Simple Algorithm for Page Layout Analysis

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Abstract—An algorithm for page layout analysis (segmentation) is suggested in the paper. It allows whitespace between text blocks to be detected on a document page. The algorithm could be used in document analysis and recognition problems. In particular, it can be used for column recognition in multicolumn text and tables. The suggested algorithm is quite simple for implementation.

INTRODUCTION

The number of documents in the world is growing rapidly; this is discussed in [6] in particular. Document analysis and recognition (DAR) systems are developed for automation of information extraction from document images [7]. Document layout analysis or page segmentation is used for dividing document into specific parts (e.g., columns, figures, tables). This is an important DAR problem. Different methods of document layout analysis are discussed in [3].

Conventionally, there are two approaches to the problem of page or table column segmentation. The first approach is to analyze text layout (text blocks); this usually requires the use of complex data structures. For example, such an approach with the use of a Voronoi diagram for page segmentation is suggested in [5]. The second approach is to analyze whitespace (free of text) on a page. Gaps separate text and table columns on a page, as is shown in Fig. 1. Algorithms using whitespace analysis are suggested in [1, 2, 8]. Algorithms [1, 8] are briefly considered in [2]. They can be used for detecting whitespace between text blocks. The authors of [2] point out that the algorithms [1, 8] are difficult for implementation. A geometrical layout analysis algorithm, simple for implementation, is presented in [2]; it provides for detecting whitespace gaps in multicolumn text and is described in terms of the largest empty rectangle problem [4]. The algorithm input is a bounding box including obstacles (rectangles). The algorithm [2] finds the largest empty rectangle among obstacles inside the bounding box. To find whitespace gaps on a page, n-better solutions (empty rectangles) in descending order are found on the page. The algorithm [2] is greedy. The found i-largest empty rectangle becomes an obstacle when searching for the next $i + 1$-largest empty rectangle. However, it is probable that some of n-better solutions (largest rectangles found) are not gaps between columns, but, e.g., horizontal gaps between paragraphs or tables on the page. This is the disadvantage of the algorithm [2].

In the paper, we suggest an unconventional simple algorithm for detecting whitespace gaps on a document page. It allows detecting vertical gaps (visually they are stretched up vertically), as well as horizontal gaps if the X and Y axis are exchanged. The suggested algorithm is simple; its Object Pascal implementation consists of about 60 lines of code (expressions).

1. PROBLEM FORMULATION

The geometrical objects considered in this work are presented in the Cartesian coordinate system, where the x-coordinates increase from left to right and y-coordinates increase from the top down. The following assumptions are used in this work. The rectangle (e.g., an obstacle, bounding box, or gap) $r = (x_l, y_t, x_r, y_b)$ is defined by the coordinates of its sides (boundaries): left $c_l = x_l(r)$, top $y_t = y_t(r)$, right $x_r = x_r(r)$, and bottom $y_b = y_b(r)$; in addition, its sides are parallel to the corresponding coordinate axes. The vertical line $l = (x, y_t, y_b)$ is normal to the X axis and is defined by its coordinates: $x = x(l)$ by the x-coordinate, $y_t = y_t(l)$ by the minimum (top) y-coordinate, and $y_b = y_b(l)$ by the maximum (bottom) y-coordinate.

It is assumed that the bounding rectangle b and the set of obstacles (rectangles) $R = \{r_1, ..., r_n\}$, $n \in \mathbb{N}$ are specified. The rectangle b usually bounds a document page or its part (e.g., a table), while the obstacles are bounding rectangles for text blocks (e.g., words or lines). The obstacles from the set R are totally inside the bounding rectangle b and do not overlap each other.

Let us define two sets of obstacles (rectangles) $R = \{r_1, r_2, ..., r_n, r_n\}$ and $R'' = \{r_1, r_2, ..., r_n, r_n\}$, where $r_1 = (x_l, y_t, x_r, y_b)$, $r_2 = (x_l, y_t, x_r, y_b)$, $r_3 = (x_l, y_t, x_r, y_t)$, $r_n = (x_l, y_b, x_r, y_b)$, $x_l = x_l(b)$, $y_t = y_t(b)$, $x_r = x_r(b)$, and $y_b = y_b(b)$. Let us also define the gap as a rectangle bounding a certain part of whitespace inside the bounding rectangle b.

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Advances in Electronic Engineering, Communication and Management Vol.1 David Jin,Sally Lin,2012-01-24 This volume presents the main results of 2011 International Conference on Electronic Engineering Communication and Management EECM2011 held December 24 25 2011 Beijing China The EECM2011 is an integrated conference providing a valuable opportunity for researchers scholars and scientists to exchange their ideas face to face together The main focus of the EECM 2011 and the present 2 volumes Advances in Electronic Engineering Communication and Management is on Power Engineering Electrical engineering applications Electrical machines as well as Communication and Information Systems Engineering **The Design and Analysis of Algorithms** Dexter C. Kozen,2012-12-06 These are my lecture notes from CS681 Design and Analysis of Algo rithms a one semester graduate course I taught at Cornell for three consec utive fall semesters from 88 to 90 The course serves a dual purpose to cover core material in algorithms for graduate students in computer science preparing for their PhD qualifying exams and to introduce theory students to some advanced topics in the design and analysis of algorithms The material is thus a mixture of core and advanced topics At first I meant these notes to supplement and not supplant a textbook but over the three years they gradually took on a life of their own In addition to the notes I depended heavily on the texts A V Aho J E Hopcroft and J D Ullman The Design and Analysis of Computer Algorithms Addison Wesley 1975 M R Garey and D S Johnson Computers and Intractibility A Guide to the Theory of NP Completeness w H Freeman 1979 R E Tarjan Data Structures and Network Algorithms SIAM Regional Conference Series in Applied Mathematics 44 1983 and still recommend them as excellent references **Algorithms and Data Structures** Helmut Knebl,2020-10-31 This is a central topic in any computer science curriculum To distinguish this textbook from others the author considers probabilistic methods as being fundamental for the construction of simple and efficient algorithms and in each chapter at least one problem is solved using a randomized algorithm Data structures are discussed to the extent needed for the implementation of the algorithms The specific algorithms examined were chosen because of their wide field of application This book originates from lectures for undergraduate and graduate students The text assumes experience in programming algorithms especially with elementary data structures such as chained lists queues and stacks It also assumes familiarity with mathematical methods although the author summarizes some basic notations and results from probability theory and related mathematical terminology in the appendices He includes many examples to explain the individual steps of the algorithms and he concludes each chapter with numerous exercises *Design and Analysis of Approximation Algorithms* Ding-Zhu Du,Ker-I Ko,Xiaodong Hu,2011-11-17 This book is intended to be used as a textbook for graduate students studying theoretical computer science It can also be used as a reference book for researchers in the area of design and analysis of approximation algorithms Design and Analysis of Approximation Algorithms is a graduate course in theoretical computer science taught widely in the universities both in the United States and abroad There are however very few textbooks

available for this course Among those available in the market most books follow a problem oriented format that is they collected many important combinatorial optimization problems and their approximation algorithms and organized them based on the types or applications of problems such as geometric type problems algebraic type problems etc Such arrangement of materials is perhaps convenient for a researcher to look for the problems and algorithms related to his her work but is difficult for a student to capture the ideas underlying the various algorithms In the new book proposed here we follow a more structured technique oriented presentation We organize approximation algorithms into different chapters based on the design techniques for the algorithms so that the reader can study approximation algorithms of the same nature together It helps the reader to better understand the design and analysis techniques for approximation algorithms and also helps the teacher to present the ideas and techniques of approximation algorithms in a more unified way   Algorithms and Programming Alexander Shen,2011-03-23 Algorithms and Programming is primarily intended for use in a first year undergraduate course in programming It is structured in a problem solution format that requires the student to think through the programming process thus developing an understanding of the underlying theory The book is easily readable by a student taking a basic introductory course in computer science as well as useful for a graduate level course in the analysis of algorithms and or compiler construction Each self contained chapter presents classical and well known problems supplemented by clear and in depth explanations The material covered includes such topics as combinatorics sorting searching queues grammar and parsing selected well known algorithms and much more Students and teachers will find this both an excellent text for learning programming and a source of problems for a variety of courses   *Guide to Programming and Algorithms Using R* Özgür Ergül,2013-07-23 This easy to follow textbook provides a student friendly introduction to programming and algorithms Emphasis is placed on the threshold concepts that present barriers to learning including the questions that students are often too embarrassed to ask The book promotes an active learning style in which a deeper understanding is gained from evaluating questioning and discussing the material and practised in hands on exercises Although R is used as the language of choice for all programs strict assumptions are avoided in the explanations in order for these to remain applicable to other programming languages Features provides exercises at the end of each chapter includes three mini projects in the final chapter presents a list of titles for further reading at the end of the book discusses the key aspects of loops recursions program and algorithm efficiency and accuracy sorting linear systems of equations and file processing requires no prior background knowledge in this area   **Encyclopedia of Algorithms** Ming-Yang Kao,2008-08-06 One of Springer s renowned Major Reference Works this awesome achievement provides a comprehensive set of solutions to important algorithmic problems for students and researchers interested in quickly locating useful information This first edition of the reference focuses on high impact solutions from the most recent decade while later editions will widen the scope of the work All entries have been written by experts while links to Internet sites that outline

their research work are provided The entries have all been peer reviewed This defining reference is published both in print and on line   Design and Analysis of Randomized Algorithms J. Hromkovic,2005-10-11 Randomness is a powerful phenomenon that can be harnessed to solve various problems in all areas of computer science Randomized algorithms are often more efficient simpler and surprisingly also more reliable than their deterministic counterparts Computing tasks exist that require billions of years of computer work when solved using the fastest known deterministic algorithms but they can be solved using randomized algorithms in a few minutes with negligible error probabilities Introducing the fascinating world of randomness this book systematically teaches the main algorithm design paradigms foiling an adversary abundance of witnesses fingerprinting amplification and random sampling etc while also providing a deep insight into the nature of success in randomization Taking sufficient time to present motivations and to develop the reader s intuition while being rigorous throughout this text is a very effective and efficient introduction to this exciting field   The Design and Analysis of Algorithms Dexter Kozen,1992   Condition Peter Bürgisser,Felipe Cucker,2013-11-27 This book gathers threads that have evolved across different mathematical disciplines into seamless narrative It deals with condition as a main aspect in the understanding of the performance regarding both stability and complexity of numerical algorithms While the role of condition was shaped in the last half century so far there has not been a monograph treating this subject in a uniform and systematic way The book puts special emphasis on the probabilistic analysis of numerical algorithms via the analysis of the corresponding condition The exposition s level increases along the book starting in the context of linear algebra at an undergraduate level and reaching in its third part the recent developments and partial solutions for Smale s 17th problem which can be explained within a graduate course Its middle part contains a condition based course on linear programming that fills a gap between the current elementary expositions of the subject based on the simplex method and those focusing on convex programming

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