

Contents

| | |
|---|-----------|
| <i>Dedication</i> | iii |
| <i>Preface</i> | iv |
| 1. Main Problems in Cancer Diagnosis and Treatments | 1 |
| 1.1 Introduction | 1 |
| 1.2 Main challenges in cancer detection | 2 |
| 1.2.1 Standard methods for cancer detection | 2 |
| 1.2.2 Recent methods for cancer detection and diagnosis | 3 |
| 1.3 Main challenges in cancer treatments | 9 |
| 1.3.1 Main cancer treatments vs thermotherapies | 9 |
| 1.4 Main challenges in the clinical application of new treatments | 12 |
| Reference list | 17 |
| 2. Bioimpedance and Cancer Detection | 21 |
| 2.1 Bioimpedance basics | 22 |
| 2.1.1 Electrical properties of the cells | 22 |
| 2.1.2 Electrical properties of malignant tissues | 24 |
| 2.1.3 Electrodes and probe | 26 |
| 2.1.4 Instrumentation | 28 |
| 2.2 Bioimpedance applications | 30 |
| 2.2.1 Circulating tumoral cells detection (CTC) | 30 |
| 2.2.2 Breast cancer detection by EIS | 32 |
| 2.2.3 Breast cancer detection by MIS | 33 |
| Reference list | 37 |
| 3. Thermal Images: Towards Cancer Detection | 41 |
| 3.1 Introduction | 41 |
| 3.2 Thermal images principles and applications | 42 |
| 3.2.1 Infrared sensors, readings, and data arrays | 44 |
| 3.2.2 Thermal camera characterization | 45 |

| | | |
|-----------|--|-----------|
| 3.2.3 | Thermal imaging in medicine | 48 |
| 3.2.4 | Correlation between physiology and thermal images | 50 |
| 3.2.5 | Thermal data and image processing | 50 |
| 3.3 | Breast cancer thermal imaging | 52 |
| 3.3.1 | Device criteria | 53 |
| 3.3.2 | Procedures for routine tests and preparing patients | 54 |
| 3.3.3 | Image analysis and interpretation | 56 |
| 3.3.4 | Risk and prognostic diagnosis | 57 |
| 3.3.5 | A comparison of thermography and other medical techniques | 58 |
| 3.4 | Current advances and perspectives | 58 |
| 3.5 | Conclusions | 60 |
| | Reference list | 61 |
| 4. | Artificial Intelligence and Cancer Detection | 64 |
| 4.1 | Introduction: Artificial Intelligence and its clinical relevance | 65 |
| 4.2 | Data acquisition | 66 |
| 4.2.1 | Clinical data | 66 |
| 4.2.2 | Cancer medical imaging | 67 |
| 4.3 | Preprocessing | 67 |
| 4.4 | Processing | 70 |
| 4.4.1 | Feature extraction and selection methods | 70 |
| 4.4.2 | Classification methods | 71 |
| 4.4.3 | Segmentation methods | 72 |
| 4.5 | Visualization and presentation | 75 |
| 4.6 | Validation and assessment of results | 75 |
| 4.7 | Conclusion | 76 |
| | Reference list | 79 |
| 5. | Hyperspectral Imaging for Cancer Applications | 81 |
| 5.1 | Introduction | 82 |
| 5.2 | HSI Instrumentation | 84 |
| 5.3 | HSI analysis algorithms | 86 |
| 5.4 | HSI applications in cancer detection | 87 |
| 5.4.1 | Skin cancer applications | 88 |
| 5.4.2 | Brain cancer applications | 90 |
| 5.4.3 | Gastrointestinal cancer applications | 92 |
| 5.4.4 | Head and neck cancer applications | 93 |
| 5.4.5 | Histological samples in cancer applications | 94 |
| 5.5 | Conclusions | 95 |
| | Reference list | 96 |

| | |
|---|------------|
| 6. Oral Cancer Detection by Multi-Spectral Fluorescence Lifetime Imaging Microscopy (m-FLIM) and Linear Unmixing | 102 |
| 6.1 Introduction | 103 |
| 6.2 Non-invasive mFLIM techniques | 104 |
| 6.3 m-FLIM optical instrumentation | 107 |
| 6.4 m-FLIM data processing and fluorescence lifetime estimation | 108 |
| 6.5 Linear unmixing | 110 |
| 6.6 EBEAE analysis of m-FLIM datasets for oral cancer detection | 111 |
| 6.7 Conclusions | 113 |
| Reference list | 115 |
| 7. Thermotherapies based on Microwaves (MW) and Radiofrequencies (RF) | 118 |
| 7.1 Introduction | 119 |
| 7.2 Thermotherapies classification | 119 |
| 7.2.1 Physical principles of Microwaves (MW) and Radiofrequency (RF) | 120 |
| 7.2.2 RF and MW applicators | 122 |
| 7.3 Clinical applications | 124 |
| 7.3.1 Requirements for the clinical application of thermal therapies | 124 |
| 7.3.2 Main application and features according to the body region | 128 |
| 7.3.3 Treatment quality and clinical studies | 128 |
| 7.4 Computational modeling and treatment planning | 132 |
| 7.4.1 Electromagnetic models (MW and RF) | 132 |
| 7.4.2 Thermal models | 134 |
| 7.4.3 Treatment planning | 135 |
| 7.5 Conclusion | 137 |
| Reference list | 138 |
| 8. Thermotherapies based on Ultrasound | 143 |
| 8.1 Introduction | 144 |
| 8.2 Physical principles of ultrasound | 144 |
| 8.2.1 Ultrasonic sources | 144 |
| 8.2.2 Acoustic propagation modeling | 147 |
| 8.2.3 Acoustic field characterization | 150 |
| 8.2.4 Tissue mimicking-material for ultrasonic source validation | 150 |

| | | |
|------------|--|------------|
| 8.3 | Clinical applications | 152 |
| 8.3.1 | Requirements for the clinical applications | 152 |
| 8.3.2 | Extracorporeal applications | 154 |
| 8.3.3 | Intracavitary and interstitial applications | 155 |
| 8.3.4 | Combining therapies and clinical studies | 156 |
| | Reference list | 159 |
| 9. | Biological Effects of Thermal Therapies (EM Waves and Mechanical Waves) | 164 |
| 9.1 | Introduction | 165 |
| 9.2 | Thermal effects | 165 |
| 9.2.1 | Biological aspects | 166 |
| 9.2.2 | Biological tissues and temperature increase | 167 |
| 9.2.3 | Tissue injury | 172 |
| 9.3 | Non-thermal effects | 173 |
| 9.4 | Exposure guidelines for electromagnetic radiation | 176 |
| 9.5 | Conclusion | 178 |
| | Reference list | 179 |
| 10. | Photothermal Techniques in Cancer Detection-Photoacoustic Imaging | 184 |
| 10.1 | Introduction | 184 |
| 10.2 | The photoacoustic techniques | 185 |
| 10.3 | Ultrasound resolution | 188 |
| 10.4 | Photoacoustic time-resolved sensitivity | 190 |
| 10.5 | Photoacoustic imaging | 190 |
| 10.6 | Photoacoustic in bone analysis | 191 |
| 10.7 | Cancer detection zones | 192 |
| 10.7.1 | Melanoma | 192 |
| 10.7.2 | Breast | 193 |
| 10.7.3 | Ovarian | 194 |
| 10.7.4 | Prostate | 195 |
| 10.8 | Final words | 195 |
| | Reference list | 196 |
| 11. | Tissue Characterization for Microwave and Ultrasonic Applications | 200 |
| 11.1 | Introduction | 201 |
| 11.2 | Tissue characterization by using open-ended coaxial probes | 201 |
| 11.2.1 | Dielectric properties: relative permittivity and electrical conductivity | 203 |

| | | |
|------------|---|------------|
| 11.3 | Temperature dependence of tissue properties | 206 |
| 11.3.1 | Electrical and thermal conductivity | 207 |
| 11.3.2 | Blood perfusion | 209 |
| 11.3.3 | Speed of sound | 213 |
| 11.4 | Tissue characterization by acoustic propagation measurements | 214 |
| 11.4.1 | Speed of sound | 214 |
| 11.4.2 | Attenuation | 215 |
| | Reference list | 216 |
| 12. | Nanotheranostics in Cancer | 222 |
| 12.1 | Introduction | 223 |
| 12.2 | Fundamentals of nanomaterials | 223 |
| 12.2.1 | Nanomaterials classification | 223 |
| 12.2.2 | Nanoparticles in cancer | 225 |
| 12.2.3 | Mechanisms for diagnostics and therapy | 227 |
| 12.3 | Multifunctional nanomaterials | 229 |
| 12.3.1 | Functionalization | 229 |
| 12.3.2 | Characterization of functionalized nanoparticles | 232 |
| 12.4 | Applications | 232 |
| | Reference list | 241 |
| 13. | Magneto Hyperthermia | 244 |
| 13.1 | Introduction | 244 |
| 13.2 | Clinical basis of induced hyperthermia | 246 |
| 13.3 | Mechanisms of magnetic nanomaterials-based hyperthermia | 248 |
| 13.4 | Factors influencing the design of formulations for magneto hyperthermia-based therapy | 250 |
| 13.4.1 | Chemical composition | 250 |
| 13.4.2 | Method of synthesis | 252 |
| 13.4.3 | Surface modification | 253 |
| 13.5 | Performance of nanomedicine systems developed for magnetic hyperthermia therapy, clinical phase studies | 256 |
| | Reference list | 259 |
| | Index | 267 |