Comp 145 UNC-Chapel Hill

Contract II

MIDAS

Submitted to

Dr. Stephen Aylward
and Prof. Greg Welch

February 13, 2001

________________________ Dr. Stephen Aylward, Client

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Preface

This document is the second version of the contract between Dr. Stephen Aylward and Group 5 (consisting of members; Adam Ross, Andy Mackelfresh, Anthony Chow, Mike Beranek, and Sharon Gravely). The first version of this document was delivered to Dr. Stephen Aylward on Monday February 5, 2001, and was discussed and revised by February 13, 2001. This contract may only be changed, if all parties involved agree to all the changes. Dr. Stephen Aylward and Group 5, must agree to and sign this document prior to continuing this project. This contract will be submitted on February 13, 2001

Document Change History

1/13/01

- Bumped previous section 5 to section 6
- Added new section 5 (validation and verification)
- Revised Preface
- Revised Introduction to become more smooth and more accurate according to Dr. Aylward

1/14/01

- Revised all parts of the document except Preface and Introduction
- Deleted State Transition Function, State Chart, Data Flow Chart 2
- Combined Data Flow Chart with the Stimuli and Actions associated with each Stimuli

Glossary

Sagital View – YZ viewing plane
Axial View – XY viewing plane
Coronal View – XZ viewing plane
CC – Cubic centimeters
MIDAS – Medical Image Display and Analysis System
MRI – magnetic resonance imaging
FLTK – Fast Light Weight Tool Kit
VTK – Visualization Tool Kit
MIDAS Libraries – Libraries used to manipulate and display the CT database
CT- Computer Tomography

1. Introduction

The project that we have taken on is called MIDAS (Medical Image Display and Analysis System). Midas is the Brainchild of Dr. Stephen Aylward. Dr. Aylward has developed some fundamental C++ libraries for viewing, analyzing, and displaying different types of medical scans (primarily CT but also MR slices). From this foundation he has gone on to attempt to create software to assist surgeons in a procedure called a Living Related Adult Partial Liver Transplant. This procedure involves removing half of a healthy adult liver and transplanting it to a relative of that person who has a failing liver. The problem with this procedure is that in order for the transplant to be successful each of the participants must receive a sufficient amount of the liver.

Currently transplant surgeons have no precise way to quantify how much of a liver is transplanted for a planned cutting path prior to the surgery. This makes the procedure very risky to both the donor and the recipient. The current technique for predicting liver transplant volume involves the surgeons studying a scan, one slice at a time and then creating a mental model of how to cut. The volume calculations are then estimated based on rough similarities between livers and ellipses. The combination of remembering the cutting plane and the rough estimates makes the predicted volumes very imprecise.

The software that is being developed will be a graphical interface where the surgeons will be able to use a modified scalpel and a touch screen to specify a cutting path on a scan's slices prior to beginning surgery. Using Dr. Stephen Aylward's libraries, the software will allow the surgeons to view the liver, as well as the vasculature within the liver in 3-D and also show the volumes of each part of the liver after the specified cuts have been made. The overall goal of everyone's efforts is to reduce the risk and increase the success of this procedure in the near future.

2. User-Level Requirements Specification

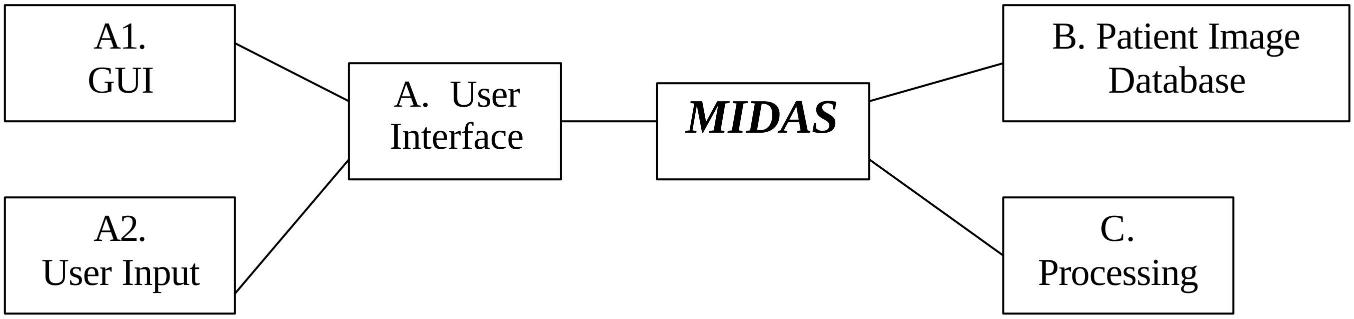


Figure 1: Context Model Diagram

2-A. User Interface / Options

The design for the user interface is one of simplicity and ease of use. The various buttons and their corresponding functions are listed below:

- Sagital/Axial/Coronal views toggle between the different views of the liver.
- Right lobe field displays the right lobe percentage of the whole.
- Right lobe volume field displays the right lobe volume in CCs.
- Total volume field displays the total volume in CCs.
- 2-D CT Image is displayed in the left-hand graphics window.

- 3-D Liver Image with corresponding surgical cutting plane is realized in the right-hand graphics window via VTK.
- Zoom button allows user to zoom used in conjunction with up and down arrows to zoom in and out of a certain slice.
- Slice button allows user to choose between different slices of data used in tandem with the up and down arrows to select the previous or next slice.
- Overlay button and overlay text box allows user to specify how many layers (slices) they wish to cut at one time (i.e. the depth of the cut).
- Undo button allows user to undo a selected number of slice cuts at one time.
- The 'files/about' pull down menu will allow file saves, program exits, etc., and provide information about the program.
- Confirm Cut button lets the user decide when they are completely done with a particular cut.

2-A1. GUI

The graphical user interface is to be created using FLTK. Its function is to allow the user to interact with the MIDAS program via the touch screen.

2-A2. User Input

The user interacts with the program via the touch screen. The touch screen is what makes this application so easy to use. Using only a scalpel (same functionality as a mouse) the user can designate a cutting path for the liver. This allows for steady hand movement and more accurate cuts.

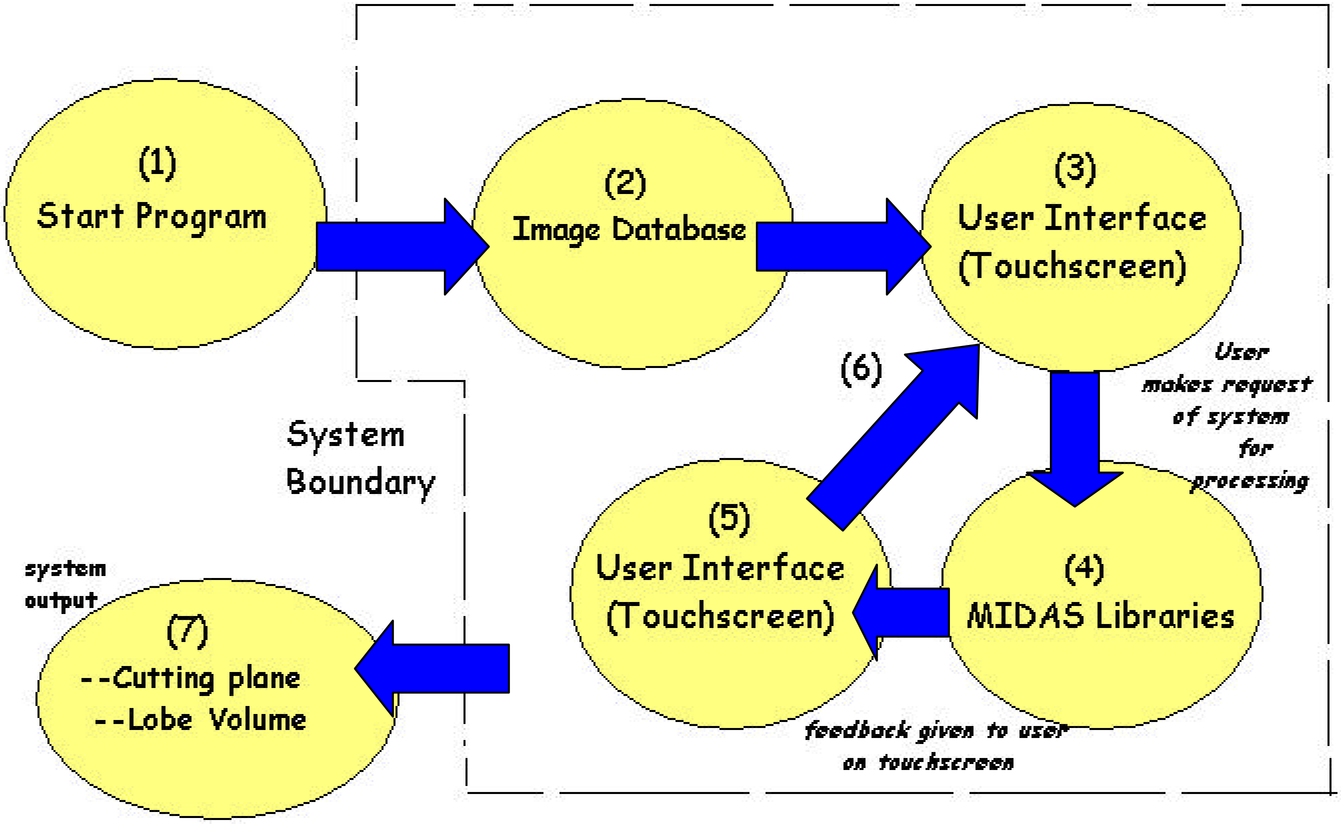
2-B Patient Image Database

The database consists of the collection of images (e.g. set of CT slices) that are available for manipulation during the course of this project from Professor Aylward. The collection of images will be displayed to the user interface via MetaImage for manipulation.

2-C Processing

Processing will be done via the MIDAS libraries. These libraries were created by Professor Aylward and are used to process the information designated by the user at the touch screen. The user can get immediate feedback on the percentages and CCs of each liver half after a request is sent.

Process Model



1. Start Program	The GUI interface is executed
2. Image Database Accessed	Image data processed and displayed in GUI
3. User request	Sends request from touch screen to processing
4. Processing	Request processed by MIDAS libraries
5. Receive response	User receives feedback via GUI
6. User makes more requests	Cycle continues
7. System output	Generated after series of request/processing interactions. Cutting plane established according to physician-specified path. Lobe volume established after each successive cut (on touch screen)

3. System-Level Requirements Specification

3.1 System-Level Requirement Specification

See Appendix A

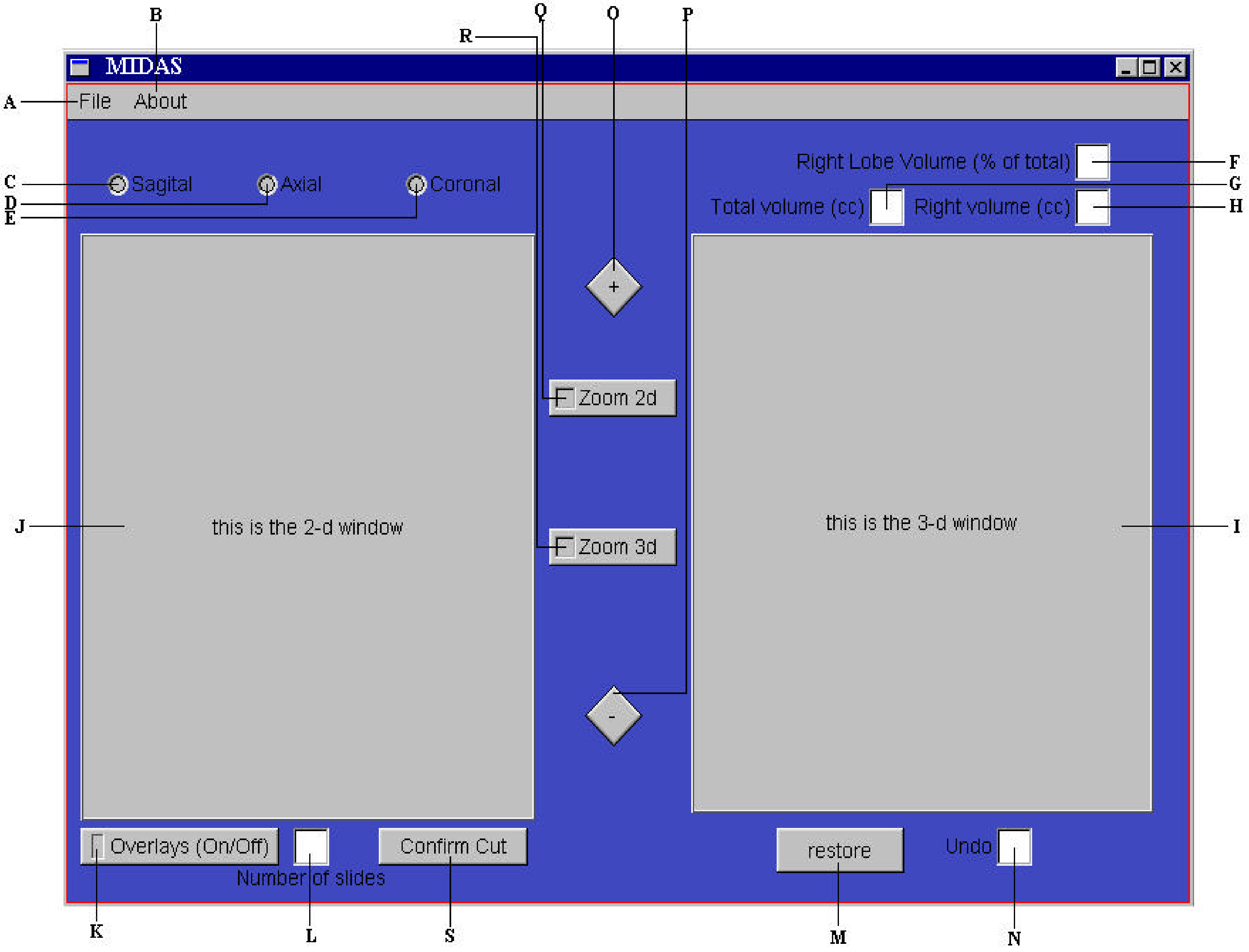
3.2 User Interface Requirements

Plan A

- Selection of Patient Image Database for that particular patient's liver
- Implementing widgets (Confirm Cut, Previous and Next Slice)
- Area displaying the 2-D slice will be displayed
- Area displaying the 3-D liver will be displayed

Plan B

- Implement cutting in the 2-D window by placing alpha blended quads where the surgeons cut (as opposed to eroding data from the Patient Image database)
- Implement an Undo button to erase cuts made
- Implement an independent zoom for 2-D CT image
- Implement an independent zoom for 3-D CT image
- Implement an auto-save function
- Implement Print 2-D window
- Implement Print 3-D window
- Implement Volume calculations and text output to the GUI
- Implement Overlay button and the number of overlays



	BUTTON / DISPLAY BOX	ACTION
A)	File	Opens file window to save, open new Patient Image Database, print 2-D 3-D window, exit
B)	About	Programmer credits
C)	Sagital	Changes image in 2-D window to the sagital view
D)	Axial	Changes image in 2-D window to the axial view

E)	Coronal	Changes image in 2-D window to the coronal view
F)	Total Volume	Displays the total volume of the liver in CCs
G)	Right Lobe Volume (%)	Displays the volume of the right half of the liver in %
H)	Right Lobe Volume (CC)	Displays the volume of the right half of the liver in CCs
I)	3-D Window	Displays the 3-D image of the liver from the Patient Image Database
J)	2-D Window	Displays the 2-D image of the liver from the Patient Image Database
K)	Overlays (On/Off)	Turns the overlays on and off
L)	Number of Slides	Text box for the user to indicate the number of Images to overlay
M)	Restore	Restores 2-D image to state before X cuts were made (works with [N] below)
N)	Undo	Text box for the user to specify the number of cuts to remove (works with [M] above)
O)	Plus (Up)	This cycles forward to the next Image or zooms closer depending on which button has been pressed by the user (works with [Q], [R], & [S] below)
P)	Minus (Down)	This cycles backwards to the previous Image or zooms away depending which button has been pressed by the user (works with [Q], [R], & [S] below)
Q)	Zoom 2-D	Enables zoom ability in the 2-D image
R)	Zoom 3-D	Enables zoom ability in the 3-D image
S)	Confirm Cut	Enables the calculations to occur and display the new data to the screen

3.3 Non-Functional Requirements

- Portability – FLTK can run on Windows or Unix environments
- Speed – Quick loading of the Patient Image Database and data updates
- Reliability – auto-save function to ensure saved data
- Simplicity – User interface must be extremely easy to follow

3.4 Goals

The project's emphasis is providing a tool that can be used by clinicians including:

- A 3-D representation of the patient’s slices visualizing a pre-planned surgical cutting plane
- A very simple user interface that can be operated from a touch screen
- A 2-D view of the patient’s slices from any three positions (Axial, Coronal, Sagital)
- A tangible way for the surgeons to draw the surgical cut on each slice and have the software construct the planar surface from each marked slice

4. Hardware and Software Resource Requirements

In order for the product to work as expected, there will be recommended hardware and software requirements. The main hardware requirement will be a powerful cpu and sufficient ram to handle the intense calculations that must be completed in approximate real time. The software testing will take place on either a Pentium III 866mhz Workstation that currently resides in the Graphics lab, or on a Pentium IV 1.4Ghz which would be acquired in the future by Dr. Stephen Aylward. The desired interface involves user interaction via a touch screen, one of these units has been obtained, and was declared insufficient. Dr. Stephen Aylward has since ordered a different touch screen, which should arrive in the near future (by 2/23/2001). This should not have a significant affect on the development of the software, but the sooner a decision can be made the better the GUI can be tapered to the interface mechanism. The utility of a force feedback pen in place of a touch screen has been explored, but due to the cost may be used as a last option.

The software requirement that will be enforced is that the computer runs either a Windows based or Unix based operating system. Most of the software development will be done using Microsoft Visual C++ under windows, which is available in the labs in the department. Also the procurement of FLTK, VTK and the MIDAS libraries is essential in the completion of the final product and has already been obtained.

5. Validation and Verification

5.1) Strategy

In order to test the software, most of the high level, overall product functionality testing will be done using a black box testing method. This process will involve using many different CT scans and known values and comparing these values to the ones that our program yields. This testing will be done at or near completion of the product. Some form of white box testing will take place throughout the entire process. During the programming, since different people will be programming different components, each of the pieces will have to be tested to ensure that they not only achieve the assigned task, but also meet the parameter requirements that will allow all the pieces to work together.

5.2) Test Cases

- Is the UI intuitive and effective? Do the surgeons like what they see, and is the feedback they receive from the program helpful?
- Does each of the functions do their individual tasks?
- Do the functions use the correct parameters and return types?
- Is the cutting plane reflected correctly in the both the 2-d and 3-d windows?
- Using data from a previous transplant, compare the volume results obtained from that procedure to the volumes obtained by using MIDAS.
- Does the final product meet the specifications set forth at the beginning of the project?

6. Preliminary Schedule

6.1) Development Items

Major Phases

- Phase I (Pre-Design Phase)

  -Meet with client to gain a good working idea of project
  -Create a rough preliminary GUI
  -Meet with Surgeons and receive their input
  -Confirm proposed re-construction of GUI with Client
  -Gain sufficient knowledge of FLTK for designing GUI

- Phase II (Design Phase)

-Refine GUI
-Present refined GUI to Client
-Make any revisions based on Client's reaction

- Phase III (Coding/Testing Phase)

  -Familiarize ourselves with Doctor Aylward's C++ Libraries and VTK
  -Assign each team member tasks associated with "Plan A" (see 6.1.B)
  -Readjust assignments to fit time constraint if needed
  -Develop testing and test "Plan A" tasks as they progress

- Phase IV (Implementation Phase)

  -Implement "Plan A" tasks as they are finalized
  -Implement Touch Screen to be active with GUI
  -Test System coordination between GUI and Touch Screen
  -Revise System based on any errors found in testing

- Phase V (Plan B {if possible})

  -Assign each team member tasks associated with "Plan B" (see 6.1.B)
  -Develop testing and test "Plan B" tasks as they progress
  -Implement "Plan B" tasks as they are finalized
  -Test system with new buttons and make any necessary revisions

<u>Tasks and Dependencies</u> – consists of the functionality of the project implemented in the buttons of the GUI. There is a list of implementations for Plan A and B in section 3.2.

<u>Milestones</u>

- Preliminary Report
- Project Web I
- Presentation of Preliminary GUI
- Contract I (with Schedule I)
- Contract II (with Schedule II)
- Meet with Surgeons for input
- Design Specification (with Schedule III)
- Obtain a Base User Interface to work with
- User Manual I
- Prototype
- Group Status Report
- Implementation of Plan A tasks
- Implementation of Touch Screen
- Implementation of Plan B tasks {if possible}

- User Manual II
- Implementation Manual
- Group Presentation
- Project Package
- WWW site complete
- Team Report
- Individual Reports
- Final Project
- Class Complete

<u>Deliverables</u>

- Preliminary Report
- Contract I
- Contract II
- Design Specification
- User Manual I
- Prototype
- Group Status Report
- User Manual II
- Implementation Manual
- Project Package
- Team Report
- Individual Reports
- Final Project

6.2) Schedule Diagrams (following pages)

Can be found at http://www.cs.unc.edu/~gravely/library under the contract II link

Gantt chart
PERT chart

6.3) Risk Analysis and Management

As a group, we are concerned about the implementation of all tasks within the given time constraint of one semester. We are currently limiting our Plan A to a feasible amount of work to accomplish so that task assignments to each team member can better be accomplished. Adjustments could be made as to how much is assigned to each member later in the semester. Once Plan A is completed, the amount of Plan B that will be attempted will be assessed then.

Another concern deals with the security in using our finished project. Surgeons will be using this tool to specify a cutting plain for a liver. If there are errors in our system, this could mean, at the worst, a loss of a life during the actual surgery. To counteract this risk, we plan very strenuous testing procedures.