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Microwave sensing approaches to monitoring physiological responses

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1. Extended Abstract

Microwave imaging and sensing approaches have been proposed for biomedical applications ranging from detecting tissue anomalies [1, 2] to monitoring bone health [3] and hydration status [4]. Typically, these tissues are illuminated with custom sensors, and signals transmitted through or reflected from the body are detected. Key challenges include estimating the tissue properties of interest from the collected data, and providing sufficient sensitivity to detect anomalies or changes in heterogeneous tissues.

To estimate permittivity and conductivity of tissues, several approaches are available. Dielectric probes have been used to estimate properties of excised tissues, as well as *in vivo* samples (e.g. skin) [4]. However, these measurements are only sensitive to tissues located several millimeters below the probe. Microwave tomography aims to estimate the spatial distribution of the permittivity and conductivity, however involves computationally intensive reconstruction algorithms and multiple sensor measurements [1]. We have developed methods to estimate the bulk permittivity and conductivity of cm-scale volumes of tissues over a wide range of frequencies [5]. While detailed spatial distributions are not available, our method does not have a high computational overhead, and requires only one tissue measurement without an immersion medium. In this contribution, we explore the ability of bulk property estimates to provide support for imaging applications, as well as the feasibility of tracking physiological responses with this technique. We have developed a system to estimate bulk properties of the breast using sensors in direct contact with the skin [6]. The convenience of measurements enables the observation of time-dependent physiological changes in human tissues, such as the breast throughout the menstrual cycle [7]. Here, we apply our estimation techniques to elucidate additional information about the tissues.

In progressing to applications where personal monitoring is appropriate, practical system-level considerations are required, including low-cost measurement instrumentation. For instance, in microwave hydration assessment, changes in signal magnitude through a tissue may provide sufficient detection of the underlying physiological changes [8], while allowing for simpler instrumentation. For ongoing monitoring applications, low-cost and robust technology suited to user needs is critical.

2. References

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