

Preface

The tongue, as the primary organ of gustation, conveys abundant valuable information about the health status of the human body, i.e., disorders or even pathological changes of internal organs can be reflected by the human tongue and observed by medical practitioners. Tongue diagnosis (TD), a noninvasive diagnostic method using inspection of the appearance of human tongue, has played an indispensable role in Traditional Chinese Medicine (TCM) for over 2,000 years. In recent years, for the purpose of academic research, significant information technologies, including digitalized data acquisition, image processing, and pattern recognition have been widely used in tongue diagnosis to improve its diagnostic validity and accuracy. Computerized tongue diagnosis (CTD), as a result, has become a fundamental part of the revolution that has taken place at an ever-increasing pace over the past decade in TCM. The growing importance and rapid progress in CTD has brought about an independent and burgeoning branch in the TCM research field, and also resulted in urgent and extensive requirements for tongue image analytical techniques.

By its very nature, tongue image analysis is cross-disciplinary in several aspects. First, before a tongue image can be analyzed, it is imperative that the basic principles of TD should be mastered. For instance, we should know what kinds of visible information are crucial for the visual inspection process of TD. This mainly includes several aspects in the TCM and computer vision (CV) research fields. Next, in order to get useful data, a special acquisition system should be carefully designed to guarantee that all the information is included in the signal acquired by the imaging sensor. This incorporates the interaction of optics of matter to the geometry and radiometry of imaging and industrial design. Finally, after being captured and converted into digital form, the tongue image should be processed, analyzed, and classified by the computer. In this chain of processes, many areas from computer science and mathematics are involved, e.g., computer architecture, algebra, analysis, statistics, algorithm theory, graph theory, system theory, and numerical mathematics, all of which have a partial or strong association with tongue image analysis.

Today, the field of modern tongue diagnosis is becoming more technical. Although practitioners need to understand the basic theory and practice of computer science such as image processing and pattern recognition, they also need guidance on how to actually address thorny problems such as automatic segmentation, color distortion, and robust classification of tongue images which are very helpful to the practicing CTD scientist.

It is the purpose of this book, as briefly and concisely as possible, to give the reader a straightforward and intuitive introduction to basic and advanced techniques in tongue image processing and analysis and their typical applications in CTD systems. It features the most current research findings in all aspects of tongue image acquisition, preprocessing, classification, and diagnostic support methodologies, from theoretical and algorithmic problems to prototype design and development of CTD systems.

In the first two chapters, the book begins with a very high-level description of CTD on a need-to-know basis which includes an overview of CTD systems and Traditional Chinese Medicine (TCM) as the context and background knowledge of tongue image analysis. From Chaps. 3 to 13, the principal part of the book then provides useful algorithms as well as their implementation methods of tongue image analysis. The most notable extensions, at a know-how level, include detailed discussions on segmentation, chromatic correction, and classification which are arranged in systematic order as follows.

The first preprocessing step of tongue image processing and CTD, automated tongue image segmentation is difficult due to two special factors. First, there are many pathological details on the surface of the tongue, which have a large influence on edge extraction. Second, the shapes of tongue bodies captured from various persons are quite different. So far, there is no single solution that can address all the problems in automated tongue image segmentation. From Chaps. 3 to 7, the book presents five different segmentation approaches to solve domain problems based on different kinds of tongue images. These methods are robust to noise caused by a variety of shapes and irrelevant information from non-tongue parts such as lips, beard, and facial skin. After segmenting the tongue area from its surroundings, a study on tongue shape analysis by using the tongue contour and its geometric features is then introduced in Chap. 8 as the end of Part II.

Part III makes a sound exposition of the quantitative classification of tongue images beginning with the correction of the color feature in tongue image. Color inconsistency is the second problem CTD scientists have to face before analyzing the tongue image. Since the colors of the tongue image produced by digital cameras are usually device-dependent, this is a serious problem in computer-aided tongue image analysis which relies on the accurate rendering of color information. In Chaps. 9 and 10, the book introduces an optimized tongue image colorchecker and correction scheme which enhances the color consistency between different acquisition devices. It has long been a controversial topic that the TCM physician mainly explores the nonquantitative features in the traditional diagnosis process. To diagnose a wide range of health conditions, CTD should examine quantitative

features of the tongue. From Chaps. 11 to 13, the book describes three tongue classification methods with excellent comprehensive performances.

In this book, some clinical applications based on the tongue image analyzing methods are also presented, for the show-how purpose, in the CTD research field. Case studies highlight different techniques that have been adopted to assist the diagnosis of diseases and health. From Chaps. 14 to 17, the book discusses relationships between diseases and the appearance of the human tongue in terms of quantitative features. In Part IV, we present case studies in the field of visual inspection for appendicitis, diabetes, and some other common diseases. Experimental results of the performance under different challenging clinical circumstances have shown the superiority of the techniques in this book.

The principles of tongue image analysis in this book are illustrated with plentiful graphs, tables, and practical experiments to simplify problems. In this way, readers can easily find a quick and systematic way through the complicated theories and they can later even extend their studies to special topics of interest. All the techniques presented in the book are well supported by experimental results using a large tongue image database, which was collected from 5,222 subjects (Over 9,000 images) by our dedicated developed image acquisition device. All these subjects were diagnosed (patient-subjects) or labeled (healthcare-subjects) into different health status (healthy, sub-healthy, and various diseases) in the hospital. To the best of our knowledge, this is the largest and most comprehensive database in the research community. This book will be of benefit to researchers, professionals, and graduate students working in the field of computer vision, pattern recognition, clinical practice, and TCM, and will also be useful for interdisciplinary research. We anticipate that physicians, biomedical scientists, engineers, programmers, and students of computers will find this book and the associated algorithms useful, and hope that anyone with an interest in computerized diagnostic research will find the book enjoyable and informative.

The book is the result of years of research on computational TCM diagnosis. Since 1998, under grant support from the National Natural Science Foundation of China (NSFC), Hong Kong Polytechnic University, and Harbin Institute of Technology, we have studied this topic. The authors would like to thank Dr. Zhaotian Zhang, Dr. Xiaoyun Xiong, and Dr. Ke Liu from NSFC for their consistent support to our research work.

Some of the material in the book, e.g., the tongue images and acquisition devices, has been under development for almost a decade. Portions of the book appeared in earlier forms as conference papers, journal papers, or experiments by my research group at The Hong Kong Polytechnic University and Harbin Institute of Technology. Therefore, these parts of the text are the newest updates based on our research.

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