Comparison of 3D Reconstruction Techniques for Engineering Drawings from Orthographic Projections

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Abstract: - 3D reconstruction of objects form orthographic projections of engineering drawing has been very crucial research area since decades. In this paper, we have critically reviewed the latest approaches dealing with single view and multi view. Different approaches have been discussed with respect to bottom-up and top-down reconstruction. Many other parameters such as type of drawing, shape of object, x-sectional view, user interaction, dead end holes and hidden lines have also been compared amongst these approaches.

Keywords: - 3D reconstruction, CSG, B-Rep, Line Drawings, Orthographic Projections

1. Introduction

Three dimensional objects always suffer from the loss of depth information whenever captured from camera perspectives. Retrieval of this lost information has always been of great concern and is a problem faced by different researchers. There are many situations in which 2D projections are to be registered to form a 3D shape of an object. The problem gets intense when the views are angle independent however, is a bit simplified with orthographic projections which is the case for most of the drawings of engineering objects. Traditionally engineering objects are represented through three orthographic views: front, top and side views. Most of the CAD tools provide this facility but it is a challenging task to transform manual drawings into CAD representation. The task gets even more complicated when 3D CAD drawings are to be generated from these 2D orthographic projections.

A lot of work has been done to solve this problem. In this paper we have critically reviewed the different techniques proposed / adopted by the researchers. These techniques mainly involve two kind of approaches: Single and multiple view approaches.

Another type of classification is based upon bottom-up and top-down approaches. Bottom-up approach is also known as wireframe or boundary representation (B-Rep) while top-down approach is also known as volume based or constructive solid geometry (CSG). We will use these terms intermittently in the following text. Very first studies were done by Idesaws [1] and Aldefeld [2] for bottom-up and top-down approaches respectively. Different reviews and surveys were performed on the research for these techniques by Wang et al. [3] in 1993 and Company et al. [4] in 2004.

In this paper we have performed a comparative study on the latest research for 3D reconstruction of engineering drawings from 2D projections as can be seen in Table 1. In Section-2 we review different techniques for multi view approach and in Section-3 review on single view approach is done.

2. Multi View Approach

In this section we will mainly focus on different approaches adopted by Cicek & Gulesin [5], Dimri & Gurumoorthy [6], Lee & Han [7] and Gong et al. [8].

2.1 Cicek & Gulesin 2004 [5]

This approach is based upon CSG and requires three orthographic views. Extrusion, revolution and Boolean operations (subtraction, intersection) are used to construct feature volumes from 2D projections. This technique handles different objects such as lines, center line, hidden lines, arcs, circles, etc. The technique is powerful in handling blind pockets, through pockets, circular pockets, through holes, blind holes, counter bored through holes, counter bored blind holes, stepped countersunk through holes and stepped countersunk blind holes.

TABLE 1
COMPARISON OF TECHNIQUES FOR 3D RECONSTRUCTION

Parameters		References					
		Cicek & Gulesin [5]	Dimri & Gurumoorthy [6]	Lee & Han [7]	Gong et al. [8]	Cooper [12]	Feng et al. [13]
Technique	Bottom-up				x	x	
	Top-down	x	x	x			x
Drawing	Perfect	x	x	x	x	x	x
	Imperfect						
Object	Straight	x	x	x	x	x	x
	Curve	x	x	x	x	x	x
X-Sectional View	Yes	x	x				
	No			x	x	x	x
Projection	Single					x	x
	Multiple	x	x	x	x		
User Interaction	Yes		x				x
	No	x		x	x	x	
Dead End Hole	Handled	x	x				
	Not Handled			x	x	x	x
Hidden Line	Yes	x	x				
	No			x	x	x	x

2.2 Dimri & Gurumoorthy 2004 [6]

This is a volume based approach requiring three views. Novelty of this technique is the reconstruction from x-sectional views. Different types of x-sections (full sections, removed sections, revolved sections, half sections, broken out sections, offset sections) are discussed. Handling of sectional views was also discussed by Wesley & Markowsky [9] but there approach is limited to full sectional views only. Aldefeld & Richter [10] and Bin [11] have also considered sectional views but require user interaction. Technique of Dimri & Gurumoorthy [6] takes into account full sectional, half sectional, offset sectional and broken out sectional views but does not cater removed sectional and revolved sectional views. This technique can handle straight and circular edges using sweep and Boolean operations (union, difference) and the objects with protrusion, depression and seek through holes. The technique requires the type of sectional view to be entered by the user.

2.3 Lee & Han 2005 [7]

They have proposed a CSG based approach to handle the solids of revolution from orthographic views. To recognize solids of revolution from orthographic views a hint based method is used. An interesting feature of this technique is the handling of intersecting as well as isolated objects. Extrusion and Boolean operations (subtraction, intersection) are used for the construction of objects including the spherical ones too but is limited to axis-aligned solids only. Their approach uses existing CSG techniques to construct solids other than solids of revolution.

2.4 Gong et al. 2006 [8]

This technique handles natural quadrics (sphere, cylinder, cone, plane) and interactive as well as isolated objects by hint based pattern matching using B-Rep. In this paper a new hybrid wireframe consisting of geometry, topology, vertices and edges is proposed. They require three views with perfect line drawing for the handling of different objects such as line, circle, arc, ellipse, circular arc, elliptical arc and higher order curves. Higher order curves are approximated in polyline.

3. Single View Approach

This section covers the approaches by Cooper [12] and Feng et al. [13].

3.1 Cooper 2005 [12]

Cooper's [12] approach deals with the construction of wireframe from single view and uses labeling technique. He has also given the necessary and sufficient conditions for the realisability. These conditions involve different semantics (convex, concave, occluding, external) and labels. The technique assumes that edges and surfaces meeting at a vertex are non-tangential and the vertices are trihedral. His approach can handle straight as well as curved lines. He has also proved that a 3D wireframe model of a polyhedron with simple trihedral vertices is unambiguous. He has also proposed a novel labeling technique which involves number of surfaces in front and behind of each edge.

3.2 Feng et al. 2006 [13]

This is a top-down approach that deals with single view, depends on human perception and requires heavy user interaction. The technique of Feng et al. [13] does not deal with hidden lines. They have proposed different perceptual constrains such as axis-alignment, symmetry, parallelism, collinearity and orthogonal corners.

4. Summary

In this paper we have performed a comparison on the basis of different parameters amongst the latest techniques for 3D reconstruction as shown in Table-1.

Cicek & Gulesin [5], Dimri & Gurumoorthy [6], Lee & Han [7] and Feng et al. [13] use top-down approach while bottom-up approach is used by Cooper [12] and Gong et al. [8]. None of these handle imperfect drawings and all can handle straight as well as curve objects. X-sectional views and dead end holes are handled by Cicek & Gulesin [5] and Dimri & Gurumoorthy [6]. Only Cooper [12] and Feng et al. [13] construct 3D shapes from single projection. Dimri & Gurumoorthy [6] and Feng et al. [13] require user interaction. Cicek & Gulesin [5] and Dimri & Gurumoorthy [6] provide handling of hidden lines too.

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