IEEE STANDARDS ASSOCIATION

# IEEE Recommended Practice for Three-Dimensional (3D) Medical Modeling

IEEE Computer Society

Sponsored by the
Standards Activity Board

IEEE
3 Park Avenue
New York, NY 10016-5997
USA

IEEE Std 3333.2.1™-2015

# IEEE Recommended Practice for Three-Dimensional (3D) Medical Modeling

Sponsor

**Standards Activities Board**
of the
**IEEE Computer Society**

Approved 16 February 2015

**IEEE-SA Standards Board**

**Abstract:** The generation and practical use of medical three-dimensional (3D) modeling for diagnostics and therapeutic applications is described in this standard. Volume rendering and surface rendering techniques for 3D reconstruction from two-dimensional (2D) medical images and a texturing method of 3D medical data for realistic visualization are included.

**Keywords:** IEEE 3333.2.1™, material properties, medical 3D decimation, medical 3D format, medical 3D reconstruction, medical 3D segmentation, standard for medical 3D, texture mapping.

The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA



PDF: ISBN 978-0-7381-9571-1 STD20132
Print: ISBN 978-0-7381-9572-8 STDPD20132

## Important Notices and Disclaimers Concerning IEEE Standards Documents

IEEE documents are made available for use subject to important notices and legal disclaimers. These notices and disclaimers, or a reference to this page, appear in all standards and may be found under the heading "Important Notice" or "Important Notices and Disclaimers Concerning IEEE Standards Documents."

## Notice and Disclaimer of Liability Concerning the Use of IEEE Standards Documents

IEEE Standards documents (standards, recommended practices, and guides), both full-use and trial-use, are developed within IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association ("IEEE-SA") Standards Board. IEEE ("the Institute") develops its standards through a consensus development process, approved by the American National Standards Institute ("ANSI"), which brings together volunteers representing varied viewpoints and interests to achieve the final product. Volunteers are not necessarily members of the Institute and participate without compensation from IEEE. While IEEE administers the process and establishes rules to promote fairness in the consensus development process, IEEE does not independently evaluate, test, or verify the accuracy of any of the information or the soundness of any judgments contained in its standards.

IEEE does not warrant or represent the accuracy or content of the material contained in its standards, and expressly disclaims all warranties (express, implied and statutory) not included in this or any other document relating to the standard, including, but not limited to, the warranties of: merchantability; fitness for a particular purpose; non-infringement; and quality, accuracy, effectiveness, currency, or completeness of material. In addition, IEEE disclaims any and all conditions relating to: results; and workmanlike effort. IEEE standards documents are supplied "AS IS" and "WITH ALL FAULTS."

Use of an IEEE standard is wholly voluntary. The existence of an IEEE standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEEE standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the standard.

In publishing and making its standards available, IEEE is not suggesting or rendering professional or other services for, or on behalf of, any person or entity nor is IEEE undertaking to perform any duty owed by any other person or entity to another. Any person utilizing any IEEE Standards document, should rely upon his or her own independent judgment in the exercise of reasonable care in any given circumstances or, as appropriate, seek the advice of a competent professional in determining the appropriateness of a given IEEE standard.

IN NO EVENT SHALL IEEE BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO: PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE PUBLICATION, USE OF, OR RELIANCE UPON ANY STANDARD, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE AND REGARDLESS OF WHETHER SUCH DAMAGE WAS FORESEEABLE.

## Translations

The IEEE consensus development process involves the review of documents in English only. In the event that an IEEE standard is translated, only the English version published by IEEE should be considered the approved IEEE standard.

A statement, written or oral, that is not processed in accordance with the IEEE-SA Standards Board Operations Manual shall not be considered or inferred to be the official position of IEEE or any of its committees and shall not be considered to be, or be relied upon as, a formal position of IEEE. At lectures, symposia, seminars, or educational courses, an individual presenting information on IEEE standards shall make it clear that his or her views should be considered the personal views of that individual rather than the formal position of IEEE.

## Comments on standards

Comments for revision of IEEE Standards documents are welcome from any interested party, regardless of membership affiliation with IEEE. However, IEEE does not provide consulting information or advice pertaining to IEEE Standards documents. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments. Since IEEE standards represent a consensus of concerned interests, it is important that any responses to comments and questions also receive the concurrence of a balance of interests. For this reason, IEEE and the members of its societies and Standards Coordinating Committees are not able to provide an instant response to comments or questions except in those cases where the matter has previously been addressed. For the same reason, IEEE does not respond to interpretation requests. Any person who would like to participate in revisions to an IEEE standard is welcome to join the relevant IEEE working group.

Comments on standards should be submitted to the following address:

Secretary, IEEE-SA Standards Board
445 Hoes Lane
Piscataway, NJ 08854 USA

## Laws and regulations

Users of IEEE Standards documents should consult all applicable laws and regulations. Compliance with the provisions of any IEEE Standards document does not imply compliance to any applicable regulatory requirements. Implementers of the standard are responsible for observing or referring to the applicable regulatory requirements. IEEE does not, by the publication of its standards, intend to urge action that is not in compliance with applicable laws, and these documents may not be construed as doing so.

## Copyrights



## Photocopies

## Updating of IEEE Standards documents

Users of IEEE Standards documents should be aware that these documents may be superseded at any time by the issuance of new editions or may be amended from time to time through the issuance of amendments, corrigenda, or errata. An official IEEE document at any point in time consists of the current edition of the document together with any amendments, corrigenda, or errata then in effect.

Every IEEE standard is subjected to review at least every ten years. When a document is more than ten years old and has not undergone a revision process, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE standard.

In order to determine whether a given document is the current edition and whether it has been amended through the issuance of amendments, corrigenda, or errata, visit the IEEE-SA Website at http://ieeexplore.ieee.org/xpl/standards.jsp or contact IEEE at the address listed previously. For more information about the IEEE-SA or IEEE's standards development process, visit the IEEE-SA Website at http://standards.ieee.org.

## Errata

Errata, if any, for all IEEE standards can be accessed on the IEEE-SA Website at the following URL: http://standards.ieee.org/findstds/errata/index.html. Users are encouraged to check this URL for errata periodically.

## Patents

Attention is called to the possibility that implementation of this standard may require use of subject matter covered by patent rights. By publication of this standard, no position is taken by the IEEE with respect to the existence or validity of any patent rights in connection therewith. If a patent holder or patent applicant has filed a statement of assurance via an Accepted Letter of Assurance, then the statement is listed on the IEEE-SA Website at http://standards.ieee.org/about/sasb/patcom/patents.html. Letters of Assurance may indicate whether the Submitter is willing or unwilling to grant licenses under patent rights without compensation or under reasonable rates, with reasonable terms and conditions that are demonstrably free of any unfair discrimination to applicants desiring to obtain such licenses.

Essential Patent Claims may exist for which a Letter of Assurance has not been received. The IEEE is not responsible for identifying Essential Patent Claims for which a license may be required, for conducting inquiries into the legal validity or scope of Patents Claims, or determining whether any licensing terms or conditions provided in connection with submission of a Letter of Assurance, if any, or in any licensing agreements are reasonable or non-discriminatory. Users of this standard are expressly advised that determination of the validity of any patent rights, and the risk of infringement of such rights, is entirely their own responsibility. Further information may be obtained from the IEEE Standards Association.

## Participants

At the time this IEEE recommended practice was completed, the 3D Based Medical Applications Working Group had the following membership:

**Younglae Moon**, *Chair*
**Kazuomi Sugamoto**, *Vice Chair*

Antonio Di Carlo
Daeok Kim
Jongmin Kim
Jaekeun Kwak
Daehyun Lee
Alberto Paoluzzi
Dongsun Shin

The following members of the entity balloting committee voted on this recommended practice. Balloters may have voted for approval, disapproval, or abstention.

Chosun University Hospital
Electronics and Telecommunications Research Institute (ETRI)
Haegeon Co. Ltd.
Korea Electronics Association (KEA)
Osaka University Graduate School of Medicine, Orthopedic Biomaterial Science Lab.
Universita degli Studi Roma Tre, Dipartimento di Matematica e Fisica
University of Utah—CEDMAV

When the IEEE-SA Standards Board approved this recommended practice on 16 February 2015, it had the following membership:

**John Kulick,** *Chair*
**Jon Walter Rosdahl,** *Vice Chair*
**Richard H. Hulett,** *Past Chair*
**Konstantinos Karachalios,** *Secretary*

Peter Balma
Farooq Bari
Ted Burse
Clint Chaplin
Stephen Dukes
Jean-Philippe Faure
Gary Hoffman
Michael Janezic
Jeffrey Katz
Joseph L. Koepfinger*
David J. Law
Hung Ling
Oleg Logvinov
T. W. Olsen
Glenn Parsons
Ron Petersen
Adrian Stephens
Peter Sutherland
Yatin Trivedi
Phil Winston
Don Wright
Yu Yuan

*Member Emeritus

Also included are the following nonvoting IEEE-SA Standards Board liaisons:

Richard DeBlasio, *DOE Representative*
Michael Janezic, *NIST Representative*

Patrick Gibbons
*IEEE-SA Content Production and Management*

Soo Kim
*IEEE-SA Technical Program Operations*

Malia Zaman
*IEEE-SA Technical Program Operations*

## Introduction

This introduction is not part of IEEE Std 3333.2.1™-2015, IEEE Recommended Practice for Three-Dimensional (3D) Medical Modeling.

Medical images from hospitals consist of a 2D dataset and provide human body information as a slice. The human body has morphological structures in 3D space. To recognize real human organs, the body should be reconstructed using 2D slices to obtain its precise position and shape. In real clinical situations, doctors expend a great deal of time and effort to learn this reconstruction process. With medical 3D data, we will obtain more information about the human body, as well as more objective data from the simulation, which may contribute to more successful treatment and surgery plans.

## Contents

# IEEE Recommended Practice for Three-Dimensional (3D) Medical Modeling



## 1. Overview

### 1.1 Background

Medical images from hospitals consist of a two-dimensional (2D) dataset and provide human body information as a slice, but the human body has three-dimensional (3D) morphology. If we should simulate this 3D morphology, we might be able to obtain more information about the body as well as contribute in the clinical environment to both treatment and surgical outcomes. Our objective is to generate 3D medical data from 2D images. Although doctors expend a great deal of time and effort in this process, the resultant 3D data is different in each institute. This protocol, therefore, provides standard, easy, and accurate 3D data for clinical fields and even for industrial markets.

A standardized file with 3D medical data, considering each data character from a different place, will yield steady quality visualization. Therefore, this standard suggests standardized data including 3D processing techniques. A more realistic 3D model and a basic model are shown in Figure 1.