Electronic Imaging Applications in Mobile Healthcare

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Preface

Information technology is changing healthcare systems in revolutionary ways; there can be no health care reform without an information revolution. One information technology that is transforming healthcare systems is mobile technology. As it develops and matures, mobile technology is having a significant impact on healthcare, and emerging mobile technologies are attracting significant attention as well as investment of time and effort among researchers and industrial developers. The combination of mobile technology with healthcare has produced an important research area called mHealth. In 2011, U.S. Secretary of Health and Human Services, Kathleen Sebelius, referred to mHealth as "the biggest technology breakthrough of our time" and maintained that its use would "address our greatest national challenge." Based on related research, mobile health is projected to be a 26 billion dollar industry by 2017.

Mobile technology has wide-ranging applications in human healthcare, such as monitoring elderly patients, security access control for electronic health records, and remote radiology. The primary drivers behind these applications are varied, as evidenced by the following facts:

- Current mobile computing devices already offer many advanced features, such as high-quality cameras, web searching, sound recording, and global positioning systems (GPS).[1]
- The capabilities of mobile computing devices (mobile tablet devices and smartphones) are growing.
- The implementation of mobile imaging platform/systems is growing. Currently, thousands of apps are available, including apps for disease diagnosis, diet and disease tracking, medication and exercise planning, and blood pressure monitoring.
- A growing number of physicians are recognizing the advantages of using mobile tools.
- The mobile technologies in current use are already providing new opportunities by boosting communication between different healthcare

> providers and between healthcare providers and patients, and by allowing access to medical images from virtually any location.

In fact, a 2012 study by Manhattan Research discovered that approximately 62% of U.S. doctors utilize some type of tablet device in their practice, nearly doubling the adoption rate since 2011.[2]

According to industry evaluations, 500 million smartphone users worldwide will be using a healthcare application by 2018, and 50% of the more than 3.4 billion smartphone and tablet users will have downloaded mobile health applications.[3] Moreover, the Food and Drug Administration (FDA) "recognizes the extensive variety of actual and potential functions of mobile apps, the rapid pace of innovation in mobile apps, and the potential benefits and risks to public health represented by these apps."[4] Finally, mobile computing devices have become commonplace in healthcare settings, leading to rapid growth in the development of biomedical software applications for these platforms.[5,6]

The aim of this book is to publish state-of-the-art research in electronic imaging technologies as applied to mobile healthcare, and to promote research in mHealth. The twelve chapters in this book are organized into four parts:

Part I deals with image processing and enhanced visualization. Chapter 1 introduces image processing techniques for mobile healthcare systems. Chapter 2 presents image enhancement technology for low-vision patients who use mobile devices to see images. Chapter 3 describes the application of fast Fourier transform-based methods for color medical imaging in mobile devices. Chapter 4 presents new quaternion-based image enhancement tools that can be used as a preprocessing step in conventional cell phone imaging systems by improving the interpretability of information in images for phone viewers. Chapter 5 develops an adapted retinex algorithm for medical image enhancement using mobile phones.

Part II deals with security issues in mobile healthcare applications. Chapter 6 examines security issues for mobile devices using cloud services and presents a homomorphic encryption method that enables direct operation over the encoded data and hence facilitates complete privacy protection. Chapter 7 proposes a novel and fast encryption of images and their decryption without loss of information for medical image viewing on a cell phone.

Part III covers human external pulsometers and activity recognition using mobile devices. Chapter 8 addresses human activity recognition and processing in mobile environments. Chapter 9 develops mobile applications to measure a person's heart rate using a mobile phone camera.

Part IV includes three chapters on mobile healthcare applications. Chapter 10 deals with skin cancer monitoring with an iPhone using image retrieval techniques. Chapter 11 presents a user interface for mobile healthcare. Finally, Chapter 12 presents an automatic multiview food classification method for a food intake assessment system on a smartphone.

We hope that this book will inspire further research in mHealth.

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Acronyms and Abbreviations

A-GPS	assisted global positioning system
ADT	Android Development Tools
AES	Advanced Encryption Standard
AF	auto-focus
API	application programming interface
BPM	beats per minute
BSS	blind source separation
CA	certificate authority
CBIR	content-based image retrieval
CFS	correlation-based feature selection
CPU	central processing unit
CT	computed tomography
DCT	discrete cosine transform
DES	Data Encryption Standard
DFT	discrete Fourier transform
DICOM	Digital Imaging and Communications in Medicine
DMP	digital motion processor
DoG	difference of Gaussian
DR	diabetic retinopathy
DSA	Digital Signature Algorithm
DT	decision table
DTr	decision tree
DT-CWT	dual-tree complex wavelet transform
DT-RCWF	dual-tree rotated complex wavelet filter
DTW	dynamic time warping
DUT	discrete unitary transform
DWT	discrete wavelet transform
ECG	electrocardiogram
EKG	electrocardiogram
E-OTD	enhanced observed time difference
FDA	Food and Drug Administration (U.S.)
FIR	finite impulse response
FISH	fluorescence *in situ* hybridization

FFT	fast Fourier transform
FPS	frames per second
GDC	great common divisor
GPS	global positioning system
GPU	graphics processing unit
GSM	Global System for Mobile communications
HAR	human activity recognition
HD	high definition
HF	heart failure
HIS	Hospital Information System
HOG	histogram of oriented gradient
HMM	hidden Markov model
HR	heart rate
HSV	hue-saturation-value
ICA	independent component analysis
ICT	information and communication technology
IDE	integrated development environment
IDFT	inverse discrete Fourier transform
IIR	infinite impulse response
INS	inertial navigation system
iOS	iPhone operating system
JVM	Java virtual machine
kNN	*k*-nearest neighbor
LAN	local area network
LBP	local binary pattern
MEMS	micro-electromechanical system
mHealth	mobile health
MRI	magnetic resonance imaging
MSER	maximally stable extremal regions
MSR	multiscale retinex
MSR-CR	multiscale retinex color restoration
MST	minimum spanning tree-based (method)
NB	naïve Bayes
NDK	Native Development Kit (Android)
OCT	optical coherence tomography
OHMD	optical head-mounted display
OTDOA	observed time difference of arrival
PACS	picture archiving and communication system
PC	personal computer
PCA	principal component analysis
PDA	personal digital assistant
PDR	Physician's Desk Reference
PFE	*p*-Fibonacci encryption

PFID	Pittsburg Fast-food Image Dataset
PKI	public key infrastructure
PPG	photoplethysmography
PSDQ	preprocessed signal data-holder queue
QDFT	quaternion discrete Fourier transform
RAM	random access memory
RMIS	remote medical information system
RMSE	root mean square error
RNS	residue number system
ROI	region of interest
RSA	Rivest, Shamir, Adleman (developers of the cryptographic algorithm called RSA)
RSDQ	raw signal data-holder queue
SD	secure digital (card)
SDK	Software Development Kit (Android)
SIFT	scale-invariant feature transform
SMC	secure multiparty computation
SNR	signal-to-noise ratio
SSR	single-scale retinex
SVM	support vector machine
UI	user interface
USB	universal serial bus
WLAN	wireless local area network
WMA	weighted moving average