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Image Registration

Principles, Tools and Methods

Springer

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To My Wife,
My Parents,
Charles E. Spearman,
and Larry L. Schumaker

Preface

Image registration is the process of finding correspondence between all points in two images of a scene. This correspondence is required in stereo depth perception, 3-D scene reconstruction, object detection and recognition, change detection, image fusion, object tracking and motion analysis. Analysis of two or more images of a scene often depends on the ability to find correspondence between points in the images.

This monograph overviews principles, tools and methods in image registration. In addition to reviewing past tools and methods and comparing their performances, new tools and methods are introduced and evaluated.

Chapter 1 describes the problem of image registration, identifies the steps involved in registering two images, defines the terminologies used in the book and categorizes image registration methods. This monograph focuses on point-based methods to image registration, although other methods are also reviewed in Chap. 11.

Chapter 2 reviews various similarity and dissimilarity measures used to register two images or find correspondence between local neighborhoods in two images. Chapter 3 reviews various point detectors and compares their performances.

Chapter 4 reviews methods for extracting various image features and Chap. 5 discusses various image descriptors that can be associated with the detected points. Chapter 6 shows that not all image features are equally informative. Some features carry more information than others or are invariant under intensity and geometric changes. Chapter 6 also describes various methods for selecting small subsets of image features to make the point correspondence process more efficient.

Chapter 7 discusses methods for finding correspondence between points in two images where each point has a feature vector associated with it. Robust matching and robust estimation of transformation parameters are discussed in Chap. 8 and various transformation models in image registration are discussed in Chap. 9.

Chapter 10 discusses the image resampling and intensity blending steps in image registration. Chapters 2–10 review various tools needed to design a particular image registration method. Specific methods that use the described tools to register images are reviewed in Chap. 11.

This monograph covers the fundamentals of digital image registration. It does not discuss applications of image registration nor does it discuss characteristics of

various types of images. However, a researcher familiar with principles, tools, and methods covered in this book should be able to design an effective method for registering a particular type of imagery and for a given application.

The content of this monograph is intended for students, image analysis software developers, engineers, and researchers who would like to analyze two or more images of a scene. It provides the basic knowledge to find corresponding points in two images and spatially align them.

The satellite images used in the examples are courtesy of NASA, the medical images are courtesy of Kettering Medical Center, Kettering, Ohio, and the aerial images are courtesy of Image Registration and Fusion Systems, Dayton, Ohio. The remaining images are those of the author. The images may be found at http://www.imgfsr.com/book2.html and may be downloaded and used in research and scientific publications without a restriction.

Dayton, OH, USA A. Ardeshir Goshtasby

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A. Ardeshir Goshtasby

Contents

Acronyms

AAID	Average absolute intensity difference
ACC	Accuracy
ASIFT	Affine-invariant SIFT
BLUE	Best linear unbiased estimation
CCH	Contrast context histogram
DCT	Discrete cosine transform
DFT	Discrete Fourier transform
DoG	Difference of Gaussians
DOLP	Difference of low pass
DT	Distance transform
DTCWT	Dual tree complex wavelet transform
EM	Expectation maximization
FN	False negative
FP	False positive
FPR	False positive rate
GLD	Gray-level difference
GLOH	gradient location and orientation histogram
GLSD	Gray-level spatial-dependence
GSBS	Generalized sequential backward selection
GSFS	Generalized sequential forward selection
HSV	Hue, saturation, value
HT	Hadamard transform
JCPD	Joint conditional probability density
JPD	Joint probability distribution
k-NN	k-nearest neighbor
LoG	Laplacian of Gaussian
LMS	Least median of squares
LTS	Least trimmed square
M	Maximum likelihood
MAD	Median of absolute differences
MLESAC	Maximum likelihood estimation sample consensus

MQ	Multiquadric
MSD	Median of square differences
MSIFT	Multispectral SIFT
MSS	Multi-spectral scanner
MST	Minimum-spanning tree
NASA	National Aeronautics and Space Administration
OLS	Ordinary least-squares
OSID	Ordinal spatial intensity distribution
PCA	Principal component analysis
PROSAC	Progressive sample consensus
R	Rank
R-RANSAC	Randomized RANSAC
RaG	Rational Gaussian
RANSAC	Random sample and consensus
RGB	Red, green, blue
RIFT	rotation-invariant feature transform
RLM	Run-length matrix
RM	Repeated median
RMSE	Root-mean-squared error
RMSID	Root-mean-squared intensity difference
S	Scale
SBS	Sequential backward selection
SFS	Sequential forward selection
SIFT	Scale-invariant feature transform
SUSAN	Smallest univalue segment assimilating nucleus
TM	Thematic Mapper
TP	True positive
TPR	True positive rate
TPS	Thin-plate spline
USGS	United States Geological Survey
WLD	Weber local descriptor
WLIN	Weighted linear
WLS	Weighted least-squares