Development of Machine Learning Algorithm for Predicting Microwave Heating Area

Aditya Rakhmadi[(1)] and Kazuyuki Saito[(2)]
(1) Graduate School of Science and Engineering, Chiba University, Chiba, Japan;
e-mail: rakhmadi_aditya@chiba-u.jp
(2) Center for Frontier Medical Engineering, Chiba University, Chiba, Japan;
e-mail: kazuyuki_saito@faculty.chiba-u.jp

Microwave energy-based medical device usage has been growing in recent years, improving patient's quality of life. Computer numerical calculation is used to design and evaluate the microwave device performance before being introduced into the market. To calculate the heating of a device requires a long numerical calculation time. This calculation can be accelerated using a supercomputer; however, this technology is not accessible for everyone. Machine learning technology can reduce numerical calculation time without the need for a high spec computer.

Microwave heating calculation uses an electromagnetic calculation to produce specific absorption rate (SAR) data and use the data to simulate the thermal calculation using bioheat transfer equation [1]. For the thermal calculation, it is necessary to preset the desired heating time and power at the start. This limitation can pose a problem if the desired time or input power is out of range or not set accordingly. In this situation, the thermal calculation needs to be redone from the start, leading to further increased calculation time. Machine learning can reduce calculation time significantly. Machine learning uses previous data to calculate and predict the next outcome. Prediction used an algorithm after the machine trained on a historical dataset and applied to predict a particular outcome. This technology can significantly reduce numerical calculation time and cover a situation when there are no simulation results used as a reference. Machine learning calculations are done using Tensorflow and Keras [2].

Figure 1 shows the model used in numerical calculation. The model uses a muscle phantom designed for industrial, scientific, and medical (ISM) 2.45 GHz. The antenna used is a single slot-coaxial antenna. Before the calculation, phantom electrical and thermal properties were measured and used in numerical calculation. The model is based on a model for transcatheter renal denervation, and a blood vessel is running through the middle of the phantom. To simplify the model, blood and blood vessel are substituted with water.

This study presents a microwave heating prediction using a machine learning algorithm. For future works, we intend to increase the measured points and further reinforce the machine learning algorithm.

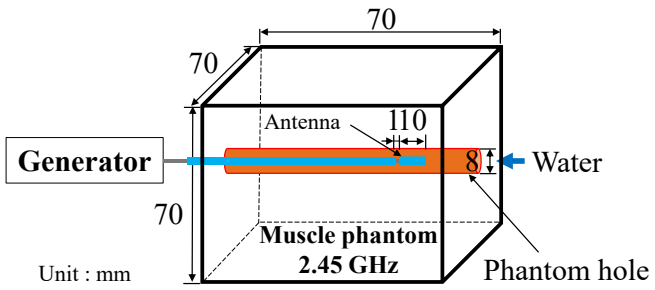

Figure 1. The model used in numerical calculations. The antenna is placed in the middle of the water model.

References

[1] H. H. Pennes, "Analysis of tissue and arterial blood temperatures in the resting human forearm," *J. Appl. Phys*., vol. 1, pp. 93-122, 1948.

[2] "Tensorflow Homepage," [Online]. Available: https://www.tensorflow.org/. [Accessed 2021 January 27].