Title:
Geometric Definition of the Hidden Part of a Line Drawing in a Sketch-to-Solid Methodology

Authors:
Sofia Kyratzi, skiratzi@aegean.gr, University of the Aegean, Greece
Philip Azariadis, azar@@aegean.gr, University of the Aegean, Greece

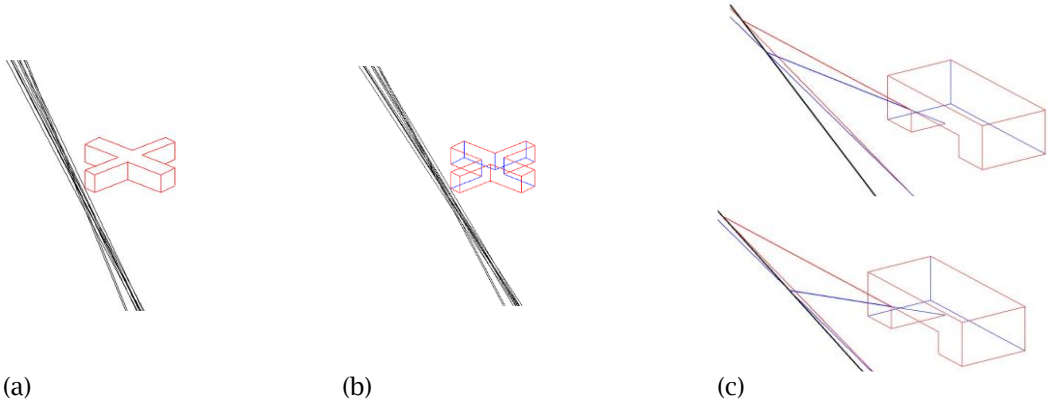
Keywords:
Computer aided sketching, sketch-to-solid, wireframe sketch

DOI: 10.14733/cadconfP.2014.81-83

Introduction:
A sketch is considered a primary tool for the communication of ideas especially in the conceptual phase of design. The growing evolution and the consistent efforts to properly found the new arising Computer Aided Sketching (CAS) systems [4] establish the importance of 2D sketches in design-oriented disciplines. The ability of humans to realize the 3D shape of a sketched object, even if the latter appears ambiguous or contains geometric errors motivate the researchers of multiple fields, such as Computer Aided Design and Sketching, Geometric Modeling, and Artificial Intelligence, to search for efficient methods for the reconstruction of a 3D model from a given single sketch [2][3][7].

In a computer-based design environment, a sketch is encountered as an arrangement of 2D lines, intersecting in junctions that lack of depth information. In its simplest form, a sketch is considered as line drawing. There are two types of sketches; natural and wireframe sketches. Natural sketches include only visible lines, while wireframe sketches include both visible and hidden lines. Proposed 3D reconstruction methods differentiate on the basis of the initial given type of sketch.

Main Idea:
The subject of this paper is related to the automatic construction of a "Polyhedron from a Single Natural Sketch". On the basis of the different topologic relations that exist in the hidden part of a sketch [2][3][6][7], the cross-section criterion [8] that asserts the realizability of a wireframe sketch (i.e., whether a sketch identifies with the projection of a valid polyhedron) and the cross-section algebraic model [1][5], this paper proposes an algorithmic method that defines the geometry of the hidden junctions and lines in a topologically reconstructed wireframe sketch.



(a) (b) (c)

Fig. 1: (a) A given natural sketch and the cross-section generated from it, (b) the produced wireframe sketch with its hidden part geometrically reconstructed, and (c) an interactive approach is studied for sketches with ambiguous hidden part geometry.

In particular, the input of the proposed algorithm is a minimal wireframe sketch (i.e., a sketch with the minimum number of hidden elements [6]) that is generated from a given natural sketch, where the geometry and topology of the visible junctions, lines, and regions (the natural sketch) are precisely defined, while for its hidden elements only their topological relations are known. On the basis of this information, the proposed method aims at constructing a wireframe sketch by defining the geometry of the hidden part. For this purpose, this paper, at first, studies the types of hidden junctions and hidden lines as these generate from the different topologic configurations that exist in the hidden part of a sketch. Then, an algebraic model is built upon the topologic relations of the hidden part having as unknowns the 2D coordinates of each hidden junction. To allow for an accurate geometric definition of all hidden junctions the cross-section realizabitity criterion is utilized. In short, according to the proposed algorithm, a cross-section is generated from the given natural sketch (Fig. 1(a)) and an algebraic system of bilinear equations is constructed for the hidden part of the sketch. A solution of the system in terms of the unknown hidden junctions produces a precisely defined wireframe sketch from the given natural sketch (Fig. 1(b)).

Conclusions:

As an advance the produced wireframe sketch is realizable since the geometric position of each hidden junction is specified by the cross-section lines that are generated from natural sketch. When the hidden part admits multiple geometric solutions as a result of strict ambiguities in the visible part, a constrained interactive approach is employed in order to resolve the underlying ambiguities (Fig. 1(c)). Moreover, the proposed algorithm is tested with sketches with various number of visible and hidden elements and to natural sketches with imperfect geometry. Concerning sketches with small errors in the visible junction coordinates, the paper studies how this error affects the position of each hidden junction. As a result, the proposed method includes algebraic criteria [1] that evaluate the realizability of the produced geometrically defined wireframe sketch.

Acknowledgements:

The research of Ph. Azariadis has been co-financed by the European Union (European Social Fund - ESF) and Greek national funds through the Operational Program "Education and Lifelong Learning" of the National Strategic Reference Framework (NSRF)-Research Funding Program: THALIS.

References:

[1] Azariadis, P.; Kyratzi, S.; Sapidis, S.N.: A hybrid-optimization method for assessing the realizability of wireframe sketches, 3D Research, 4(1), 2013, Article: 3.

[2] Cao, L.; Liu, J.; Tang, X.: What the Back of the Object Looks Like: 3D Reconstruction from Line Drawings without Hidden Lines, IEEE Transactions on Pattern Analysis and Machine Intelligence, 30(3), 2008, 507-517. http://dx.doi.org/10.1109/TPAMI.2007.1185

[3] Company, P.; Piquer, A.; Contero, M.; Naya, F.: A survey on geometrical reconstruction as a core technology to sketch-based modeling, Computers and Graphics, 29(6), 2005, 892-904. http://dx.doi.org/10.1016/j.cag.2005.09.007

[4] Contero, M.; Varley, P.; Aleixos, N.; Naya F.,: Computer-aided sketching as a tool to promote innovation in the new product development process, Computers in Industry, 60(8), 2009, 592-603. http://dx.doi.org/10.1016/j.compind.2009.05.018

[5] Kyratzi S.; Azariadis P.; Sapidis N.S: Realizability of a Sketch: An Algorithmic Implementation of the Cross-Section Criterion, Computer Aided Design and Applications, 8(5), 2009, 665-679. http://dx.doi.org/10.3722/cadaps.2011.665-679

[6] Kyratzi, S.; Sapidis, N.: Extracting a polyhedron from a single view sketch: Topological construction of a wireframe sketch with minimal hidden elements, Computers and Graphics, 33(3), 2009, 270-279. http://dx.doi.org/10.1016/j.cag.2009.03.001

[7] Varley, P.: Automatic Creation of Boundary-Representation Models from Single Line Drawings, Ph.D. Thesis, Cardiff University, 2002.
[8] Whiteley, W.: Weavings, Sections and Projections of Spherical Polyhedra, Discrete Applied Mathematics, 32(3), 1991, 275-294. http://dx.doi.org/10.1016/0166-218X(91)90004-G