SpringerBriefs in Computer Science

Series editors

Stan Zdonik, Brown University, Providence, RI, USA
Shashi Shekhar, University of Minnesota, Minneapolis, MN, USA
Xindong Wu, University of Vermont, Burlington, VT, USA
Lakhmi C. Jain, University of South Australia, Adelaide, SA, Australia
David Padua, University of Illinois Urbana-Champaign, Urbana, IL, USA
Xuemin Sherman Shen, University of Waterloo, Waterloo, ON, Canada
Borko Furht, Florida Atlantic University, Boca Raton, FL, USA
V. S. Subrahmanian, University of Maryland, College Park, MD, USA
Martial Hebert, Carnegie Mellon University, Pittsburgh, PA, USA
Katsushi Ikeuchi, University of Tokyo, Tokyo, Japan
Bruno Siciliano, Università di Napoli Federico II, Napoli, Italy
Sushil Jajodia, George Mason University, Fairfax, VA, USA
Newton Lee, Institute for Education, Research, and Scholarships, Los Angeles, CA, USA

SpringerBriefs present concise summaries of cutting-edge research and practical applications across a wide spectrum of fields. Featuring compact volumes of 50 to 125 pages, the series covers a range of content from professional to academic.

Typical topics might include:

- A timely report of state-of-the art analytical techniques
- A bridge between new research results, as published in journal articles, and a contextual literature review
- A snapshot of a hot or emerging topic
- An in-depth case study or clinical example
- A presentation of core concepts that students must understand in order to make independent contributions

Briefs allow authors to present their ideas and readers to absorb them with minimal time investment. Briefs will be published as part of Springer's eBook collection, with millions of users worldwide. In addition, Briefs will be available for individual print and electronic purchase. Briefs are characterized by fast, global electronic dissemination, standard publishing contracts, easy-to-use manuscript preparation and formatting guidelines, and expedited production schedules. We aim for publication 8–12 weeks after acceptance. Both solicited and unsolicited manuscripts are considered for publication in this series.

More information about this series at http://www.springer.com/series/10028

Xin Wei • Liang Zhou

Multimedia QoE Evaluation

Springer

Xin Wei
Liang Zhou

Nanjing University of Posts and Telecommunications
Nanjing, China

ISSN 2191-5768 ISSN 2191-5776 (electronic)
SpringerBriefs in Computer Science
ISBN 978-3-030-23349-5 ISBN 978-3-030-23350-1 (eBook)
https://doi.org/10.1007/978-3-030-23350-1

© The Author(s), under exclusive license to Springer Nature Switzerland AG 2019
This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.
The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.
The publisher, the authors, and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Switzerland AG.
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

With the rapid development of information technology and the establishment of "human-oriented" new type communication fashion, multimedia services have become more and more accessible everywhere, and everyone can quickly obtain the required information from operators or content providers through multimedia terminals. However, future multimedia service emphasizes not only speed, bandwidth, and quality of service sources but also user feeling and satisfaction. Therefore, for multimedia content providers and network operators, promoting user feeling or even their viscosity is very important in the context of video service explosion and heavy competition.

Based on this background, the concept of multimedia quality of experience (QoE), which is a key metric for the description and evaluation of user subjective feeling for multimedia services, receives much attention. However, due to the existence of big data and subjective characteristic of multimedia user experience, there are several pain points and technical challenges during multimedia QoE evaluation. To handle these issues, this book aims at deeply investigating the key technologies and realizations of multimedia QoE evaluation.

In Chap. 1, we provide the background, motivation, and necessity for research on multimedia QoE evaluation. In Chap. 2, we give technical premise and an overview of existing research works on this topic, including the definition of multimedia QoE, various factors influencing QoE, and multimedia QoE evaluation based on machine learning. In Chap. 3, we describe several representative datasets adopted in our research. Moreover, we propose several methods for extracting influencing factors, especially subjective user-related factors such as viewing time ratio, user interest, user type, user behavior, user comment, and danmaku. In Chap. 4, we design several modeling and prediction algorithms, such as multimedia user complaint prediction for imbalanced dataset and multimedia QoE modeling and prediction based on neural networks and broad learning systems. In Chap. 5, based on the theoretical research results, we realize multimedia QoE evaluation based on a big data platform. It concerns data management, data collection and storage, data analysis and mining, and evaluation result demonstration. In Chap. 6, we summarize this book and highlight the future research directions.

The authors would like to thank Prof. Xuemin Sherman Shen of the University of Waterloo for his invitation and valuable suggestions on this book. The authors would also like to thank Ruochen Huang, Yun Gao, Qi Duan, Jiali Mao, Chaoping Lv, and Qifeng Liu of Nanjing University of Posts and Telecommunications for their contributions in the presented research works.

Nanjing, China — Xin Wei
Nanjing, China — Liang Zhou
May 2019

Acknowledgments

This work is partly supported by the National Natural Science Foundation of China (Grant No. 61571240), the Priority Academic Program Development of Jiangsu Higher Education Institutions, and the Natural Science Foundation of Jiangsu Province (Grant No. BK20161517).

Contents

1 Introduction 1
1.1 Background 1
1.2 Motivation 2
1.3 Necessity 3
References 4

2 Technical Premise 7
2.1 Definition and Quantification 7
2.1.1 Definition of Multimedia QoE 7
2.1.2 Quantification of Multimedia QoE 8
2.2 Influencing Factors 9
2.2.1 System-Related Influencing Factors 10
2.2.2 Context-Related Influencing Factors 11
2.2.3 User-Related Influencing Factors 12
2.3 Multimedia QoE Evaluation Based on Machine Learning 13
2.3.1 Decision Tree 13
2.3.2 Support Vector Machine 14
2.3.3 Artificial Neural Network 15
2.3.4 Bayesian Network 15
2.3.5 Hidden Markov Model 16
2.3.6 Other Models 16
2.4 Challenges 17
2.5 Summary 18
References 18

3 Multimedia Service Data Preprocessing and Feature Extraction 21
3.1 Multimedia Service Data Collection and Preprocessing 21
3.1.1 IPTV Service Dataset 21
3.1.2 OTT Service Dataset 22
3.1.3 Dataset Crawled Across the Web 27

3.2 Feature Extraction for Subjective Influencing Factors 28
3.2.1 User Viewing Time Ratio Calculation 29
3.2.2 User Interest Inference 32
3.2.3 User Type Classification 35
3.2.4 User Behavior Analysis 36
3.2.5 User Comment & Danmaku Parsing 38
3.3 Summary 40
References 41

4 Multimedia QoE Modeling and Prediction 43
4.1 Multimedia User Complaint Prediction for Imbalanced Dataset 43
4.1.1 GMM-Based Oversampling Algorithm 43
4.1.2 Decision Tree-Based Cost-Sensitive Algorithm 46
4.2 Multimedia QoE Modeling and Prediction Based on Neural Networks 49
4.2.1 Artificial Neural Networks (ANN) 49
4.2.2 LSTM-Attention Model 51
4.3 Multimedia QoE Modeling and Prediction Based on Broad Learning System 58
4.4 Summary 61
References 61

5 Implementation and Demonstration 63
5.1 Establishment of Big Data Platform 63
5.2 Multimedia QoE Data Management Tool 65
5.2.1 Architecture of Cloudera Manager 65
5.2.2 Cluster and Service Management 66
5.3 Multimedia QoE Data Collection and Storage 67
5.3.1 Multimedia QoE Data Collection 67
5.3.2 Multimedia QoE Data Storage 71
5.4 Multimedia QoE Data Analysis and Mining 72
5.4.1 Operating Principle of Spark 72
5.4.2 Data Analysis and Mining by Spark 73
5.5 Multimedia QoE Evaluation Result Demonstration 76
5.5.1 User Complaint Prediction Result 76
5.5.2 User Interest Inference Result 76
5.5.3 User QoE Prediction Result 77
5.6 Summary 78
References 78

6 Conclusion 81
6.1 Concluding Remarks 81
6.2 Future Work 82