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# Standard Terminology System Referenced by 3D Human Body Model

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## Abstract

In this study, a system to increase the expressiveness of existing standard terminology using three-dimensional (3D) data is designed. We analyze the existing medical terminology system by searching the reference literature and perform an expert group focus survey. A human body image is generated using a 3D modeling tool. Then, the anatomical position of the human body is mapped to the 3D coordinates' identification (ID) and metadata. We define the term to represent the 3D human body position in a total of 12 categories, including semantic terminology entity and semantic disorder. The Blender and 3ds Max programs are used to create the 3D model from medical imaging data. The generated 3D human body model is expressed by the ID of the coordinate type (x, y, and z axes) based on the anatomical position and mapped to the semantic entity including the meaning. We propose a system of standard terminology enabling integration and utilization of the 3D human body model, coordinates (ID), and metadata. In the future, through cooperation with the Electronic Health Record system, we will contribute to clinical research to generate higher-quality big data.

**Index Terms**: 3D human body model, Virtual terminology, Semantic entity, SNOMED CT

## I. INTRODUCTION

The Electronic Health Record (EHR) system and Order Communication System (OCS) have been increasingly used globally. Considerable medical information is generated through informatization, and it is meaningfully utilized in various fields such as clinical decision-making and medical management. Semantic interoperability not only among hospital systems (EMR, OCS, invoicing) but also among many systems outside the hospital requires that clinical data elements are captured in a standardized form [1]. Several ”standards” exist, even in areas of medical terminology such as Systematized Nomenclature of the Medicine Clinical Terms (SNOMED CT), Logical Observation Identifiers Names and Codes (LOINC), International Classification of Disease (ICD), and Korea Standard Terminology of Medicine (KOSTOM). However, each standard has its own purpose and the structure fits its goal, which is used only for its purpose [2]. Recently, the importance of establishing EHR systems has emphasized, for patient safety, the reduction in medical errors, efficiency improvement, and cost reduction [3-4]. To achieve this, EHR systems should capture structured clinical information to support the health services' research [5]. Therefore, standardization of terminology with guaranteed interoperability among medical systems is necessary.

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Clinical descriptions can be highly abstractive in terms of locations and shapes of disease. It can be even more difficult for clinicians to define lesions when they are coded using a standard terminology system. One traditional means of overcoming the expressiveness limitation is drawing figures on medical records. A simple, small figure can be more informative than a long, narrative description. However, a recent advancement in imaging technology is also revolutionizing disease visualization. It is a spatial resolution that reaches 1 mm in the case of a typical computed tomography (CT) scan. It is believed that the gap between the image and clinical terminology in terms of expressiveness is increasing over time. In addition, patients are having difficulty understanding their disease because standard terminology does not include visualization.

Recently, there have been areas where healthcare workers achieve additional expressiveness by adopting 3D data in the medical field [6, 7]. Radiation therapies are designed by three-dimensional (3D_ data to generate optimal intensities while protecting adjacent tissue [8]. 3D anatomical models could be applied in clinical training and surgical planning, as well as in medical imaging research [7]. Simulation-based training with 3D anatomical models reduces the risks of surgical interventions, and it is directly linked to patient experience and healthcare costs [9]. In surgical theater, operation is often guided by 3D navigation systems. Arthroplasties are designed and simulated before surgery using 3D technology. Researchers are also studying ways to simulate operation tactics using 3D data by 3D printing, augmented reality (AR), and virtual reality (VR) [10-12]. Because 3D data can deliver accurate spatial information regarding the human body, it is evident that a standard terminology system will provide additional expressiveness when 3D data is adopted in medical informatics. Because anatomy is key feature information in many clinical descriptions, 3D data can increase the accuracy and expressiveness of clinical terminology. Largely, 3D data are numbers that can be processed using mathematical functions; they provide more computability in research, software production, and artificial intelligence. However, there is limited research on the terminology system for representation using 3D data.

The purpose of this study is to design a system to increase the expressiveness of existing standard terminology using 3D data. The terminology system for representation of a 3D human body position is intended to be used in EHR, personal health records, and various medical research purposes.

## II. SYSTEM MODEL AND METHODS

In this study, we analyzed existing medical terminology systems both nationally and internationally by searching reference literature. In addition, we performed an expert-group focus survey to determine the problems with current medical terminology systems. International Organization for Standardization (ISO) standard documents related to 3D human body data were analyzed to define components and terms for system design.

We designed a standard terminology system referenced by 3D human body modeling through two processes. The first step was to create images; image creation is the process of illustration using 3D modeling tools. This study used the Blender and 3ds Max programs to create a 3D human body model. In these programs, there is menu that creates a basic 3D model. For example, Blender has a function that creates a torus, cone, cylinder, icosphere, ultraviolet sphere, circle, cube, and plane. If a blood-vessel model is to be created, one first adds a circle using the add-circle menu. Then, the circle is extruded. Extrusion and rotation of angles are repeated. Then, a new model of the blood vessel is created. A 3D model is composed of data that are largely dots or vertices in a 3D space. During the second step, the anatomical position of the human body is mapped to the 3D coordinates' identification (ID) and metadata. The meaning of the coordinates ID includes surface, line, point, and volume (Fig. 1, Fig. 2).

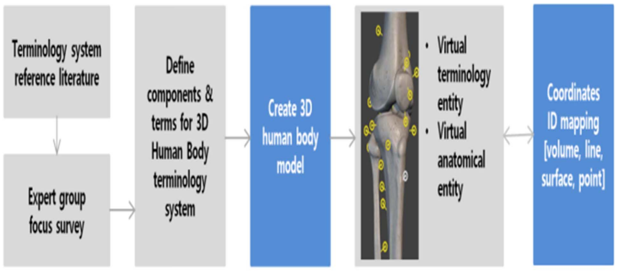
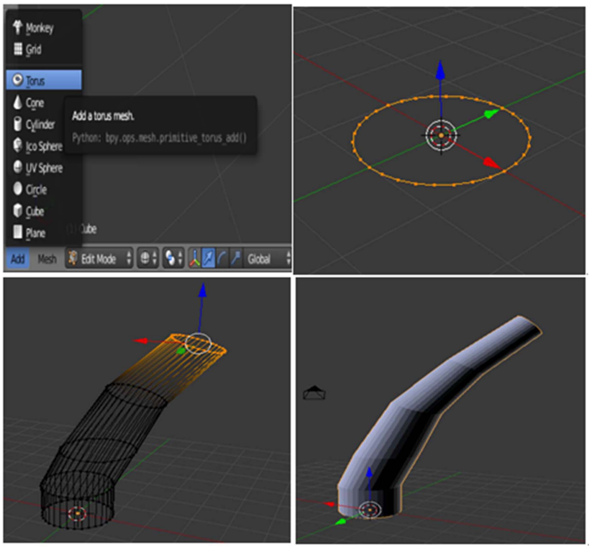


**Fig. 1.** Study process.



Add a torus mesh.

Python: bpy.ops.mesh.primitive_torus_add()

**Fig. 2.** Process of 3D image creation using Blender.

## III. RESULTS AND DISCUSSION

### A. Analysis of Medical Terminology System

SNOMED CT is widely known as a highly comprehensive clinical healthcare terminology system developed at the College of American Pathologist [13]. SNOMED CT is composed of the three elements of concept, description, and relationships. SNOMED CT consists of concepts that are divided into 19 hierarchies [14]. The updated SNOMED CT version, January 2018 release, contains 341,000 active concepts, 1,062,000 active relationships and 1,156,000 active descriptions. The major categories of concepts in SNOMED CT are disorders (22%), procedures (17%), body structures (11%), clinical findings other than disorders (10%), and organisms (10%) [15]. The greatest feature of SNOMED CT is that it can express a combination of existing concepts, that is, pre-coordination support, as well as post-coordination to express a combination of multiple concepts [2]. In addition, mappings are maintained between SNOMED CT and a number of terminology systems. These include the World Health Organization (WHO) classifications (ICD-10), International Classification of Primary Care (ICPC-2), International Classification for Nursing Practice (ICNP), and Logical Observation Identifiers Names and Codes (LOINC) [15]. Therefore, in this study, we developed a 3D human-body position terminology system based on SNOMED CT.

LOINC is widely used in clinical diagnostic terminology and was developed at the Regenstrief Institute of Indiana University in 1994 in the United States [16]. LOINC codes are currently used in more than 165 countries throughout the world [16]. The Regenstrief Institute continues to update LOINC. The December 2017 version, version 2.63, contains more than 86,000 terms covering the full scope of laboratory testing (chemistry, microbiology, molecular pathology, etc.) and a broad range of clinical measurements (e.g., vital signs, clinical electrocardiography patient-reported outcomes) [15]. LOINC uses a semantic data model containing six major attributes for concepts [17]. The major attributes of the LOINC system are as follows: component (e.g., what is measured, evaluated, or observed); kind of property (e.g., mass, substance, catalytic activity); time aspect (e.g., 24-hour collection); system type (e.g., context or specimen type within which the observation was made); type of scale (e.g., ordinal, nominal, narrative); type of method (e.g., procedure used to make the measurement or observation) [15, 17].

The International Classification of Diseases (ICD), proposed by WHO, is the most important worldwide standard for mortality and morbidity statistics [18]. Currently, ICD-10 is used internationally, but WHO has promulgated a version of ICD–11 [19]. The ICD-11 revision process is fundamentally different from previous ICD revisions as follows: (1) it is computerized and supported by ontology-driven tools [20]; (2) it distinguishes between a multi-hierarchical ICD Foundation Component; and (3) the Foundation Component is intended to have at its core a common ontology with SNOMED CT [19]. Attributes and code examples of the three terminology system types are as follows (Table 1).

### B. Definition of Components and Terms for System Design

A focus survey of a medical terminology expert group was carried out to grasp the needs of the standard medical terminology system. The focus survey questions were regarding the accuracy of information exchange and utilization of indexes of the Electronic Medical Record (EMR) system using the current standard terminology (ICD-10). The following opinions were presented in the focus survey: (1) there is difficulty in inputting free text other than disease terminology; (2) it is impossible to retrieve disease and disorder positions and sizes ; (3) the ICD-10 code is inefficient in exchanging medical information because the information on lesion location, size, and staging is not included; (4) there is a lack of education on ICD-10 codes for physicians; and (5) it is necessary to construct a system that can save accurate and detailed information.

Moreover, we reviewed the existing ISO document related to the standard terminology system with reference to the focus survey result presented earlier. The relevant ISO document is shown in Table 2.

For the development of the 3D medical terminology system reflecting the improvement points, we referred to the ISO document and defined the components of the terminol-

**Table 1.** Attributes and code examples of each terminology

| Type | Attribute | Code example |
|---|---|---|
| SNOMED CT | Concept, Description, Relationships | 66607001<br>Midtarsal arthrodesis, transverse, with osteotomy as for flatfoot correction (procedure) [14] |
| LOINC | Component, Property, Timing, System, Scale, Method | 2951-2<br>Sodium[Moles/volume] in Serum or PlasmaSodium(Component):SCnc (Property):Pt(Time):Ser/Plas(System):Qn(Scale) [15] |
| ICD-11 | Primary care, Morbidity, Mortality | BA41.0 & XA7RE3<br>Acute myocardial infarction, STEMI, anterior wall: [19]<br>SNOMED CT 401303003 + 54329005 |

**Table 2.** ISO standard documents related to 3D human body terminology

| Standard No. | Subject |
|---|---|
| ISO/TS 16843-1:2016 | Categorial structures for representation of acupuncture – Part 1: Acupuncture points |
| ISO 1828:2012 | Categorial structure for terminological systems of surgical procedures |
| ISO 7250-1:2017 | Basic human body measurements for technological design – Part 1: Body measurement definitions and landmarks |
| ISO 9241-910:2011 | Ergonomics of human-system interaction – Part 910: Framework for tactile and haptic interaction |
| ISO/TS 13399-301:2013 | Cutting tool data representation and exchange – Part 301: Concept for the design of 3D models based on properties according to ISO/TS 13399-3: Modeling of thread-cutting taps, thread-forming taps and thread-cutting dies |
| ISO/TR 9241-331:2012 | Ergonomics of human-system interaction – Part 331: Optical characteristics of autostereoscopic displays |
| ISO 20685-1:2018 | 3-D scanning methodologies for internationally compatible anthropometric databases- Part 1: Evaluation protocol for body dimensions extracted from 3D body scans |
| ISO 16278:2016 | Categorial structure for terminological systems of human anatomy |
| ISO 18104:2014 | Categorial structures for representation of nursing diagnoses and nursing actions in terminological systems |
| ISO 19233-1:2017 | Implants for surgery – Orthopaedic joint prosthesis – Part 1: Procedure for producing parametric 3D bone models from CT data of the knee |
| ISO 9241-960:2017 | Ergonomics of human-system interaction – Part 960: Framework and guidance for gesture interactions |
| ISO 16087:2013 | Implants for surgery – Roentgen stereophotogrammetric analysis for the assessment of migration of orthopaedic implants |
| ISO 9241-392:2015 | Ergonomics of human–system interaction - Part 392: Ergonomic recommendations for the reduction of visual fatigue from stereoscopic images |
| ISO 20685-2:2015 | Ergonomics – 3D scanning methodologies for internationally compatible anthropometric databases - Part 2: Evaluation protocol of surface shape and repeatability of relative landmark positions |

**Table 3.** Categories of 3D human body model terminology system

| Categories | Concepts |
|---|---|
| Virtual terminological entity | Entity that represents medical concept in virtual space |
| Virtual anatomical entity | Entity that constitutes the structured organization of a particular 3D human body model |
| Pre-coordinated virtual entity | 3D compositional concept representation within a formal system with an equivalent single, unique identifier |
| Semantic terminological entity | Entity that is defined as semantic terminology |
| Semantic disorder | Semantic entity that constitutes disorder |
| Semantic finding | Semantic entity that constitutes finding |
| Semantic action | Semantic entity that constitutes action such as procedures and measurement |
| Semantic anatomy | Semantic entity that constitutes body structure |
| Virtual disorder | Virtual entity that constitutes finding |
| Virtual finding | 3D models |
| Virtual action | 3D models |
| Virtual event | 3D models |

ogy system. “Virtual terminological entity” is defined as an “Entity that represents a medical concept in virtual space”. “Virtual terminological entity” consists of text, code, description, and space. “Virtual anatomical entity” is defined as an “Entity that constitutes the structured organization of a particular 3D human body model.” “Pre-coordinated virtual entity” is defined as a “3D compositional concept representation within a formal system with an equivalent single unique identifier.” In addition, we define the term to represent the 3D human body position with a total of 12 categories including semantic terminology entity and semantic disorder (Table 3).

### C. Creation of 3D Model and Addition of ID to Model

The 3D human body models were generated using 3D modeling tools. The Blender and 3ds Max programs were used to create 3D models from medical imaging data (Fig. 3). Anatomical images were extracted using a 3D modeling tool and fabricated in a stereo lithography file (STL) format. The 3D file of the converted human body skeleton is coordinated using a dedicated program included in Computer Aided Design (CAD), a computer graphics design software. The generated 3D human body model, the virtual terminological entity, is represented in ID (coordinates) and mapped to semantic entity (metadata) (Fig. 4). In general, metadata are data created for any purpose, and thus metadata describe the attributes of the data material. In other words, they are data for information related to data, such as structure definition, classification, etc. Metadata are used to summarize available datasets and act as a source of information for searching and retrieving relevant data [21]. As demands for interoperability and automation in clinical studies increase, so does the need for sound metadata [22].

It is suggested that the virtual anatomical site can be used in combination with the existing clinical terminology. In other words, the standard terminology system referenced by the 3D human body model can not only create a new terminology system, but also use the existing clinical terminology

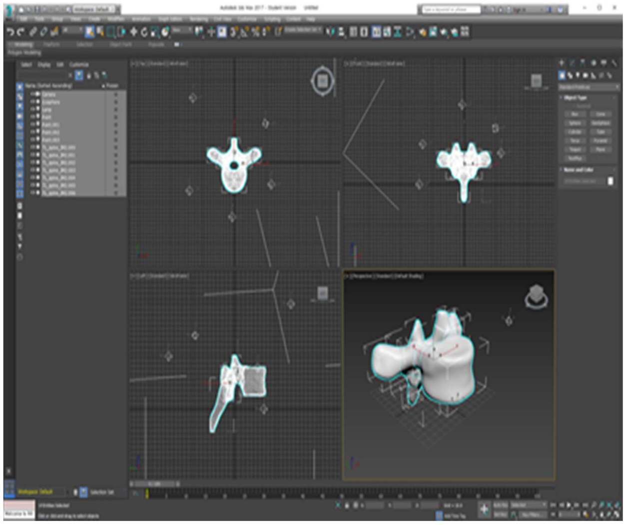


**Fig. 3.** Process of 3D modeling tool using.

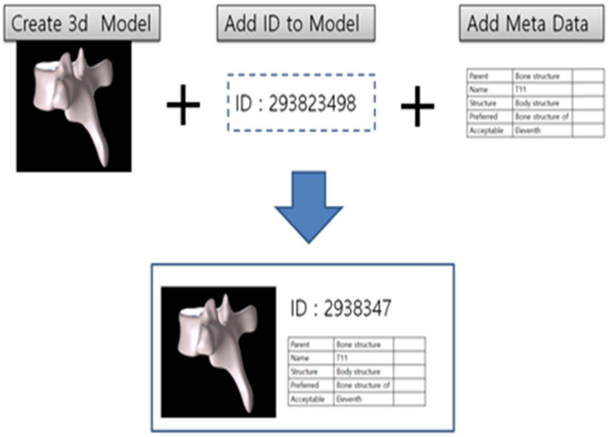


**Fig. 4.** Process of adding an ID to a 3D human body model.

system. The terminology system referenced by the 3D human body allows medical description in more detail than semantic clinical terminology. This terminology system is accurate and less ambiguous, and allows better interoperability of clinical data. Moreover, it is also possible to visualize diseases for patients and caregivers. As healthcare providers, financers, and government officials focus on developing interoperable electronic health networks, data standards are being increasingly required for clinical utility [23]. A data standard is equivalent to a terminology system standard.

However, conventional studies only compare and analyze the existing terminology system [13, 19, 24], and there is no research regarding the cooperation of the terminology system with the 3D human body model. Therefore, it can be said that this research is significant in attempting to develop a new terminology system with a flexible, accurate, expansion possibility using the 3D human body model.

However, this study has several limitations. First, we did not analyze the effectiveness of actual users on the proposed 3D human body terminology system. Second, there was no consultation with a more diverse group of experts.

In the future, it is necessary for research to progress to analyzing system effectiveness after its use linked with an actual hospital EMR system.

## IV. CONCLUSIONS

In this research, we proposed a system of standard terminology enabling integration and utilization of 3D human body models, coordinates (ID), and metadata. In the proposed method, it is easy to create a new terminology system by creating metadata of the anatomical position and shape and it can also be applied to change and supplement the existing terminology system. It can reduce the existing terminology system's inaccuracy and chaotic nature and add search and reference functions.

It is expected that it can be utilized as a convenient tool for integrating and managing knowledge of specializations in various medical fields through continuous research of the standardized term system with high interoperability. In the future, through cooperation with the EHR system, we can contribute to clinical research to generate higher-quality big data.

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