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) $r = (x_l, y_l, x_r, y_b)$ 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) $R = \{r_1, \ldots, r_n\}$, $n \ll \mathbb{N}$ 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) $R = \{r_1, r_2, \ldots, r_n, r_n\}$ and $R'' = \{r_1, r_2, \ldots, r_n, r_n\}$, where $r_l = (x_l, y_l, x_r, y_b)$, $r_t = (x_l, y_l, x_r, y_b)$, $r_r = (x_l, y_l, x_r, y_b)$, $r_b = (x_l, y_l, x_r, y_b)$, $x_l = x_l(b)$, $y_t = y_t(b)$, $x_r = x_r(b)$, 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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