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Orthanc: a Lightweight, Open-Source DICOM Server for Medical Imaging Informatics

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The management and exchange of digital medical images are central to modern healthcare, supporting diagnosis, treatment planning, and follow-up in nearly all specialities, as well as clinical research. The volume of generated imaging data has grown rapidly in recent years, driven by two converging trends. The first is longitudinal imaging, in which patients are imaged repeatedly over time, whether to monitor disease evolution in routine care (e.g., oncology or cardiology) or to track biomarkers in long-term studies. The second is multimodal imaging, in which several complementary modalities (such as MRI, PET, and CT) are acquired for the same patient, in fields ranging from neurology to orthopaedics. The handling of this expanding data places considerable demands on the underlying IT infrastructure.

The Digital Imaging and Communications in Medicine (DICOM) standard provides the technical foundation for handling medical imaging data. DICOM specifies an exchange format for medical images and associated metadata (commonly referred to as "DICOM files"), as well as a network protocol for their transmission. This protocol, extensively used in hospitals worldwide, supports querying the content of a remote imaging device, sending images to it, or requesting a transfer between two remote devices. Hospitals typically deploy a central, large-scale database known as a Picture Archiving and Communication System (PACS), which stores and manages all DICOM images generated across their clinical departments.

Because DICOM is an open standard, a rich ecosystem of free and open-source software has matured around it. Such software broadly falls into three categories: libraries for processing DICOM files and handling DICOM networking (e.g., DCMTK, pydicom, GDCM, VTK, or dcm4che), viewers for displaying image content (e.g., OHIF, 3D Slicer, Horos, or Weasis), and servers for managing databases of medical images (e.g., dcm4chee, Dicoogle, or ConQuest). Free and open-source software plays a particularly significant role in medical imaging. It lowers the barrier to entry for clinics, research institutions, and low-resource settings that cannot afford commercial licensing fees. It supports knowledge sharing and auditability, which are important for clinical and industrial research. Beyond that, it allows healthcare institutions to build workflows that expand the features their central PACS offers. Indeed, proprietary PACS are often optimised for routine radiology and are rarely flexible enough to support clinical trials, multicenter studies, and the training and evaluation of artificial intelligence (AI) models on medical imaging data. Open-source DICOM tools enable institutions to build custom pipelines along with their existing infrastructure. This paper presents Orthanc, a free and open-source DICOM server that was developed to fill a gap in the open-source ecosystem for medical imaging [1].

The Orthanc project

Orthanc originates from the University Hospital of Liège (Belgium). It was first released in 2012

and is licensed under the GNU General Public License. The design of Orthanc reflects close observation of daily clinical and research practices. Indeed, it became clear that existing free and open-source PACS solutions, while powerful, required significant expertise and configuration effort before they could be put to use. Orthanc takes a different approach: It is distributed as a single executable with no external dependencies and runs out-of-the-box on all major operating systems, including commodity hardware such as standard desktop computers, as well as containerised environments. This is possible thanks to the fact that Orthanc is a standalone C++ software that embeds a SQLite database. Importantly, Orthanc exposes a RESTful API that wraps DICOM functionality over standard HTTP/HTTPS connections, enabling integration with contemporary Web technologies and lowering the barrier to programmatic interaction with medical imaging data, which was a feature no other open-source DICOM server offered at the time. The result is a server that is lightweight, pragmatic, interoperable, and accessible to users without deep DICOM expertise. Since 2021, the Orthanc project has been actively maintained and extended by UCLouvain University (Belgium) in an academic setting.

Orthanc is used in a wide range of applications. It often serves as an ancillary DICOM server in clinical environments, notably to support autorouting workflows, but it can also function as a full PACS in low-resource hospitals, as well as in industrial and research settings. It is widely used to support inter-site image exchange and to automate de-identification workflows, for example, in multicentre studies or AI data curation pipelines. Through its integration with multiple open-source viewers, it can also be used as a teleradiology platform, including for remote expertise and second opinions.

Beyond these use cases, Orthanc has attracted considerable interest for its extensibility. A plugin architecture allows the core server to be augmented with additional capabilities, ranging from advanced database backends (e.g., PostgreSQL) and cloud storage connectors to inference engines for AI-assisted image analysis. In particular, the automation of DICOM workflows can be implemented through Python scripts executed by a dedicated plugin. As illustrated in Figure 1, plugins have also been developed to serve popular open-source, Web-based DICOM viewers through the embedded Web server of Orthanc. Orthanc plugins also delivered the first open-source implementation of the DICOMweb protocol in 2015, as well as DICOM support for whole-slide pathology imaging in 2016. More recently, plugins have been developed to turn Orthanc into a teaching platform, including Moodle integration, or to distribute deep learning models, for instance, for the detection of masses in mammography.

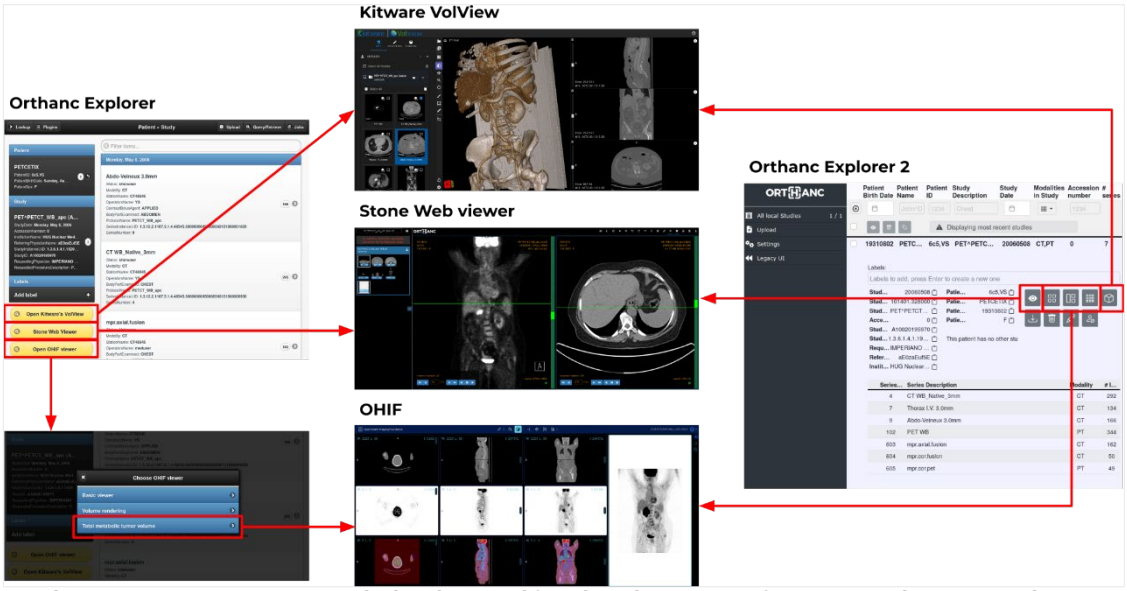

Figure 1: Three open-source DICOM viewers can be directly accessed from the Orthanc user interfaces: Kitware VolView, Stone Web Viewer, and OHIF.

As a companion project to its DICOM server, the Orthanc ecosystem also features a lightweight Web-based DICOM viewer designed specifically for teleradiology contexts, where network bandwidth efficiency is essential [2]. This viewer, named the Stone Web Viewer and depicted in Figure 2, is notable for being written primarily in C++ and compiled for Web browsers using the WebAssembly technology. This technological choice enables code reuse with desktop or mobile applications. The Stone Web Viewer additionally offers partial support for rendering DICOM structured reports, including those containing measurements or observations produced by AI algorithms, in line with the IHE "AI Results" profile.

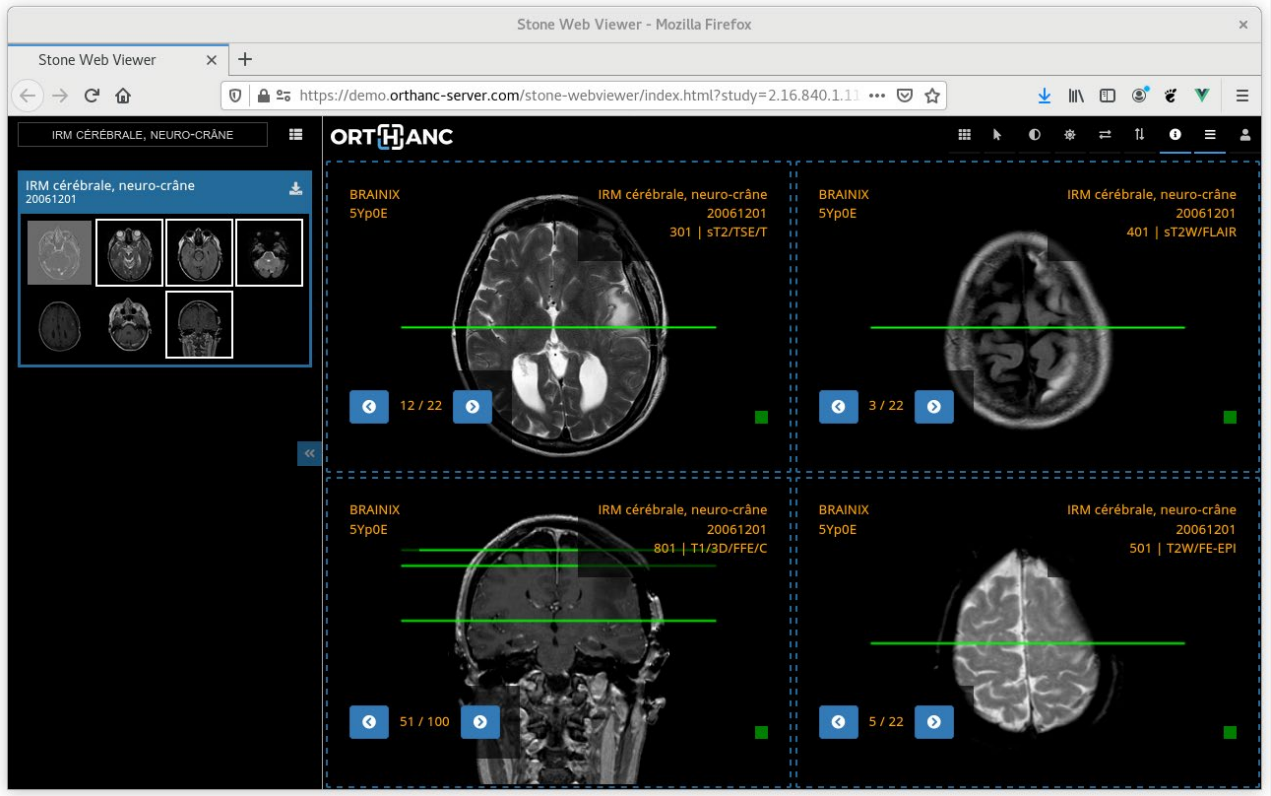

Figure 2: Stone Web Viewer displaying an MRI study (reproduced from [2]).

The Orthanc ecosystem is an established project with a worldwide community. It has been recognised as a Digital Public Good by the UN-endorsed Digital Public Goods Alliance (DPGA). Integrations with the GNU Health and OpenMRS free and open-source electronic health record (EHR) systems are available, linking patient records with medical images. Professional support is also provided by private companies.

Conclusion

The mission of the Orthanc project is to make technological knowledge about medical imaging freely accessible. By providing open, well-documented, and easy-to-deploy tools, Orthanc lowers the barriers that separate clinical practice, research, and software development. As medical imaging increasingly intersects with artificial intelligence, this mission extends to supporting the infrastructure needed to collect, curate, and process imaging data. The project is based on the conviction that such foundational tools should be a shared resource, available to any institution regardless of its size or means.

The homepage of the Orthanc project is available at: https://orthanc.uclouvain.be/.

References

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