Portable and Conformal RF Sensor for High-Accuracy Real-Time Imaging

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Portable sensors with real-time imaging capabilities can bring forward new possibilities in several areas, such as deep tissue imaging for medical monitoring and diagnostics, sub-surface object detection, liquid flow measurements, etc. Specifically, magnetic resonance tomography, and X-rays are the most common approaches for medical imaging. However, these technologies are complex, require major investments, and are not portable. Wearable real-time imaging sensors would significantly improve the quality of life for sufferers and reduce healthcare costs by enabling early diagnosis.

Along these lines, we have introduced a novel method of deep-tissue pixel-by-pixel imaging using a wearable sensor. The sensor consists of several dipoles wrapped around the human body. One dipole transmits RF power at a time, while the others are used for receiving. All possible combinations of transmit and receive dipoles may be utilized to obtain the scattering parameters (S-parameters) around the imaging domain. The underlying permittivity and conductivity values can then be calculated from the measured S-parameters using a linear regression model. The weight coefficients of this linear model are obtained after training the system for several hundred known conditions. Simulation results using this approach have confirmed imaging accuracies as high as 6%.

Nevertheless, the relation between the measured S-parameters and the underlying permittivity and conductivity values is in practice non-linear. As such, the aforementioned linear approximation will only work for a narrow range of electrical property values. With this in mind, we recently proposed an Artificial Neural Network (ANN) based algorithm to capture this non-linearity. Preliminary simulation results have shown imaging accuracies as high as ~1%, viz. 5% better than before.

The proposed sensor and image extraction algorithm can be applied to several applications that require real-time imaging in a portable way. At the conference, we will show results for deep-tissue imaging as well as sub-surface dielectric object detection.