Signature based Characterization for Performance Evaluation of Symbol Localization

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In recent years there has been a noticeable shift of attention, within the graphics recognition community, towards performance evaluation of symbol recognition systems. This interest has led to the organization of several international contests and development of performance evaluation frameworks [1]. However, up to date this work has been focussed on recognition of isolated symbols. It didn't take into account the localization of symbols in real documents. Indeed, symbol localization constitutes a hard research gap, both for recognition and performance evaluation tasks.

Today, different research outputs allow to fill this gap. A groundtruthing framework for complete documents has been proposed in [2] and different effective systems working at localization level in [3, 4]. The key problem is now to define characterization methods working in a localization context. Indeed the characterization of localization in complete documents is harder, as comparison of results with groundtruth needs to be done between sets of symbols. These sets could be of different size, and large gap could appear between the localizations of a result symbol (provided by a given method) and the corresponding one in groundtruth. Characterization metrics must then be reformulated to take these specificities into account.

This problem is well known in other research fields such as computer vision [5], handwriting segmentation [6], layout analysis [7], text/graphics separation [8], etc. Performance characterization algorithms aim to detect possible matching cases between groundtruth and localization results, as detailed in Table 1. In addition, different criteria could be computed exploiting these detection results such as segmentation rates or retrieval measures (precision, recall, F-measure).

one to one	an object in groundtruth matches with only one result object
miss	an object in groundtruth doesn't match with any result objects
false alarm	a result object corresponds to none objects in groundtruth
one to many	an object in groundtruth corresponds to two or more result objects
many to one	a result object corresponds to two or more objects in groundtruth

Table 1. Matching cases between groundtruth and localization results

Two kinds of characterization matching exist in the literature [7]: pixel-based and geometry-based. Pixel-based matching is very accurate because it works at pixel level. It is usually employed to evaluate segmentation tasks in computer vision [5] or handwriting recognition [6]. However, groundtruth creation is more cumbersome and requires a lot more storage. The matching is also time-consuming because it is done at pixel level. In geometry-based matching, Regions Of Interest (ROI) are described using geometric shapes (bounding boxes, ellipsis, polygons, etc.). This approach is commonly used in document analysis field as it is more semantically focused [7, 8]. Because the main goal of these systems is recognition, evaluation could be limited to detection aspects only (i.e. to decide about a bad or a correct localization without evaluation of segmentation accuracy). Comparison algorithms are time-efficient, and corresponding groundtruth is straightforward to produce.

In this work we propose a new geometry-based method for performance characterization of symbol localization. The key point when developing such a method, is to decide about representations to be used, both for results and groundtruth. To do this, we have considered the following specificities related to symbol localization.

(1) Symbol localization systems provide ROI as results. These ROI could correspond to different shapes (bounding box, convex hull, ellipsis, etc.) depending of systems. In addition, some systems use signature-based filtering to localize symbols [9, 10, 4]. They produce as results single points centered on pre-defined sliding windows. A characterization method must take into account these different localization modes, and put them at same level to perform evaluation.

(2) In drawings, areas corresponding to symbols are small as compared to area of background. Thus, this makes the detection of over segmentation results difficult. It could happen that none overlapping would appear between over segmented areas. It seems important to control the sizes of ROI provided by systems.

(3) Symbols are complex shapes difficult to describe with standard geometrical objects (bounding boxes, ellipsis, convex hulls, etc.). Concave polygons must be employed to provide precise localization information in groundtruth. However, comparison of concave polygons requires time-consuming algorithms working at least within a $O(n)$ complexity [11]. This leads to the use of alternative solutions for their comparison, such as the isothetic polygons based method described in [7].

In order to address these specificities, we propose in this work a specific characterization method detailed in Fig. 1. Our key idea is to consider localization results of systems as points, and to overlay ROI defined in groundtruth to them. If an intersection exists between the two ROI, the localization result is validated. This approach presents several advantages. First, it makes evaluation of methods regarding (1) homogenous. Next, it limits the size of the ROI provided by the systems to avoid the problems detailed in (2). At last, it reduces the complexity of the algorithms when dealing with accurate representations of ROI (3). Indeed, it is possible to pre-compute all possible intersection cases previously.

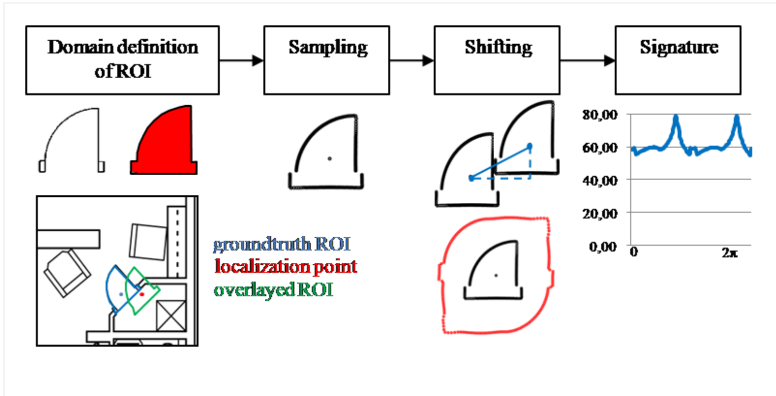

Fig. 1. Our approach

To do it, our system exploits a signature based characterization (Fig. 1). Starting from a domain definition of a ROI for every symbol models, it samples the contours of the models in the $[0 - 2 \times \pi]$ directions. Then, it uses the sampled points in a shifting algorithm to detect the null intersection cases between the two ROI. At last, these points are used to build-up a $[\theta, d]$ plot, with θ the directions and d the distances. Each plot is next processed with a polynomial interpolation algorithm to extract a signature f. Intersection tests are processed within a $k \times \theta(1)$ complexity, by computing the values (θ, d_1) between the groundtruth center and a localization point, and checking the condition $d_1 < d_2$ with $d_2 = f(\theta)$. Exploiting this method, we present results obtained by the system [3] on database of synthetic architectural floorplans [2], composed of 100 images and around 2500 symbols.

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