CHAPTER I

INTRODUCTION

1.1 Introduction and Problem Review

The problem of machine interpretation of line drawings of an engineering object is one of the classical research topics in computer vision and machine intelligence. The problem is interesting because line drawing offers information of what a machine and a robot could recognize, together with the fact that humans are also able to infer 3D objects just from the boundary information. Imitating the human capability in interpreting line drawing, therefore, is a challenge to the researchers in the fields. It is believed that human interpretation of line drawings is a skill which can be learned. If such skills could be translated into algorithms, computers could understand line drawings [1, 2, 3]. Although, for humans, they have no difficulty in seeing a 3D structure from its 2D line drawings, it is difficult to find a good algorithm to cope with every possible aspect by a machine. The problem of machine interpretation of line drawing from a given 2-dimensional polyhedral line drawing has been extensively studied as surveyed in Sugihara's work [4] and Ros's thesis [5]. One main subproblem in machine interpretation of line drawing is known as the 3-dimensional object realizability problem [6, 7, 8, 9, 10, 11, 12, 13]. It is the problem of deciding whether a given line drawing is realizable; that is, whether it is the correct projection of some 3-dimensional scene of polyhedral objects [14]. Therefore, many existing classical methods tried to propose what conditions must be verified so that a 2D line drawing captures a possible 3D object (3D realizable object). The concepts proposed in the existing classical methods assume that a realizable line drawing is given in forms of a graph whose vertices and edges represent the corners (junctions) and ridges (segments) of the possibly realizable 3D object, respectively. All vertices and edges are essential for realizing the corresponding 3D object. In the other word, no redundant vertices and edges occur in the given 2D image. This graph has polyhedral surfaces and it is obviously a planar graph.

In this research, we consider a new aspect of this realizability problem as follows. Given a set of finite number of lines laying on a 2-dimensional space, extract a 3D object realizable from these lines. The given lines are obtained from either a scanned image or a photographic image after applying some line extracting process. However, the process of perfect line extraction from the image is not the main concern of this study. We assume that all lines are perfectly extracted and are given to our algorithm. Our studied problem defined different constraints from the classical problem. First, all given lines can be extended to infinity. They can cross one another to form segments. Second, each crossing point can be considered as a junction and each line segment can be viewed as a segment (edge) of a line drawing object. Some of these segments and points are redundant and not applicable to the realization.

Figure 1.1 and Fig. 1.2 show the difference between the classical problem and our studied problem. Figure 1.1(a) and Fig. 1.1(b) show two examples of the given input for the classical problem. All essential segments and junctions are given prior to the realization. Example of input to the classical problem when a given object is realizable show in Fig. 1.1(a). Figure 1.1(b) is an example of input when a given object is non-realizable. The object in Fig. 1.1(b) is non-realizable because the segment marked by asterisk ($*$) is an impossible segment. Therefore, methods in the classical work should consider such a given object in Fig. 1.1(a) as a realizable object but consider a given object in Fig. 1.1(b) as a non-realizable object.

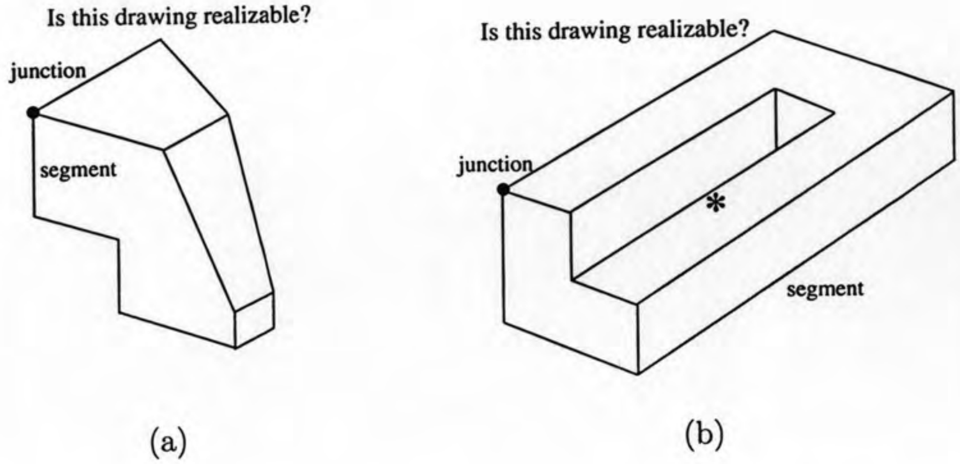

Figure 1.1: The classical realizability problem. All essential segments and junctions of an object are given. The problem is deciding whether a given object is realizable. (a) Example of input to the classical problem when a given object is realizable. (b) Example of input to the classical problem when a given object is non-realizable because the segment marked by an asterisk (∗) is an impossible segment.

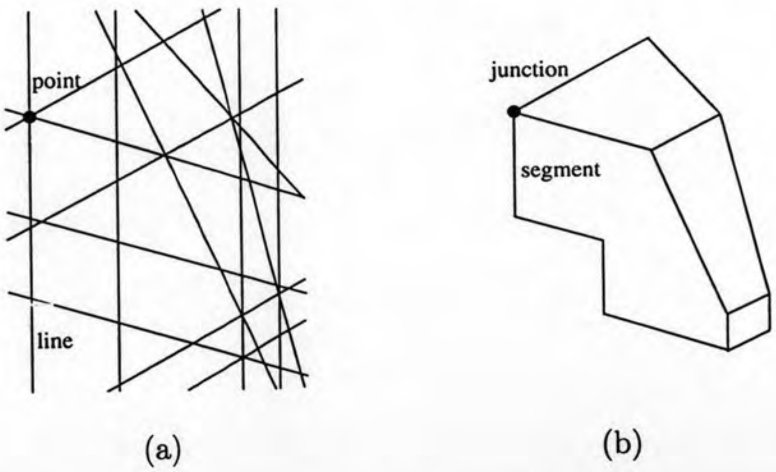

Figure 1.2: Our studied realizability problem. Given a realizable object hidden under the crossing lines, identifying and extracting a realizable object from such lines. (a) A set of crossing lines and line crossing locations are given as the input. (b) The identified object extracted from a given set of crossing lines after removing all irrelevant points and line segments.

Figure 1.2 shows our studied realizability problem. Given a realizable object hidden under the crossing lines, identify and extract a realizable object from such lines. Figure 1.2(a) is a given input consisting of lines with infinite length. All points are at the line crossing locations. The identified object extracted from a given set of crossing lines after removing all irrelevant points and line segments is shown in Fig. 1.2(b). The problem is which crossing points and line segments are significant and essential in the realization.

Ros [6] pointed out that it was difficult to directly apply the existing classical methods on realizability problem to real image processing due to the strong assumption that all vertices and edges in a given graph are known in advance and essential in the realization. However, our study concerns this difficulty. For a real 2D image, prior to the realization, all lines forming the ridges of the object in the image must be identified. One possible identifying process is to use Radon transform [15] or edge detection [16]. Once all lines are identified, the realization process can be performed. In this research, our main concern is based on the assumption that all given lines are correctly identified and used as the inputs for our proposed algorithm. No disconnected segments occurring in each given line.

1.2 Problem Formulation

Our studied problem is defined as follows. Given a set of crossing lines in a 2D image space, extract a realizable 3D object from some relevant line segments and crossing points of these given lines. The problem is based on these assumptions:

1. The essential line segments and crossing points for identifying the 3D object are not known in advance.

2. Each line has infinite length inside the image frame.

3. The extracted object is a single solid object; no hidden segments.

4. There is no any line drawing (texture) on any visible surface of the extracted object.

5. Each given line is relevant and comprised of at least one essential line segment of the corresponding extracted object.

1.3 Research Objective

Identifying and extracting a 3D realizable polyhedral line drawing object from a set of given lines.

1.4 Scope of the Study

1. Each studied and tested line drawing image contains only a single 3D realizable object obtained from Varley's thesis [2].

2. Any line drawing objects which are ambiguous or cannot be decided by human whether it is 3D realizable will not be covered in this dissertation.

1.5 Research Plans

1. Study related articles and document on 3D realizability problem and line drawing interpretation problem.

2. Collect the polyhedral line drawing images to be used in testing.

3. Explore and collect the features of most 3D realizable line drawing objects.

4. Find the conditions and rules in extracting and identifying a 3D line drawing object with 3D realizable in a given set of lines.

5. Find the algorithm in identifying and extracting a 3D realizable line drawing object.

6. Experiment, analyze the experimental results, and conclude the outcomes.

7. Write the thesis.

1.6 Research Advantages

The proposed algorithm can be used to obtain a 3D object in forms of a wired frame directly from its given 2D image. This will be beneficial and applicable to the problem in engineering CAD and reversed engineering design, and computer vision, as well.