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SURFACE CONSTRUCTION FROM ORTHOGONAL SLICES (English)

Summary. This paper is concerned with the problem of reconstructing surfaces of 3D objects, given mutually orthogonal sets of planar parallel slices representing cross sections through the objects. Our proposal of solution is presented and its properties plus some results are discussed.

KONSTRUKCJE POWIERZCHNI Z PRZEKROJÓW PROSTOPADŁYCH

Streszczenie. Praca ta zajmuje się problemami rekonstrukcji powierzchni obiektów 3D w oparciu o odpowiednio wybrane prostopadłe i równoległe przekroje tegoż obiektu 3D. W opracowaniu przedstawiono pewne propozycje rozwiązania problemu, cechy i wyniki badań.

1. Introduction

3D surface reconstruction from a set of planar contours is an important problem in many fields. For example in clinical medicine, the data produced by various imaging techniques such as computed axial tomography (CAT), ultrasound, and nuclear magnetic resonance (NMR) provide a series of cross-sections through the object of study. Biologists try to understand the shape of microscopic objects from serial sections through the object. In Computed Aided Design (CAD), lofting techniques specify the geometry of an object by means of series of contours.
Usually, one set of planar slices where each slice contains several contours is used as an input of existing methods. A large set separation between the planes of adjacent sections causes problems since the loss of the information is too high [1-4, 6]. If it is possible to use more than one set of planar slices (i.e., if the original object was scanned in more than one plane) then the reconstruction could be easier and the quality of its results increases.

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2. Orthogonal sets of slices

If an object is represented by more than one set of parallel slices and especially when these sets are mutually orthogonal, the orthogonal sets of parallel planar slices are obtained [5], see Fig. 1. We suppose polygonal contours in each slice.

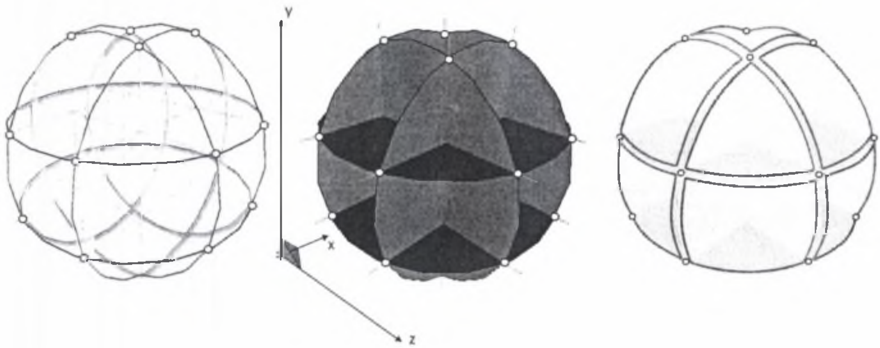

Fig. 1. Left: Orthogonal sets of slices. Center: Contours of one set are filled by a unique color. Right: Denoted spatial polygons that are to be patched

Rys. 1. Lewa strona - Zbiór przekrojów prostopadłych Środek - Kontury jednego zbioru są wypełnione jednym kolorem. Prawa strona - Zaznaczono przestrzenne poligony, które maja być uzupełnione powierzchnią

3. Principle of the reconstructing algorithm

The motivation for our algorithm was the study of the situations similar to the one presented in Fig. 1. The planes of slices divide space into a set of spatial cells. We distinguish two kinds of cells, the active and the empty cells. There are parts of contours on some sides of an active cell, which means that the resultant surface intersects the cell, see Fig. 2.

The intersection of two orthogonal slices is a set of points. Such points we call node points, see Fig. 2. Now we focus on an active cell. The important discovery is that parts of input contours and the node points form spatial polygons placed on the surface, see Fig. 2.

We consider each contour as a subgraph (alias component) of a graph *G*. Graph *G* is directed, its set of vertices V_G is formed by contour vertices, the set of edges E_G is formed by contour edges.

If we add a node point (node vertex) to a graph *G* then the number of components decreases. Node vertex represents a connection of two components. Our aim is to show that if graph *G* is connected then we are able to get surface with the same structure of the sampled part of the input object.

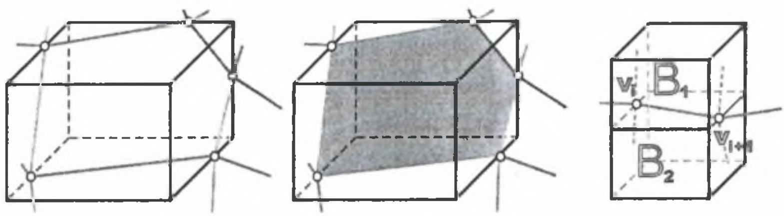

Fig. 2. Left, Center: An active cell. Parts of contours on sides of the cell together with node points form spatial polygons to be patched. Node points are denoted as white spots. Right: Each edge is adjacent with two blocks

Rys. 2. Lewa strona, środek - Aktywna komórka, Części konturów leżące na bokach komórki wraz z węzłami, które mają być uzupełniane powierzchnią. Punkty węzłów są zaznaczone jako białe kółka. Prawa strona - Każda krawędź przylega do dwóch ścian

Our algorithm consists of 4 steps. In the first step we compute node vertices of each contour, in the second step we find all pairs of corresponding node vertices (each of the two points is a part of a different contour, which are orthogonal). These pairs are transformed to valid node vertices of graph *G*. In the third step we find (using a set of criteria) those parts of graph *G* (circles) that form spatial polygons positioned on the surface of the object. In the last step we patch these polygons.

The most important step is the detection of circles (polygons). Each edge *e* of the graph *G* is adjacent with two blocks B_1 and B_2, in the other words each edge is adjacent with two polygons P_1 and P_2 that are searched. Marching on the neighboring edges we search the following vertices. For each block $b \in \{B_1, B_2\}$ we search next vertices that should be added to the polygon. Each such vertex must be incident with the block *b*. As long as we reach the starting vertex the polygon $p \in \{P_1, P_2\}$ is complete and can be patched.

4. Results

In order to prove the capabilities of the proposed algorithm we have verified it for more complicated data sets as well; see Fig. 3. The artifacts on the surface such as holes or overlaying triangles are caused by incorrect graph *G*, which, in fact, is the most problematic part of the method. Linear approximation of the graph edges causes loss of details of the original surface.

We have presented a new approach for surface reconstruction using orthogonal sets of slices. The experiments proved that the presented algorithm reconstructs complex data sets. In further research we will deal with incorrectnesses of the graph construction stage. Detailed information can be found at http://herakles.zcu.cz.

Fig. 3. Left: A set of orthogonal slices. Center, Right: Sample results of the reconstruction process
Rys. 3. Lewa strona - Zbiór prostopadłych przekrojów, Środek, prawa strona – Przykłady rezultatów procesu rekonstrukcji

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Recenzent: Dr inż. Renata A. GÓRSKA

Abstract

This paper is concerned with the problem of reconstructing surfaces of 3D objects, given sets of planar parallel slices representing cross sections through the objects. We present a new approach, which is based on considering more than one mutually non-parallel sets of slices. The paper includes our proposal of solution for orthogonal sets of slices. The properties and sample results are discussed.