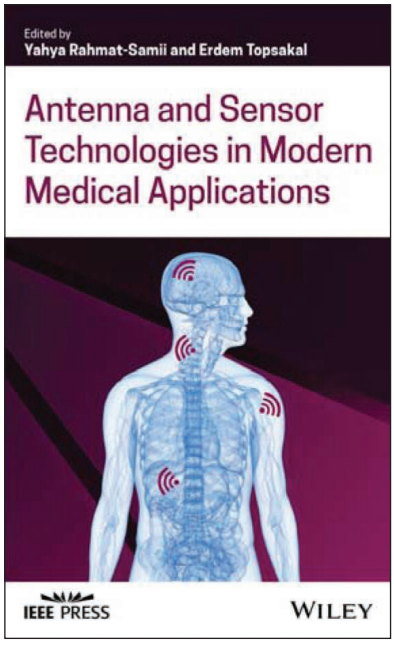
Antenna and Sensor Technologies in Modern Medical Applications

Edited by Yahya Rahmat-Samii and Erdem Topsakal
Reviewed by Mahta Moghaddam

The role of engineering technologies in various aspects of human health and well-being is expanding at a remarkable rate. Whether it's in routine health screening, diagnostics, monitoring, intraoperative guidance, delivery of treatments, drug and vaccine discovery, or just lifestyle enhancement, the ever-increasing importance of engineering technology is undeniable. In particular, devices and techniques that take advantage of electromagnetics (EM) principles are among the key enablers of medical technologies, providing otherwise-unavailable methods for information collection, information transmission, and treatment and intervention. The areas of influence of EM are numerous; we are not just talking about microwave imaging, which is perhaps one of the earliest applications of EM in biomedicine. There are many other innovative application areas that have emerged in the recent past, including implantable devices, new antenna materials for enhancing traditional applications, wireless power transfer, wearables, and the like.

It is difficult to parse through and keep track of all of the ways in which EM is revolutionizing modern medical applications. Just try searching for "electromagnetics in medicine" in Google Scholar! And even after recognizing these different areas of impact, there are many layers of detail and sophistication with which one can understand, and therefore push the envelope of advancement within, these technologies. The book *Antenna and Sensor Technologies in Modern Medical Applications*, edited by Prof. Yahya Rahmat-Samii and Prof. Erdem Topsakal, addresses these two challenges, especially as regards antennas and sensors, and achieves an exceptionally successful result.



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Rahmat-Samii and Topsakal, two of the leading researchers in EM and particularly in applications of EM in medicine, have assembled an outstanding lineup of contributions from top experts in this field. Each of the contributed chapters addresses a unique class of topics. Each chapter provides a brief, yet highly informative, background, in many cases providing the historic perspective that puts the current state-of-the-art technical material in context. The contributing authors have done an excellent job in starting from high-level material of general interest and then becoming progressively more detailed in explaining a diverse set of methods, techniques, or devices. Each chapter contains a comprehensive literature review on its topic, selecting to focus on a representative subset to the extent that the inevitably limited page budgets have allowed. Whether the reader is new to the topic area of a given chapter or an expert, there is plenty of informative content to peruse.

There are multiple crosscuts one can take in reading the book. As I was reading the different chapters, I didn't necessarily come up with a preferred sequence. But, depending on the reader's interest, it may be beneficial to consider the chapters based on various groupings of the overarching topic areas. For example, one can focus on chapters that are relevant to medical diagnostics,

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quality-of-life enhancements, implantable devices, wearables, or therapeutics, keeping in mind that there may be various other groupings and many overlaps.

For medical diagnostics, consider starting with Chapter 2, on the role of novel flexible antennas for magnetic resonance imaging to enable more compact and targeted observation scenarios. Or you may wish to start with Chapter 6, which focuses on ingestible devices that allow a less intrusive alternative to endoscopy and one that may be able to provide more accurate and targeted diagnostic results.

On the topic of sensors and systems for quality-of-life enhancement, Chapter 3 provides an excellent coverage on a range of sensors and techniques for human motion capture. There are many areas of daily life that benefit from the knowledge of human movement, including senior care, recovery from sports injuries or surgeries, entertainment and gaming, and athletic training. This topic also overlaps with chapters that focus on wearables, namely, Chapters 11, 12, 13, and 14.

For implantables, Chapters 4, 5, 7, and 8 provide a wealth of information on the latest devices and applications. In Chapter 4, you will find in-depth material on the optimal electromagnetic design of antennas and wireless links for battery-free, brain-implantable devices based on both inductive coupling and far-field radiation. Options for integrating these two complementary approaches are presented. Chapter 5 presents methods for both in vitro and in vivo testing of implantable antennas and options for materials used for building them, such as tissue-mimicking gels. Chapter 7 covers the topic of ultrawideband channel characterization for an implanted sensor used for liver monitoring (post-transplant surgery). Chapter 8 describes inductive power transfer and the successful example of applying it to transmit power to prosthetic systems, such as an artificial retina.

For wearables, you can find an interesting diversity of topics in Chapters 11, 12, 13, and 14. Chapter 11 focuses on fabricating wearables by additive manufacturing and 3D printing, for example, via the use of ink-jet printing. Chapter 12 describes some of the recent electronic textile technologies, which allow the integration of computing, sensing, and communication electronics into fabrics and clothing. One such method takes advantage of embroidering conductive threads as a means of integrating radio-frequency circuits and sensors into clothing fabric. Chapter 13 discusses readout techniques for fully passive sensors, such as some wearables. In Chapter 14, wireless wearable biomarkers are discussed; these devices allow physiological monitoring at the point of person. These would include measurement of chemical signals, preconditioned on the development of appropriate small chemical sensors.

If your interest is in the area of therapeutics, Chapters 9 and 10 are where you find excellent material. Chapter 9 focuses on precision wireless drug delivery under the umbrella of precision medicine. This is an emerging area, especially in the treatment of conditions that require frequent interventions and the repeated use of pharmaceuticals. The ability to deliver high concentrations of drugs to targeted sites, such as tumors, thereby avoiding systemic ingestion of potentially toxic chemicals, can provide many benefits to patients. Recent developments in microchip and micromachined devices make it possible to achieve this precision drug delivery via transdermal and implantable devices. A very different class of therapeutics is described in Chapter 10, where minimally invasive microwave ablation antenna designs are discussed. The authors show how miniaturized interstitial antennas allow surgeons to reduce the invasiveness and increase the flexibility of ablation treatments.

For those of us working in the applications of EM in health and medicine, *Antenna and Sensor Technologies in Modern Medical Applications* is an excellent resource. It should be considered a necessary addition to our working library!

ABOUT THE REVIEWER

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