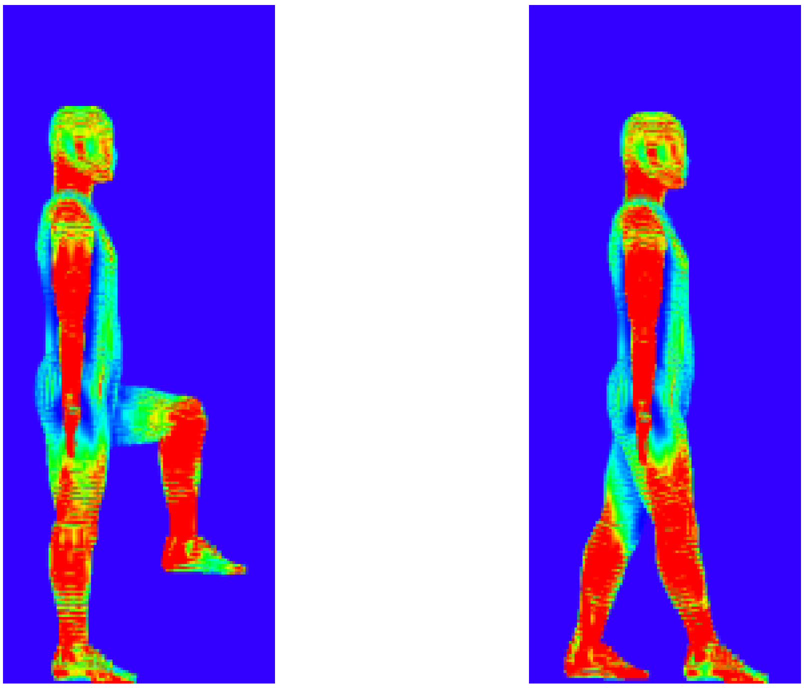

Figure 4: Calculated SAR distribution on the surface of the whole-body human model, shown in Fig. 3, exposed to E-polarized plane wave at 1 GHz. The plane wave propagates from right side of the models to left side.