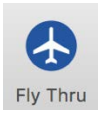
(a) As displayed in Horos (b) As exported

Figure 8.2. Exporting all displayed 2D Viewers in a single Movie Sequence file

The default movie export format in Horos is QuickTime format (.mov) or H264 (MPEG4) format. A number of third party applications are available to convert .mov or MPEG4 files to other formats.



FLY THRU

You can create movies of 3D scenes in three 3D viewers; 3D MIP, 3D Volume Rendering, 3D Surface Rendering, and 3D endoscopy Viewer. To begin, open a patient series, double click on an image from that series in the bottom of the database window, and then choose 3D Volume render from the 2D/3D options button in the toolbar. With your 3D volume rendered, select the 3D Viewer menu from the top menu bar (Figure 8.3) and click on Add FlyThru Point option (or use the keyboard shortcut ⌘ **F1)**.

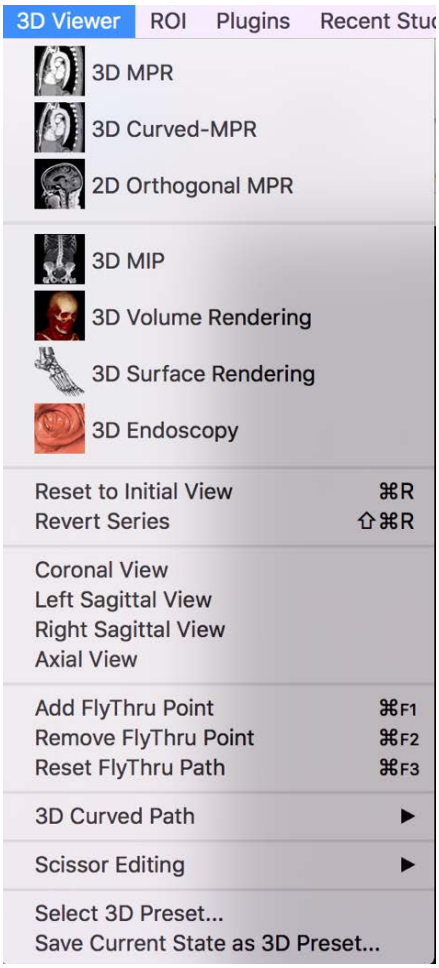


Figure 8.3. The options under the 3D Viewer menu bar.

The Fly Through popup window appears (Figure 8.4) with a thumbnail of the 3D volume rendered image in index 1. Move or rotate the 3D volume to a new position and click on the + symbol at the bottom left of the Fly Trough popup window. This adds a new index for that position. You can continue to add (plus sign) or delete (minus sign) index steps to the Fly Through window (Figure 8.4) or using the Remove FlyThru Point (⌘ **F2**) or Reset FlyThru Point (⌘ **F3**) options from the 3D Viewer menu. When you are finished, you will have a series of steps that comprise the movie (think of them as scenes). You can now create and export the movie using the Export button at the bottom of the Fly Through window. Horos will interpolate the missing frames between the steps (indexed frames) to generate a smooth sequence of frames for your movie. If you choose the Movie button at the top right of the Fly Through window, you will see a new popup window that allows you to choose how many frames between indexed steps, the method for interpolation (spline or linear), and an option to loop the movie (Figure 8.4). The Spline method generates smoother transitions between steps. Clicking on the Compute button generates the interpolated movie.

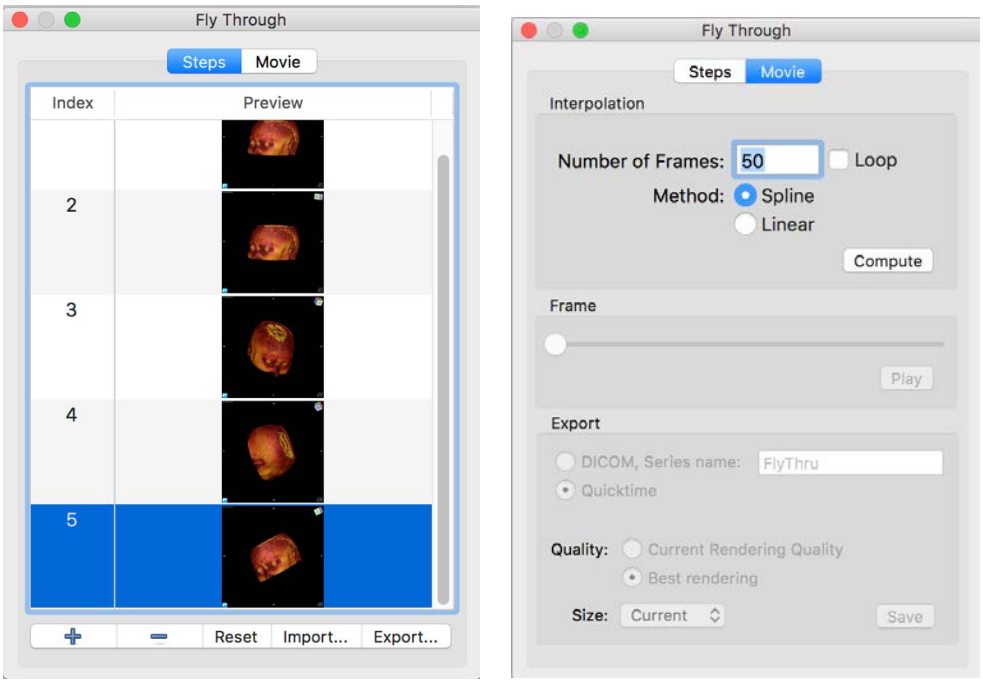


Figure 8.4. The Fly Through popup window. The left image is the Steps mode showing a series of 5 indexed steps. The right image is the Movie mode with 50 frames between each step.

You can play the newly created movie using the Play button in the middle of the Movie popup window. Finally, you can export the movie as a DICOM series or as a Quicktime (.mov) file in three size options (using the Size dropdown choices).

Note that in addition to rotating or moving the image between steps, you can also change image transparency, thresholding, color settings or other parameters between indexed images. Horos allows you to save a script file of the indexed images in XML format to disk for later retrieval.

Indexed steps are also called key steps and are d-dimensional vectors with d parameters. For example, if K is a key step, then:

$$\boldsymbol{K = k_1, k_2, \cdots, k_d}$$

Where k_i is the ith parameter.

A linear path between two key steps K and L is a series of n points (P_i with i =1, …, n) where P_1 = K and P_n = L.

And where:

$$\boldsymbol{\|P_i - P_{i+1}\| = \|P_{i+1} - P_{i+2}\| \; \forall i \in \{1, \cdots, n-2\}}$$

The difference between a linear path and a spline path is that a linear path contains points of a succession of paths going from K_i to K_{i+1} (i =1, …, m-1) and a spline path is a succession of equidistant points from a polynomial interpolation (as defined in 14).

At each key step the camera position, camera focal point, camera view up, and camera view angle are recorded. If available, WL/WW, fusion percentage, and cropping box dimension and position are also recorded. A 3D state in generated for each point and a new frame is rendered along the interpolated path.

Chapter 9

Using Horos in a Network and General Concepts

Introduction

This chapter covers some of the general concepts of functionality of Horos and how it interacts with a Picture and Archiving System (PACS) and other workstations. The concepts of the DICOM standard, DICOM nodes and DICOM protocols are also included in this chapter.

PACS Network

Within a Picture Archiving and System (PACS) there is typically a central server which stores the images on a database, in DICOM Standard format. Each imaging modality linked to the PACS, (MRI, CT, Ultrasound, CR, DDR etc) are set up to automatically send images to the PACS server using a protocol known as DICOM C-STORE. The data which includes the DICOM images and the DICOM-DIR files, the latter of which contains the field information such as imaging modality and patient information, are all communicated via a network.

The concept of a PACS is all based upon a client/server framework. Users wishing to access the DICOM images stored on the PACS are known as ‘clients’. To access DICOM images stored on a PACS the ‘client’ must first send a ‘Query & Retrieve’ request. This is done through a protocol known as DICOM C-STORE. This request is automatic if the client has networked access to the PACS.

For a ‘client’ to display the images on their own computer, medical imaging software such as Horos, is required. This software is known as a DICOM viewer. Images stored on a PACS will automatically appear in a ‘clients’ database.

Importing and Receiving Data

Images can be imported into a Horos database in one of two ways

- Directly from a CD/DVD or other external storage device. See Chapter 4 for more details
- Through the network via a PACS

To receive images through a PACS, Horos just has to be running. Files received in this way are automatically stored and indexed in the Horos Data folder. See Chapters 3 and 4 for more details.

The standard DICOM protocol used by Horos for receiving images and the associated data is **DICOM C-STORE SCP.**

Other more advanced or recent protocols supported are; WADO downloading, DICOM C-GET SCU and DICOM C-MOVE SCU. More information on DICOM protocols can be found later in this chapter.

Sending Data

Horos sends data to other workstations or comparable software using the DICOM C-STORE SCU protocol. For more information can be found on the C-STORE and other DICOM protocols later in this chapter.

Studies, series or images can be sent using this protocol in a number of ways:

- The contextual *File* menu
- Using the *Send* tool on the toolbar
- From the *Sources* section of the left hand side panel
- Auto-routing
- Automatic rules.

The first three are described in detail in Chapters 9 and 4. Auto-routing and automatic rules are described later in this chapter.

Sharing Data

Multiple protocols are available to share images with other Horos or DICOM compatible workstations. This provides the user with the option to use Horos as a PACS server, DICOM router or to share images or files created or manipulated in Horos for example reports, annotations and volume rendered images.

The built in protocols are:

- DICOM Query & Retrieve
- Database Sharing
- Auto-routing
- Synchronize and Archive
- HTTP Web Server
- PACS Server

DICOM Query & Retrieve

This feature, based on standard DICOM protocols, allows Horos to browse, search and download images from any distant DICOM-compatible software. This could include a PACS server or other Horos workstation and will allow any DICOM compatible software to use it. Further details on running a DICOM Query and Retrieve can be found later in this chapter and in Chapter 4.

DICOM communications

DICOM standard is most commonly understood as the format in which files store images. It also describes the standard protocols for sending, retrieving, printing and integration with a Radiology Information System (RIS) PACS, all performed on a network-based service.

As described earlier in the chapter under the *PACS* section, communications between DICOM applications and/or a PACS are based upon a client/server framework.

In order to exchange information, for example to access DICOM images stored on a PACS, a connection must be established and the following agreed between the two connected applications:

- Who is the server and who is the client.
- Which DICOM protocol its required to complete the requested task e.g. C-STORE
- Which format to transmit the image(s) in e.g. DICOM, JPEG2000, uncompressed

As these protocols are used within standard Transmission Control Protocol/Internet Protocol (TCP/IP), any TCP/IP interface can be used e.g. Wifi, Ethernet or 3G/4G. A TCP/IP is a group of standard protocols used to connect networked devices via the internet. The same protocols can also be used on a local intranet.

A DICOM node describes any networked DICOM software or hardware, which is used to manage, process or transfer DICOM images. This is essentially a workstation or PACS server. Each DICOM node is uniquely identified by the TCP/IP address of the computer e.g. 174.14.5.18 as well as the TCP/IP Port e.g. 4686 and its Application Entity (AE) title e.g. Horos.

If a software or hardware acts as a server it is described as ‘offering a service’ and is the ‘Service Class Provider’ (SCP).

If a software or hardware uses a service it is described as 'acting as a client' and is the Service Class User' (SCU).

Should you wish to search for images on a networked PACS, a series of DICOM services are engaged to perform this function. An example of the DICOM services engaged to search for and retrieve an image from a networked PACS, through the *Query and Retrieve* tool are shown below:

Action	**DICOM service**	**SCU**	**SCP**
Horos sends query to PACS	C-FIND	Horos	PACS
Horos retrieves study from PACS	C-MOVE, C-GET or WADO	Horos	PACS
PACS sends study to Horos	C-MOVE, C-STORE, C-GET or WADO	PACS	Horos

Adapted from Osirix user manual SCU, Service Class User. SCP, Service Class provider

DICOM protocols

In order to perform services on a DICOM network and communicate with other PACS and workstations, Horos employs and supports a number of recognized DICOM protocols. These protocols are described in the DICOM Standard [10].

In the case of a Service Class Provider (SCP), where the software or hardware acts as a server and is described as 'offering a service', these protocols are 'always-up' and ready to respond to a request.

In the case of a Service Class User (SCU), these protocols only run when a task or the tool is triggered by the user.

A list of the protocols supported by Horos is displayed below:

Protocol Name	**SCU/SCP**	**Description**
C-STORE	Both	Listener and Send Functions
C-FIND	Both	Image Queries*
C-MOVE	Both	Image retrieval*
C-GET	Both	Image retrieval*
C-ECHO	Both	DICOM Nodes test functions*
C-PRINT	SCU	DICOM printing
WADO	Both	HTTP Web protocol for image transfer

**These protocols are run through the Query and Retrieve Window*

Detailed descriptions of these protocols can be found at the end of this Chapter.

DICOM Listener

In order for your workstation to work as a PACS server, you will need to set up the DICOM Listener and configure your workstation as a DICOM-compliant *node.* A DICOM node describes any networked DICOM software or hardware, which is used to manage, process or transfer DICOM images. This is essentially a workstation or PACS server. Each DICOM node is uniquely identified by the TCP/IP address of the computer e.g. 174.14.5.18 as well as the TCP/IP Port e.g. 4686 and its Application Entity (AE) title e.g. Horos.

To setup the DICOM Listener, select the *Listener* tab from the *Preferences* (Fig 9.1). The dialogue window which is displayed requires you to enter:

- The Application entity (AE title) of your workstation e.g. Horos
- Your IP address e.g. 174.14.5.18
- The name and identity of the port used e.g. 4686

This information will be required both by your PACS server, and any other devices which you choose to send images to. More information on setting up the DICOM Listener can be found in Chapter 2.

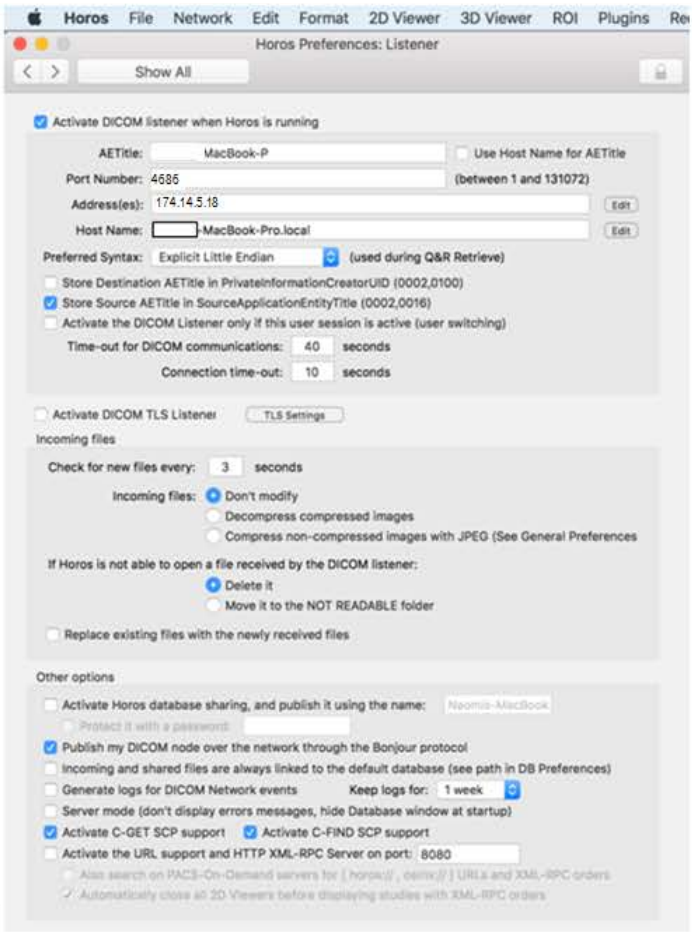


Figure 9.1 The DICOM Listener preferences window