UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

(4)

REPORT DOCU

1a REPORT SECURITY CLASSIFICATION
Unclassified

AD-A207 722

2a SECURITY CLASSIFICATION AUTHORITY

MAY 15 1989

2b DECLASSIFICATION / DOWNGRADING SCHEDULE

4 PERFORMING ORGANIZATION REPORT NUMBER(S)
KSC-TR-88-003

5. MONITORING ORGANIZATION REPORT NUMBER(S)
0001AC

6a. NAME OF PERFORMING ORGANIZATION
Kensal Consulting

6b OFFICE SYMBOL (If applicable)
0D9C9

7a. NAME OF MONITORING ORGANIZATION
Office of Naval Research

6c. ADDRESS (City, State, and ZIP Code)
Building 36, 5701 E. Glenn St.
Tucson, AZ 85712

7b. ADDRESS (City, State, and ZIP Code)
800 North Quincy St.
Arlington, VA 22217-5000

8a. NAME OF FUNDING / SPONSORING ORGANIZATION

8b. OFFICE SYMBOL (If applicable)

9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
N00014-88-C-0717

8c. ADDRESS (City, State, and ZIP Code)

10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO.
SDIO-W	None	None	None

11. TITLE (Include Security Classification)
Technical Progress Report Number 3

12. PERSONAL AUTHOR(S)
Kendall Preston Jr.

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Progress	FROM 88DEC01 TO 88DEC31	89JAN15	36

16 SUPPLEMENTARY NOTATION

17 COSATI CODES		
FIELD	GROUP	SUB-GROUP
17	11	None
17	05	01

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
Target Detection, Cellular Automaton, Infrared, Signal Processing.

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

This project on subpixel target detection relates to research in the optimization of three-dimensional computing structures for use in target detection and to research in the reduction of an optimum computing to an efficiently-designed silicon chip. During the work period reported this project concentrated on developing a software package which would permit us to implement three-dimensional cellular logic for target detection on the Macintosh personal computer. The purpose of this package is to emulate target detection in the tetradecahedral tessellation. Results are displayed on the screen and may be printed or stored on disk for later use. Measurements may be made on the contents of the tetradecahedral workspace and stored for later analysis.

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT
☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS

21. ABSTRACT SECURITY CLASSIFICATION
Unclassified

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DD FORM 1473, 84 MAR

83 APR edition may be used until exhausted.
All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFIED

89 5 15 061

TECHNICAL PROGRESS REPORT

NUMBER 3

Topic Number: SDIO 88-10

Title: Three Dimensional Cellular Automata for Subpixel Target Detection

Contract Number: N00014-88-C-0717

From: Kensal Consulting, Tucson, Arizona (Code: 0D9C9)

To: Dr. Keith Bromley, NOSC, San Diego (Code: N00014)

Project Description:

This project on subpixel target detection relates to research in the optimization of three-dimensional computing structures for use in target detection and to research in the reduction of an optimum computing structure to an efficiently-designed silicon chip.

Technical Progress:

During December work on this project concentrated on developing a software package which would permit us to implement three-dimensional cellular logic for target detection on the personal computer which has been rented in accordance with our contract budget. After careful deliberation, a 68000-based machine was selected, namely, the MacIntosh II. The program description is the main topic of this report and is included in the following pages. The authors of this documentation are Messrs. Auvenshine and Carless, two Kensal engineers who are working part-time on this contract while pursuing their studies at the University of Arizona.

Plans for January 1989:

Plans for January 1989 are to continue and document our work with Visual Information Technology on chip design and, at the same time, continue analytical work based on both two-dimensional processing and three-dimensional processing, for the purpose of determining the optimum computing architecture in terms of pixels per unit time per device.

Three Dimensional Cellular Logic Data Analyzer

Kensal Consulting
PROJECT: 88507

General Description of Program:

The purpose of the Three Dimensional Cellular Logic Data Analyzer program is to demonstrate target detection in the tetradekahedral tessellation. For reference see Chapter 3 of Modern Cellular Automata. This program is designed to display and analyze three-dimensional threshold target data in any one of eight 64X64X56 workspaces. Commands are performed in the three-dimension tetradekahedral tessellation where each volume element is considered in conjunction with its twelve neighbors. The results are displayed on the screen and may be printed or stored on disk for later use. Measurements may be made on the contents of the workspace area displayed on the screen and stored for later analysis. The user interface is consistent with the standard for Macintosh™ applications as defined in Inside Macintosh, Volume I, Section 2.

Program Features:

The Three Dimensional Cellular Logic Data Analyzer program provides the following operations:

Disk File Operations - Both input and output of images in TIFF and Workspace format. Workspace format is simply a 64X64X56 bit stream unique to the Three Dimensional Cellular Logic Data Analyzer program. TIFF adds a standard Aldus/Microsoft TIFF header to the bit stream.

Display Operations - Any of the eight workspace areas provided in memory may be displayed on the screen for subsequent processing or printing. An example of a workspace area with the border set is shown in Figure 1.

Set Operations - This group of operations allows the user to set single voxels or groups of voxels such as boundaries, tracks, as well as geometric cubes and spheres. In addition, the workspace area displayed on the screen may filled with random noise or completely erased. All such set operations set voxels in the workspace area displayed on the screen to ones. A voxel which has been set to one is displayed as black, while voxels set at zero are displayed as white.

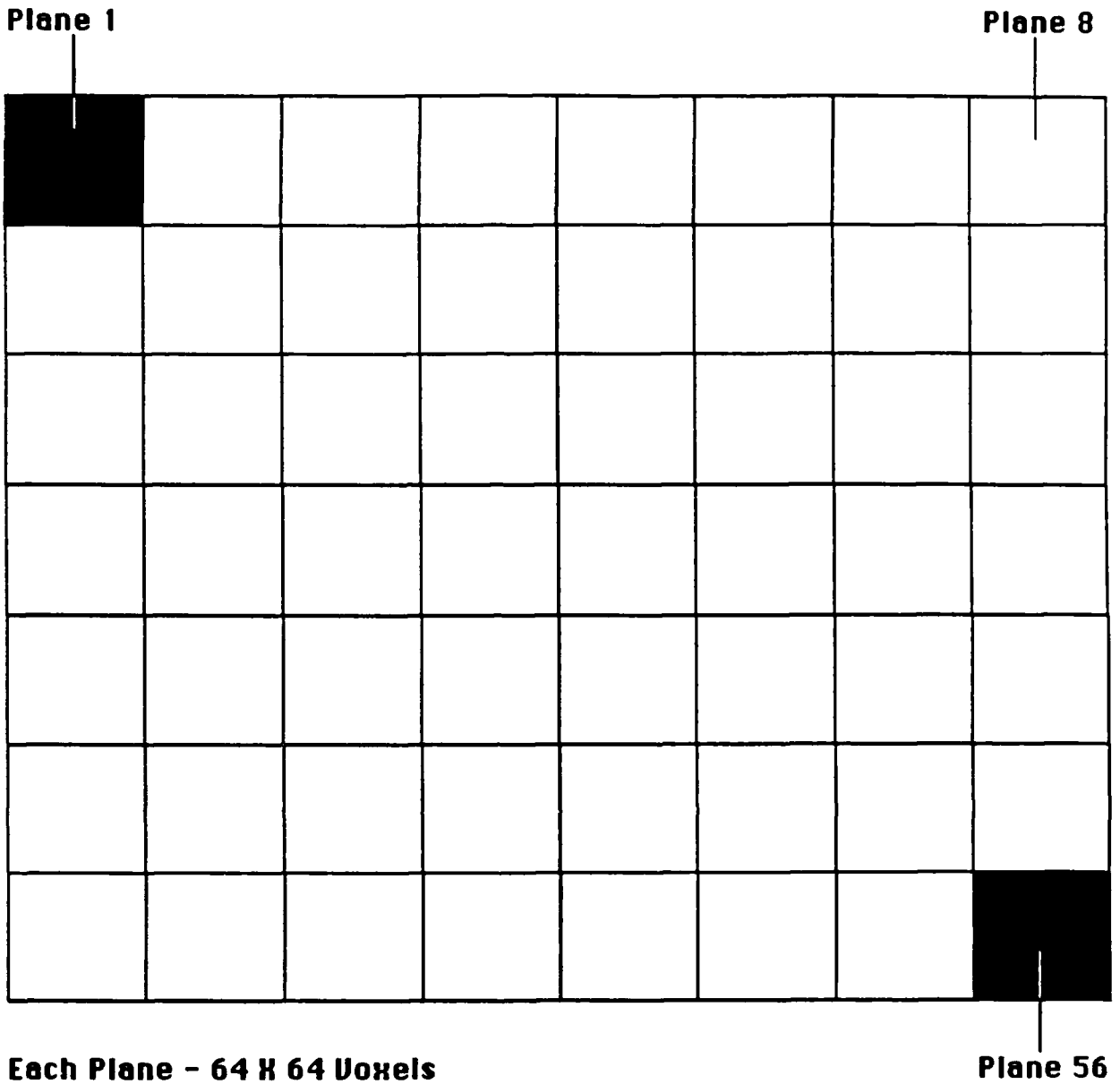

Figure 1

Boolean Operations - The program provides the AND, OR, Exclusive OR, and INVERT boolean operations from any two of the eight available workspaces into a third workspace.

Process Operations - The AUGRED and XIFILTER operations are available and act on the workspace which is displayed on the screen.

Copy Workspace - Any workspace area may be copied into any other workspace.

Measurement Operations - The total number of voxels in the displayed workspace may be counted. Measurements may be saved to a file on disk for later analysis.

Program Operation:

The Three Dimensional Cellular Logic Data Analyzer resides on the disk as a standard Macintosh application and is executed in the usual Macintosh fashion. The user may launch the program directly by selecting the program icon and then selecting "Open" from the desk top "File" menu, or by double clicking on program icon. The user may also launch the program indirectly by opening a workspace file, which automatically executes the Three Dimensional Cellular Logic Data Analyzer program and loads the selected workspace file into workspace area 1. The icons for the program and workspace files are shown in Figure 2. Workspace files are automatically given the icon labeled "Target 1" shown in the left of the "Triakis" window, while the program itself is represented by the icon labeled "3-D Data Analyzer" shown in the right of that window.

After the program has loaded, the main menu bar, shown in Figure 3, will be displayed. If the program was launched by selecting a workspace file, that file will be displayed on the screen underneath the main menu bar. With the exception of "Shade", any of the options on the main menu bar may be selected by pressing on them with the mouse. "Shade" is not implemented in this version of the program and has been dimmed to remind you that it is not supported.

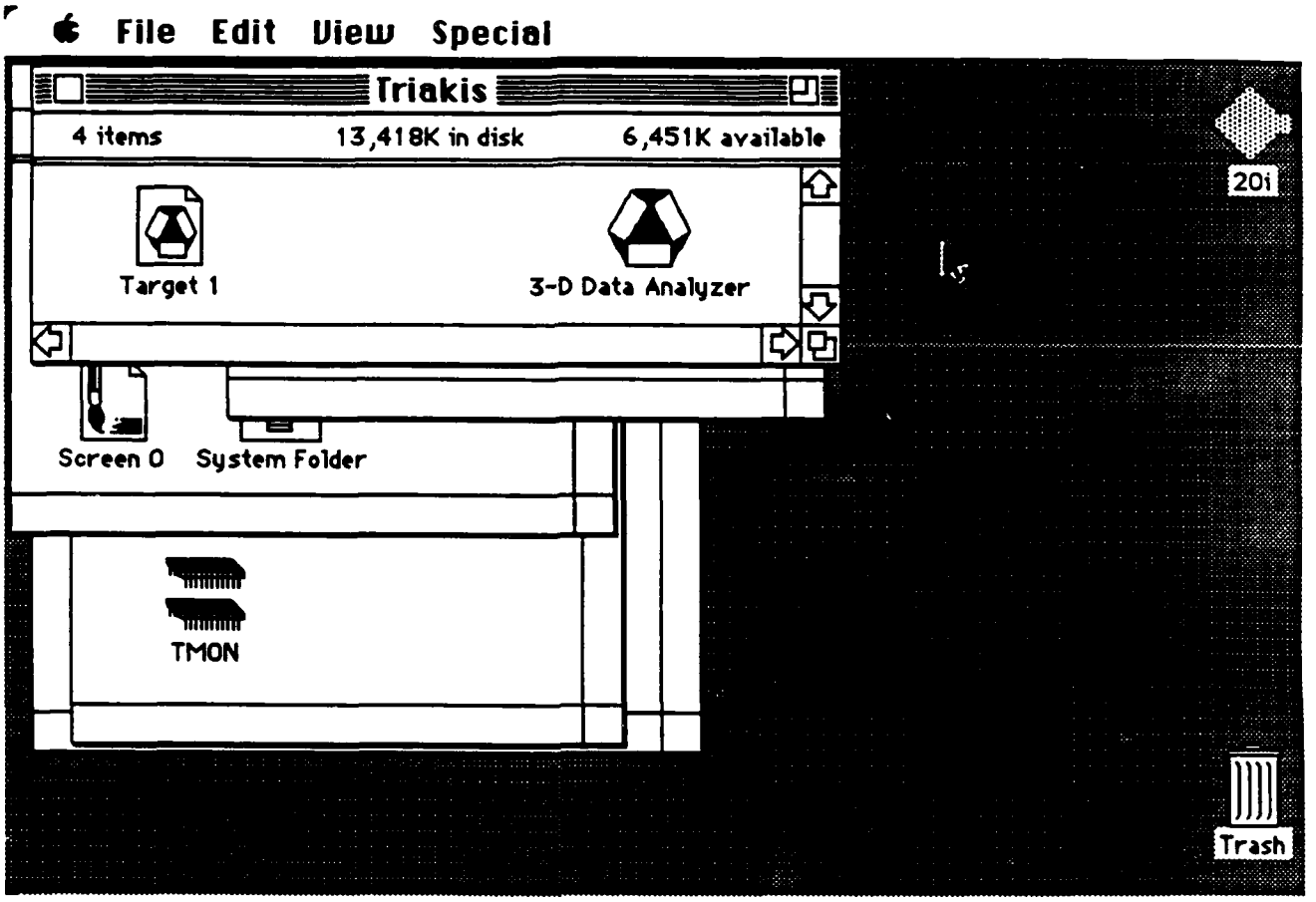

Figure 2

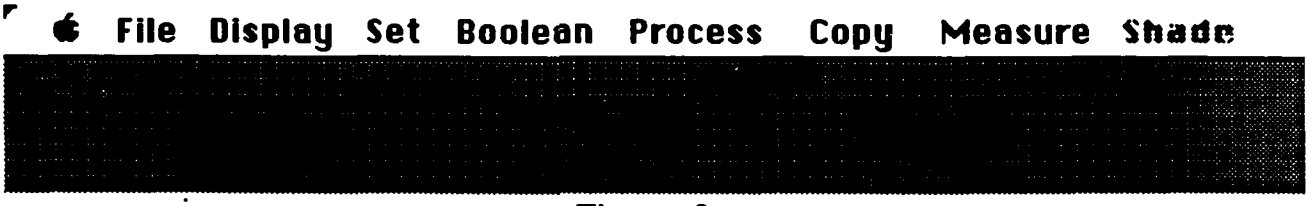

Figure 3

The File Menu: This menu contains all the commands necessary for handling workspace files on disk. Select the File menu by pressing on the word File in the main menu bar. Selecting the file menu produces the menu shown in Figure 4.

The Open Command: The Open command is used to load an existing image file into a workspace. The Open command may be executed by either selecting it from the File menu with the mouse or holding down the command key (⌘) while pressing O on the keyboard. When the Open command is selected, the selection box shown in Figure 5 appears. Select the workspace area you wish to load the image into. Next, select the folder where the image is located by using the file list and current folder boxes to traverse the disk directories. To see the files in a folder listed in the file list, double click on it with the mouse. To see the files in a folder which contains the current folder, press the current folder name (located directly above the files list) and then drag the highlight bar to the appropriate folder. To see the folders and files on another disk drive, click on the "Drive" button. To eject the floppy disk currently mounted in the drive so that another may be inserted, click on the "Eject" button. After you have selected the appropriate folder and the file you wish to load is displayed in the files list, select the file by double clicking on it. Once the selected image has been loaded, it will automatically be displayed on the screen.

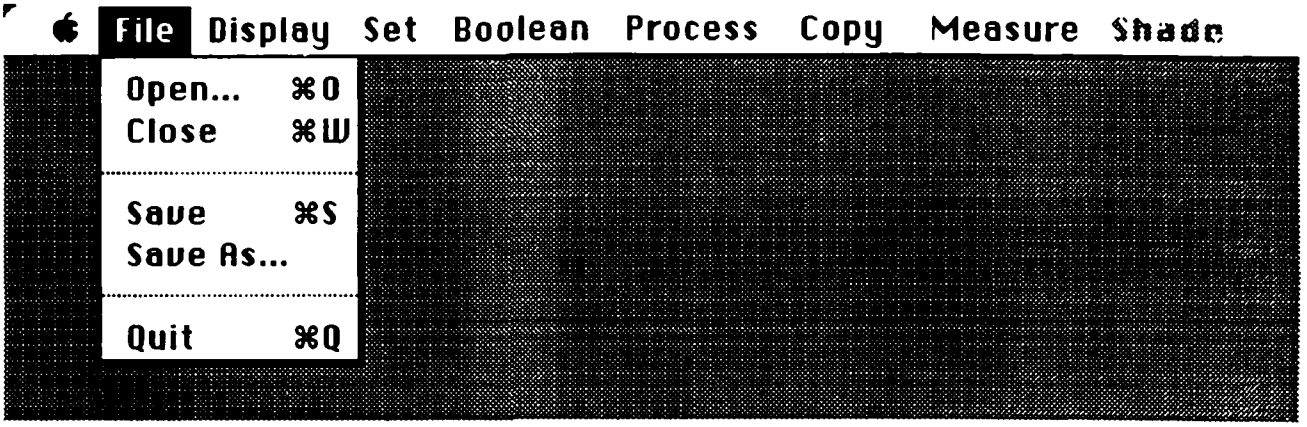

Figure 4

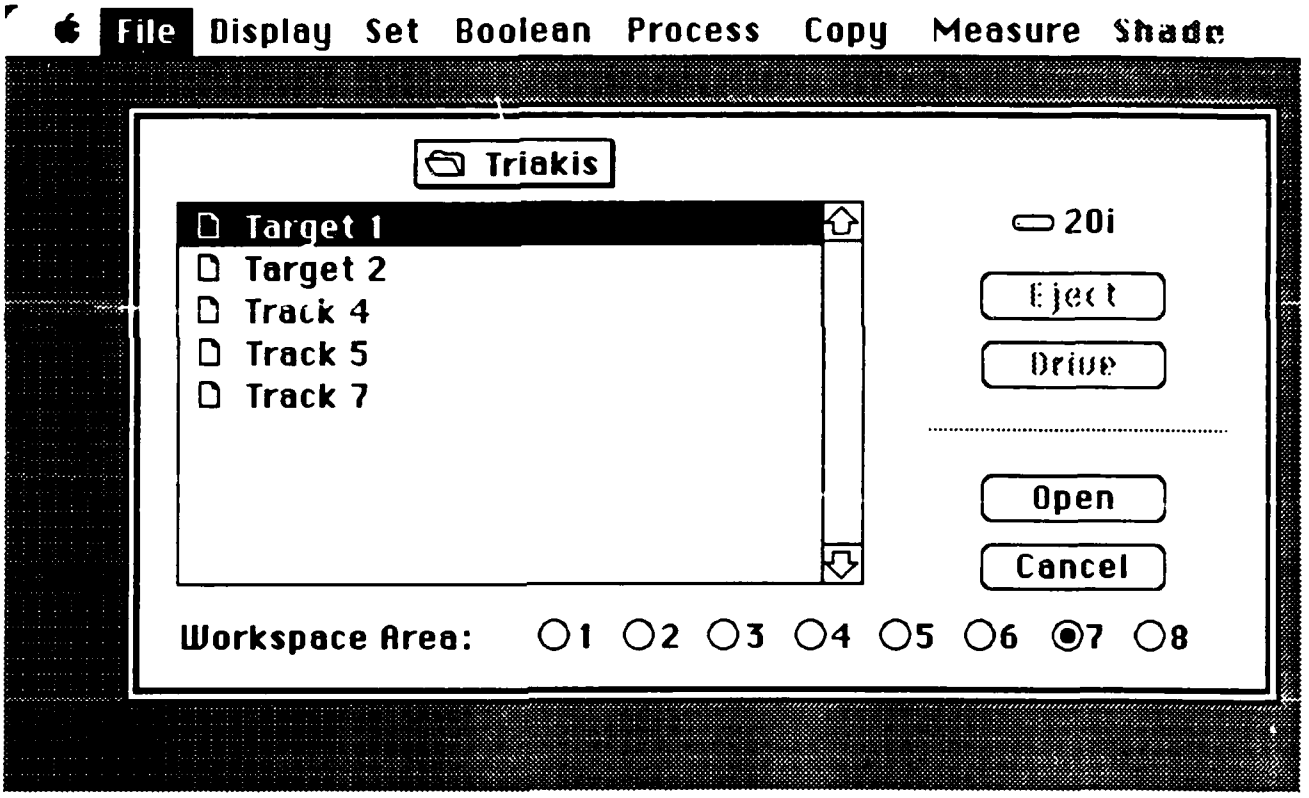

Figure 5

The Close Command: The Close command is used to close a workspace area without saving it. The Close command may be executed by either selecting it from the File menu with the mouse or holding down the command key (⌘) while pressing W on the keyboard. When the Close command is selected, the workspace area displayed on the screen along with its associated file information is cleared and control is immediately returned to the mouse unless changes have been made to the workspace since it was last saved. If you have not saved changes to the workspace you are attempting to close, you will be presented with the warning box shown in Figure 6. Pressing the return key or clicking on the "Yes" button will save the workspace before closing it in the same manner as the Save command described below. Clicking on the "No" button will close the workspace area without saving it, and clicking on the "Cancel" button will cancel the Close operation and return control to the mouse.

The Save Command: The Save command is used to save a workspace area to disk. The Save command may be executed by either selecting it from the File menu with the mouse or holding down the command key (⌘) while pressing S on the keyboard. When the Save command is selected, the workspace are displayed on the screen is saved to disk and control is immediately returned to the mouse unless the workspace area has not been assigned a file name. If the workspace does not have a file name, you will be presented with the "Save As"dialog box shown in Figure 7. Proceed according to the instructions for the "Save As" dialog box described with the "Save As" command below.

The Save As Command: The Save As command is used to save a workspace area which has not previously been given a file name or for which a new file name is desired. The Save As command may be executed by selecting it from the File menu with the mouse. When the Save As command is executed, you will be presented with the "Save As" dialog box shown in Figure 7. Select the format in which you wish to save the file by clicking on the "Workspace" or "TIFF" button. Then, select the appropriate folder for you file in the same manner as the was described with the Open command. Next, type in the appropriate file name. The file names of all existing files in the folder are shown in the dim font to remind you of which file names have already been used. When you are satisfied with the name, location, and format of the file, press return or click on the "Save" button to complete the operation. You may cancel the Save As operation by clicking on the "Cancel" button.

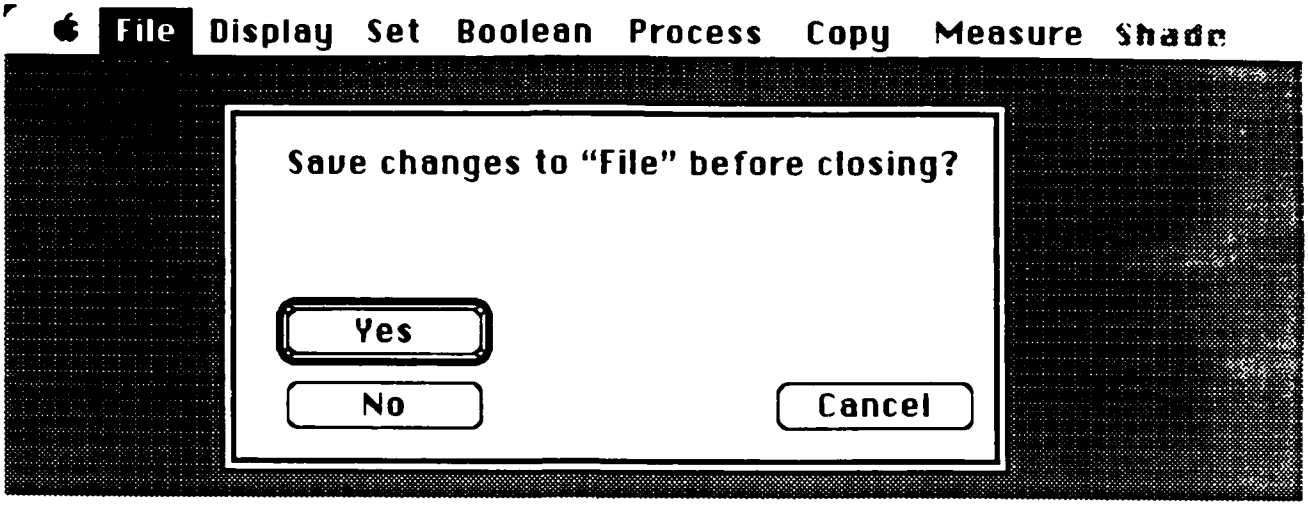

Figure 6

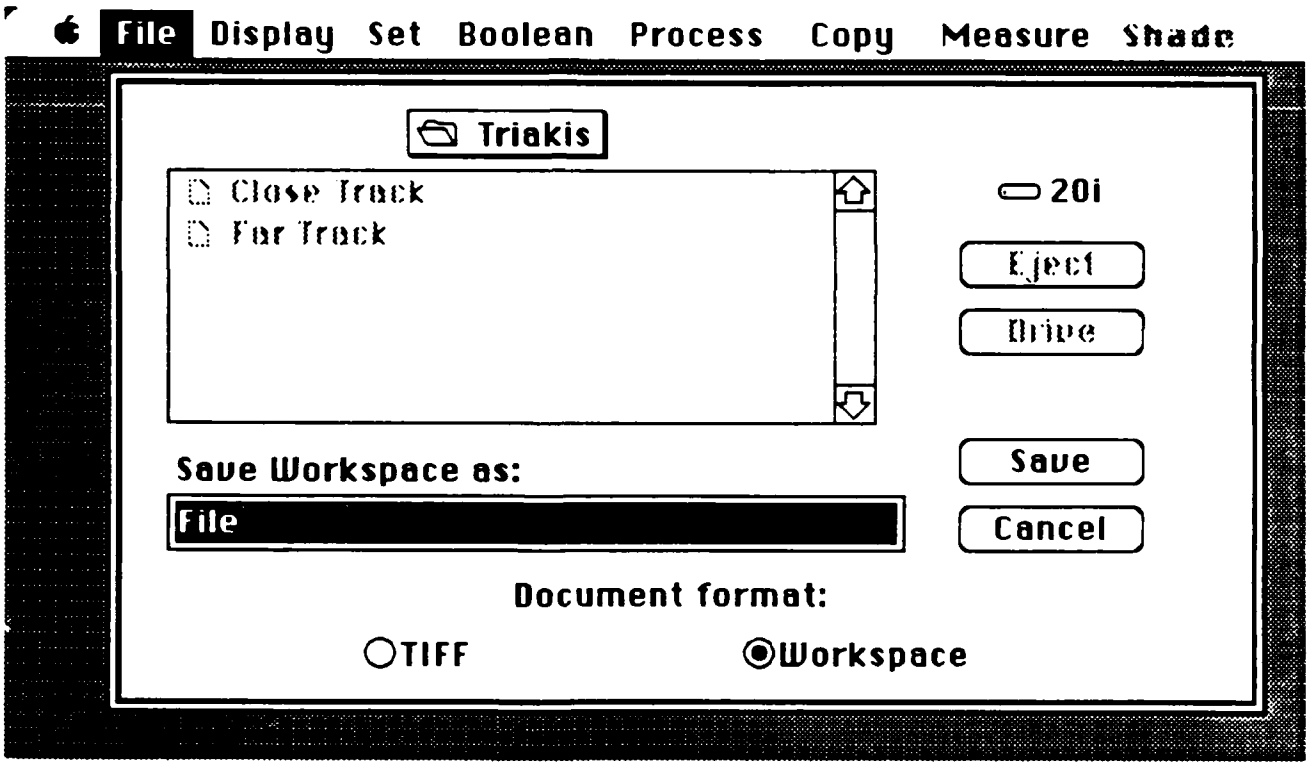

Figure 7

The Quit Command: The Quit command is used to exit the Three Dimensional Cellular Logic Data Analyzer program. The Quit command may be executed by either selecting it from the File menu with the mouse or holding down the command key (⌘) while pressing Q on the keyboard. When the Quit command is selected, the screen is cleared and control is returned to the desktop unless you have not saved one or more of the eight workspace areas. If you have not saved changes to a workspace, you will be presented with the warning box shown in Figure 8. Each of the workspaces which has not been saved will generate a separate warning box. Pressing the return key or clicking on the "Yes" button will save the workspace before quitting in the same manner as the Save command described previously. Clicking on the "No" button will quit without saving the workspace area, and clicking on the "Cancel" button will cancel the Quit operation and return control to the mouse.

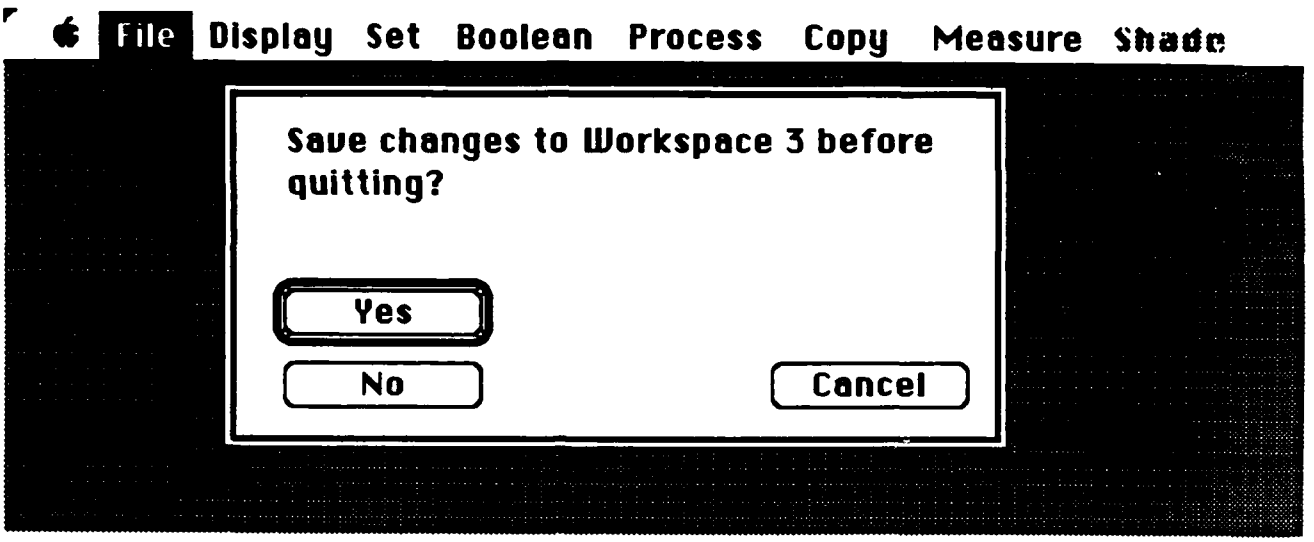
File
Display
Set
Boolean
Process
Copy
Measure
Shade
Save changes to Workspace 3 before quitting?
Yes
No
Cancel

Figure 8

The Display Menu: This menu contains the command for choosing which workspace is displayed on the screen. Select the Display menu by pressing on the word Display in the main menu bar. Selecting the Display menu produces the menu shown in Figure 9. Note that the commands shown in the dim font: Shaded, Grey Level, and Scan Display (play), are not implemented in this version of the Three Dimensional Cellular Logic Data Analyzer.

The Binary Display Command: This command allows the user to select which of the eight workspace areas is displayed on the screen. The Binary Display command may be executed by selecting it from the Display menu with the mouse. When the Binary Display command is executed, the selection box shown in Figure 10 is displayed. Select the workspace area you wish displayed by clicking on the button next to its number. The selection box will then disappear, the chosen workspace will be displayed, and control will be returned to the mouse.

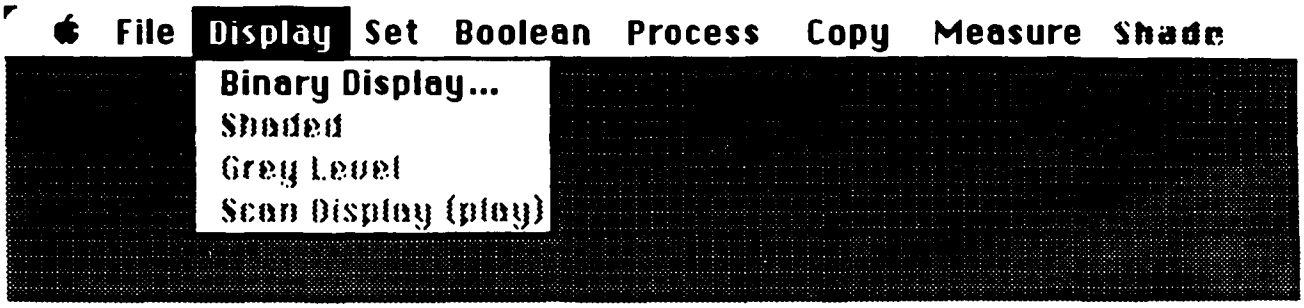

Figure 9

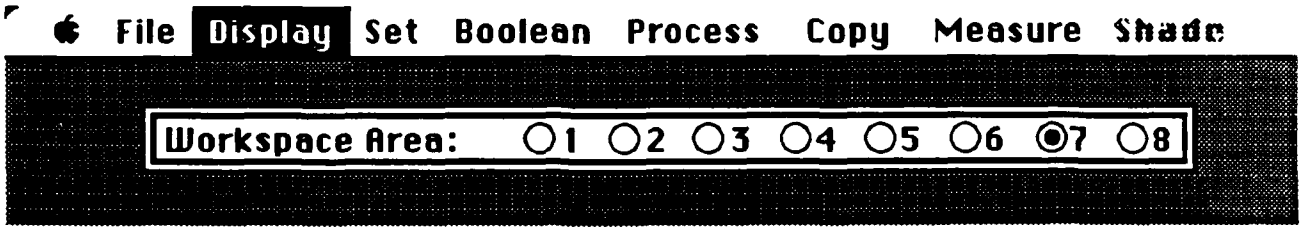

Figure 10

The Set Menu: This menu contains commands for directly changing the voxels in the workspace area displayed on the screen. Select the Set menu by pressing on the word Set in the main menu bar. Selecting the Set menu produces the menu shown in Figure 11.

The Set Voxel Command: The Set Voxel command is used to set a voxel in the workspace area displayed on the screen. The Set Voxel command may be executed by selecting it from the Set menu with the mouse. When the Set Voxel command is executed, you will be presented with the dialog box shown in Figure 12. Type in the plane, line, and point for the voxel you wish to set, typing return after each entry. If you make a mistake, you may use the keyboard editing keys or the mouse pointer to correct it. When you are satisfied with your entries, click on the "OK" button. You may cancel the Set Voxel operation by clicking on the "Cancel" button.

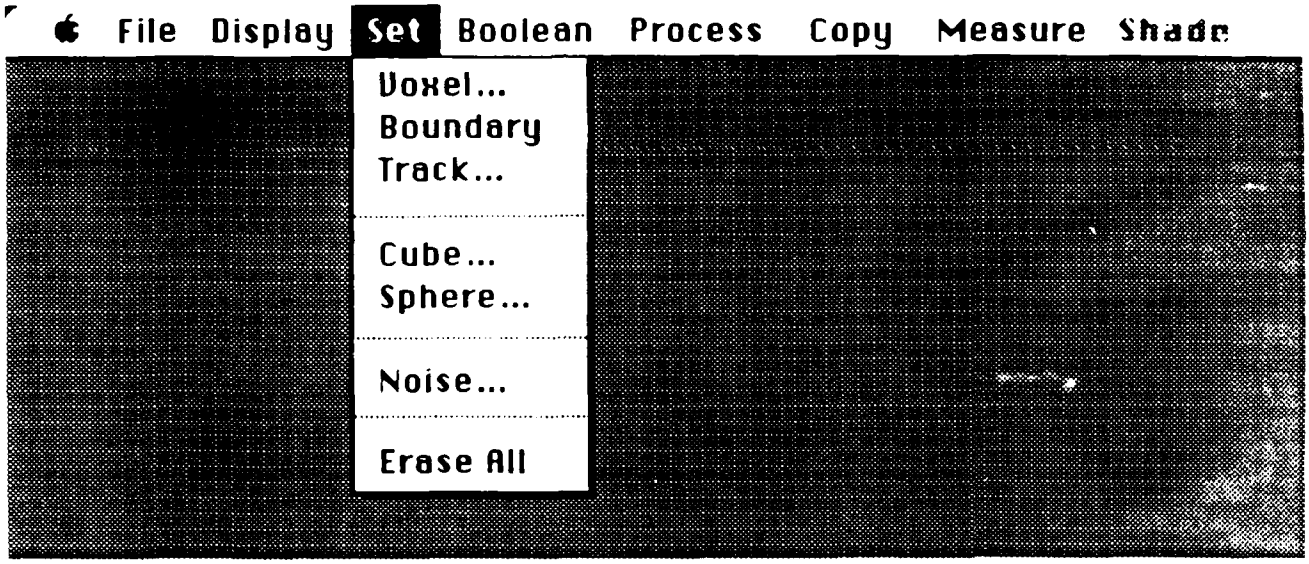

Figure 11

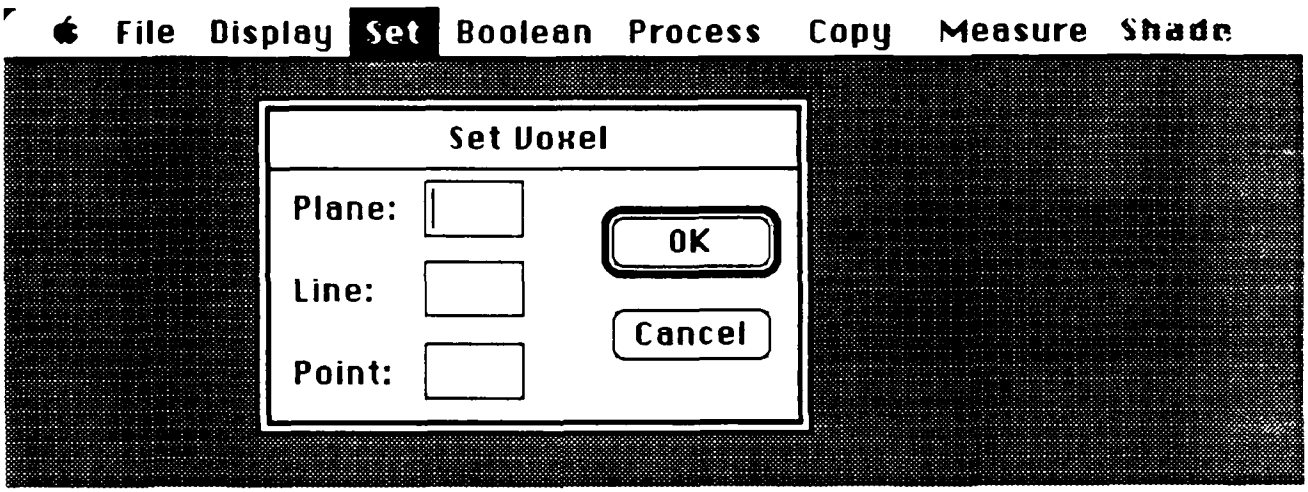

Figure 12

The Set Boundary Command: The Set Boundary command is used to set the boundary of the workspace area displayed on the screen. The Set Boundary command may be executed by selecting it from from the Set menu with the mouse. When the Set Boundary command is executed, the boundary will be set and control will immediately be returned to the mouse.

The Set Track Command: The Set Track command is used to set a track in the workspace area displayed on the screen. The Set Track command may be executed by selecting it from the Set menu with the mouse. When the Set Track command is executed, you will be presented with the dialog box shown in Figure 13. Type in the plane, line, and point for each of the endpoints of the track you wish to set, typing return after each entry. If you make a mistake, you may use the keyboard editing keys or the mouse pointer to correct it. When you are satisfied with your entries, click on the "OK" button. You may cancel the Set Track operation by clicking on the "Cancel" button.

The Set Cube Command: The Set Cube command is used to set a cube in the workspace area displayed on the screen. The Set Cube command may be executed by selecting it from the Set menu with the mouse. When the Set Cube command is executed, you will be presented with the dialog box shown in Figure 14. Type in the plane, line, and point of the lower, left, forward voxel of the cube you wish to set. Then, type in the half-width of the cube. The length of the side of the cube generated is equal to twice the half width plus one. If you make a mistake, you may use the keyboard editing keys or the mouse pointer to correct it. When you are satisfied with your entries, click on the "OK" button. You may cancel the Set Cube operation by clicking on the "Cancel" button.

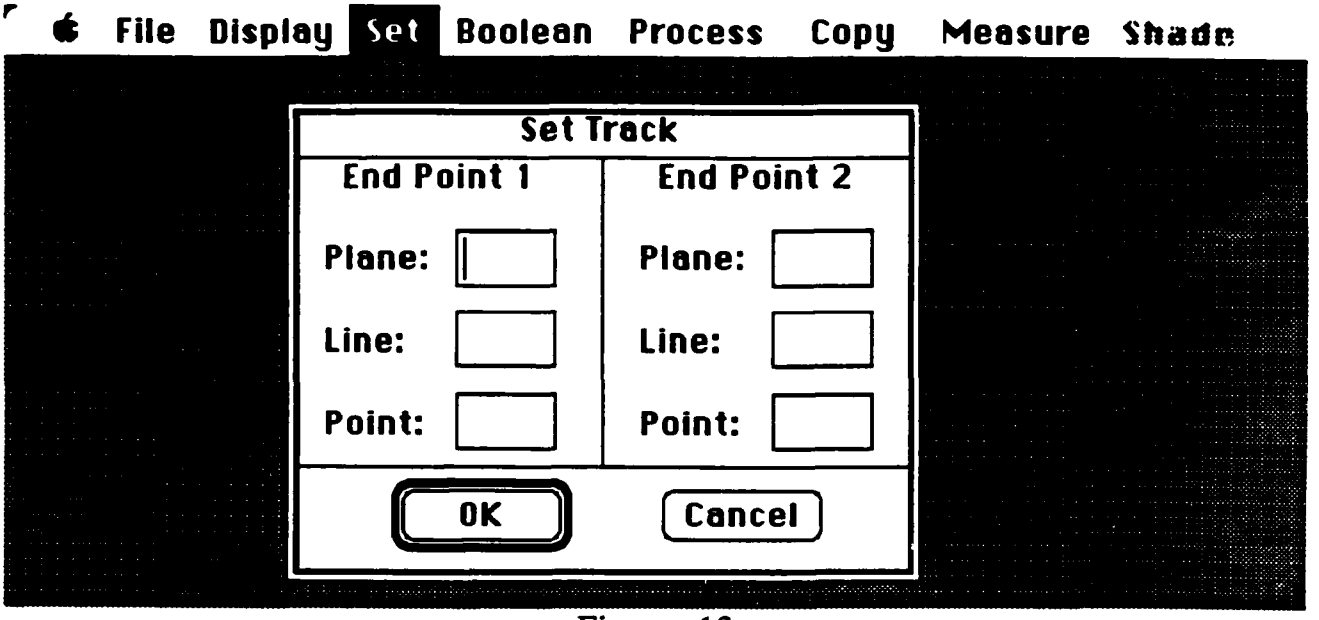

Figure 13

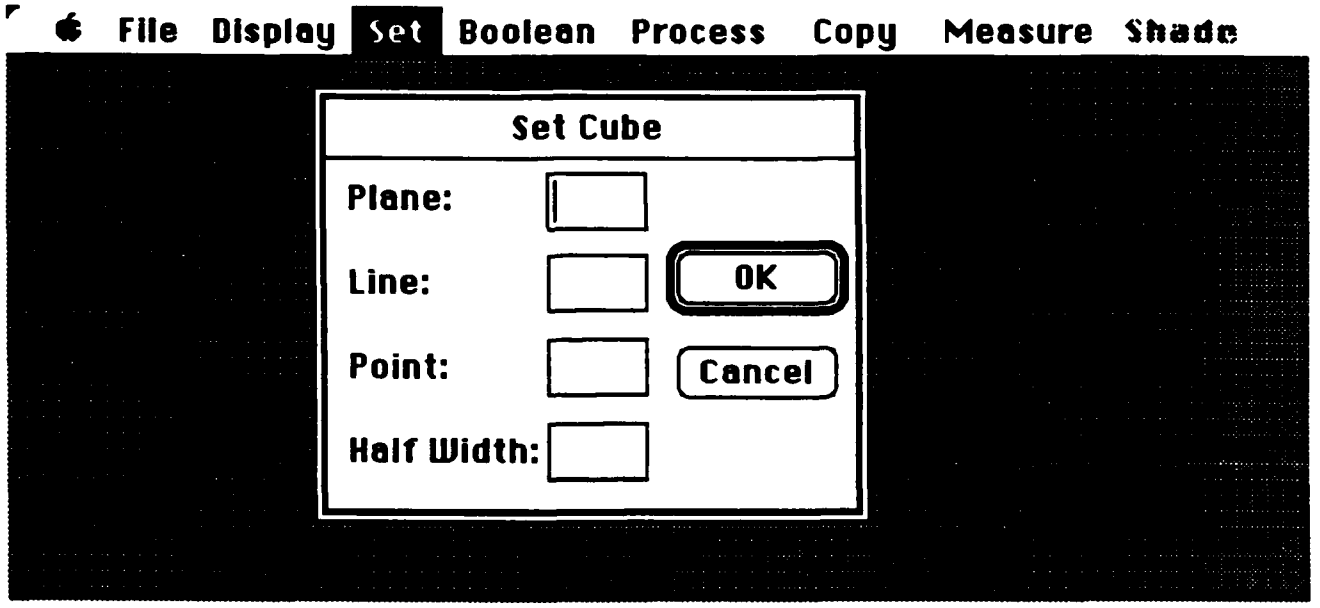

Figure 14

The Set Sphere Command: The Set Sphere command is used to set a sphere in the workspace area displayed on the screen. The Set Sphere command may be executed by selecting it from the Set menu with the mouse. When the Set Sphere command is executed, you will be presented with the dialog box shown in Figure 15. Type in the plane, line, and point for the center of the sphere, followed by its radius. The sphere generated will have a diameter equal to twice the radius plus one. If you make a mistake, you may use the keyboard editing keys or the mouse pointer to correct it. When you are satisfied with your entries, click on the "OK" button. You may cancel the Set Sphere operation by clicking on the "Cancel" button.

The Set Noise Command: The Set Noise command is used to set random noise in the workspace area displayed on the screen. The Set Noise command may be executed by selecting it from the Set menu with the mouse. When the Set Noise command is executed, you will be presented with the selection box shown in Figure 16. Select the desired sigma value by clicking on the button next to the appropriate number. The sigma value determines the amount of random noise that will be placed in the workspace area. When you are satisfied with you selection, click on the "OK" button. You may cancel the Set Noise operation by clicking on the "Cancel" button.

The Erase All Command: The Erase All command is used to erase (set to zero) all of the voxels in the workspace area displayed on the screen. The Erase All command may be executed by selecting it from the Set menu with the mouse. When the Erase All command is executed, the workspace displayed on the screen will be erased and control will be returned to the mouse. Note that, unlike the close command, any file name information associated with the workspace area being cleared will be retained.

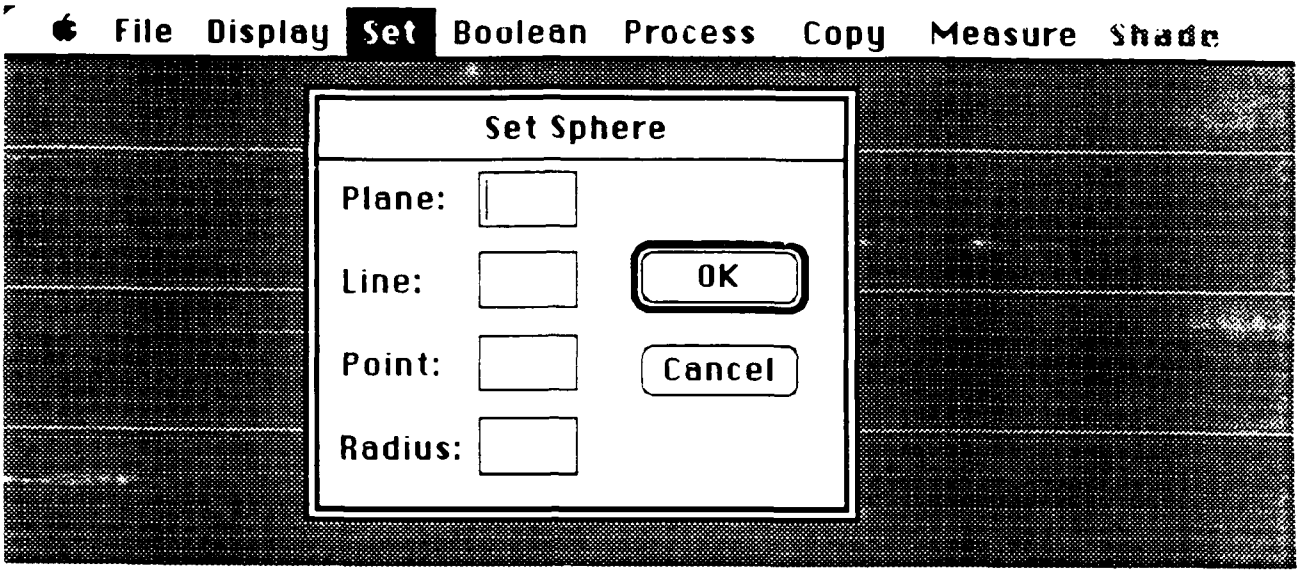

Figure 15

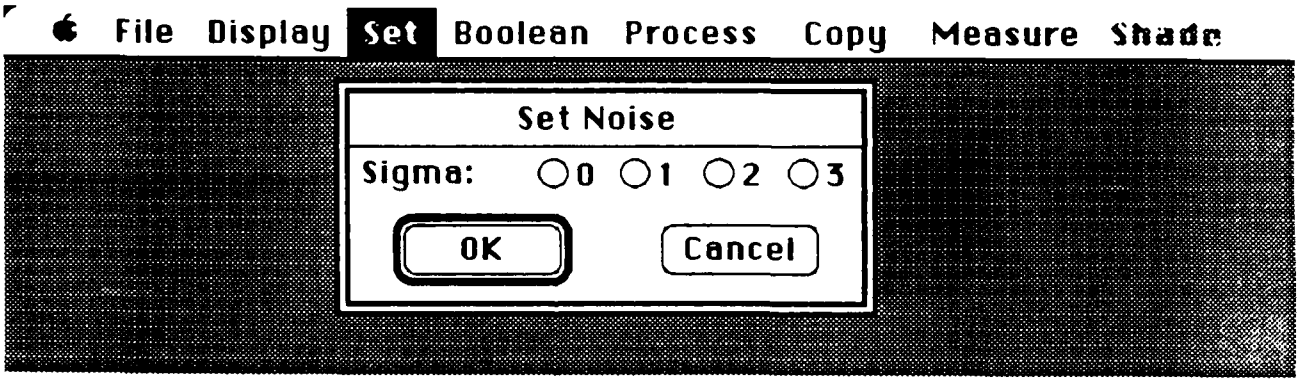

Figure 16

The Boolean Menu: The Boolean Menu contains commands for performing the boolean And, Or, Exor, and Invert operations on any of the eight workspace areas. Select the Boolean menu by pressing on the word Boolean in the main menu bar. Selecting the Boolean menu produces the menu shown in Figure 17.

The And Command: The And command is used to perform the boolean And operation from any two of the eight workspace areas into a third workspace area. The And command may be executed by selecting it from the Boolean menu with the mouse. When the And command is executed, you will be presented with the selection box shown in Figure 18. Select both of the source workspaces and the destination workspace by clicking on the button next to its number. When you are satisfied with your selections, click on the "OK" button. You may cancel the And operation by clicking on the "Cancel" button.

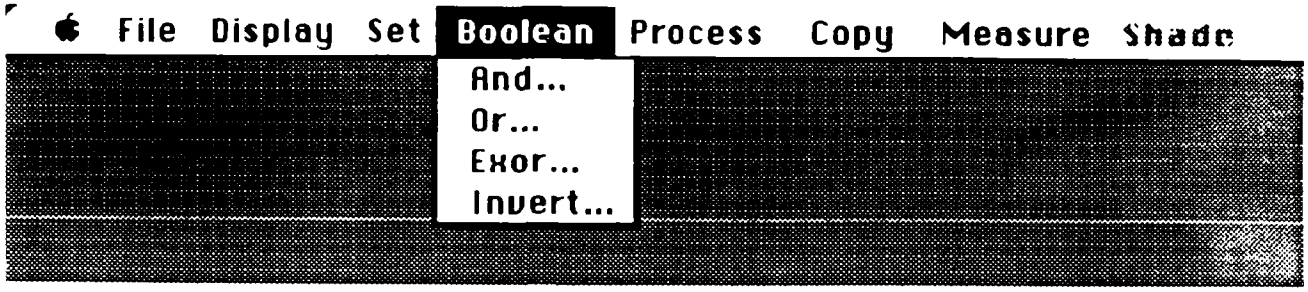

Figure 17

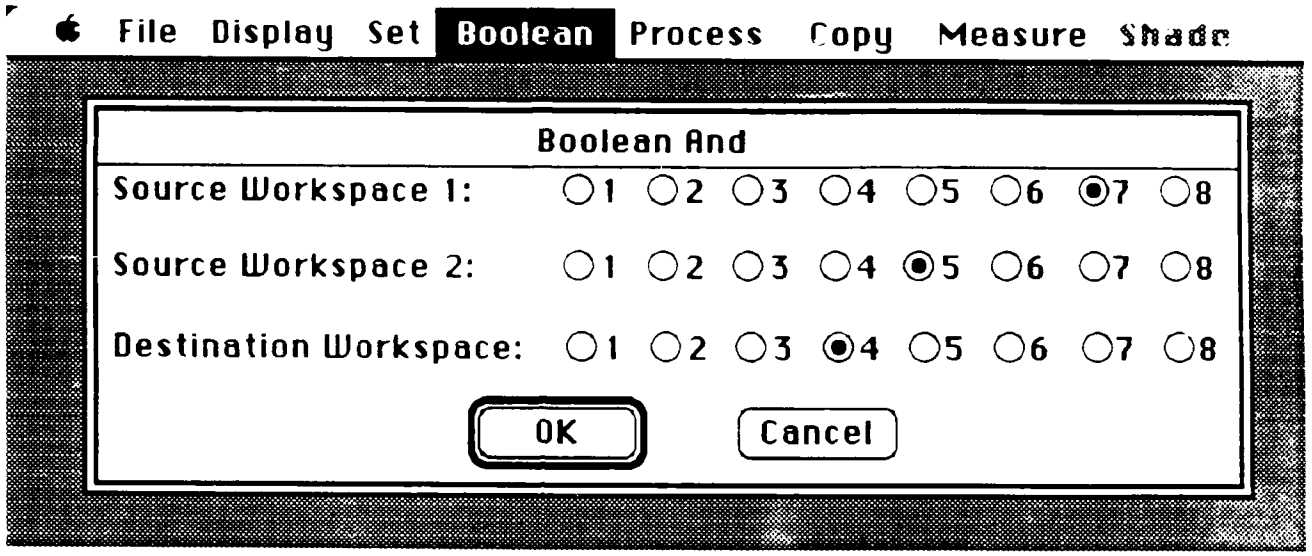

Figure 18

The Or Command: The Or command is used to perform the Boolean Or operation from any two of the eight workspace areas into a third workspace area. The Or command may be executed by selecting it from the Boolean menu with the mouse. When the Or command is executed, you will be presented with the selection box shown in Figure 19. Select both of the source workspaces and the destination workspace by clicking on the button next to its number. When you are satisfied with your selections, click on the "OK" button. You may cancel the Or operation by clicking on the "Cancel" button.

The Exor Command: The Exor command is used to perform the Boolean Exor operation from any two of the eight workspace areas into a third workspace area. The Exor command may be executed by selecting it from the Boolean menu with the mouse. When the Exor command is executed, you will be presented with the selection box shown in Figure 20. Select both of the source workspaces and the destination workspace by clicking on the button next to its number. When you are satisfied with your selections, click on the "OK" button. You may cancel the Exor operation by clicking on the "Cancel" button.

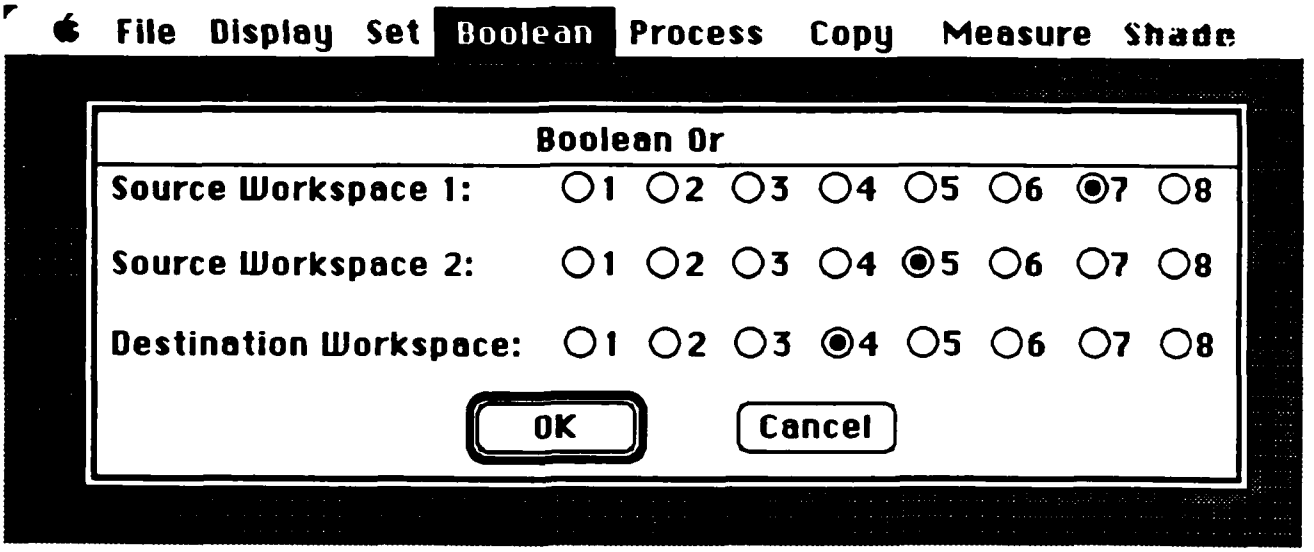

Figure 19

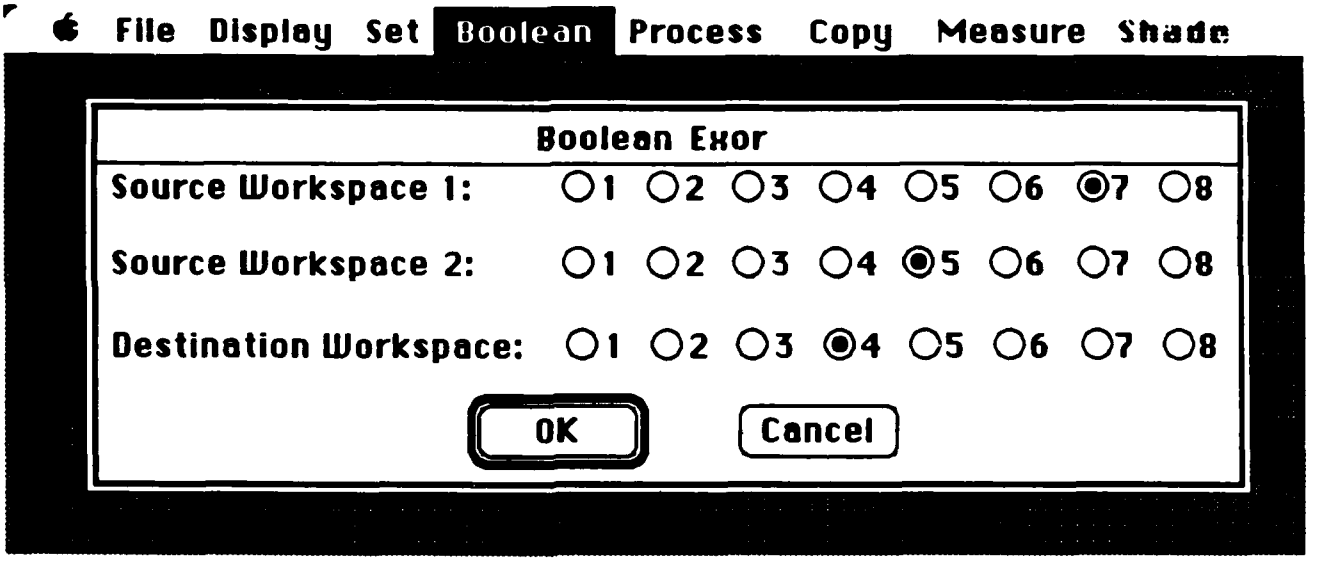

Figure 20

The Invert Command: The Invert command is used to perform the Boolean Invert operation on any of the eight workspace areas into a second workspace area. The Invert command may be executed by selecting it from the Boolean menu with the mouse. When the Invert command is executed, you will be presented with the selection box shown in Figure 21. Select the source and the destination workspaces by clicking on the button next to their numbers. When you are satisfied with your selections, click on the "OK" button. You may cancel the Invert operation by clicking on the "Cancel" button.

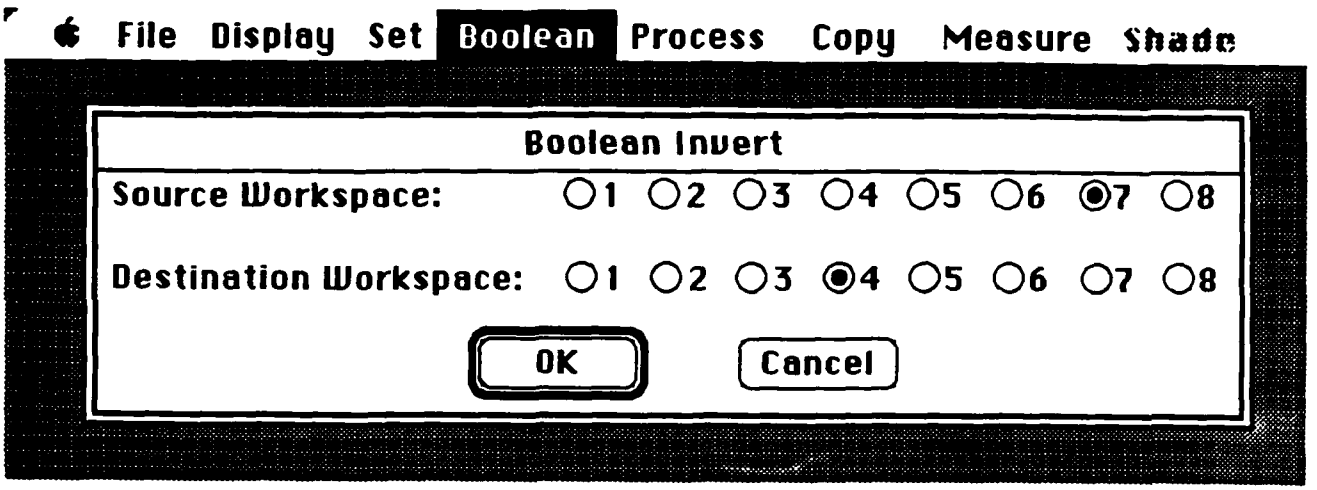
File
Display
Set
Boolean
Process
Copy
Measure
Shade
Boolean Invert
Source Workspace:
1
2
3
4
5
6
7
8
Destination Workspace:
1
2
3
4
5
6
7
8
OK
Cancel

Figure 21

The Process Menu: This menu contains commands for performing the Augred and Xifilter cellular logic operations. Select the Process menu by pressing on the word Process in the main menu bar. Selecting the Process menu produces the menu shown in Figure 22.

The Augred Command: The Augred command is used to perform the augred cellular logic operation on the workspace area displayed on the screen. The Augred command may be executed by selecting it from the Process menu with the mouse. When the Augred command is executed, you will be presented with the dialog box shown in Figure 23. Type in the number of cycles and the factor, typing return after each entry. If you make a mistake, you may use the keyboard editing keys or the mouse pointer to correct it. Next, choose Cnum0, Cnum1, Mode, and Border by clicking on the button next to the appropriate number. When you are satisfied with you selections, click on the "OK" button. You may cancel the Augred operation by clicking on the "Cancel" button.

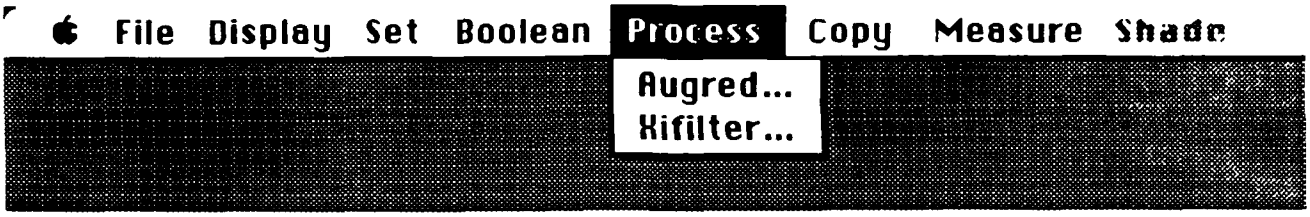

Figure 22

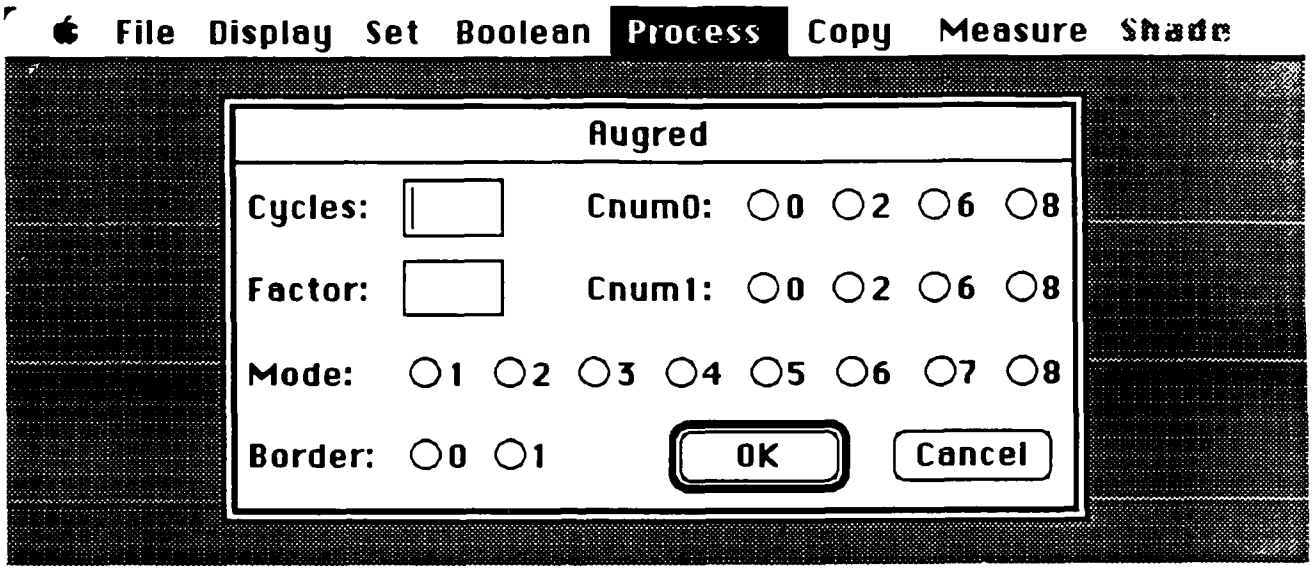

Figure 23

The Xifilter Command: The Xifilter command is used to perform the xifilter cellular logic operation on the workspace area displayed on the screen. The Xifilter command may be executed by selecting it from the Process menu with the mouse. When the Xifilter command is executed, you will be presented with the dialog box shown in Figure 24. Type in the number of cycles and the factor, typing return after each entry. If you make a mistake, you may use the keyboard editing keys or the mouse pointer to correct it. Next, choose Cnum0, Cnum1, Mode, and Border by clicking on the button next to the appropriate number. When you are satisfied with you selections, click on the "OK" button. You may cancel the Xifilter operation by clicking on the "Cancel" button.

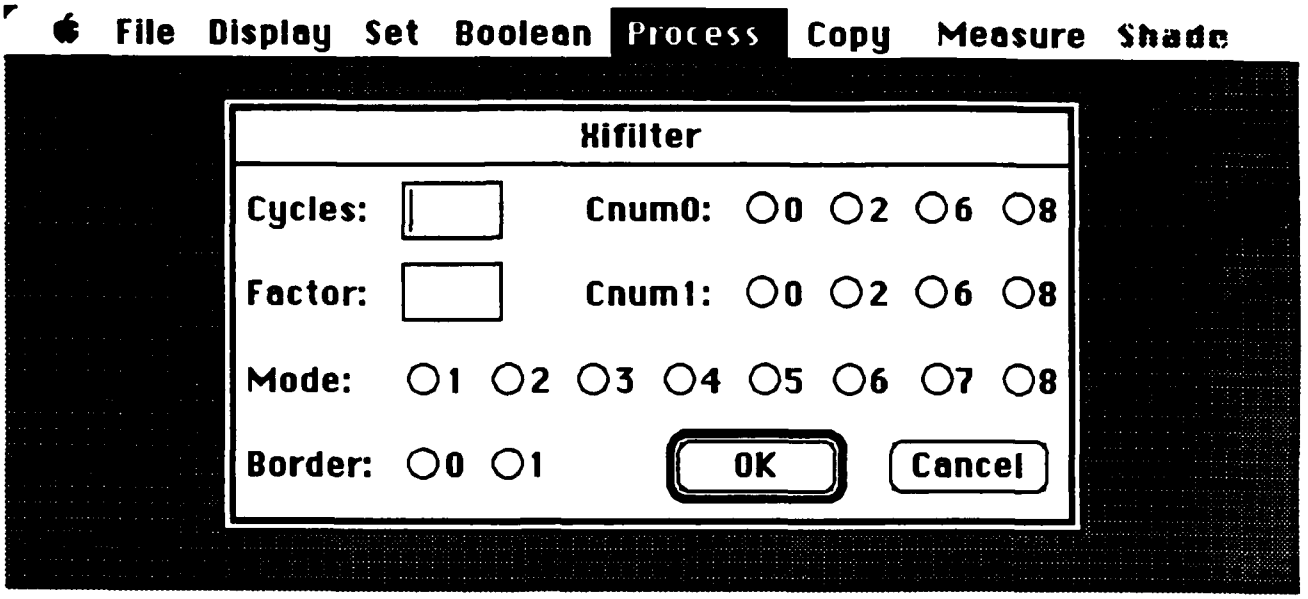
File Display Set Boolean Process Copy Measure Shade
Hifilter
Cycles:
Factor:
Mode: 1 2 3 4 5 6 7 8
Border: 0 1
Cnum0: 0 2 6 8
Cnum1: 0 2 6 8
OK
Cancel

Figure 24

The Copy Menu: This menu contains the command for copying one workspace area into another. Select the Copy menu by pressing on the word Copy in the main menu bar. Selecting the Copy menu produces the menu shown in Figure 25.

The Copy Workspace Command: The Copy Workspace command is used to copy the contents of one workspace into another. The Copy Workspace command may be executed by selecting it from the Copy menu with the mouse. When the Copy Workspace command is executed, you will be presented with the selection box shown in Figure 26. Select the source and destination workspaces by clicking on the buttons next to their numbers. When you are satisfied with your selections, click on the "OK" button. You may cancel the Copy Workspace operation by clicking on the cancel button.

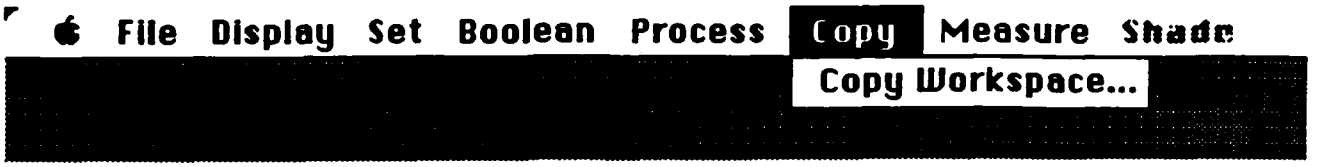

Figure 25

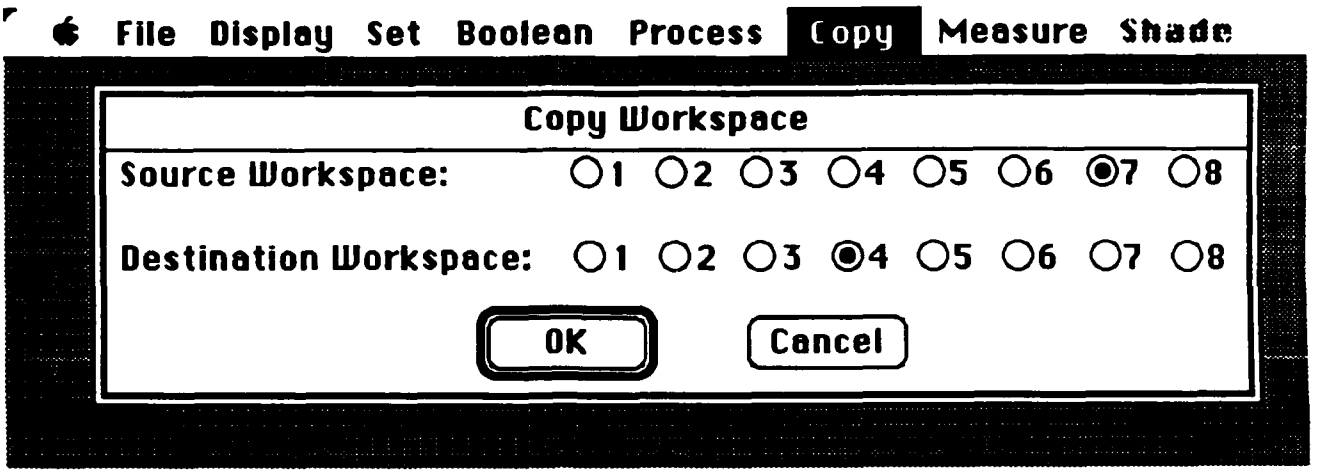

Figure 26

The Measure Menu: This menu contains commands for measuring various quantities in the workspace area displayed on the screen. Select the measure menu by pressing on the word Measure in the main menu bar. Selecting the Measure menu produces the menu shown in Figure 27. Note that only the Volume command, which measures the number of voxels that are set in the workspace displayed on the screen, is supported. The Surface, Edges, and Corners commands are shown in the dim font to remind you that they are not supported in this version of the The Three Dimensional Cellular Logic Data Analyzer.

The Measure Volume Command: The Measure Volume command is used to measure the number of true voxels in the workspace area displayed on the screen. The Measure Volume command may be executed by selecting it from the Measure menu with the mouse. When the Measure Volume command is executed, the program will calculate the volume and display the results in the box shown in Figure 28. You may then save the measurement to a file called "Measurements" by clicking on the "OK" box. If you do not wish to save the value to the measurements file, click on the cancel button.

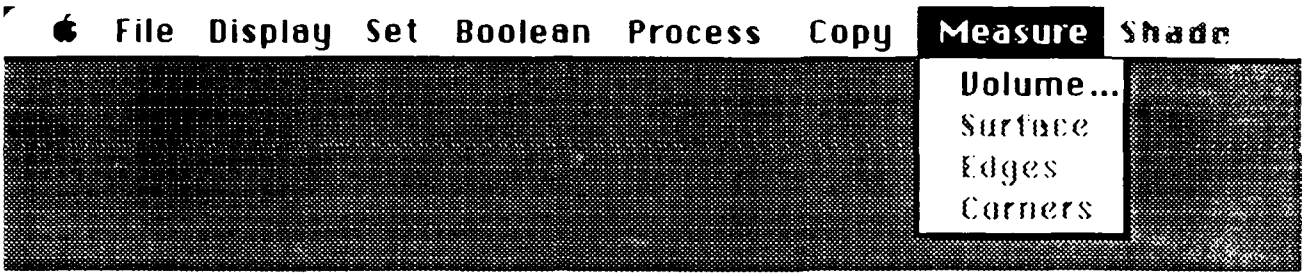

Figure 27

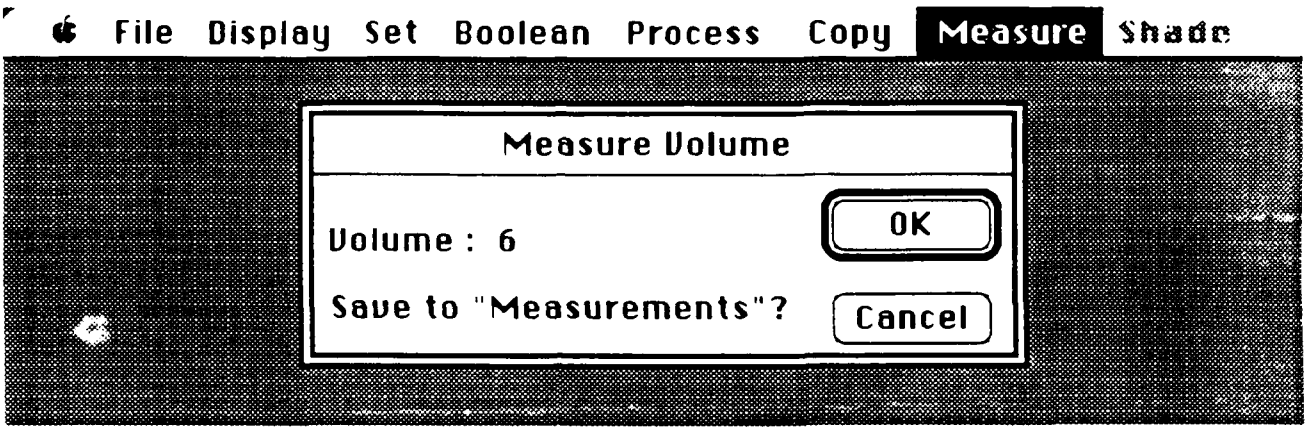

Figure 28