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Contour Junction Extraction

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Abstract

This paper introduces an intermediate grouping phase whereby structures, meant to correspond to generic 3D junctions of planar and curved surfaces, are extracted from imperfect basic constant curvature contour primitives. This research work is part of a more generic project for detecting and describing generic high-level structures corresponding to 3D objects and/or parts of 3D objects in a single illuminance image of a cluttered scene. MAGNO (Multi-level Access to Generic Notable Objects), a computer vision system exploiting generic constraints at each of its hierarchical processing levels is at the heart of the project.

1 Introduction

In a context of a generic 3D object detection and description task, high-level structures need to be extracted from basic contour primitives in an illuminance image of a cluttered scene. Low-level processing of the image produces illuminance contours that are to be processed further to obtain the sought-for structural description.

Cluttered scenes offer a structural complexity that has to be recovered from contours extracted at the pixel level with no *a priori* knowledge about the scene and the objects present. The contour structure is not fully representative of the underlying structure of the scene. Furthermore, some contours may be missing. Others may be incomplete especially at surface junctions. Still others may be spurious. The challenge is to recover the scene structure and each object structure despite these difficulties.

This paper presents our original method for the extraction of contour junctions leading to the formation of generic high-level structures in a single illuminance image of a cluttered scene. This method is a main step of MAGNO (Multi-level Access to Generic Notable Objects), a computer vision system exploiting generic constraints at each of its hierarchical processing levels [6]. Figure 1 summurizes the complete system.

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2 From Image Contours to Contour Junctions

The proposed method extracts geometric features at two levels, using a two-phase grouping process.

2.1 Phase 1: Basic Primitive Extraction

The first phase consists in the extraction of generic structural information from a single illuminance image of a cluttered scene. The result of this phase is a primitive map made up of constant curvature segments (named *ccs*). Any given *ccs* is a straight line segment *sls* or a circular arc *ca*. These segments are referred to as *basic primitives*. The extracted basic primitives are structured according to the original image contours. They have a small number of defining parameters which makes them an adequate basis for the compute-intensive second phase of the method. At the end of this first phase, the description is not meant to reveal yet the structure of each visible object.

2.2 Phase 2: Contour Junction Extraction

The second phase consists in grouping basic primitives according to various principles of perceptual organization, e.g. continuity, proximity, similarity, and good-form [4]. The obtained groups are referred to as *intermediate primitives* or *contour junctions*. Contour junctions provide cues to the structure of the scene and its volumetric objects. In that sense, they help reintroduce a missing aspect of a single illuminance image that is, the depth or third dimension. A significant innovative aspect of this phase is to consider circular arc primitives in addition to straight line segment primitives of previous methods such as [1][2][3][5].

The formation of contour junctions is based on planar geometrical relations between oriented versions of the extracted constant curvature segments. Any given segment *ccs* gives rise to two *oriented segments* referred to as $\underline{v}_{ccs}$ ($\underline{v}_{sls}$ or $\underline{v}_{ca}$ in Figure 2). The oriented segments have complementary origin and terminating extremities or endpoints. Any given oriented segment may be a *member* of or *participate* to more than one contour junction. For instance, two oriented segments may give rise to a contour junction and the same two combined with a third segment may give rise to a three-segment contour junction.

A contour junction J obtained from a pair of oriented segments has an associated *junction point* in the plane. This junction point is at the intersection of the supporting straight line or circle of each member segment (see Figure 2a-e). Besides, it is restricted to be *in front* of each oriented segment. That is, the junction point must appear nearby (see Figure 2c,e) or after the terminating endpoint (see Figure 2a,b,d). Circular arcs spanning too large a sector (approaching a full circle) have to be processed as a special case. It is to be noted that many two-segment junctions are directly available from the connected contour primitives extracted during the previous phase. A contour junction obtained from three or more oriented segments has a junction point defined by the average position of the pairwise intersection points of its member segments (see Figure 2h). Figure 2 shows some valid contour junction configurations and their localization.

Each contour junction has a *quality factor* associated to it. This is computed from various parameters of its member segments and their structure: lengths, gaps at pairwise intersection points, relative orientation of tangents at pairwise intersection points, etc. The quality factor is a real value number normalized between 0 and 1. Each junction has attached to it a *rank of appearance* parameter for each of its member segments. The rank of appearance of a junction for one oriented segment is computed according to *(i)* the *arc distance* between the terminating extremity and the junction point if this latter is lying on the supporting axis or *(ii)* the combination of the *shortest distance* between the junction point and the supporting axis (at point P) and the *arc distance* between this point P and the terminating extremity if the junction point is not lying on the supporting axis. The rank of appearance is a positive integer value number.

Four types of contour junctions are extracted. Each type gives rise to a list $\mathcal{L}(.)$ The four lists are, in the order of their extraction:

1• $\mathcal{L}(IJ)$, type *INTERSECT* with two $\underline{v}_{ccs}$ from the same or different contours. In the literature, these junctions are usually called V or L junctions according to the angle of incidence between the two segments (symbolized by the shape of these two letters). Some valid two-segment junctions and their localization are shown on Figure 2a-e.

2• $\mathcal{L}(TJ)$, type *TANGENT* with two tangent, colinear or co-circular $\underline{v}_{ccs}$ from different contours (see Figure 2f,g). Detection of this type of contour junctions occurs during the *INTERSECT* junction detection process.

3• $\mathcal{L}(MJ)$, type *MULTIPLE* with three or more $\underline{v}_{ccs}$ from at least two different contours (see Figure 2h), and

4• $\mathcal{L}_1(OJ)$, type *OCCLUSION* with one $\underline{v}_{ccs}$ and one *ccs* (on which is the junction point) (see Figure 2i-l) or $\mathcal{L}_2(OJ)$, type *OCCLUSION* with one $\underline{v}_{ccs}$ and two tangent $\underline{v}_{ccs}$, also from at least two different contours (see Figure 2m). In the literature, this type of junctions is usually called T or λ.

The junction detection algorithm builds those lists in turn, combines the last two to form $\mathcal{L}(OJ)$, and then sorts the four resulting lists according to the quality factors of the contour junctions. For each oriented segment, a list of the junctions in which it participates is also built. This list is sorted according to the rank of appearance of the junctions for that segment. The quality factor and rank of appearance of the contour junctions are to be used in the next phase to select a subset of best junctions for the search processes in the generic structure detection. Figures 1 and 3 show by the way of detected structures some contour junctions. The extraction process and the quality factor computation are original and specific to each junction type. Full details appear in [6].

3 Conclusion

The paper presented details of each of the two first grouping phases of our original high-level structure extraction method, together with a number of results from its implementation. Firstly, we summarized the extraction of the basic primitives from an illuminance image. This was followed by a more thorough description of the contour junction extraction phase. In order to illustrate the overall behavior of our proposed method, various results obtained using a fully automatic implementation were presented. Results are directly linked to the generic high-level structures extraction phase [6].

References

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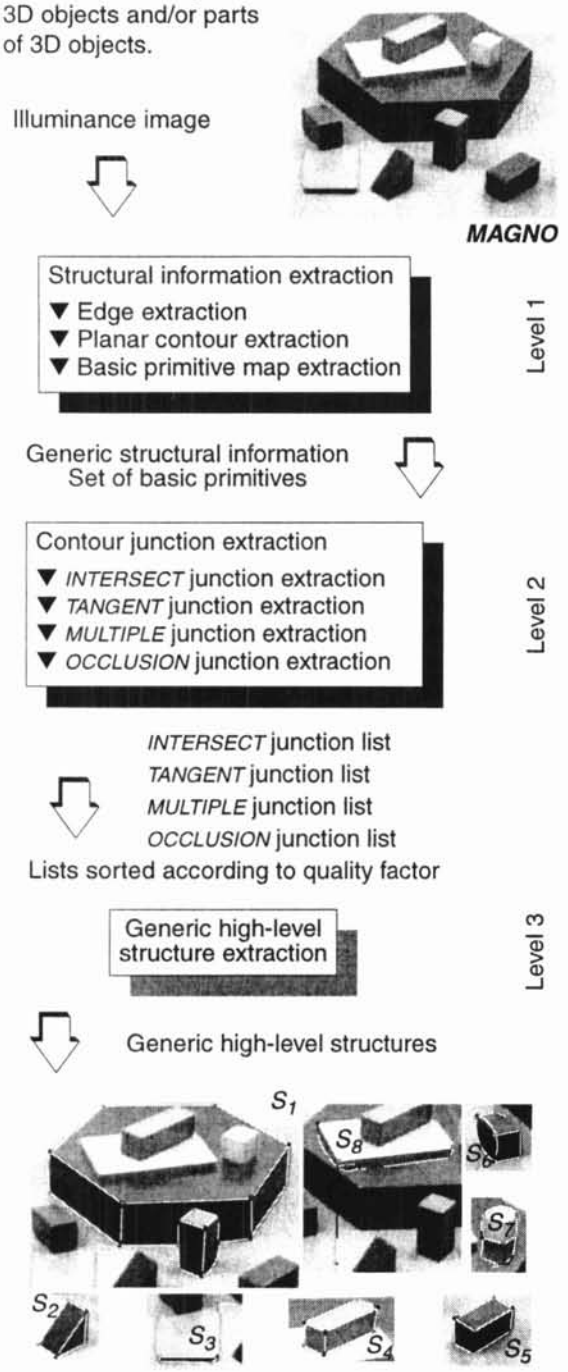
Figure 1: From a single illuminance image to 3D objects and/or parts of 3D objects.



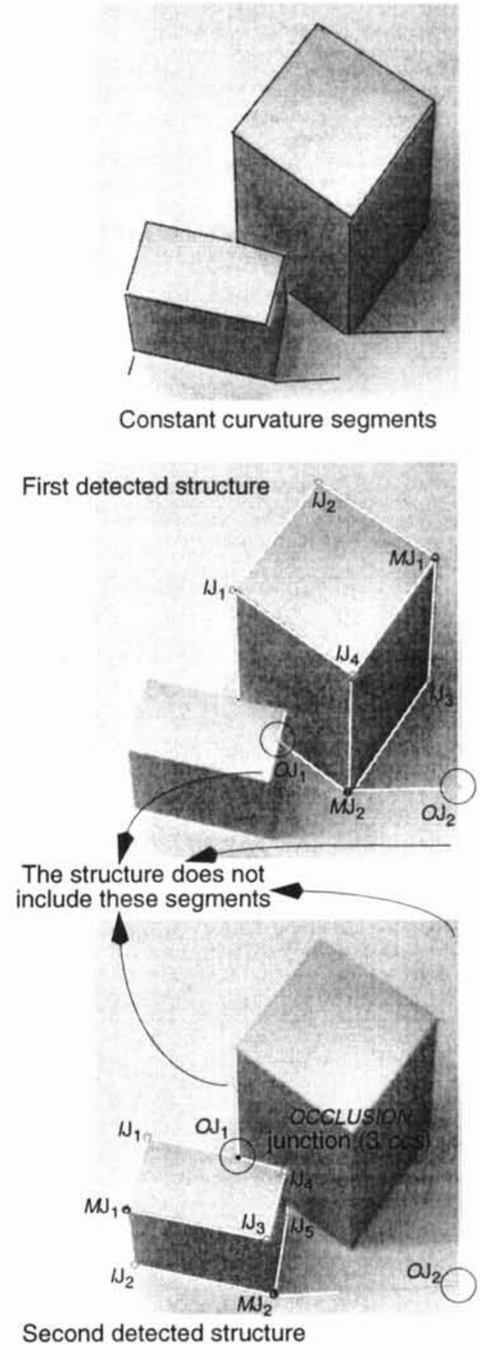


Figure 3: From constant curvature segments to generic structures via contour junctions.

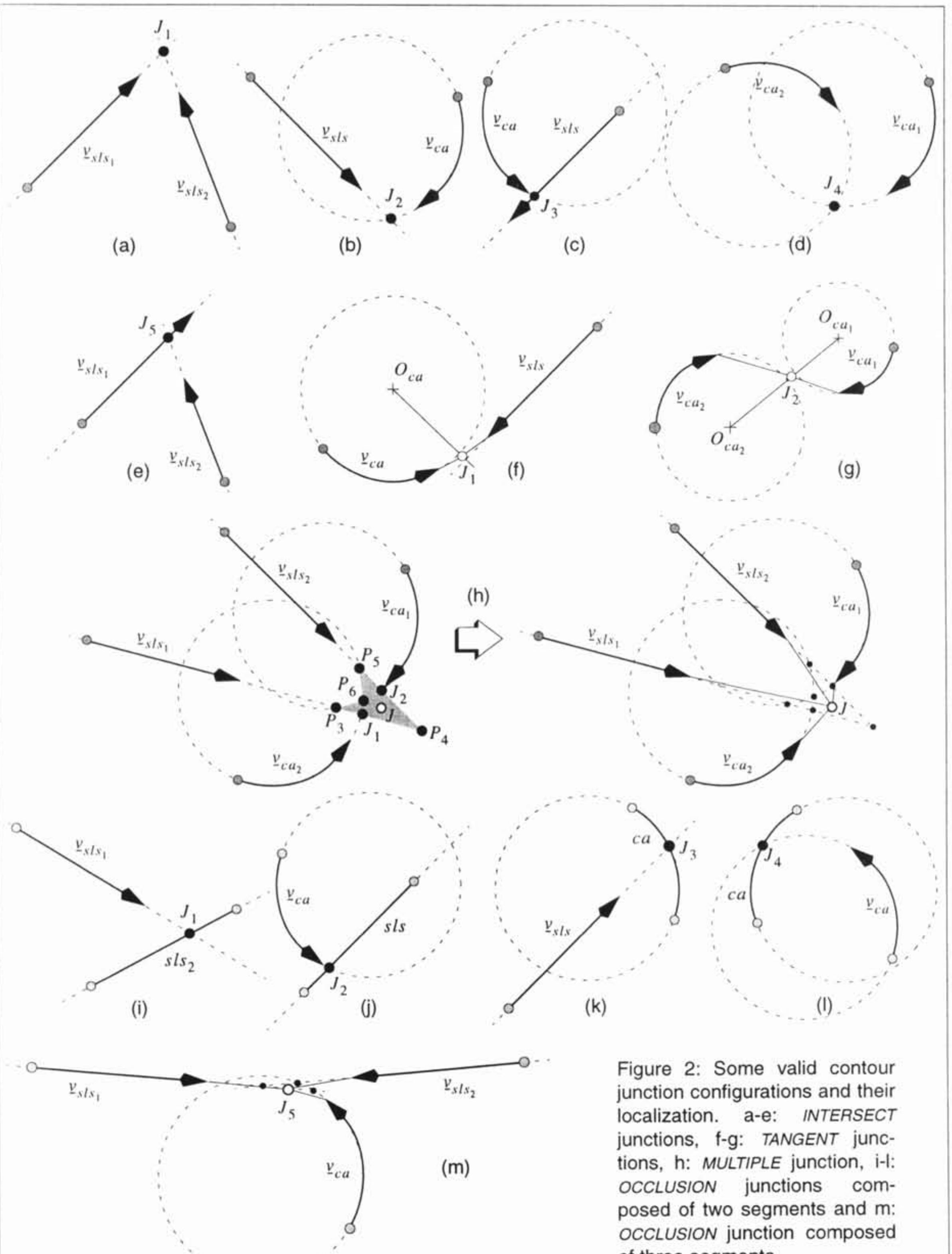


Figure 2: Some valid contour junction configurations and their localization. a-e: *INTERSECT* junctions, f-g: *TANGENT* junctions, h: *MULTIPLE* junction, i-l: *OCCLUSION* junctions composed of two segments and m: *OCCLUSION* junction composed of three segments.