

Content-Based Image Retrieval

Vipin Tyagi

Content-Based Image Retrieval

Ideas, Influences, and Current Trends

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To
My teacher
Prof. Vinod K. Agarwal, Meerut

Foreword

In the last decade, we have been witnesses to a continuous growth of the number of digital pictures which are taken, stored, and shared every day. Have you ever asked yourself how many images are on the Internet? According to the research published by server *mylio.com* (see <http://mylio.com/true-stories/tech-today/how-many-digital-photos-will-be-taken-2017-repost>), the conservative estimate of the number of digital photographs taken in 2017 is over 1 trillion. About 85% of them were taken by mobile phones. Another estimate from 2016 says that in 2017, there will be almost 5 trillion photographs stored in digital form worldwide. A big part of them is available on the Internet through www pages, photo-banks such as Flickr and Shutterstock, and various social media—Facebook, Instagram, and others. A vast majority of these “image databases” are neither sorted nor accompanied with metadata and tags. If this was the case, searching in these databases would be simple and fast.

Let us imagine we want to retrieve from a database images containing, for instance, a lion. If there are no tags, we are required to make search solely based on the image content. We use a picture of a lion as a query image and ask the system to return “similar” images. This process is called *content-based image retrieval* (CBIR). Considering the huge number of images everywhere around us, developing fast CBIR algorithms and arranging the databases such that the search is efficient are of prime importance.

Any CBIR algorithm must resolve two main challenges—how to efficiently, highly compressively, characterize the image content by a low-dimensional descriptor (this stage is called image indexing) and how to search the index space quickly. This book “Content-Based Image Retrieval” covers both stages. The main emphasis is given to mathematical features describing the image content. The features capturing color, texture, and object shape are systematically reviewed. The author pays also a significant attention to the measurement of similarity between the query and database images in the feature space. CBIR which uses MPEG-7 standard is reviewed as well. At the end of the book, an outlook to the future of the CBIR is presented.

The book presents, in an understandable and accessible form, a comprehensive overview of CBIR techniques including the necessary mathematical background. The book is suitable for image database developers, designers of image storage and communication platforms, and as a supplementary reading for students of image analysis.

I wish the readers happy image retrieving!

Jan Flusser

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Preface

Content-based image retrieval (CBIR), which is aimed to search images from a large size image database based on visual contents of images in an efficient and accurate way as per the user's requirement, is an intensive research area these days. The major objective of this research monograph "Content-Based Image Retrieval: Ideas, Influences, and Current Trends" is to introduce the subject to the readers and bring forward the state-of-the-art techniques and approaches in the area of image retrieval. Various latest algorithms, techniques, and databases used in the image retrieval research are described in the book.

Chapter 1 of the book describes the basic concepts related to content-based image retrieval. It starts from the concept of information retrieval and moves to content-based image retrieval.

Chapter 2 of the book deals with the review of various techniques in the area of content-based image retrieval.

Chapter 3 gives the concept of region-based image retrieval, which is a type of content-based image retrieval. In this type of image retrieval techniques, instead of matching the whole image, the part(s) of the image called region-of-interest are matched to find out the results. The chapter discusses this concept.

Chapter 4 deals with similarity measures and performance evaluation used in various content-based image retrieval techniques.

MPEG-7 is a multimedia content description standard by ISO/IEC 15938, which is used for designing various techniques related to fast and efficient searching of multimedia content. Chapter 5 explains this standard.

Content-based image retrieval techniques use low-level features of images for retrieval. Chapters 6–8 introduce the concepts of shape, color, and texture low-level features, respectively.

Chapters 9–14 describe various techniques used for content-based image retrieval. These techniques can be used to understand the concepts of designing a content-based image retrieval system.

Chapter 15 gives various research issues that can be researched for the development of next-generation effective and efficient content-based image retrieval systems.

The details of some commonly used texture image and natural image databases to test the techniques proposed by researchers are provided in Appendix A, and a brief description of some popular image retrieval systems is provided in Appendix B. A bibliography of the research work in the area is also provided.

The target audience spans the range from the undergraduate with less exposure to the subject to research students seeking advanced information on CBIR. I hope this book will provide reference of many of the techniques used in the field as well as generate new research ideas to further advance the field.

This work would not have been possible without the help and mentoring from many, in particular, Prof. J. S. P. Rai, Vice Chancellor, Jaypee University of Engineering and Technology, Guna. My sincere thanks to all. The encouragement and support from my colleagues Prof. Anuj Kumar and Dr. Sudip Sharma is also acknowledged.

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Guna, India

Vipin Tyagi

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Acronyms

AGR	Adaptive grid resolution
ANMRR	Average Normalized Modified Retrieval Rank
ART	Angular radial transformation
BAS	Beam angle statistics
BM	Boltzmann machines
BOVW	Bag-of-visual-words
BoW	Bag-of-words
BQMP	Binary quaternion-moment preserving
CBIR	Content-based image retrieval
CBRD	Completed binary region descriptor
CBVR	Content-based video retrieval
CCD	Common Color Dataset
CCH	Chain code histogram
CCH	Color co-occurrence histogram
CCM	Color concurrence matrix
CCQ	Common Color Queries
CECH	Color edge co-occurrence histogram
CHKM	Color histogram for K-means
CHV	Color coherence vector
CLD	Color layout descriptor
CMY	Cyan, magenta, yellow
CS	Coding Schemes
CSS	Curvature scale space
CVAAO	Color variances among adjacent objects
CVLBP	Completed volume local binary pattern
CWT	Complex wavelet transform
DBM	Deep Boltzmann machine
DBN	Deep belief network
DBSCP	Difference between pixels of scan pattern
DCC	Differential chain codes

DCD	Dominant color descriptor
DCT	Discrete cosine transform
DDL	Description Definition Language
DLBP	Dominant local binary patterns
DNN	Deep neural networks
Ds	Descriptors
DSs	Description Schemes
DST	Discrete sine transform
DT	Decision tree
EBU	European Broadcasting Union
EGWC	Enhanced Gabor wavelet correlogram
EHD	Edge histogram descriptor
EI-MST	Edge integrated minimum spanning tree
ELBP	Extended local binary pattern
EMD	Earth Mover Distance
FARG	Fuzzy attributed relational graph
FCC	Federal Communication Commission of America
FD	Fourier descriptor
FIDS	Flexible image database system
GAVG	Global average
GFD	Generic Fourier descriptor
GLCM	Gray-level co-occurrence matrix
HDTV	High-definition television
HMMD	Hue min–max difference color space
HSB	Hue, saturation, brightness
HSL	Hue, saturation, luminance
HSV	Hue, saturation, value
HTD	Homogeneous texture descriptor
ICM	Iterated conditional modes
IEC	International Electrotechnical Commission
IM	Invariant moments
IP	Information preserving
IPM	Intersection point map
IR	Information retrieval
IRM	Integrated region matching
ISO	International Standards Organization
KL divergence	Kullback–Leibler divergence
LAD	Local average difference
LBP	Local binary pattern
LBPV	Local binary pattern variance
LDA	Linear discrimination analysis
LEPINV	Line edge pattern for image retrieval
LEPSEG	Line edge pattern for segmentation
LMP	Local mesh patterns
LSE	Least square error

LTP	Local ternary pattern
LTrP	Local tetra pattern
MBP	Median binary pattern
MPEG	Moving Picture Experts Group
MPFT	Modified Polar fourier transform
MRF	Markov random field
MRSAR	Multiresolution simultaneous autoregressive model
MSD	Microstructure descriptors
MS-LBP	Multiscale local binary pattern
MTH	Multitexton Histogram
NIP	Non-information preserving
NISP	Noise-invariant structure pattern
NMRR	Normalized Modified Retrieval Rank
OCLBP	Opponent color local binary pattern
OFMM	Orthogonal Fourier–Mellin moment
PBD	Perceptual browsing descriptor
PCA	Principal component analysis
PLBP	Pyramid-based local binary pattern
PR	Precision–recall
PWT	Pyramid-structured wavelet transform
QBIC	Query By Image Content
QF	Quadratic form
RBIR	Region-based image retrieval
RBM	Restricted Boltzmann machines
RCC	Resampling chain codes
RCM	Radial Chebyshev moments
RF	Relevance feedback
RGB	Red, green, blue
RI-LBP	Rotation-invariant image local binary pattern
RLBP	Robust local binary patterns
ROBs	Region of blocks
ROI	Region of interest
RSA	Region similarity arrangement
RST	Rotated, scaled, or translated
RWF	Rotated wavelet filter
SAR	Simultaneous autoregressive
SCD	Scalable color descriptor
SDR	System-designated ROI
SED	Structure element descriptor
SEH	Structure element histogram
SIFT	Scale-invariant feature transform
SMPTE	Society of Motion Picture and Television Engineers
SOM	Self-organization map
SPD	Spectral power distribution
SRLD	Short run length texture descriptor

SRLH	Short run length histogram
SVM	Support vector machine
TBIR	Text-based image retrieval
TCM	Texton co-occurrence matrix
TWT	Tree-structured wavelet transform
UDR	User-designated ROI
VCC	Vertex chain code
VLBP	Volume local binary pattern
WT	Wavelet transform
ZM	Zernike moments