Clinical White Paper

Anatomical GPS functionality for your software: How Snke OS Anatomical Patient Model powers the next generation of mint Lesion™

Summary

Brainlab introduces Snke OS™, a health tech software platform company that offers access to market-proven Brainlab technology frameworks to 3rd party B2B partners. For many years, the Anatomical Patient Model (APM) has been providing robust anatomical segmentations unleashing clinical context for the Brainlab product portfolio. So far, applications include task automation and standardization with intuitive usability for clinical workflows from radiotherapy planning to imaging-based stereotactic neurosurgery. Now, we bring this technology to radiology. First and foremost, to mint Lesion™, leading software for cognition-guided radiological assessment and structured reporting. The Snke OS APM unlocks a plethora of use cases within mint Lesion, driving further workflow automation. For example filtering the reporting options to the ones that are relevant for structures identified in the current image slice or automating organ volumetrics. The APM currently covers more than 190 validated structures across CT and MRI with unprecedented coverage of cranial and spinal features. It can be accessed via a Remote Procedure Call (gRPC) application programming interface (API) call and for now is available on-premises, with a cloud version to follow. In addition to a full segmentation, services for MRI sequence detection, MRI/CT localization based-queries (voxel-based location and context), and a (prototypic) cranial pathology detection have been made accessible so far. Further functionalities including rigid/elastic fusions, “smart views” or various statistical/analytics functionalities will follow.

Snke OS: Making Brainlab technology assets available as service

Snke OS was founded in 2020 to open and extend the Brainlab technology frameworks to B2B partners. Snke OS aims to provide modular services for non-differentiating IT heavy lifting, such as connectivity services (e.g., DICOM, HL7/FHIR), secure hybrid-cloud application runtime environments as well as cutting edge video analytics or medical image processing.

The Snke OS Anatomical Patient Model—in particular its multi-modality segmentation capabilities—is a key asset that will be made available for integration as a service into 3rd party software. This paper outlines how the APM was integrated into mint Lesion, gives a technical background into the model and the service itself, and a brief outlook on functionality to come.

Case study: “Anatomical GPS” for mint Lesion

mint Lesion is Mint Medical’s best-in-class structured reporting and electronic data capture (EDC) solution for clinical routine, academic and industry-sponsored multi-center studies and contract research organizations (CROs). mint Lesion guides users in the assessment and measurement of image-based observations inside a radiologic viewer, according to best practice radiologic templates or clinical trial protocols. In this way, users create a semantic link between the image and their assessment.

Currently, mint Lesion annotations are typically performed manually or with semi-automatic tools. Hence, users provide information about the position of observations in the anatomical space as well as filtering of questions to appropriate (anatomical) context/structure.

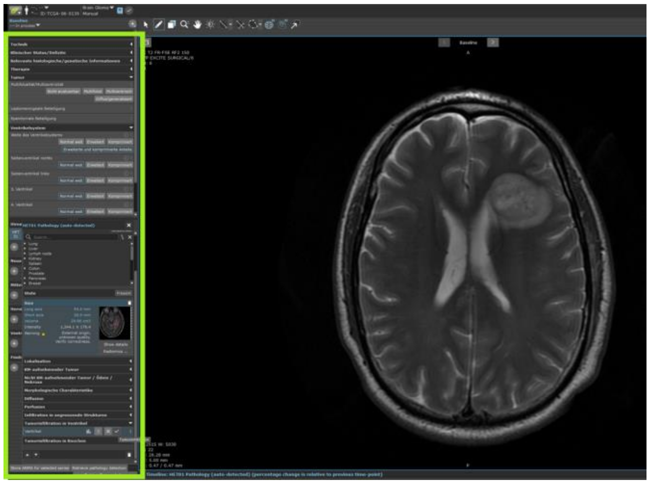

Figure 1: Current reporting workflow of mint Lesion: the user scrolls through image series and needs to look for the appropriate section of the reporting pane to document observations.

To further increase automation and assist with clinical decision making, Snke OS set out to equip mint Lesion with an anatomical understanding by leveraging the Anatomical Patient Model.

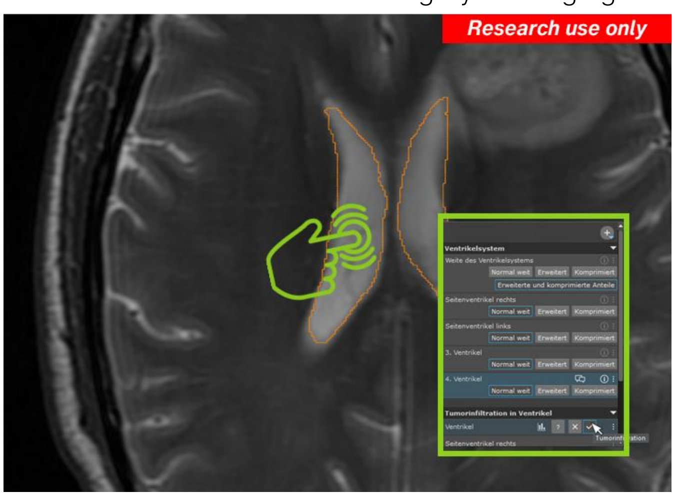

Figure 2: After integration of the Anatomical Patient Model as "Anatomical GPS": users click on any anatomical structure/organ (e.g., ventricle) and are instantly offered a pane with the relevant items. Also, the selected structure may be segmented automatically (orange) for full volumetric measurements.

Major structures and organs in the image series can now be registered and segmented prior to the radiological reading workflow. With the APM addition, mint Lesion offers full awareness of the anatomical context. For example, answer options may be tailored to the relevant ones, depending on where the user clicks. Volumes of organs and cranial lesions can be automatically calculated, providing input into clinical decision-making (e.g., tumor monitoring and resection possibilities). Also, detection of anomalies, such as irregular enlargements will be available in future releases.

For research-study-relevant imaging quality control workflows, steps such as checking the type of acquired MRI sequence, presence of contrast agent or acquired/non-cropped body parts are now automated. Furthermore, as structures can be annotated automatically, users receive a much richer dataset for analytics and machine learning use cases, with zero additional effort.

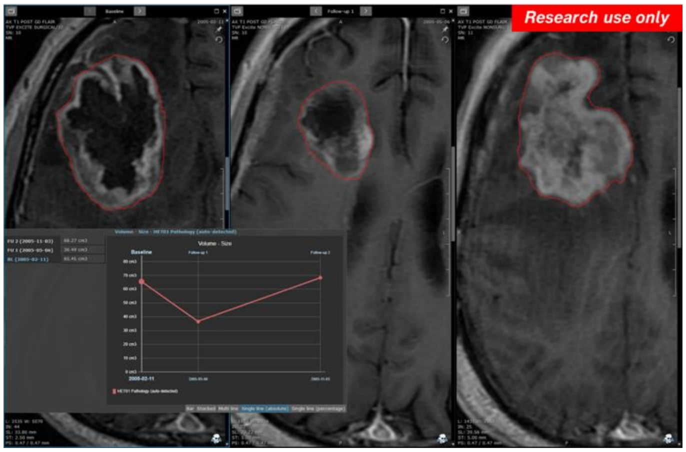

Figure 3: Pathology detection and full segmentation (currently as beta version and restrained to cranial lesions), allowing for automated (volumetric) tumor monitoring: baseline (left), postoperative state (middle) and volume increase with recurrent growth in follow-up (right)"

The first prototype already delivers an array of possible use cases and benefits with plans to expand as more functionality from the Anatomical Patient Model and Snke OS will be made available as service.

Inside the Anatomical Patient Model: Simulating a digital patient representation
The Anatomical Patient Model combines AI algorithms with a comprehensive tissue model of the human body. It has been refined over many years and powers Brainlab surgery and radiotherapy planning and navigation products. Now offered independently through Snke OS, this service allows any medical device company to identity anatomical, functional or pathological structures in medical image datasets.

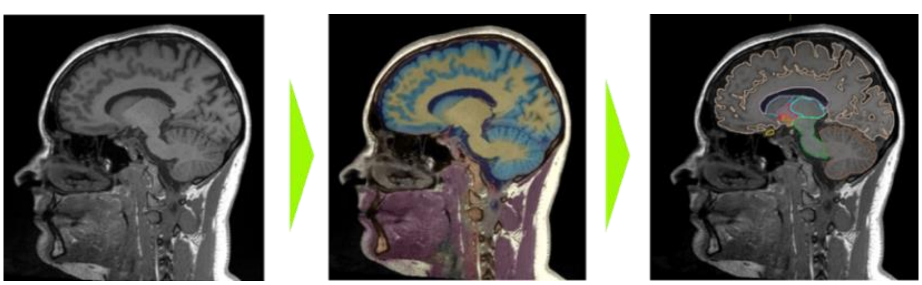

Figure 4: Anatomical Patient Model (APM): Simulating a modality-independent synthetic tissue model and fitting it to patient-specific anatomy.

Unlike classic atlas-based technologies, the APM is independent of imaging modality and accounts for a patient's individual anatomy, via a novel approach: Using patient-specific imaging data, the software simulates a synthetic tissue model of the human body with the same imaging characteristics which is then tailored to represent the precise anatomy of that specific patient. This is possible because the APM knows the patient-specific anatomical and biophysical properties of each voxel as seen by MRI and CT. This makes it also possible to correct for temporal image-distorting biophysical effects such as brain shift during neurosurgery—subject to later releases of the service.

The APM also simultaneously co-registers up to six image volumes from the same study, allowing for increased accuracy and speed, compared to serial-processing approaches of other methods.

Organ and modality coverage of the Anatomical Patient Model

The Anatomical Patient Model currently contains over 190 clinically validated structures (101 MR only, 48 CT only and 43 MR/CT), with X-Ray to follow in 2022.

For cranial, spine, and the head & neck region, there is an unprecedented coverage of structures, for both CT and particularly MRI, from segmentation of individual brain ganglia to all vertebrae. Full body coverage of major organs and bone structures is available for CT.

Organ coverage is steadily improving and extending to align with B2B partner demand. Beyond the structures validated by clinicians as the gold standard, and which are already part of the released Brainlab medical device product portfolio, partners will have access to a much wider array of non-validated experimental structures/regions of interest, including 2D landmarks.

The Anatomical Patient Model as an API service: How to leverage it for your application

First functionalities of the Anatomical Patient Model have been made accessible via an API, leveraging the open-source gRPC framework which balances performance and ease of implementation.

As shown in Figure 3, images need to be loaded into the Snke OS Data Hub before they can be queried. For loading, two options exist: The client application can push images directly to the Data Hub. Alternatively, the Data Hub can be commanded to query DICOM source systems, such as PACS. This opens convenient, configurable scheduling options for the processing algorithms. For example, data sets that match certain rules, e.g., modality, body-region, patient name/identifier, etc., can be processed as soon as they are acquired, and then automatically forwarded to the client application.

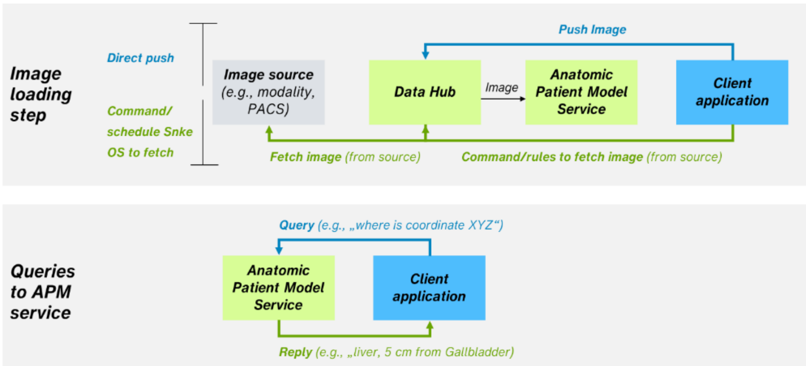

Figure 5: High level overview of APM service architecture. Snke OS components are in green.

After loading, images are registered with the APM, which depends on available computing resources, number of series and scans and resolution, but typically only takes a few minutes. Images can then be interrogated using simple or advanced semantic queries displayed in Table 2. For example, giving a 3D coordinate (voxel) within the image will return the position in the anatomical space, such as intersecting structures/organs. Those types of queries have very low latency, allowing for real-time applications, such as navigation or interactive user sessions.

API functionality	Query input	Query output
Segmentation of structure	• DICOM image references • Structure to be segmented • Precision of the APM	• Segmented structure as gRPC message (easily convertible to DICOM seg)
Voxel localization query	• DICOM image references • Point (voxel) in image series • Structures of interest	• Hierarchical list of intersecting structures
MRI sequence and CT contrast agent detection	• DICOM image reference(s)	• MRI sequence type • Use of contrast agent • Use of fat suppression
Imaged structures query	• DICOM image references • Region of interest • Structures of interest	• Hierarchical list of imaged structures within the region of interest • SNOMED CT codes of imaged structures • Rough, estimated locations of structures (bounding boxes)
Cranial MRI abnormality detection (beta version)	• DICOM image references	• Segmentation of the largest detected abnormality

Table 1: High level overview of APM Service architecture. Snke OS components are in green.

In addition to providing services, Snke OS can also provide documentation and consulting to help customers incorporate the APM into a released medical product, as is the case with mint Lesion. Currently, a full on-premises version of the services are available, with a fully cloud-based version due in 2022. Snke OS services will start as a time-based software-as-a-service (SaaS) with a pay-per-use arrangement to follow.

Future outlook: Getting the full arsenal of cutting-edge image processing
Beyond segmentation and semantic queries, the Brainlab image processing framework holds many more capabilities that will be converted into a service and released by Snke OS to external partners.

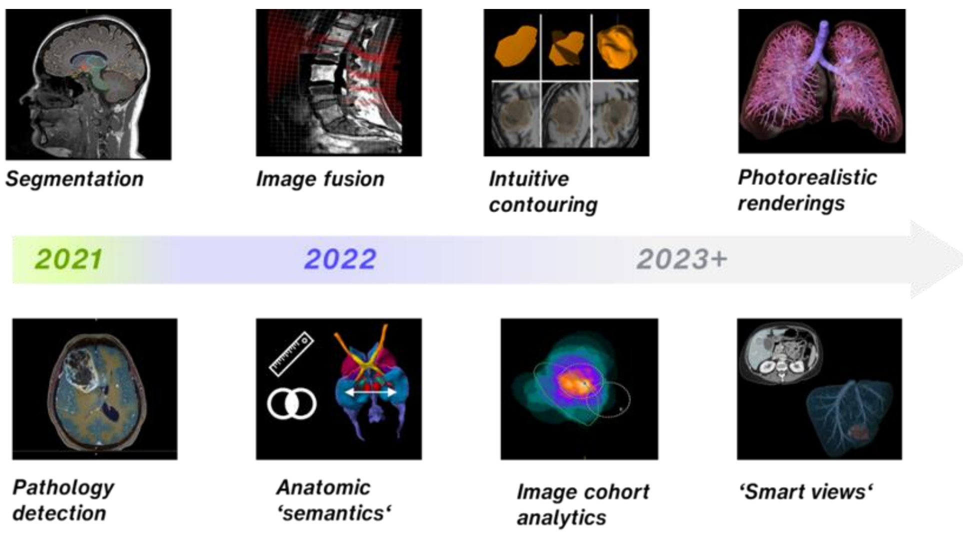

Figure 6: High level overview of APM service architecture. Snke OS components are in green.

An overview of the roadmap is shown in Figure 5, with some of the highlights being:

- Image fusion: toolbox of rigid and elastic co-registrations with support for CT-MRI multi-modal and multi-timepoint fusions, i.e., for follow-up diagnostics/tumor monitoring
- Pathology detection: detection and segmentation of brain tumors and metastases; other diseases in future iterations
- Intuitive contouring: Brainlab "SmartBrush" toolbox that allows for ultra-precise, intuitive contouring of structures and volumetric measurements
- Image cohort analytics: toolbox to perform statistics in standardized image space across multiple series, timepoints, or patients, for example anatomical regions correlated with treatment outcome/sub-groups
- Photorealistic renderings: 3D reconstructions of segmented objects, with real-life textures, leveraging cutting edge video-gaming technologies from Brainlab subsidy, Level Ex
- Smart views: pre-defined, reconstructed views along medically relevant projections, e.g., organ axes, scroll through slices along "spine axis", etc.

In addition to image processing capabilities, Snke OS aims to offer services for connectivity beyond DICOM (e.g., FHIR, HL7, IoT), access to a global footprint of over 5,500 hospitals, and pre-configured application components, e.g., data selection, patient selection, image viewer, etc., to quickly convert products from ideas and algorithms without the typical IT heavy lifting.

To discuss how Snke OS can enhance your applications reach out to us at info@snkeos.com.