User Guide

Olea Sphere

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A Product Description

Olea Sphere™ is a medical viewing, analysis and processing software package (PACS) compliant with the DICOM standard and running on Windows, Macintosh or Linux operating systems.

Olea Sphere™ allows the display, analysis and post-processing of medical images. These images, when interpreted by a trained physician, may yield clinically useful information.

The software provides a wide range of basic image processing and manipulation functions, in addition to comprehensive dynamic image processing and display. The main features of the software are:

- Image Loading & Saving,
- Image Viewing,
- Image Manipulation,
- Image Analysis,
- Imaging Processing,
- Perfusion post processing,
- Permeability post processing,
- Diffusion Weighted Imaging / Tensor Imaging post processing,
- Fiber Tracking post processing.

The main users of the program are medical imaging professionals who need to visualize and analyze images acquired primarily with MRI systems. Lossy compressed mammographic images and digitized film screen images must not be reviewed for primary image interpretations.

B Intended Use

Olea Sphere™ is an image processing software package to be used by trained professionals including but not limited to physicians and medical technicians. The software runs on a standard "off-the-shelf" workstation and can be used to perform image viewing, processing and analysis of medical images. Data and images are acquired through DICOM compliant imaging devices and modalities.

Olea Sphere™ provides both viewing and analysis capabilities of functional and dynamic imaging datasets acquired with MRI or other relevant modalities; including a Diffusion Weighted MRI (DWI) / Fiber Tracking Module and a Dynamic Analysis Module (dynamic contrast enhanced imaging data for MRI).

The DWI Module is used to visualize local water diffusion properties from the analysis of diffusion-weighted MRI data. The Fiber Tracking feature utilizes the directional dependency of the diffusion to display the white matter structure in the brain or more generally the central nervous system.

The Dynamic Analysis Module is used for visualization and analysis of dynamic imaging data, showing properties of changes in contrast over time where such techniques are useful or necessary. This functionality is referred to as:

Perfusion Module – the calculation of parameters related to tissue flow (perfusion) and tissue blood volume.

Permeability Module – the calculation of parameters related to leakage of injected contrast material from intravascular to extracellular space.

C Warnings & Cautions

Olea Sphere™ software is designed to help physicians in their daily practice.

The use of Olea Sphere™ can by no means replace a diagnosis by a licensed and competent physician nor constitute medical advice or diagnosis which can only be obtained from a physician. The physician bears the sole responsibility for the diagnosis. The calculated parameters cannot be used without medical advice from a licensed physician with competent knowledge.

Olea Medical® does not guarantee the quality, the accuracy or the legality of the MR images based on which the software calculates parameters. The user must, therefore, use caution when using the software.

Olea Sphere™ is compatible with the DICOM 3.0 standard, a format that allows the interchange of medical images. DICOM is a standard format for encoding and transmitting medical images. Olea Sphere™ is interoperable with all MR scanners or PACS systems that meet this standard. This compatibility should be validated when the software is installed and should be maintained with every PACS server, magnetic resonance imaging device changes.

Caution: U.S. Federal law restricts this device to sale by or on the order of a practitioner licensed by the law of the State in which he/she practices.

D Introduction

This manual is the user guide for Olea Sphere™, software developed, marketed, and entirely owned by Olea Medical®. It provides information for a better understanding and thus a better use of the Olea Sphere™ software.

Scope

Identification

This document applies to the Olea Sphere™ project. Olea Sphere™ workflow is made easier and more intuitive allowing within the same study, the use of different processing/analyzing plug-ins, according to the acquisition protocol and available DICOM images. Olea Sphere™ has also been designed to make future extensions easier with additional plug-ins inside the same framework.

Overview

This user guide is composed of 5 main parts:

- General display overview,
- Workflow,
- Image processing,
- Study analysis,
- Application modules.

Acronyms and Glossary

Acronyms

AIF	Arterial Input Function
AUC	Area under the curve
CA	Contrast Agent
cSVD	Circular Singular Value Decomposition
DCE	Dynamic Contrast Enhancement
DICOM	Digital Imaging and Communications in Medicine
DSC	Dynamic Susceptibility Contrast
DTI	Diffusion Tensor Imaging
DWI	Diffusion-Weighted Imaging
EES	Extravascular Extracellular Space
FDA	Food and Drug Administration
HMI	Human Machine Interface
MPR	Multi Planar Reconstruction
MRI	Magnetic Resonance Imaging
MTT	Mean Transit Time
N/A	Not Applicable
oSVD	Oscillation Singular Value Decomposition
PWI	Perfusion Weighted Imaging
rBF	relative Blood Flow
rBV	relative Blood Volume
rcBV	relative corrected Blood Volume
ROI	Region of interest
sSVD	Standard Singular Value Decomposition
SVD	Singular Value Decomposition
TE	Echo time
TBD	To Be Defined

TMAX	Residue Function time to peak
tMIP	Temporal Maximum Intensity Projection
TME	Time to Maximum Enhancement
TR	Repetition Time
TTP	Time To Peak
VOF	Venous Output Function
VOI	Volume of interest

Glossary

The user	Medical or paramedical professional staff (including but not limited to physicians and medical technicians) with medical imaging education.

Conventions

⚠ : This symbol stands for **CAUTION**

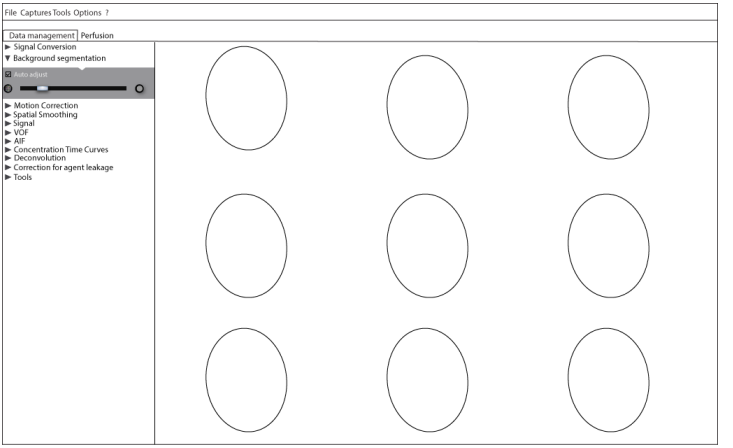
ℹ : This symbol stands for **NOTE**

E General Display Overview

Workspaces

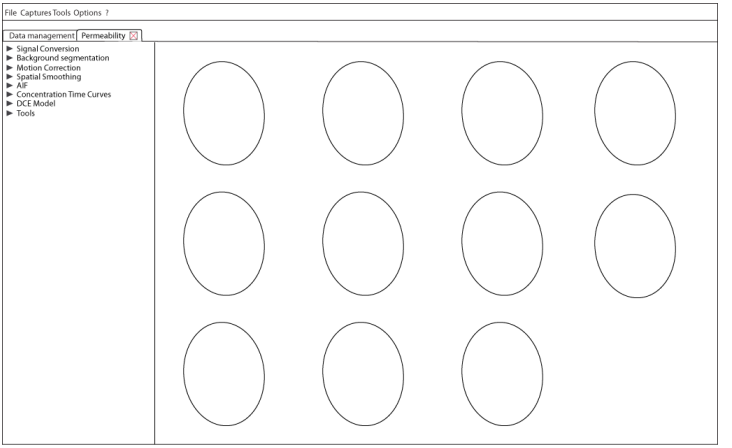
Perfusion Image Post-processing

Figure E.1.



Permeability Image Post-processing

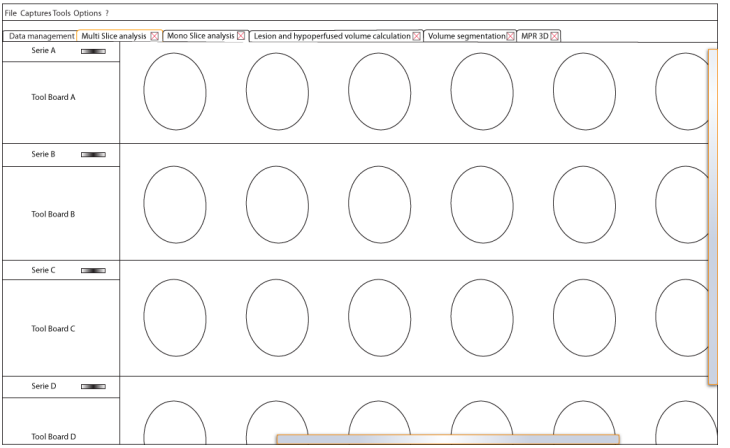
Figure E.2.



Analysis

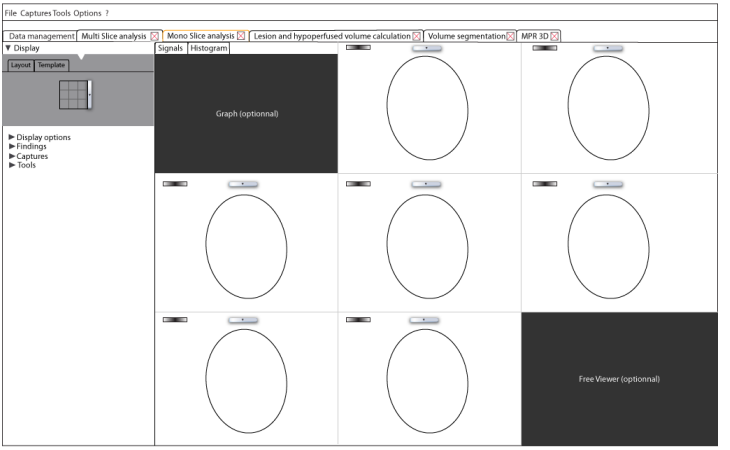
Multi slices

Figure E.3.



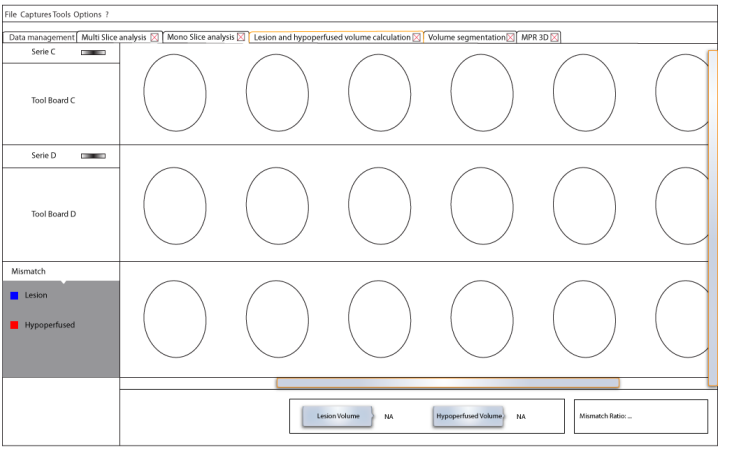
Mono slice

Figure E.4.



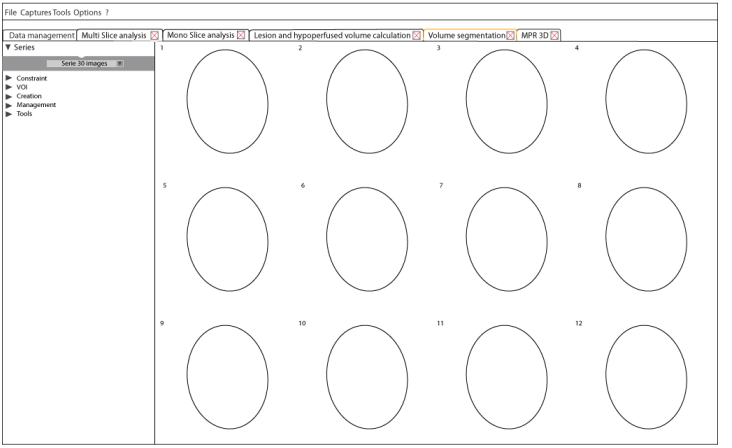
Lesion and hypoperfused volume calculation

Figure E.5.



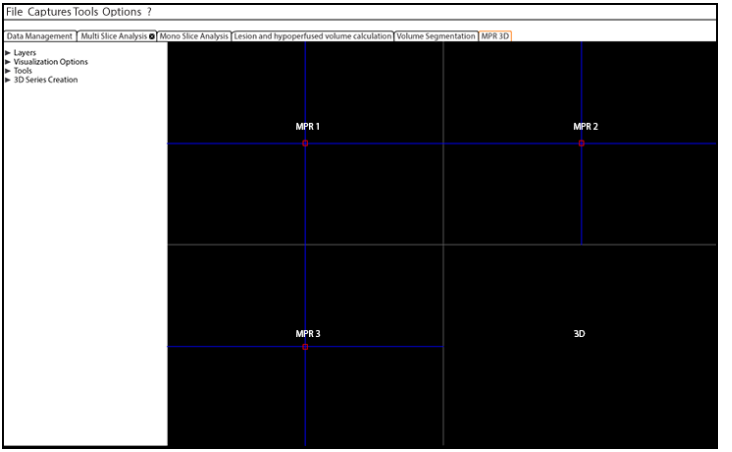
Volume segmentation

Figure E.6.



MPR 3D

Figure E.7.



Longitudinal analysis

Figure E.8.

File menu

Configuration

Olea Sphere™ allows the user to customize the environment display, generate VOI labels, etc. It is accessed via the menu **“file”** → **“configuration”**.

Templates

Configure different dedicated displays to be used in the Analysis module. Choose the template configuration, from one single view to 9 views, add or not different elements such as graphs, free DICOM viewer. It is also possible to select the needed tools or have a default display.

VOI labels

Configure the VOI category.

Series Identification

Configure the series automatic identification. Two different actions are possible:

- Choose series to be automatically selected when loading a study case,
- Suppress irrelevant series.

Captures

Note that these features are common to all modules.

Make current tab capture

Olea Sphere™ provides a tab capture tool which is the equivalent of the keyboard “print actual window”. It will generate a snapshot visible after a PDF generation (if the snapshots are selected).

Make a screen capture

Olea Sphere™ provides a screen capture tool which is the equivalent of the keyboard “print screen”. It will generate a snapshot visible after a PDF generation (if the snapshots are selected).

Make user capture

Olea Sphere™ provides a user capture tool which allows the user to manually do a capture of any part of an image or a capture of a set of images.

Key images

Olea Sphere™ provides a key image table. All the created key images along with the statistics will be displayed after a PDF generation (if the key images have been created and selected).

?

About

The about section provides:

- The version number,
- The build id,
- Olea Medical® website address,
- The support contact email address.

Processing File menu

Close

Close your study. You can now access to a new patient datasets or reopen a previously saved study.

Reopen

Reopen the current study to manually select the adequate series.

Export to Vitrea

Export the patient study to Vitrea in DICOM RGB format (computed maps, derived maps, key images, snapshots, 2D and 3D image series measurements.) .

Configuration

Please refer to the configuration sub-menu of the file menu chapter.

Quit

Quit Olea Sphere™.

When quitting the application the user can choose to export and save the session into Vitrea.

All the sessions can be identified by the date and time if they have been previously saved.

Captures menu

Make current tab capture

Olea Sphere™ provides a capture tool which allows the user to do a capture of the active module.

Make a screen capture

Please refer to the “Capture” sub-menu of the data manager menu chapter.

Make user capture

Please refer to the “Capture” sub-menu of the data manager menu chapter.

Key images and snapshots management

Olea Sphere™ provides a tool to manage the key images and snapshots. This tool allows to:

- Delete images,
- Add comments.

Tools menu

This application is only available in the analysis module. This menu gives access to the 3D coregistration module.

Icons

Basics icons

: Test

: No previous settings

: Select an image. If you double click, depending on the space you are in, you can magnify the image, which will be displayed in a standalone window. Double click again to come back to the previous view.

: Validate action

: Undo action

: Display symmetry plane

: Make a screen capture

: Add all key images

: Make a user capture

: Make a current tab capture

: Reset MPR/3D

: Display Graphs

: Display DICOM viewer

: Display color bar

: Display VOI

: Display ROI and measurements

: Show/Hide 3D pointer

: Open extended findings management window

: Change ROI/VOI color

Analysis tools icons

Monoslice analysis icons

Top left tools

: Fit views to content: reset the image, zoom in/out, pan, etc.

: Generate a key image

: Link current zoom/pan between views

: Automatic Windowing

Top right tools

: Freehand ROI

: Circular ROI

: 2D Magic Wand

: Reference ROI

: Segment Measurement tool

: Arrow. Use arrow(s) to annotate images and their point of interest

: Long/Short axis measurement tool. The axis is perpendicularity constrained

Bottom left tools

: Axial orientation

: Coronal orientation

: Sagittal orientation

: Reset to default orientation

Bottom right tools

: Elliptic ROI template

: Sector ROI template

: Sector plus ROI template

Multi-slice editor: Per Slice View icons (double click on slice)

: Small, medium and large erasers

: Freedhand shape lasso: removes pixels within the selected zone

: Freedhand shape lasso: removes pixels out of the zone selected zone

: Open the histogram

: Same action than the scrolling wheel from left (described § Mouse operation).

: Same action than the scrolling wheel from right (described § Mouse operation).

VOI management icons

: Add lasso. Here, the lasso stands for a freehand selection tool. Add the selected region to the VOI (note that it will only be applied to the selected slice, on the contrary to the 3D magic wand which is applied to all slices).

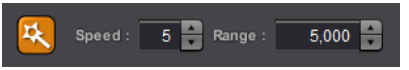
: Remove lasso. Here, the lasso stands for a freehand selection tool. Remove the selected region from the VOI (note that it will only be applied to the selected slice, on the contrary to the 3D magic wand which is applied to all slices).

: Exclude current VOI

: Include current VOI

: Add volume

: Remove volume



: Magic wand, 3D volumetric tool. The speed of the 3D region growing process is the pixels selection sensitivity. The range corresponds to the maximum pixels selected around the initial voxel value. Here, the range is the interval of pixel values to include from the central value of the initial seed-pixel.

: Change the color of ROI, arrows, etc. There are 3 different types of color section: Swatches – HSB – RGB.

: Validate the VOI to apply it.

: Reload VOI

: Add to current VOI

: Reset MPR 3D

MPR/3D

: Add an image series layer

: Add a VOI layer

: Add tracks layer

: Move the selected layer up

: Move the selected layer down

: Reset MPR 3D

: Save current overlay in the DICOM series

Fiber tracking icons

: Box seed. When placing this cube shape seed, fibers passing through that shape will be generated. When placing two cubes, fibers passing through both of them will be tracked.

: Free hand seed. When placing this freehand shape seed, fibers passing through that shape will be generated. When placing two freehand shape seeds, fibers passing through both of them will be tracked.

: Circular/Oval seed. When placing this oval shape seed, fibers passing through that shape will be generated. When placing two oval shapes seeds, fibers passing through both of them will be tracked.

: Include seed to previoulsly tracked seeds

: Exclude seed from previoulsly tracked seeds

: Hide seed

: Show selected result

: Hide selected result

: Rename the result

: Create a 3D video

Longitudinal analysis icons

: Manual co-registration

: Open Volume vs Time table

: Display ROI

: Display VOI

: Display toggle localizer

: Master Series

Keyboard shortcuts

Windows environment Data Manager keyboard shortcuts

KEYBOARD SHORTCUT	ACTION
Ctrl + A	Select all
Ctrl + left click	Select only the image series needed (step by step selection)
Alt + S	Save
Ctrl + F4	Close
Alt + Q	Quit
Alt+A	Open the Capture menu
Alt+ F	Open the file menu

Windows environment diffusion/DTI keyboard shortcuts

KEYBOARD SHORTCUT	ACTION
F	Fit to content
Delete	Delete selection (Tractography panel)
Ctrl + A	Select all
Alt + ⬆	Move selection (Tractography panel)
Esc	Close popup windows (Tractography panel)
Ctrl+A	Select all (Tractography panel)
Ctrl+C	Copy (Tractography panel)
Ctrl+V	Paste (Tractography panel)
K	Key image (Tractography panel)

Windows environment perfusion and permeability workspaces keyboard shortcuts

KEYBOARD SHORTCUT	ACTION
Enter	Ok
Alt + Q	Quit the application
Alt + L	License Manager settings
Alt + P	Make a capture of current tab
Ctrl + F4	Close the study

Windows environment analysis monoslice view and longitudinal analysis keyboard shortcuts

KEYBOARD SHORTCUT	ACTION
F	Fit to content
K	All Key images
ESC	Close popup windows
Ctrl + C	Copy
Ctrl + V	Paste
Ctrl + I	Zoom in
Ctrl + O	Zoom out
Ctrl + A	Select all ROIs
Delete	Delete current selection
↑	Slice up
↓	Slice Down

Windows environment analysis multislice view

KEYBOARD SHORTCUT	ACTION
F	Fit to content
K	All Key images
ESC	Close popup windows
Ctrl + C	Copy
Ctrl + V	Paste
Ctrl + I	Zoom in
Ctrl + O	Zoom out
Ctrl + A	Select all ROIs
Delete	Delete current selection

Enter	Open Editor
↑	Slice up
↓	Slice Down

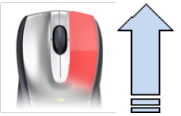
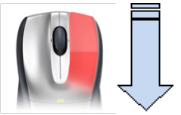
Windows environment analysis volume segmentation view

KEYBOARD SHORTCUT	ACTION
F	Fit to content
R	Reset MPR view
D	Constraint down (stack mode)
U	Constraint up (stack mode)
ESC	Close popup windows
Ctrl + I	Zoom in
Ctrl + O	Zoom out
Ctrl + Z	Undo
Delete	Delete current selection
Enter	Validate volume segmentation

Windows environment analysis MPR 3D view

KEYBOARD SHORTCUT	ACTION
F	Fit to content
R	Reset Camera
ESC	Close popup windows
Ctrl + I	Zoom in
Ctrl + O	Zoom out

Mouse operation

	Pan the selected image series
	Zoom on the selected image series; the image series is opened in a pop up window. Clicking again twice disables the zoom function and resets the image to normal size
	Higher image luminosity resolution (if the auto level is deactivated by clicking on the automatic windowing button – ref §basic icons)
	Lower image luminosity resolution (if the auto level is deactivated)
	Higher image contrast resolution (if the auto level is deactivated)
	Lower image contrast resolution (if the auto level is deactivated)
	Use the scroll wheel (up and down) to navigate into the slices of the image series. Use the shift + scroll wheel to zoom on the sliced images

F Workflow

Olea Sphere™ provides a service allowing a customizable workflow. The workflow customization can be executed locally or on another workstation. A workflow is a predefined and ordered list of modules. Each module can be processed in an interactive (through the UI) or hidden mode (with predefined options) if supported.

If the workflow is composed with hidden module steps, it could be executed remotely on another workstation/server.

Workflow creation

⚠ Only a dedicated member of Olea Medical® is able to create workflows.

Studies status definition

The following status is defined:

- Read: The study has been opened in at least one module.
- Exported: The study has been exported.

G Study viewing & analysis

Olea Sphere™ offers dedicated analysis methods and visualization tools for dynamic contrast enhanced imaging data where a bolus injection of a contrast agent material results in a temporal change in the signal intensity. This dynamic change in signal intensity is used to calculate functional parameters related to tissue flow (perfusion) and tissue blood volume as well as leakage (due to capillary permeability) of the injected contrast material from the intravascular to the extracellular space.

Viewing

Application choice from the data manager

Before loading the image series to the workspace from the data manager, an application menu is displayed on the right bottom. This menu is different depending on the type of acquisition as shown below:

Figure G.1. Applications menu

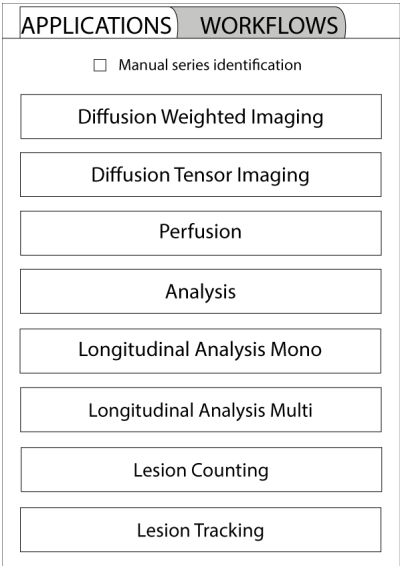
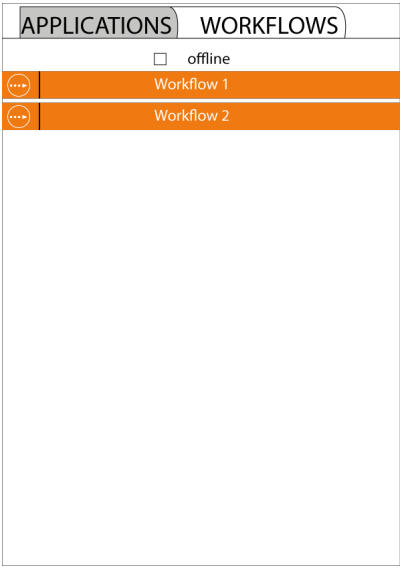


Figure G.2. Workflows menu



Once the application selected, the corresponding modality's workspace is opened.

Loading the image series to the corresponding workspace

When an image series or volume is loaded, a window containing the images appears on the Olea Sphere™ workspace. Any number of images or image volumes may be loaded onto the Olea Sphere™ workspace, limited only by the system memory space. Images are viewed as single slices in the image window.

When multiple image sets are loaded, all image specific menu options apply to the active image set.

Image viewing

This optional plug-in of Olea Sphere™ provides tools to improve the viewing of a single study and its analysis including:

- One slice or multi slice view of series based on registering series and resizing image display in order to facilitate comparisons inter/intra series,
- Display settings tools (LUT, window center and width) to highlight visualization of series,
- Image segmentation and masking based on threshold and freehand shape segmentation,
- Annotations tools and markers,
- Image series measurements (2D) including segment measure, Regions of Interest,
- Image series measurements (3D) including Volumes of Interest.

This plug-in is intended to allow the visualization and analysis of series that can include for example:

- Perfusion maps,
- Permeability maps,

- Diffusion series and derived maps,
- Conventional series,
- Any miscellaneous modalities (fMRI, any MR DICOM monochrome).

Mono slice viewer

The monoslice view is activated in the analysis environment by switching tabs. The view can be customized, depending on the template option selection and the layout selection. In the monoslice view, only one slice level is displayed each time. This display allows the user to navigate through all slices and all available series. Images are synchronized for operation of zoom in, zoom out and move/pan of the images (ref.§ Per Slice View icons). Here the brightness/contrast as well as pixels filtering can be adjusted (§Image analysis). For each series it is possible to switch between native acquisition and reformatted views (axial, coronal, sagittal). Olea Sphere™ also features overlay between two series (eg. rBV over Flair).

Image analysis

Image filtering and masks

The visualization and analysis of series can be improved by pixel filtering which consists in removing (masking) useless pixels of images (E.g.: noise, artifacts...).

A mask defines a set of pixels to be eliminated from an image. Once generated, the mask is applied to a whole series or single image. Applying the mask sets the value of pixels captured by the filtering to the baseline value, leaving the value of the other pixels unchanged. The result is the generation of a filtered image.

Olea Sphere™ features two different tools to filter images:

- Min/max threshold,
- Freehand shape filtering.

Filtering pixels by minimal and maximal threshold

Olea Sphere™ allows generating a mask by filtering the pixels with values outside a lower and upper threshold [min, max] previously defined by the user. The values outside the thresholds [min, max] are eliminated. Depending of the nature of the series, filtering pixels by thresholds values can be used advantageously to remove useless pixels and structures. For example, on diffusion series (B0, B1000...), bones and external noise have usually the lowest pixel values making it possible to define a mask to get rid of them.

Freehand shape filtering

Olea Sphere™ allows generating a filtering mask by the use of freehand tools (Eg: eraser, lasso).

Mask application between series

Filtering masks defined on a source series can be applied to another well-registered series to take advantage of filtering on both of them.

Mono slice measurements (2D images)

Olea Sphere™ features a set of tools to allow measurement on 2D images (mono slice) including:

- Segment measure,
- Region of interest (ROI),
- Long/short axis,
- Magic Wand,
- Arrow tool.

These measures are intended to allow quantitative analysis and make reporting and follow up easier.

The filtering masks defined on images are taken into account while doing 2D measurements. Manipulating and managing the 2D measurement tools

includes modifying their size and position. The measures based on them are updated accordingly. A copy/paste of these elements is also provided to duplicate them on the same image or another image. Their data (picture and measurement results) can be saved and exported to Vitrea as DICOM series (Monochrome or RGB).

Segment measure

A segment can be drawn on a 2D image (slice). Olea Sphere™ computes and displays the length of the segment.

Region Of Interest (ROI)

This option is used to obtain the pixel values from one or multiple ROIs. The ROI's shape is to be found on the toolbar. The shape of the ROI can be defined on a 2D image (slice) by the user with predefined or free-hand shapes. Using a midline section, ROI can be generated in mirror. Olea Sphere™ makes also possible to define a ROI using a magic wand based on a growing region of interest. From ROI, Olea Sphere™ computes statistical values related to the distribution of pixels inside the ROI (E.g.: mean value, surface...) and allows comparison of two ROI statistics (E.g.: ratio).

Long/short axis

Olea Sphere™ allows delineating long and short axis of elements of interest. Olea Sphere™ computes and displays the product of the two axes measurements.

Magic Wand

It is also possible to define a ROI using the magic wand. The magic wand is based on a growing ROI. From ROI, Olea Sphere™ computes statistical values related to the distribution of pixels inside the ROI such as mean value, surface, etc. It also allows the comparison of two ROIs statistics such as the ratio.

3D Midline and relative threshold

The 3D midline is set by default thus the user can define a midline separation. From this midline, the user can segment volumes of interest based on a relative threshold. The pixel values are then divided symmetrically and compared to the relative threshold. Only pixels that satisfy the threshold criteria are used in the segmentation of the volume of interest.

Volume management and 3D Image series measurements

Besides the image filtering tools Olea Sphere™ features additional tools that can be used to segment Volumes Of Interest and make 3D image measurements.

The segmentation of Volumes Of Interest is based on segmentation masks defined using tools like:

- 3D magic wand,
- Freehand tools,
- Islet filtering and completion,
- Midline and relative threshold.

The segmentation masks are usually used to isolate areas of interest on several slices of a series.

Considering the surface area defined by the segmentation masks times the spacing between slices defines volumes of Interest that can be measured and visualized.

These 3D image measurements are intended to allow quantitative analysis and make reporting and follow up easier.

3D magic wand

Olea Sphere™ features a 3D magic wand tool. From the seed pixel selected by the user on the series, the magic wand tool identifies a growing vol-

ume whose pixel values are close to the pixel selected. The user controls this process and can decide whenever he wants to stop the growth of the segmentation.

Once satisfied, it is needed to press the “enter” key to generate it and press the “create new VOI” button to validate it.

The user has the possibility to roll back at any moment of this process by using the mouse’s scroll button. Hence, to be able to navigate through the slices, the VOI has to be previously saved.

Freehand volume segmentation tools

Olea Sphere™ allows segmenting volumes of interest using freehand tools such as the lasso tool. They can either be used to add/remove pixels to/ from the volume segmentation masks.

Islet filtering and completion

The Islet filtering consists in removing from the volume segmentation small groups containing less than a certain number of pixels. Reciprocally, the islet completion consists in adding pixels into the volume segmentation to have a more homogenous volume of interest (with few holes).

An islet is a group of pixels with a non-null value and spread on a continuous zone: each pixel in the group shares a side or a corner with another pixel in the group.

Computing 3D image measurements

From the segmentation of volumes of interest, Olea Sphere™ computes statistical values such as mean value, volume, etc. The volume is estimated considering the surface area defined by the segmentation masks times the spacing between slices.

Comparison of VOI

Olea Sphere™ can enhance the visual comparison of two VOI to assess the mismatch between the two and provides comparison of two VOI statistics such as ratio.

Management of VOI

Olea Sphere™ allows managing VOI that can include modifying the volume segmentation on which they are based. The measures based on them are updated accordingly. A copy/paste of volumes of interest is also provided to duplicate them from a series to another one.

H Image Processing (Optional plug-in)

MPR/3D

The MPR windows enable visualization of an image volume onto 3 orthogonal planes. The various functions and features available are described in the following chapters. It also includes various tools for visualization and interaction with analyzed data such as DTI, fiber tracking.

Interaction panel

Layers

This is the overlay toolbar. All datasets available are provided in the current session where each dataset can be selected. It is possible to add or delete layers. The displayed layers can be series, VOIs or fiber tracks . Depending on their position in the row, they can be set as foreground or background image series.

Visualization options

This is the layers properties manager. The layer is selected, its 2D opacity can be changed as well as the 3D rendering mode. Two different display mode options are featured:

The MIP (Maximum Intensity Projection) function generates MIP maps from image volumes.

The VR (Volume Rendering) is used to display a 2D projection of a 3D data set.

It is always possible to reset the MIP or the VR result transformation by using the “reset MPR/3D” button.

MPR/3D

The Multi-Planar Reconstruction or Reformatting (MPR) function projects a desired image volume onto three orthogonal planes. Independently of image volume orientation an axial, a coronal and a sagittal projection from the volume is displayed. When the MPR is activated the axial projection is in the upper left panel, the coronal projection is in the upper right panel and the sagittal projection is in the lower left panel.

MPR window allows visualization with two different coordinate systems and the user may toggle between these two systems. By default visualization with respect to the Image volume system is chosen.

Navigation in the MPR includes the selection of a position in one of the projection images; this is done either by clicking on the 3D pointer and holding your left mouse button or, by clicking and holding your left mouse button on the double headed arrow on the lines (vertical or horizontal). This selection determines the coordinates of the projection planes in the two other projection panels and leads to their update. The rotation mode allows the user to rotate the projection plane around the axis that is orthogonal to the plane. Thus in the sagittal projection panel any rotation occurs around the left-right axis.

Overlay

Overlays may be visualized in MPR the same way as in any environment in the Olea Sphere™ workspace. One may modify their opacity settings. In the image window they are interpolated into the coordinate system of the underlay. This means that parts of overlay volumes that extend beyond the bounds of the underlay volume are truncated.

In MPR overlays may be displayed in their full extent. Overlays may extend above or below the underlay. It is always possible to reset the MPR result transformation by using the “reset MPR/3D” button.

Registration

The co-registration module contains functionality to co-register both intra- and inter-modality within the same subject. As for the MPR/3D, the co-registration window floats independently of the study workspace. The MPR window includes 2 main components. These are, from left to right.

- "Interaction Panel",
- Co-registration view.

Perfusion (Optional plug-in)

Introduction

The perfusion module can be used to obtain qualitative as well as (semi-) quantitative perfusion maps based on the dynamic (first-pass) effect of a contrast agent (CA). The perfusion module assumes that the input data describes a well-defined and transient signal response following rapid administration of a contrast agent. Analysis can be performed using a variety of different techniques.

This optional plug-in of Olea Sphere™ provides image-processing tools enabling to generate:

- Perfusion maps of time to peak (TTP), temporal Maximum Intensity Projection (tMIP), relative blood volume (rBV), relative blood flow (rBF), mean transit time (MTT) and residue function time to peak (TMAX),
- Perfusion maps of corrected rBV and permeability estimation map K2 based on an algorithm intended to correct the contrast agent extravasations effect.

Olea Sphere™ offers the following features to generate perfusion maps:

- Pre-processing options for automatic or manual background segmentation,
- Manual or automatic selection of arterial pixels for use in computing an arterial input function (AIF),
- Interactive or automatic selection of venous pixels for use in computing a venous output function (VOF),
- Deconvolution of the tissue curves to yield the residue function via standard Singular Value Decomposition (sSVD), block-circulant (or circular) Singular Value Decomposition (cSVD) or oscillating index singular Value Decomposition (oSVD),
- Enhanced display of perfusion maps,
- Correction for contrast agent leakage to extra-vascular space through the estimation of a leakage parameter (K2).

Selecting a study in the DICOM database and the perfusion plug-in from the study management window launches the Perfusion Module. Olea Sphere™ is able to load raw perfusion 4D dataset series acquired with Magnetic Resonance Imaging (MRI) modalities.

The acquisition time of the 4D series is given by DICOM attributes.

Semi quantitative/qualitative maps

Olea Sphere™ computes qualitative ("semi-quantitative") perfusion maps including:

- Time To Peak (TTP),
- Temporal Maximum Intensity Projection (tMIP).

These maps being based on direct properties of the concentration time curves without any underlying model are said to be qualitative or semi-quantitative. A time to peak map shows the regional distribution of the time needed to reach the maximum concentration, and thus, the maximum of the curve.

Computing time to peak perfusion map

Olea Sphere™ computes the Time To Peak (TTP) map. This map represents the time needed to reach the maximum concentration (the peak of the concentration of the perfused tissue)

Computing the Temporal Maximum Intensity Projections (tMIP) map

The tMIP map is constructed from the raw perfusion series by displaying for each pixel its maximal concentration over the acquisition time. Olea Sphere™ computes the Temporal Maximum Intensity Projections (tMIP). This map represents the maximal concentration value of pixels over the acquisition time.

Relative

Olea Sphere™ computes quantitative perfusion maps including:

- relative Blood Volume (rBV)
- relative Blood Flow (rBF)

These maps being all derived from the standard perfusion model using vascular deconvolution, they are said to be quantitative.

Relative means that blood volume (rBV) and blood flow (rBF) units are arbitrary and determined up to multiplicative constants.

Indeed an absolute quantification is hampered by partial volume effects. Also for MR acquisition, an absolute quantification of blood flow (unit ml/100g/min) and blood volume (unit ml/100g) would require the knowledge of proportionality constants that intervene in the conversion of signals into concentration time curves. These constants depending on the medical imaging equipment, the contrast agent and the acquisition parameters are usually unknown, thus allowing only an estimation of relative blood volume and relative blood flow.

Relative Blood Volume (rBV)

The relative blood volume is the blood volume of the capillaries and venules per tissue volume.

Relative Blood Flow (rBF)

Blood Flow is the instantaneous capillary flow in tissue.

Absolute

Mean Transit Time (MTT)

Mean Transit Time measures the length of time a certain volume of blood spends in the capillary circulation.

TMAX

Tmax represents the time to peak of the residue function.

Time To Peak (TTP)

The Time To Peak represents the time needed for the tracer to reach its peak (highest concentration value) in the perfused volume of tissue.

Loading of dynamic data

The user can select a study in the DICOM database and launch the perfusion plug-in from the study management window. Olea Sphere™ is able to load raw perfusion 4D dataset series acquired with Magnetic Resonance Imaging (MRI) modalities.

The acquisition time of the 4D (time) series is given by DICOM attributes.

Perfusion analysis settings

Automatic or manual background segmentation

Background segmentation can be defined to filter the surrounding noise and exclude background pixels on the perfusion raw series. Thresholds are ap-

plied on each slice. The result of this step is the generation of a mask for each slice. The threshold filter is automatically set but can be changed by the user at his or her convenience. This feature is available in the **"background segmentation"** panel, part of the image series adjustment tools of the perfusion plug-in.

Pre processing

Baseline

The baseline corresponds to the part of the signal before the arrival of the product. The baseline value is then computed as the mean of pixel values in this interval. In case the product arrives early after the start of the acquisition, the user has the possibility to change the baseline range. Perfusion maps are computed from the dynamic perfusion raw data. This feature is available in the **"Signal"** panel, part of the image series adjustment tools of the perfusion plug-in.

Time range

Olea Sphere™ allows modifying manually the range of the perfusion dynamic acquisition (i.e. selection of a subset of time points) used to compute perfusion maps.

Motion Correction

Olea Sphere™ includes a motion correction algorithm. This feature offers the possibility to correct patient motion artifacts during the dynamic acquisition (raw perfusion data). The patient motion, if not corrected, is likely to disturb and lower the quality of perfusion map computation. The corrected raw perfusion images replace the initial images. It is always possible to cancel this operation. Canceling will reload the initial raw and computed perfusion images.

Spatial smoothing

Olea Sphere™ performs a spatial and temporal filtering (smoothing) on raw data in order to reduce the background noise and improve the visualization of computed permeability maps. It is always possible to cancel this operation. Canceling will reload the initial raw and computed perfusion images.

Vascular Deconvolution

AIF

The response to the tracer at the arterial level is distinct from the tissue response. The AIF is the concentration curve of one or several pixels selected in major arteries. Olea Sphere™ provides to the operator the capability to select either manual or automatic arterial input function. This is achieved by selecting a point or a region on desired raw perfusion images. The user has a visual feedback of the point or region selected and the resulting AIF curve. The user can change the selection if the selected AIF doesn't fit his or her requirements.

VOF

The Venous Output Function (VOF) is a concentration curve of a pixel selected in a major vein. Since veins are larger than arteries, pixels in regions of veins are less prone to partial volume effects.

Olea Sphere™ allows the user to select a manual or automatic VOF. This is achieved by selecting a point or a region on desired raw perfusion images. The user has a visual feedback of the point or region selected and the resulting VOF curve. The user can change the selection if the selected VOF doesn't fit his or her requirements.

The automatic VOF's selection is based on a dedicated algorithm. The algorithm selects automatically several concentration time curves in major veins. The mean/average curve is then used as an automatic VOF. The user has a visual feedback of the pixels selected by the algorithm and the resulting VOF curve. The user can use the interactive selection of the VOF if the automatic VOF doesn't fit his or her requirements.

Deconvolution

The concept of Deconvolution is widely used in the techniques of signal processing and image processing. Deconvolution of the tissue curves is computed to yield the residue function. Olea Sphere™ proposes to choose the Deconvolution method between:

- sSVD (standard Singular Value Decomposition),
- cSVD (circular Singular Value Decomposition),
- oSVD (oscillating index Singular Value Decomposition).

By design, the cSVD method produces perfusion parameters estimates (e.g. blood flows) that are independent of the delay (delay-in- sensitive) between the arrival time of the contrast agent in the AIF and the arrival time of the contrast agent in the tissue.

The oSVD method is Block circulant matrix singular value decomposition with semi-adaptive oscillation index-based thresholding. Like cSVD, this method is also delay-insensitive since it is based on the same block circulant convolution matrix. The oSVD is delay-insensitive like cSVD but is also semi-adaptative. It means that while in cSVD the number of small singular values to be truncated is fixed once and for all by the threshold value, in oSVD this number is determined for each voxel by minimizing a smoothness criterion on the residue function to be estimated. As a consequence, oSVD is more robust and thus provides more accurate estimates than other SVD-based algorithms.

For more information, please refer to the Semi quantitative/qualitative maps sub-chapter page 60 & Relative sub-chapter page 61.

Contrast agent leakage correction

This feature only applies to MR perfusion weighted acquisition. The underlying standard Deconvolution model used in this perfusion plug-in assumes that the contrast agent is contained in the intravascular space for the duration of the dynamic acquisition. This method assumes that the contrast agent exhibits T2 or T2* effects (susceptibility-contrast signal intensity loss) in the intravascular compartment but that the contrast effect is mainly T1-shortening once the agent leaks into the extravascular extracellular space. Consequently the susceptibility-contrast signal intensity loss can be masked by loss of compartmentalization and signal intensity increase in regions where T1-shortning effects are significant. Therefore, in regions of contrast

agent leakage the concentration time curve is likely to decrease below the baseline value due to T1-shortning effects causing a potential underestimation of relative blood volume.

Olea Sphere™ features a correction of the contrast agent leakage from the intravascular to extracellular space. When leakage correction is enabled, Olea Sphere™ computes a corrected relative Blood Volume map and an additional map (K2). The latter is the permeability map estimation in which the pixel intensity is proportional to the rate of contrast leakage from the intravascular to the extravascular extracellular space.

To better visualize the effects of the leakage correction algorithm, Olea Sphere™ displays the corrected concentration curve, which is used to compute the corrected rBV and to estimate permeability. Olea Sphere™ allows the user to enable or respectively disable the correction for contrast agent leakage from the intravascular to the extravascular extracellular space. When applied, this algorithm computes a corrected relative Blood Volume and a permeability estimation map named **K2**.

The user has a visual feedback of the effects of the leakage correction algorithm on the concentration time curves.

J Permeability (Optional plug-in)

Introduction

The Dynamic Contrast Enhanced (DCE) analysis module can be used to obtain qualitative as well as semi-quantitative maps of several parameters related to vascular permeability and intra- extravascular volumes based on the dynamic effect of a contrast-enhancing agent (CA). Analysis can be performed using a variety of different techniques. In particular, the following features are included:

Olea Sphere™ offers the features to generate permeability maps:

- Pre-processing options for automatic or manual noise threshold,
- Interactive or automatic selection of arterial pixels for use in generating an arterial input function (AIF),
- Enhanced display of permeability maps.

- Measurement of qualitative dynamic curve parameters,
  - Initial up-slope of the curve (wash-in),
  - Down-slope of the curve (wash-out),
  - Area under the curve (AUC),
  - Time to maximum enhancement (TME),
  - Peak enhancement (Peak).
- Computation of quantitative permeability maps including:
  - Rate constant for transfer of contrast agent from plasma to extravascular, extracellular space (EES) (Ktrans),
  - Rate constant for transfer of contrast agent from EES to plasma (Kep),
  - Plasma volume (Vp),
  - Fractional volume of EES (Ve),

These maps being all derived from the two-compartment tracer kinetic modeling, they are said to be quantitative.

Qualitative, Semi quantitative maps

Olea Sphere™ computes qualitative ("semi-quantitative") permeability maps including:

- Time to Maximum Enhancement (TME),
- Area Under the Curve (AUC),
- Peak enhancement (PEAK),
- Initial up-slope of the curve (Washin),
- Down-slope of the curve (Washout).

These maps being based on direct features of the concentration time curves without any underlying model, they are said to be qualitative or semi-quantitative.

Quantitative dynamic curve maps

Time to Maximum Enhancement map (TME)

The Time to Maximum Enhancement map (TME) shows the regional distribution of the time needed to reach the maximum concentration thus, the maximum of the curve.

Area Under Curve map (AUC)

This map represents the integration of contrast agent concentration over time.

PEAK enhancement map

This map represents maximal concentration of contrast agent.

Wash in map

This map represents the initial up-slope of the concentration time curve.

Wash out

This map represents the down-slope of the concentration curve.

Quantitative parameter maps

KTrans map

This map represents the rate constant for transfer of contrast agent from plasma to extravascular, extracellular space.

Kep map

This map represents the rate constant for transfer of contrast agent from extravascular, extracellular space to the plasma.

Ve map

This map represents the fractional volume of vascular plasma space.

Vp map

This map represents the fractional volume of vascular plasma space.

Loading of Dynamic Data

Select a study in the DICOM database, containing dynamic contrast enhanced acquisition, and launch the permeability plug-in from the study management window [ref. § Workspaces]. Respecting the image acquisition order, Olea Sphere™ loads raw permeability 4D dataset series acquired with Magnetic Resonance Imaging (MRI) modalities.

Analysis

Automatic and manual background segmentation

Background segmentation can be defined to filter the surrounding noise. The result of this step is the generation of a mask used for the computation of derived permeability maps and to improve their display. Thresholds are applied on each slice. This filter is automatically set and can be changed by the user at his or her convenience.

Pre-processing

Spatial and temporal filtering

Olea Sphere™ performs a spatial and temporal filtering (smoothing) on raw permeability data in order to reduce the background noise and improve the visualization of computed permeability maps.

Motion correction

This feature can be used each time the patient's organs moved during the dynamic raw acquisition. If not corrected, the patient motion is likely to disturb and lower the quality of permeability map computation.

Baseline

The baseline corresponds to the part of the signal before the arrival of the product. The baseline value is then computed as the mean of pixel values in this interval. The user has the possibility to change the baseline range in case the product arrives early after the start of the acquisition.

Time range

The user can modify the range of the permeability dynamic acquisition used to compute permeability maps.

Manual and automatic AIF

The user has the possibility to choose between an automatic AIF or a manual AIF. Once selected (either way), the user has a visual feedback of the point/region selected and the resulting AIF curve. Once selected, the AIF can still be changed.

DCE Model

Several computation settings are available to calculate the quantitative permeability maps. Olea Sphere™ uses Tofts & Kermode (without Vp) and Extended Tofts (with Vp). Each of these two models are numerically computed using Kinetic modeling with measured global arterial input function.

K Diffusion Analysis (Optional plug-in)

Loading Diffusion-weighted imaging analysis

The user can select a study in the DICOM database and launch the diffusion-weighted imaging plug-in from the data management window. An automatic identification of gradient value (x›o s/mm2) and orientations (Gx, Gy, Gz) is done based on DICOM attribute reading. Olea Sphere™ computes and displays:

- Isotropic,
- ADC,
- Exponential ADC.

If no identification is possible, Olea Sphere™ displays a warning and aborts the computation.

Background segmentation is automatically applied on these computed maps to filter the surrounding noise and exclude background pixels. This threshold can easily be adjusted manually.

For both the raw data (DWI dataset) and the computed maps, the image display can be improved by manually changing the window center and width.

Diffusion Tensor Imaging Analysis (Optional plug-in)

As for the DWI, a study is selected in the DICOM database and the diffusion tensor-imaging plug-in is launched from the data management window. An automatic identification of gradient value (x › o s/mm2) and direction is done based on DICOM attribute reading. The coordinates of the diffusion gradient are displayed for each image. If no identification is possible, Olea Sphere™ displays a warning and aborts the computation.

Computation of anisotropy diffusion indices

From the different diffusion gradient directions, Olea Sphere™ computes and displays:

- The Trace Weighted images: Trace_W,
- The Mean Diffusivity: Mean_Diffusivity,
- The Axial Diffusivity: Axial_Diffusivity,
- The Radial Diffusivity: Radial_Diffusivity,
- The Fractional Anisotropy: FA,
- The Relative Anisotropy: RA,
- The Volume Ratio: VR,
- The color coded map of the main diffusion direction: Color_DTI.

A background segmentation is automatically applied on these computed maps to filter the surrounding noise and exclude background pixels. This threshold can easily be adjusted manually.

For both the raw data (DTI dataset) and the computed maps, the image display can be improved by manually changing the window center and width.

Fiber tracking

The fiber tracking plug-in allows reconstructing axonal tracts using diffusion tensor imaging. Olea Sphere™ performs fiber tracking using the Fiber Assignment by Continuous Tracking (FACT) algorithm. The FACT method basically consists in selecting a seed region from which a line is propagated in both retrograde and orthograde directions. The tracking is stopped when it meets the bounds of the parenchyma or termination criteria. The fiber tracking algorithm relies on the calculated diffusion tensors from a DTI dataset. This is why the tract reconstruction can only be performed after DTI analysis.

The performance of the fiber tracking algorithm is likely to be dependent on both the image quality of source data and the inherent limitations of the fiber tracking algorithm. For example, in case the diffusion pathways are overlapping (crossing/kissing), the fiber tracking algorithm may fail to correctly reconstruct the tracts. Specific care should be taken when interpreting the tract reconstruction which should be reserved to trained practitioner.

The fiber tracks can be loaded in the MPR 3D view.

Fiber tracking from exhaustive search

The fiber tracking can be initiated from all voxels within the volume.

Fiber tracking from seed search

The fiber tracking can be initiated from defined seed-voxels. In this case, the seed-region has to be defined within the image volume using volume of interest definition.

M Multiple Studies Analysis (Optional plug-in)

Introduction

If several examinations have been done for the same patient, Olea Sphere™ offers tools to enhance the visualization and analysis of the followup examinations. The follow-up allows the user to visualize the evolution through different studies. This can be useful to see how abnormalities evolve over time. Similarly 2D such as ROI or 3D such as VOI image series measurements can be followed through different studies to see the evolution over time.

The multiple studies viewing has been designed to extend the functionalities of the study viewing and analysis plug-in which was initially intended for a single study only. That is why many tools are common between these two displays.

Loading studies

This plug-in is available in the application menu under the name of **"Longitudinal analysis"**.

When launching the plug-in, Olea Sphere™ looks for all the studies that belong to the same currently selected patient. From all those loaded studies, the user can choose the studies and series he or she wants to load and display in the workspace. For memory and display constraints, only three loaded studies can be selected at the same time.

This plug-in has been designed to offer two display modes: the mono and multi modalities.

Mono modality display

Olea Sphere™ allows the user to choose a mono modality display mode. This mode allows following up the different acquisitions of a same sequence, such as a series like FLAIR, that have been acquired over time.

Multi modalities display

Olea Sphere™ allows the user to choose a multi modalities display mode. This mode allows following up series that have been acquired over time from different modalities such as FLAIR, DWI or MRI, CT, etc.

Viewing & Measurements

2D and 3D measurement tools

The 2D image measurements tools are exclusively available in the mono-modality mode. Moreover, the generation of Region of interest (ROI) is made synchronously on the different acquisitions of a same modality over time. The 3D images series measurements are also available. Olea Sphere™ allows visualizing the evolution in time of the measures supplied by the 2D and 3D image series measurements.

Co-registration

Olea Sphere™ performs an automatic co-registration of series using DICOM header to make sure that displayed series are always well-registered according to their position described in the patient coordinate system. The 3D co-registration tool (ref. § MPR/3D) is available to allow manual co-registration of series within a single study.

Whenever dealing with follow up examinations of a patient, the different acquisitions over time are likely not to share the same patient coordinate system. The co-registration is then essential to allow consistent follow up of

series. Olea Sphere™ gives the possibility to the user to automatically or manually register series.

The co-registration feature is based on a MPR display. It consists in registering the displayed acquisitions.

Icons & Tools

Olea Sphere™ features additional tools that can be used to segment Volumes Of Interest and make 3D image measurements. By activating the icon tool a floating window will display the volume segmentation. Clicking the "Inner" button will open a floating co-registration window. For more information please refer to Volume management and 3D Image series measurements and § Icons.

N

Lesion Counting and Tracking

Olea Sphere™ features these modules to track lesions on images (lesion counting) and compare the amount over time (lesion tracking).

0 Best Practices

Reporting and snapshots

All the results coming from the analysis of a single or multiple studies using one or several plug-ins can be used to generate reports. Enhancing and making easier reports is an important goal of Olea Sphere™ to provide reliable information that can be shared between practitioners.

Managing screen capture

A screen capture consists in the capture of one or several images and their attached 2D image measurements. This feature is specifically useful to generate personalized reports. Screen captures can be generated from the selection of one or all the images displayed on the screen. The user has the possibility to add comments to each of them.

Export results

These results can be exported to Vitrea as DICOM series.

The format of the export can either be:

- Magnetic Resonance format (monochrome),
- Other type format (RGB),

The export function allows the user to:

- Configure the content display,
- Select the series to export,
- Edit the DICOM data.

Saving and restoring sessions

The user has the possibility to save his session. A session includes all the work done by the user from the opening of the data. To be able to save and restore a session, it has to be previously generated series and derived maps. They are saved in the DICOM database as DICOM series (monochrome MR DICOM format).

All user inputs selected during the current session can be saved in the DICOM database as a configuration DICOM series (Other Type {OT} format).

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