# Title Page

Some title

**Brian M. Anderson PhD1, Kevin L. Moore1, Casey Bojechko1**

*The University of California San Diego Health*

***1****Department of Radiation Medicine & Applied Sciences*

# Abstract

Consistency of nomenclature within radiation oncology is becoming increasingly important as data sharing becomes more prevalent and accessible. The American Association of Physicists in Medicine (AAPM) have created a report, Number 263 titled ‘Standardizing Nomenclatures in Radiation Oncology’ to assist in this nomenclature. Unfortunately, the burden of converting to the new nomenclature requires retraining of staff or creation of templates, depending on the treatment planning system implemented. Our work aims to provide a simple method of creating DICOM RT Structure files, along with providing several templates already conforming to Report 263. The C# program has been written as an installable executable on any Windows system, and has been evaluated for ease of use and functionality. The program will be publicly available via our GitHub page, allowing feedback and improvement as needed from community use.

# Introduction

In the creation of a treatment plan within radiation oncology, regions of interest (ROIs) must be defined. These ROIs can be the target of radiation therapy, organs at risk (OARs), or contrast agents, etc. While the Digital Imaging and Communications in Medicine (DICOM) provides a standard for communicating these generated structures (RT-Structures) in treatment planning systems, the creation of the RT-Structures is often left to the treatment planning system.

The most important ROIs will vary based on the treatment site. For example, when treating disease in the skull, the Liver will likely not be of interest. Depending on the treatment planning system, the user will then be required to manually create each ROI, individually labeling the structures involved (‘Brain’, ‘Brainstem’, etc.). This can be not only tedious, but also error prone (‘Brian’ instead of ‘Brain’). Furthermore, the naming of an ROI can vary from person to person (‘Lung\_R’ vs ‘Right Lung’). While several treatment planning systems provide a method of creating templates to automatically create the desired ROIs based on the treatment site[ref for varian, others?], these templates must be created manually.

The American Association of Physics in Medicine (AAPM) has created Report 263 titled ‘Standardizing Nomenclatures in Radiation Oncology’, whose purpose is to provide guidance on naming of ROIs. Unfortunately, adoption of this can be difficult based on the tools available in the clinic. In a recent survey provided by TG-263, 689 responses from members of AAPM, the American Society for Radiation Oncology (ASTRO), and the American Association of Medical Dosimetrists (AAMD) were asked about their likelihood for adopting TG-2631. For respondents who had not yet adopted the new nomenclature, the majority stated that the largest hurdle was difficulty with retraining staff and/or a lack of time/resources to create new templates. With this work, we hope to provide a simple, server based system that will automatically create the desired RT-Structure files, and provide several ‘standard’ templates for commonly treated sites.

# Methods and Results

The program was written using the C# coding language [ref]. Manipulation of DICOM files was facilitated via the publicly available FellowOakDicom package2, and a C# wrapper for the ITK coding package, SimpleITK3.

## Creation of Template

The basic layout of the program is to create an RT-Structure file based on the ROIs present within a template. Templates can be user defined, or built from the default structures provided in the program. These default structures are based on ROIs defined at [anonymized for submission purposes].

The template is saved and read as a folder containing a ‘Paths.txt’ file, which indicates where the program should watch for DICOM files, and an ‘ROIs’ folder.

### Creation of ROIs

Each ROI is saved as an individual text file, consisting of three lines. The first line is the RGB color which will be presented for the ROI in the treatment planning system. The second line is the associated ontology, which will be further discussed below. The third line is the ROI interpreted type, as listed in the DICOM Standard Brower: <https://dicom.innolitics.com/ciods/rt-structure-set/rt-roi-observations/30060080/300600a4>. The interpreted type can be changed at any time within the template software, as shown in Figure 1.

Graphical user interface, application

Description automatically generated

Figure 1: Ability to change the interpreted type of a region of interest after creation. Likewise, the color, name, and ontology can be changed

ROIs can be added manually, or uploaded from an existing RT-Structure file, via the ‘Add ROIs from RT Structure File’ button. This will populate the template with ROIs, and populate the available Ontologies based on the ontologies present in the RT Structure.

### Defining monitored DICOM paths

User specified paths must be provided for each template. These paths are locations where RT structures files will be created. Paths can be added within each template with the ‘Edit monitored DICOM paths’ button.

### Creation of Ontologies

DICOM RT Structures have an Identification Code Sequence which is a code, typically an unambiguous sequence of numbers, that relates the ROI with a name defined by the coding scheme. The sequence is defined by several items, including a code value, coding scheme designator, and code meaning. Detailed descriptions of each of these can be found in the DICOM Standard Brower, <https://dicom.innolitics.com/ciods/rt-structure-set/rt-roi-observations/30060080/30060086>.

Any newly created ROI is required to have an associated ontology. These can be uploaded manually, by including a Common Name, associated Code, and Code Scheme. For example, the ‘Brain’ in the Foundation Model of Anatomy (FMA)2 is defined as having a code value of 50801 (<http://purl.org/sig/ont/fma/fma50801>), Figure 2. A list of available code schemes can be found online: <https://dicom.nema.org/medical/dicom/current/output/chtml/part16/chapter_8.html>.

Graphical user interface, diagram

Description automatically generated

Figure 2: Demonstration of ontology ‘Brain’. Based on the FMA model, the ‘Brain’ has a code value of 50801.

When ontologies are not present, a newly created ROI will default to ‘Undefined Normal Tissue’, this is not an FMA ontology, but instead a Varian Medical Systems code.

## Creating RT Structures

The main RT-Structure server is started by selecting the ‘Run DICOM server’ on the main splash screen. While running, the program will loop through each of the monitored paths defined within each template. A file system watcher monitors for file changes at each path, waiting 3 seconds between each change to ensure all files are uploaded before the process begins.

An image series reader then identifies all present DICOM files, separating them based on the series instance UID. This ensures that a unique RT structure file will be made for each image series, even if all the files are placed within the same folder.

For each unique series instance UID, a new RT-Structure file is created, updating the necessary frame of reference UID, and SOP Instance UID for the associated images. Several other DICOM tags are associated with the Structure to match the associated image, including: study time, study date, accession number, referring physician name, study description, patient name, patient ID, patient birthdate, patient sex, study instance UID, and study description.

To prevent the program from recreating the RT-Structure file, it will check if a file exists of the form ‘Template\_UID’, Figure 3.

Graphical user interface, application

Description automatically generated

Figure 3: Example of three created RT-Structure files, the standard naming convention creates a fast way of ensuring the program does not recreate pre-existing structures.

Generated RT Structure files have been evaluated within the treatment planning system of Eclipse. Colors are accurately represented, as well as names, interpreter types, and associated ontologies, Figure 4.

Graphical user interface

Description automatically generated

Figure 4: Evaluation of generated RT Structure ‘TG263\_Breast’ after importation into anonymized patient

## Program Installation

The program can be downloaded as a standalone executable from our google drive, [anonymized for submission]. Future updates to the program can be identified via our GitHub page, [anonymized for submission], or built from the source code.

# Discussion and Conclusion

RT Structure files are generated within 5 seconds of the images of being uploaded to the monitored paths, making it efficient with regard to clinical workflow. Templates can be easily edited in case of future changes, and default TG263 templates can be easily downloaded from our publicly available google drive.

We believe this simple tool can be of significant benefit to clinics which do not have access to templates within their treatment planning systems, or do not have sufficient resources to create new templates.

# References

1. Larouche, R., Mayo, C., Tantot, L., Ying, X., Covington E. Update from AAPM TG263U1: Standardizing Nomenclatures in RO. In: ; 2022.

2. fo-dicom/fo-dicom: Fellow Oak DICOM for .NET, .NET Core, Universal Windows, Android, iOS, Mono and Unity. Accessed July 22, 2022. https://github.com/fo-dicom/fo-dicom

3. Beare R, Lowekamp B, Yaniv Z. Image segmentation, registration and characterization in R with simpleITK. *J Stat Softw*. 2018;86(1):1-35. doi:10.18637/jss.v086.i08

4. Foundational Model of Anatomy - Summary | NCBO BioPortal. Accessed July 22, 2022. https://bioportal.bioontology.org/ontologies/FMA?p=summary