EE 492

Senior Design Project Proposal

ESTIMATION OF THE EFFECTS OF MATCHING LAYER ON WEARABLE AND IMPLANTABLE ANTENNAS USING NEURAL NETWORK

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3 November 2020

I. Introduction

Wireless wearable and implantable devices are becoming popular within various areas such as medical, fitness, business operations, video games etc. Wearable devices can be in the form of glasses, watches, or any kinds of tools which are worn. These devices are used to track the user's movement, location, vital signs, calorie expenditure, sleep, and some other specific information. Implantable devices are more precision and usually require surgery; however, they can obtain information which cannot be accessible to sensors externally placed to the body. In the medical field, wearable and implantable devices have applications of monitoring, diagnosis, and treatment of various diseases.

Body centric wireless communications (BCWC) are established using wearable and implantable devices which provide wireless communication link between human body and the surroundings via wearable and implantable antennas. There exist mainly three different communication types in BCWC such as *on-body* communications, which occur between on-body devices, *in-body* communications, which are formed within implanted devices, and *off-body* communications, which occur between on-body and off-body devices [1]. The Fig. 1 shows a schematic of the mentioned communication types.

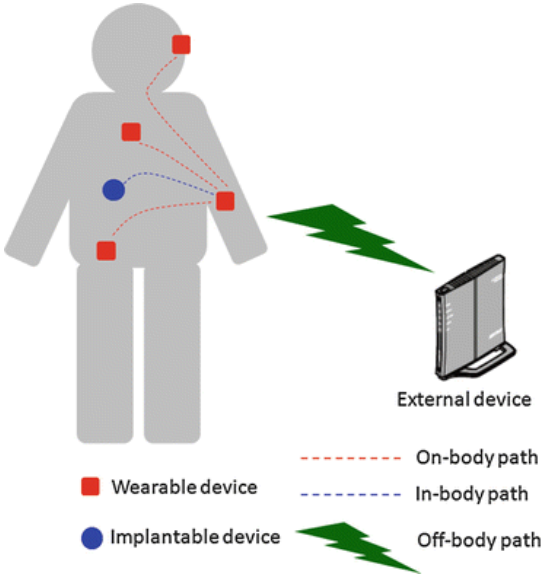

Fig. 1. A schematic of body centric wireless communications [1]

The antennas used in these devices are very sensitive to their surroundings. The properties of the implanted antenna such as average transmitted power, return loss, resonance frequency, bandwidth, etc are highly impacted by the presence of the body due to the fact that the human body is formed by highly lossy materials for radio frequency propagation [2]. These negative effects are mainly stemmed from path losses, which are caused by the impedance mismatch between the propagation environments (air and the body), near field losses and reflection. These factors result in an inefficient power transmission of the radio wave in the in-body communications and the on-body communications. Therefore, in order to improve the quality of the in-body and on-body communication links, a *matching layer* can be placed. By altering the permittivity and width of the matching layer, the quality of the in-body and on-body communication links can be enhanced.

II. Objectives

The determination of the matching layer parameters is accomplished by the means of simulation tools such as ANSYS HFSS. Also, where to place the antenna is a part of the design problem since the permittivity of the human body is not constant and it affects the performance of the antenna. Thus, in order to decide the optimum matching layer parameters and the location of the antenna, the simulation should run for a very long time.

The aim of this project is to build a neural network which can estimate the antenna's transmitted average power, return loss, and resonance frequency in terms of the permittivity and width of the matching layer and the permittivity of the human body.

III. Approach and Methodology

As a first step of the project, the literature about the artificial intelligence (AI) used in the field of the wearable and implantable antennas will be investigated. The knowledge of how the neural networks are constructed and which models are used will be obtained. After gaining an insight on the approach of neural network, a data set should be generated in order to train and test the constructed network. The data set will be generated by running simulation in the HFSS with some predetermined parameters of matching layers and human body. Finally, with the adequate data set, the well-constructed network will be trained and tested.

IV. Expected Results and Accomplishments

The expected result of the project is mainly to be able to reduce the simulation time for the determination of the matching layer parameter and the location of the antenna by establishing a well-constructed neural network. With the neural network, the estimation of the parameter will be available without running a full simulation. In the end, it is not very clear whether the built neural network gives the optimum parameters for the matching layer, it will be considered to alter the estimation method to a new approach if the proposed method fails to provide expected results.

V. Realistic Constraints

How many hours on a week are required to accomplish this project and the current level of knowledge of mine are the main constraints of the project. I plan to work 16 hours on a week but it might lengthen or shorten depending on other things. Another restriction is my knowledge about this field, I need to spend a couple of weeks on reviewing the literature to gain an insight on the neural network approach to the wearable and implantable antenna field.

A. Social, Environmental and Economic Impact

The estimation of the effect of matching layers using neural network can save the time which is spent on the determining the parameters of matching layer using simulation tools. So, the antenna designer will have more time to work on the other aspects of the antenna.

B. Cost Analysis

There exist some computer tools to realize the project such as, a simulation tool, ANSYS HFSS will be used and its licence is provided by the university; a platform to run the neural network algorithm, Google Colab is used and it's free.

C. Standards

The project will comply with IEEE, IET, EU and Turkish standards and the engineering code of conduct will be followed through the project.

VI. Time Schedule

The overall time invested in the project is 13 weeks. The tentative time schedule is given in the Table I.

TABLE I
THE TENTATIVE TIME SCHEDULE

Research of the AI used in the field of the wearable and implantable antennas	3-4 weeks
Construction of the scheme of the neural network	3-4 weeks
Generation of the data set using HFSS	1-2 weeks
Training and testing the built neural network	2-3 weeks
Making adjustments to increase the accuracy of the neural network	1-2 weeks
Reporting the results	1 week

REFERENCES

[1] Ito K., Lin CH., Lin HY. (2015) Evaluation of Wearable and Implantable Antennas with Human Phantoms. In: Chen Z. (eds) Handbook of Antenna Technologies. Springer, Singapore.

[2] Gabriel, C. (1996). Compilation of the Dielectric Properties of Body Tissues at RF and Microwave Frequencies. http://niremf.ifac.cnr.it/docs/DIELECTRIC/Report.html [Accessed 2 November 2020]