SPRINGER BRIEFS IN ELECTRICAL AND COMPUTER ENGINEERING · SIGNAL PROCESSING

Long Xu
Weisi Lin
C.-C. Jay Kuo

Visual Quality Assessment by Machine Learning

Springer

SpringerBriefs in Electrical and Computer Engineering

Signal Processing

More information about this series at http://www.springer.com/series/11560

Long Xu · Weisi Lin · C.-C. Jay Kuo

Visual Quality Assessment by Machine Learning

Springer

Long Xu
National Astronomical Observatories
Chinese Academy of Sciences
Beijing
China

C.-C. Jay Kuo
University of Southern California
Los Angeles, CA
USA

Weisi Lin
Nanyang Technological University
Singapore
Singapore

ISSN 2191-8112 ISSN 2191-8120 (electronic)
SpringerBriefs in Electrical and Computer Engineering
ISSN 2196-4076 ISSN 2196-4084 (electronic)
SpringerBriefs in Signal Processing
ISBN 978-981-287-467-2 ISBN 978-981-287-468-9 (eBook)
DOI 10.1007/978-981-287-468-9

Library of Congress Control Number: 2015935610

Springer Singapore Heidelberg New York Dordrecht London

Printed on acid-free paper

Springer Science+Business Media Singapore Pte Ltd. is part of Springer Science+Business Media (www.springer.com)

Preface

After visual signals (referring to image, video, graphics, and animation) are captured or generated, they undergo a variety of processings, including compression, enhancement, editing, retargeting, and transmission. These processes change the quality of visual signals. To measure the extent of such changes, visual quality assessment (VQA) has gained popularity as a hot research topic during the last decade. The psychological and physiological research results have been plugged into this research field to provide fundamental knowledge of the visual perception mechanism and theoretical support for developing VQA models. In addition, the newly developed computer vision, artificial intelligence, and machine learning techniques have been applied to this research field; they have cooperated with psychological/physiological principles to produce more powerful and general computational models of VQA.

On the basis of acquired knowledge about the human visual system (HVS) to visual perception, a variety of VQA approaches have been developed in seeking agreement with the perception mechanism of the HVS to visual signal stimulus. However, due to the sophisticated nature of the HVS, it is difficult to model the HVS response and perception to image/video features directly and explicitly in general, with the current understanding and knowledge on the HVS. Many model-based and signal-driven VQA systems have been developed with strong assumptions. Therefore, machine learning can be used to emulate the mechanisms of complicated models as a new trend of VQA development, without resorting to prior, unrealistic assumptions. There have been a variety of machine learning-based VQA approaches in the recent literature with increase in necessary databases publicly available. The learning-based VQA has become an emerging category of VQA, apart from the model-based and signal-driven ones.

The content of this book is arranged into six chapters. Chapter 1 is the introduction to VQA. The fundamental knowledge, history, and major approaches (including model-based, signal-driven, and learning oriented ones) of VQA are presented. The important relevant documents and major subjective database resources are also provided in this chapter to be a convenient reference for readers. Chapter 2 briefly introduces the basic concepts and methods of machine learning.

Chapter 3 states the basic and advanced image features. These features are applicable to both general machine learning tasks and for specific purposes. We also introduce the relevant issues concerning feature extraction and feature selection in this chapter. Chapter 4 gives the ML-based feature pooling strategies on VQA, where the traditional ML tools, the newly proposed pairwise rank learning approach, and an ensemble-based scheme accounting for feature pooling are presented in detail. In Chap. 5, a fusion scheme of VQA metrics is presented. This fusion scheme takes advantage of the combined metrics to overcome the shortcomings of each metric used individually. The final chapter concludes this book and gives the potential research prospects in the VQA field.

This book is mainly targeted at researchers, engineers, and students of computer science, information science, mathematics, and perception science who are interested in VQA, machine learning applications, and image/video processing.

October 2014

Long Xu
Weisi Lin
C.-C. Jay Kuo

Acknowledgments

We thank Dr. Issac Niwas Swamidoss for proofreading. The related research was partially supported by the National Natural Science Foundation of China under Grants 61202242, 61370113, Singapore National Research Foundation under its IDM Futures Funding Initiative and administered by the Interactive and Digital Media Programme Office, Media Development Authority, and Ministry of Education (MoE) AcRF Tire 1 Funding, Singapore, under Grant 2014-T1-002-068.

Contents

Acronyms

AdaBoost	Adaptive boosting
AI	Artificial intelligence
AIQS	Advanced image quality score
AIQs	Advanced image quality scorers
ANN	Artificial neural network
BIQS	Basic image quality score
BIQs	Basic image quality scorers
BN	Bayesian network
CD-MMF	Content-dependent MMF
CNN	Convolutional (deep) neural network
CS	Computer science
CSF	Contrast sensitivity function
DBN	Deep belief network
DCT	Discrete cosine transform
DFT	Fourier transform
(D)MOS	(Difference) mean opinion score
DNN	Deep neural network
DoG	Difference of Gaussian
DWT	Discrete wavelet transform
FR	Full reference
GLCM	Gray-level co-occurrence matrix
GPU	Graphics processing unit
HDR	High dynamic range
HVS	Human visual system
IQA	Image quality assessment
IQSs	Image quality scorers
JND	Just noticeable difference
KLT	Karhunen–Loeve transform
LoG	Laplacian of Gaussian
MAP	Mean average precision
ML	Machine learning
MMF	Multi-method fusion
mRMR	Minimum redundancy maximum relevance

MSE	Mean square error
NDCG	Normalized discounted cumulative gain
NLP	Neuro-linguistic programming
NR	No reference
NSS	Natural scene statistics
PC	Pairwise comparison
PCA	Principal component analysis
PLCC	Pearson's linear correlation coefficient
PRLIQA	Pairwise rank learning image quality assessment
PSNR	Peak signal-to-noise ratio
PVQM	Perceptual visual quality metric
RBM	Restricted Boltzmann machine
RMSE	Root mean square error
RR	Reduced reference
SD	Standard definition
SIFT	Scale-invariant feature transform
SROCC	Spearman's rank order correlation coefficient
SURF	Speeded up robust feature
SVD	Singular value decomposition
SVM	Support vector machine
SVR	Support vector regression
VA	Visual attention
VQA	Visual quality assessment
WCSS	Within-cluster sum of squares

Chapter 1
Introduction

Abstract With the development of digital visual signal processing, efficient and reliable assessment of image quality becomes more and more important. Measuring the image quality is of fundamental importance for image processing applications, where the goal of image quality assessment (IQA) methods is to automatically evaluate the quality of images in agreement with human visual quality judgments. In the past decade, researchers have made great efforts to develop many IQAs to fulfill this goal. According to the availability of reference, these IQAs can be classified into full-reference, reduce-reference, and no-reference IQAs. For most of the applications, there is no reference available during visual signal processing, e.g., decoding of compressed visual signal in client's terminal without the original signal stored in server. The absence of reference raises a great challenge for visual quality assessment (VQA). To address this challenge, machine learning was widely used to approximate the response of the human visual system (HVS) to visual quality perception. This chapter will present the fundamental knowledge of VQA, overview of the state-of-the-art IQAs in the literature, resource of VQA, standards developed for subjective quality assessment, and summary of all related items.

Keywords Image quality assessment · Mean opinion score · Subjective quality assessment · Objective quality assessment · Human visual system

After images are captured, operations of compression, enhancement, editing, retargeting, and transmission are usually performed, resulting in image quality changes. To measure the extent of such changes, the mean square error (MSE) or one of its variants between an original image and a revised one is calculated. However, MSE/PSNR (peak signal-to-noise ratio) cannot reflect the actual human-perceived quality of images, and therefore a bunch of visual quality assessment (VQA) approaches from the aspects of the human visual system (HVS) and human visual psychology have been proposed during the last decade.

Since humans are the ultimate receivers of the majority of visual signals being processed, the most accurate way of assessing image/video quality is to ask humans for their opinions of the quality of an image or video, known as the subjective VQA. The subjective image quality scores gathered from all subjects are processed to be the mean opinion score (MOS), which is regarded as the ground truth of image quality.

L. Xu et al., *Visual Quality Assessment by Machine Learning*,
SpringerBriefs in Signal Processing, DOI 10.1007/978-981-287-468-9_1