Graphics Recognition
A Historical Perspective and Recent Advances
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Computer Science and Engineering
University of South Florida
Tampa, Florida, USA

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IAPR/ICDAR Award

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Lawrence O’Gorman, Endorser
Gabriella Sanniti di Baja, Endorser
Karl Tombre, Endorser
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ICDAR 2017 Organizing Committee

Koichi Kise and Team
IAPR/ICDAR Award

I would like to Dedicate this award to

My 70+ Students

Who Performed Much of the Research I am Recognized for Over the Past 35 Years
Thank You

Some of those who made it all possible
Representing them all here is
Sameer Antani, Ph.D.

Sameer Antani: *Video Content Characterization via Robust Recognition of Scene and Caption Text, Ph.D.*, 2001
IAPR Leaders, Freeman, Fu, Sakai, and Pavlidis at First Meeting of the IAPR Governing Board, Kyoto, 1978
What is Graphics Recognition?

A Typical Document: Three Components

Text Regions - Recognized by OCR
Images - Processed by Image Processing
Graphics - Analyzed by Graphics Recognition

Graphics include Block Diagram, Chart, Graph, Line Art, Map, Schematic, Table, etc.
Graphics Recognition: 60 Year History

- Early Days (1955) to First IJCPAR (1973)
- First IJCPAR (1973) to First GRec (1995)

IJCPAR: International Joint Conference on Pattern Recognition
(Became ICPR after 1978)
GRec: IAPR Workshop on Graphics Recognition
Graphics Recognition – Early Days
1955 - 1972
“Pattern Recognition and Modern Computers”
O. G. Selfridge, AFIPS '55 (Western) Proceedings, 1955

“Pattern Recognition… extraction of significant features from a background of irrelevant detail”

Describes Following Problems

Two Class Problem: Large group of VERTICAL LINES on LEFT or RIGHT

Recognize Oriented Rectangles by Corner Detection

Conclusion: “simple visual patterns can be recognized by the computer, and … may improve its recognition by learning”
“Pattern Recognition and Modern Computers”
O. G. Selfridge, AFIPS '55 (Western) Proceedings, 1955

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Fig. 6—Vertical concavity.

Locate all left edge points.

Yields lower inside corner points on a left edge [see point labeled (10) in Fig. 7(a)]. At this point the accumulator contains all vertical edges facing left which start from inside corner points as described in 10) above.
"Apictorial Jigsaw Puzzles…"
H. Freeman and L. Garder, IEEE T. on Electronic Computers, 1964
Distances Functions

Introduced

- City Block
- Square
- Hexagonal
- Octagonal
- Euclidean

1968: Pattern Recognition journal begins publication
First issue includes the paper
“Distance Functions on Digital Pictures”
A. Rosenfeld and J. L. Pfaltz, Pattern Recognition, Issue 1, 1968

Just Graduated with B. Eng
(Electrical)
Outstanding Student Award
“Recognition of Convex Blobs”  
J. Sklansky, Pattern Recognition, 1970

- Relationships among convex figures, concave figures, and their cellular images on a rectangular mosaic are presented.
- An algorithm using "minimum-perimeter polygon" is described for testing the convexity.

![Fig. 1. Two blobs.](image)

![Blob A](image) ![Blob B](image)

![Fig. 2. Cellular images of the blobs of Fig. 1.](image)
Graphics Recognition: 1970s

Pattern Recognition gets Established as a Scientific Discipline during 1970s

Several Books on PR are Published

I(J)CPR, PRIP (CVPR), IAPR and PAMI All start during 1970s

Graphics Recognition Topics frequently appear in these
Several Books were Published during 1973-78

“Pattern Classification and Scene Analysis”

“Pattern Recognition Principles”
J.T. Tou and R.C. Gonzalez, 1974

“Syntactic Methods in Pattern Recognition”
K.S. Fu, Academic Press, 1974

“Structural Pattern Recognition”
T. Pavlidis, Springer-Verlag, 1978
1973: First International Joint Conference on Pattern Recognition
“Contour Detection in Noisy Pictures…”
A. Martelli, 1st IJPR, 1973

Original

Noisy

Boundary

Computer Vision and Pattern Recognition Laboratory
"Computer Processing of Line-Drawing Images"
H. Freeman, Computing Surveys, 1974

Fig. 13 Chain coding scheme (lower right), and some chain-coded boundary lines from Fig. 12

Fig. 23 Illustration of the map-matching problem

Fig. 24 Chain-encoded contour map. (From S. P. Morse, "Generalized computer techniques for the solution of contour-map problems", Ph.D dissertation, New York University, 1967)

Fig. 25 Determination of minimum-area rectangle
IEEE Pattern Recognition and Image Processing
PRIP Series Begins in 1977 (Changes to CVPR in 1983)
“Shape Matching using Relaxation Techniques”
L.S. Davis, PRIP, 1977

Figure 1. Data Base.

Figure 2. Templates.

Figure 3. Superpositions.

(c) Cuba
(d) Dominican Republic
(e) Guadeloupe
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**Contributors**

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A Minicomputer-Based Geographical Data Processing System  
Dieter Steiner

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A. Raymond Boyle

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A Spatial Data Structure for Geographic Information Systems  
Robert M. Haralick

Design of a Spatial Information System  
Linda G. Shapiro

What Is a “Good” Data Structure for 2-D Points?  
George Nagy

Tree Structures for Region Representation  
Azriel Rosenfeld

Analysis and Manipulation of Lineal Map Data  
Herbert Freeman

Representation and Recognition of Cartographic Data  
Larry S. Davis

The Effects of Generalization in Geographical Data Encoding  
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**Map Data Processing: Proceedings of NATO Workshop**  
Edited by H. Freeman and Pieroni, 1979
A Hierarchical Syntactic Shape Analyzer

THEODOSIOS PAVLIDIS, SENIOR MEMBER, IEEE, AND FARHAT ALI

Example of encoding of the boundary of a handwritten numeral.

Fig. 5. Contours of a printed wiring board whose descriptions are given in Table IX. Note that the size notations in the table \( (L, M, S, N) \) are relative with respect to the size of the whole contour.
Early work in Music Recognition
“A Critical Survey of Music Image Analysis”

A Comprehensive Survey of some 50 papers on Music Recognition including
• Recognition of Music Symbols
• Staff Lines
• Symbol Classification
• Relative Positions of Symbols
• Syntactic Methods (for analysis)
• Dance Notation

Fig. 2. Illustration of some terms for musical notation.
“A Width Independent Fast Thinning Algorithm”
C. Arcelli and G. Sanniti di Baja, IEEE T. PAMI, 1985
Workshop series on Syntactic and Structural Methods in Pattern Recognition
First event organized in 1981 by K.S. Fu, T. Pavlidis, J.L. Mundy and J.K. Aggarwal
This complemented the Workshop series on Statistical Methods In Pattern Recognition
These are often held in the same location (S+SSPR 2016 held in Mérida, Mexico)

Kasturi-1981
Graduate Student at Texas Tech University
Topic: Image Restoration in Signal Dependent Noise
1982: With John F. Walkup, Advisor

Joined the Pennsylvania State University
Had to find a new topic for my research

Always interested in MAPS

Image Analysis Techniques for Cartographic Data Processing

The objective(s) of this project is (are):

Design an intelligent computer based system to "understand" and extract information from cartographic data and answer queries related to spatial features and structure of geographical data. Image analysis techniques such as region growing, line tracking and representation using conic arcs and edge

Proposal submitted in January 1983; Grant for $48,000
Received from National Science Foundation in April 1983
Finally, started working in Graphics Recognition!
Some Results from Map Analysis project (1983-87)
O. Morean and R. Kasturi, My First ICPR, Montreal, 1984
R. Kasturi and J. Alemany, IEEE TSE, 1988

R. Fernandez, who worked on this project, was hired to lead the Yahoo Maps project.

- Developed Algorithms for
  - Text-Graphics Separation
  - Symbol Recognition
  - Dashed Line Detection
  - Query Processing
  - Shortest Distance

Show “Roads” Within “State” Containing “Lubbock”

Simplified Map of Western USA

Map after Text String Separation
“Development of Auto-Digitizer…”
S. Kakumoto, T. Miyatake, S. Shimada, and M. Ejiri, CVPR 1983

Figure 3.10 Automatic digitizers: (a) drum-type for color drawings; (b) flatbed-type for monochrome drawings.

Hitachi Central Research Laboratory, Japan
IAPR Workshop on Machine Vision Applications, Tokyo, 1990
Organized by Masakazu Ejiri

- Map and Line Drawing Processing
  - Raster-to Vector Conversion
  - Interpretation of Road Maps
  - Shorthand Recognition
  - Jigsaw Puzzle Assembly
  - Traffic Sign Detection

- Structured Document Recognition
  - Layout Structure Analysis
  - Page Reader

- Fingerprint Classification
"Model based Understanding of Document Images"
K. Kise, et al., IAPR MVA Workshop, 1990

Fig. 1 Document model

(a) hypothesis generation  (b) hypothesis testing

Fig. 2 Actual results

Table 2 Results of understanding

<table>
<thead>
<tr>
<th></th>
<th>organization</th>
<th>position</th>
<th>title</th>
<th>name</th>
<th>header</th>
<th>address</th>
<th>postcode</th>
<th>telephone</th>
<th>fax</th>
<th>telex</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of components</td>
<td>100</td>
<td>136</td>
<td>130</td>
<td>100</td>
<td>41</td>
<td>119</td>
<td>119</td>
<td>167</td>
<td>10</td>
<td>25</td>
<td>947</td>
</tr>
<tr>
<td>Understanding rate</td>
<td>81.0%</td>
<td>94.9%</td>
<td>98.5%</td>
<td>89.0%</td>
<td>87.8%</td>
<td>93.3%</td>
<td>82.4%</td>
<td>74.3%</td>
<td>20.0%</td>
<td>84.0%</td>
<td>86.5%</td>
</tr>
</tbody>
</table>
“Automatic Digitizing of the Colour-Layer of Thematic Maps”
R. Espelid, et al., IAPR MVA Workshop, 1990

Figure 3. a) Original image. b) Thresholded image. c) Classified areas. d) Borderlines of classified areas.

Figure 4. a) Original image. b) Classified image.
IAPR TC10
From Map and Line Drawing Processing to Graphics Recognition

- TC10 on Map and Line Drawing Processing
  - Established during early years of IAPR
  - I was appointed as its Chair by President Martin Levine in 1988
    - First Experience in Leadership Activities

- Renamed as TC10 on Graphics Recognition in 1992 to broaden its appeal

- Provided a home for researchers with interest in Graphics Recognition to exchange their experiences

- Graphics Recognition became an Identified Scientific Topic
Fig. 1. Test image 1.
General Purpose Graphics Recognition Project
After Text Separation
While there is a segment, L, which is not used in any line or tested for starting a new line, Do

1: Select the "Head" end of Segment L by setting Terminal = 1
2: Let $S_0 = L$ and $t_0 = \text{Terminal}$
3: Select an unmarked segment $S_1$ having the highest priority to continue the line at
   $t_0$ end of $S_0$
   If $S_1$ exists, then
   Mark $S_1$. Locate the other end of $S_1$. If it is a head, then set $t_1 = 1$ else set
   $t_1 = 2$
   Go to Step 4
   elseif Terminal = 1 then
   Terminal = 2
   Go to Step 2 (to extend the line at the other end of starting segment L)
   else
   Label all the segments which belong to the current line
   Clear all marks of segments which are not part of a dashed line
   Continue to find other lines (by returning to the While loop)
   end if
4: Select an unmarked segment $S_1$ having the highest priority to continue the line at
   $t_1$ end of $S_0$
   If $S_1$ exists, then
   Mark $S_1$
   If $l_{13} \neq l_{12}$ Or $g_{13} \neq g_{12}$ then Go to Step 4
   Locate the other end of $S_1$. If it is a head, then set $t_1 = 1$ else set $t_1 = 2$
   Go to Step 5
   else
   Go to Step 3
   end if
5: Select an unmarked segment $S_1$ having the highest priority to continue the line at
   $t_1$ end of $S_1$
   If $S_1$ exists, then
   Mark $S_1$
   If $l_{13} \neq l_{12}$ Or $g_{13} \neq g_{12}$ then Go to Step 5.
   Locate the other end of $S_1$. If it is a head, then set $t_1 = 1$ else set $t_1 = 2$
   Label $S_1$ and $S_2$ as extensions of current line. Set $S_0 = S_2$, $t_0 = t_1$, $S_1 = S_3$, 
   and $t_1 = t_r$
   end if
6: Go to Step 4
end while
### General Purpose Graphics Recognition Project

#### Recognition of Shapes and their Attributes

<table>
<thead>
<tr>
<th>Object</th>
<th>Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Regular Hexagon</td>
<td>P: (1258, 1081), L = 133, $\phi$ = 1.51</td>
</tr>
<tr>
<td>2 Parallelogram</td>
<td>P: (727, 1268), L1 = 292, L2 = 146, $\Theta$ = 46.1, $\phi$ = 0</td>
</tr>
<tr>
<td>3 Trapezoid</td>
<td>P: (73, 1081), L1 = 718, L2 = 390, H = 217, $\Theta$ = 90.68, $\phi$ = -0.16</td>
</tr>
<tr>
<td>4 Rhombus</td>
<td>P: (339, 1791), L = 220, $\Theta$ = 30.1, $\phi$ = -0.45</td>
</tr>
<tr>
<td>5 Trapezoid</td>
<td>P: (1220, 1194), L1 = 221, L2 = 150, H = 68.6, $\Theta$ = 65, $\phi$ = 0.77</td>
</tr>
<tr>
<td>6 Triangle</td>
<td>P1: (1295, 1153), P2: (1363, 1151), P3: (1325, 1122), Isoceles</td>
</tr>
<tr>
<td>7 Triangle</td>
<td>P1: (1396, 1826), P2: (1106, 1831), P3: (1256, 1971), Isoceles</td>
</tr>
<tr>
<td>8 Rectangle</td>
<td>P: (457, 1044), W = 835, H = 564, $\phi$ = -0.4, Table</td>
</tr>
<tr>
<td>9 Quasi-Hexagon</td>
<td>P: (692, 1497), L1 = 440, L2 = 303, $\Theta$ = 89.1, $\phi$ = 3.0</td>
</tr>
<tr>
<td>10 Parallelogram</td>
<td>P: (765, 1790), L1 = 297.1, L2 = 148, $\Theta$ = 89.0, $\phi$ = -1.35, Single hatch: $a_1$ = 135, $d_1$ = 30</td>
</tr>
<tr>
<td>11 Triangle</td>
<td>P1: (1256, 1897), P2: (1399, 1755), P3: (1108, 1753), Isoceles</td>
</tr>
<tr>
<td>12 Polygon, irregular</td>
<td>Number of segments: 6, Center: (1556, 1706), Coordinates of vertices...</td>
</tr>
</tbody>
</table>

### Lines and Their Interconnections

<table>
<thead>
<tr>
<th>Line</th>
<th>Head</th>
<th>Tail</th>
<th>From</th>
<th>To</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>(1404,1748)</td>
<td>(1399,1755)</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>L2</td>
<td>(910,1416)</td>
<td>(911,1271)</td>
<td>9</td>
<td>2</td>
</tr>
</tbody>
</table>

#### Spatial Relationships Among Objects in Test Image 1

<table>
<thead>
<tr>
<th>Objects</th>
<th>Spatial Relationships</th>
</tr>
</thead>
<tbody>
<tr>
<td>11 Triangle</td>
<td>Overlaps Object 7</td>
</tr>
<tr>
<td>1 Regular Hexagon</td>
<td>Encloses Objects 5 and 6</td>
</tr>
<tr>
<td>10 Parallelogram</td>
<td>Single Hatch</td>
</tr>
<tr>
<td>3 Trapezoid</td>
<td>Small Shape Fillings</td>
</tr>
</tbody>
</table>

#### Lines With Multiple Segments

<table>
<thead>
<tr>
<th>PL1 S1:</th>
<th>(330,1531)</th>
<th>(260,1537)</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>S2:</td>
<td>(260,1537)</td>
<td>(265,1791)</td>
<td></td>
</tr>
<tr>
<td>S3:</td>
<td>(265,1791)</td>
<td>(332,1790)</td>
<td></td>
</tr>
<tr>
<td>S4:</td>
<td>(332,1790)</td>
<td>(339,1791)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PL2 S1:</th>
<th>(1064,1715)</th>
<th>(1252,1719)</th>
<th>10</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>S2:</td>
<td>(1252,1719)</td>
<td>(1252,1750)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Processing Graphics Containing Circular Arc Segments

Fig. 16. Graphics containing circular arc segments.

<table>
<thead>
<tr>
<th>CIRCLE</th>
<th>RADIUS</th>
<th>CENTER X</th>
<th>CENTER Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>381</td>
<td>493</td>
<td>469</td>
</tr>
<tr>
<td>2</td>
<td>228</td>
<td>1193</td>
<td>890</td>
</tr>
<tr>
<td>3</td>
<td>230</td>
<td>1195</td>
<td>257</td>
</tr>
<tr>
<td>4</td>
<td>338</td>
<td>495</td>
<td>473</td>
</tr>
<tr>
<td>5</td>
<td>221</td>
<td>1472</td>
<td>697</td>
</tr>
<tr>
<td>6</td>
<td>233</td>
<td>1455</td>
<td>415</td>
</tr>
<tr>
<td>7</td>
<td>236</td>
<td>1418</td>
<td>1548</td>
</tr>
<tr>
<td>8</td>
<td>233</td>
<td>1180</td>
<td>591</td>
</tr>
<tr>
<td>9</td>
<td>95</td>
<td>917</td>
<td>1647</td>
</tr>
<tr>
<td>10</td>
<td>210</td>
<td>596</td>
<td>554</td>
</tr>
<tr>
<td>11</td>
<td>209</td>
<td>368</td>
<td>463</td>
</tr>
<tr>
<td>12</td>
<td>98</td>
<td>129</td>
<td>1654</td>
</tr>
<tr>
<td>13</td>
<td>97</td>
<td>529</td>
<td>1864</td>
</tr>
<tr>
<td>14</td>
<td>96</td>
<td>906</td>
<td>1190</td>
</tr>
<tr>
<td>15</td>
<td>92</td>
<td>125</td>
<td>1207</td>
</tr>
<tr>
<td>16</td>
<td>96</td>
<td>509</td>
<td>980</td>
</tr>
<tr>
<td>17</td>
<td>210</td>
<td>548</td>
<td>359</td>
</tr>
<tr>
<td>18</td>
<td>97</td>
<td>519</td>
<td>1422</td>
</tr>
<tr>
<td>19</td>
<td>457</td>
<td>509</td>
<td>1422</td>
</tr>
</tbody>
</table>

Circle 19 is partially occluded
Interpretation of 3-D from Orthographic Projections

According to the exception in Rule E1, edge AB is not created because lines ab and cd (whose nodes correspond with vertices A and B) are parallel to the view-pair angle between the front and right-side views.

Fig. 13a. Engineering drawing and b correctly interpreted object
“Engineering Drawing Conversion: Arrow Detection”
Antoine, Collin, and Tombre, SSPR 1990
“Interpretation of Telephone System Manhole Drawings”
Arias, Lai, Surya, Kasturi, and Chhabra, PRL, 1994

Original Drawing
Extracted Manhole
Cable Connections
Summary Table
“Automatic Digitization of Large Scale Maps”
Andreas Illert, ACSM-ASPRS, Vol. 6, pp. 113-122, 1991
ICDAR Series Began in 1991

Conference Chairs
Guy Lorrette
Ching Suen

Program Chairs
Robert Haralick
Sargur Srihari
Georges Stamon

Sponsored by
TC10 (R. Kasturi, Chair)
TC11 (R. Plamondon, Chair)

100+ Papers from 200+ Authors
1000 Page Proceedings
14 Sessions
Special Issue of IEEE Computer 1992
L.O’Gorman and R. Kasturi, Editors

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5 Guest Editors’ Introduction: Document Image Analysis Systems
Lawrence O’Gorman and Ramachandram Kasturi

10 A Prototype Document Image Analysis System for Technical Journals
George Nagy, Shomeet Seth, and Mahesh Venkatesan
Intelligent document segmentation can bring electronic browsing within the reach of most users. The authors show how this is achieved through document processing, analysis, and parsing the graphic sentence.

25 An Interpretation System for Land Register Maps
Luca Bonato, Vincente Coretto, Monica Del Balso, Saverio Di Zellicchio, Yvonne Everta, Alessandra Esposti, Francesco Melchioni, Mario Molinelli, Andrea Minelli, Marco Miniscu, Stefano Scardia, and Marco Taver
The semantics of land register maps drive this document conversion system. However, its methods of image representation, vectorization, and symbol recognition can be generalized to other classes of line drawings.

34 Postal Address Block Location in Real Time
Paul W. Polat محافظة, Sergio N. Sridhar, Jung Soh, Ramakrishnan Sridhar, and Victor Demjanenko
A postal automation system locates destination address blocks on letter mail pieces with a high success rate. Pipelining and multiprocessor techniques achieve real-time processing speeds.

46 Celestis: CAD Conversion of Mechanical Drawings
Paul Vachet and Karl Thomas
A prototype CAD conversion system extracts higher level structures for knowledge-based analysis. It recognizes such entities as screws, ball bearings, and shafts.

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Abdul Quttin, Mike Atkinson, and Sameh Al-Attar

75 Understanding Diagrams in Technical Documents
Robert P. Fatourco, Joanna A. Kukulini, Jeff Alexander, Catherine M. Carrion, Niko Siderakis, and Joseph M. Patrille
Next Three: Montreal, 1995; Ulm 1997; and Bangalore, 1999

S.N. Srihari and R. Kasturi (General Chairs)

Computer Vision and Pattern Recognition Laboratory
Graphics Recognition – Recent Progress
1995 - Present
First International Workshop on Graphics Recognition
August 9-11, 1995
Pennsylvania USA

Session Topics

- Basic Techniques and Symbol-level Recognition
- Map Processing
- Engineering Drawings
- Applications of Graphics Recognition
- Performance Evaluation

Dashed Line Detection Contest
GRec Contests

- 1995: Dashed Line Detection
- 1997: Raster to Vector Conversion
- 2001: Arc Segmentation
- 2003: Symbol Recognition
- 2005: Symbol Recognition II
- 2007: Symbol Recognition III
- 2009: Arc Segmentation II
- 2011: Isolated Symbol Recognition and Symbol Spotting
- 2013: Music Scores Competition: Staff Removal
- 2013: Arc and Line Segmentation
- 2015: Engineering Drawing Challenge I
- 2017: Engineering Drawing Challenge II
GRec 1995
State College
Pennsylvania

Dov Dori receiving Dashed Line Detection Award
(Winning Team: D. Dori, L. Wenyin and M. Peleg)
Document Analysis Systems Workshops Begin in 1994

DAS 2008

Proceedings of the 8th IAPR International Workshop on Document Analysis Systems

September 16-19, 2008
Nara Prefectural New Public Hall, Nara, Japan

Editors: Koichi Kise and Hiroshi Sako
International Journal on Document Analysis and Recognition

Begins Publication in 1998

Current Editors-in-Chief: K. Kise; D. Lopresti; S. Marinai

Foundaing Managing Editor: David Doermann

Computer Vision and Pattern Recognition Laboratory
New Workshop on Camera-Based Document Analysis and Recognition since 2005
Text Detection in Video/Images: An Example

J. Zhang and R. Kasturi, CBDAR 2013 and IEEE TIP 2014

Results on 2003-05 ICDAR Dataset
Grec 1995 to 2017

- GREC 2017, Kyoto
  - 27 papers organized into 6 sessions
  - Interpretation of engineering drawings, maps, charts, etc.
  - Symbol Recognition and Spotting
  - Optical Music Recognition
  - Interpretation of drawings, music scores, tables, etc.
  - Raster to Vector and drawings
  - Performance Evaluation and Interpretation
  - Engineering Drawing Challenge II

- GREC 1995, State College, Pennsylvania
  - Basic Techniques and Symbol-level Recognition
  - Map Processing
  - Engineering Drawings
  - Applications of Graphics Recognition
  - Performance Evaluation
Graphics Recognition Today

- Some 250 papers on GR Topics since 2007
- Fewer papers in Raster to Vector Conversion, Map Analysis, Tables, etc.
- Continuing interest in Music Recognition and Historical Document Analysis
- Increased interest in analyzing natural Video/Image data captured by cameras
- Much Interest: Sketch or Example-driven Recognition (SIGGRAPH/EuroGraphics, Multimedia and CBIR Communities are Ahead of us).
Historical Documents: An Example From U.S. National Archives
Historical Documents: One Example
Text from Microfilm Images of Punched Cards
An Example of Historical Document Processing
S.Kumar and R. Kasturi, ICPR 1992
Processing Steps

Skew Correction

Morphological Processing

Final Image

Decoded Text

32430970BRENKEN-WILBUR-F--------23181232
7180842PVN*T-829-0000/5*----023160/1*3130/6*0/6*730/1*0/3*0/7*0/7*
One Final Thought:
Do we need an Open GR?

- We have seen the impact of Open CV in accelerating Computer Vision research.
- But most Graphics Recognition applications appears to be still built from scratch.
- Should we invest in developing an Open GR?
  - Perhaps contribute to adding Graphics Recognition tools to Open CV?
  - Build upon Other Initiatives such as Aletheia?
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Research Collaborators

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Questions?
Thank You
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W. El-Masri: *Recognition and Description of Graphical Primitives*, MSEE, 1988
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J. Min: *Human Activity Recognition Using Motion Trajectories*, Ph.D., 2005
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D. Crandall: Detection of Stylized Text in Video, M.S. CSE and BS (Honors), May 2001
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Y.L. Tang: An Airborne System for Runway Recognition and Obstacle Detection, Ph.D., August 1994
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H. Vajaria: *Localization and Identification of Participants in Meeting Archives, Ph.D., 2008*
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J. Zhang: Extraction of Text Objects in Image and Video Documents, Ph.D. 2012
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H. Halliyal: *Speech Recognition System for Kannada Language*, MSEE, 1987
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P. Devaux: *Experimental Verification of Automated Interpretation of Engineering Drawings*, MSEE, May 1995
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S. Antani: *Video Content Characterization via Robust Recognition of Scene and Caption Text*, Ph.D., 2001
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S. Chandran: Structural Recognition of Tabulated Data,
MSCmpE, 1993
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G. Zamzmi: Infant Pain Analysis, Ph.D. 2018
Ph.D. Candidate
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A. Prasad: *System for Intelligent Interpretation of Text from Telephone Company Drawings*, MSCmpE, August 1995

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J. Arias: *Efficient Techniques for Line Drawing Interpretation*, PhD, August 1995
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N. Muralidhar: *Collection of Training Data for OCR of Kannada Characters*, 1999
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S. Hinduja: Pedestrian Detection in Low Quality Moving Camera Videos, MS, 2016,
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J.H. Park: *Manifold Learning in Computer Vision, Ph.D., 2005*
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J. Candamo: *Boundary Profile Representation for Objects and Their Surroundings in Outdoor Videos*, Ph.D. 2009
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M. Fathollahi: *Estimation of human pose categories*, Ph.D. 2017
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J. Viswanathan, Continuous Identity Assurance, MS, 2016
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Those Not Pictured

- A. Modi, Pedestrian detection at traffic intersections, MS, 2017
- V. Kamath, Survival prediction for colon cancer patients, M.S., 2005
- S. Natarajan, *A Hierarchical Scheme for Invoice Classification*, MS, 1997
- S. Balasubramanian, *Information Extraction From Tabular Drawings*, MSEE, May 1994
- S. U. Kumar, *Text Data Extraction from Microfilm Images of Punched Cards*, MS, 1992
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- J.Tyson, *Classification and Recognition of Invoice Documents*, 1993
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- M.I. Kahn, *Collision Free Path Planning in Unstructured, Dynamic Environments for Mobile Robots and Manipulators*, 1987
- Y. Choe, *Two-Dimensional Multiresolution Matching Algorithm*, 1987
- M.C. Chen, *Thresholding and Edge Detection Techniques in Computer Vision*, 1987
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- **B.S. Honors Thesis Students**
  - Oluwabukola Akinbo, *Visual Memory Assistant Portable FacialRecognizer*, 2006
  - S.Oswald, *Hierarchical Segmentation of Video Sequences*, 1995