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Springer

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Preface

Humans receive the great majority of information about their environment through sight, and at least 50% of the human brain is dedicated to vision. Vision is also a key component for building artificial systems that can perceive and understand their environment. Computer vision is likely to change society in many ways; for example, it will improve the safety and security of people, it will help blind people see, and it will make human-computer interaction more natural. With computer vision it is possible to provide machines with an ability to understand their surroundings, control the quality of products in industrial processes, help diagnose diseases in medicine, recognize humans and their actions, and search for information from databases using image or video content.

Texture is an important characteristic of many types of images. It can be seen in images ranging from multispectral remotely sensed data to microscopic images. A textured area in an image can be characterized by a nonuniform or varying spatial distribution of intensity or color. The variation reflects some changes in the scene being imaged. For example, an image of mountainous terrain appears textured. In outdoor images, trees, bushes, grass, sky, lakes, roads, buildings etc. appear as different types of texture. The specific structure of the texture depends on the surface topography and albedo, the illumination of the surface, and the position and frequency response of the viewer. An X-ray of diseased tissue may appear textured due to the different absorption coefficients of healthy and diseased cells within the tissue.

Texture can play a key role in a wide variety of applications of computer vision. The traditional areas of application considered for texture analysis include biomedical image analysis, industrial inspection, analysis of satellite or aerial imagery, document image analysis, and texture synthesis for computer graphics or animation.

Texture analysis has been a topic of intensive research since the 1960s, and a wide variety of techniques for discriminating textures have been proposed. Most of the proposed methods have not been, however, capable to perform well enough for real-world textures and are computationally too complex to meet the real-time requirements of many applications. In recent years, very discriminative and computationally efficient local texture descriptors have been developed, such as local binary patterns (LBP), which has led to a significant progress in applying texture methods to various computer vision problems. The focus of the research has broadened from 2D textures to 3D textures and spatiotemporal (dynamic) textures.

With this progress the emerging application areas of texture analysis will also cover such modern fields as face analysis and biometrics, object recognition, motion analysis, recognition of actions, content-based retrieval from image or video databases, and visual speech recognition. This book provides an excellent overview how texture methods can be used for solving these kinds of problems, as well as more traditional applications. Especially the use of LBP in biomedical applications and biometric recognition systems has grown rapidly in recent years.

The local binary pattern (LBP) is a simple yet very efficient operator which labels the pixels of an image by thresholding the neighborhood of each pixel and considers the result as a binary number. The LBP method can be seen as a unifying approach to the traditionally divergent statistical and structural models of texture analysis. Perhaps the most important property of the LBP operator in real-world applications is its invariance against monotonic gray level changes caused, for example, by illumination variations. Another equally important is its computational simplicity, which makes it possible to analyze images in challenging real-time settings. LBP is also very flexible: it can be easily adapted to different types of problems and used together with other image descriptors.

The book is divided into five parts. Part I provides an introduction to the book contents and an in-depth description of the local binary pattern operator. A comprehensive survey of different variants of LBP is also presented. Part II deals with the analysis of still images using LBP operators. Applications in texture classification, segmentation, description of interest regions, content-based image retrieval and 3D recognition of textured surfaces are considered. The topic of Part III is motion analysis, with applications in dynamic texture recognition and segmentation, background modeling and detection of moving objects, and recognition of actions. Part IV deals with face analysis. The LBP operators are used for analyzing still images and image sequences. The specific application problem of visual speech recognition is presented in more detail. Finally, Part V provides an introduction to some related work by describing representative examples of using LBP in different applications, such as biometrics, visual inspection and biomedical applications, for example.

We would like to thank all co-authors of our LBP papers for their invaluable contributions to the contents of this book. First of all, special thanks to Timo Ojala and David Harwood who started LBP investigations in our group in fall 1992 during David Harwood's visit from the University of Maryland to Oulu. Since then Timo Ojala made many central contributions to LBP until 2002 when our very frequently cited paper was published in IEEE Transactions on Pattern Analysis and Machine Intelligence. Topi Mäenpää played also a very significant role in many developments of LBP. Other key contributors, in alphabetic order, include Jie Chen, Xiaoyi Feng, Yimo Guo, Chu He, Marko Heikkilä, Vili Kellokumpu, Stan Z. Li, Jiri Matas, Tomi Nurmela, Cordelia Schmid, Matti Taini, Valtteri Takala, and Markus Turtinen. We also thank the anonymous reviewers, whose constructive comments helped us improve the book.

Matlab and C codes of the basic LBP operators and some video demonstrations can be found from an accompanying website at www.cse.oulu.fi/MVG/LBP_Book. For a bibliography of LBP-related research and links to many papers, see www.cse.oulu.fi/MVG/LBP_Bibliography.

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Contents

Abbreviations

1DHFLBP-TOP	One Dimensional Histogram Fourier LBP-TOP
2DHFLBP-TOP	Two Dimensional Histogram Fourier LBP-TOP
ALBP	Adaptive Local Binary Pattern
AM	Appearance-Motion
ARMA	Autoregressive and Moving Average
ASM	Active Shape Model
ASR	Audio only Speech Recognition
AVSR	Audio-Video Speech Recognition
BIC	Bayesian Intra/Extrapersonal Classifier
BLBP	Bayesian LBP
BSM	Binary Similarity Measures
CBIR	Content-Based Image Retrieval
CE	Capsule Endoscope
CLBP	Completed LBP
CNN-UM	Cellular Nonlinear Network-Universal Machine
Cohn-Kanade	A facial expression database
CRF	Conditional Random Field
CRIM	A video face database
CS-LBP	Center-Symmetric Local Binary Patterns
CT	Computed Tomography image
CTOP	Contrast from Three Orthogonal Planes
CUReT	A texture database
DFT	Discrete Fourier Transform
dLBP	Direction coded LBP
DLBP	Dominant Local Binary Patterns
DoG	Difference of Gaussians
DT	Dynamic Texture
DT-LBP	Decision Tree Local Binary Patterns
EBGM	Elastic Bunch Graph Matching
EBP	Elliptical Binary Patterns
EER	Equal Error Rate

E-GV-LBP	Effective Gabor Volume LBP
ELTP	Enlongated Ternary Patterns
EM	Expectation-Maximization
EPFDA	Ensemble of Piecewise Fisher Discriminant Analysis
EQP	Enlongated Quinary Patterns
EVLBP	Extended Volume Local Binary Patterns
FAR	False Acceptance Ratio
FCBF	Fast Correlation-Based Filtering
FDA	Fisher Discriminant Analysis
FERET	A face database
FLS	Filtering, Labeling and Statistic
FPLBP	Four-Patch Local Binary Patterns
FRGC	A face database
FSC	Fisher Separation Criteria
F-LBP	Fourier Local Binary Patterns
GFB	Gaussian Feature Bank
GMM	Gaussian Mixture Models
HCI	Human-Computer Interaction
HKLBP	Heat Kernel Local Binary Pattern
HLBP	Haar Local Binary Pattern
HMM	Hidden Markov Models
Honda/UCSD	A video face database
HOG	Histogram of Oriented Gradients
ILBP	Improved Local Binary Patterns
JAFFE	A facial expression database
KDCV	Kernel Discriminative Common Vectors
KTH-TIPS	Texture databases
LAB	Locally Assembled Binary Haar features
LABP	Local Absolute Binary Patterns
LBP	Local Binary Patterns
LBPV	Local Binary Pattern Variance
LBP/C	Joint distribution of LBP codes and a local Contrast measure
LBP-TOP	LBP from Three Orthogonal Planes
LBP-HF	Local Binary Pattern Histogram Fourier
LDA	Linear Discriminant Analysis
LDP	Local Derivative Patterns
LEP	Local Edge Patterns
LFW	The Labeled Faces in the Wild database
LGBP	Local Gabor Binary Patterns
LLBP	Local Line Binary Patterns
LP	Linear Programming
LPCA	Laplacian Principal Component Analysis
LPM	Local Pattern Model
LPP	Locality Preserving Projections
LPQ	Local Phase Quantization

LQP	Local Quinary Patterns
LTP	Local Ternary Patterns
MBP	Median Binary Patterns
MB-LBP	Multiscale Block Local Binary Pattern
MEI	Motion Energy Images
MHI	Motion History Images
MIR	Merger Importance Ratio
MLBP	Monogenic-LBP
MoBo	The CMU Motion of Body (MoBo) database
MR	Magnetic Resonance
MR8	A texture operator
MSF	Markov Stationary Features
MTL	Multi-Task Learning
NIR	Near-Infrared
OCLBP	Opponent Color Local Binary Patterns
Outex	A texture database
PCA	Principal Component Analysis
PLBP	Probabilistic LBP
PLS	Partial Least Squares
PPBTF	Pixel-Pattern-Based Texture Feature
RCC	Renal Cell Carcioma
SIFT	Scale Invariant Feature Transform
SILTP	Scale Invariant Local Ternary Pattern
SIMD	Single-Instruction Multiple-Data
SOM	Self-Organizing Map
SVM	Support Vector Machine
SVR	Support Vector Regression
S-LBP	Semantic Local Binary Patterns
tLBP	Transition coded LBP
TPLBP	Three-Patch Local Binary Patterns
VidTIMIT	An audio-video database
VLBP	Volume Local Binary Patterns
WLD	Weber Law Descriptor
XM2VTS	An audio-video database