

Original article

NOWinBRAIN 3D neuroimage repository: Exploring the human brain via systematic and stereotactic dissections



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ABSTRACT

Purpose: Cadaveric and electronic dissections are well-established procedures to examine the brain. They are typically variable, content-specific, and not determined in any stereotactic space. We propose a novel approach to use systematically designed stereotactic multi-sequences of neuroimages of the dissected brain with non-dissected 3D structures/systems of interest. Our purpose is three-fold to propose a method for systematic brain dissecting, create a gallery of systematically dissected brain images located in a stereotactic space, and integrate this gallery with the NOWinBRAIN 3D neuroimage repository for public use.

Basic procedures: Systematic brain sectioning consists in the generation of a sequence of dissected image sequences and providing an image naming syntax. Brain dissections are defined by four parameters, dissection direction, dissection location, view of presentation, and appearance (parcellation and labeling).

Main findings: The created dissection gallery contains brain dissections with non-dissected cerebral ventricles, deep gray nuclei, white matter tracts, intracranial arteries, deep cerebral veins, and cranial nerve nuclei. It has 1,942 images organized in 6 albums and 32 sub-albums.

Principal conclusion: Systematic and stereotactic virtual brain dissections cum labeling facilitates exploration of location, course, continuity, extent, and cerebral context of structures and systems which are otherwise fully or partly obscured by the parenchyma. Because of its advantages, user simplicity, and free availability, the dissection gallery with NOWinBRAIN of overall 7,761 images is vital in medicine and beyond for medical students, residents, educators, medical professionals, neuroscientists, medical illustrators, patients, and brain enthusiasts for brain studying, teaching, testing, exploring, referencing, and communicating. This is the first work introducing stereotaxy to brain sectioning.

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1. Introduction

The human brain is the most complex organ in the known universe. Therefore, this is not surprising that several studies carried out in various countries have demonstrated that neuroanatomy, neuroscience, and/or neurology are reported to be the most difficult in medical education [4,6,9,17,22]. To facilitate copying with this issue I have created NOWinBRAIN - a large, systematic, comprehensive, expandable, spatially consistent, homogeneous, to be long-lasting, easy to use, beautiful, and freely available repository of 3D images of the human brain extended to the head and neck bridging neuroanatomy, neuroscience, neuroradiology, neuroeducation, and informatics [14,20]. Despite a remarkable development of numerous brain-related resources as reviewed in [14] such a repository was not available earlier.

NOWinBRAIN is designed as a web-based hierarchical repository with diverse 3D neuroimage galleries. The anatomic galleries G1-G6 were created earlier. Galleries G1-G5 comprise surface (3D) anatomy parcellated and labeled, and organized into image (appearance and context) sequences [14]. Gallery G1 contains 26 numbered primary tissue classes further subdivided into 207 subclasses forming the building blocks from which the other galleries are built (like from Lego blocks). Each tissue (sub-)class is stored in an album (folder). The primary tissue classes are the central nervous system; brain; cerebrum; cerebral lobes; cerebral poles, planes, and areas; cerebral gyri and lobules; cerebral sulci and fissures; cerebellum; brainstem; cervical spinal cord; deep (gray) nuclei; cerebral ventricles; white matter; white matter tracts; intracranial arterial system; intracranial venous system; extracranial arteries; extracranial veins; cranial nerves and nuclei; head muscles; glands; skull; cervical spine; skin; auditory system; and visual system. Gallery G2 comprises double-tissue classes (e.g., deep nuclei and cerebral ventricles), gallery G3 triple-tissue classes (e.g.,

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skull, cranial nerves, and head muscles), gallery G4 quadruple (or more)-tissue classes (e.g., intracranial arterial and venous systems, and extracranial arteries and veins), and gallery G5 comprises context image sequences. Gallery G6, especially useful for neuroradiology, spatially correlates planar (2D obtained by reformatting) and surface anatomy bridging 2D neuroradiology with 3D neuroanatomy [13].

Brain dissectioning is a traditional and well-established way to examine the brain as presented in a form of photographs or drawings in several textbooks [1–3,7,8,10,18]. As dissectioning of cadaveric brains is destructive and has limitations with respect to specimen availability, cost, and ethical issues, it is preferentially replaced by electronic dissecting of volumetric brain scans. This approach, however, is often restricted in terms of views and usually does not provide a surrounding context and suitable detail. Moreover, dissections are content-dependent and they are not determined in any stereotactic space.

These limitations are lessened by the approach proposed here with the use of the 3D atlas along with the NOWinBRAIN framework allowing for arbitrary brain dissections in multiple directions, combining the dissected brain with full non-dissected 3D virtual models of structures and systems of interest, providing any context in terms of the 26 primary tissue classes, and enabling structure parcellation by color and labeling. In addition, brain dissectioning is systematic in terms of dissection direction, dissection location, view of presentation, appearance and image naming, and the resulting dissected images are located in stereotactic space.

This work is an extended version of an electronic poster presented at the ECR (European Congress of Radiology) 2022 meeting [15]. The goals of this work are to present a novel method for systematic brain dissecting, create a gallery of systematically dissected brain images located in a stereotactic space, and integrate this gallery with the NOWinBRAIN repository for the public use by a wide spectrum of users in medicine and beyond.

2. Material and methods

The NOWinBRAIN repository is designed as a hierarchical architecture with image galleries at the top subdivided into albums (folders) and further down into sub-albums. The undivided (atomic) albums and sub-albums are populated with the images. To create the content images, a 3D atlas of the brain, head, and neck was employed [11] available publicly at [21].

This multi-award winner atlas was created for over a decade from multiple 3 and 7 Tesla MR and high-resolution CT scans of the same living specimen. The atlas contains about 3,000 3D components that are completely parcellated by color, fully labeled with *Terminologia Anatomica* [5], and placed in the Talairach stereotactic coordinate system based on the anterior (AC) and posterior (PC) commissures [19]. The atlas provides functions for composing any 3D scene and labeling it, volume reformatting in any arbitrary direction, and image saving which features were exploited to generate the images [12].

The NOWinBRAIN repository requirements, architecture, design, implementation, and image content of the first five galleries (G1–G5) were addressed earlier [14]. Gallery G6 correlating surface with planar neuroanatomy was presented in [13]. NOWinBRAIN provides functions for image display, resizing, scrolling, searching, and saving (downloading) by the user. To facilitate use, additional materials are provided along with the complete image content (i.e., the full indices with tissue classes and sub-classes and the image lists for all galleries). NOWinBRAIN has a systematic design in terms of standard views (anterior (A), left (L), posterior (P), right (R), superior (S), and inferior (I) (and arbitrary views too)), appearance (non-parcellated unlabeled, parcellated unlabeled, and

parcellated labeled images), and types of presentation (with diverse spatially co-registered image sequences).

Based on this framework, the proposed method for image generation has six following steps. A structure (or structures) or system of interest is (are) selected to be examined in the context of the dissected brain or some of its part. The brain can be dissected in anterior, left, posterior, right, superior, and inferior orthogonal directions without cutting the structure(s)/system of interest. The dissected brain along with the non-dissected structure(s)/system of interest is presented from five orthogonal views, the dissection view along with four views orthogonal to it (i.e., the sixth view opposite to the dissection is unused as it does not show any dissection effect). For each view, a sequence of parallel dissections is produced at locations at a constant step apart covering the studied structure(s)/system of interest. At each location, a sequence of images with various appearances in terms of parcellation and labeling is created. These images can be non-parcellated (mono-colored) or parcellated (multi-colored) with three color maps corresponding to the cerebrum parcellation into lobes, gyri, and sulci with gyri. An image can be unlabeled or labeled and the 3D labels are automatically generated by the atlas (though the image creator must place them interactively). The labels are placed on both the structures/system of interest and the dissected brain (or its component) including its surface (on the lobes, gyri, and/or sulci) and/or the dissection itself (on the subcortical structures). All the generated images are spatially co-registered and have the same size of the structure(s)/system of interest. Finally, the images are uniquely named to enable their location, identification, and searching within NOWinBRAIN. Consequently, the procedure for generation of the dissection gallery produces a set of images as follows:

For each structure(s)/system of interest

For each direction

For each view

For each location

For each appearance

Create image

This set of images forms a sequence of image sequences defined by four parameters, dissection direction, dissection (plane) location, view direction, and appearance. Various image sequences can be obtained by varying some parameters and fixing the others. By varying the dissection location and fixing the other three parameters, the dissection image sequence is created. By varying the view direction and fixing the other three parameters, the view image sequence is obtained. By varying the appearance and fixing the other three parameters, the appearance image sequence is received. By varying the dissection direction and fixing the other three parameters, the direction image sequence is obtained.

The image naming syntax determines the image content, dissection direction, view, location, and appearance (color and labeling). It includes the gallery (G), tissue classes and/or sub-classes (T) numbered as determined in the primary tissue classes G1, image view (V), dissection determined by a direction and a location as a single coordinate (D), mono- (M) or multi-color (C), and label (L), and is the following:

Gn.Tm-n.Vn.Dnmm.Cm-n.Ln.Brain_component-Structure(s)/
system_of_interest

where:

G – gallery; n = 7.

T – tissue class; m – brain component (including the cervical spinal cord), n – structure(s)/system of interest; for multiple tissue classes n,...,q, Tm-n-...-q.

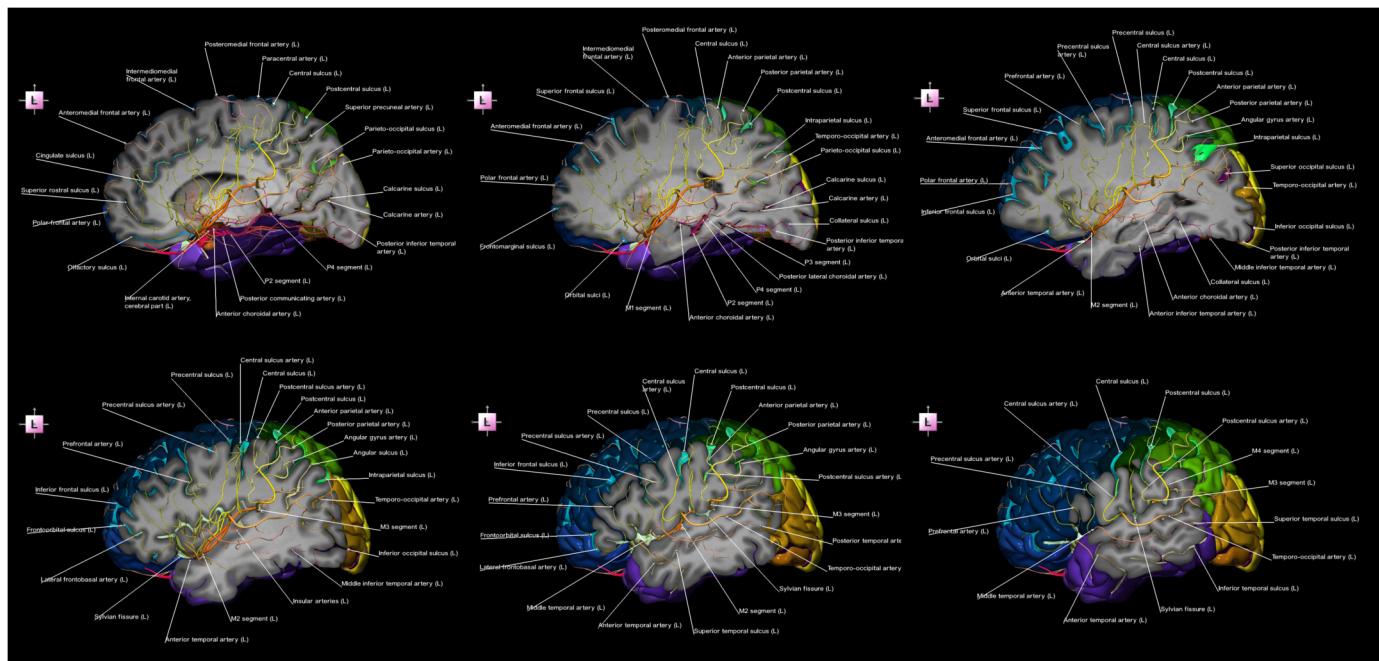


Fig. 1. Illustration of a dissection image sequence of a left dissected cerebrum exposing the course, extent, and cortical context of the intracranial arteries deep in the cerebral sulci. The cerebrum and arteries are parcelled by color, and the sulci and arteries are labeled. The dissections are spanning from 10 mm to 60 mm from the midsagittal plane, 10 mm apart. The locations of 3D labels placed in the vicinity of the dissection planes convey depth.

V – view; n = {1 A (anterior), 2 L (left), 3 P (posterior), 4 R (right),
5 S (superior), 6 I (inferior)}.

D – dissection direction and localization in mm; n = {a (anterior), l (left), p (posterior), r (right), s (superior), i (inferior); also in axial (si), coronal (ap), and sagittal (lr) orientations}.

C - color; for brain component color m = {1 mono-color; 2-4 multi-color, 2 l (lobes), 3 g (gyri), 4 gs (gyri and sulci)}; for structure(s)/system of interest color n = {1 mono-color; 2 multi-color; 5 RGB for the white matter tracts}; if m = n, then Cm; for multiple tissue classes n,...,q, Cm-n,...-q.

L - label; n = {0 unlabeled, 1 labeled (standard), 2 (and higher) extra labels}.

3. Results

By employing the proposed image generation method 1,942 dissected neuroimages have been created forming a separate gallery G7 organized in 6 albums, each for the structure(s)/system of interest, and 32 sub-albums. This dissection gallery G7 includes brain dissections along with the following structures/systems of interest: cerebral ventricles, deep gray nuclei, white matter tracts, intracranial arteries, deep cerebral veins, and cranial nerve nuclei. The anatomic index of G7 is given in the Appendix providing tissue classes and sub-classes (their names and numbers), the number of images in each of them, dissection directions, and views.

Various image sequences of the dissected cerebrum exposing the location, course, extent, and cortical context of the intracranial arteries running deep in the cerebral sulci are presented in Figs. 1–3. Fig. 1 shows a dissection image sequence for the left dissection. Fig. 2 illustrates a view image sequence for the superior dissection. Fig. 3 presents appearance image sequences for the anterior dissection at two various locations. Note that both the dissected cerebrum and the intracranial arteries are labeled.

A part of an image sequence demonstrating a sagittally dissected cerebrum exposing the deep structures is presented in Fig. 4. The images vary in terms of dissected direction (left and right), appearance (parcellated unlabeled and parcellated labeled), views (superior and inferior), and dissection plane location (four planes

starting from the midsagittal plane 10 mm apart). Below each image, its name is given as specified by the image naming syntax.

Fig. 5 illustrates some images of a coronally dissected brain exposing the ventricular system. The images vary in terms of the dissected direction (anterior and posterior), appearance (parcelated unlabeled and parcelated labeled), views (anterior and left), and dissection plane location. These images are already integrated with the NOWinBRAIN repository and are shown within its framework. Then, on the top bar on the left, a path to this album is displayed (allowing the user to move up on the album hierarchical structure) and on the right, there are controls for display.

Images of a superiorly dissected brainstem with the exposed and labeled cranial nerve nuclei presented in the anterior and left lateral views are illustrated in Fig. 6.

An inferiorly dissected cerebrum with the exposed white matter tracts is shown in the superior view in Fig. 7. Two types of color maps are employed for the tracts, standard RGB that is tract direction-dependent and color-coding uniquely parcellating the tracts.

Fig. 8 illustrates the deep veins inside an inferiorly dissected brain. The location of the veins with respect to the deep structures, such as the thalamus, caudate nucleus, putamen, and globus pallidus as well as the ventricular system, is clearly depicted.

4. Discussion

Cadaveric and subsequently electronic brain dissections are standard procedures to study the brain and to reveal its internal structures. The novelty of our approach is to use systematically designed stereotactic multi-sequences of 3D neuroimages with a dissected brain and non-dissected structures and systems of interest. These image sequences can be created for various dissection directions, viewing directions, dissection locations, and appearances in terms of labeling and parcellation by color. In this work, image sequences with the dissected brain (or its component) were created with the non-dissected intracranial arteries, deep gray nuclei, cerebral ventricles, cranial nerve nuclei, white matter tracts, and

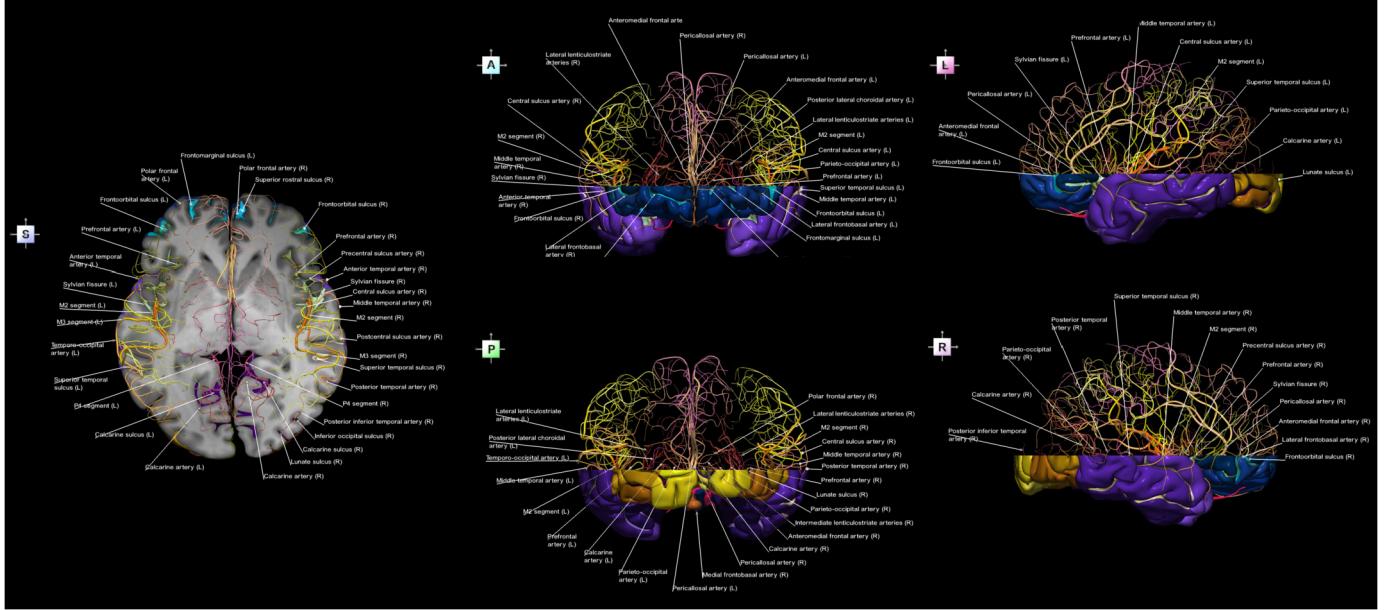


Fig. 2. Illustration of a view image sequence of a superiorly dissected cerebrum at the intercommisural (AC-PC) level exposing the course, extent, and cortical context of the intracranial arteries. The cerebrum and arteries are parcellated, and the sulci and arteries are labeled. The five views are superior (S), anterior (A), left (L), posterior (P), and right (R).

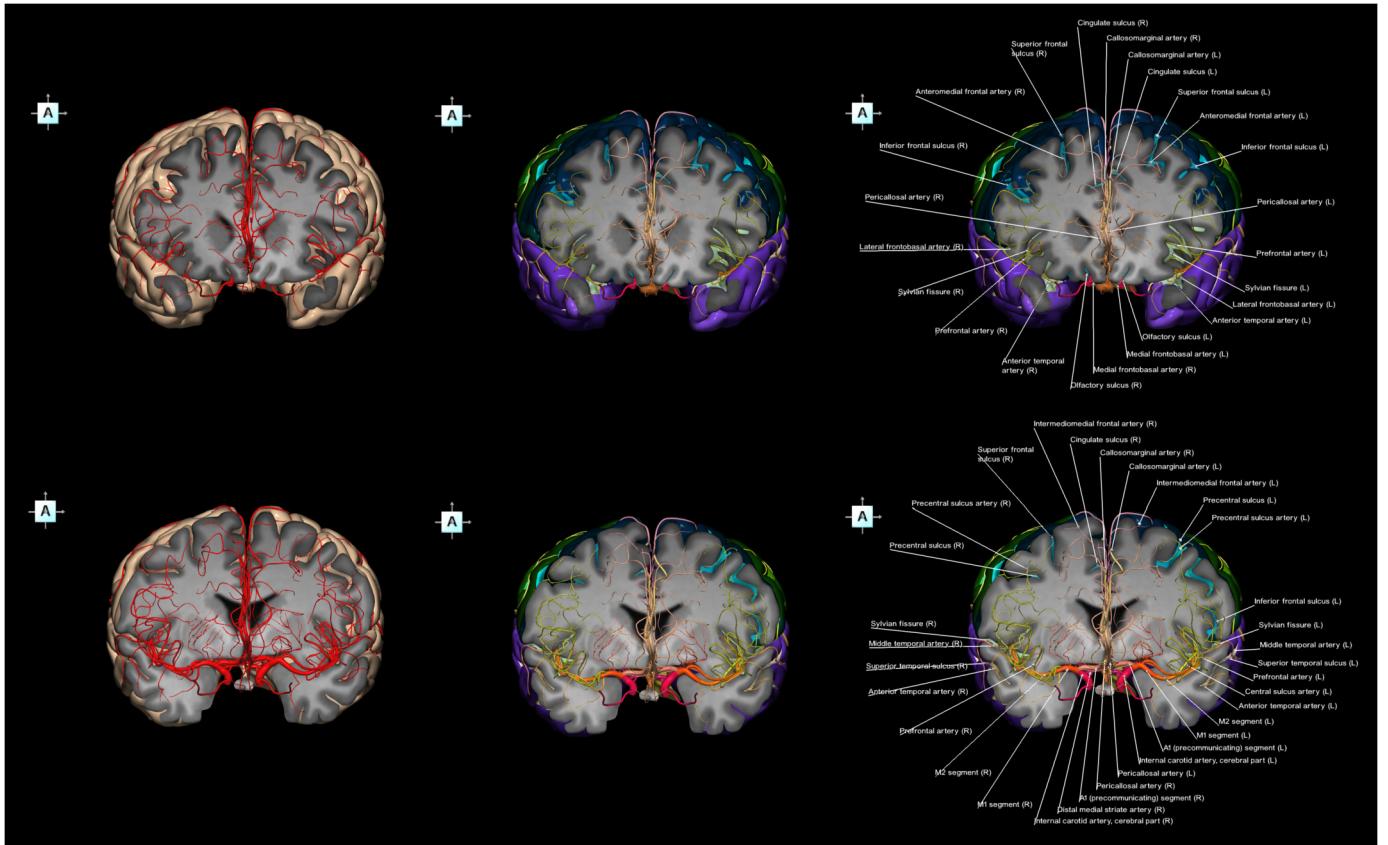


Fig. 3. Illustration of two appearance image sequences of an anteriorly dissected cerebrum at 20 mm in front of the AC plane (top row) and the AC plane (bottom row) exposing the course, extent, and cortical context of the intracranial arteries. The images are non-parcelled (left column), parcellated and unlabeled (middle column), and parcellated and labeled (right column).

deep cerebral veins. Subsequently, these images were integrated with the NOWinBRAIN 3D neuroimage repository for public use forming a separate dissection gallery G7.

The intracranial arteries are numerous, highly complicated, and with a convoluted course. Consequently, the folder with the in-

tracranial arteries is the largest in gallery G7 with 885 images organized in 11 sub-albums. Tracing the course of individual arteries is not easy even when they are parcellated by color (Fig. 9 left). Displaying them on the parcellated cerebrum provides some context, mainly in terms of gyri, but obscures the arteries that are

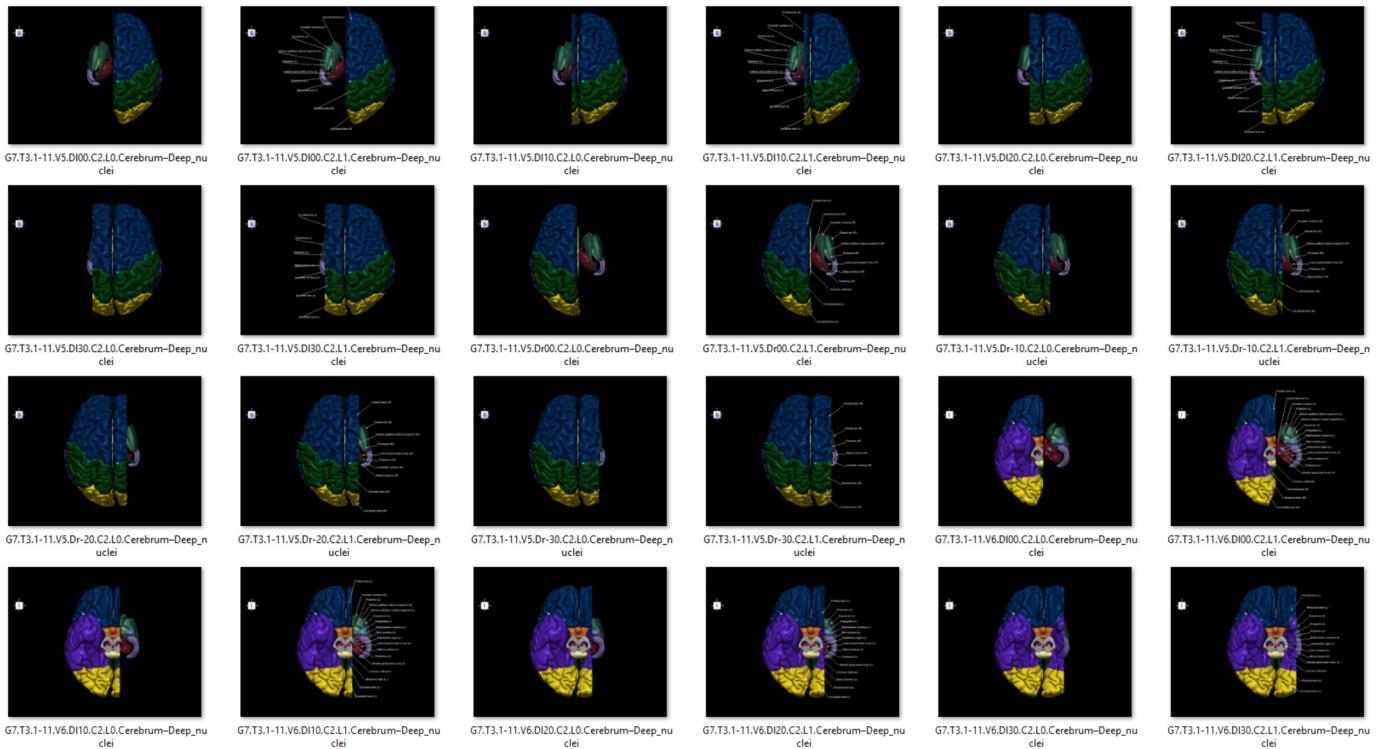


Fig. 4. Illustration of a combination of dissection, view, and appearance image sequences for a laterally (left and right) dissected cerebrum with deep gray nuclei (the superior and inferior views). The cerebrum and deep nuclei are parcellated and the deep nuclei are labeled. Image naming, as shown at the bottom of each image, encloses the tissue classes (T3.1-11), view (V5 and V6), dissection direction (DI and DR), dissection plane location (in mm), labeling (L0 and L1), and content (text).

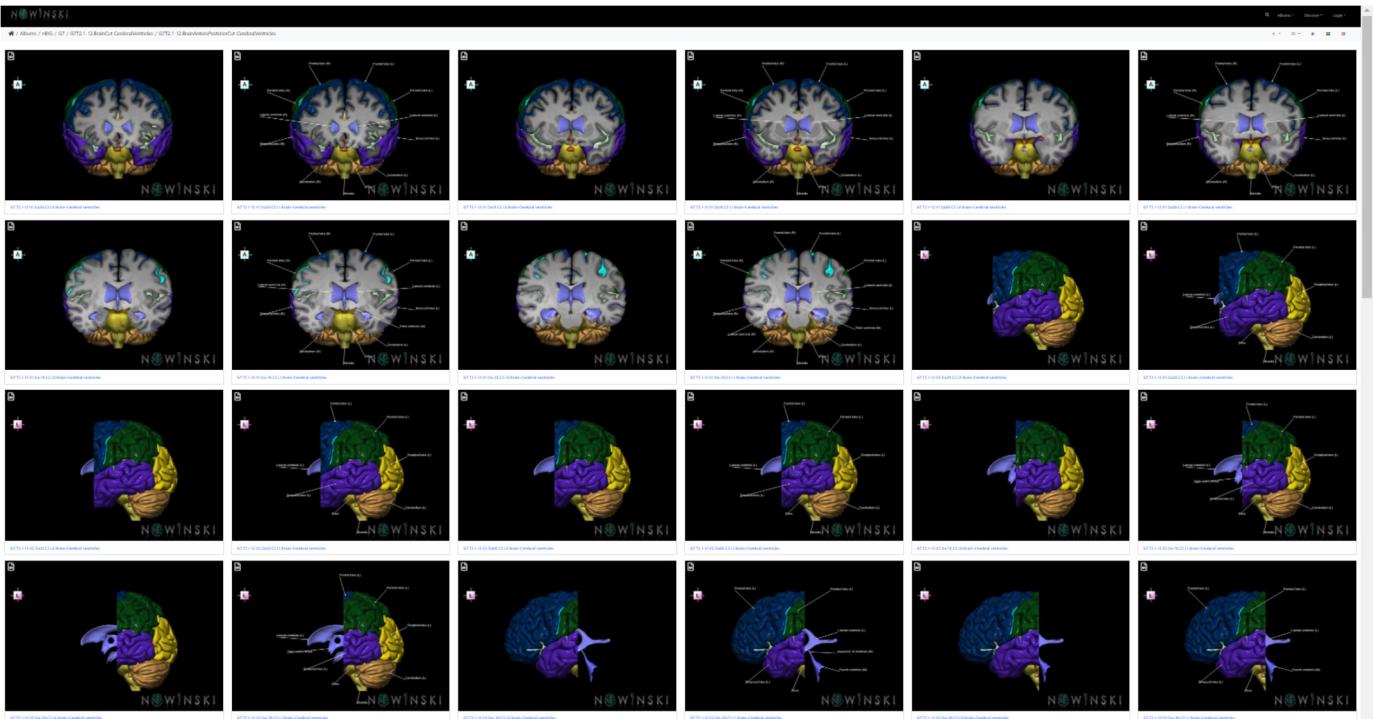


Fig. 5. Illustration of a combination of appearance, dissection, and view image sequences for a coronally (anterior and posterior) dissected brain with cerebral ventricles (the anterior and left views). The cerebrum and ventricles are parcellated and labeled. The grid view as it is displayed by the NOWinBRAIN repository.

partly hidden in the depth of the sulci (Fig. 9 center). A properly dissected cerebrum provides both a better context in terms of the surrounding gyri and open sulci and as well as the depiction of the vessels running in the neighborhood of the dissection (Fig. 9 right). The use of multiple diverse image sequences is ben-

eficial to demonstrate the location, course, continuity, extent, and cortical context of the intracranial arteries hidden in the cerebral sulci, including the dissection image sequence (Fig. 1), view image sequence (Fig. 2), and appearance image sequence (Fig. 3). Structure labeling at locations in the vicinity of the dissection planes

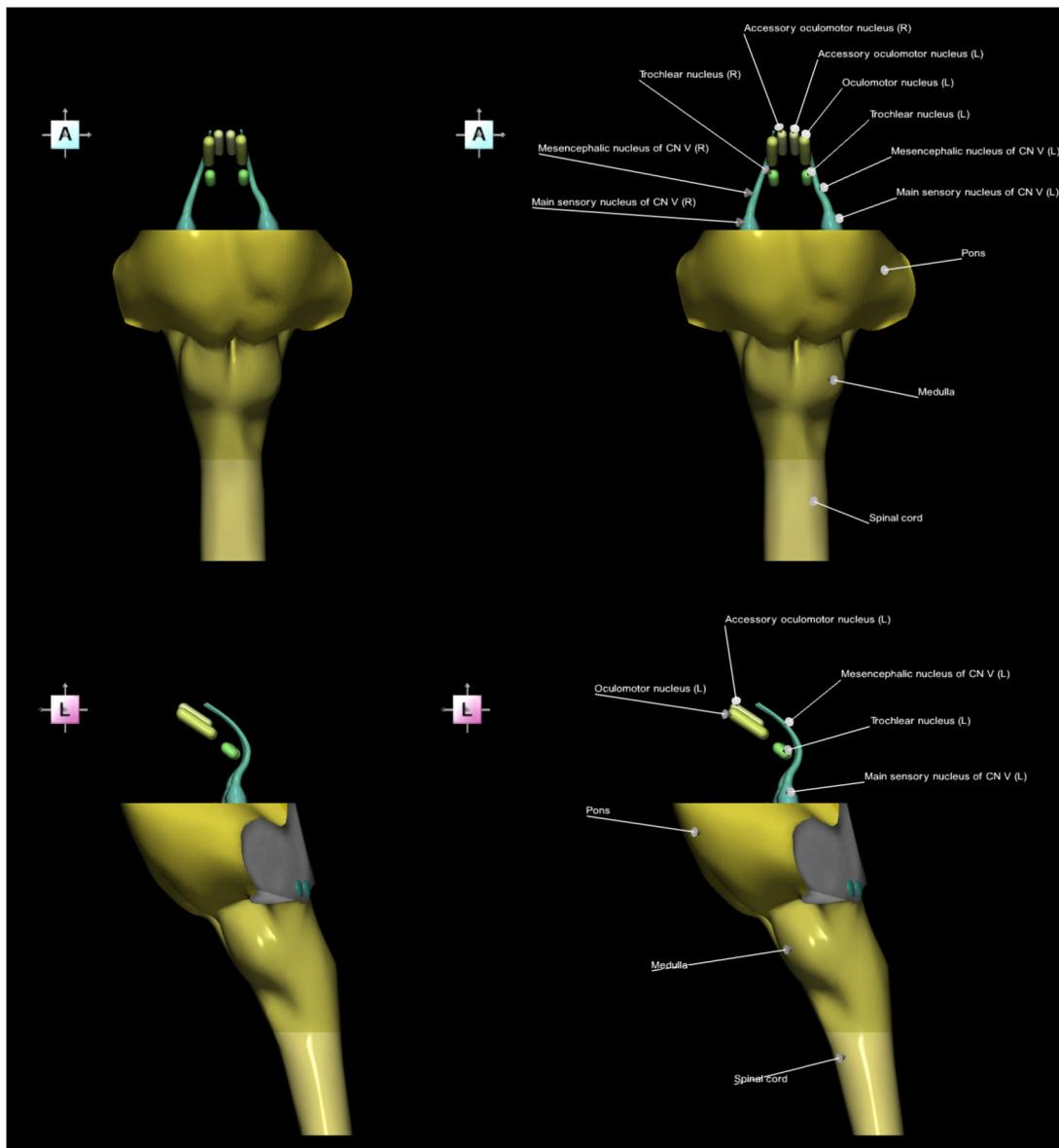


Fig. 6. Superiorly dissected brainstem with the exposed cranial nerve nuclei: the anterior view (top row) and left lateral view (bottom row).

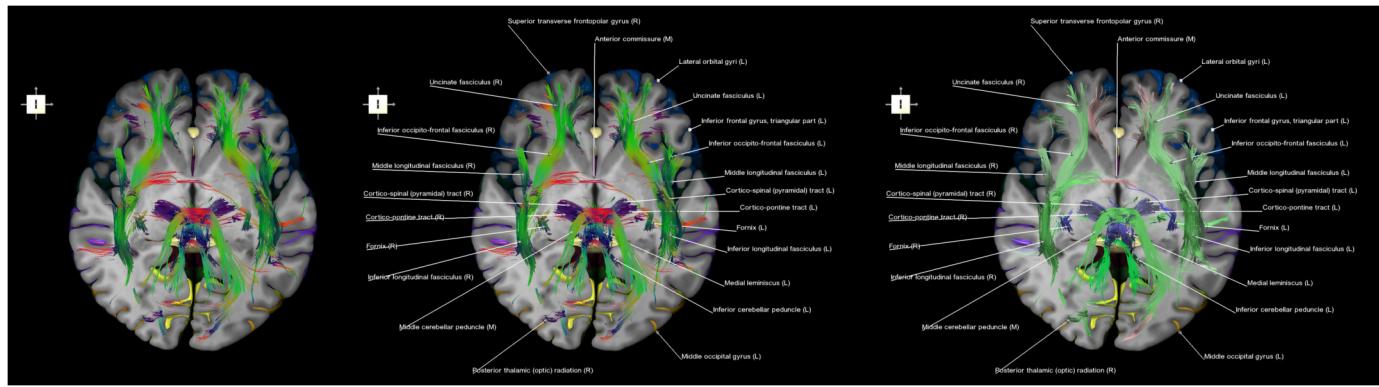


Fig. 7. Inferiorly dissected cerebrum at the intercommissural level showing white matter tracts; (left) unlabeled with standard RGB tract coloring, (middle) labeled with standard RGB tract coloring, and (right) parcellated by a unique color and labeled.

additionally approximates depth. Moreover, the arteries in G7 are labeled on both hemispheres (i.e., dissected and non-dissected) for better comparison and referencing. In [16] I proposed to use the white matter surface to fully expose the cerebral sulci and present

them on dual white matter-cortical surfaces. Consequently, 54 dual sulcal maps were created and integrated with NOWinBRAIN. These kinds of maps can also enhance the presentation of the intracranial vessels.

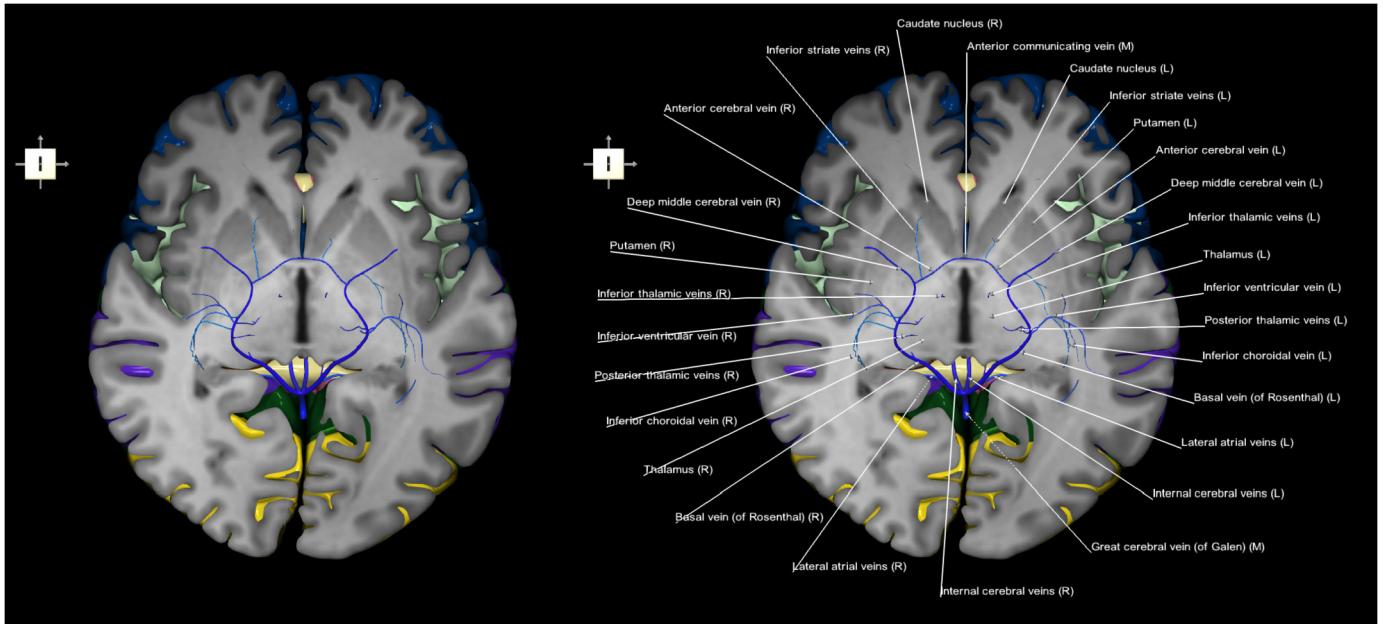


Fig. 8. Inferiorly dissected cerebrum at the intercommissural level with the deep cerebral veins; (left) non-parcellated and unlabeled, (right) parcellated and labeled. Note labeling of both 3D surface and 2D dissection subcortical structures.

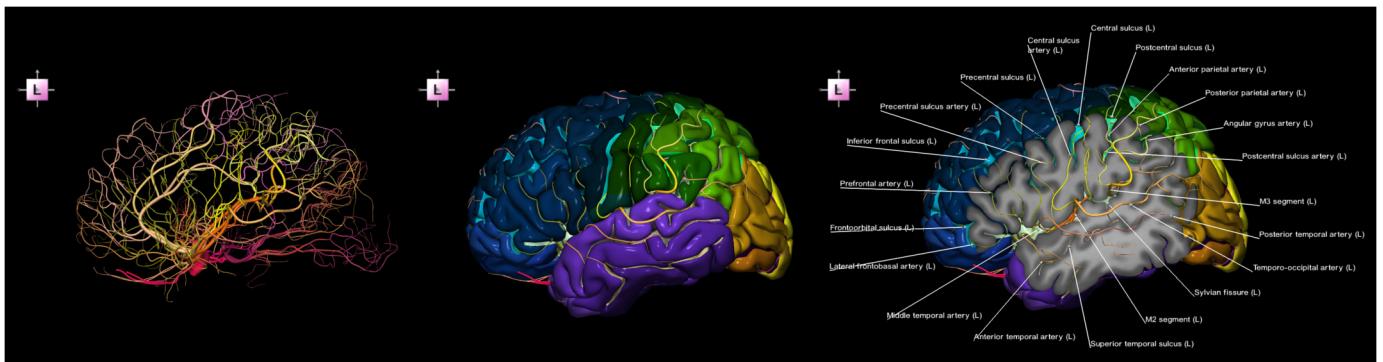


Fig. 9. Intracranial arteries (left lateral view): (left) individual intracranial arteries; (center) intracranial arteries with a non-dissected cerebrum; (right) intracranial arteries with a dissected cerebrum.

Although brain dissections nicely reveal the subcortical structures and the ventricular system on dissected (2D) images, with our approach of combining a dissected brain with a full non-dissected 3D cerebral model, the continuity of a structure or system also can be traced. Additionally, in these images, the locations of the deep structures and the cerebral ventricles with respect to the cerebral lobes are clearly depicted (Figs. 4 and 5).

The brainstem is densely packed with nuclei, white matter tracts, and diffused networks of neurons. A dissected brainstem excellently demonstrates the locations of the cranial nerve nuclei in the midbrain, pons, and medulla as well as their mutual spatial relationships (Fig. 6).

The images of a dissected brain with the white matter tracts depict both cortical regions and subcortical structures, such as the basal ganglia, thalamus, and hippocampus (Fig. 7).

The cortical veins are superficial and showing them within a dissected brain does not provide any additional value. On the other hand, the deep veins are hidden within the depth of the brain, hence brain dissections provide a context, including the neighboring subcortical structures, such as the thalamus, putamen, and caudate nucleus (Fig. 8). The use of other NOWinBRAIN image galleries can provide additional context for the deep veins, such as the complete cerebral ventricles in double-tissue gallery G2.

This proposed method of virtual brain dissectioning and the created content have several advantages. Standard brain dissectioning characterizes rather variable, content-specific dissections not located in any stereotactic space, while our method introduces systematism and stereotaxy in brain sectioning. Systematic and stereotactic virtual brain dissections cum parcellation and labeling facilitate exploration of the location, course, continuity, extent, and cerebral context of structures and systems which are otherwise fully or partly obscured by the parenchyma. This brain sectioning is systematic through a way of generation of a sequence of dissected image sequences and naming these images. An instance of the image sequence depends on four parameters, dissection direction, location, view, and appearance. By varying a single parameter and fixing the other three, the basic image sequences are obtained, namely, the dissection image sequence, view image sequence, appearance image sequence, and direction image sequence. The number of images in the dissection image sequence is variable such that to cover the structures or system of interest. A view image sequence contains five images. An appearance image sequence typically comprises three images (non-parcellated unlabeled, parcellated unlabeled, and parcellated labeled); its number is seven when all three cortical color maps are employed (and it may be even higher when additionally two white matter color maps are considered). The direction image sequence contains three images.

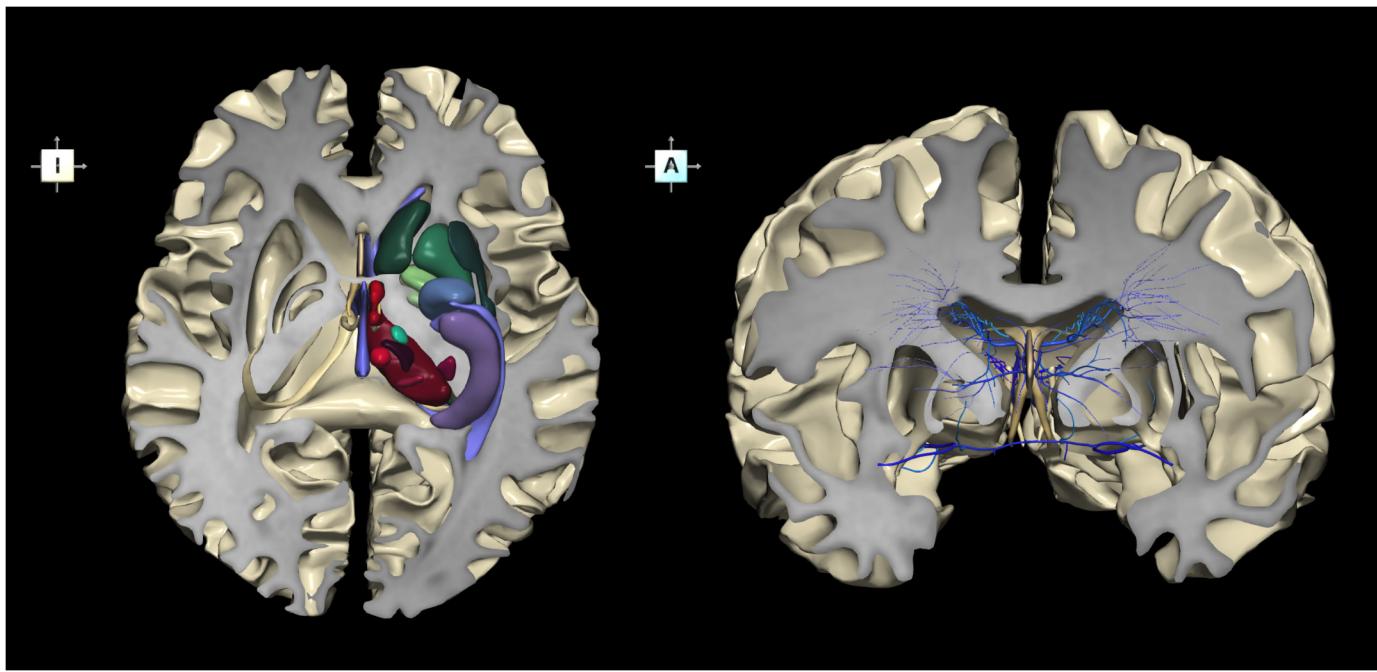


Fig. 10. White matter dissections: (left) inferior with the left deep nuclei and the left lateral and third ventricles; (right) anterior with the deep veins.

The created dissection gallery G7 includes the intracranial arteries, deep cerebral veins, deep gray nuclei, cerebral ventricles, white matter tracts, and cranial nerve nuclei. It contains 1,942 images organized in 6 albums and 32 sub-albums.

Image sequences with the spatially co-registered component images can imitate layers which provides interactive learning opportunities via on/off switching of labels and various parcellations as well as facilitates creating animations across dissections.

A unique coding of image content, dissection direction, view, appearance, and dissection plane location in image names, i.e., with no need for direct image indexing (as shown in Figs. 5 and 6), facilitates image identification, localization, and searching available in NOWinBRAIN.

Color-coded neuroanatomic content makes the brain (along with the examined structures/systems) beautiful and facilitates its learning and understanding. Note that the cerebrum (Fig. 3) and white matter tracts (Fig. 7) have multiple color maps.

Finally, the NOWinBRAIN repository supplements the examined structures or systems with additional context. NOWinBRAIN itself has several advantages, as it is large, systematic, extendable, comprehensive, spatially correlated and consistent, conceptually and image-wise homogeneous, easy to use, beautiful, and searchable based solely on the image naming. It is web-based, runs on low-cost computers and mobile devices, and is freely available at www.nowinbrain.org and requires no password/registration. Although there is a plethora of brain resources with diverse content for various applications, NOWinBRAIN is unique because of its content and design, and it differentiates from them in terms of data organization, source of image generation, features, content, and types of presentation with several image sequences. To my best knowledge, this is the world's largest public collection of more than 7,700 3D images (and it is continuously growing) of the live human brain extended to the head and neck created by a single person. Because of its advantages, user simplicity (despite overall complexity), and free availability this repository is vital in medicine and beyond for a wide spectrum of users, undergraduate and postgraduate medical students, residents, fellows, educators, medical professionals, neuroscientists, medical illustrators, and laymen (including patients and brain enthusiasts) for brain studying,

teaching, testing, exploring, referencing, communicating, and for being inspired. NOWinBRAIN is particularly valuable for users from less privileged countries, as it is freely available online, and easily affordable and accessible.

The proposed approach has several limitations. The dissections are planar along the orthogonal directions. Though the brain atlas provides reformatting in any arbitrary plane, orthogonal and planar reformatting enables systematic and stereotactic dissectioning and easy plane location. Curved dissections might be useful for some specific situations, however, they will probably require a content-specific curvature, variable from image to image. Moreover, systematic indexing of these kinds of images might be questionable. Despite comprising 1,942 images, the content of the dissection gallery still requires further extensions. Moreover, this current content is limited to single tissue classes. Potential future extensions could contain double- or generally multiple-tissue classes, for instance, the ventricular system with the deep veins or the white matter tracts with the subcortical structures (such as the thalamic projections with the thalamus). Another avenue to explore is to use dissections of the white matter itself. Some potential of this avenue is presented in Fig. 10 demonstrating the inferiorly dissected cerebral white matter with the left deep nuclei and the left lateral and third ventricles, and the anteriorly dissected white matter with the deep veins. These dissections provide a better 3D context in the deep spaces corresponding to the removed subcortical gray matter. As NOWinBRAIN is expandable, the existing galleries will be continually extended and new galleries are under planning.

5. Conclusions

Systematic and stereotactic virtual brain dissections cum parcellation and labeling facilitate exploration of the location, course, continuity, extent, and cerebral context of structures and systems which are otherwise fully or partly obscured by the parenchyma. This approach is enabled here by multiple brain dissections defined by four parameters, dissection direction, dissection location, view of presentation, and appearance (parcellation and labeling), forming a sequence of dissected image sequences. The image naming syntax encloses the values of these parameters and image content.

Image sequences can be created for various parameters, and the basic sequences are the dissection image sequence, view image sequence, appearance image sequence, and direction image sequence. Here image sequences with the dissected brain (or its part) were created for the intracranial arteries, deep gray nuclei, cerebral ventricles, cranial nerve nuclei, white matter tracts, and deep cerebral veins. The produced 1,942 images form the dissection gallery organized into six albums and 32 sub-albums. Subsequently, the dissection gallery was integrated with the NOWinBRAIN web-based repository with over 7,700 diverse 3D neuroimages grouped into 533 (sub-)albums available publically at www.nowinbrain.org. The created dissection gallery along with the entire NOWinBRAIN repository is a valuable tool and resource for 1) medical students and residents to study and understand the human brain, 2) clinicians to serve as a refresher and for doctor-patient communication, 3) educators to prepare presentations as well as teaching and testing materials, 4) neuroscientists to provide a neuroimaging reference, 5) medical illustrators, 6) lay public to learn about the brain, and 7) artists to be inspired by the beautiful brain. To my best knowledge, this is the first work introducing stereotaxy to brain sectioning.

Human and animal rights

The author declares that the work described has not involved experimentation on humans or animals.

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Author contribution

The author attests that he meets the current International Committee of Medical Journal Editors (ICMJE) criteria for Authorship.

This is my labor of love and a free contribution to society.

Declaration of competing interest

The author declares that he has no known competing financial or personal relationships that could be viewed as influencing the work reported in this paper.

Data sharing statement

The created brain dissection gallery with 1,942 3D neuroimages is publicly available online at www.nowinbrain.org.

Appendix A. Gallery 7 (G7) index

- 2.1-12. Brain cut – Cerebral ventricles (240 images)
- 2.1-12. Brain antero-posterior cut – Cerebral ventricles ((Dap,Cl-C,L); 6V(A/P,L,R,S,I)): 90 images
- 2.1-12. Brain left-right cut – Cerebral ventricles ((Dlr,Cl-C,L); 6V(A,L/R,P,S,I)): 80 images
- 2.1-12. Brain supero-inferior cut – Cerebral ventricles ((Dsi, Cl-C,L); 6V(A,L,P,R,S/I)): 70 images
- 3.1-11. Cerebrum cut – Deep nuclei (200 images)
 - 3.1-11. Cerebrum antero-posterior cut – Deep nuclei ((Dap, Cl-C,L); 6V(A/P,L,R,S,I)): 70 images
 - 3.1-11. Cerebrum left-right cut – Deep nuclei ((Dlr,Cl-C,L); 6V(A,L/R,P,S,I)): 80 images
 - 3.1-11. Cerebrum supero-inferior cut – Deep nuclei ((Dsi,Cl-C,L); 6V(A,L,P,R,S/I)): 50 images
- 3.1-14. Cerebrum cut – White matter tracts (32 images)

- 3.1-14.1 Cerebrum inferior cut – White matter tracts all ((Di,Cg-C,Cg-RGB,L); 1V(I)): 8 images
- 3.1-14.3 Cerebrum supero-inferior cut – Commissural tracts ((Dsi,Cg-C,Cg-RGB,L); 2V(S/I)): 16 images
- 3.1-14.4 Cerebrum superior cut – Projection tracts ((Dsi,Cg-C,Cg-RGB,L); 1V(S)): 8 images
- 3-15. Cerebrum cut – Intracranial arteries (885 images)
- 3-15 Cerebrum antero-posterior cut – Intracranial arteries (432 images)
 - 3.1-15.2 Whole cerebrum antero-posterior cut – All intracranial arteries ((Dap,M-M,Cgs-C,L); 6V(A/P,L,R,S,I)): 240 images
 - 3.2-15.3 Left cerebrum antero-posterior cut – Left intracranial arteries ((Dap,M-M,Cgs-C,L); 3V(A/P,R)): 96 images
 - 3.3-15.4 Right cerebrum antero-posterior cut – Right intracranial arteries ((Dap,M-M,Cgs-C,L); 3V(A/P,L)): 96 images
- 3-15 Cerebrum left-right cut – Intracranial arteries (210 images)
- 3.1-15.2 Cerebrum left cut – Intracranial arteries ((Dl,M-M,Cgs-C,L); 5V(A,L,P,S,I)): 105 images
- 3.1-15.2 Cerebrum right cut – Intracranial arteries ((Dr,M-M,Cgs-C,L); 5V(A,P,R,S,I)): 105 images
- 3-15 Cerebrum supero-inferior cut – Intracranial arteries (243 images)
 - 3.1-15.2 Whole cerebrum supero-inferior cut – All intracranial arteries ((Dsi,M-M,Cgs-C,L); 6V(A,L,P,R,S/I)): 135 images
 - 3.2-15.3 Left cerebrum supero-inferior cut – Left intracranial arteries ((Dsi,M-M,Cgs-C,L); 3V(R,S/I)): 54 images
 - 3.3-15.4 Right cerebrum supero-inferior cut – Right intracranial arteries ((Dsi,M-M,Cgs-C,L); 3V(L,S/I)): 54 images
- 3.1-16.6. Cerebrum cut – Deep cerebral veins (345 images)
 - 3.1-16.6 Cerebrum antero-posterior cut – Deep veins (((Dap,M-M,Cl-C,L); 6V(A/P,L,R,S,I)): 150 images)
 - 3.1-16.6 Cerebrum left-right cut – Deep veins (((Dlr,M-M,Cl-C,L); 6V(A,L/R,P,S,I)): 120 images)
 - 3.1-16.6 Cerebrum supero-inferior cut – Deep veins ((Dsi, M-M,Cl-C,L); 6V(A,L,P,R,S/I)): 75 images
- 9-10-19.16. Brainstem-Cervical spinal cord cut – Cranial nerve (CN) nuclei (240 images)
- 9-10-19.6 Brainstem-Cervical spinal cord antero-posterior cut – CN nuclei ((Dap,C,L); 6V(A/P,L,R,S,I)): 70 images
- 9-10-19.6 Brainstem-Cervical spinal cord left-right cut – CN nuclei ((Dlr,C,L); 6V(A,L/R,P,S,I)): 60 images
- 9-10-19.6 Brainstem-Cervical spinal cord supero-inferior cut – CN nuclei ((Dsi,C,L); 6V(A,L,P,R,S/I)): 110 images

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