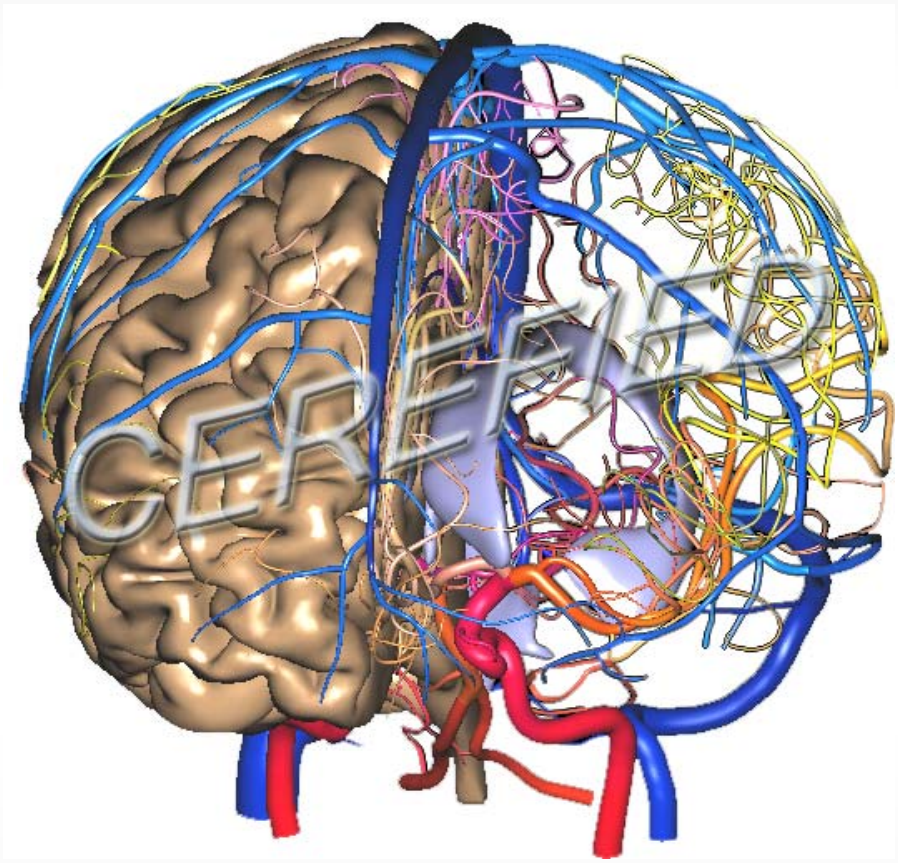
The Cerefy® Atlas of Cerebral Vasculature



USER GUIDE

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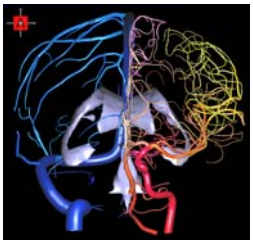
1. Introduction

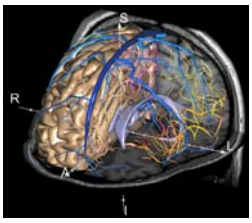
The Cerefy® Atlas of Cerebral Vasculature (*CACV*) is a sophisticated and user-friendly application on CD-ROM correlating the cerebrovasculature with surface and sectional neuroanatomy for a wide use in neuroradiology, neurosurgery, neurology, neuroanatomy, neuroscience, and neuroeducation.

The *CACV* has the following features:

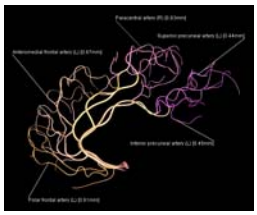
- it contains a three-dimensional (3D), detailed, highly parcellated, electronically dissectible, fully segmented, and completely labeled surface model of the cerebral vasculature



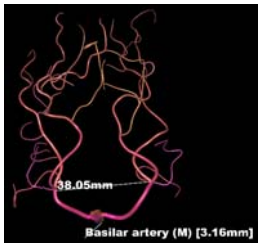
- the 3D cerebrovascular model comprises both the arterial and venous systems which are further subdivided into groups and individual branches, each of them uniquely color-coded
- the 3D cerebrovascular model can freely be manipulated in real time and displayed from any viewpoint and at any magnification



- the 3D cerebrovascular model is co-registered with 3D neuroanatomical models of the hemispheres and the ventricular system
- the 3D cerebrovascular and 3D neuroanatomical models are correlated with neuroimaging: MRI and MRA scans of the same specimen presented simultaneously on three orthogonal planes (triplanar)



- the 3D cerebrovascular model can be dissected electronically allowing the user to interactively build any vascular network composed of individual arteries and/or veins
- the 3D cerebrovascular model or any part of it and the 3D neuroanatomical models can be manipulated (rotated, zoomed, and panned) and displayed along with the MR scan triplanar handled as a 3D object



- each individual vessel is labeled with its name and diameter at any location
- the 3D cerebrovascular model is also labeled with the description of cerebrovasculature, description of variability, and references
- this is a reference atlas that is placed in a stereotactic coordinate system and provides localization and quantification of cerebrovasculature including coordinates, distances, and vessel diameter
- it provides image capturing and self testing.

The *CACV* design follows the main principles of our previous five brain atlases published by Thieme [9-13], namely:

- atlases fully segmented and completely labeled with the names of structures
- two-way mapping between the atlas images/models and the index
- cross-referencing among the orthogonal orientations
- quantitative assessment including coordinates and distances.

The new design principles employed in the development of the *CACV* include:

- novel presentation and exploration fully in 3D
- correlation of the 3D cerebrovascular model with the surrounding surface and sectional neuroanatomy
- spatial co-registration of the MRI and MRA scans
- 3D and (meta) labeling of vessels with name, diameter, cerebrovasculature description, variability description, and references.

2. Materials and methods

2.1. Materials

The *CACV* contains three groups of materials:

- MRI and MRA scans of the same specimen (WLN)
- 3D cerebrovascular and neuroanatomical models
- textual material on vascular anatomy and variability, and references.

The MR scans include two 3 Tesla (T) axial acquisitions:

- MRA (3D TOF)
- MRI (MPRAGE).

The MRA scan was employed to construct the 3D cerebrovascular model. The MRI scan was used to build the 3D neuroanatomical models of the hemispheres and the ventricular system.

***Note**: Several connections could not be resolved and some parts of the venous system were not completely present in the MRA scan (e.g., the left transverse sinus and left inferior anastomotic vein). We made use of some additional scans (1.5T MRV and multiple 7T acquisitions) to cope with these problems.*

At the core of the *CACV* is the 3D cerebrovascular model with the arterial and venous systems correlated with the 3D cortical and ventricular models and sectional neuroimaging. The sub-division of these models is given in Section 3.1.

The textual material (of 215 pages) on vascular anatomy and variability has been complied from the following books:

1. Grand W, Hopkins LN: *Vasculature of the Brain and Cranial Base: Variations in Clinical Anatomy*. Thieme, Stuttgart – New York 1999.
2. Huber P: *Cerebral Angiography*. 2nd ed. Thieme, Stuttgart – New York 1982.

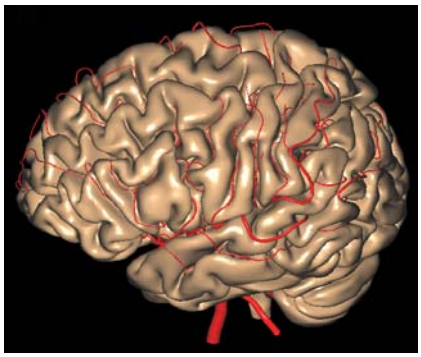
3. Kretschmann HJ, Weinrich W: *Cranial Neuroimaging and Clinical Neuroanatomy*. 3rd ed. Thieme, Stuttgart – New York 2004.

2.2. Methods

The development of the *CACV* was a long-term, multi-stage, and meticulous process requiring the use of several methods and tools [14]. We faced numerous challenges in the development of the *CACV* and they are addressed in the introduction on the home page.

2.2.1. Construction of 3D models

The 3D cerebrovascular model was constructed from the MRA scan manually by employing a dedicated and sophisticated vascular editor. The meticulous care was undertaken during the interactive process of atlas creation to accurately extract all vessels including these whose diameters were smaller than the MRA pixel size and those hardly visible in the scan. A vessel modeling technique applied to build the surface model is detailed in [18]. The vessels are modeled as tubes with circular cross-sections (the anterior part of the superior sagittal sinus is modeled with elliptical cross-sections). All vessels are uniquely color-coded: the arteries with the red color being dominant and the veins with the blue color being dominant.



The brain and ventricles were extracted from the MRI scan and their 3D surface models were constructed. The sulci were "opened" (enlarged) manually to make the vessels completely visible inside them.

The coronal and sagittal MRA and MRI images were generated by orthogonal reformatting. The images on the manipulable (3D) scan triplanar are represented as 8 bit textures. To increase their contrast, low intensities (mainly the background) and very high intensities of the original 16 bit images were truncated and mapped into 8 bit images.

2.2.2. Scan-model co-registration

The 3D cerebrovascular model, 3D neuroanatomical models, and MRI and MRA scans were spatially co-registered by applying 3D rotation, translation, and scaling based on their voxel sizes (as they correspond to the same specimen). The anterior commissures (located at the origin of the coordinate system) of the MR scans were aligned. The MRI scan was rotated (reformatted) to match more closely the MRA scan.

3. Overview

3.1. 3D model content

The *CACV* contains 3D surface (polygonal) models of:

- arterial system
- venous system
- hemispheres

- ventricular system.

The arterial system is divided into:

- left
- right,

and each of them subdivided further into:

  - Anterior Cerebral Artery (ACA)
  - Middle Cerebral Artery (MCA)
  - Posterior Cerebral Artery (PCA)
  - Internal Carotid Artery (ICA)
  - Basilar Artery (BA)
  - Vertebral Artery (VA).

The venous system is divided into:

- left
- right.

Moreover, any individual vessel or group of vessels can be selected from the vascular index (Section 4.5) and displayed as a 3D model.

The hemispheres are divided into:

- left
- right.

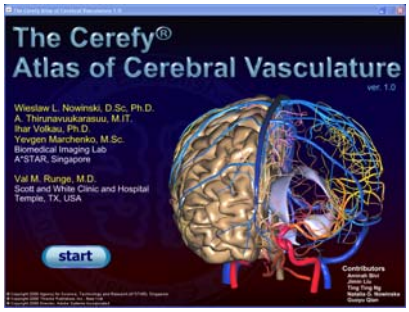
3.2. Functionality

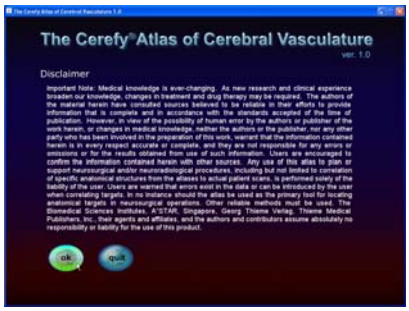
The main groups of functions provided by the *CACV* are the following.

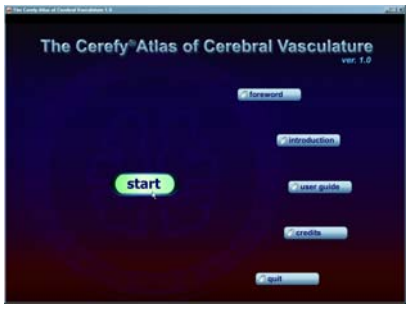
- **Model/triplanar display**
  - 3D models (of arteries, veins, left and/or right hemispheres, and/or ventricular system)
  - MR scan triplanar (axial, coronal, and/or sagittal orientations)
  - preset views (superior (S), inferior (I), anterior (A), posterior (P), left (L), or right (R))
  - animate.
- **Vessel selection**
  - arteries (left, right, ACA, MCA, PCA, ICA, BA, VA and/or CW – circle of Willis)
  - veins (left, right)
  - any individual vessel or group of vessels from the vascular index.
- **Vessel labeling/highlighting**
  - 2D labeling of the cerebrovascular model
  - 3D (manipulable) labeling of the cerebrovascular model
  - name and hemisphere of the pointed vessel
  - vessel diameter at the pointed location
  - description of vascular anatomy, description of variability, and references

- vessel showing and hiding
- vessel highlighting and searching.

- **Model/triplanar manipulation**
  - zoom
  - rotate
  - pan
  - preset views.
- **Quantification**
  - coordinates
  - distances
  - vessel diameter.







3.3. Getting started

Upon starting the *CACV* (see Section 6 for details), the title page is displayed first, followed by the disclaimer page, and the home page.

Click on the *start* button on the title page to start the *CACV*.

Click on the *ok* button on the disclaimer page to continue.

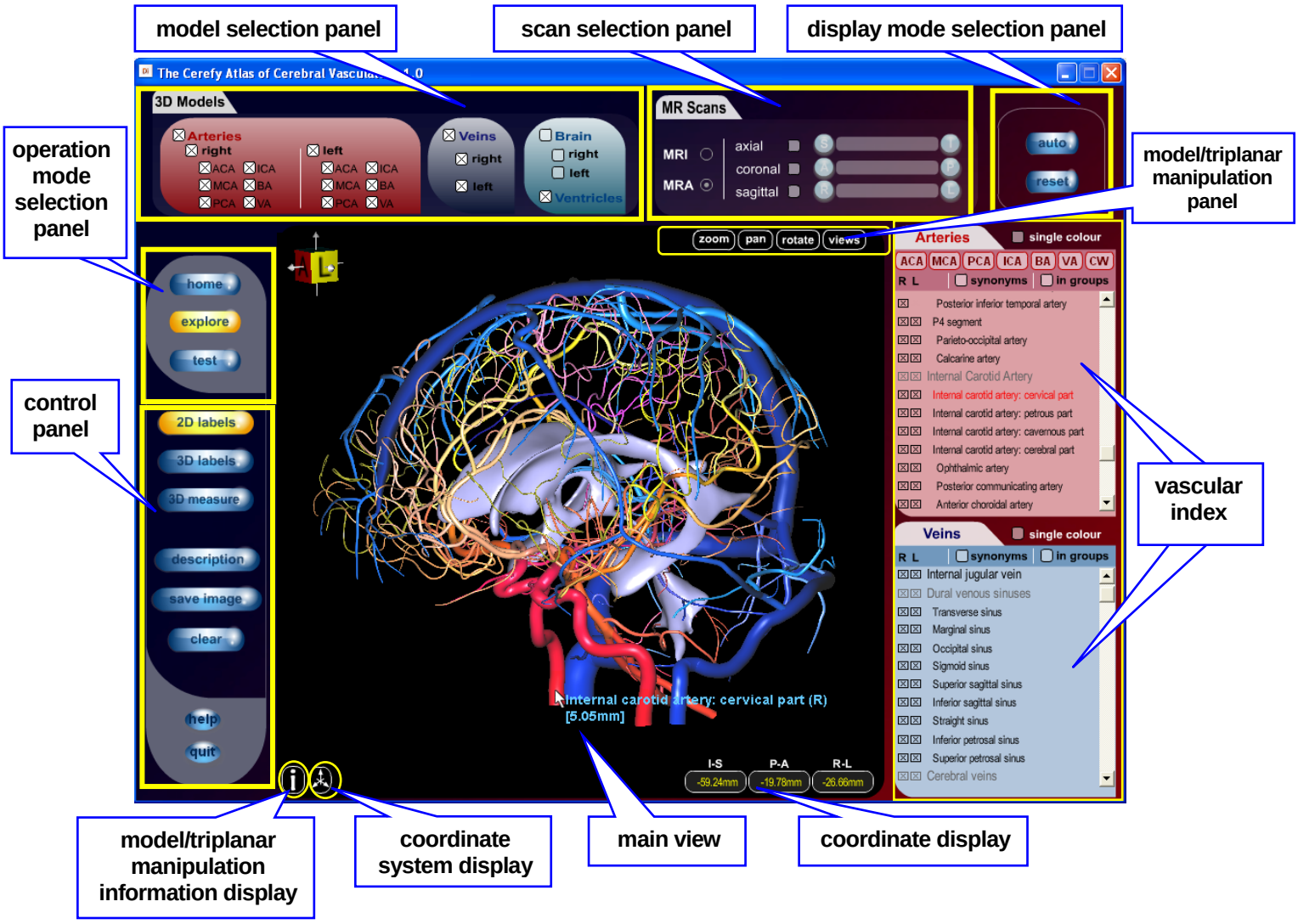
Click on the *start* button on the home page to continue. You can also read the foreword, introduction and credits, and get access to the user guide by clicking on the corresponding button.

3.4. User interface

The user interface contains the following main components:

- **main view**
- **vascular index**
  - panel with the arteries
  - panel with the veins
- **controls**
  - model selection panel
  - scan selection panel
  - display mode selection panel
  - model/triplanar manipulation panel
  - operation mode selection panel
  - control panel

- o model/triplanar manipulation information display control
- o coordinate system display control
- o coordinate display.



The model selection panel enables the user to select 3D models for display in the main view. The user can select the entire cerebrovascular model or any part of it and display it alone or jointly with the neuroanatomical models.

The operation mode selection panel allows the user to choose the operation mode: explore or test (see Section 3.5). The user can also go to the home page (see Section 3.3) by clicking on the *home* button.

The control panel is an area with the buttons for 2D labeling, 3D labeling, 3D measurement, getting description, saving image, clearing the main view, getting help, and quitting the *CACV* (see Section 4.4).

The scan selection panel sets the MR triplanar and enables the user to select a scan (MRI or MRA), its orientation(s), and image(s) for display in the main view (see Section 4.2).

The vascular index, separated into the upper panel with the arteries and the lower panel with the veins, lists all the vessels available in the *CACV*. It is active (clickable) and provides functions for vessel selection, highlighting, and searching (see Section 4.5).

The selected models and the MR scan triplanar are displayed in the main view. The results of most of the operations are displayed in this view.

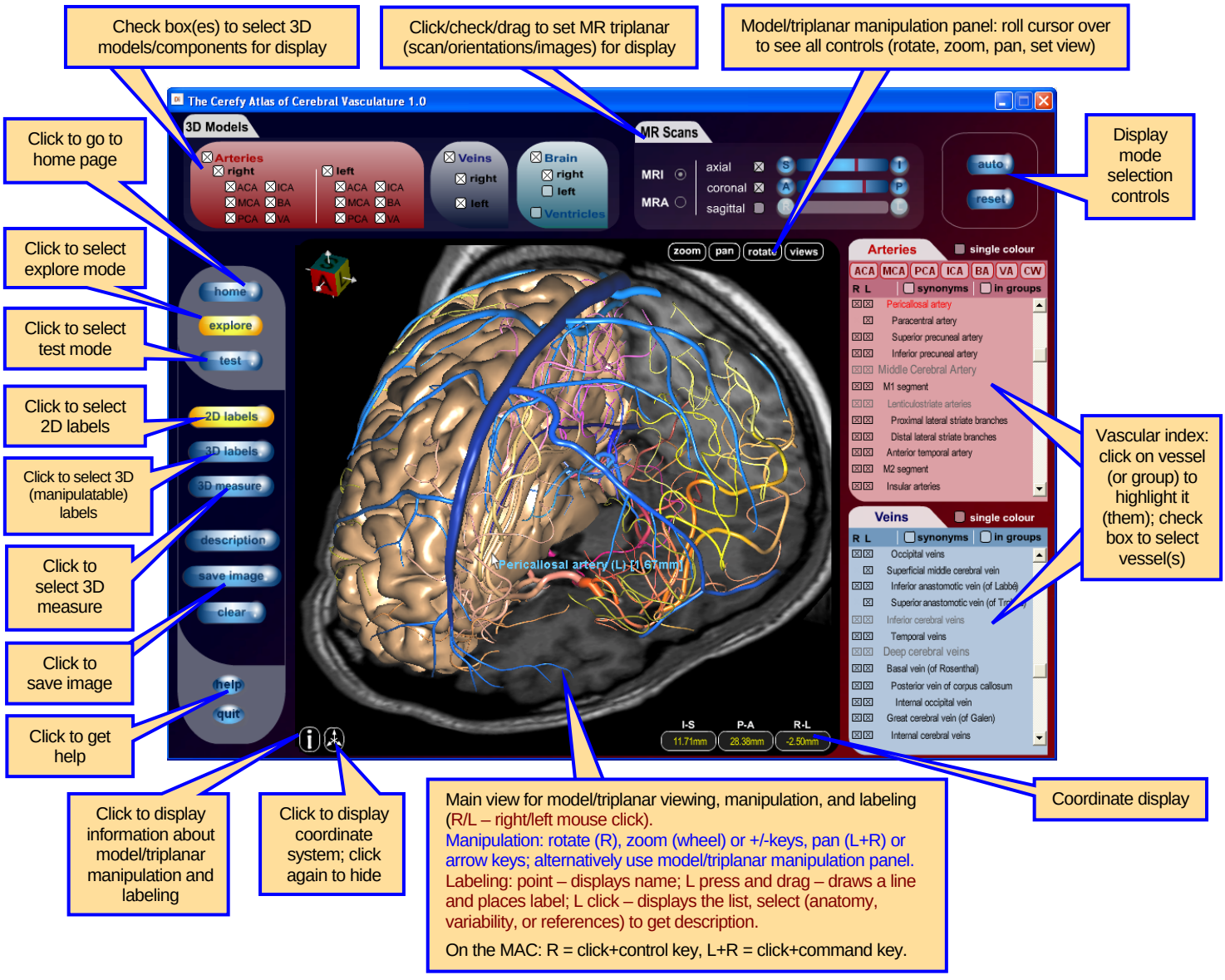
3.5. Operation modes

The *CACV* works in two modes:

- atlas exploration mode to present, navigate, and explore the 3D cerebrovascular and neuroanatomical models along with MR neuroimages displayed on the 3D triplanar (see Section 4)
- test mode for self-testing (see Section 5).

3.6. Help and user guide

The *CACV* provides help and this user guide to facilitate its use. Click on the *help* button on the control panel to get help about the *CACV* as shown below. Click on the *user guide* button on the home page to get access to this user guide available in PDF format.



The authoring tool employed for the *CACV* development does not recognize the right mouse button on the MAC. Therefore, the right mouse click on the MAC is simulated by mouse clicking with the control key held down; the simultaneous left and right mouse clicks are simulated by mouse clicking with the command key pressed.

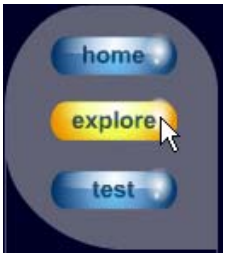
3.7. Terminology

Vascular terminology is generally not consistent across textbooks. Creating a 3D vascular atlas (where every vascular location is labeled with name) that has to serve various communities (neuroradiology, neurosurgery, neurology, neuroanatomy, neuroscience, and neuroeducation) is a challenge. In the *CACV*, as in our previous brain atlases, we have adapted *Terminologia Anatomica* [1], suitably expanded and modified. It is used in terms of nomenclature (names) and topology (hierarchical structure). To better meet the needs from various communities, we have extended *Terminologia Anatomica* with synonyms taken from several textbooks including [2-8], [15-17]. While extending, we also tried to avoid naming which may cause confusion, for instance:

- "anterior temporal artery" (M1 segment), "anterior temporal branch" (M3 segment), and "anterior temporal branches" (P3 segment) in *Terminologia Anatomica*;
- "frontoorbital artery" (ACA) and "frontoorbital artery" (MCA) in [4], [17].

In addition, to avoid long lists of synonyms, some minor variations in naming were disregarded; for instance: "artery of central sulcus", "artery to central sulcus", and "central sulcus artery" were assigned a single name: "central sulcus artery".

4. Atlas exploration mode



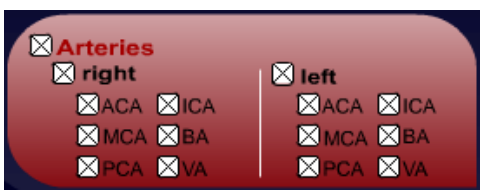
The atlas exploration mode allows the user to present, navigate and explore the 3D cerebrovascular model, neuroanatomical models, and MR neuroimages presented on the 3D triplanar. This mode is set by clicking on the *explore* button on the mode selection panel (see Section 3.4). The *CACV* works by default in the atlas exploration mode (the *explore* button is activated upon starting).

4.1. Model selection

The 3D models can be shown or hidden from display. Each model or sub-model (as listed in Section 3.1) has its corresponding check box on the model selection panel. This enables the user to show or hide a selected model as follows:

- check (i.e., click on it to cross it) the check box to display its corresponding model 
- uncheck the check box to hide its corresponding model from display. 

4.1.1. Selection of arteries



All the arteries are selected for display by checking the *Arteries* check box. The

arteries of the right hemisphere (and the midline) are displayed by checking the *right* check box. The arteries of the left hemisphere (and the midline) are displayed by checking the *left* check box.

In addition, the following groups of arteries can be shown or hidden:

- Anterior Cerebral Artery (ACA)
- Middle Cerebral Artery (MCA)
- Posterior Cerebral Artery (PCA)
- Internal Carotid Artery (ICA)
- Basilar Artery (BA)
- Vertebral Artery (VA).

4.1.2. Selection of veins

All the veins are selected for display by checking the *Veins* check box. The veins of the right hemisphere (and the midline) are displayed by checking the *right* check box. The veins of the left hemisphere (and the midline) are displayed by checking the *left* check box.

4.1.3. Selection of hemispheres

The hemispheres are selected for display by checking the *Brain* check box. The right hemisphere is displayed by checking the *right* check box. The left hemisphere is displayed by checking the *left* check box.

4.1.4. Selection of ventricles

The ventricles are selected for display by checking the *Ventricles* check box.

4.2. Selection of MR scan, orientations, and images

The MR neuroimages to be displayed as the triplanar are selected from the scan selection panel. It enables the user to select a scan, its orientation(s), and image(s).

4.2.1. Scan selection

The user can select the MRI or MRA scan for triplanar display. The scan can be displayed individually or together with any 3D model.

4.2.1.1. Selection of MRI scan

To select the MRI scan for display, click on the *MRI* radio button.

4.2.1.2. Selection of MRA scan

To select the MRA scan for display, click on the MRA radio button.

4.2.2. Orientation selection

The scans are displayed in three orthogonal orientations: axial, coronal, and sagittal. The user can select one, two, or all three orientations for a simultaneous display (as a 3D manipulable triplanar).

The axial orientation is selected by checking the *axial* check box.

The coronal orientation is selected by checking the *coronal* check box.

The sagittal orientation is selected by checking the *sagittal* check box.

4.2.3. Scan image scrolling

For the selected scan and its orientation(s), the images can be scrolled forward and backward to set the triplanar as follows.
For the axial orientation:

- clicking on the *S* button displays the next superior image
- clicking on the *I* button displays the next inferior image
- dragging the slider scrolls the axial images.

For the coronal orientation:

- clicking on the *A* button displays the next anterior image
- clicking on the *P* button displays the next posterior image
- dragging the slider scrolls the coronal images.

For the sagittal orientation:

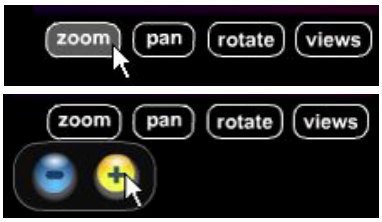
- clicking on the *L* button displays the next left image
- clicking on the *R* button displays the next right image
- dragging the slider scrolls the sagittal images.

Each click scrolls one image; when the button is kept pressed, the images keep scrolling.

4.3. Model – MR scan triplanar manipulation

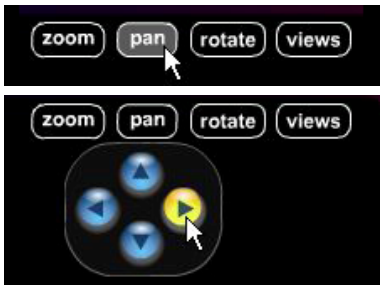
To manipulate the objects in the main view (i.e., the cerebrovascular model or any part of it, the neuroanatomical models, and/or the MR scan triplanar), four operations are provided: zoom, rotate, pan, and view setting. The corresponding buttons are located for convenience in the top right corner of the main view on the model/triplanar manipulation panel (see Section 3.4). Each button when rolled over drops down its specific control buttons.

4.3.1. Zoom



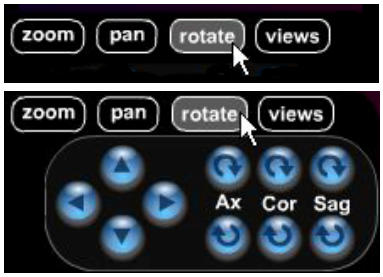
The zoom operation enables the user to continuously magnify or reduce objects in the main view. This operation is activated by pointing to the *zoom* button. Then, the drop-down buttons appear and the user can zoom in (by clicking on "+") or zoom out (by clicking on "–"). Keeping the button pressed continues zooming.

4.3.2. Pan



The pan operation enables the user to continuously pan objects in four directions. It is particularly useful when the object is zoomed in and the region of interest does not fit well into the main view. This operation is activated by pointing to the *pan* button. Then, the drop-down buttons appear and the user can pan the objects in four directions (up, down, left, and right) by clicking on the corresponding button. Keeping the button pressed continues panning.

4.3.3. Rotate

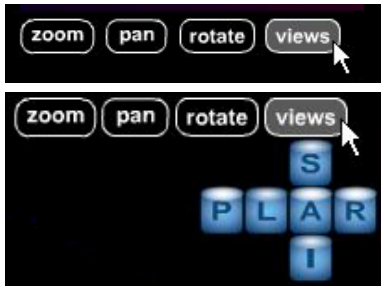


The rotate operation enables the user to continuously rotate objects in four directions as well as along the axial (*Ax*), coronal (*Cor*), or sagittal (*Sag*) reference axis. This operation is activated by pointing to the *rotate* button. Then, the drop-down buttons appear and the user can rotate the objects in two ways by clicking on the corresponding button:

- in four directions (up, down, left, and right) around the center of the cerebrovascular model with 2° step;
- along each reference axis (axially clockwise, axially counterclockwise, coronally clockwise, coronally counterclockwise, sagittally clockwise, and sagittally counterclockwise) with 1° step.

Keeping the button pressed continues rotation.

4.3.4. Views



This operation enables the user to view objects from any of the six preset views:

- S – superior
- I – inferior
- A – anterior
- P – posterior
- L – left
- R – right.

The operation is activated by pointing to the *views* button. Then, the drop-down buttons appear and the user can set the view by clicking on the corresponding button (*S*, *I*, *A*, *P*, *L*, or *R*).

4.4. Operations

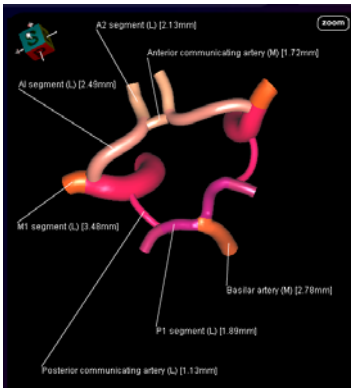
The control panel enables the user to label the cerebrovascular model, measure in 3D the cerebrovascular and neuroanatomical models along with the sectional neuroanatomy, get descriptions of vascular anatomy and variability, get references, capture images to prepare presentations and teaching materials, and get help.

4.4.1. Labeling

Labeling means that any location in the 3D cerebrovascular model, when pointed to, provides some information about itself. The default information is its name, coordinates of location, and diameter (or the major and minor axes in the case of elliptical modeling). It addition, for the pointed vessel its description of vascular anatomy, description of variability, and references can be given (Section 4.4.1.3).

4.4.1.1. 2D labels

Click on the *2D label* button on the control panel to activate 2D label reading (this operation is activated by default when the *CACV* starts). By pointing to any vessel in the main view, the vessel's name (including its synonyms, if selected, see Section 4.5.3) and its diameter are given. This name is displayed automatically next to the pointed location along with the vessel location identifier: R (right), L (left), or M (midline). Moreover, this name is highlighted in the vascular index by a change in color to red (which also facilitates determining the vessel's parent). In addition, by clicking on any vessel, dragging the mouse, and releasing it, a line is drawn and a label is placed at the end of this line. In this way the user can place dynamically multiple labels permanently (until cleared). 2D labels are cleared automatically when performing model manipulation or by clicking on the *clear* button (see Section 4.4.5).



4.4.1.2. 3D labels

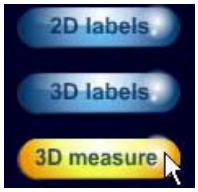
Click on the *3D label* button on the control panel to activate 3D label reading. By pointing to any vessel in the main view, the vessel's name (including its synonyms, if selected, see Section 4.5.3) and its diameter are given. This name is displayed automatically next to the pointed location. By clicking on any vessel, dragging the mouse, and releasing it, a line is drawn and a 3D label is placed at the end of this line. The vessel location identifier (R (right), L (left), or M (midline)) is also appended. Moreover, this name is highlighted in the vascular index by a change in color to red. 3D labels remain in the main view and keep facing the user when performing manipulation which facilitates atlas exploration. In addition, a 3D label is kept displayed even when the labeled vessel is obscured by other vessels.

4.4.1.3. Labeling with description of vascular anatomy, description of variability, and references

The arteries and veins can be labeled with description of vascular anatomy and variability (complied from the sources listed in Section 2.1) as well as with references. Click on a selected vessel, get the pull-down menu, and select *anatomy*, *variability*, or *references*. The related textual material is then displayed in a pop-up (browser) window.

***Note**: The textual material can be printed or saved to an external file from the browser.*

4.4.2. Measure



Measuring is activated in the main view by clicking on the *3D measure* button on the control panel.

4.4.2.1. Distance reading

When measuring is activated by clicking on the *3D measure* button, then distance reading is feasible between any two points located on any object(s) in the main view. By clicking on any location, dragging the mouse, and releasing it at another location, the *CACV* draws a line segment between these two locations and displays their distance in millimeters. The distance display is manipulation independent. This operation assists the user in studying the spatial relationships among the cerebral vessels and the surrounding surface and sectional neuroanatomy.

4.4.2.2. Coordinates

The inferior-superior (I-S), posterior-anterior (P-A), and right-left (R-L) coordinates (in millimeters) of a pointed location on any object are displayed in the bottom right corner of the main view. No user action is required to activate this function.

When the MR scan triplanar is displayed, the coordinates indicating the location of the selected images are displayed even when the cursor is outside the main view.

4.4.3. Description

This operation displays the entire textual materials (see Section 2.1) with the vascular anatomy, variability, and references. Click on the *description* button to have the text displayed in a pop-up (browser) window.

***Note**: The textual materials can be printed or saved to an external file from the browser.*

4.4.4. Save image

This operation saves the current image displayed in the main view as annotated with the label(s) and/or distance(s) by the user. The operation is performed by clicking on the *save image* button on the control panel. The image is saved in TIFF format to

an external file and the user is prompted for its name and location.

4.4.5. Clear

The clear operation removes 2D and 3D labels and distances (along with the corresponding lines) from the main view. This operation is performed by clicking on the *clear* button on the control panel.

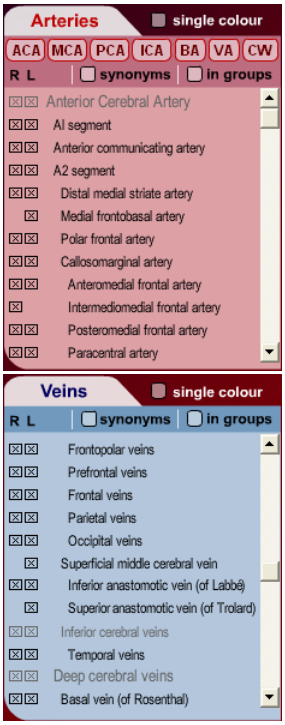
4.4.6. Help

Click on the *help* button to get help about the *CACV* (see also Section 3.6).

4.4.7. Quit

Click on the *quit* button to quit the *CACV*.

4.5. Vascular index operations



The hierarchical vascular index is active permanently meaning that each listed vessel is clickable (both its name and the corresponding check boxes). It enables the user to show/hide vessels in the main view, highlight them, and search for any vessel. An item in the index has its corresponding check boxes: one for the left and one for the right hemisphere (a few vessels are present unilaterally and, consequently, each has a single check box). When checked, the corresponding vessel is displayed; when unchecked, the vessel is hidden. A vessel alone or along with its all sub-vessels (as defined by the hierarchy of the vascular index) can be selected; in the latter case the *in groups* check box must be checked (its default status is uncheck).
Each of the *Arteries* and *Veins* indices is scrollable by dragging the vertical scroll bar on the right. In addition, the *Arteries* index can be scrolled to a given group of arteries (ACA, MCA, PCA, ICA, BA, VA, or CW) by clicking on its corresponding button.

4.5.1. Vessel showing and hiding

The user can select any vessel from the vascular index by checking its corresponding check box and add it to the 3D model already composed in the main view. Unchecking the check box results in vessel removal from the composed model. This mechanism supplements and fine tunes that of the model selection panel (Section 4.1) and enables the user to build interactively any cerebrovascular model composed of individual arteries and/or veins.

4.5.2. Vessel highlighting

The user can choose any vessel from the vascular index by clicking on its name and the location of this vessel will be highlighted in the main view (provided that the vessel is present there) by a change in color to white/red. The name of the chosen vessel is additionally highlighted in the vascular index by a change in color to red. When the *in groups* check box is checked, the highlighting is

applied to the chosen vessels and its all sub-vessels as defined by the hierarchy of the vascular index. This feature allows for a rapid localization of vessels and/or their groups in the entire cerebrovascular model or any part of it.

4.5.3. Synonyms

By checking the *synonyms* box, the user can display synonyms as listed in Appendix A (arteries) and Appendix B (veins and sinuses). The default setting is no synonyms. This operation is applied to the vascular index and to labeling in the main view.

4.5.4. Single color

The cerebrovascular model is color-coded. If needed, each of the arterial and venous systems may be displayed in a single color: red and blue, respectively. The single color display is set by checking the *single color* box. The default setting is unchecked (multiple colors).

4.5.5. Vessel search

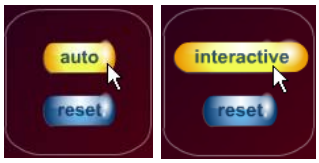
Searching enables the user to localize and highlight any vessel(s) of interest. As the vascular index displayed contains all the vessels (as listed in Appendices A and B), the highlighting mechanism (see Section 4.5.2) is also suitable for searching. The user selects the vessel to be searched from the vascular index by clicking on its name. The searched vessel is highlighted in the main view by a change in color to white/red.

4.6. Display mode selection

The user can explore the atlas in two display modes: interactive (default) and automatic. In the interactive mode, the user can perform model and MR scan triplanar manipulation interactively. In the automatic mode, the selected model(s) and/or triplanar are animated (continuously rotated). In this mode, the functions for model selection and interactive manipulation are still enabled. The user can rotate, scale and pan the 3D model(s) along with the MR scan triplanar while selecting or hiding vessels and neuroanatomical models. Any 3D labels and distances are kept in the automatic mode. Vessel highlighting is also enabled in the automatic mode allowing the user for a quick and friendly exploration.

4.6.1. Automatic/interactive mode

Click on the *auto* toggle button to set the automatic mode. Click on it again to restore the interactive mode. The automatic mode clears any 2D labels.



4.6.2. Reset

Click on the *reset* button to reset the display of the 3D models and MR scan triplanar in the main view. Resetting does not work in the automatic mode.

4.7. Model/triplanar manipulation information display

The 3D cerebrovascular and neuroanatomical models along with the MR scan triplanar can be manipulated in two ways. The standard way is to use the

operations provided on the model/triplanar manipulation panel (Section 4.3). An alternative way is to use shortcuts as follows:

- rotate: R
- zoom: wheel or +/- (standard) keys
- pan: L+R or arrow keys

where R (L) means the right (left) mouse click.

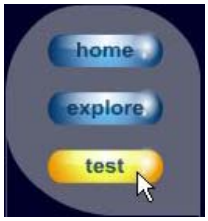
The authoring tool employed for the *CACV* development does not recognize the right mouse button on the MAC. Therefore, the right mouse click on the MAC is simulated by mouse clicking with the “control” key held down; the simultaneous left and right mouse clicks are simulated by mouse clicking with the “command” key pressed.

Click on the icon in the bottom left corner of the main view to display this information (along with the information on labeling). Move the mouse cursor outside the text to clear it.

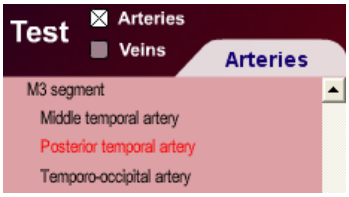
4.8. Coordinate system display

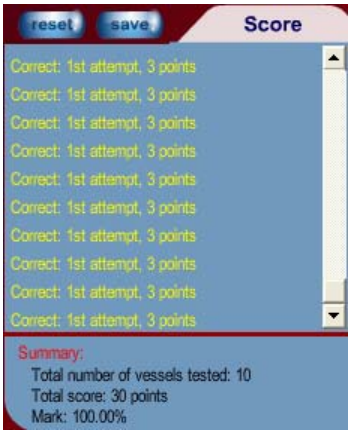
Click on the coordinate system icon in the bottom left corner of the main view to display the coordinate system axes. The origin of the coordinate system is placed at the anterior commissure. The axes are represented as 3D objects and the marks (disks) on them are at 10 mm distance. Since the axes are handled as 3D objects, the distance reading (Section 4.4.2.1) and coordinates (Section 4.4.2.2) are feasible on them. Click on the icon again to hide the coordinate system.

5. Test mode



The test mode allows the user to test his or her knowledge of 3D cerebrovasculature. This mode is activated by clicking on the *test* button on the mode selection panel.





In the test mode, the user is tested against naming of the arteries by checking the *Arteries* check box or the veins by checking the *Veins* check box. These two check boxes are on the test panel on the right. The *CACV* generates randomly a name of a vessel (highlighted in the vascular index by a change in color to red) and the user must identify this vessel in the main view by clicking on it.

The score for the current operation and the aggregated score are also displayed below the vascular index. The user can reset the score by clicking on the *reset* button and/or save it to an external text file by clicking on the *save* button.

To facilitate testing and vessel identification, exploration is enabled in the test mode.

6. Installation, system requirements, and technical support

6.1. Installation

For the PC. Run “setup.exe” from the CD-ROM and follow instructions. After a successful installation:

1) from the installed folder double click on 'CACV 1.0.exe' or
2) under the Windows programs menu 'Start’ select 'The Cerefy Atlas of Cerebral Vasculature 1.0'.

For the MAC. Run “CACV 1.0 Installer” from the CD-ROM and follow instructions. After a successful installation, from the installed folder double click on 'CACV 1.0'.

Important general information

(i) It is advised to have OpenGL or DirectX drivers installed in your system. This enables a smoother and faster manipulation of the 3D models.

(ii) Having a good video card provides a better running environment for the *CACV*.

(iii) An operating system with other than the English version (such as Japanese, Hungarian or Polish) may cause the program to run abnormally.

(iv) When running 'Setup' from the CD-ROM, please note that it might take several seconds to start the installation depending on the system's hardware.

(v) Set *Screen resolution* to 1024 x 768 pixels or higher and *Color quality* to 16 bit or higher. If you explore the vascular model along with its description, set *Screen resolution* to 1280 x 1024 or higher.

(vi) The electronic version of this user guide can be read from the CD-ROM as a PDF document located in the user_guide folder. It is also available in the installed folder on the hard disk.

6.2. System requirements

PC minimum requirements

2 GHz Intel Core 2 Duo or higher
1 GB RAM or greater
128 MB video card memory or greater
305 MB hard disk space
Monitor resolution: 1028 x 768 pixels and 16 bit colors or higher
Windows XP Service Pack 2 or later, or Vista (the English version is recommended)

The recommended browsers are Internet Explorer and Firefox.

MAC minimum requirements

2.8 GHz Intel Core 2 Duo or higher
2 GB RAM or greater
128 MB video card memory or greater
340 MB hard disk space
Monitor resolution: 1028 x 768 pixels and 16 bit colors or higher

MAC OS X 10.4 (the English version is recommended)
The recommended browser is Safari.

6.3. Technical support

Updates of *The Cerefy® Atlas of Cerebral Vasculature* will be available from www.cerefy.com.

If you have any problems, comments or suggestions, please contact us at CACV@cerefy.com.

Please visit www.cerefy.com for the latest updates and information.

Happy Cerefying

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Appendix A: List of arteries

Anterior Cerebral Artery
- Al segment; Precommunicating part
- Anterior communicating artery
- A2 segment; Postcommunicating part
  - Distal medial striate artery; Long central a.; Recurrent a. (of Heubner)
  - Medial frontobasal artery; Medial orbitofrontal a.
  - Polar frontal artery; Frontopolar a.
  - Callosomarginal artery
    - Anteromedial frontal artery; Anterior internal frontal a.
    - Intermediomedial frontal artery; Middle internal frontal a.
    - Posteromedial frontal artery; Posterior internal frontal a.
    - Paracentral artery
  - Pericallosal artery
    - Paracentral artery
    - Superior precuneal artery; Superior internal parietal a.
    - Inferior precuneal artery; Inferior internal parietal a.

Middle Cerebral Artery
- M1 segment; Sphenoid part; Horizontal part
  - Lenticulostriate arteries; Anterolateral central aa.;
    - Proximal lateral striate branches; Medial lenticulostriate arteries
    - Distal lateral striate branches; Lateral lenticulostriate arteries
  - Anterior temporal artery
- M2 segment; Insular part
  - Insular arteries
- M3 segment; Inferior terminal branches; Inferior cortical bb.; Opercular part
  - Middle temporal artery
  - Posterior temporal artery
  - Temporo-occipital artery
- M4 segment; Superior terminal branches; Superior cortical bb.; Terminal part
  - Lateral frontobasal artery; Lateral orbitofrontal a.
  - Prefrontal artery
  - Precentral sulcus artery; Precentral a.; Prerolandic a.
  - Central sulcus artery; Central a.; Rolandic a.
  - Postcentral sulcus artery; Postcentral a.
  - Anterior parietal artery
  - Posterior parietal artery
  - Angular gyrus artery; Angular a.

Posterior Cerebral Artery
- P1 segment; Precommunicating part
- P2 segment; Postcommunicating part
  - Posterior lateral choroidal artery
- P3 segment; Lateral occipital artery
  - Anterior inferior temporal artery
  - Middle inferior temporal artery; Intermediate temporal a.
  - Posterior inferior temporal artery
- P4 segment; Medial occipital artery
  - Parieto-occipital artery
  - Calcarine artery

Internal Carotid Artery
- Internal carotid artery: cervical part
- Internal carotid artery: petrous part
- Internal carotid artery: cavernous part
- Internal carotid artery: cerebral part
    - Ophthalmic artery
    - Posterior communicating artery
    - Anterior choroidal artery

Basilar artery
- Anterior inferior cerebellar artery
    - Labyrinthine artery
- Pontine arteries
- Superior cerebellar artery

Vertebral artery
- Posterior inferior cerebellar artery
    - Cerebellar tonsillar artery
    - Choroidal branch to fourth ventricle
- Anterior spinal artery

Cerebral arterial circle (of Willis)

Appendix B: List of veins and sinuses

- **Internal jugular vein**
- **Dural venous sinuses**
  - Transverse sinus
  - Marginal sinus
  - Occipital sinus
  - Sigmoid sinus
  - Superior sagittal sinus
  - Inferior sagittal sinus
  - Straight sinus
  - Inferior petrosal sinus
  - Superior petrosal sinus
- **Cerebral veins**
  - **Superficial cerebral veins**
    - Superior cerebral veins
      - Frontopolar veins
      - Prefrontal veins
      - Frontal veins
      - Parietal veins
      - Occipital veins
    - Superficial middle cerebral vein; Superficial sylvian v.
      - Inferior anastomotic vein (of Labbé)
      - Superior anastomotic vein (of Trolard)
    - Inferior cerebral veins
      - Temporal veins
  - **Deep cerebral veins**
    - Basal vein (of Rosenthal)
      - Posterior vein of corpus callosum; Dorsal v. of corpus callosum
        - Internal occipital vein
    - Great cerebral vein (of Galen)
      - Internal cerebral veins
        - Lateral direct veins
    - Superior thalamostriate vein
      - Anterior vein of septum pellucidum
  - **Cerebellar veins**
    - Superior vein of vermis
    - Inferior vein of vermis
    - Superior veins of cerebellar hemisphere
    - Inferior veins of cerebellar hemisphere
    - Precentral cerebellar vein
    - Petrosal vein