REPROVIP – ENHANCING REPRODUCIBILITY OF SCIENTIFIC RESULTS IN MEDICAL IMAGING

AUTHORS

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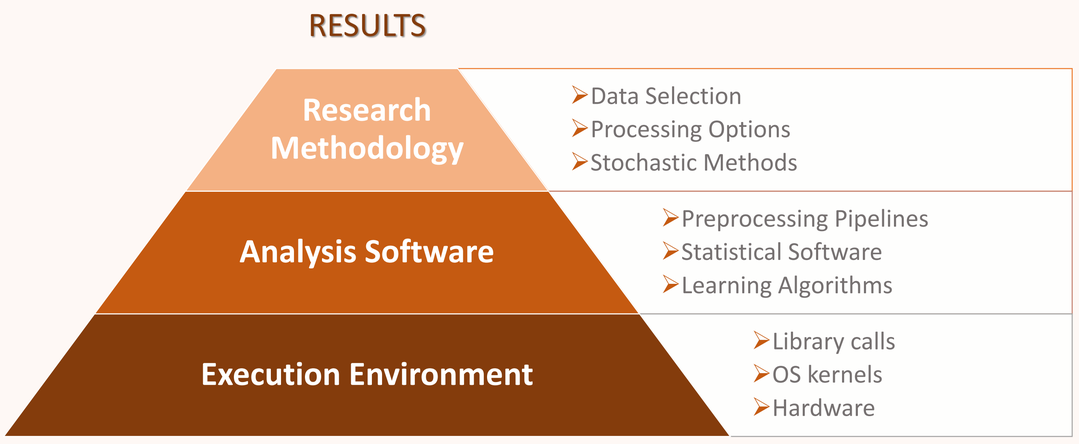
VIP : THE VIRTUAL IMAGING PLATFORM

- **Free & open** platform for simulation / processing of medical images.
  - ✓ 1400+ registered users;
  - ✓ 20+ applications available as a service;
  - ✓ Web portal: https://vip.creatis.insa-lyon.fr/
- Uses **EGI** resources to provide users with transparent access to high-throughput computing, through the **DIRAC** framework [1].

RESEARCH ISSUE

*Medical Imaging Research (MIR) is facing a **reproducibility crisis**.*

- Most MIR applications are unable to produce the same results twice, when applied the same sets of inputs.
- Sources of variability can be identified in distinct layers of data processing : (i) the research **methodology** [2], (ii) the analysis **software** (3] and (iii) the execution **environment** [4].



- Environment-related variability (iii) is poorly acknowledged by the MIR community and may cause versatilities in scientific results based on **distributed computing**.
- The ReproVIP project is funded by the French National Research Agency (grant N°ANR-21-CE45-0024-01), to address reproducibility issues at each layer of processing.

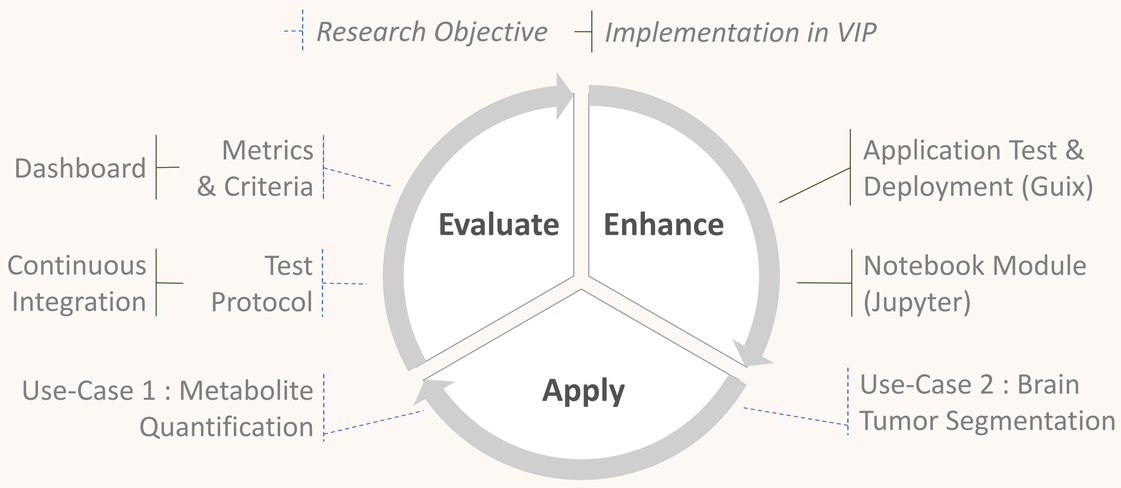
PROJECT OUTLINE

The project is structured around three complementary goals :

A. **Evaluate** the uncertainty of an application's digital outcomes.
- ❑ Define metrics & criteria to validate a "reproducible" scientific result;
- ❑ Design a reproducibility test protocol to be run after each app execution.

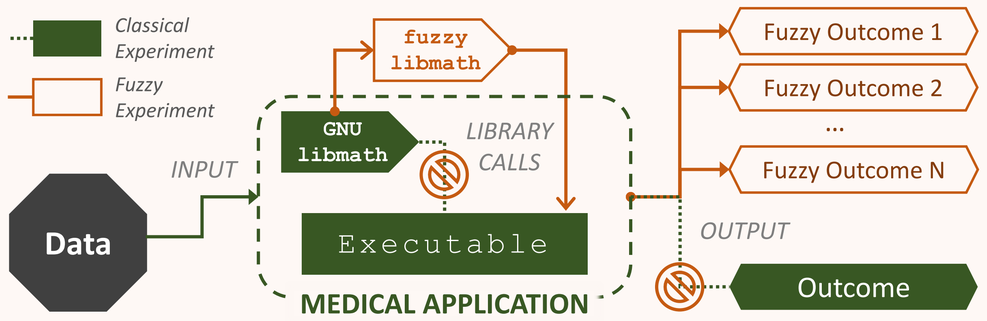
B. **Enhance** the numerical reproducibility of VIP outcomes using software solutions for open science.
- ❑ For the Research Methodology layer (i), provide EGI-based Jupyter Notebooks on the Web portal (able to use the DIRAC framework);
- ❑ For the Execution Environment layer (iii), run MIR applications on *Guix* : a GNU-based Linux distribution for advanced package management.

C. **Apply** reproducibility metrics & know-how on two MIR issues.
- ❑ Metabolite quantification in magnetic resonance spectroscopy;
- ❑ Automatic tumor segmentation in the lower brain regions.



EARLY PROSPECTS

- By leveraging cross-environment computing resources from the EGI e-infrastructure, VIP will provide a virtual playground to **experiment** variability in a pipeline's results at the environment level (iii).
- In the meantime, inter-OS variability can be efficiently **simulated** by introducing random perturbations in a pipeline's mathematical operations [5]. This can be done by using a fuzzy version of the GNU mathematical library: Fuzzy-LibMath (compiled with Verificarlo API).



- Variability can be assessed across empirical or simulated outcomes.

Literature

1. (Glatard, Tristan, et al. 2013), « A Virtual Imaging Platform for Multi-Modality Medical Image Simulation ». *IEEE Transactions on Medical Imaging 32* (1): 110-18
2. Botvinik-Nezer, Rotem, Felix Holzmeister, Colin F. Camerer, Anna Dreber, Juergen Huber, Magnus Johannesson, Michael Kirchler, et al. 2020. « Variability in the analysis of a single neuroimaging dataset by many teams ». *Nature* 582 (7810): 84-88. https://doi.org/10.1038/s41586-020-2314-9.
3. Bowring, Alexander, Camille Maumet, et Thomas E. Nichols. 2019. « Exploring the Impact of Analysis Software on Task FMRI Results ». Human Brain Mapping 40 (11): 3362-84. https://doi.org/10.1002/hbm.24603.
4. Glatard, Tristan, Lindsay B. Lewis, Rafael Ferreira da Silva, Reza Adalat, Natacha Beck, Claude Lepage, Pierre Rioux, et al. 2015. « Reproducibility of Neuroimaging Analyses across Operating Systems ». *Frontiers in Neuroinformatics* 9 (april). https://doi.org/10.3389/fninf.2015.00012.
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