Ethical AI for Biomedical Imaging: A FOSS Extension for KNIME Integrating YOLO and SAM

13 November 2025

KNIMEVizLab

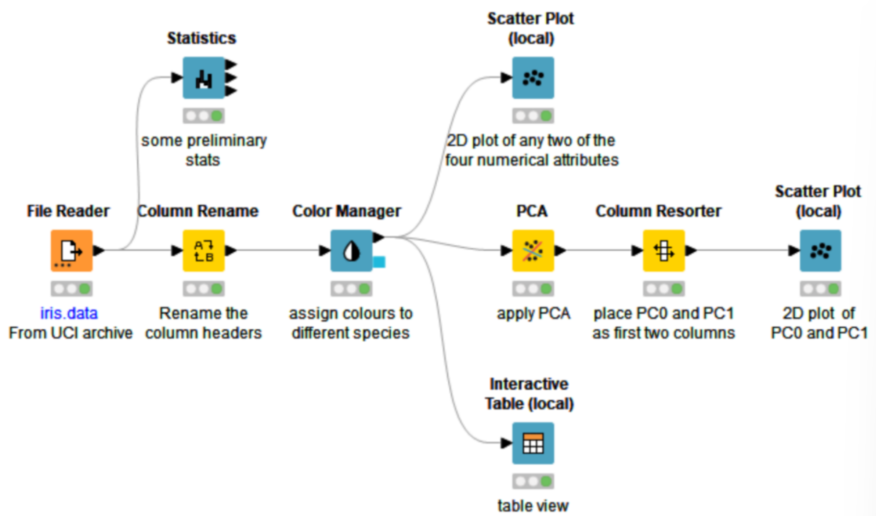
Prof. Giuseppe Di Fatta, Dr. Andrea Rosani,

Dr. Thomas Borsani, Dr. Ali Bhatti

Outline

- KNIME
- Image processing pipeline using KNIME
- Deep learning applications using KNIME
- Conclusions

- KNIME is an **open-source** Data Science and Machine Learning Platform
  - codeless Machine Learning and Data Science
  - open-source and free (General Public License)
  - open and extendible platform



a KNIME data workflow
(an acyclic graph of computations)

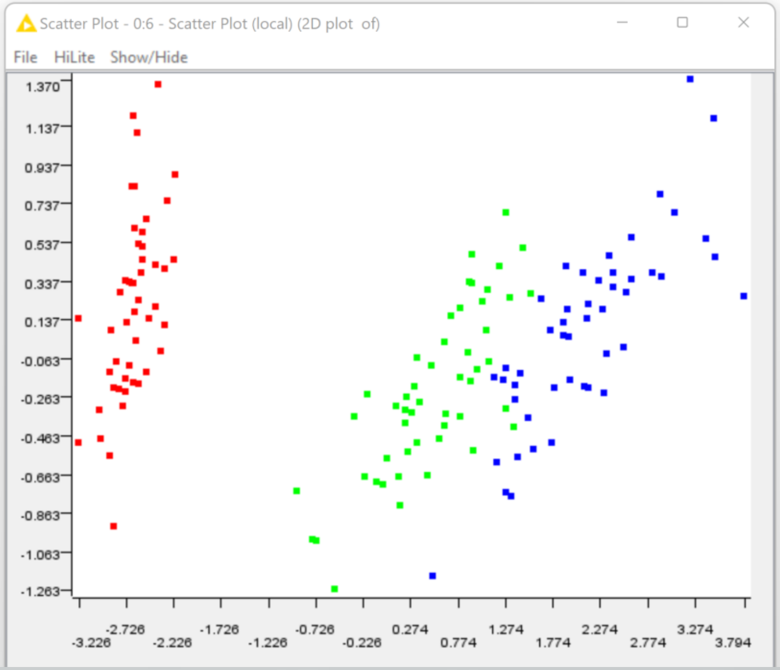


Image processing – ML pipeline

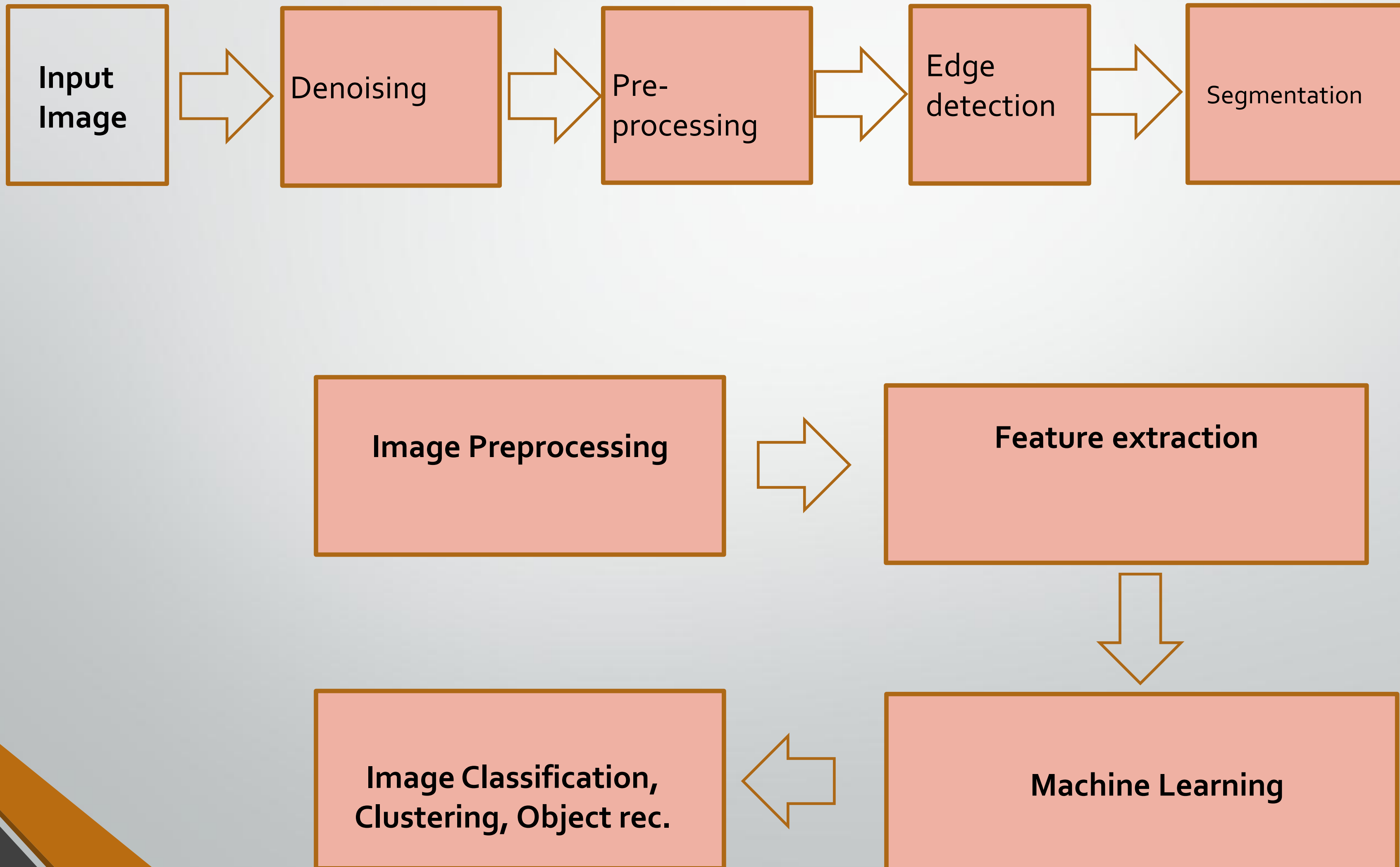
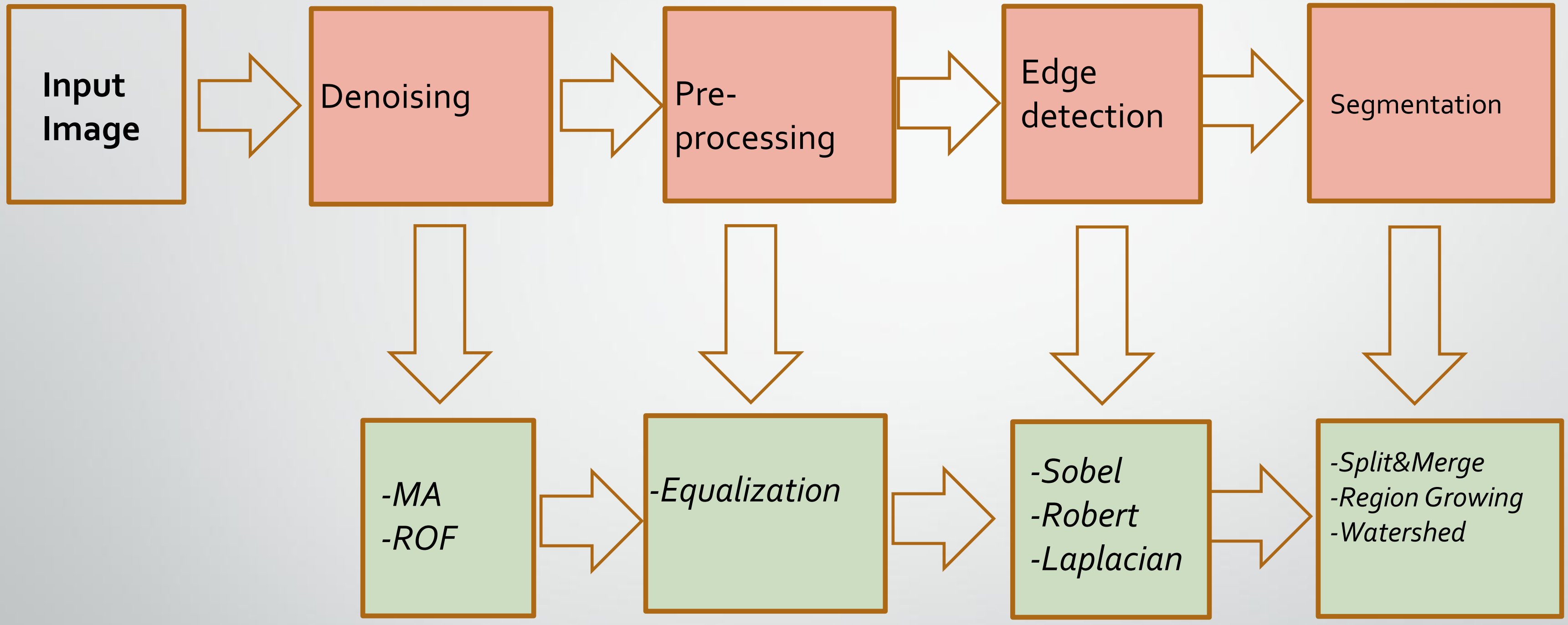


Image processing – ML pipeline

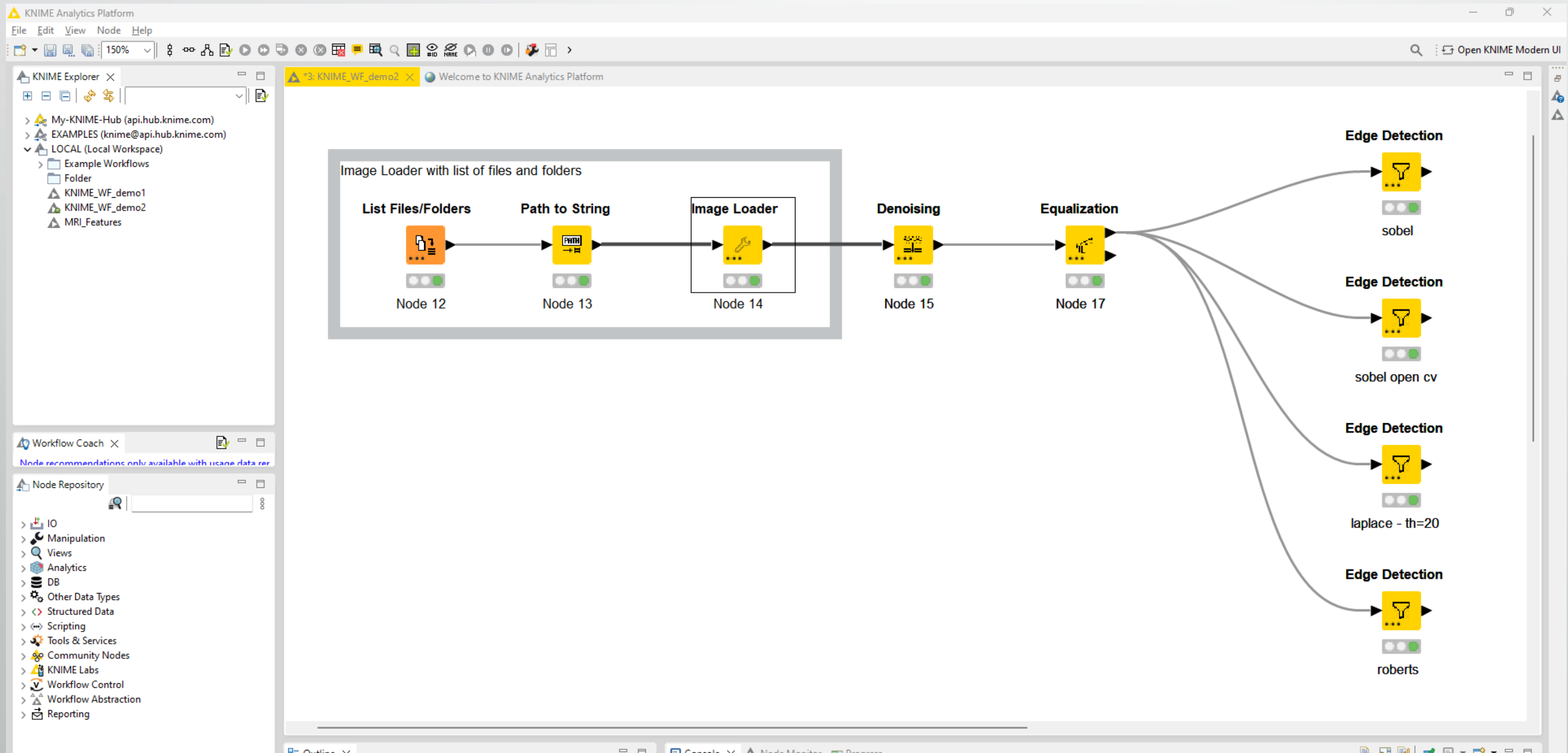


Current status of development of nodes

- I/O
  - Image loader
    - JPEG, PNG input file format
    - only PNG output port
- Denoising (sequential and multithread algorithms)
  - Gaussian and Median Filters
- Preprocessing
  - Equalization
- Edge detection
  - Sobel (vanilla, with openCV), Roberts, Laplacian

Open to new collaborations!

Current status of development of nodes



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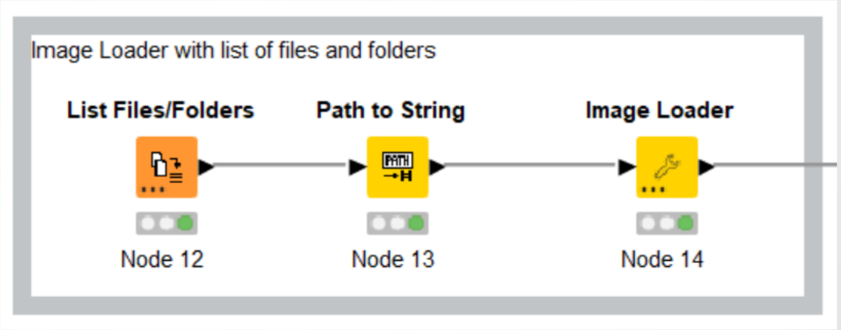

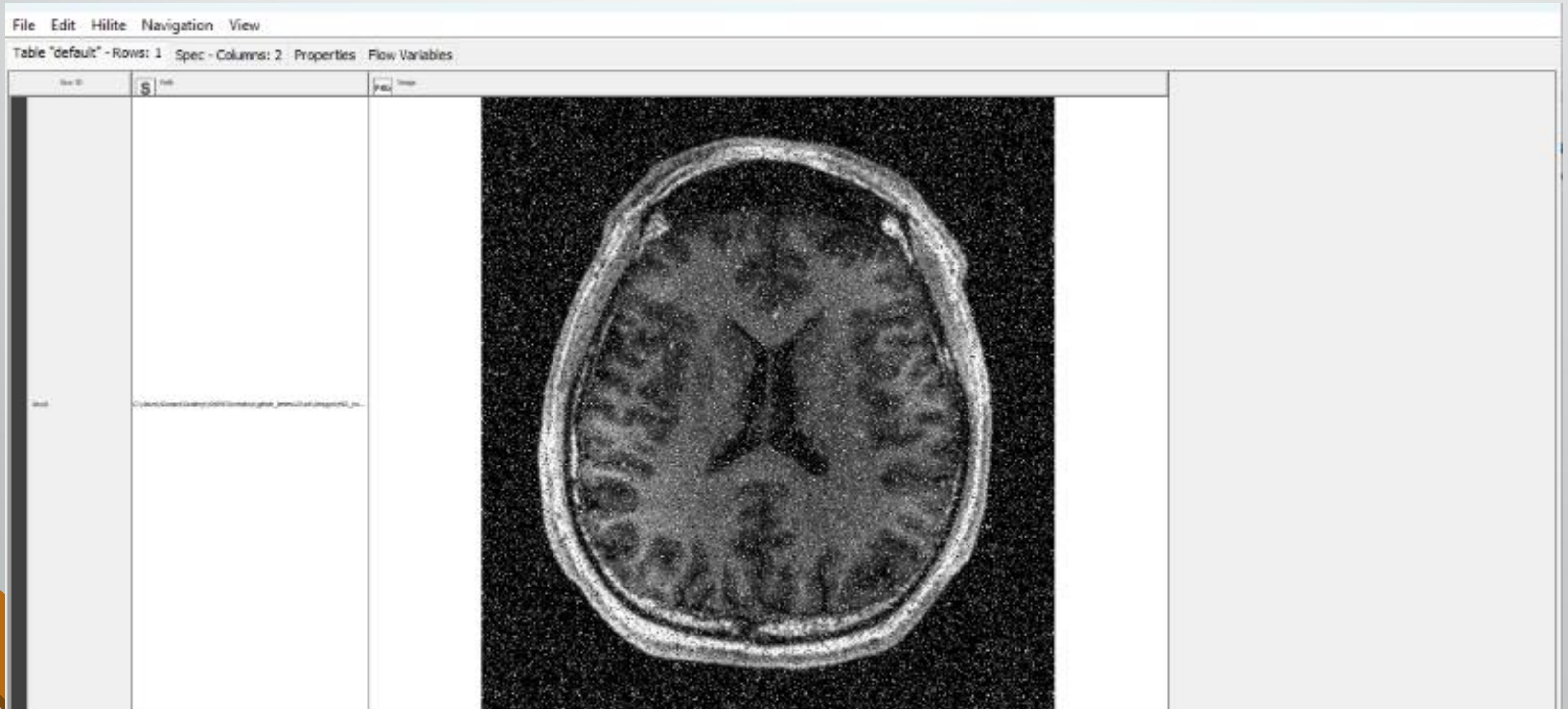

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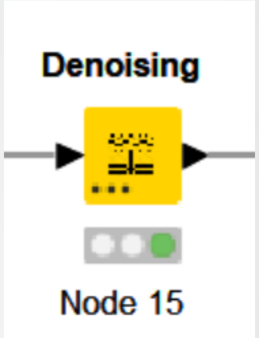

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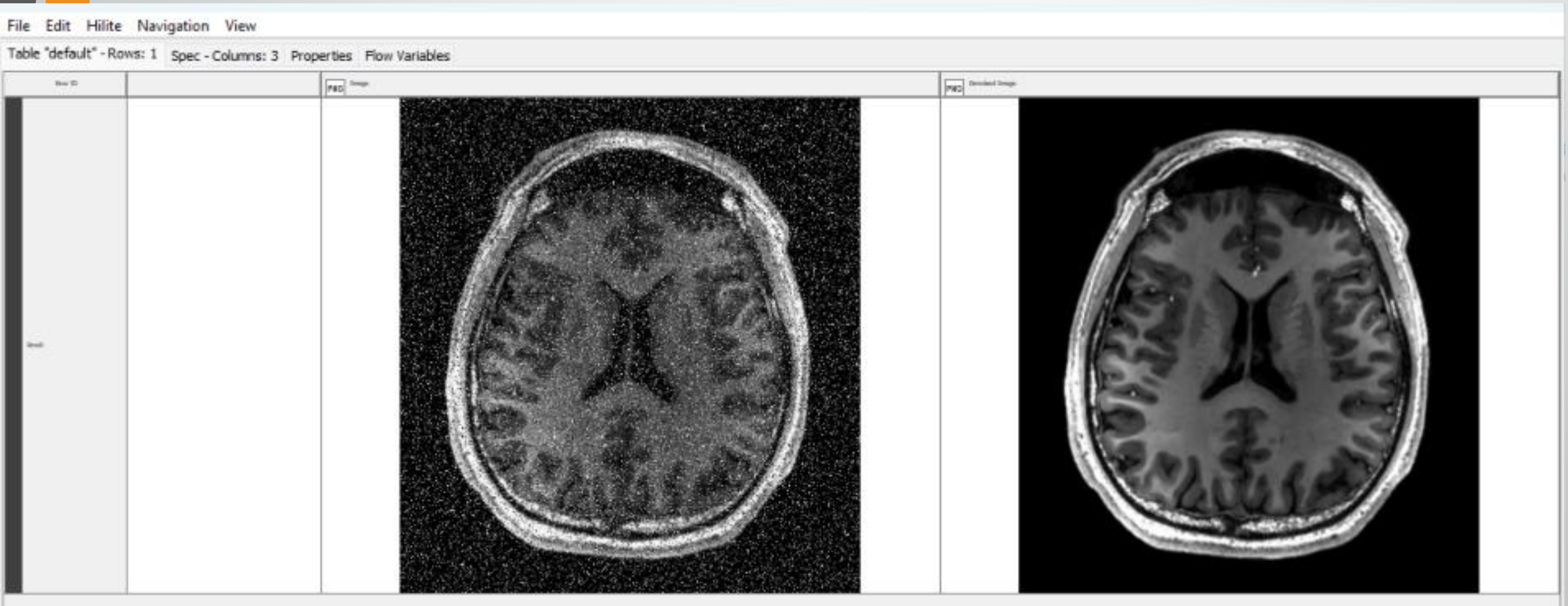
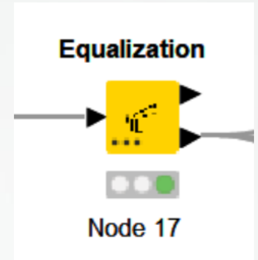
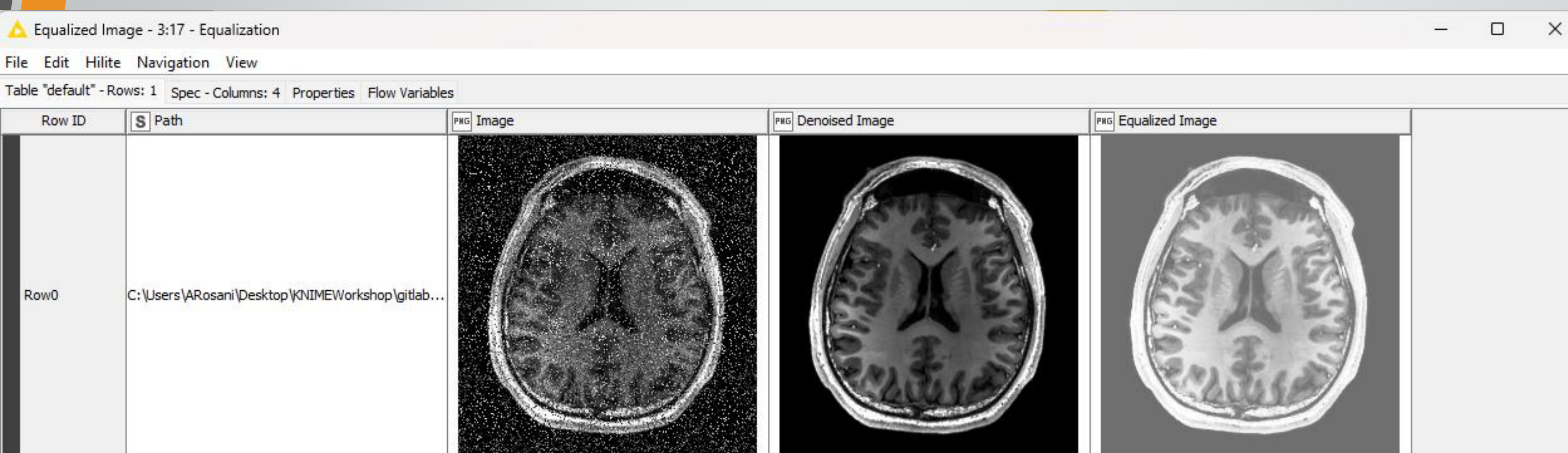


Current status of development of nodes

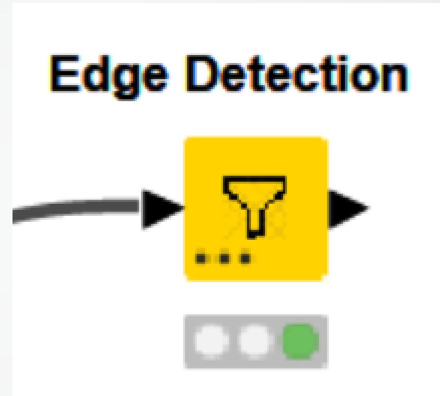


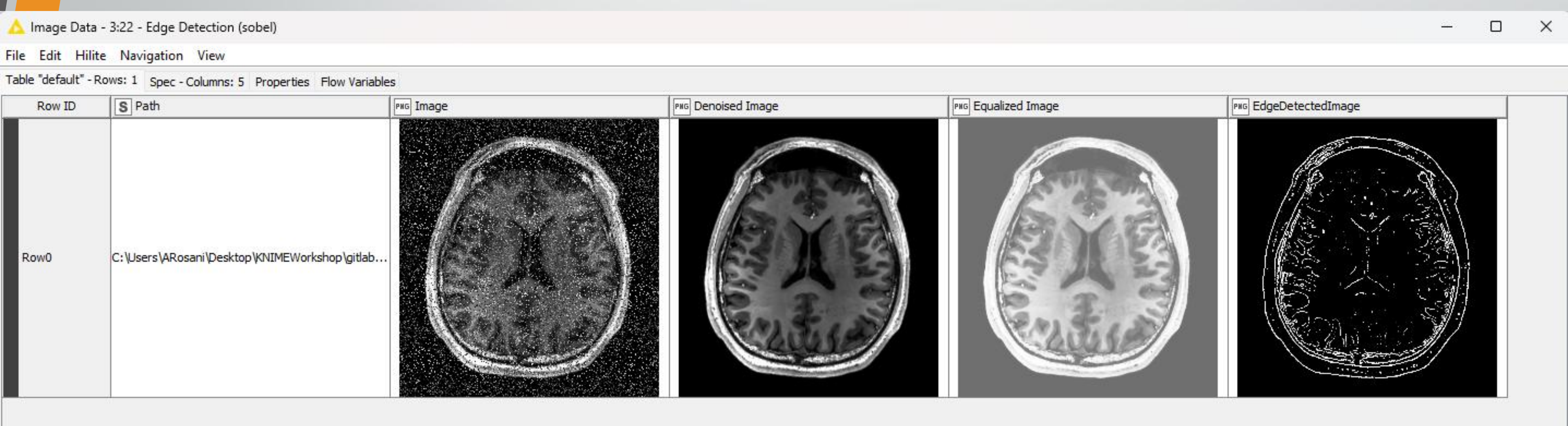
- Preprocessing
  - Equalization



Current status of development of nodes

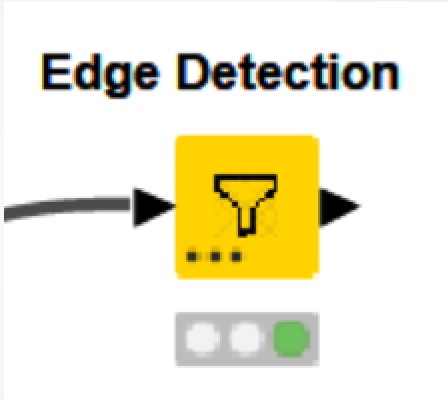
- Edge detection
    - Sobel (naïve implementation)

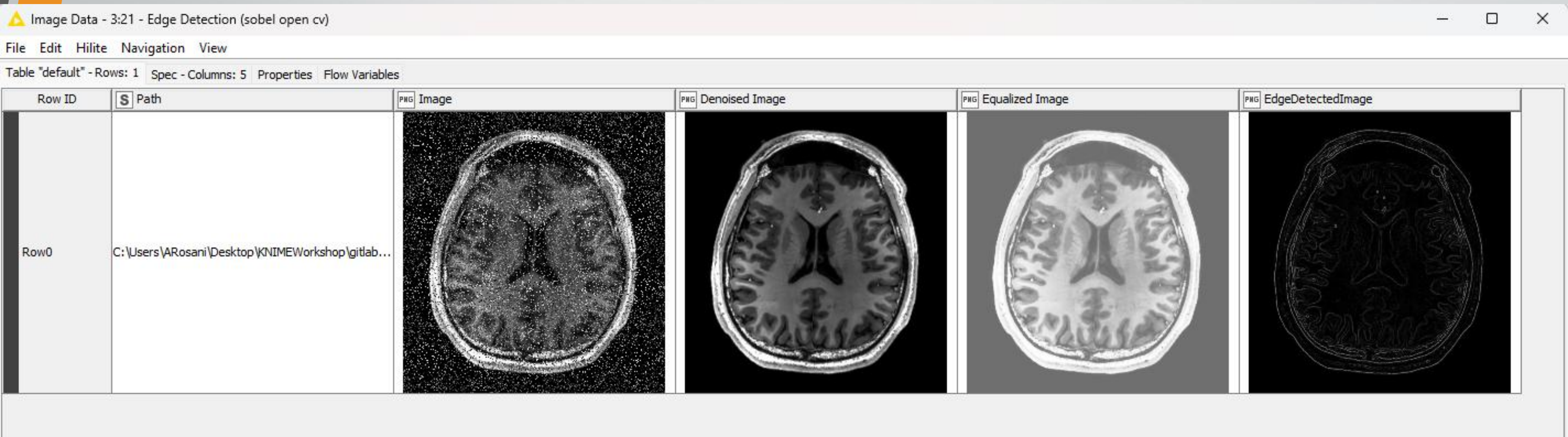




Current status of development of nodes

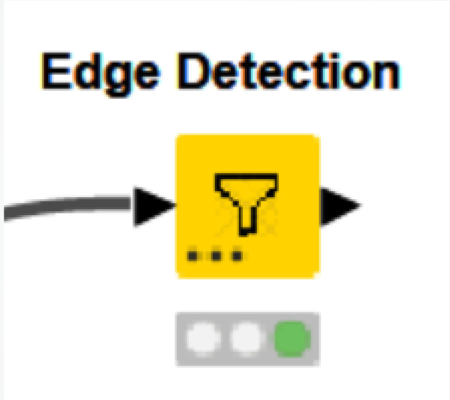
- Edge detection
  - Sobel (openCV)

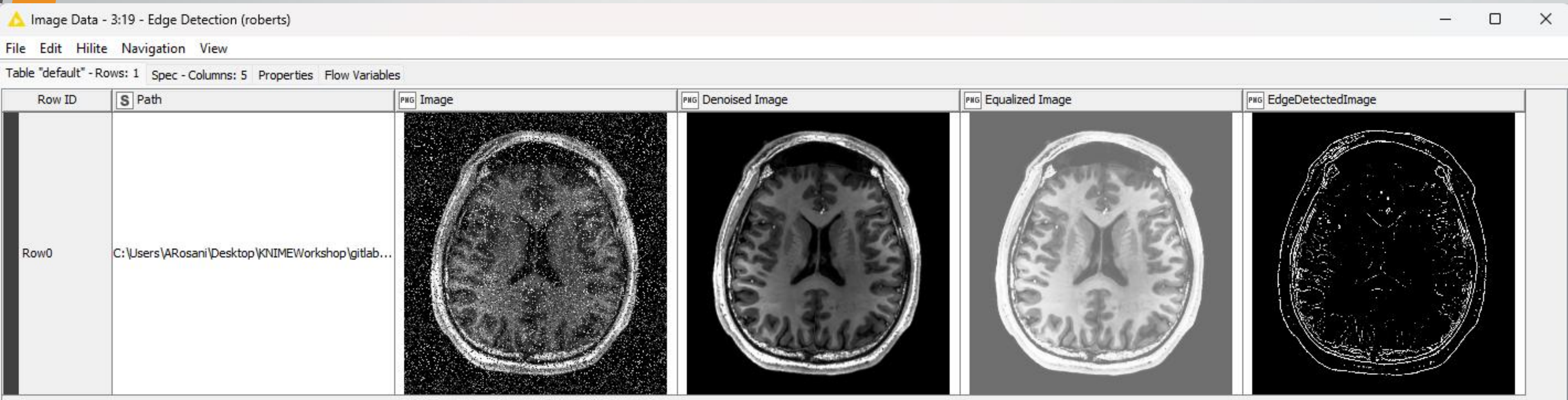




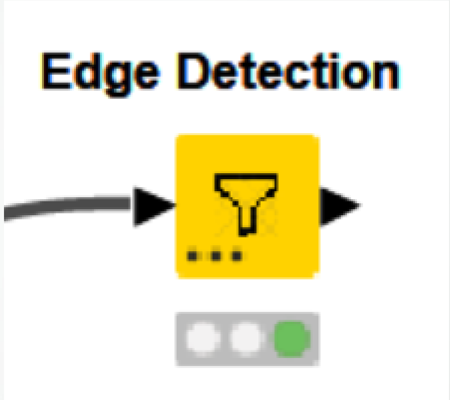
Current status of development of nodes

- Edge detection
  - Roberts

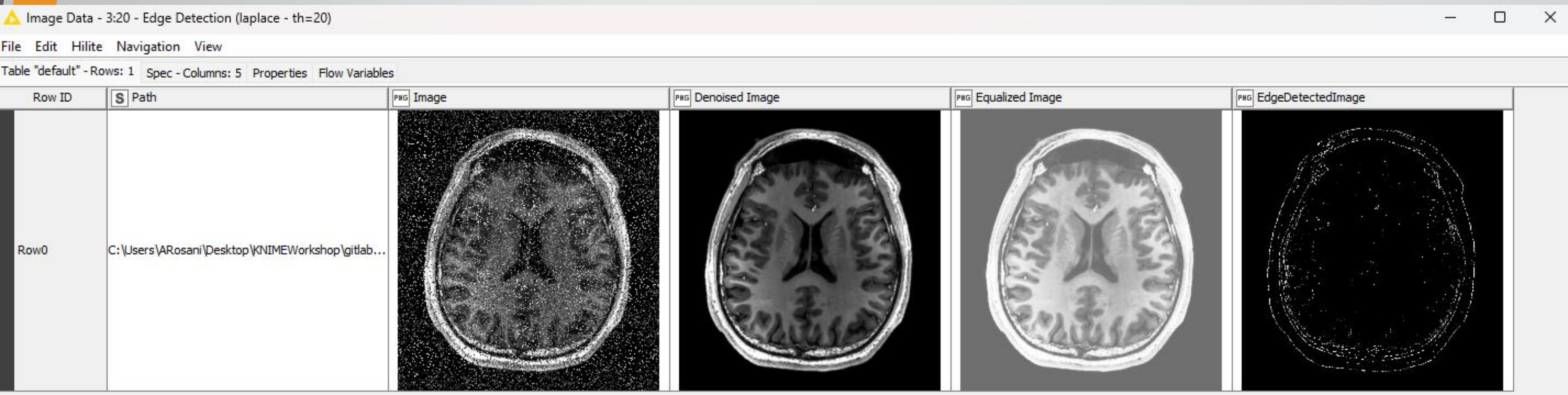




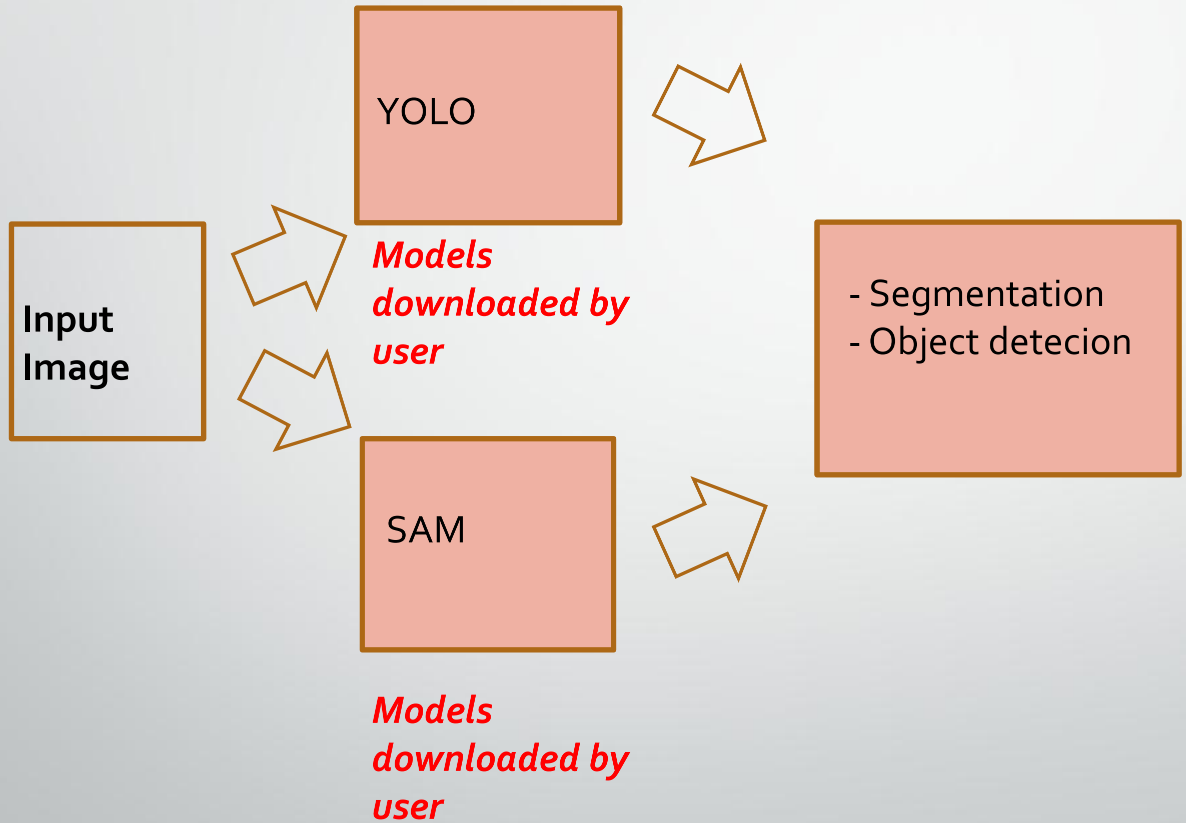
Current status of development of nodes



- Edge detection
  - Laplacian



Deep learning applications



Deep learning applications I/O

- **INPUT**
- **List of images in PNG format**

- **OUTPUT**
- **3 tables** with
  - Segmentation mask
  - Bounding boxes of objects
  - (classification of objects)

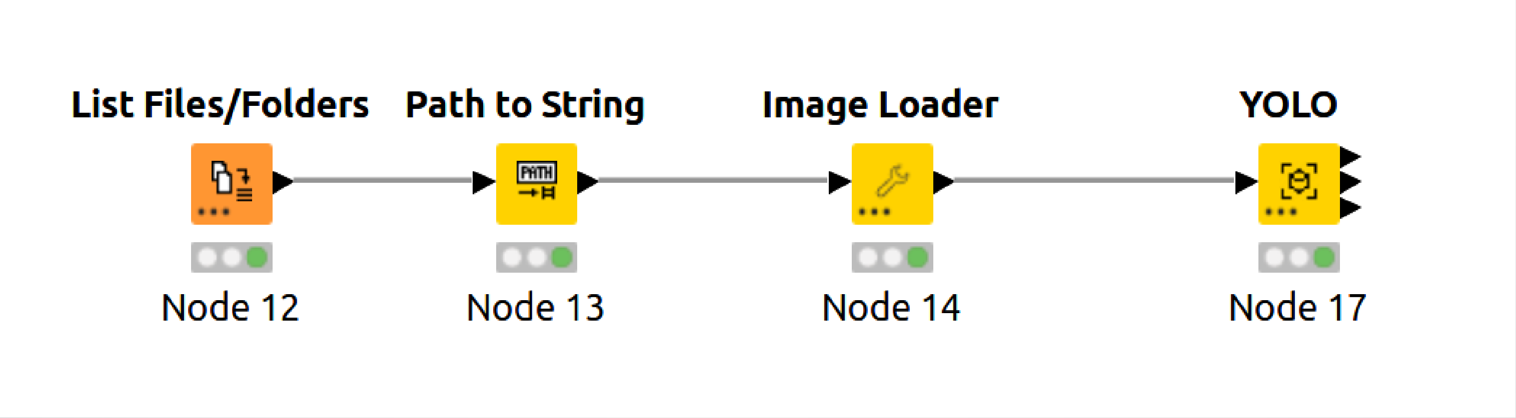
Current status
of development of nodes
DEMO 1

- **YOLO**

Redmon, J., Divvala, S., Girshick, R., & Farhadi, A. (2016). You Only Look Once: Unified, Real-Time Object Detection. In *2016 IEEE Conference on Computer Vision and Pattern Recognition (CVPR)* (pp. 779–788). https://doi.org/10.1109/CVPR.2016.91

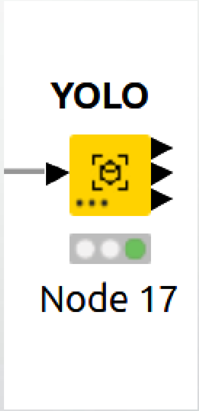
- **object count**
- **custom model**

YOLO segmentation



YOLO segmentation

Input Image



YOLO segmentation

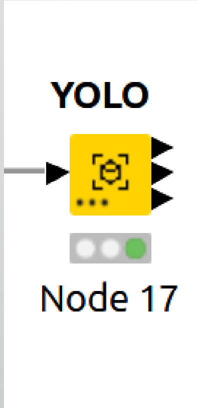
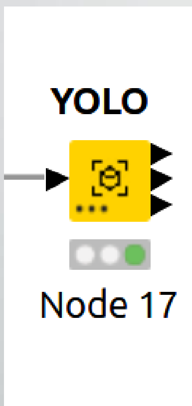


Image output

YOLO segmentation



Bounding box output table

Row ID	S img_id	D x_center	D y_center	D width	D height
Row0	/home/tb/Documents/UNIBZ_research/knime/knimevizlab/Segmentation/img.png	0.327	0.56	0.098	0.133
Row1	/home/tb/Documents/UNIBZ_research/knime/knimevizlab/Segmentation/img.png	0.622	0.614	0.094	0.194
Row2	/home/tb/Documents/UNIBZ_research/knime/knimevizlab/Segmentation/img.png	0.512	0.563	0.071	0.081
Row3	/home/tb/Documents/UNIBZ_research/knime/knimevizlab/Segmentation/img.png	0.114	0.853	0.227	0.293
Row4	/home/tb/Documents/UNIBZ_research/knime/knimevizlab/Segmentation/img.png	0.658	0.654	0.245	0.148
Row5	/home/tb/Documents/UNIBZ_research/knime/knimevizlab/Segmentation/img.png	0.285	0.732	0.223	0.425
Row6	/home/tb/Documents/UNIBZ_research/knime/knimevizlab/Segmentation/img.png	0.25	0.733	0.149	0.416
Row7	/home/tb/Documents/UNIBZ_research/knime/knimevizlab/Segmentation/img.png	0.509	0.662	0.069	0.12
Row8	/home/tb/Documents/UNIBZ_research/knime/knimevizlab/Segmentation/img.png	0.43	0.726	0.144	0.423
Row9	/home/tb/Documents/UNIBZ_research/knime/knimevizlab/Segmentation/img.png	0.398	0.662	0.065	0.077
Row10	/home/tb/Documents/UNIBZ_research/knime/knimevizlab/Segmentation/img.png	0.378	0.664	0.123	0.074
Row11	/home/tb/Documents/UNIBZ_research/knime/knimevizlab/Segmentation/img.png	0.398	0.616	0.059	0.021
Row12	/home/tb/Documents/UNIBZ_research/knime/knimevizlab/Segmentation/img.png	0.552	0.607	0.028	0.038

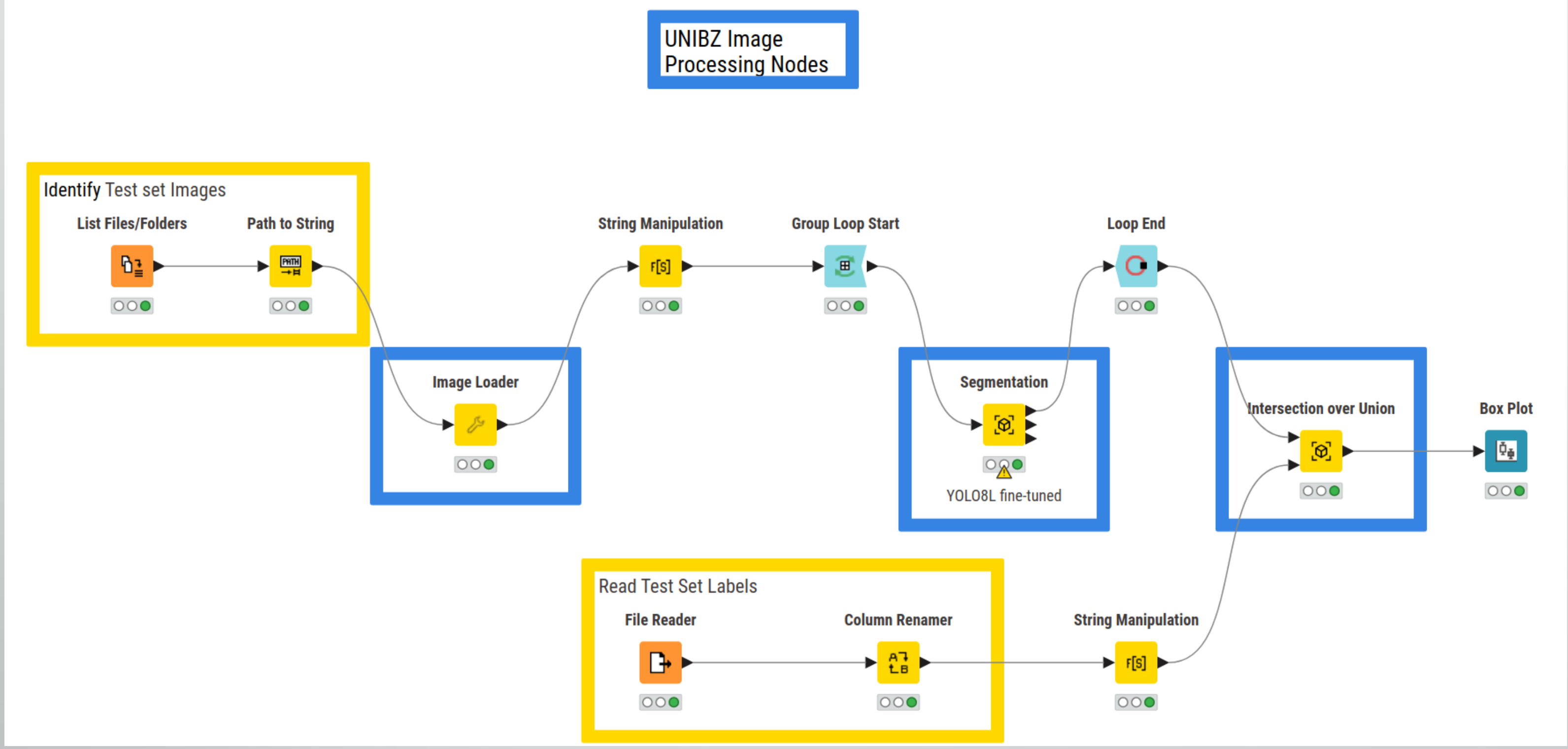
Segmentation mask output table

Row ID	S img_id	[...] masks
Row0	/home/tb/Documents/UNIBZ_research/knime/knimevizlab/Segmentation/img.png	[0.317137748003006,0.4958333373069763,0.317137748003006,....
Row1	/home/tb/Documents/UNIBZ_research/knime/knimevizlab/Segmentation/img.png	[0.6125306487083435,0.512499988079071,0.612530648708343...
Row2	/home/tb/Documents/UNIBZ_research/knime/knimevizlab/Segmentation/img.png	[0.5078146457672119,0.5208333730697632,0.50781464576721...
Row3	/home/tb/Documents/UNIBZ_research/knime/knimevizlab/Segmentation/img.png	[0.002989795757457614,0.7041666507720947,0.002989795757...
Row4	/home/tb/Documents/UNIBZ_research/knime/knimevizlab/Segmentation/img.png	[0.5875238180160522,0.71875,0.5890867710113525,...]
Row5	/home/tb/Documents/UNIBZ_research/knime/knimevizlab/Segmentation/img.png	[0.3921581506729126,0.9145833253860474,0.39215815067291...
Row6	/home/tb/Documents/UNIBZ_research/knime/knimevizlab/Segmentation/img.png	[0.20148128271102905,0.9208333492279053,0.1967925131320...
Row7	/home/tb/Documents/UNIBZ_research/knime/knimevizlab/Segmentation/img.png	[0.4718673825263977,0.6041666865348816,0.47186738252639...
Row8	/home/tb/Documents/UNIBZ_research/knime/knimevizlab/Segmentation/img.png	[0.4062245190143585,0.7854166626930237,0.40153574943542...
Row9	/home/tb/Documents/UNIBZ_research/knime/knimevizlab/Segmentation/img.png	[0.3655884265899658,0.6208333373069763,0.36558842658996...
Row10	/home/tb/Documents/UNIBZ_research/knime/knimevizlab/Segmentation/img.png	[0.3155748248100281,0.6291666626930237,0.31557482481002...
Row11	/home/tb/Documents/UNIBZ_research/knime/knimevizlab/Segmentation/img.png	[0.3655884265899658,0.6041666865348816,0.36558842658996...
Row12	/home/tb/Documents/UNIBZ_research/knime/knimevizlab/Segmentation/img.png	[0.5406360626220703,0.5874999761581421,0.54063606262207...

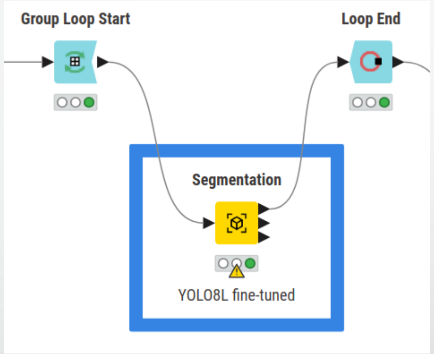
Test case:
Synthetic to Real Object Detection

- **Motivation:**
  - **Synthetic data promises:**
    - Cost-effectiveness
    - Scalability
    - Reduced bias
  - **BUT:** Synthetic-Trained Models Often Fail in Real-World Conditions
- **Objective:**
  - **Training Phase**
    - **Dataset:** 100% Synthetic Data
    - **Goal:** Train an object detection model to identify Cheerio boxes
  - **Testing Phase**
    - **Validation:** Detect Cheerio boxes in real-world images
    - **Key Challenge:** Evaluate the synthetic-to-real performance gap

Test case:
Synthetic to Real Object Detection



Test case:
Synthetic to Real Object Detection



Row ID	S img_id	D x_center	D y_center	D width	D height
Row0	000000003	0.425	0.433	0.211	0.468
Row1	000000004	0.617	0.647	0.119	0.13
Row2	000000008	0.377	0.528	0.086	0.212
Row3	000000010	0.227	0.519	0.263	0.366
Row4	000000013	0.533	0.477	0.223	0.174
Row5	000000014	0.472	0.454	0.067	0.342
Row6	000000014	0.992	0.4	0.016	0.08
Row7	000000019	0.503	0.514	0.094	0.182
Row8	000000020	0.514	0.316	0.113	0.343
Row9	000000022	0.582	0.137	0.059	0.26
Row10	000000024	0.504	0.656	0.15	0.526
Row11	000000025	0.521	0.296	0.181	0.35
Row12	000000026	0.57	0.111	0.086	0.223
Row13	000000026	0.57	0.064	0.085	0.128

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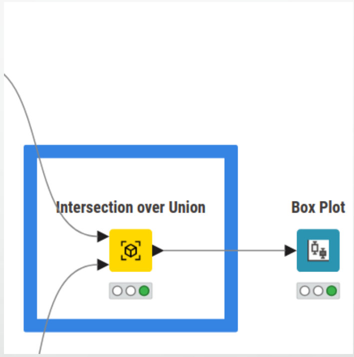

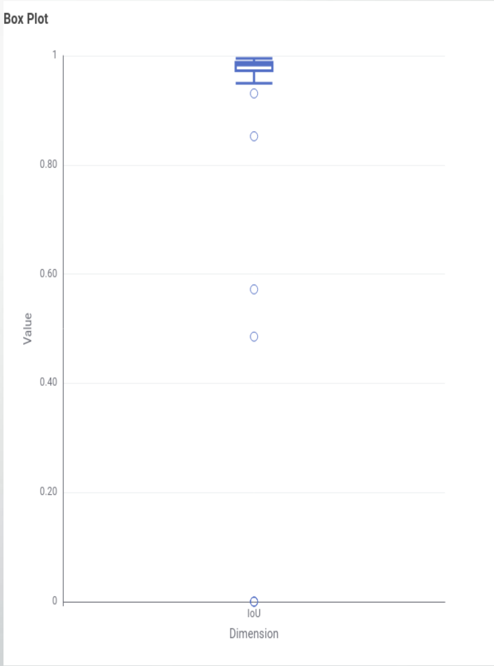

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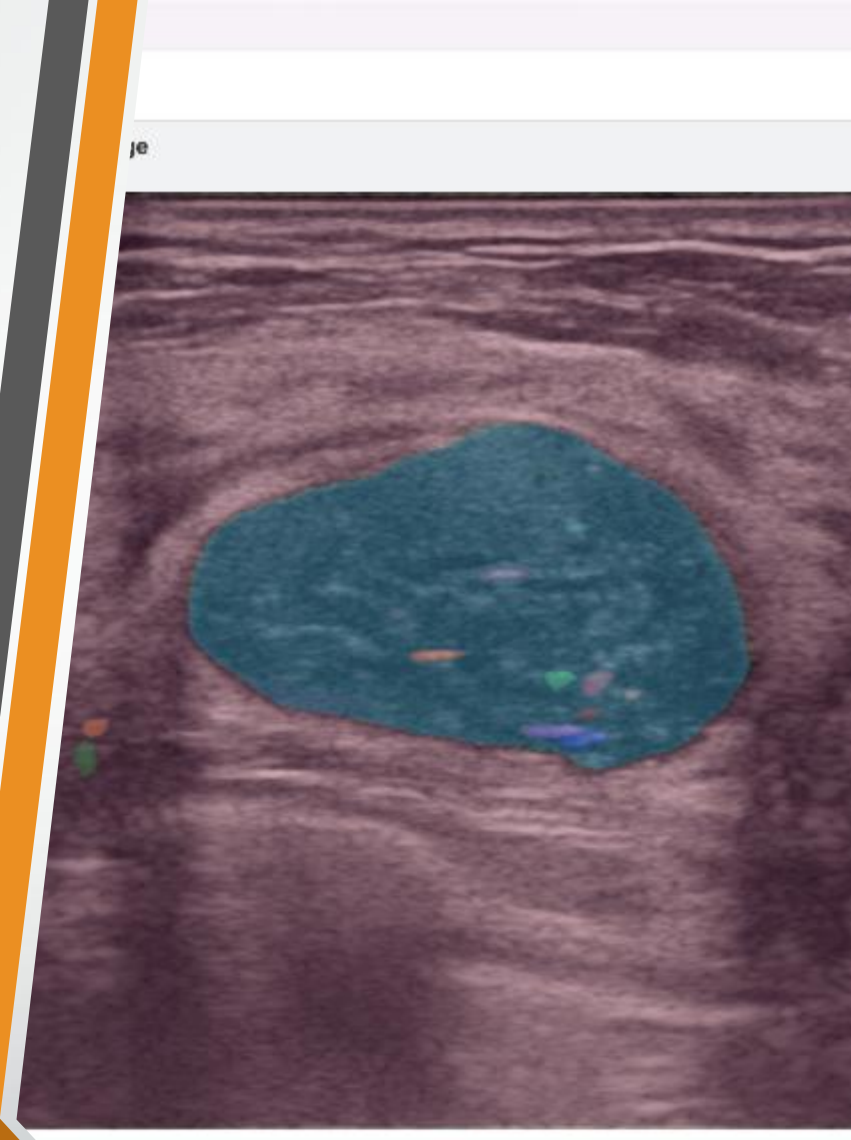
Current status
of development of nodes
DEMO 2

- **SAM**

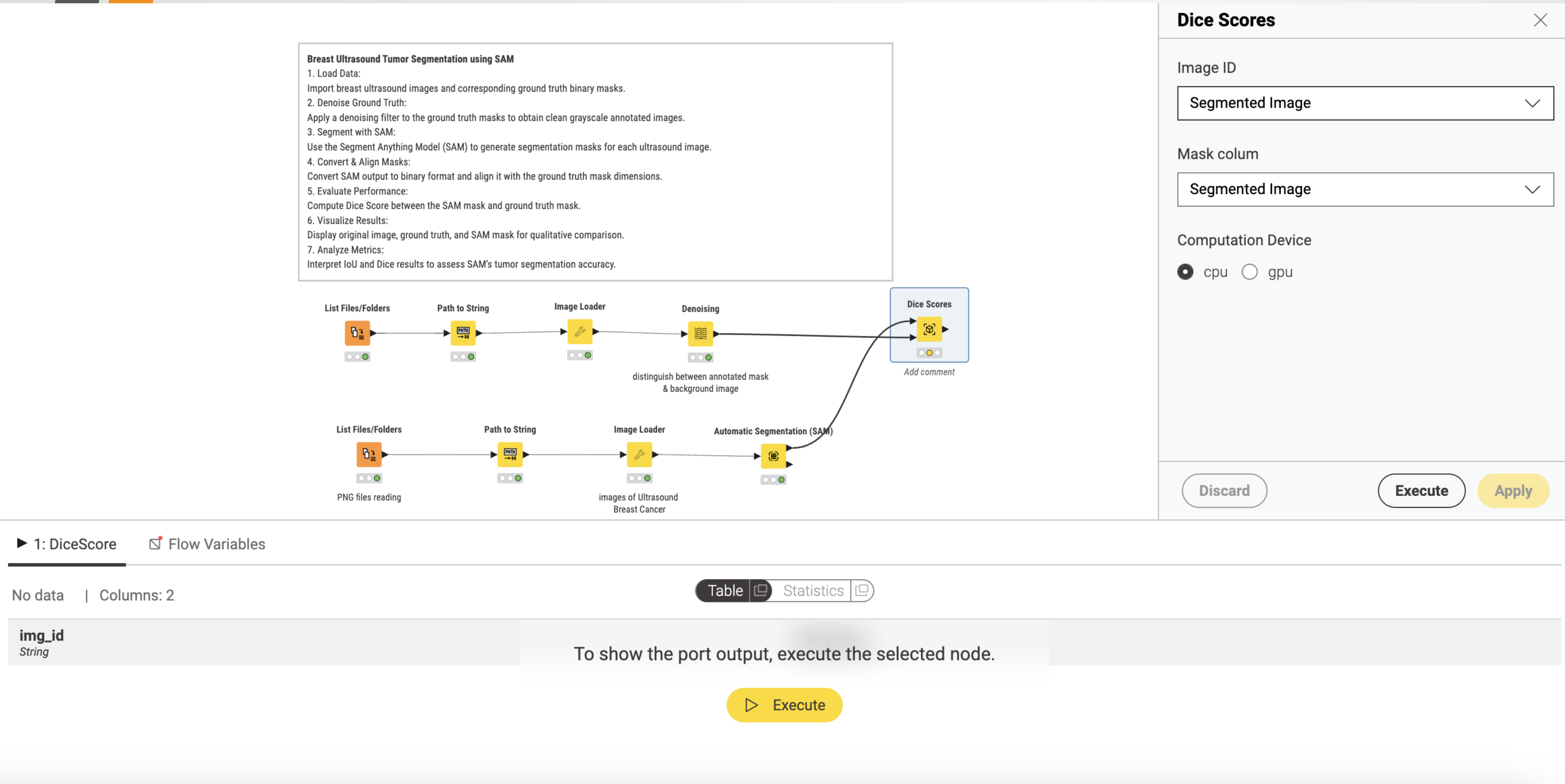
Ma, J., He, Y., Li, F. et al. Segment anything in medical images. Nat Commun 15, 654 (2024). https://doi.org/10.1038/s41467-024-44824-z

Biomedical images

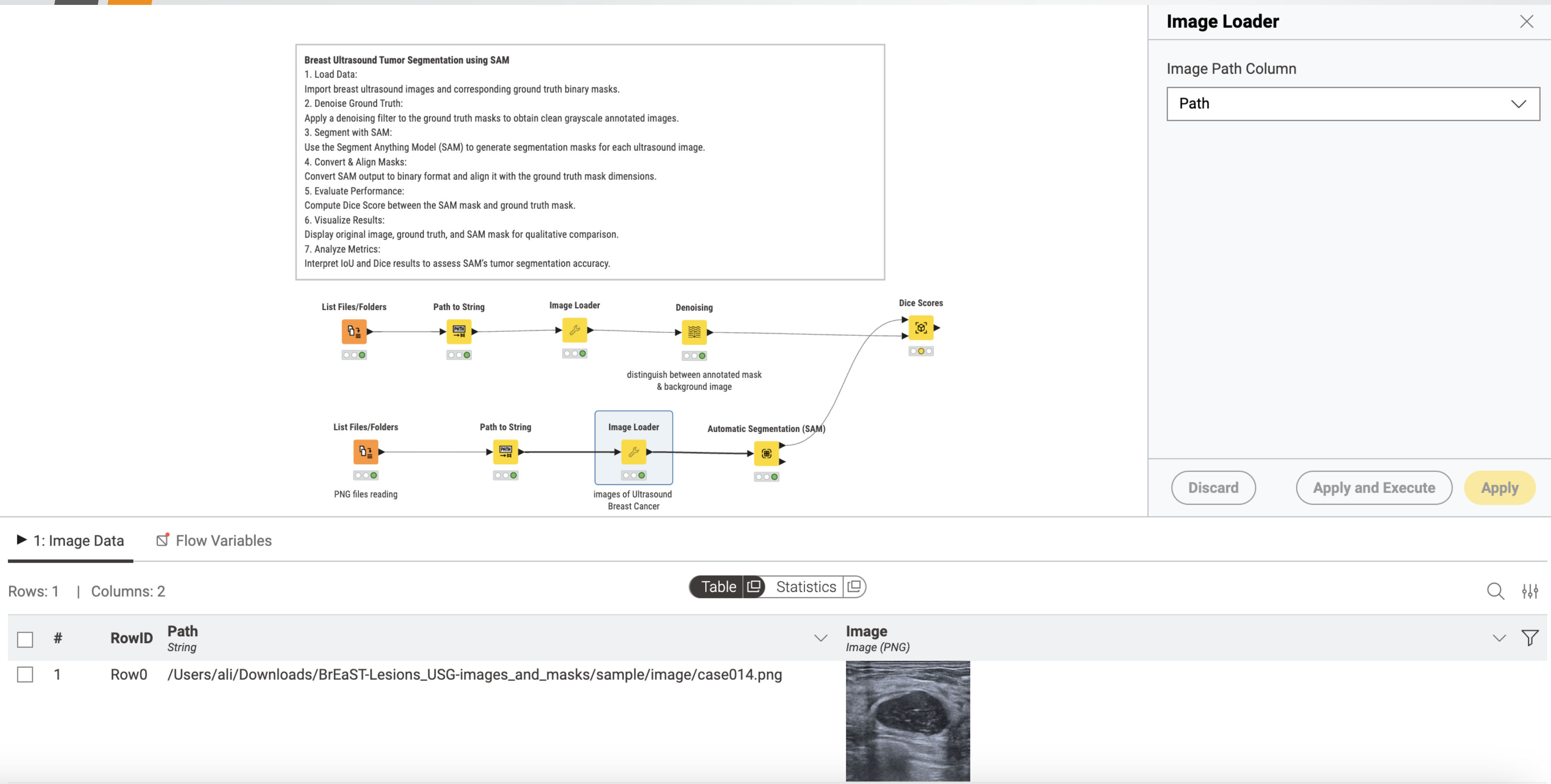
https://www.kaggle.com/code/orvile/breast-lesions-usg-seperation



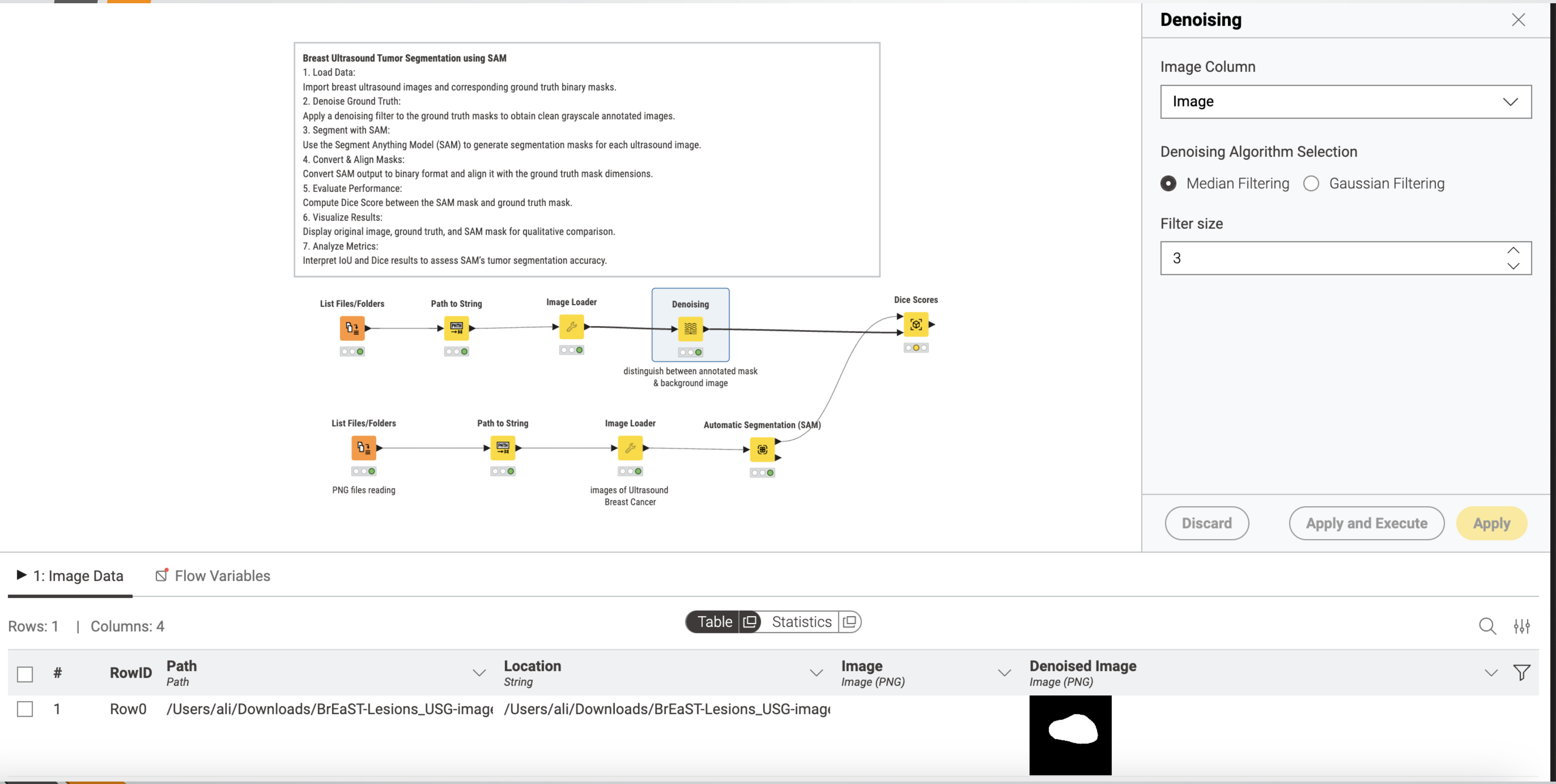
SAM segmentation



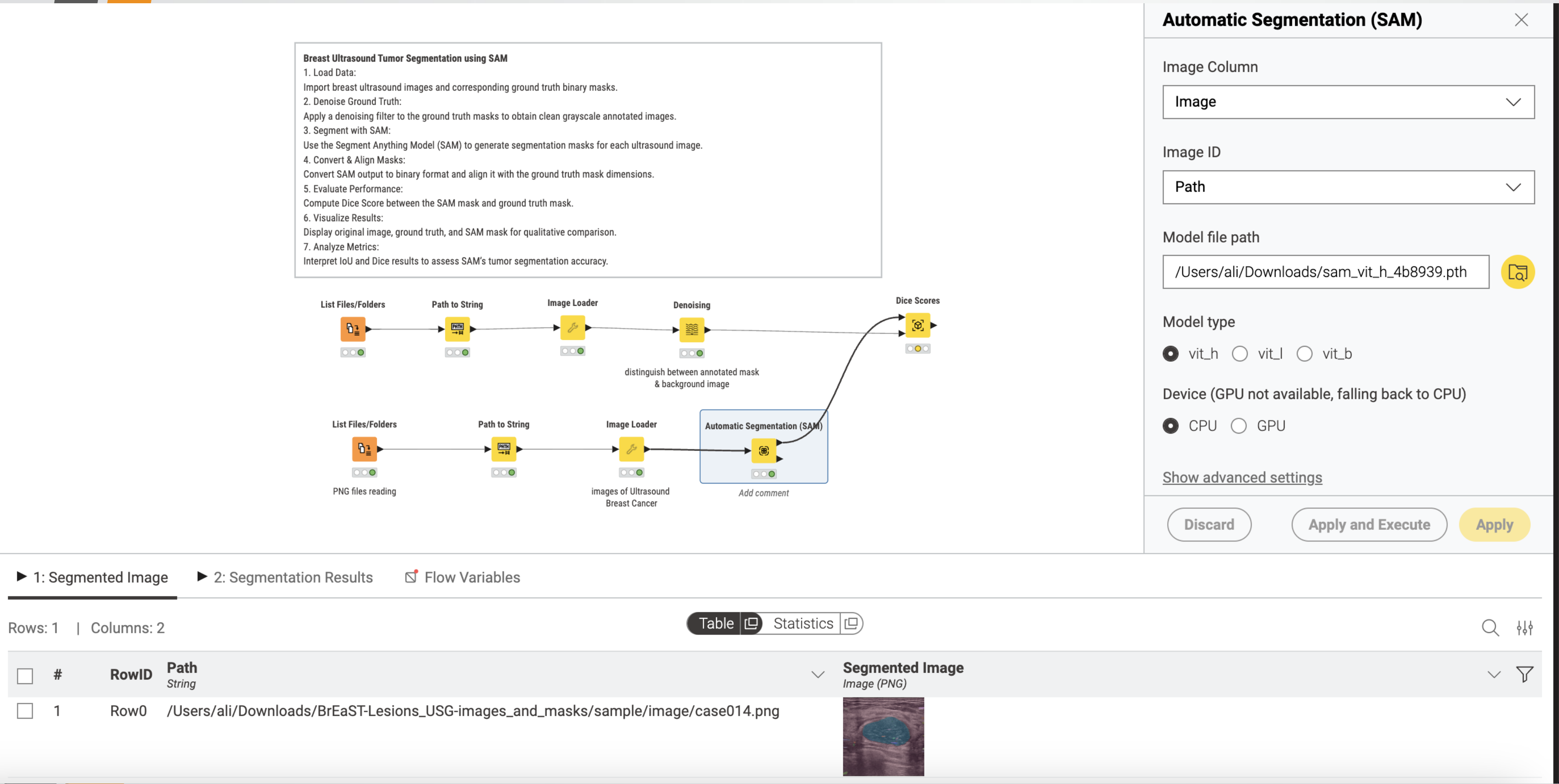
SAM segmentation



SAM segmentation



SAM segmentation



Thank you!

- **KNIMEVizLab**

Prof. Giuseppe Di Fatta, Dr. Andrea Rosani,

Dr. Thomas Borsani, Dr. Ali Bhatti

- Contact: andrea.rosani@unibz.it
- https://github.com/unibzMLgroup/KNIMEvis