Josep Lladós
Young-Bin Kwon (Eds.)

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Graphics Recognition

Recent Advances and Perspectives

5th International Workshop, GREC 2003
Barcelona, Spain, July 2003
Revised Selected Papers

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Preface

This book contains refereed and improved papers presented at the 5th IAPR[1] International Workshop on Graphics Recognition (GREC 2003). GREC 2003 was held in the Computer Vision Center, in Barcelona (Spain) during July 30–31, 2003. The GREC workshop is the main activity of the IAPR-TC10, the Technical Committee on Graphics Recognition[2]. Edited volumes from the previous workshops in the series are available as Lecture Notes in Computer Science: LNCS Volume 1072 (GREC 1995 at Penn State University, USA), LNCS Volume 1389 (GREC 1997 in Nancy, France), LNCS Volume 1941 (GREC 1999 in Jaipur, India), and LNCS Volume 2390 (GREC 2001 in Kingston, Canada).

Graphics recognition is a particular field in the domain of document analysis that combines pattern recognition and image processing techniques for the analysis of any kind of graphical information in documents, either from paper or electronic formats. Topics of interest for the graphics recognition community are: vectorization; symbol recognition; analysis of graphic documents with diagrammatic notation like electrical diagrams, architectural plans, engineering drawings, musical scores, maps, etc.; graphics-based information retrieval; performance evaluation in graphics recognition; and systems for graphics recognition. In addition to the classic objectives, in recent years graphics recognition has faced up to new and promising perspectives, some of them in conjunction with other, affine scientific communities. Examples of that are sketchy interfaces and on-line graphics recognition in the framework of human computer interaction, or query by graphic content for retrieval and browsing in large-format graphic documents, digital libraries and Web applications. Thus, the combination of classic challenges with new research interests gives the graphics recognition field an active scientific community, with a promising future.

Following the tradition of the previous workshops in the series, the scientific program of GREC 2003 was organized in a single-track 2-day workshop. It comprised eight sessions dedicated to specific topics. For each session, there was an overview talk, followed by a number of short presentations. Each session was concluded by a panel discussion. The workshop had 47 registered participants from 15 different countries. After the workshop, all the authors were invited to submit enhanced versions of their papers for this edited volume. The authors were encouraged to include ideas and suggestions that arose in the panel discussions of the workshop. Every paper was evaluated by three reviewers. At least one reviewer was assigned from the attendees to the workshop. As a result of the reviewers' comments, many of the papers that appear in this volume were

[1] International Association for Pattern Recognition, `http://www.iapr.org`
[2] `http://www.iapr-tc10.org`

thoroughly revised and improved. Hence, we feel that the scientific contents of this book have excellent quality.

This volume is organized into seven sections, reflecting the session topics in the workshop: platforms, architectures and document knowledge models; technical documents, maps and charts; perceptual organization, indexing and graphical signatures; image analysis and low-level processing; symbol recognition, graphical matching and classification; on-line processing and user interfaces; and performance evaluation and contests.

Two contests were held during GREC 2003: The *Second Arc Segmentation Contest*, organized by Liu Wenyin, with two participants. And the *First Symbol Recognition Contest*, organized by Ernest Valveny and Philippe Dosch, with four participants. The contests were a big success, and the inclusion of them has become a key issue in GREC workshops. Contests are useful not only to evaluate the state-of-the-art on algorithms related to different problems of graphics recognition, but also to provide evaluation databases and ground-truth to the community. This time, all the material used in the contests was distributed in a CD among GREC 2003 delegates and can be downloaded from the TC10 Web page.

We owe special thanks to the contributing authors, the reviewers and also to the workshop chairs that stimulated active panel discussions at the end of the sessions. We also especially acknowledge the support provided by the sponsors of the workshop: the IAPR (International Association for Pattern Recognition), CVC (Computer Vision Center), UAB (Universitat Autònoma de Barcelona), AERFAI (Asociación Española de Reconocimiento de Formas y Análisis de Imágenes), DURSI (Departament d'Universitats Recerca i Societat de la Informació, Generalitat de Catalunya), MCyT (Ministerio de Ciencia y Tecnología, TIC2002-11614-E), and HP (Hewlett-Packard). Many thanks also to Javier Jiménez, Enric Martí, Oriol Ramos, Gemma Sánchez, and Ernest Valveny, who were responsible for local arrangements, and worked hard both for the organization of the workshop and during the preparation of this book.

The 6th Graphics Recognition Workshop (GREC 2005[3]) will be held in Hong Kong, China, in August 2005, and it will be organized by Dr. Liu Wenyin.

April 2004

Josep Lladós
Young-Bin Kwon

[3] http://www.cs.cityu.edu.hk/grec2005/

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On-line Processing and Sketchy Interfaces

Performance Evaluation, Contests

Strategy for Line Drawing Understanding

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Abstract. In this paper, we present different strategies for localization and recognition of graphical entities in line drawings. Most systems include first a segmentation step of the document followed by a sequential extraction of the graphical entities. Some other systems try to recognize symbols directly on the bitmap image using more or less sophisticated techniques. In our system, an intermediate representation of the document provides a precise description of all the shapes present in the initial image. Thereafter, this representation constitutes the main part of a shared resource that will be used by different processes achieving the interpretation of the drawings. The actions (recognition) done by these different specialists are scheduled in order to read and understand the content of the document. The knowledge that is provided by the shared representation is used instead of the bitmap image material to drive the interpretation process. In the current system, the specialists are trying, during several cycles to interpret the drawings in an intelligent way by interpreting the simplest parts of a drawing first and making the shared representation evolve until the total understanding of the document.

1 Introduction

Most of the works achieved in the field of line drawing analysis and recognition, concern low level processing [1, 2] or symbol recognition [3, 4, 5] but very few studies deal with interpretation strategies or knowledge management in interpretation systems. Recently, Song [18] described and compared some algorithms that realize line or curve extraction in one or two step methods but do not deal with higher level processing. Nevertheless, it is obvious the way the different elementary tasks are performed and linked is of great importance, indeed, a better use of the techniques would improve quality of results. We are proposing a general approach for line drawing study, relying on an image representation that can evolve along the process and can be used by some actors to achieve any specific processing. In the first part of this paper, the classical strategies used for line drawing interpretation are presented from the extracted knowledge management point of view. Next, we propose another way to tackle the understanding problem. In our system, we have chosen to extract first the easy to recognize graphical entities such as text, curves and other high level symbols.

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Then, the more complex or more ambiguous cases benefit from the previously acquired knowledge. This extraction strategy we have called "from the simplest to the most complex" is detailed in section 4. In a last part, we illustrate the cyclic aspect of the strategy (notion of perceptive cycles) that allows the contextual extractions.

Thanks to the images presented all along the paper, we show the experimental results we have obtained on engineering drawings and how this system can be adapted to the analysis of different other types of drawings such as maps.

2 Traditional Interpretation Strategies

Here, we are to briefly recall the most traditional interpretation strategies. They can be divided in two classes. On one hand are the methods that rely on a multi-layer approach and on the other hand those that look for entities directly in the bitmap image.

2.1 Sequential Analysis

Traditional pattern recognition methods divide an interpretation process into two successive phases: the segmentation (low level processing) and the recognition (high level processing).

For line drawings, in most of the systems, the algorithms involved in the segmentation process are highlighting a layer organization of these documents [1, 6]. Their physical structure is generally composed of a thin line layer that contains the major part of the information and that can be divided in several other sub-layers, of a filled shape layer, of a text layer corresponding to annotations, and of some other possible layers that may be small symbols (arrowheads, disks, ...).

When all the layers have been extracted, the high level entities have to be rebuilt during the recognition stage. Then, we do not speak anymore of the physical structure of the drawing but rather of the underlying syntax. These syntactical rules are specifying the relations that may occur between shapes and that allow to recognize the different symbols. Numerous recognition methods (structural, syntactic, statistical, ...) could then be applied and a semantic analysis can bring some help to the analysis [7, 8].

Unfortunately, since the different parts of the high level entities can be dispatched among several layers, some difficulties may arise. Besides, the inconsistencies between information provided by different layers may be numerous and they are very difficult to handle because the segmentation result cannot be modified. So, the approach has to be limited quite simple drawings in order to act correctly. The figure 1a summarizes the classical architecture of such automatic reading systems.

It can be noticed (figure 1a) that low level processes P1, P2, ... use only the static bitmap image and some a priori knowledge to achieve the layer segmentation. The high level processes use the results of the segmentation (in the different layers) and some syntactic or semantic rules to interpret the drawing [9, 10, 11]. It is regrettable

that no communication between processes of high and low levels or even of the same level exists when this processing scheme is adopted.

2.2 Direct Analysis

Some other systems use algorithms dedicated to symbol recognition which work directly on the image without any previous segmentation step. In this case, two classical ways to proceed can be mentioned :

- comparison of the connected components of the image with the different symbols or shapes we want to localize and that have been stored in a dictionary [12].
- looking for some particular configurations of lines in the image (closed loops, junctions, end points, ...) corresponding to potential symbols [8, 17].

If different processes are used to recognize these different shapes, their order of activation have to be defined. In this case, the processes can be managed by a controller (expert system). The activation of the recognition algorithms is then realized according to a set of rules specifying prerequisites for the extractions. We can also choose to create a hierarchical structuration of the recognition processes. Low level processing will be at the bottom of the tree and algorithms dedicated to high level object recognition will be at the top. Recognition algorithms should be adapted before being plugged in a such system and then we can speak of multi-agent systems.

These systems use a more opportunistic analysis method in order to understand the drawings, nevertheless the cooperation and activation of the different agents are very difficult to manage (implementation of the controller or cooperation). This is probably why we do not hear a lot about such processes. Figure 1b summarizes the architecture needed for direct analysis of drawings.

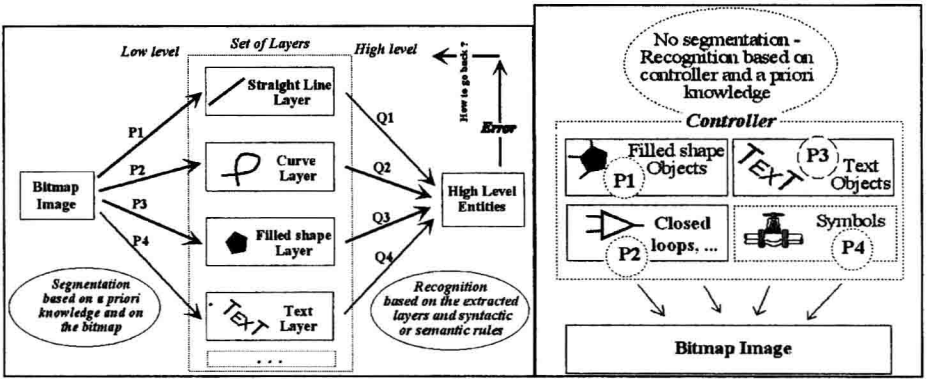


Fig. 1. (a) Sequential or (b) direct interpretation of a drawing

Finally, we can conclude that the extraction of graphical entities in a document is most often achieved either in a sequential or a hierarchical way [11, 13]. The global

task is then decomposed into a succession of elementary stages and an entity of a given level can always be considered as a composition of some lower level elements.

We are now to present how we propose to deal with the problem. First we precise the different tools we have defined and the architecture of the process. Then the strategy is the object of the last section.

3 Cyclical Interpretation

We have decided to mix the two previous approaches. To do that, first a representation has been defined to describe and manage all the present shapes and all the available information known about in the studied document. Both the use of a powerful representation that enables an easy share of the information and of several agents each one achieving a precise task makes it possible, during the document analysis, to put segmentation and recognition processes at the same level. We have also tried to separate the a priori knowledge and the extracted information from the interpretation algorithms.

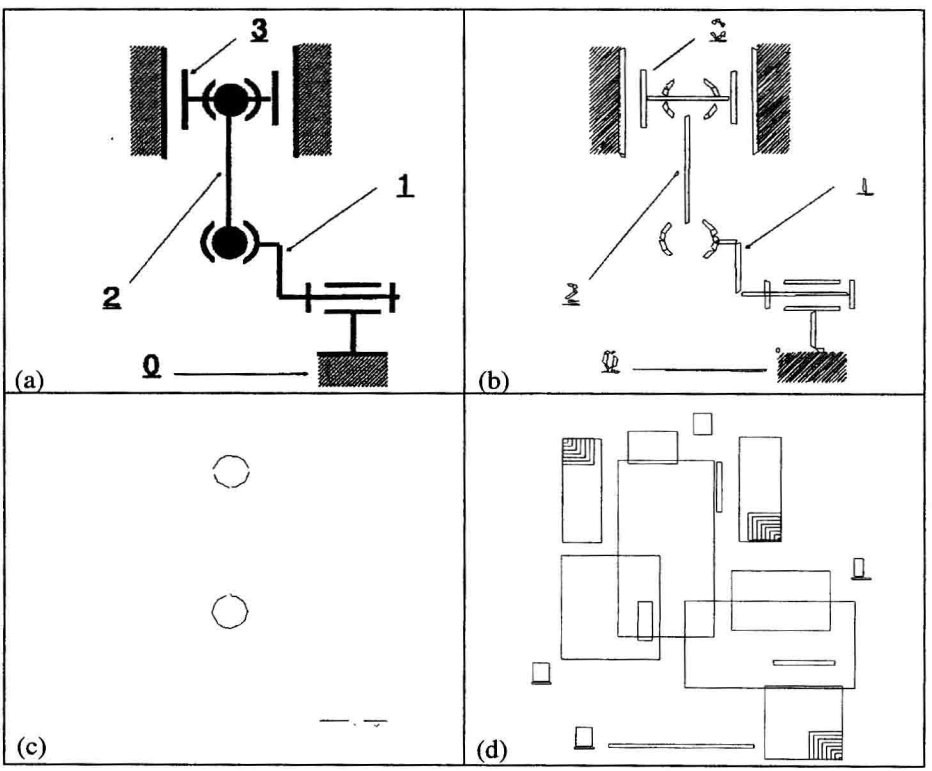


Fig. 2. (a) Initial image and its representation (b) Quadrilaterals and (c) contours Vectors, (d) Connected Components (CC)

3.1 The Image Representation

The representation to be shared by different processors will replace the initial bitmap image and evolve along the recognition process. It is achieved by a contour vectorisation step followed by a structural graph construction [14]. The elementary entities are such as quadrilaterals and vectors. Our vectorisation algorithm can be compared to Shimotsuji's [15] or Shih's [16] methods. Through a one step computation it provides several interesting pieces of information (figure 2):

- a set of quadrilaterals for the representation of the thin shapes (lines)
- a set of contour vectors for the filled shapes
- all the connected components of the image

Next, a structural graph was found the most adapted way to represent topological relations (parallel, corner, intersection, above, below, ...) between the elements present in the built representation. The patterns (vectors, quadrilaterals, ...) label the nodes of the graph while the arcs describe the nature of the existing topological relations between these patterns (figure 3).

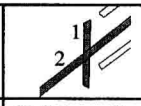
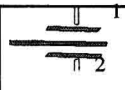
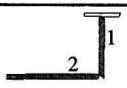
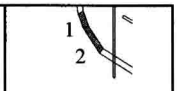
Examples of patterns in the representation					
Topological relation	T junction T(1,2)	X (Intersection) X(1,2)	P (Parallel) P(1,2)	L junction L(1,2)	S (Successive) S(1,2)

Fig. 3. Topological relations between patterns

As we tend towards understanding of the document, we have modeled the way human observer can focus on any of the patterns by the definition of an influence zone. Figure 4 describes the graph construction process applied to the influence area (the dotted rectangle) of a Quadrilateral pattern (in gray). After the construction of the sub-graphs corresponding to all the patterns present in the representation, we obtain the global image structural graph.

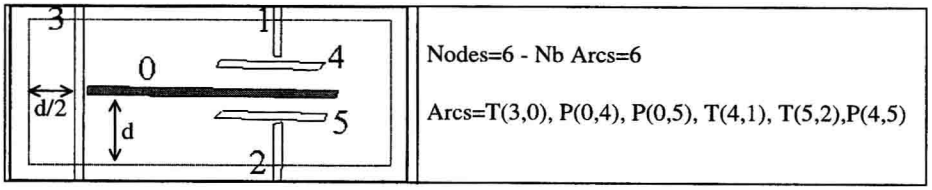


Fig. 4. Influence area of the Quadrilateral 0 and the corresponding sub-graph

3.2 Perceptive Cycles

The interpretation of the drawings is achieved using different processes we have called specialists. No controller is needed to activate these specialists, the chosen

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