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Bridging Open-Source Photogrammetry : Toward Synergies Between Meshroom, MicMac and others

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Abstract

This paper introduces MicMacRoom, a prototype that bridges the qualitative photogrammetric workflow of MicMac with the intuitive, node-based interface of Meshroom, addressing critical limitations of open-source photogrammetry in usability, interoperability, and sustainability. Developed by a working group of the French National 3D Consortium, MicMacRoom targets Cultural Heritage applications by providing customizable workflows for key processes ; dense cloud generation, meshing, and orthophoto production. As an open-source project, MicMacRoom provides public access to its source code, documentation, and processing templates, laying the foundation for a unified and sustainable photogrammetry ecosystem. The current version of the prototype is a starting point for future developments, focusing on expanding interoperability with additional image-based modeling tools and methods. This article also presents the ongoing integration of colour calibration as a preliminary step for ensuring future compatibility with advanced multi-view photometric workflows.

1. Introduction

Photogrammetry spans diverse applications, from cultural heritage preservation to industrial inspection, relying on varied acquisition devices. This diversity underscores the need for adaptable, customizable workflows. Free Libre Open-Source Software (FLOSS) addresses this demand by providing flexible, transparent, and cost-effective solutions. This paper examines FLOSS's pivotal role in photogrammetry and introduces MicMacRoom, a prototype integrating Meshroom and MicMac to improve accessibility and precision in 3D image-based modeling.

Despite the potential of open-source tools in terms of robustness and adaptability, persistent challenges remain in user experience, interoperability, and long-term sustainability. Key obstacles include: (1) a steep learning curve due to insufficient documentation and unintuitive interfaces; (2) fragmented workflows, lacking seamless tool and output integration; and (3) limited interoperability, restricting advanced reconstruction pipelines and hybrid approaches (e.g., RTI, NeRF). This work thus focuses on developing the MicMacRoom prototype, a collaborative solution designed to bridge these gaps, enhance usability, and streamline open-source image-based modeling workflows.

Initiated in 2020 by the Image-Based Modeling and Software Synergies Working Group of the French National 3D Consortium for Humanities and Social Sciences, this project began with an analysis of existing FLOSS solutions, user experience (UX), and feature requirements derived from daily practice. These insights shaped the future interface of MicMac Version 2, tailored for cultural heritage (CH) applications. Ultimately, the collaboration within our network fostered a strategic alliance between the two leading open-photogrammetry contributors: MicMac, renowned for its rigorous metrological capabilities but hindered by complexity, and Meshroom, praised for its modular, node-based architecture yet lacking certain CH-specific tools.

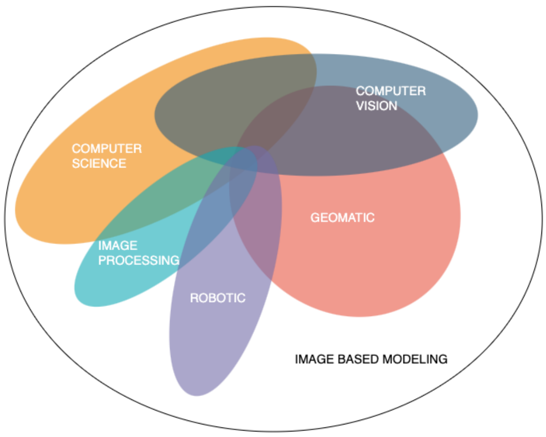

Figure 1. Diagram of Image Based modeling paradigm.

2. State of the art

The scientific positioning of this research-driven software prototype is addressed at two levels: first, a general contextualization in image-based modeling, with a focus on open photogrammetry (Section 2.1); second, an in-depth technical analysis of each component involved in the software prototype.

2.1 Past initiatives and open challenges in open photogrammetry

A critical review of open photogrammetry over the past decade reveals a persistent gap in stable and sustainable solutions. Photogrammetry, positioned at the intersection of geomatics, computer vision, and image processing(Hartley and Mundy, 1993, W. Schindler, 2018), has advanced significantly toward accurate and accessible 3D modeling—often referred to as photogrammetric Structure from Motion (SfM) (Aicardi et al., 2018). Open-source photogrammetry tools have emerged as viable alternatives to commercial software, serving diverse applications such as Cultural Heritage (CH), CGI/VFX, and forensics. However, CH applications demand higher accuracy, advanced quality control, and georeferencing, driving interest in photogrammetric methods. Meanwhile, challenges like massive digitization (complex sites or large datasets) and multimodal approaches (multisensor and incremental processing) are pushing CH users toward SfM methods, which offer improved speed and robustness for unstructured image sets.

As illustrated in Figure 2, FLOSS photogrammetry tools provide as many alternatives as commercial packages (Luhmann, 2016, Schönberger and Frahm, 2016, Schönberger et al., 2016, Lindenberger et al., 2021, Pamart et al., 2020, Sweeney et al., 2015, Griwodz et al., 2021, Morelli et al., 2024). Notably, recent initiatives emphasize cross-library integration (Gonzalez-Aguilera et al., 2018, Ruiz de Oña et al., 2023, Pan et al., 2024). Despite these advancements, FLOSS adoption remains limited, particularly among non-technical CH users, due to insufficient documentation, tutorials, and hands-on training (Verriez et al., 2023). While FLOSS tools are cost-free, they incur hidden costs :

- Performance gaps: Open solutions lag behind commercial alternatives in processing speed and computational efficiency.
- Learning curve: FLOSS tools are less intuitive, with uneven documentation, requiring significant effort for regular use.
- User experience (UX): Many tools lack graphical user interfaces (GUIs) or feature unfriendly UX designs.

Finally, the absence of open standards for photogrammetry project files hinders interoperability for exchange, archiving and reproductibility purposes. While inputs (images, GCPs) and outputs (point clouds, meshes, textures) use exchangeable formats, intermediate data (tie points, depth maps) remain difficult to convert. Some formats, such as Bundler (.out), N-View Matches (.nvm), and COLMAP's data structure, enjoy partial support, with Kaptur emerging as a popular open SfM format and conversion tool. Alternatives like the Open Photogrammetry Format (OPF) and LIGHTCAM (Nocerino et al., 2020) exist but face adoption challenges or discontinuation.

2.2 Fostering synergies between open-source image-based modeling

MicMac [IGN]
MicMac is a free and open-source photogrammetry suite developed since 2003. It generates high-resolution 3D surface models, orthomosaics, and displacement fields from overlapping images. Originally designed for the French National Mapping Agency (IGN), MicMac prioritizes metrological precision and georeferencing accuracy. It has been widely adopted for applications such as cultural heritage documentation (Abergel et al., 2023), dyke surveillance (Tournadre et al., 2015), tectonic plate analysis (Rosu et al., 2015), and glacier volume quantification (Ghuffar et al., 2022). MicMac is integrated into ESA's Geohazard Thematic Platform and FORM@TER for ground deformation monitoring. Since 2021, MicMac v2 (MMVII) has been under development. Since the early development of MicMac, GUI attempts have faced maintenance challenges, with the most reliable interface being v-commands—QT-based Low-Level Interfaces (LLI) automatically generated for new functionalities.

Alice Vision / Meshroom [Mikros Image - Technicolor]
Meshroom is a node-based visual programming tool designed to create, manage, and automate workflows. It integrates AliceVision nodes and pipelines for computer vision and machine learning tasks. Its nodal architecture allows users to build custom pipelines by connecting nodes, where each node represents a processing step. Meshroom's cache-based invalidation mechanism ensures that only affected downstream nodes are recomputed when parameters change. Nodes can be executed locally or distributed across render farms, enabling parallel processing (Griwodz et al., 2021). Since its 2014 release, Meshroom has been widely adopted in VFX, medical augmented reality (Collins et al., 2021), cultural heritage (Sá et al., 2019, Bici et al., 2020), archaeology (Milàn et al., 2020, Falkingham et al., 2020, Lallensack et al., 2022), biology (Carlucci et al., 2020, Ortega-Jiménez and Sanford, 2021), insect 3D reconstruction (Chowdhury et al., 2021, Plum and Labonte, 2021), video surveillance (Wallner et al., 2021), 3D printing (Horvath and Cameron, 2020, Bellis et al., 2021, Ravi et al., 2021), tourism (Nomikou and et Al., 2020, Poux et al., 2020), virtual reality (Poux et al., 2020, El Saer et al., 2020a, Oersen et al., 2020, El Saer et al., 2020b). Its applications also include forensic analysis (Galanakis et al., 2021, Tóth et al., 2021, Larsen et al., 2021) and building inspections (Yokota and Frangopol, 2021, Merkle et al., 2020, Perry et al., 2020), demonstrating the versatility and adaptability of the solution.

SHAFT [UNIBO]
(SAT & HUE Adaptive Fine Tuning (SHAFT)(Gaiani et al., 2018) is the target-based Color Calibration (CC) solution developed from 2017 to achieve an accurate apparent color reproduction of the digitized artefacts. SHAFT is fully automated (requires only the target selection) and uses a Calibrite ColorChecker Classic or Passport. The workflow is organized in three steps i) RAW image linearization ii) Exposure compensation and white balance iii) CC through a linear matrix then a per-channel polynomial fitting algorithm (Gaiani et al.,

Solution	Type	Process	Licence	Provider	Platform	GUI	CLI / API	Pro	Cons	Last release and update frequency
Photomodeler	Software	Photogrammetry	Commercial	Eos System Inc (Canada)	Windows	YES	YES	Still here	Not used in CH	2026.0.0 Dec 2025 Quartely
Metashape	Software	Photogrammetry CV	Commercial	Agisoft (Russia)	Multi	YES	YES	Robust	Under embargo for some public institutions	2.3.0 Oct 2025 Quartely
MicMac (v1) MMVII (v2)	Library	Photogrammetry	FLOSS	IGN (FR)	Multi	YES but NO	YES	Completeness Refactorized	Lack of user-friendlyness In development	1.1.1 March 2023 Beta First release
Open-MVG	Library	Computer Vision	FLOSS	P. Moulon (FR/USA)	Multi	NO	YES	Maintenance	No interface	V2.1 dec 2023 yearly
Reality Capture	Software	Computer Vision	Commercial	EPIC Games (USA)	Multi	YES	YES	Free	Licencing unpredictable Target community (CGI-VFX)	V2.1 Nov 2025 yearly
iTwin Capture Modeler	Software	Photogrammetry	Commercial	Bentley (USA)	Windows	YES	YES	Accurate and versatile	Pricing	23.0.0.1317 june 2025 Yearly
PIX4DMatic	Software	Photogrammetry CV	Commercial	PIX4D (Switzerland)	Windows MacOS	YES	YES	UAV expertise	Licences	2.0.0 , jan 2026
COLMAP	Library	Computer Vision	FLOSS	J. Schönberger (Switzerland/USA)	No MacOS	NO YES	YES	Very robust Basemap for NERF	High GPU/memory demand	3.11 nov 2024 Monthly
Regard3D	Software	Computer Vision	FLOSS	R. Hiestand (Switzerland)	Multi	YES	NO	Cross-library (O-MVG + COLMAP)	Homebrew	1.0.0 March 2019 End-of-Life
Theia	Library	Computer Vision	FLOSS	C. Sweeney UC Santa Barbara (USA)	No	NO	YES	Velocity	Infrequent updates	0.8 Oct 2018 End-of-Life
AliceVision Meshroom	Library Software	Computer Vision	FLOSS	IRIT/ Mikros Technicolor (FR)	No MacOS	YES	YES	Powerful Expendable	Computer Vision oriented No GCP, Ortho etc	2025.1.0 aug 2025 Yearly
Graphos	Software	Photogrammetry	FLOSS	TIDAL/ISOP (Spain) - ISPRS	Windows	YES	YES	Cross-library COLMAP + others	Still in beta	2.0.0 beta 9 jul 2025 Semiannual
GLOMAP	Library	Computer Vision	FLOSS	ETH Zurich (Switzerland)	Multi	NO	YES	Cross-library (COLMAP + Theia + PoseLib)	Sensitive to suboptimal inputs	1.2.0 Oct 2025 Semiannual
PixSfM	Library	Computer Vision	FLOSS	ETH Zurich (Switzerland)	Linux only	NO	YES	Optimization of COLMAP	Single release	1.0 may 2023 Yearly
TACO	Library	Photogrammetry	FLOSS	A.Pamart (CNRS – FR)	Multi	NO	YES	Optimization / automation of MicMac	No release yet	Beta Jan 2022 End-of-Life
PhotoMatch	Library	Computer Vision	FLOSS	ISPRS (EU)	No	NO	YES	Multi-libraries features craft-based extraction	2D Matching only	2.0.0 Alpha Nov 2022 End-of-Life
Deep Image Matching	Library	Computer Vision	FLOSS	FBK (3D-OM – Italy)	Multi	In Dev	YES	Multi-libraries features AI-based extraction	Bridge to 3D SfM	2.0.0 August 2025 Yearly

Figure 2. Overview of 3D image-based modeling software and libraries (Last update 9 January 2026). In blue, the solutions existing in 2014, in red negative aspects, in green positive ones, in orange mitigated elements, in pink the synergic tools, in violet missing or odd data

2017)before a global refinement at patch level to ensure the minimization of Delta E (Mokrzycki and Tatol, 2011). Under controlled lighting, SHAFT yields result with color discrepancies within the 0,5 – 1,5 CIELAB unit range, providing a strong basis for colorimetric reproduction of CH artefacts. SHAFT has already been successfully applied in the field of 3D acquisition through the imaging of ancient paintings (Fantini et al., 2023) and drawings (Apollonio et al., 2015) with stereo photometric and photogrammetric techniques. It has also been applied in the field of historical architecture and larger scale (Remondino et al., 2016), also museum objects using wide range of cameras, from medium format, SLR or mirrorless cameras but also smartphone imagers (Apollonio et al., 2025). SHAFT2 will be released soon and will explore the Meshroom's framework to rely on stable and evolutive GUI moreover bridging cross-solution image-based techniques.

This critical review of the state of the art in FLOSS for image-based modeling reveals some remaining challenges :

- Maintenance and sustainability issues: FLOSS initiatives struggle with long-term support.
- Interoperability: Tools often lack complete functionality, forcing users into fragmented workflows without stable exchange formats.
- User accessibility: Many tools require command-line expertise, limiting adoption by non-technical users.

The MicMacRoom prototype addresses these challenges by leveraging the strengths of two leading open-source solutions: Meshroom (with its intuitive GUI and nodal architecture) and MicMac (a powerful yet complex CLI-based tool), while also supporting potential plug-in integrations such as SHAFT2 for color calibration. This paper pursues a twofold objective: (i) presenting the current state of the prototype, which enables the construction and execution of MicMac pipelines within the Meshroom environment, and (ii) outlining our vision for a fully interoperable framework in open image-based modeling.

3. MicMacRoom prototype

Development of the MicMacRoom prototype began as a collaborative effort between developers and expert users, which explains the initial inertia in both development and adoption. Key achievements to date include the creation of 27 functional nodes, covering essential photogrammetric processes such as tie-point generation, bundle block adjustment, dense cloud reconstruction, meshing, and texturing (see Figure 4). Additionally, a Node Generator (NG) was developed to seamlessly integrate MicMac commands into Meshroom's modular framework. The project also aims to provide enhanced documentation and tutorials to foster community engagement—both among users and developers—thereby addressing a long-standing barrier to adoption.

The current prototype leverages two native features from each software's source code: the Node Generator (NG) on the Meshroom side and the Low-Level Interface (LLI) on the MicMac side. The NG inherits from Meshroom's core *desc* class, enabling the generation of modules within the GUI. The LLI, also known as MicMac's vCommand mode, generates Qt-based graphical modules from command-line documentation. The prototype's architecture, incorporating these components, is illustrated in Figure 3. Our development relies on Python, ensuring versatility and ease of implementation. Pipeline and template management use Meshroom's internal .MG format—a JSON-derived structure that is both intuitive and efficient.

The initial prototype was developed during a hackathon in July 2023 at a partner research unit, bringing together developers and expert users from both Meshroom and MicMac. This version underwent alpha-testing with experienced MicMac users, despite a limited end-user documentation. In the first half of 2024, beta-testing and tutorial creation were assigned to undergraduate students from the French National School of Geomatic Sciences (ENSG). This second phase resulted in a forked version with expanded features but reduced stability (several bugs persist) compared to the hackathon release. In 2026, a new development phase will commence, supported by a recently funded project (see Sections 3.4 and 4 for details).

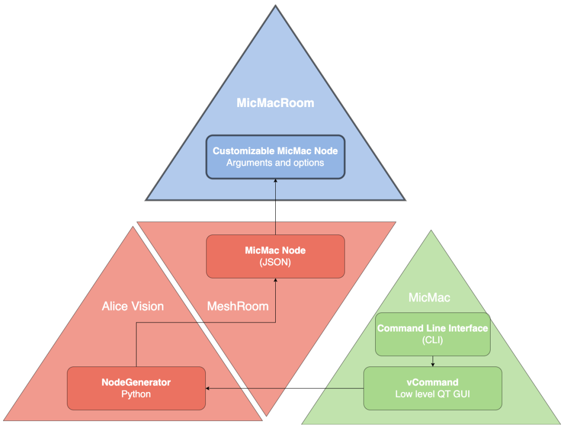

Figure 3. Current architecture of the MicMacRoom prototype.

3.1 Results and discussions

The current version of MicMacRoom is fully functional but remains experimental, serving primarily as a research prototype. To ensure a progressive development strategy, a roadmap has been established for the next phase of prototyping, implementation, and dissemination. This roadmap defines three levels of synergy:

- Low level: Focuses on debugging and optimization to achieve a stable beta version.
- Medium level: Addresses interoperability challenges to enhance workflows and prepare an official release.
- High level: Aims to develop a global framework for broader integration of image-based solutions and scalable deployment.

3.2 Open system and single entry point

The preliminary results obtained with the MicMacRoom prototype demonstrate significant potential for streamlining photogrammetric workflows in both terrestrial and aerial contexts. The system currently supports end-to-end processing pipelines, enabling the generation of dense point clouds, textured meshes, and orthophotomosaics, while integrating global orientation and georeferencing capabilities. These pipelines benefit from Meshroom's modular architecture, which allows users to adapt parameters and customize visual outputs, such as color schemes, labels, and annotations, to meet specific project requirements. To facilitate accessibility, the node-based workflows are made available through two complementary distribution formats. The first consists of preconfigured processing templates—including MicMacBasic, MicMacOrtho, MicMacTexturedMesh, and MicMacAeroGCP—which can be directly accessed via the interface and require only the user's image dataset as input. The second format comprises tutorial-based templates, designed to guide users through reproducible workflows for various acquisition scenarios, including incremental processing.

The complete resource package, which includes technical documentation, step-by-step tutorials, sample datasets, and the full source code, is centralized and accessible in the repository: https://linkstack.fr/@MicMacRoom.

3.3 Limitations

Several limitations persist and must be explicitly communicated to potential users, particularly regarding known bugs and missing features. While the ready-to-use pipelines are customizable to facilitate adoption by non-expert MicMac users, the original, non-intuitive command names have been preserved for node labeling. A revised and simplified naming convention is currently under consideration (e.g., replacing Tapioca, Tapas, AperiCloud, and C3DC with 2D Matching, Camera Calibration and Pose Estimation, Sparse Cloud, and 3D Dense Matching, respectively). Nevertheless, significant efforts have been dedicated to clarifying parameter options and relocating expert features into a advanced settings tab, thereby simplifying the interface for non-expert users (see Figure 5). The prototype currently requires a custom installation process, involving the configuration of system environment variables to manage dependencies. While this approach may introduce compatibility challenges—particularly when integrating additional packages (e.g. Python, SHAFT2) with their own dependencies—the MeshroomResearch environment was designed to mitigate such issues. The prototype is compatible only with Windows and Linux platforms (no MacOS version), though it inherits the hardware dependencies of AliceVision/Meshroom. Beyond installation constraints, certain core functionalities remain unavailable. Unlike node parametrization, interactions with processing data—such as point picking, mask generation, and point cloud visualization—are not yet fully integrated and are prioritized for future development. Finally, bridging the gap between AliceVision/Meshroom's incremental, node-based workflow management and MicMac's

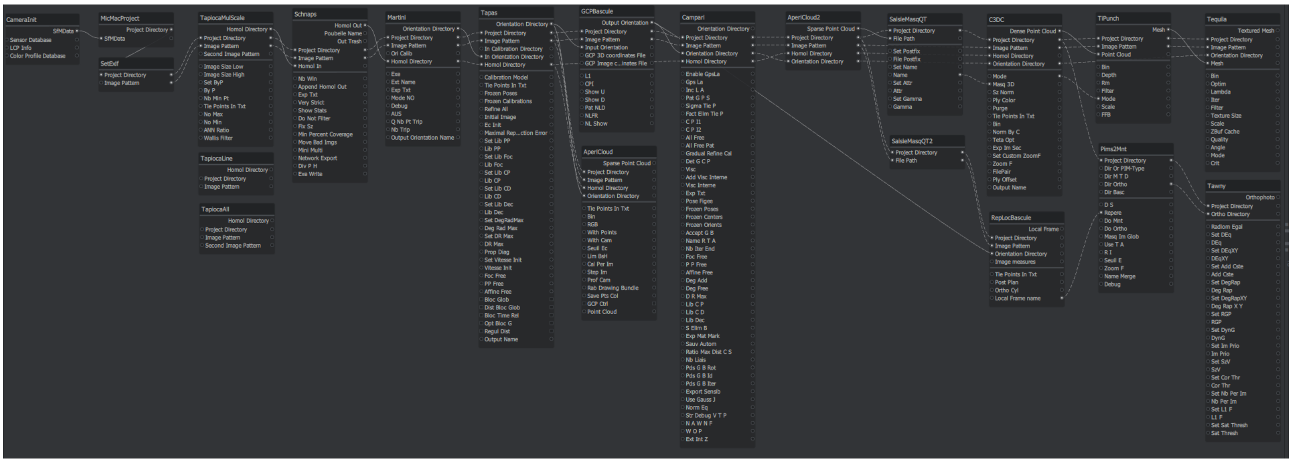

Figure 4. Current states of MicMac based the modules and options implemented.

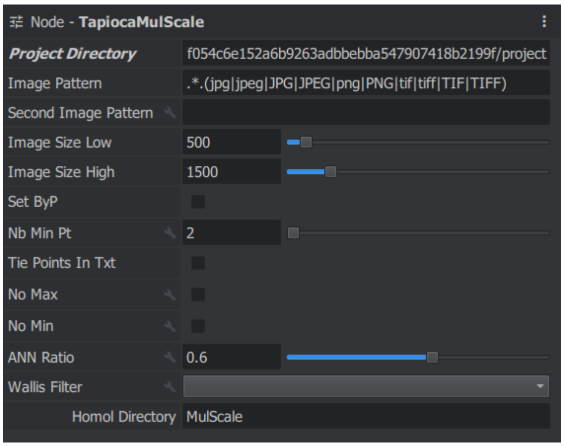

Figure 5. Example of MicMac module (Tapioca) within MeshRoom.

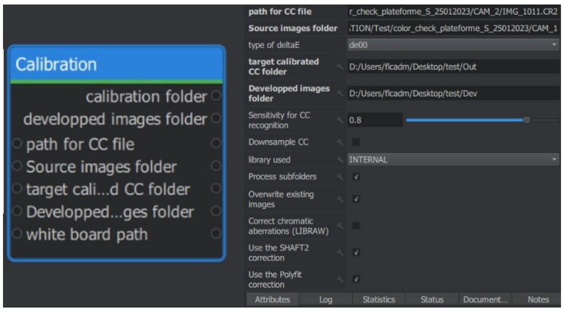

Figure 6. Experimental node of SHAFT2 to manage Color Calibration prior to MicMac-based photogrammetric processing within the Meshroom powered prototype.

strictly procedural (I/O-based) approach remains a critical challenge to achieving seamless interoperability for synergistic workflows.

3.4 Future works

The future development strategy adopts a three-tiered approach to progressively enhance synergies between MicMac, AliceVision, and other image-based FLOSS solutions. On the MicMac side, the prototype opens new dissemination avenues for MMVII (MicMac V2), which—unlike its predecessor—is truly multi-platform. The introduction of Python bindings will further expand interaction capabilities with MMVII's source code, while its modular dense image matching architecture enables the integration of state-of-the-art algorithms into existing pipelines. This modularity, central to the MeshroomResearch framework, lays the groundwork for a versatile open toolbox in image-based modeling. To this end, experimental nodes have already been developed to demonstrate feasibility, including integrations with PotreeConverter and Python-based scripting (e.g. parsing, data conversion, and management). Given that any command-line interface (CLI) tool can potentially be adapted to Meshroom's plug-in environment, the long-term goal is to establish a comprehensive open toolbox for photogrammetric workflows. In parallel, ongoing efforts focus on integrating color calibration via SHAFT2 (previously introduced) into a unified pipeline (see Figure 6). Color calibration (CC) represents a critical preprocessing stage for both photogrammetric/SfM and multi-light image collections (e.g., RTI, PS), particularly for combined approaches (Brument et al., 2024, Laurent et al., 2025). As these advanced multi-view photometric techniques are currently being implemented within the same Meshroom environment—and under the same funding program for open-source software consolidation—their accessibility within a unified, interoperable framework would not only add significant value but also demonstrate the transformative potential of FLOSS synergies.

4. Conclusion and perspectives

In this article, we presented MicMacRoom as a proof-of-concept prototype, introducing an open framework designed to enhance image-based modeling. The current beta version enables users to execute complete MicMac-based workflows directly within the Meshroom GUI, as detailed in Section 3. These workflows encompass the full photogrammetric pipeline, including 2D matching, camera calibration and pose estimation, sparse cloud generation, 2D/3D filtering, global orientation and compensation (via GCP and georeferencing), 3D dense matching, meshing, texturing, orthorectification, and mosaicing.

The prototype is fully open-source, providing not only the source code but also comprehensive technical documentation, with a particular emphasis on tutorials and sample datasets to facilitate adoption. Our objective is to build a community of developers and users to support and sustain this initiative, ensuring its long-term evolution. Currently, our prototype relies on three core dependencies: MicMac for the 3D reconstruction pipeline, Meshroom for the GUI environment, and SHAFT2 for color calibration preprocessing, demonstrating the potential for broader synergies among open-source tools. This approach is grounded in a deep understanding of the challenges and needs of open photogrammetry and cultural heritage (CH) applications, as discussed in Section 2.1. While the current version remains experimental, it already addresses fundamental requirements for CH photogrammetry and is extensible to other domains, as explored in Section 2.2. This extensibility underscores its potential for broader impact across diverse applications, even more considering the evolution of multi-view stereo photometric methods.

The work presented in this article, along with the proposed roadmap for future development, serves as the foundation for a recently funded project: COCORICO (Consolidation of Open-source and Collaborative Software for Resilient Interoperable Photogrammetric Communities). This initiative embodies our vision of a sustainable, community-driven ecosystem in open photogrammetry, exemplified by the MicMacRoom prototype. The project has been selected under the OPEN program (CNRS Innovation), which specifically targets the technological development and transfer of open-source solutions. The primary objective of COCORICO is to deliver a stable, official release of the MicMacRoom prototype, prior to expanding its scope toward open-core systems and SaaS deployment, as illustrated in Figure 7. Additionally, the project will integrate complementary prototypes to enhance its functionality, including semantic annotation with AIOLI (Abergel et al., 2023), virtual tour generation with MYRTE (Bergerot, 2024), metadata management with ANAMNESIS (Pamart et al., 2026), on-site SLAM-based capture with DURAIR (De Luca et al., 2026).

Ultimately, this research work aspires to establish a unified open photogrammetry framework, integrating and enhancing existing and emerging FLOSS image-based solutions. By optimizing workflows and expanding functional capabilities, this initiative seeks to redefine the open image-based modeling paradigm, rendering it more accessible, efficient, and adaptable—not only for Cultural Heritage applications but also for diverse domains beyond.

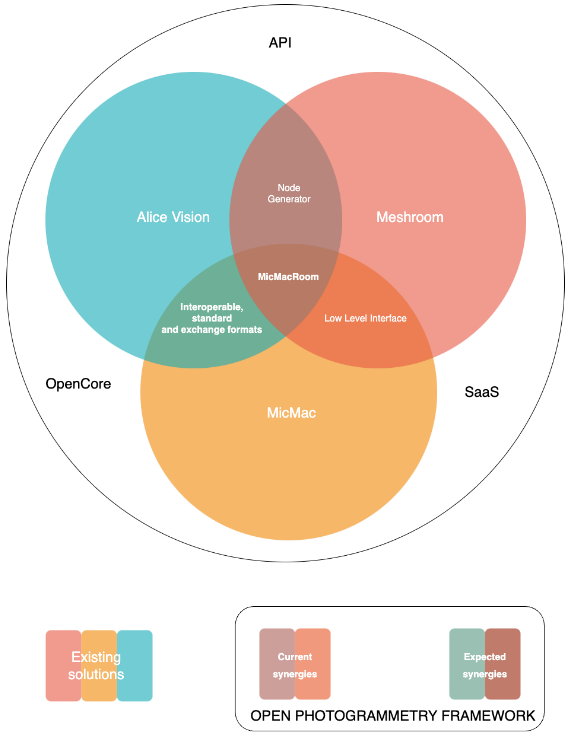

Figure 7. Diagram of MicMacRoom envisioned synergies.

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Roles and contributions

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