SIGGRAPH '87 REVIEW FORM

Thank you for agreeing to review a paper for SIGGRAPH '87. Your job as a reviewer is to provide an expert analysis of the content and form of this technical paper and to present your conclusions to your senior reviewer. Each senior reviewer collects at least two reviews as well as reviewing the paper himself/herself. These reviews will be summarized by the senior reviewer and used at the technical program committee meeting to make the selection of papers for the conference. It is your job to help your senior reviewer, and ultimately the program committee, make a fair and accurate judgment of the paper.

Please begin by reading the rest of this memo and the SIGGRAPH '87 Guide for Authors. After carefully reading the paper and viewing all accompanying A/V materials, please fill out the SIGGRAPH '87 Review Form on the reverse side of this sheet. You may use a separate page in your own format rather than fill in the form if you prefer. Return the results, the paper, and all accompanying A/V materials to your senior reviewer by Friday, **February 27, 1987.** Your comments will be returned to the authors to help them improve their paper.

Summarize the main point of the paper.

All good papers should be written for a purpose, which should be obvious to an expert reader. It may present the solution to a technical problem, or may address issues of technical scholarship as in a survey or analysis paper. You as an expert should be able to summarize the main purpose and state whether the authors met their goals. If you can't, the paper is not worth considering for the conference.

What does this work contribute to the field of Computer Graphics and Interactive Techniques?

Assuming the authors have met their goals, is the result a significant new contribution to the field of Computer Graphics and Interactive Techniques, or is it an obvious derivation of previous results? Will a large cross-section of the community be interested in the result or does it serve a very specialized audience? What parts of the community will care about this work? If the paper is of no interest to the SIGGRAPH audience, say so here.

Is the paper adequately written?

This is a general question about how well the content of the paper is presented. Are all assumptions stated and is all terminology defined? Do the title, abstract and conclusions effectively summarize the paper? How hard did you have to work to find the purpose of the paper?

How is the overall use of English, sentence structure, grammar, punctuation and spelling? Are there missing tables, illustrations, headings, references, illustrations? If there are missing references, please list them. Illustrations should be judged on how well they illustrate their point, whether they are a simple diagram or the principal result of the paper.

Authors will be allowed a final formatting pass on their paper, and generally illustrations, grammar, etc. are improved on this pass. However, we cannot guarantee that major flaws will be corrected.

Could an experienced practitioner in the field duplicate the results from the paper and the references?

This is a completeness test. Could the results be duplicated or used in a similar situation? If not, what's missing? Think of giving it to a graduate student or junior colleague to work from as well as using it yourself. How much expertise is required to use it?

Should we accept this paper for SIGGRAPH '87? WHY?

Please make time to summarize the reason for your decision. Remember that the senior reviewer has to compare your review to two others, so additional information here will help her/him do this analysis.

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Paper Number: 3 4 - 1   **Reviewer Number:** B 1

Summarize the main point of this paper.

See attached sheets.

What does this work contribute to the field of Computer Graphics and Interactive Techniques?

Is the paper adequately written?   Yes   (Easily Fixed)   No
What needs to be improved? (grammar, illustrations, missing references, too long, etc.)

Could an experienced practitioner in the field duplicate
the results from the paper and the references?   Yes   (Almost)   No
What needs to be added?

Should we accept this paper for SIGGRAPH '87?

            Yes   (Probably)   Doubtful   Never
Why?

Review of Marching Cubes: A High Resolution 3D Surface Construction Algorithm - SIGGRAPH 87

Main point of the paper:

A new algorithm for detecting constant density surfaces and representing them in the form of triangles is presented. The algorithm is illustrated using single examples of image data sets from computed tomography, magnetic resonance imaging and SPECT. This algorithm provides high surface detail at the expense of moderate computer time. Enhancements to the efficiency and functionality of the algorithm are mentioned.

What does this work contribute:

Several methods already exist for extracting 3-D surfaces from medical slice data sets, and rendering them on 2-D displays. The new algorithm presented in this report is innovative in its use of cubes formed by assigning adjacent voxels to its vertices, rather than attempting to compute surfaces at each individual point using its neighbors. A table lookup procedure is used to aid in surface detection, and gradients used to improve the quality of the final display images. The quality of images produced by the new algorithm are considered by the authors to be superior to previous methods, but no direct comparison is made.

Is the paper adequately written?

Specific comments keyed to the text:

The statement (page 3, 2nd paragraph) "In addition to structure, SPECT can show the presence of blood in structures." is confusing. Both MRI and CT show the presence of blood in structures too. It is not clear what the authors intend in this descriptive sentence.

The explanation of gradient computation (bottom of page 6, top half of

page 7) is difficult to follow. The authors state that the gradient vector, **g**, is the derivative of the density function (eqtn 1), **provided the density distribution is continuous**. This is most certainly not the case at high contrast surfaces found in CT and other types of scanned images. The discontinuity in density distribution at cube vertices is used to compute the index into the triangulated cube table. In the same paragraph, the authors "Note that to calculate the gradient there must be four slices in memory at once.". This is not true, since only three slices are needed to calculate the gradient at any vertex (according to equations 2,3 and 4). Four slices are needed to compute the gradient<u>s</u> at all the vertices of the marching cubes, however, and this statement should be reworded.

In paragraph 5.1 (and figure 5), I was unable to understand how coherence accounted for all edges except for e6, e7 and e12. The authors state that "We can obtain the other nine edges from previous slices, lines or pixels." How did they do it?

Figure 10 is upside down. Figure 11 was grossly overexposed, revealing no internal soft tissue detail (I think internal soft tissue detail was the point of including Figure 11).

I couldn't understand Figure 13 at all. None of the structures in the image are identified.

The images in Figures 8 - 10 have been shown at previous meetings, and there may be considerable overlap between this manuscript and reference 37 (which I could not find, incidentally).

Should we accept this paper?

The actual utility of the proposed new method for medical images is

uncertain since only single instances of CT, MR and SPECT data sets were used. The SPECT image (Figure 13) is uninterpretable, and may be deleted (along with reference to SPECT), since I don't believe that the algorithm produced a useful result in this case.

The limited examples used in this paper fail to give any information regarding the performance of the algorithm under other than ideal circumstances. "Averaging down" the data sets to save computation time is mentioned several times, but no results were shown. It is difficult to assess the gain in image quality by the new marching cubes method, since no comparable images performed with more conventional methods were shown. It is simply taken as self evident that the new images are better than those that could be produced by other previously described techniques.

On behalf of the manuscript, the algorithm description is reasonably complete (except for the part describing gradient computation and the use of coherence). The approach of using cubes where each vertex is a different volume element from the original scan data set is innovative.

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Paper Number: 31-2   **Reviewer Number:**

Summarize the main point of this paper.

The authors present a new algorithm for constructing a 3D object surface description from a stack of 2D data slices. It is automatic, threshold-based, free of many difficulties of previous methods, and generates very nice surfaces.

What does this work contribute to the field of Computer Graphics and Interactive Techniques?

Many people have been working in this area (3D surface reconstruction) and this paper provides a useful new algorithm to be added to the repertoire for comparison and further development.

Is the paper adequately written?   Yes   (Easily Fixed)   No

What needs to be improved? (grammar, illustrations, missing references, too long, etc.)

If this paper is accepted, I would recommend cutting down on the number of references. It is no longer necessary, for example, to refer to papers on ray casting, depth shading, color shading, Gouraud shading, etc, when simply mentioning these techniques. Similarly, multiple references to one technique (e.g., G. Herman) are not necessary and clutter the paper.

Could an experienced practitioner in the field duplicate the results from the paper and the references?   (Yes)   Almost   No

What needs to be added?

Should we accept this paper for SIGGRAPH '87?

(Yes)   Probably   Doubtful   Never

Why?

The authors present an interesting new algorithm which results in very nice models. It is still limited by its reliance on a good threshold to determine the surface, but appears to do a better job for those situations in which it can be applied than algorithms currently extant.

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Paper Number: 34   **Reviewer Number:**   3

Summarize the main point of this paper.

an algorithm for extracting a surface model from ~~actual~~ volume density data.

What does this work contribute to the field of Computer Graphics and Interactive Techniques?

it's an elegant, simple, clever algorithm; the problem it solves is certainly important, and the solution seems easy, practical and convincing.

Is the paper adequately written?   (Yes)   Easily Fixed   No
What needs to be improved? (grammar, illustrations, missing references, too long, etc.)

I think the name "marching cubes" is misleading and unhelpful.

Could an experienced practitioner in the field duplicate the results from the paper and the references?   (Yes)   Almost   No
What needs to be added?

Should we accept this paper for SIGGRAPH '87?
(Yes)   Probably   Doubtful   Never

Why?

Summarize the main point of this paper.

This paper presents an algorithm for processing multiple 2-D image slices of 3-D anatomical structures to generate polygonal models of constant density surfaces for display using standard polygon-rendering hardware and software.

What does this work contribute ?

The authors state that their technique provides a method for interactive viewing of 3-D surfaces which provides significant advantages other methods because it introduces fewer artefacts, throws away less useful information, and automatically generates a representation that can be displayed using standard hardware and software. Although I am not familiar with all the other techniques, I generally accept the authors' assertions.

The images are indeed remarkable in their detail. However, I am somewhat concerned by the large number of triangles produced. Although the number is easily reduced, it is not clear that images produced from models using more reasonable numbers of polygons are superior to other methods of displaying such data.

Is the paper adequately written ?

Easily fixed. Overall, the paper is quite well written. The figures need explanatory captions, in addition to the explanation in the text. Section 5.2 is difficult to follow and needs considerable revision. It would be nice if the disorder of the patient in the study of Section 7.1 were put in layman's terms so that the reader might be aware of the abnormality to be viewed. A fuller explanation of how texture mapping is done is needed.

Could an experienced practitioner duplicate the work ?

Yes. The algorithm is really quite straightforward and well presented, and it could readily be implemented by anyone having a basic familiarity with raster graphics and related mathematics. A worker trying to implement the algorithm would be helped by a pseudo-code statement of the algorithm if space allows. Just a listing of the "edge table" would be quite helpful if it could be included compactly enough.

A little more about the method used for texture mapping is needed.

Should we accept this paper ?

Yes. It clearly and concisely describes a new algorithm for generating polygonal models from a very common type of medical image data (although it is not clear that this type of data is limited to the medical field). It is encouraging to see more work on generation of data bases.

SIGGRAPH '87 REVIEW FORM

Paper Number: 34   **Reviewer Number:** 5

Summarize the main point of this paper. 3D object descriptions consisting of many tiny triangles is constructed from 3D medical density array data at a selected isodensity level. A tiny fraction of the surface is constructed at each cube of 2×2 density sample points. The surface can cut through this cube in one of only 14 different ways, keyed on which corners of the cube have density greater than, which less than the selected isodensity.

What does this work contribute to the field of Computer Graphics and Interactive Techniques? The demonstrated object have up to 500,000 triangle. Cut planes possible with some solid modeling

Is the paper adequately written?   (Yes)   Easily Fixed   No

What needs to be improved? (grammar, illustrations, missing references, too long, etc.)

Reference to Michael Zyda's papers (he's at Naval Postgrad School, Monterey, Calif.)

Could an experienced practitioner in the field duplicate the results from the paper and the references?   (Yes)   Almost   No

What needs to be added?

Nothing

Should we accept this paper for SIGGRAPH '87?

(Yes)   Probably   Doubtful   Never

Why? Best pictures yet from CT; very simple technique though not different much from Zyda's work.