

Full-Reference Image Quality Expression via Genetic Programming

Illya Bakurov, Marco Buzzelli, Raimondo Schettini, Mauro Castelli, and Leonardo Vanneschi

Abstract—Full-reference image quality measures are a fundamental tool to approximate the human visual system in various applications for digital data management: from retrieval to compression to detection of unauthorized uses. Inspired by both the effectiveness and the simplicity of hand-crafted Structural Similarity Index Measure (SSIM), in this work, we present a framework for the formulation of SSIM-like image quality measures through genetic programming. We explore different terminal sets, defined from the building blocks of structural similarity at different levels of abstraction, and we propose a two-stage genetic optimization that exploits hoist mutation to constrain the complexity of the solutions. Our optimized measures are selected through a cross-dataset validation procedure, which results in superior performance against different versions of structural similarity, measured as correlation with human mean opinion scores. We also demonstrate how, by tuning on specific datasets, it is possible to obtain solutions that are competitive with (or even outperform) more complex image quality measures.

Index Terms—image quality, full-reference image quality assessment, image similarity, ssim, genetic programming

I. INTRODUCTION

Nowadays, digital imaging constitutes a whole new way of communication and, due to technological advancements, creating any sort of digital content and sharing it to a virtual community of millions of people is just a matter of a few clicks and seconds. Such ease of digital content creation also encourages the demand for its efficient management. In this sense, one of the key concepts underpinning numerous digital imaging management techniques is the one of image similarity. Notwithstanding, the concept of similarity is vague and multifaceted, therefore open to different interpretations and definitions: it can be analytically defined with objective criteria, but it can also refer to subjective interpretations. Image similarity can be used to quantify the perceived visual quality of digital images, typically employed in the field of signal compression and telecommunication, serve as the basis for image-based search and image clustering, both useful in the management of personal photo collections and in detecting cases of copyright infringement and use of proprietary content without proper credit. In this study, we focus on the objective means to quantify images' visual quality.

Many aspects influence the perceived visual quality of a digital image or video. For instance, an accidental shake of

the capturing device during the acquisition process can blur the whole image. Likewise, poor lighting conditions can result in images with a low dynamic range and high noise levels. Also, raindrops adhering to a window or camera lens can significantly decrease the performance of scene recognition systems for automotive applications, etc. Moreover, several image processing steps usually occur before the final users can employ the digital imagery. Frequently, these are organized into a sequential set of steps, like digitization, compression, storage, transmission, and reproduction, and may result in a noticeable visual degradation of the output digital imagery. From the perspective of media quality perception, this might result in a sub-optimal viewing experience. In this sense, to better manage the ever-growing digital content (images in particular) and improve users' experience, it becomes necessary to efficiently quantify the perceived visual quality of images. For those types of applications in which humans ultimately view the images, the most appropriate method for images assessment is through the human visual system itself [1], i.e., by involving people to assess images' quality. However, in the context of a digital society where hundreds of millions of photos are being generated and uploaded to social media every day, subjective evaluation becomes impractical as it is time-consuming, expensive, and highly sensible to the experimental design [2]. Considering the aforementioned limitations, several researchers have proposed objective measures that can automatically (i.e., without human involvement) estimate the perceived visual quality as humans would do. These are called image quality assessment measures (IQAMs) and are frequently classified based on the availability of a pristine reference image. When a measure assesses the similarity between a pristine reference image and its degraded variant, it is usually called full-reference IQAM (FR-IQAM). On the other hand, when the reference is not available, the measure is often called no-reference IQAM (NR-IQAM). Moreover, when the reference image is not completely provided (i.e., only some partial information is available, as a given set of the extracted features), the measure is frequently called reduced-reference IQAM (RR-IQAM). Historically, researchers hand-crafted these measures based on their understanding of the human visual system, mathematics, and information theory. One of the most notable is the Structural Similarity Index Measure (SSIM) and its numerous variations [1]. The simplicity of the SSIM formulation resulted in high levels of human interpretability (each component amounting to the final SSIM value can be individually analyzed and assessed), as well as high efficiency.

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Quality Of Expression

**Chris S. Jones, Jiyu Zhang, Jorge
Fernando Pereira, Russell Jessup**

Quality Of Expression:

Expression of emotion in music and vocal communication Anjali Bhatara, Petri Laukka, Daniel J. Levitin, 2014-08-18 Two of the most important social skills in humans are the ability to determine the moods of those around us and to use this to guide our behavior To accomplish this we make use of numerous cues Among the most important are vocal cues from both speech and non speech sounds Music is also a reliable method for communicating emotion It is often present in social situations and can serve to unify a group s mood for ceremonial purposes funerals weddings or general social interactions Scientists and philosophers have speculated on the origins of music and language and the possible common bases of emotional expression through music speech and other vocalizations They have found increasing evidence of commonalities among them However the domains in which researchers investigate these topics do not always overlap or share a common language so communication between disciplines has been limited The aim of this Research Topic is to bring together research across multiple disciplines related to the production and perception of emotional cues in music speech and non verbal vocalizations This includes natural sounds produced by human and non human primates as well as synthesized sounds Research methodology includes survey behavioral and neuroimaging techniques investigating adults as well as developmental populations including those with atypical development Studies using laboratory tasks as well as studies in more naturalistic settings are included

The Future of Rice Demand: Quality Beyond Productivity Antonio Costa de Oliveira, Camila Pegoraro, Vívian Ebeling Viana, 2020-03-27 This book aims to provide an overview of the challenges and available technologies to improve rice and provide a response to the challenge posed by increasing world population and the resultant food shortages Nutritional aspects of rice products and omics and the molecular technologies currently being used are covered in depth As a staple food for over 50% of the world s population an estimated 9 billion people will need to be fed by 2050 and healthy and uncontaminated foods need to reach consumers in developed and developing countries This makes quality beyond productivity incredibly important and is one of the overriding themes of this work The Future of Rice Demand Quality Beyond Productivity offers researchers a better understanding of the nutritional aspects of rice Omics technologies applied to cereal grain quality have been scarce in the literature published to date making this text an excellent single source for researchers in regions where rice is a major crop The first section of the book focuses on the major aspects of the industrial processing of all rice types Further sections look at contamination prevention and biofortification special rice types and omics and other molecular tools used in the mass production and processing of healthy rice products

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research on computational methods including theory algorithms numerical simulation error and uncertainty analysis and their applications the book offers a valuable resource for doctoral students and researchers in the fields of Computer Science and Engineering

Principles of Vocal Expression William Benton Chamberlain,1898

Medical BioMethods Handbook John M. Walker,Ralph Rapley,2007-10-09 John Walker and Ralph Rapley have collected a wide ranging group of molecular and biochemical techniques that are the most frequently used in medical and clinical research especially diagnostics The authors well established investigators who run their own research programs and use the methods on a regular basis outline the practical procedures for using them and describe a variety of pertinent applications Among the technologies presented are southern and western blotting electrophoresis PCR cDNA and protein microarrays liquid chromatography in situ hybridization karyotyping flow cytometry bioinformatics genomics and ribotyping The applications include assays for mutation detection mRNA analysis chromosome translocations inborn errors of metabolism protein therapeutics and gene therapy

Perspectives in Avian Skeletal Systems and Skeletal Abnormalities Chongxiao

(Sean) Chen,Anthony Pokoo-Aikins,Prafully Regmi,Shu-cheng Huang,Mujeeb Ur Rehman,2023-10-16 The avian skeletal system is drawing increasing attention from researchers because it serves as a unique research model to study bone metabolism and pathologies as well as the importance of bone health and its relationship with animal productivity and welfare The avian skeleton is a delicate system providing structural support to the bird and minerals for eggshell formation meanwhile functioning as an immune organ There is a lack of complete understanding of the physiological difference between mammalian and avian bones the impact of genetic improvements the interaction between immunity and bone health the avian bone 3D structural development and turnover the biological function of avian bone and its relationship with animal well being Additionally skeletal abnormalities can have a serious effect on poultry farming whereby conditions such as osteomyelitis rickets and chondrodystrophy among others can cause changes in gait patterns reduced walking ability and other pathophysiologicals with subsequent detrimental effects on feed conversion and growth as well as economic losses

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Liu,2011-09-15 The development of sustainable and renewable biofuels is attracting growing interest It is vital to develop robust microbial strains for biocatalysts that are able to function under multiple stress conditions This Microbiology Monograph provides an overview of methods for studying microbial stress tolerance for biofuels applications using a systems biology approach Topics covered range from mechanisms to methodology for yeast and bacteria including the genomics of yeast tolerance and detoxification genetics and regulation of glycogen and trehalose metabolism programmed cell death high gravity fermentations ethanol tolerance improving biomass sugar utilization by engineered *Saccharomyces* the genomics on tolerance of *Zymomonas mobilis* microbial solvent tolerance control of stress tolerance in bacterial host organisms metabolomics for ethanologenic yeast automated proteomics work cell systems for strain improvement and unification of

gene expression data for comparable analyses under stress conditions

Competing on Supply Chain Quality Anna Nagurny, Dong Li, 2016-05-30 This book lays the foundations for quality modeling and analysis in the context of supply chains through a synthesis of the economics operations management as well as operations research management science literature on quality The reality of today s supply chain networks given their global reach from sourcing locations to points of demand is further challenged by such issues as the growth in outsourcing as well as the information asymmetry associated with what producers know about the quality of their products and what consumers know Although much of the related literature has focused on the micro aspects of supply chain networks considering two or three decision makers it is essential to capture the scale of supply chain networks in a holistic manner that occurs in practice in order to be able to evaluate and analyze the competition and the impacts on supply chain quality in a quantifiable manner This volume provides an overview of the fundamental methodologies utilized in this book including optimization theory game theory variational inequality theory and projected dynamical systems theory It then focuses on major issues in today s supply chains with respect to quality beginning with information asymmetry followed by product differentiation and branding the outsourcing of production from components to final products to quality in freight service provision The book is filled with numerous real life examples in order to emphasize the generality and pragmatism of the models and tools The novelty of the framework lies in a network economics perspective through which the authors identify the underlying network structure of the various supply chains coupled with the behavior of the decision makers ranging from suppliers and manufacturers to freight service providers What is meant by quality is rigorously defined and quantified The authors explore the underlying dynamics associated with the competitive processes along with the equilibrium solutions As appropriate the supply chain decision makers compete in terms of quantity and quality or in price and quality The relevance of the various models that are developed to specific industrial sectors including pharmaceuticals and high technology products is clearly made Qualitative analyses are provided along with effective and easy to implement computational procedures Finally the impacts of policy interventions in the form of minimum quality standards and their ramifications in terms of product prices quality levels as well as profits are explored The book is filled with many network figures graphs and tables with data

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Table of Contents Quality Of Expression

1. Understanding the eBook Quality Of Expression
 - The Rise of Digital Reading Quality Of Expression
 - Advantages of eBooks Over Traditional Books
2. Identifying Quality Of Expression
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Quality Of Expression
 - User-Friendly Interface
4. Exploring eBook Recommendations from Quality Of Expression
 - Personalized Recommendations
 - Quality Of Expression User Reviews and Ratings
 - Quality Of Expression and Bestseller Lists
5. Accessing Quality Of Expression Free and Paid eBooks
 - Quality Of Expression Public Domain eBooks
 - Quality Of Expression eBook Subscription Services
 - Quality Of Expression Budget-Friendly Options

6. Navigating Quality Of Expression eBook Formats
 - ePub, PDF, MOBI, and More
 - Quality Of Expression Compatibility with Devices
 - Quality Of Expression Enhanced eBook Features
7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Quality Of Expression
 - Highlighting and Note-Taking Quality Of Expression
 - Interactive Elements Quality Of Expression
8. Staying Engaged with Quality Of Expression
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Quality Of Expression
9. Balancing eBooks and Physical Books Quality Of Expression
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Quality Of Expression
10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
11. Cultivating a Reading Routine Quality Of Expression
 - Setting Reading Goals Quality Of Expression
 - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of Quality Of Expression
 - Fact-Checking eBook Content of Quality Of Expression
 - Distinguishing Credible Sources
13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
14. Embracing eBook Trends
 - Integration of Multimedia Elements

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