

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,

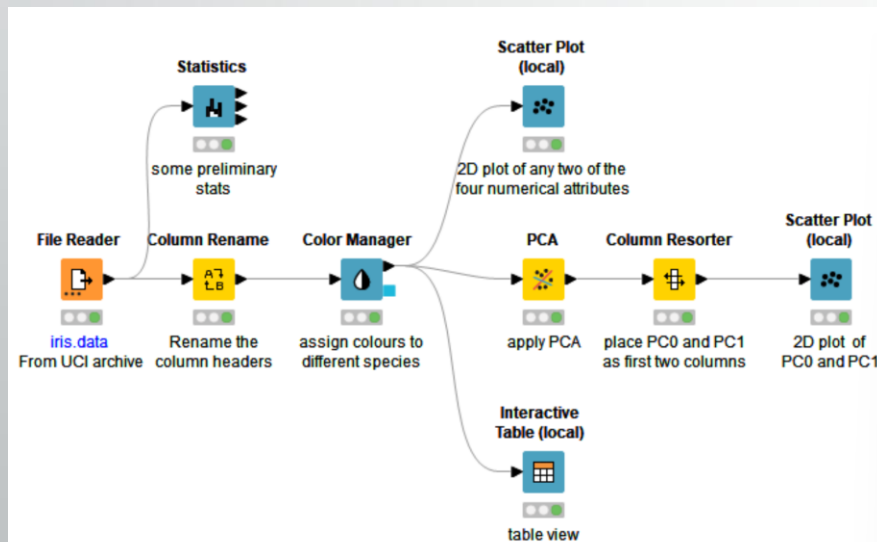
Dr. Thomas Borsani, Dr. Ali Bhatti



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)

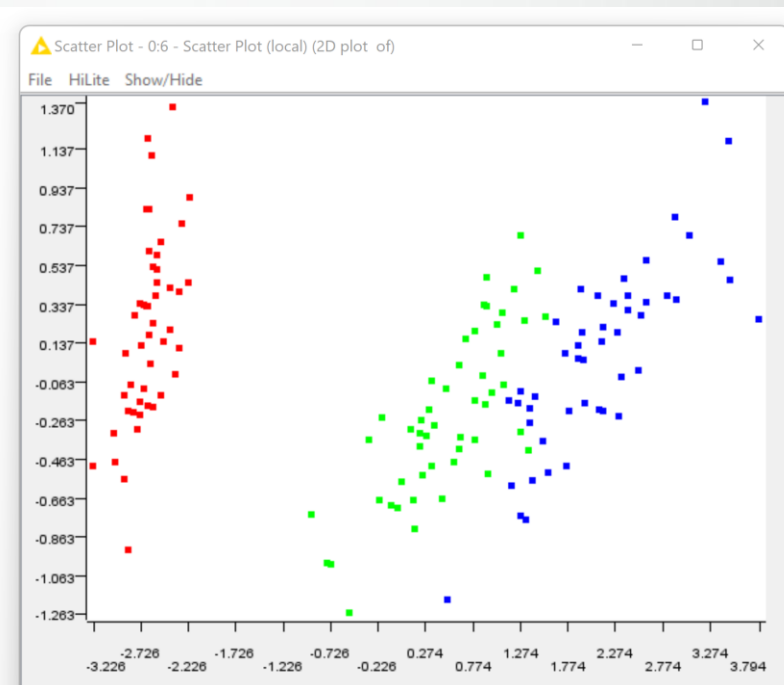


Image processing – ML pipeline

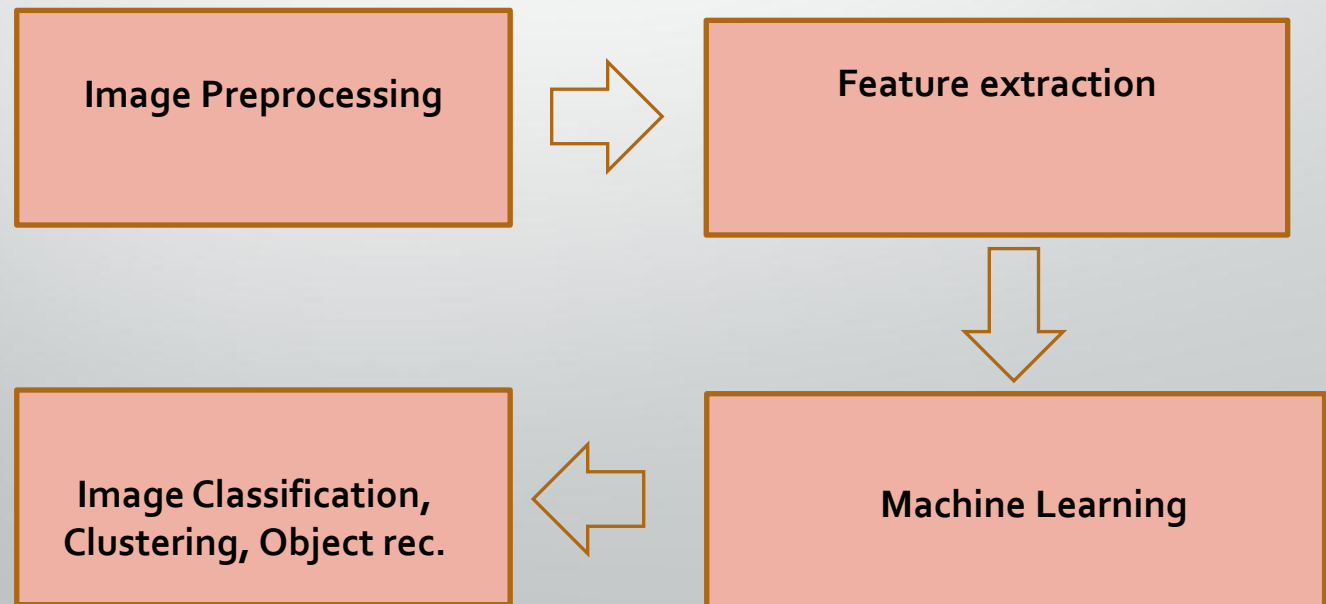
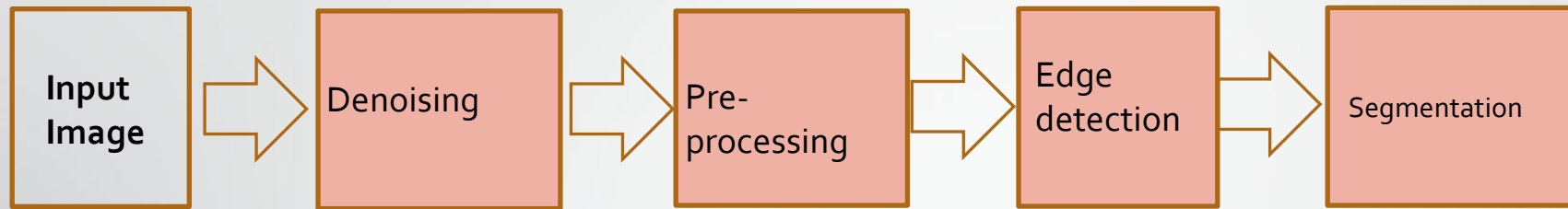
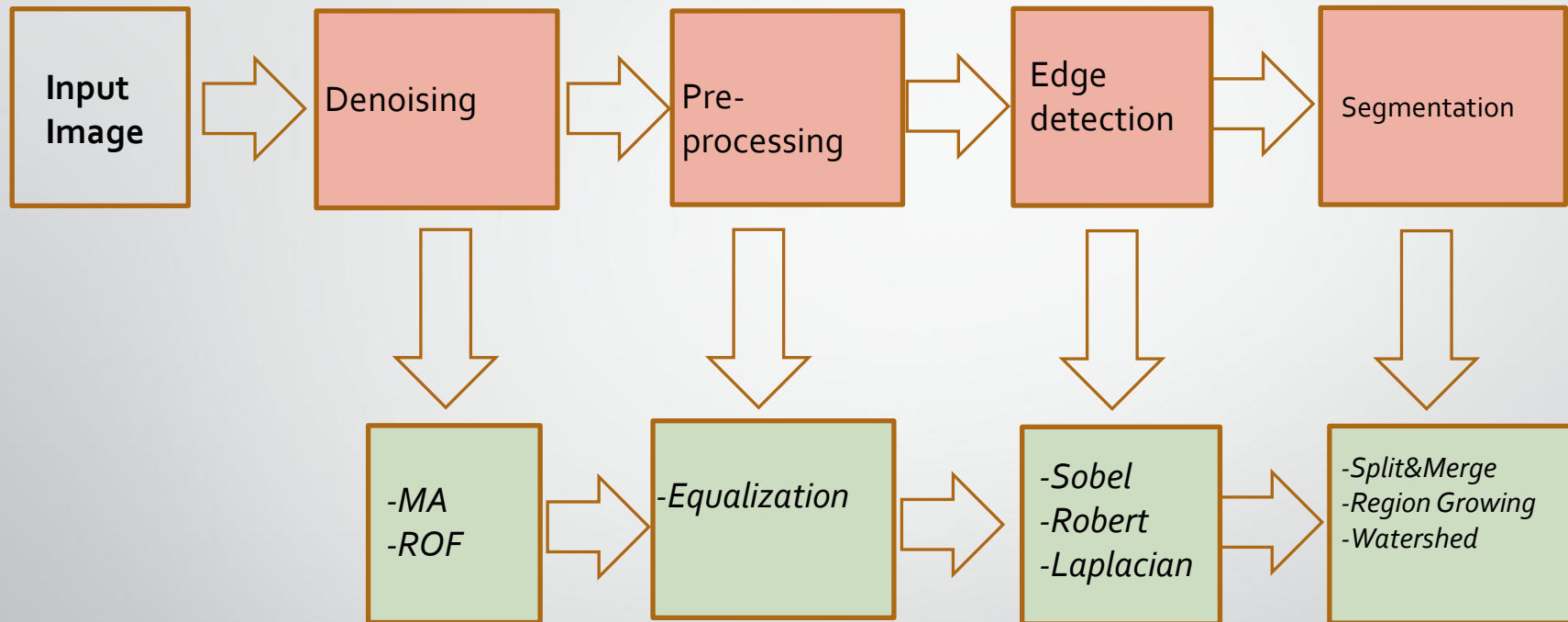


Image processing – ML pipeline



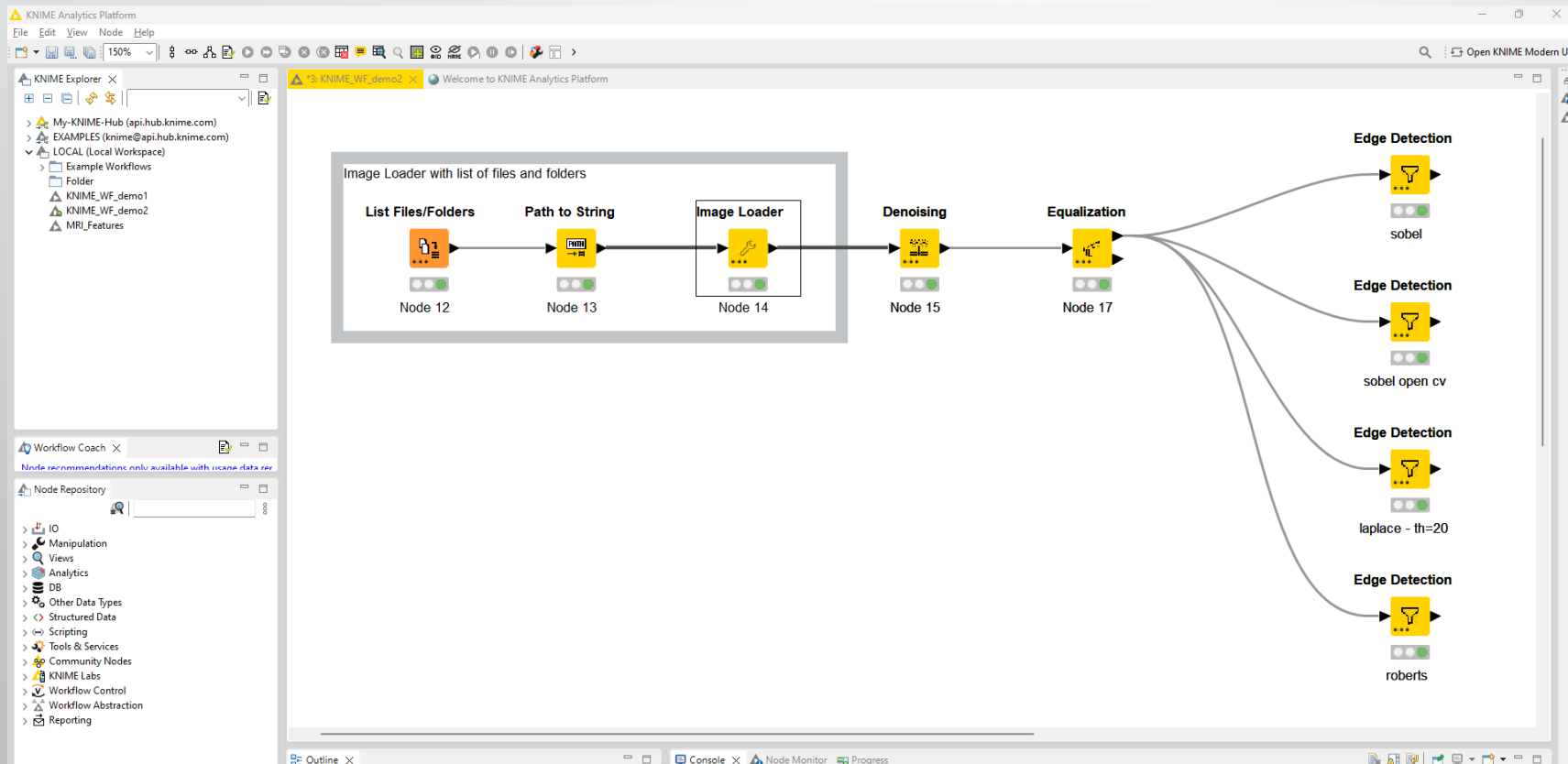
Current status of development of nodes

- 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



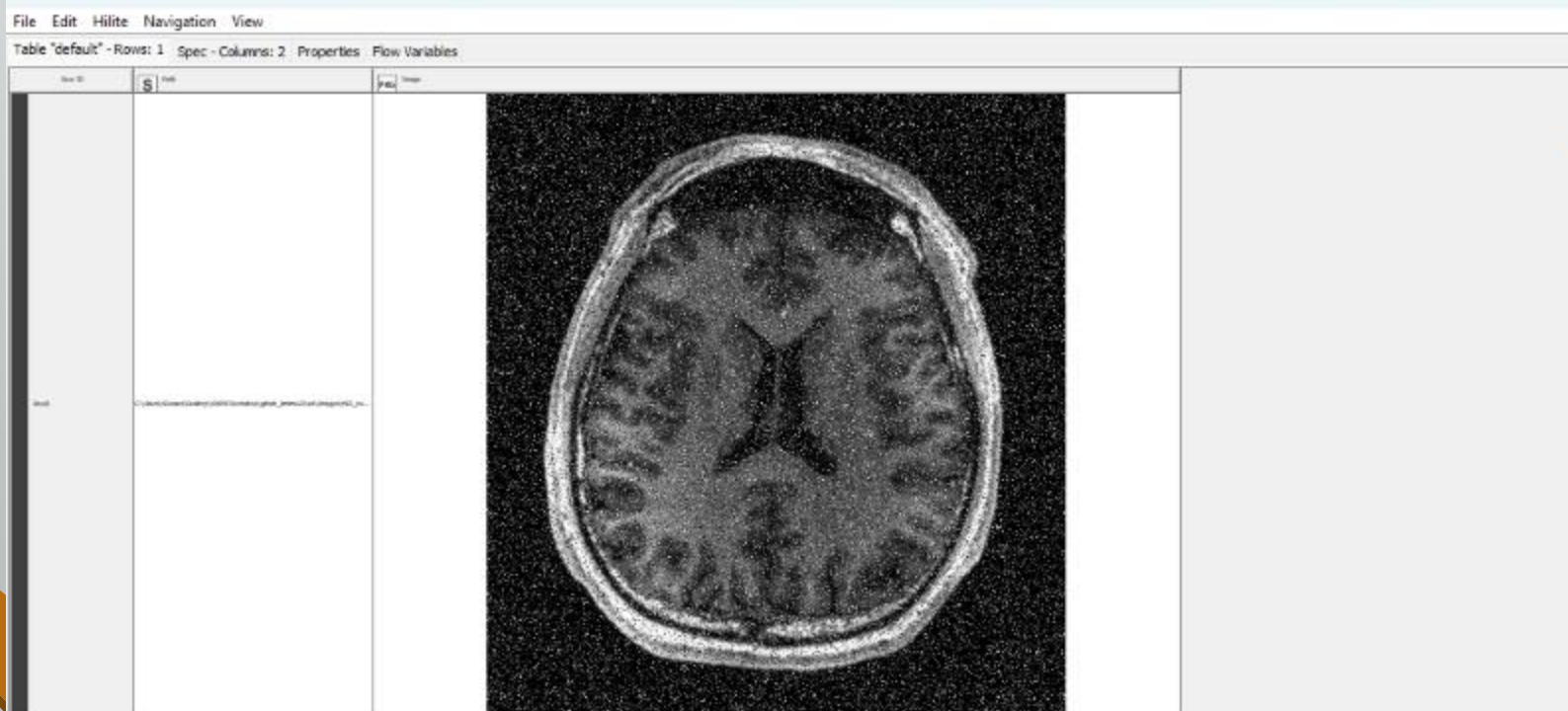
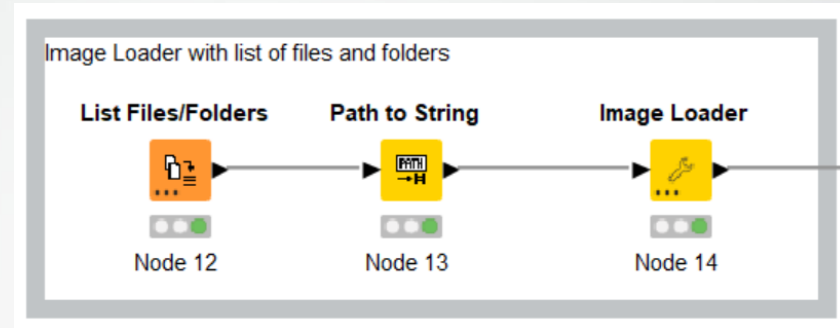
Open to new
collaborations!

Current status of development of nodes

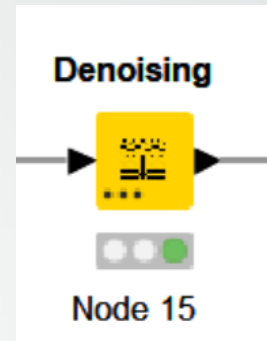


Current status of development of nodes

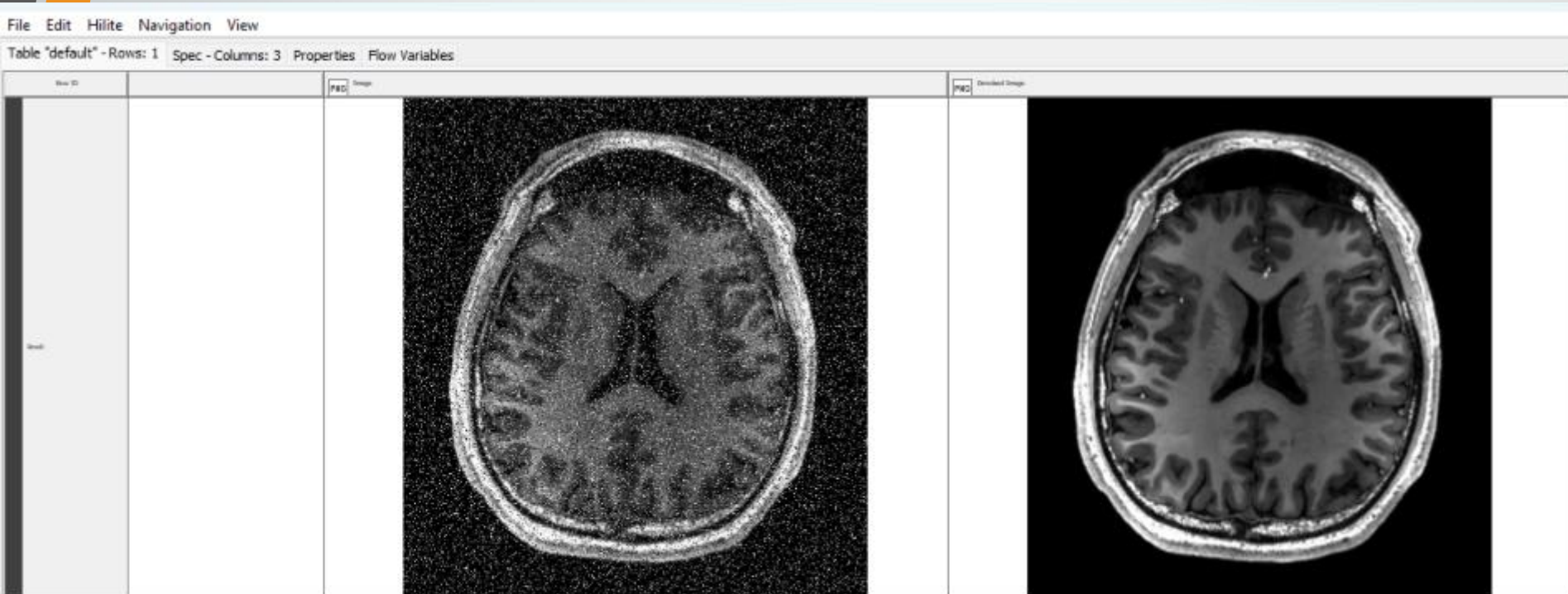
- I/O
 - Image loader
 - JPEG, PNG input file format
 - only PNG output port



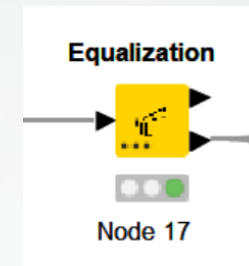
Current status of development of nodes



- Denoising (sequential and multithread algorithms)
 - Gaussian and Median Filters



Current status of development of nodes

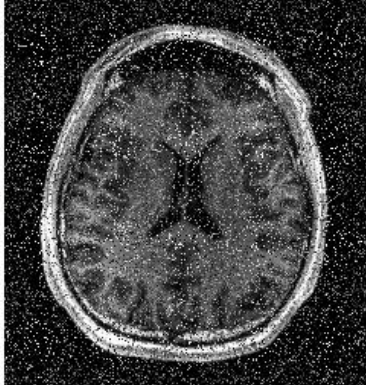
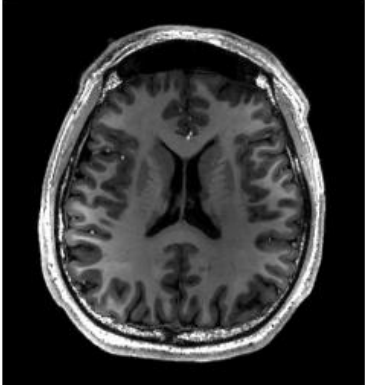
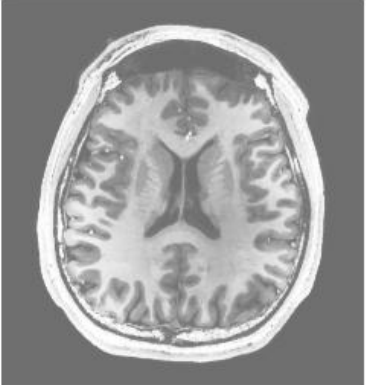


- Preprocessing
 - Equalization

Equalized Image - 3:17 - Equalization

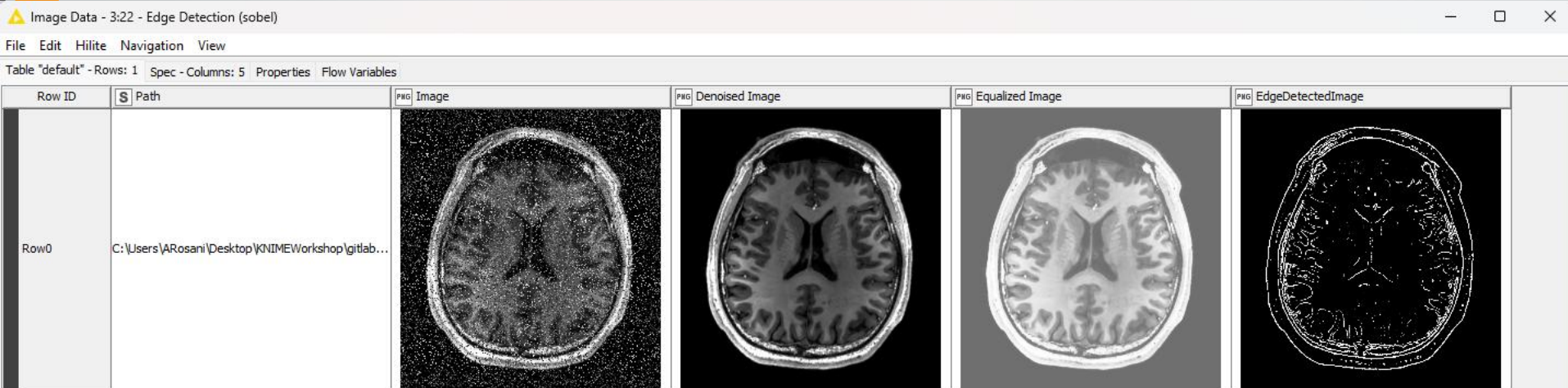
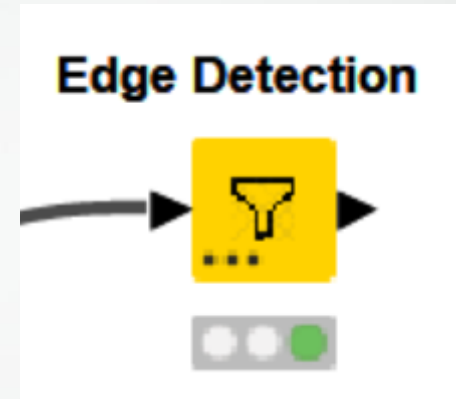
File Edit Hilite Navigation View

Table "default" - Rows: 1 Spec - Columns: 4 Properties Flow Variables

Row ID	S Path	PRG Image	PRG Denoised Image	PRG Equalized Image
Row0	C:\Users\ARosani\Desktop\KNIMEWorkshop\gitlab...			

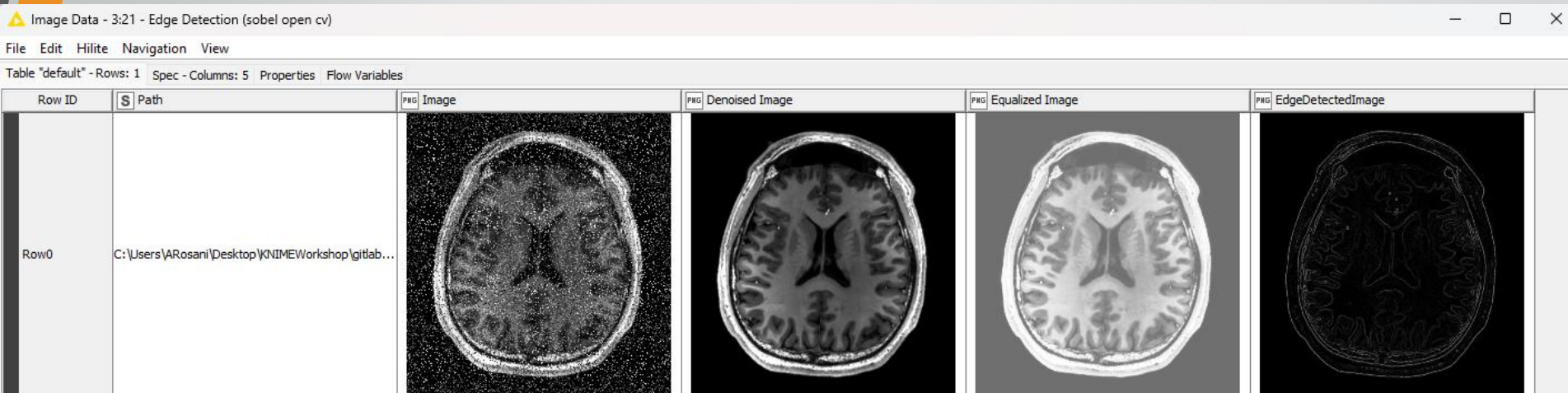
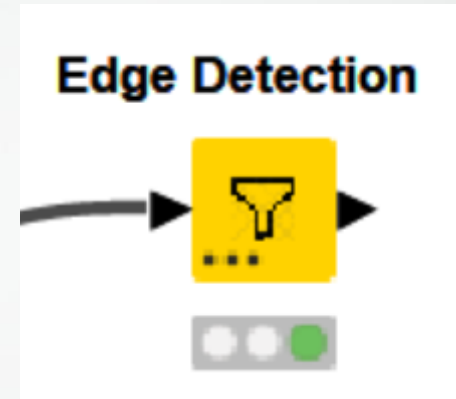
Current status of development of nodes

- Edge detection
 - Sobel (naïve implementation)



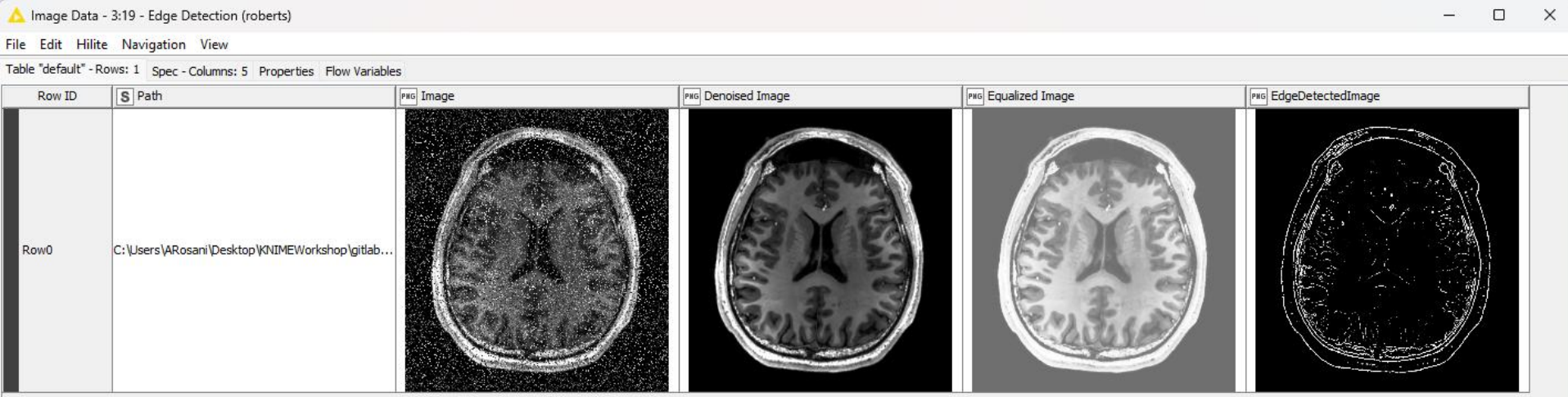
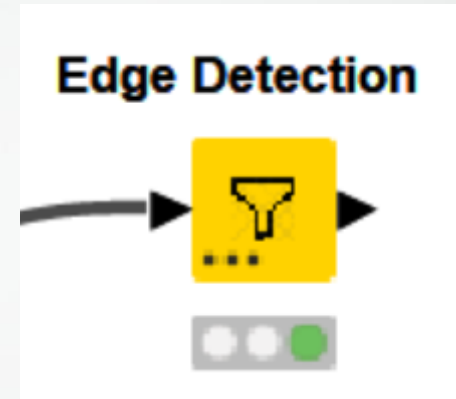
Current status of development of nodes

- Edge detection
 - Sobel (openCV)



Current status of development of nodes

- Edge detection
 - Roberts



Current status of development of nodes

- Edge detection
 - Laplacian

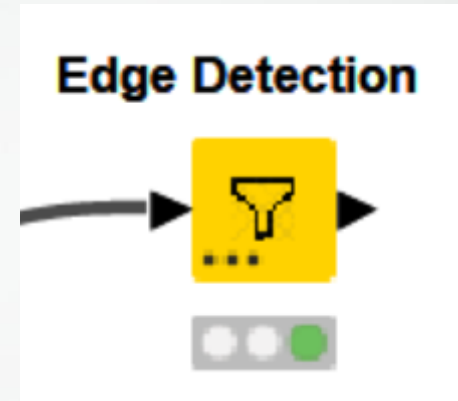
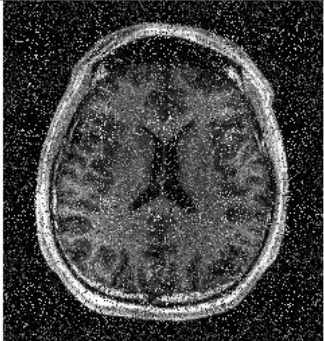
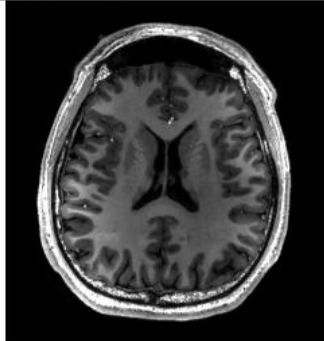
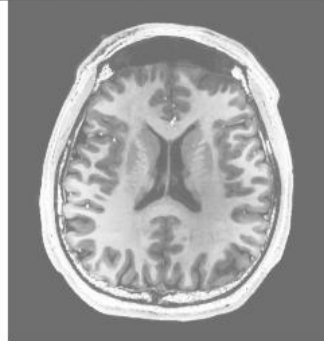
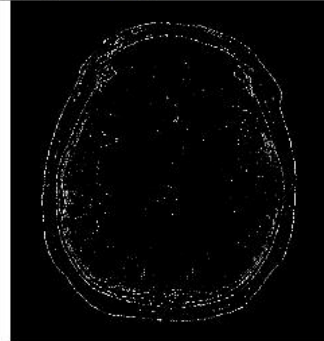


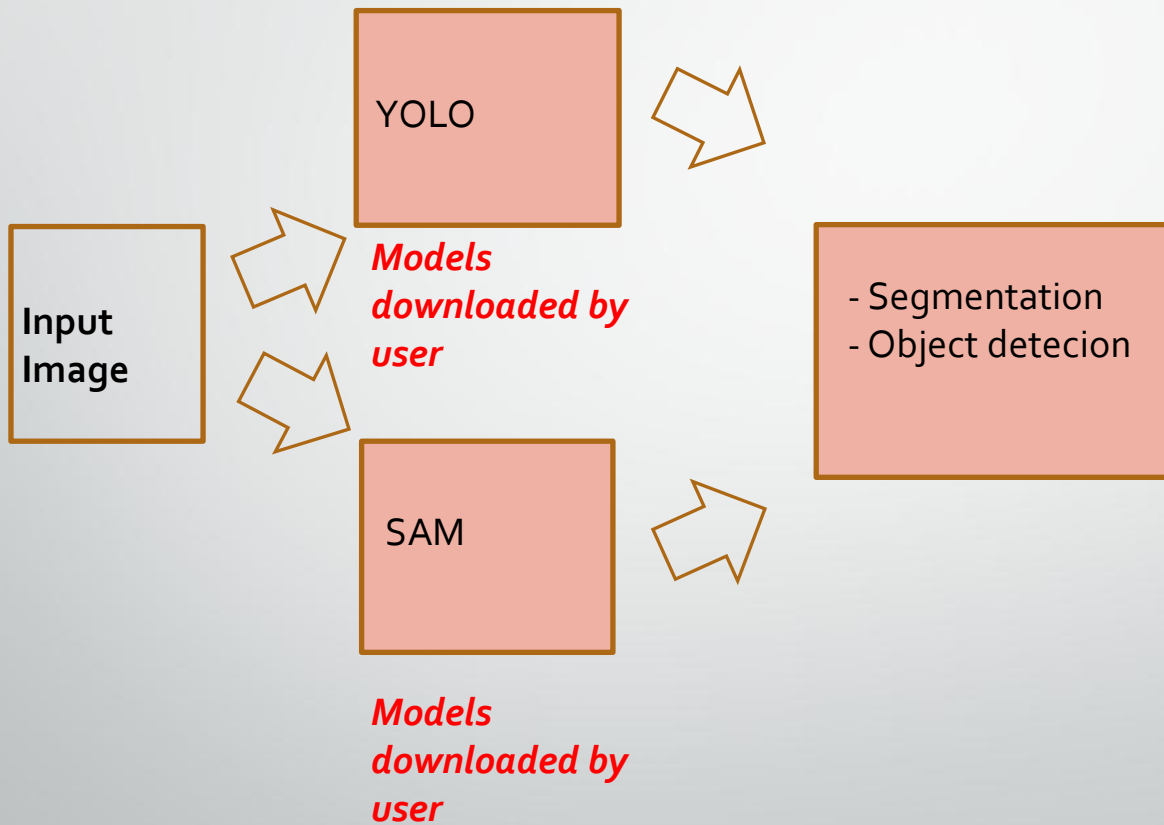
Image Data - 3:20 - Edge Detection (laplace - th=20)

File Edit Hilite Navigation View

Table "default" - Rows: 1 Spec - Columns: 5 Properties Flow Variables

Row ID	Path	Image	Denosed Image	Equalized Image	EdgeDetectedImage
Row0	C:\Users\ARosani\Desktop\KNIMEWorkshop\gitlab...				

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)

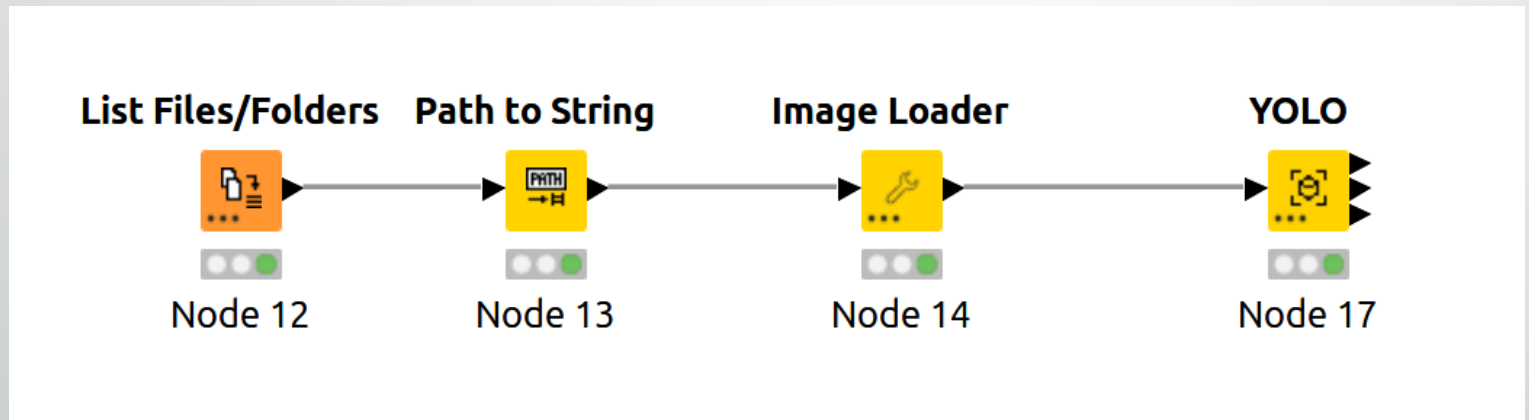
Current status of development of nodes DEMO 1

- **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



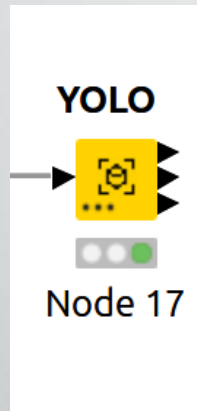
YOLO segmentation

Input Image



YOLO segmentation

Image output



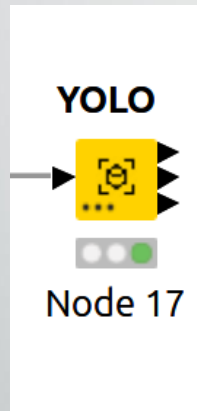
YOLO segmentation

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

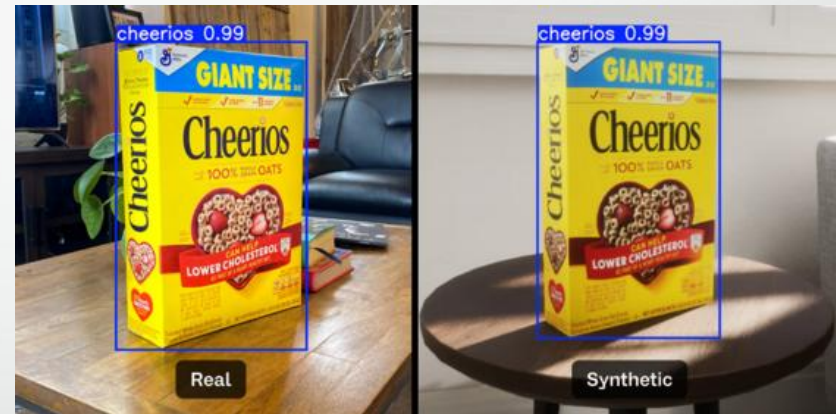
Segmentation mask output table

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	[0.3655884265899658,0.620833373069763,0.36558842658996...
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...

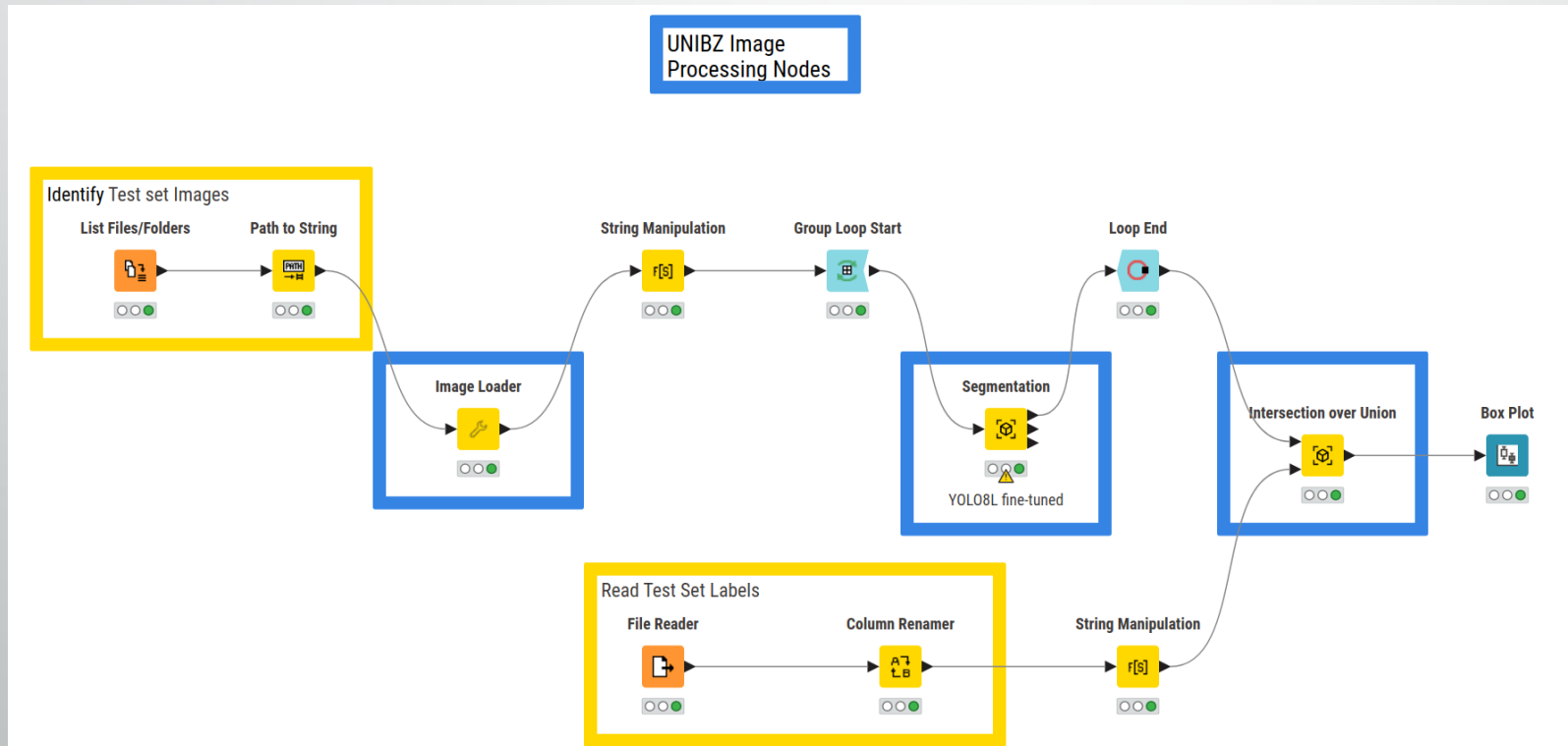


Test case: Synthetic to Real Object Detection

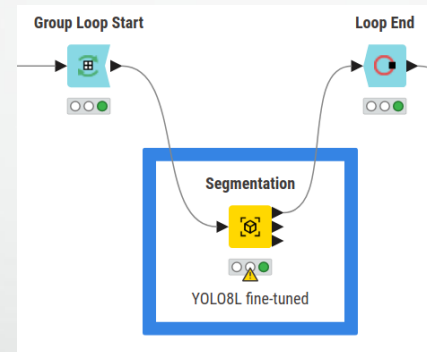
- **Motivation:**
 - **Synthetic data promises:**
 - Cost-effectiveness
 - Scalability
 - Reduced bias
 - **BUT:** Synthetic-Trained Models Often Fail in Real-World Conditions
- **Objective:**
 - **Training Phase**
 - Dataset:** 100% Synthetic Data
 - Goal:** Train an object detection model to identify 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

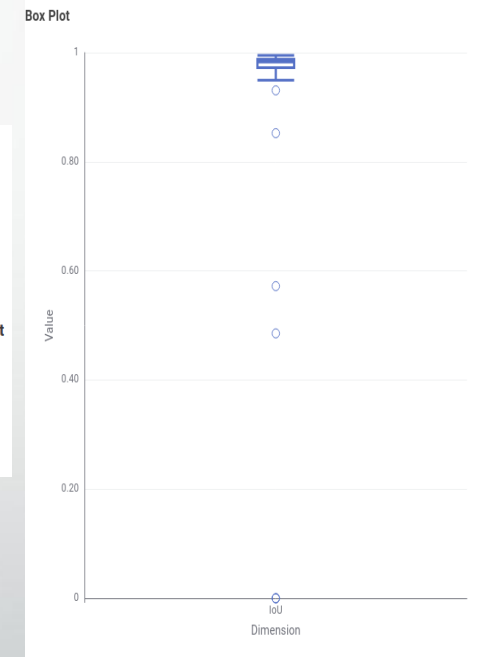
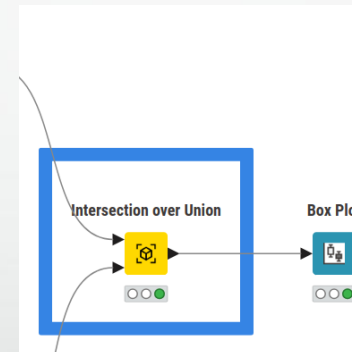


Row ID	S img_id	D x_center	D y_center	D width	D height
Row0	000000003	0.425	0.433	0.211	0.468
Row1	000000004	0.617	0.647	0.119	0.13
Row2	000000008	0.377	0.528	0.086	0.212
Row3	000000010	0.227	0.519	0.263	0.366
Row4	000000013	0.533	0.477	0.223	0.174
Row5	000000014	0.472	0.454	0.067	0.342
Row6	000000014	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

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
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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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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



Current status of development of nodes DEMO 2

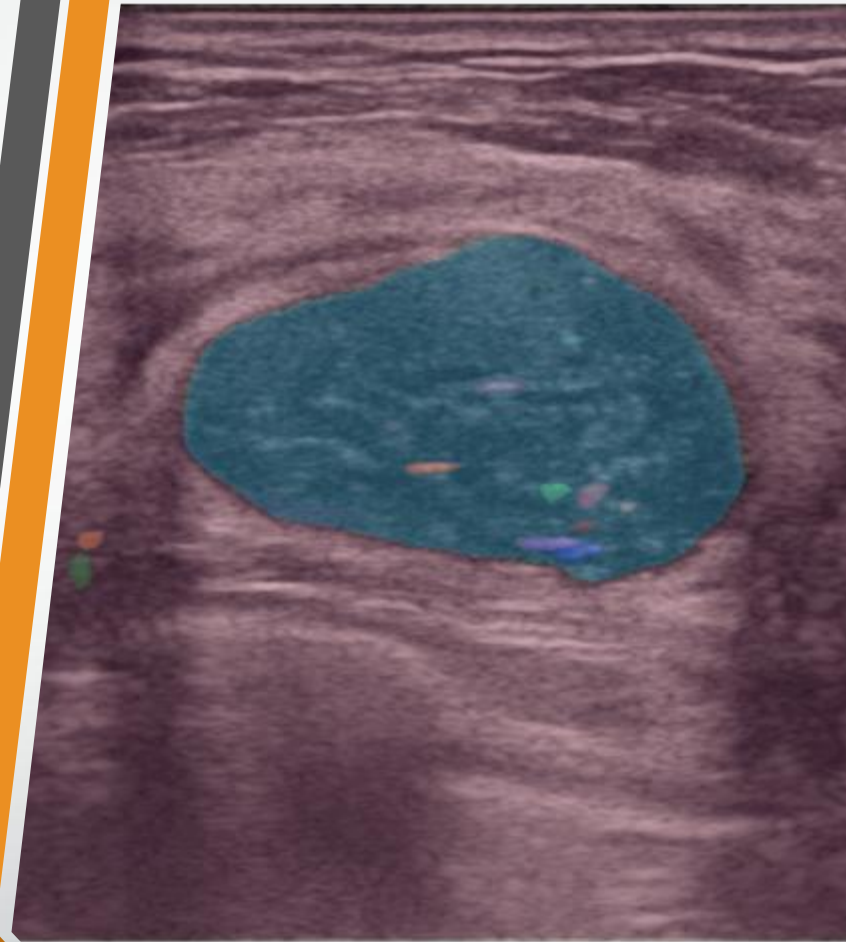
- **SAM**

Ma, J., He, Y., Li, F. et al. Segment anything in medical images. Nat Commun 15, 654 (2024).

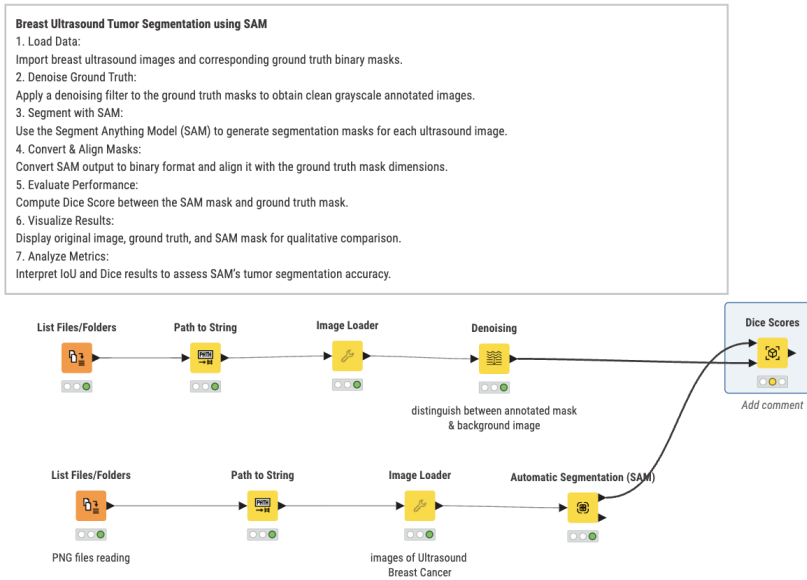
<https://doi.org/10.1038/s41467-024-44824-z>

Biomedical images

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



SAM segmentation



Dice Scores

Image ID
Segmented Image

Mask column
Segmented Image

Computation Device
☒ cpu ☐ gpu

Discard Execute Apply

► 1: DiceScore Flow Variables

No data | Columns: 2

Table Statistics

img_id
String

To show the port output, execute the selected node.

Execute

SAM segmentation

Breast Ultrasound Tumor Segmentation using SAM

1. Load Data:
Import breast ultrasound images and corresponding ground truth binary masks.
2. Denoise Ground Truth:
Apply a denoising filter to the ground truth masks to obtain clean grayscale annotated images.
3. Segment with SAM:
Use the Segment Anything Model (SAM) to generate segmentation masks for each ultrasound image.
4. Convert & Align Masks:
Convert SAM output to binary format and align it with the ground truth mask dimensions.
5. Evaluate Performance:
Compute Dice Score between the SAM mask and ground truth mask.
6. Visualize Results:
Display original image, ground truth, and SAM mask for qualitative comparison.
7. Analyze Metrics:
Interpret IoU and Dice results to assess SAM's tumor segmentation accuracy.

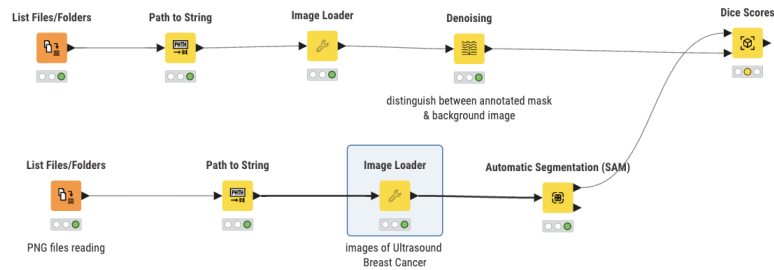


Image Loader

Image Path Column

Path

Discard

Apply and Execute

Apply

► 1: Image Data

Flow Variables

Rows: 1 | Columns: 2

Table

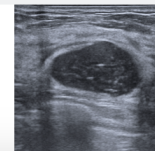


Statistics



☐	#	RowID	Path String
☐	1	Row0	/Users/ali/Downloads/BrEaST-Lesions_USG-images_and_masks/sample/image/case014.png

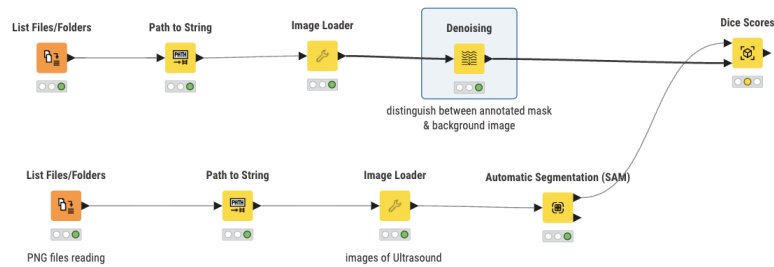
Image
Image (PNG)



SAM segmentation

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Interpret IoU and Dice results to assess SAM's tumor segmentation accuracy.



Denoising

Image Column

Image

Denoising Algorithm Selection

☒ Median Filtering ☐ Gaussian Filtering

Filter size

3

Discard

Apply and Execute

Apply

► 1: Image Data

Rows: 1 | Columns: 4

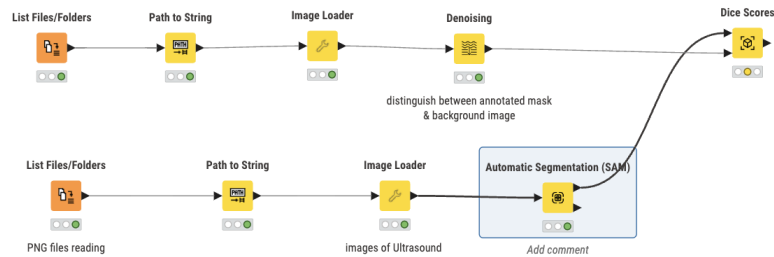
Table Statistics

☐	#	RowID	Path Path	Location String	Image Image (PNG)	Denoised Image Image (PNG)	
☐	1	Row0	/Users/ali/Downloads/BrEaST-Lesions_USG-image	/Users/ali/Downloads/BrEaST-Lesions_USG-image			

SAM segmentation

Breast Ultrasound Tumor Segmentation using SAM

1. Load Data:
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Interpret IoU and Dice results to assess SAM's tumor segmentation accuracy.



Automatic Segmentation (SAM)

Image Column

Image

Image ID

Path

Model file path

/Users/ali/Downloads/sam_vit_h_4b8939.pth

Model type

☒ vit_h ☐ vit_l ☐ vit_b

Device (GPU not available, falling back to CPU)

☒ CPU ☐ GPU

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Discard

Apply and Execute

Apply

► 1: Segmented Image ► 2: Segmentation Results Flow Variables

Rows: 1 | Columns: 2

Table Statistics

☐	#	RowID	Path String	Segmented Image Image (PNG)
☐	1	Row0	/Users/ali/Downloads/BrEaST-Lesions_USG-images_and_masks/sample/image/case014.png	

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>

