User Interface Design Document

Enabling 3D Printing of a Medical CT-Scan:

A Web App for Patients and Practitioners

Prepared by The Slice Is Right

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Client: Terry Yoo

COS 397 - Computer Science Capstone 1

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1. Introduction

The purpose of this project is to create a browser-based, client-side web application that allows users to upload medical CT scans in DICOM format, view the volumetric data, and generate anatomical models that can be printed in both STL and G-code formats. One of the main goals is to address the client's need for research software that can convert CT data into 3D-printable models of bone, skin, and muscle, while also making sure that all medical data stays on the user's local computer for privacy and security reasons. To achieve this, the tool will make use of open-source components, such as DICOM readers, Marching Cubes surface extraction, STL writers, and custom algorithms for generating G-code, adapting or extending them as needed to support medical imaging research in the Laboratory for Convergent Science. The client is looking for a way to make it easier to select tissues, preview models, and export files for use in clinical, educational, and research settings. This document will describe the user interface that will help accomplish these tasks, and it is being submitted as part of the capstone requirement for the Bachelor of Science in Computer Science at the University of Maine.

1.1 Purpose of This Document

This User Interface Design Document serves to outline and explain the visual and interaction design choices made for the *Enabling 3D Printing of a Medical CT-Scan* system. It is intended for a range of readers, including the customer, course instructors, and the development team known as The Slice Is Right. The document lays out the standards for the interface, including how screens are organized, how users will navigate through the system, and the rules for entering data. These elements are all designed to support the workflow that was described in the project proposal, which involves selecting CT data, choosing specific tissue types, previewing the results, and finally exporting either STL or G-code files. By establishing these specifications, the document aims to guide the implementation process and to make sure that the interface remains consistent, easy to use, and maintainable across all browsers and operating systems that are supported.

1.2 References

Primary Project Source

Yoo, Terry. *Enabling 3D Printing of a Medical CT-Scan: A Web App for Patients and Practitioners.* University of Maine, Laboratory for Convergent Science, 2025.

Web and Technical References

- "DICOM Standard." National Electrical Manufacturers Association (NEMA). Available at: https://www.dicomstandard.org/
- Lorensen, William E., and Harvey E. Cline. "Marching Cubes: A High Resolution 3D Surface Construction Algorithm." *ACM SIGGRAPH Computer Graphics*, vol. 21, no. 4, 1 Aug. 1987, pp. 163–169, https://doi.org/10.1145/37402.37422.
- "STL (File Format) Specification." 3D Systems. Available at: https://www.3dsystems.com/support
- "G-code Reference." RepRap Wiki. Available at: https://reprap.org/wiki/G-code websites).
- "JavaScript library for scientific visualization"(vtk.js). Kitware. Available at: https://kitware.github.io/vtk-js
- "Vtk-s Github Repository." Kitware. Available at: https://github.com/Kitware/vtk-js/tree/master
- "Selenium Automates Browsers." Selenium. Available at: https://www.selenium.dev/
- "ITK-Wasm." *ITK-Wasm*, 2024, docs.itk.org/projects/wasm/en/latest/. Accessed 4 Dec. 2025.

2. User Interface Standards

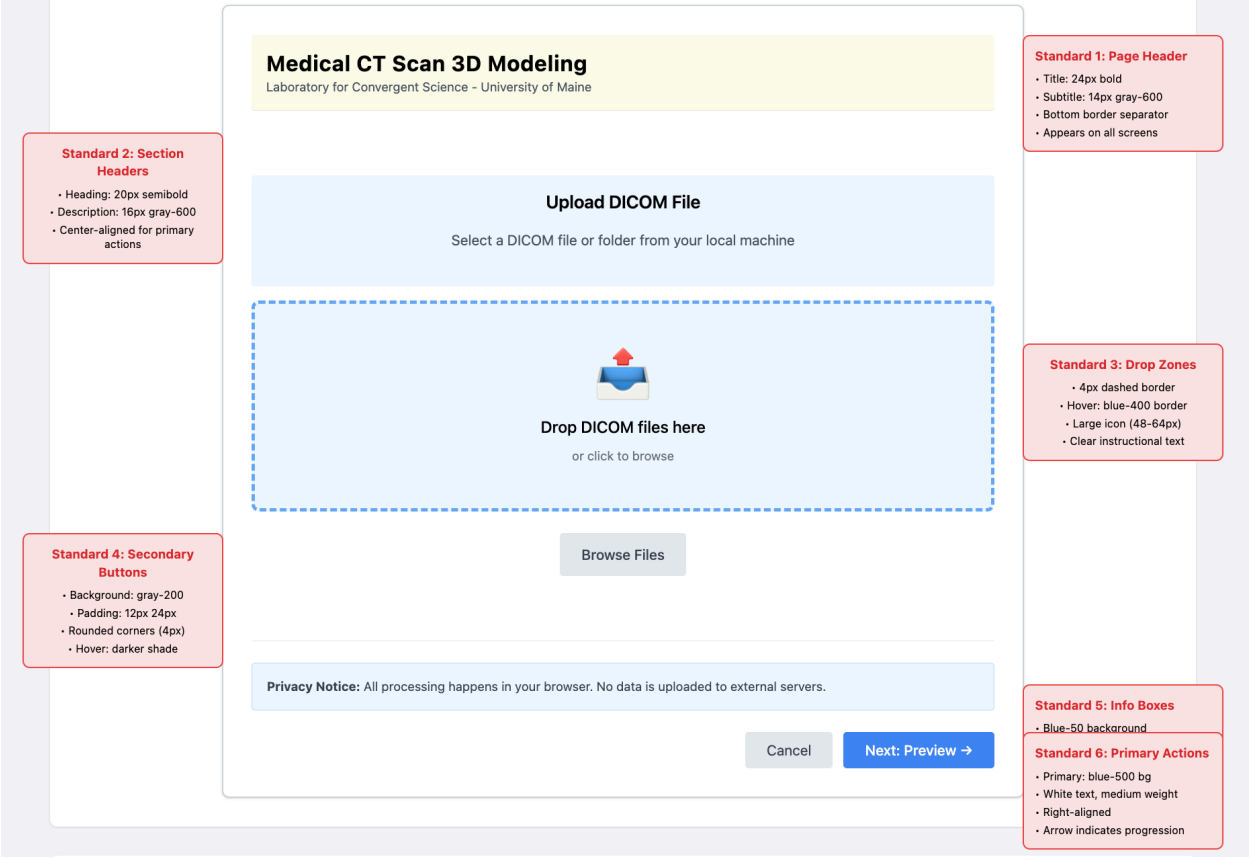
The user interface standards for the Slice Is Right system are outlined in detail. The primary purpose of setting these standards is to create a sense of consistency, predictability, and overall usability throughout every part of the web-based application. By defining the general layout, navigation structure, commonly used components, and the patterns for handling errors, these standards serve as the foundation for the entire system. Establishing these conventions is important because it allows users to have a unified and reliable experience as they move through tasks such as uploading CT scans, previewing anatomical structures, and generating printable output files. It is important to note that all of the screen designs, walkthroughs, and workflows that will be discussed in later sections are based on the principles and guidelines that are introduced here.

2.1 General Screen Layout

All screens in the system will follow a shared structural template consisting of:

1. Header Bar: Displays the application title, current file status(e.g., “No DICOM Loaded”), and quick-access icons.
2. Navigation Panel: Provides access to primary actions including Upload, Preview, Export, and Settings.
3. Main Content Area: Dynamically changes depending on the selected module (upload form, viewer canvas, Export selections, Settings).
4. Message/Alert Popup: Used for success notifications, warnings, and general errors.

Figure 2.1: General Screen Layout



Early conception of the General Screen Layout Including a DICOM file uploader with descriptions on actions and future existing items

2.2 Common Interface Components

- The following reusable components will be used throughout the system:
- Primary Action Buttons(e.g., “Upload”, “Preview”, “Export”):
    - Located in the top navigation bar. These represent the main actions users take within each module and follow a consistent color and style hierarchy.
- Secondary Buttons (e.g., “Reset”, “Cancel”, “Clear”)
    - Found within forms, upload areas, and settings panels. These perform reversible or less critical actions and are styled distinctly from Primary Buttons.
- Drop-down Selectors
    - Selectors follow consistent interaction patterns and validation rules. Used for choosing configurable options such as:
        - Slice thickness
        - Export resolution
        - Algorithm selection
        - Reconstruction or meshing presets
- File Input Component
    - A standardized uploader for importing .dcm files or zipped DICOM sets. This component includes file validation, drag-and-drop support, and visible progress reporting.
- 3D Viewer Canvas (VTK.js)
    - The interactive visualization window where CT slices, meshes, and thresholded anatomy are displayed. This component supports rotation, zooming, HU filtering, and slice navigation.
- Progress Indicators
    - Displayed during operations such as file upload, DICOM parsing, mesh generation, and STL export. These may appear as inline spinners, a progress bar, or step indicators.
- Hounsfield Unit (HU) Adjustment Slider
    - A real-time slider component that allows users to set HU window/level thresholds. Adjusting the slider updates the viewer immediately and is used for isolating tissue types (bone, skin, muscle).
- Viewer Interaction Controls
    - Standardized interaction methods available in all viewer-related modules:
        - Mouse wheel: zoom in/out
        - Click + drag: 3D rotation
        - Arrow keys: fine-grain rotation adjustments
        - Slice sliders: navigate through slices
    - These controls maintain consistent behavior across tools so users do not need to relearn interactions.

- Modal Dialogs
    - Used for critical confirmations (e.g., overwriting an export), platform warnings, and operations that require explicit user acknowledgement.

Each module reuses these components to ensure predictable behavior and consistent visual language throughout the application. .

2.3 Navigation Standards

Navigation is intentionally simple and task-oriented:

- A persistent top navigation bar that allows switching between Upload, Preview, Export, and Settings at any time
- Navigation should not interrupt long-running tasks such as DICOM parsing or mesh generation. Users should be able to view progress without losing work.
- Cancel and back options must be available in all modules where user actions can be undone.
- Viewer-specific controls (rotation, zoom, HU slider, slice sliders) remain active when navigating between preview-related submodules to ensure continuity.

2.4 Error Handling Standards

Errors will be communicated in a consistent manner across all screens:

- Inline Error Messages
    - Displayed under specific fields when invalid input is detected (e.g., invalid slice thickness, unsupported file type).
- Alert Bar Messages: Appear at the top of the content area for warnings, such as:
    - “Failed to parse DICOM header”
    - “Upload failed”
    - “STL conversion failed”
- Toast Notifications:
    - Used for positive or informational events (e.g., “STL exported successfully”).

Errors will always explain the issue and provide remediation guidance when possible.

2.5 Data Persistence Standards

The system uses lightweight browser-based persistence (cookies or local storage) to retain non-sensitive user preferences without requiring a login. This supports a smooth workflow by preserving:

- Last used HU slider values
- Preferred viewer orientation or slice position
- Recently used export settings (resolution, file type)
- Recently uploaded DICOM file

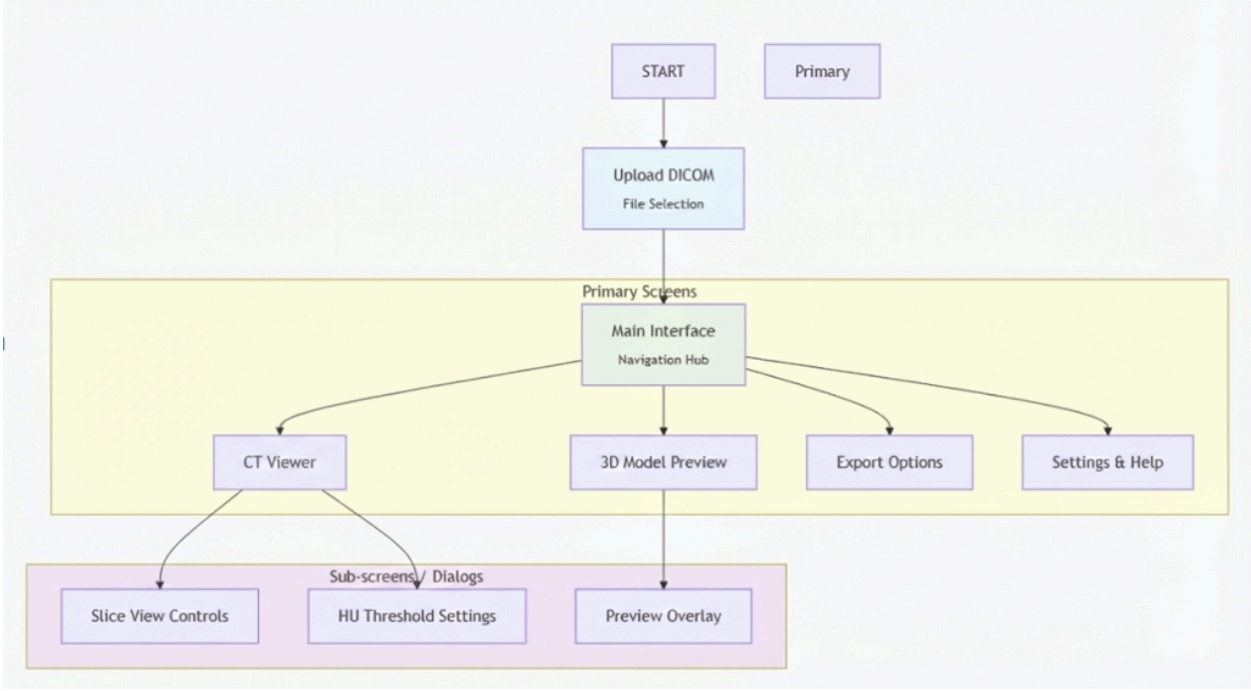
Persistent data never includes personal information; only settings that improve usability are stored.

3. User Interface Walkthrough

This section provides a comprehensive walkthrough of the primary user interface screens that make up the system. It begins with a navigation diagram illustrating how users move between major system components and continues with detailed screen mockups that demonstrate the layout and function of each interface. The walkthrough explains how users upload DICOM files, select tissue types, preview the resulting 3D models, and export files in STL or G-code format. All screens shown in this section follow the standards defined in Section 2, ensuring a consistent user experience across the application.

3.1 Navigation Flow

Figure 3.1 Navigation Flow



Typical Navigation of a user interacting with the system including where they would start and what would take the user where.

Application Purpose: A medical CT scan 3D modeling application that enables users to convert imaging data into 3D-printable models.

Core Workflow: The user flow begins with uploading DICOM files and progresses through visualization, segmentation, and export.

Key Feature - Data Privacy: All processing is performed client-side, ensuring no medical data is transferred over the network.

Navigation Structure: The app uses a hub-and-spoke model, centered around a "Main Interface / Navigation Hub."

Start Point: The journey begins at the "Upload DICOM / File Selection" screen.
Primary Screens: From the main hub, users can access four core modules:

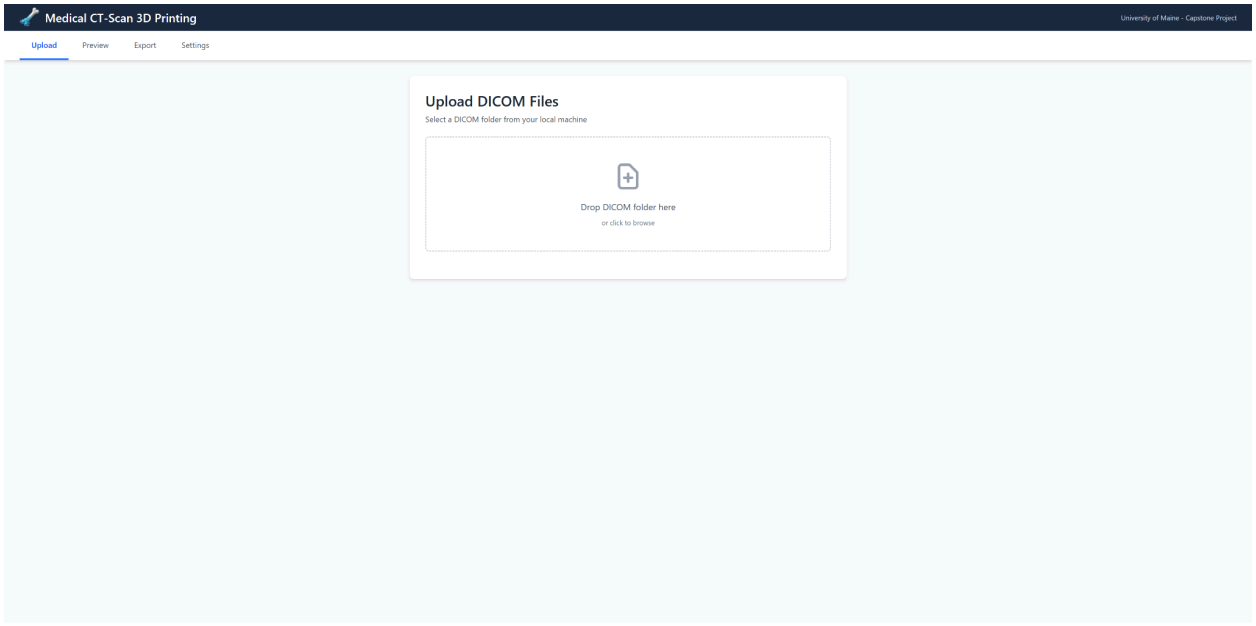
- Upload DCIM
- CT Viewer
  - Tissue Selection (Segmentation)
  - 3D Model Preview
- Export Options
- Settings & Help

Sub-Screens: Primary screens often contain specialized sub-screens for detailed tasks, such as "Slice View Controls" and "HU Threshold Settings" for the CT Viewer

3.2 Screen Walkthrough

Home Page

Figure 3.2 DICOM Uploader



Main Upload Area where the user can upload a DICOM scan into the dropbox area to allow the system to process it

Primary Method: A large, central interactive zone with the text "Drop DICOM files here or click to browse".

Functionality: This area supports the two standard methods for file input:

Drag-and-Drop: Users can drag one or more DICOM files or a folder from their desktop directly into this zone.

Click to Browse: Clicking anywhere in this zone will open the system's native file explorer dialog.

Action Button:

"Browse Files" Button: A secondary, explicit button to trigger the file browser. This provides a familiar, unambiguous alternative to clicking the upload zone.

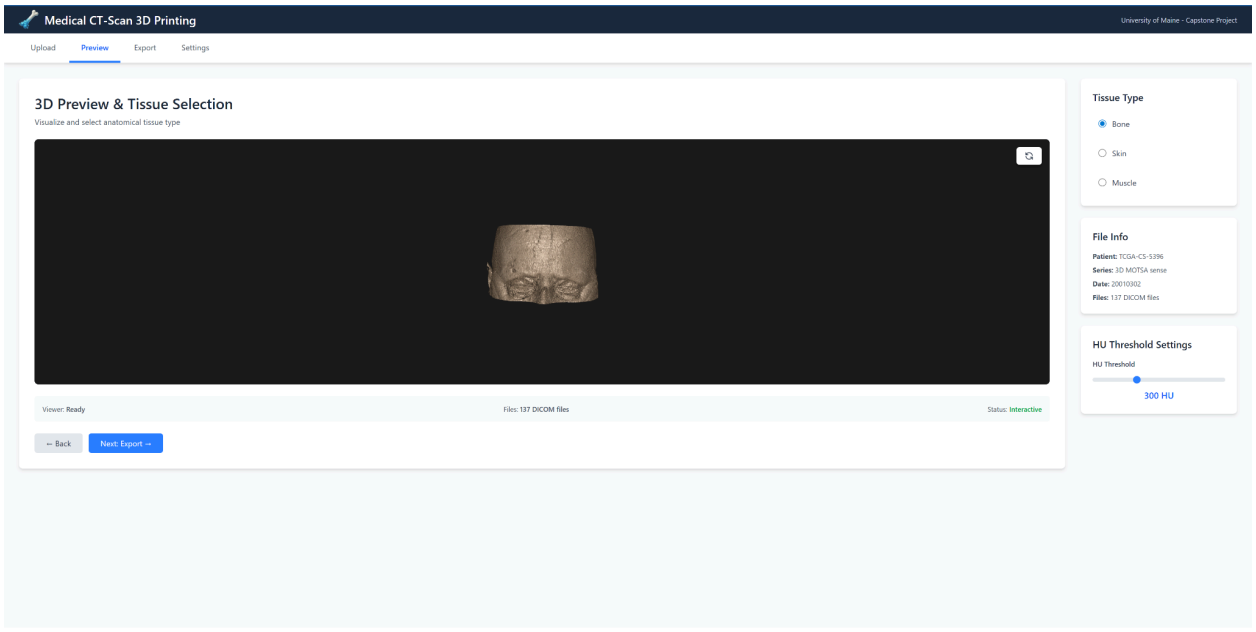
Standardized Navigation & Features:

Browser Back Button: The primary method to return to a previous screen or the application homepage is assumed to be the standard web browser's "Back" button, as no dedicated on-screen "Back" or "Cancel" button is present.

Proceeding to the Next Screen: Navigation to the next part of the application is automatic and triggered after a successful file selection and upload. the application will advance to “3D Preview” upon processing the valid DICOM data.

3.3 3D Preview

Figure 3.3 3D Viewer



After the user has uploaded a DICOM they can view it in the viewer, moving the figure and scaling it to their needs

Control Panels (Left Sidebar):

Tissue Type Selection: A list of anatomical presets (Bone, Skin, Muscle) allowing users to select which tissue to segment and visualize in the 3D preview.

File Information Panel: Displays crucial metadata from the loaded DICOM file:

File: The source file name
Slices: The number of axial slices in the volume
Dimensions: The voxel grid size
Spacing: The physical size of each voxel, indicating high resolution

HU Threshold Settings: Can control HU Threshold of the 3d model through this slider

Status Bar: Located below the control panels, it provides real-time feedback:

Performance: 30 FPS (Indicates smooth, real-time rendering)
Polygons: 125,430 (Shows the complexity of the currently displayed 3D mesh)
Status: Ready (Confirms the system is idle and awaiting user input)

Main Visualization Area:

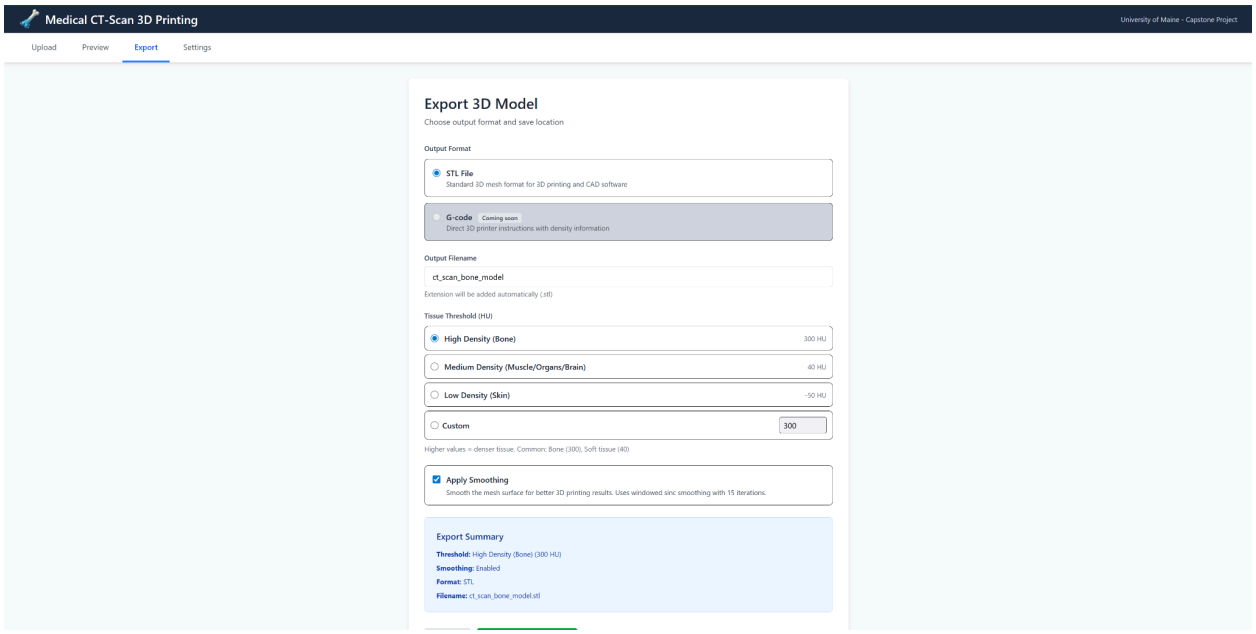
Label: "3D Model Preview"
Primary Function: An interactive WebGL viewport for the generated 3D model.
Interaction Hints: Labeled "[Rotate - Zoom - Pan]" instructs the user on how to manipulate the view using standard mouse/touch controls.

Navigation:

Proceeding Forward: A "Next: Export →" button or link is present, typically in the bottom-right corner, to advance to the export screen once the user is satisfied with the tissue selection and preview.
Returning Back: As a standardized feature, the user can likely use the browser's "Back" button to return to the previous screen (e.g., the DICOM upload page).

3.4 Export

Figure 3.4 3D Modeler Exporter



3D Modeler Exporter allows the user to customize their 3D model options and make it readily available to ship

Output Format Selection:

STL File Option:

Description: "Standard 3D mesh format for 3D printing and CAD software"
Key Features: Polygonal surface representation, compatibility with slicing software, preserves geometry.
Use Case: Standard 3D printing workflow where the user will use external slicing software.

G-code Option:

Description: "Direct 3D printer instructions with density information"
Key Features: Mimics X-ray attenuation, reproduces tissue density, ready for printing.
Use Case: Advanced users who want to print density-mapped models directly.

File Settings Panel:

Output File Name: An editable text field pre-populated with "ct_scan_bone_model" where users can customize the output file name. The appropriate file extension (.stl or .gcode) will be added automatically.

Save Location: Shows the current destination path "/Downloads" with a "Browse..." button to open a system dialog for selecting a different save folder. Help text "Select where to save the output file" provides additional guidance.

Export Summary Panel: Provides a final confirmation of the export parameters:

Tissue Type: Shows which segmentation preset is being exported)
Format: Confirms the selected output format

Estimated Size: Manages user expectations for file size
Processing Time: Informs the user about potential wait time

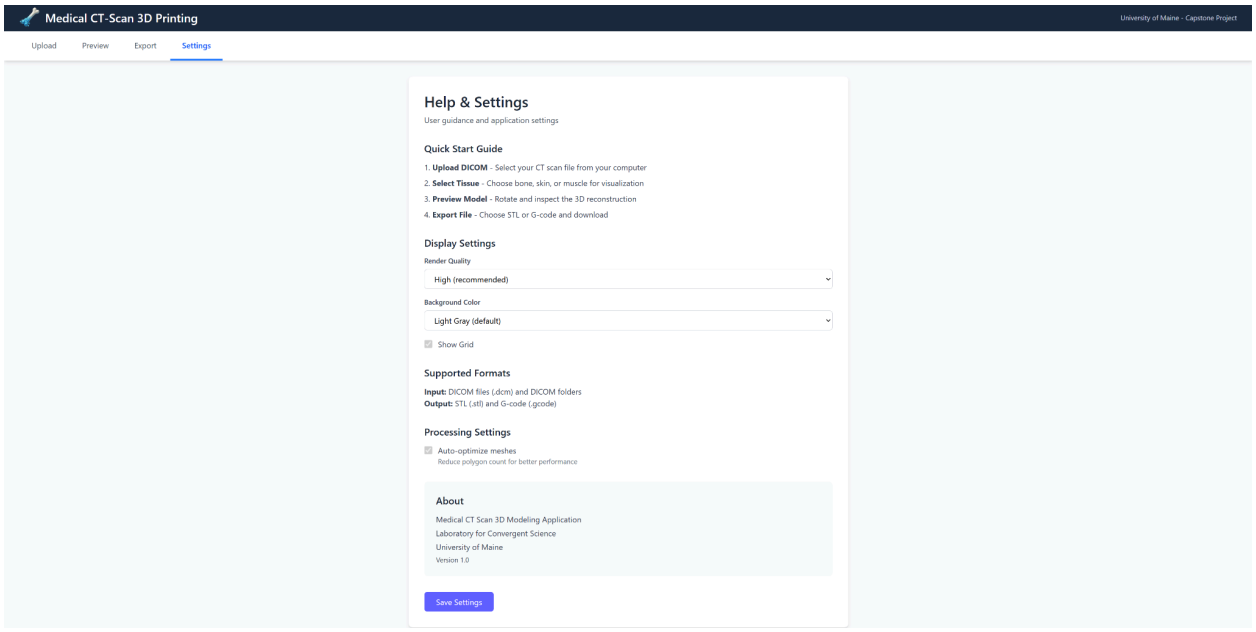
Action Buttons:

Back: Returns the user to the previous screen (3D Preview & Tissue Selection) to make changes.
Cancel: Aborts the export process entirely, likely returning to the main application hub.
Generate & Download: The primary action button that initiates the file generation process and triggers the download to the specified location once processing is complete.

Standardized Navigation: The browser's back button would provide an alternative method to navigate back to the previous screen, consistent with the application's navigation pattern.

3.5 Settings:

Figure 3.5 Help Page and Settings



The user can navigate through the help page if there are any issues with the navigation or understanding and the user can adjust their settings to customize the experience

Quick Start Guide Section: Provides a simple, 4-step workflow overview for new users:

Upload DICOM: Select CT scan files from the computer.
Select Tissue: Choose bone, skin, or muscle for segmentation.
Preview Model: Rotate and inspect the 3D reconstruction.
Export File: Choose STL or G-code format and download.

Display Settings Panel:

Render Quality: A dropdown (set to "High (recommended)") to balance visual fidelity against performance.
Background Color: A dropdown (set to "Light Gray (default)") to change the canvas color around the 3D model for better contrast.
Show Grid: A toggleable option to display a reference grid in the 3D preview.

Supported Formats Panel:

Input: Clearly lists accepted file types: "DICOM files (.dcm) and DICOM folders".
Output: Lists generated file formats: "STL (.stl) and G-code (.gcode)".

Processing Settings Panel:

Auto-optimize meshes: A checkbox option to "Reduce polygon count for better performance" during processing.
Default Export Format: A setting (shown as "STL") to pre-select the user's preferred output format.

Browser Compatibility Panel: Lists supported web browsers, with "Chrome (recommended)" highlighted, followed by Firefox and Safari.

Privacy & Data Panel:

> **Save recent files (cookies):** A toggleable setting for whether the app should remember recent files.
> **Clear History Button:** An action button that immediately wipes all locally saved browser data and cookies related to the application.

About Panel: Displays application information:

> **Application Name:** "Medical CT Scan 3D Modeling Application"
> **Developing Institution:** "Laboratory for Convergent Science, University of Maine"
> **Version Number:** "Version 1.0.0"

Navigation & Action Buttons:

> **Back to Home:** A navigation button to return to the main application interface or previous screen.
>
> **Save Settings:** The primary action button that applies any changes made to the settings. Changes are likely not permanent until this button is clicked.

Standardized Navigation: The browser's back button would provide an alternative method to navigate back without saving changes.

4. Data Validation

This section defines validation rules for all user-entered or user-selected data in the application. For each item we specify the control, data type, formats, limits (including boundary cases), defaults, and the precise validation behavior and error text.

ID	Screen / Control	Data item	Type	Allowed values / format	Limits & boundary cases	Required?	Default	Validation & error message
DV-01	Upload DICOM -> “Choose file(s)”	CT study files	File list	.dcm files or a DICOM folder (case-insensitive extension)	Min 1 file; Max total size ≤ 1.0 GB; must contain a single consistent series (orientation, spacing, dimensions); reject corrupt/non-DICOM; multi-series -> prompt to pick one; empty selection not allowed	Yes	—	On select: validate header + series consistency. Errors: “No DICOM files selected.” / “File is not valid DICOM.” / “Mixed or inconsistent series—select one series to continue.” / “Dataset exceeds 1.0 GB; load a smaller study.”
DV-02	Segmentation panel -> “Tissue”	Anatomical region	Enum	Bone, Skin, Muscle	Only these presets; switching re-applies thresholds	Yes	Bone	On change: re-segment + refresh preview. Error: “Unsupported tissue type.”
DV-03	Segmentation panel -> “HU Threshold”	Lower HU threshold	Integer	Whole number HU	Range −1024 … 3071; step 1; out-of-range clamps to nearest bound	No (overrides preset)	Preset per tissue	On blur: clamp; Error (only if typed outside range): “Enter a value between −1024 and 3071 HU.”
DV-04	Preview -> “Render mode”	Render mode	Enum	Surface, Volume	—	Yes	Surface	Invalid selection error: “Choose Surface or Volume.”
DV-05	STL Export -> “Smoothing iterations”	Mesh smoothing iterations	Integer	Digits only	0 … 10; step 1	No	2	Error: “Smoothing iterations must be 0–10.” (If post-process fails, export raw mesh and warn.)
DV-06	Export -> “Output type”	Export format	Enum	STL, G-code	Must match file extension rule in DV-08	Yes	STL	Error: “Select STL or G-code to continue.”
DV-07	Export -> “File name”	Output filename	String	1–128 chars; letters, numbers, spaces, dash/underscore; no path	Must not contain \/:*?"<>|; auto-append .stl or .gcode to match DV-06; not blank; deduplicate existing names by suffixing (1) etc.	Yes	Suggested from study UID (sanitized)	Errors: “Enter a file name.” / “File name contains invalid characters.” / “Extension doesn’t match selected format—using .stl/.gcode.” (App writes only to user-chosen location; no PHI embedded in exports.)
DV-8	G-code Settings -> “Printer profile”	Printer configuration	Enum	Generic FDM plus any user-saved profiles	If unavailable, fall back to default profile	No	Generic FDM	Warning (not blocking): “Printer profile unavailable—using defaults.”

Appendix A – Agreement Between Customer and Contractor

This User Interface Design Document constitutes a formal agreement between the Customer, Terry Yoo, and the Contractor, The Slice Is Right, regarding the architectural and detailed design for the Enabling 3D Printing of a Medical CT-Scan system. By signing below, both parties acknowledge that this document accurately translates the requirements specified in the Software Requirements Specification into a technical blueprint for system construction. The Customer agrees that this design provides a sufficient and appropriate basis for the system's implementation, and the Contractor agrees to develop a system that faithfully adheres to the design described herein.

Any future changes, additions, or modifications to the design specified in this document must be managed through a formal change control process. A request for change must be submitted in writing by either party and will be evaluated for its impact on the system's architecture, project scope, schedule, and feasibility. An amended version of this UIDD, or a formal change order referencing this document, must be mutually agreed upon and signed by authorized representatives of both the Customer and the Contractor before any design changes are implemented in the project.

Name	Signature	Date	Comments
Cooper Stepankiw			
Bryan Sturdivant			
Israk Arafat			
Greg Michaud			
Ethan Wyman			
Terry Yoo			

Appendix B – Team Review Sign-off

This document confirms that all undersigned members of The Slice Is Right project team have thoroughly reviewed the entirety of this User Interface Design Document for the Enabling 3D Printing of a Medical CT-Scan system. By signing below, each team member acknowledges their understanding of the proposed system architecture and detailed design and formally agrees that the content, scope, and technical direction outlined in this document are accurate, feasible, and provide a suitable foundation for the implementation phase of the project.

The comment section provided for each team member is to be used for noting any minor suggestions, editorial feedback, or non-substantive points of clarification. It is recognized that for this sign-off to be granted, there are no major points of contention regarding the architectural or detailed design decisions outlined within this UIDD.

Name	Signature	Date	Comments
Cooper Stepankiw			
Bryan Sturdivant			
Israk Arafat			
Greg Michaud			
Ethan Wyman			
Terry Yoo			

Appendix C – Document Contributions

Member Name	Primary Responsibilities	Estimated Percentage
Israk Arafat	Section 4	20%
Gregory Michaud	Introductions, 3.1	20%
Cooper Stepankiw	Appendix A,B,C, Section 3	15%
Bryan Sturdivant	Section 2, Section 3 mockups	25%
Ethan Wyman	Section 3	20%
Total		100%