Gemelli

Fondazione Policlinico Universitario Agostino Gemelli IRCCS
Università Cattolica del Sacro Cuore

Future: Is pathology more than a specimen?

Konstantinos Zormpas-Petridis, Ph.D.

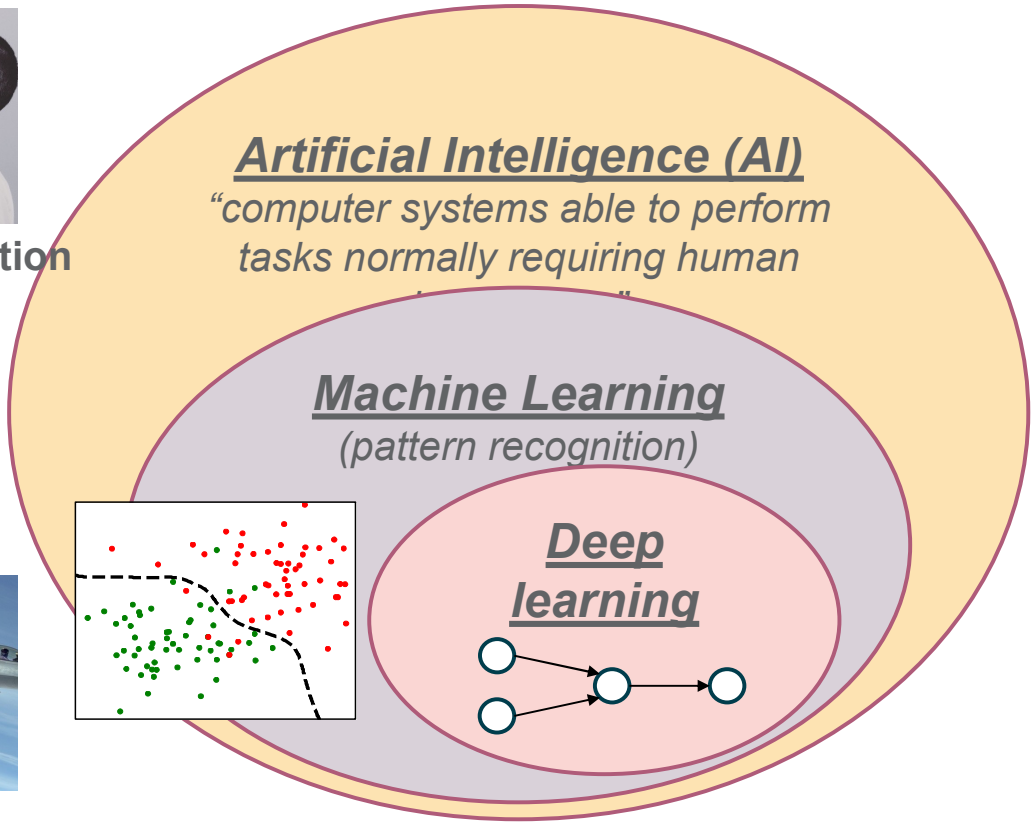
"Computational Pathology and Spatial-omics" Lab

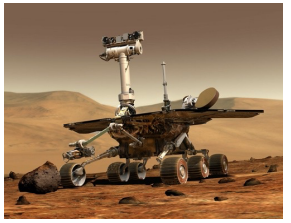
Artificial Intelligence

Speech Recognition

Finance

Aviation





Robotics

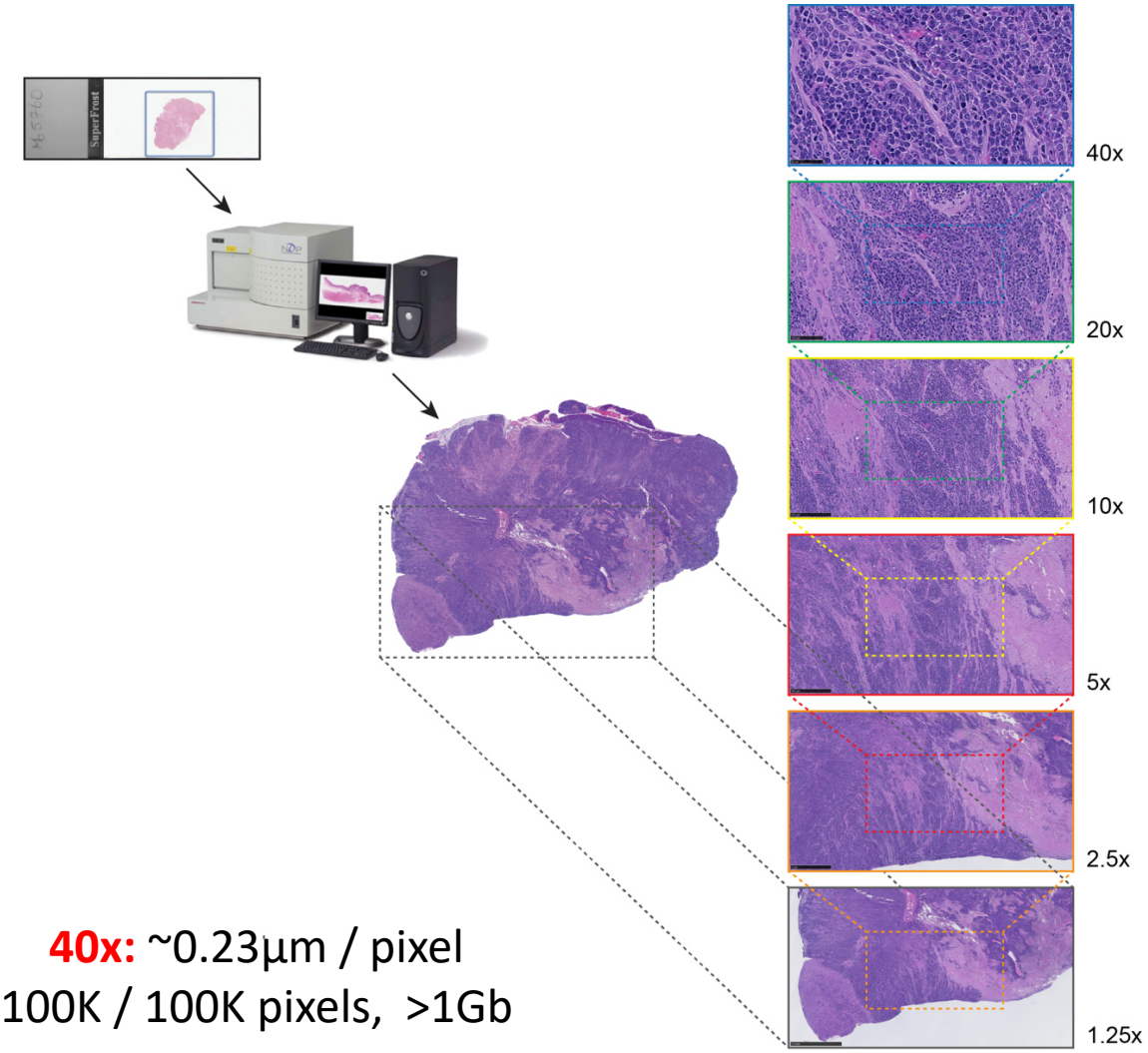
Navigation

Gaming

Courtesy of Dr. Matthew Blackledge

Digital Pathology

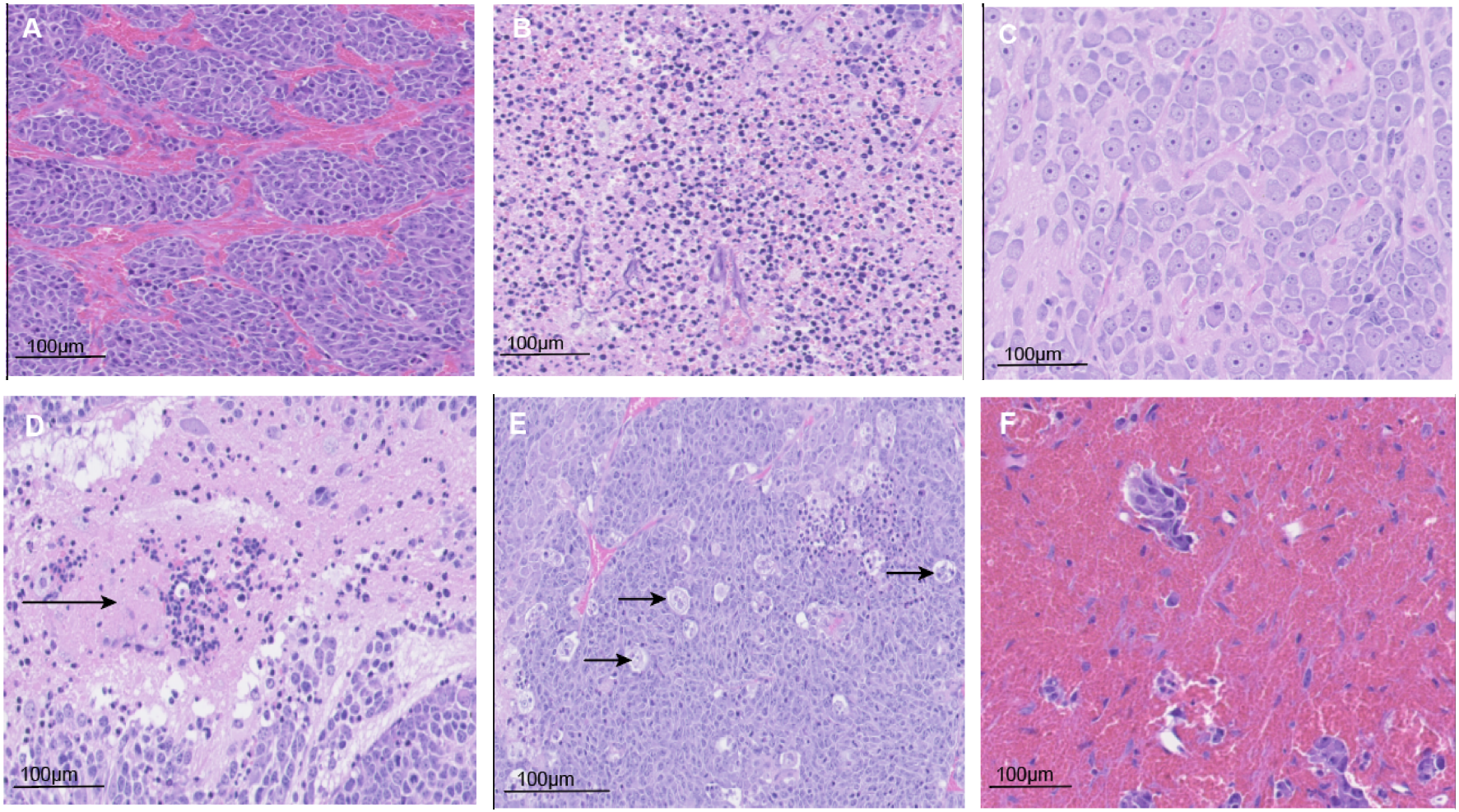
- Analysis of tissue samples under the microscope by pathologists – the “gold-standard” of cancer patient management
- Qualitative or semi-quantitative
- The new era of digital pathology
- Going forward: Full digitization
  e.g. The PathLAKE consortium



40x: ~0.23µm / pixel
100K / 100K pixels, >1Gb

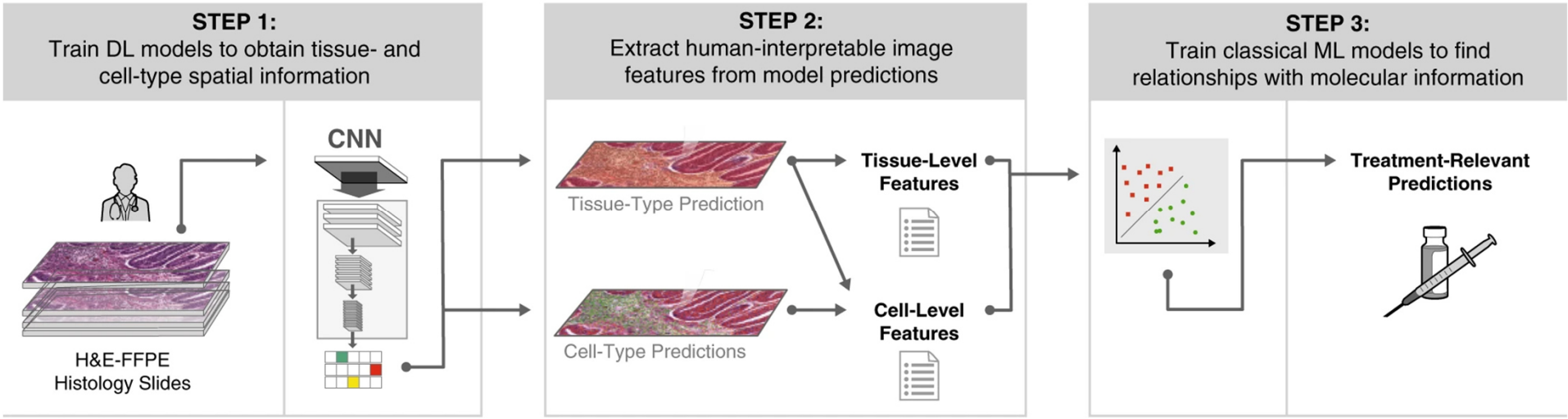
Digital Pathology – Sample heterogeneity

Pre-clinical Neuroblastoma (Th-*MYCN* transgenic mouse model)



Digital Pathology – Phenotypic quantification

A typical pipeline



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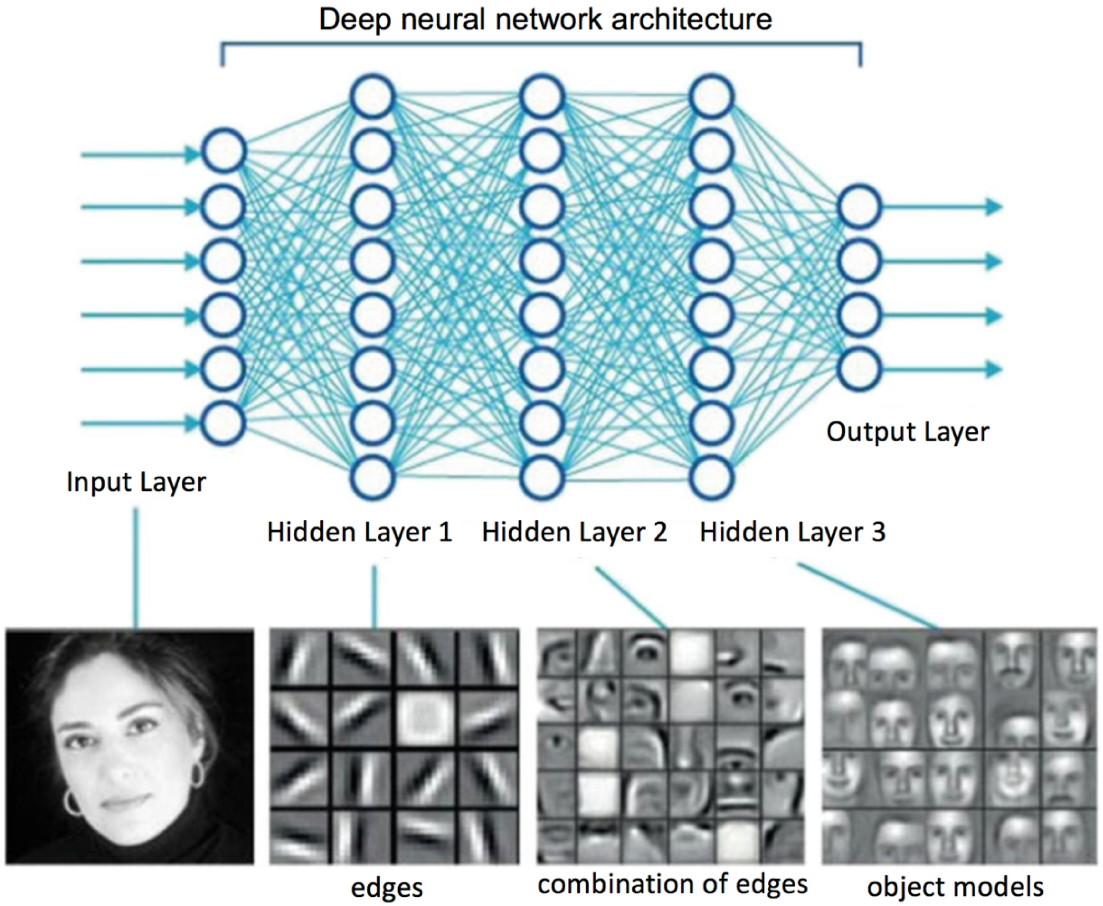
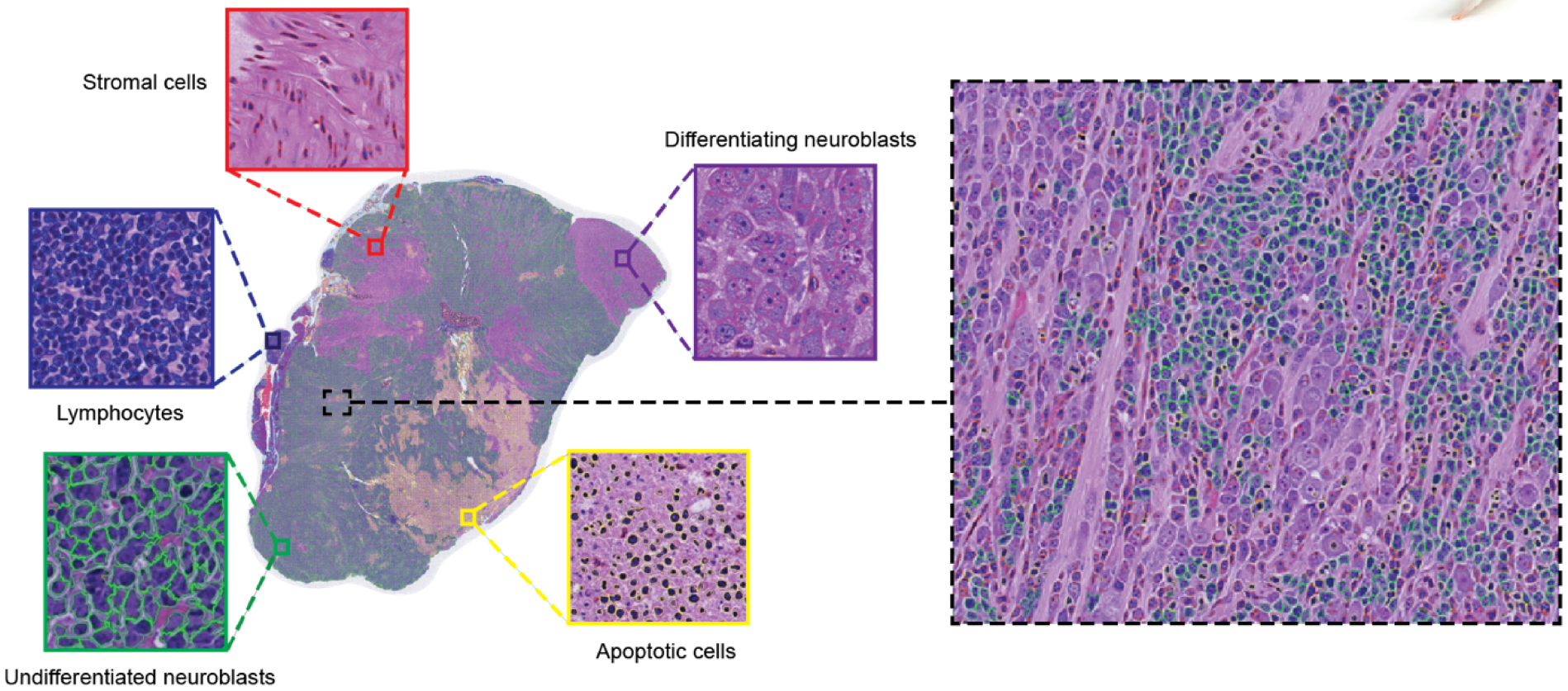
Deep learning – Computer Vision



Adapted from Artificial Intelligence in Medical Imaging: Opportunities, Applications and Risks

Digital Pathology – Phenotypic quantification

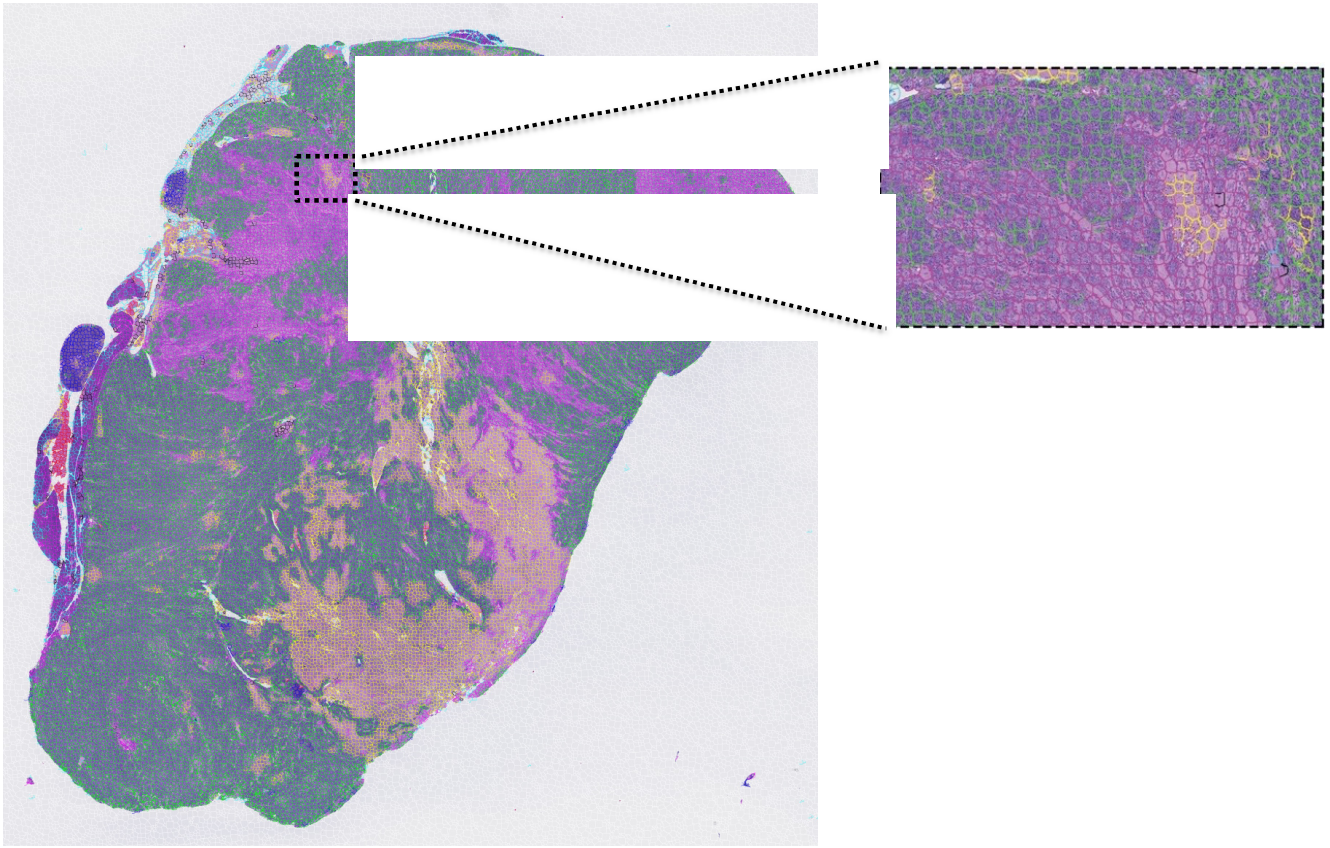
Cell segmentation / classification



Digital Pathology – Region / Tissue-level classification

Pre-clinical Neuroblastoma (Th-*MYCN* transgenic mouse model)

- Tumour
- Cell death
- Differentiation
- Blood
- Lymphocyte cluster
- Muscle
- Other



K. Zormpas-Petridis et al, Front. In Oncol. (2021)

Digital Pathology – Region / Tissue-level classification

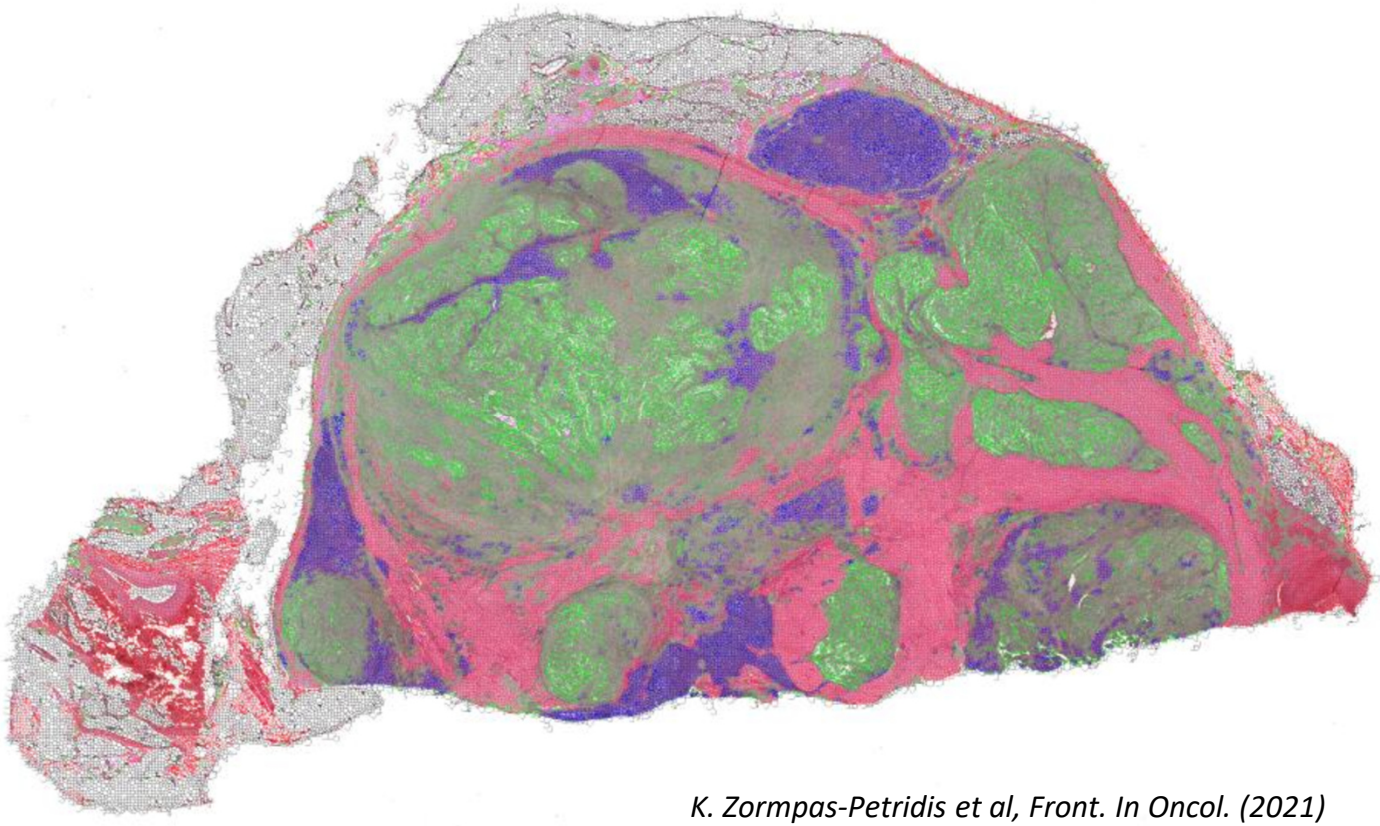
Melanoma

Tumour

Stroma

Lymphocyte cluster

Fat



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Digital Pathology – Region / Tissue-level classification

Melanoma

Tumour

Stroma

Lymphocyte cluster

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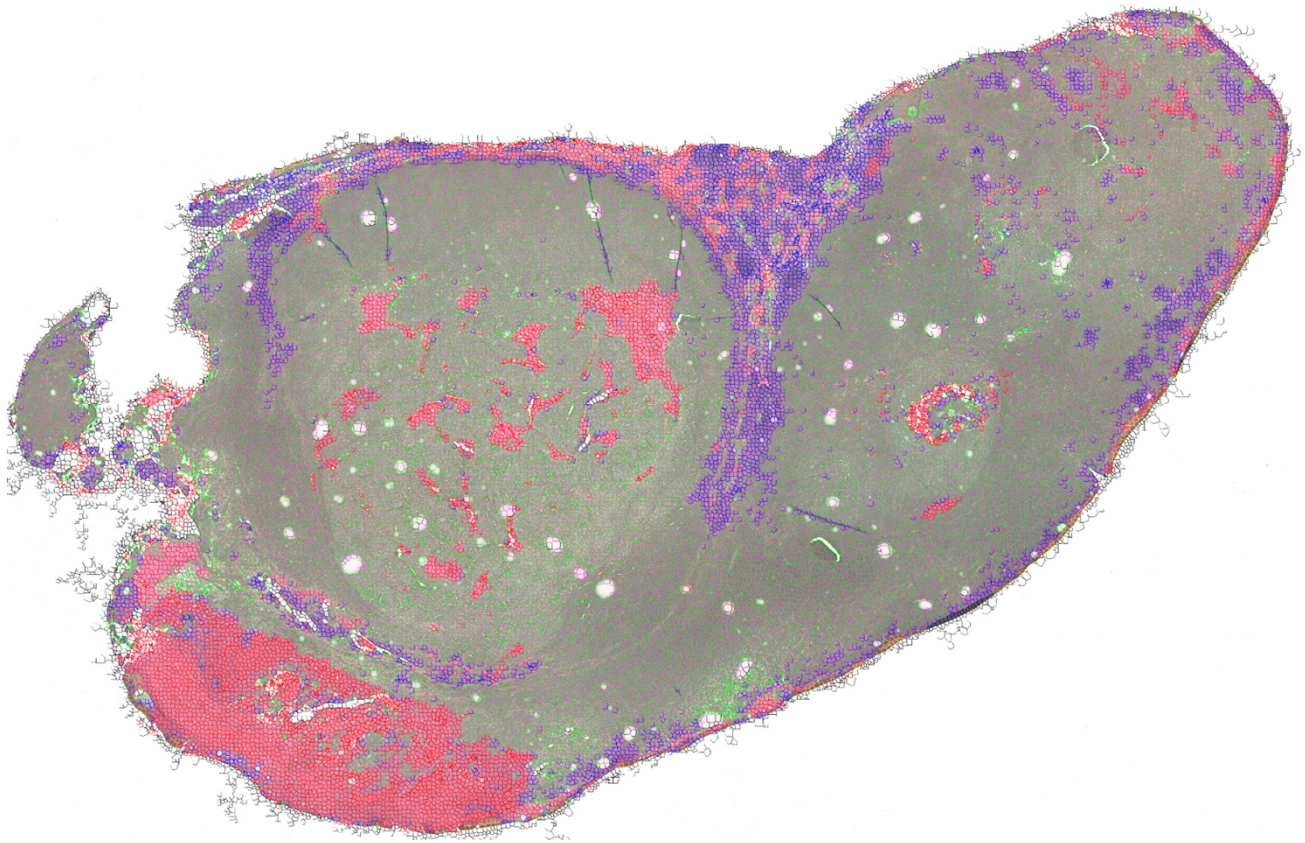
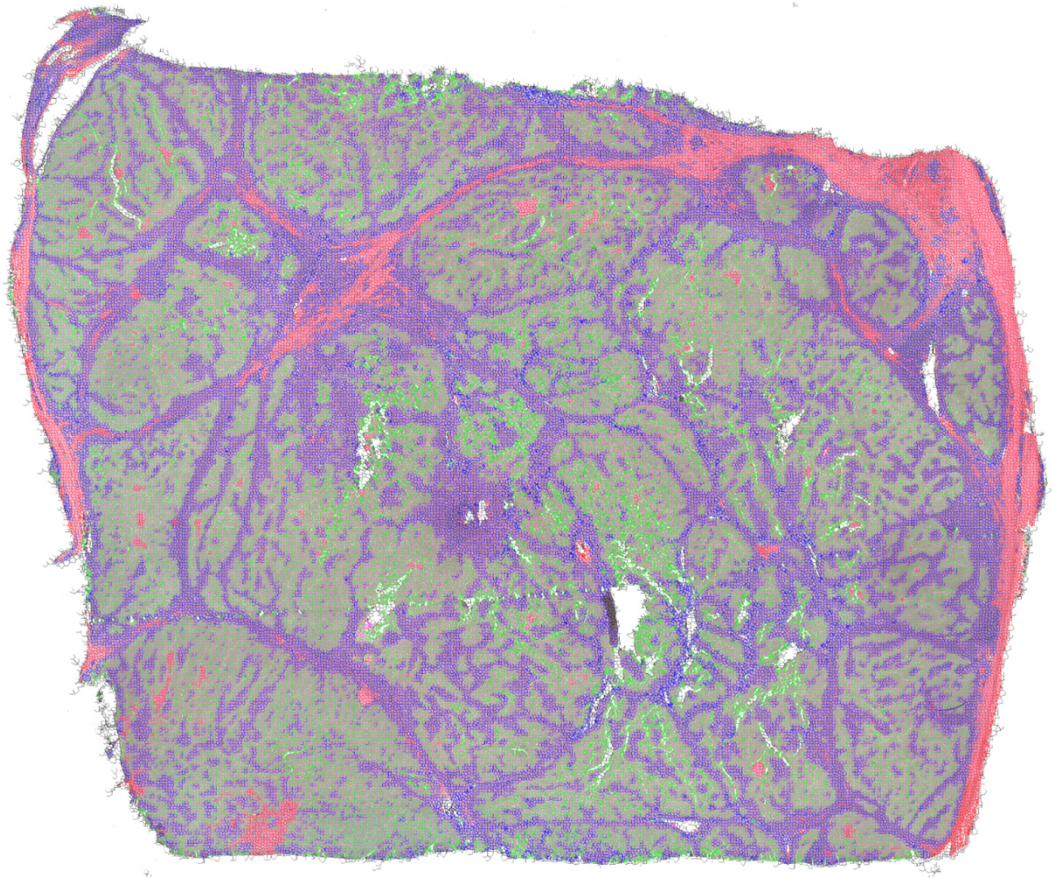


K. Zormpas-Petridis et al, Front. In Oncol. (2021)

Digital Pathology – Region / Tissue-level classification

Melanoma

- Tumour
- Stroma
- Lymphocyte cluster
- Fat

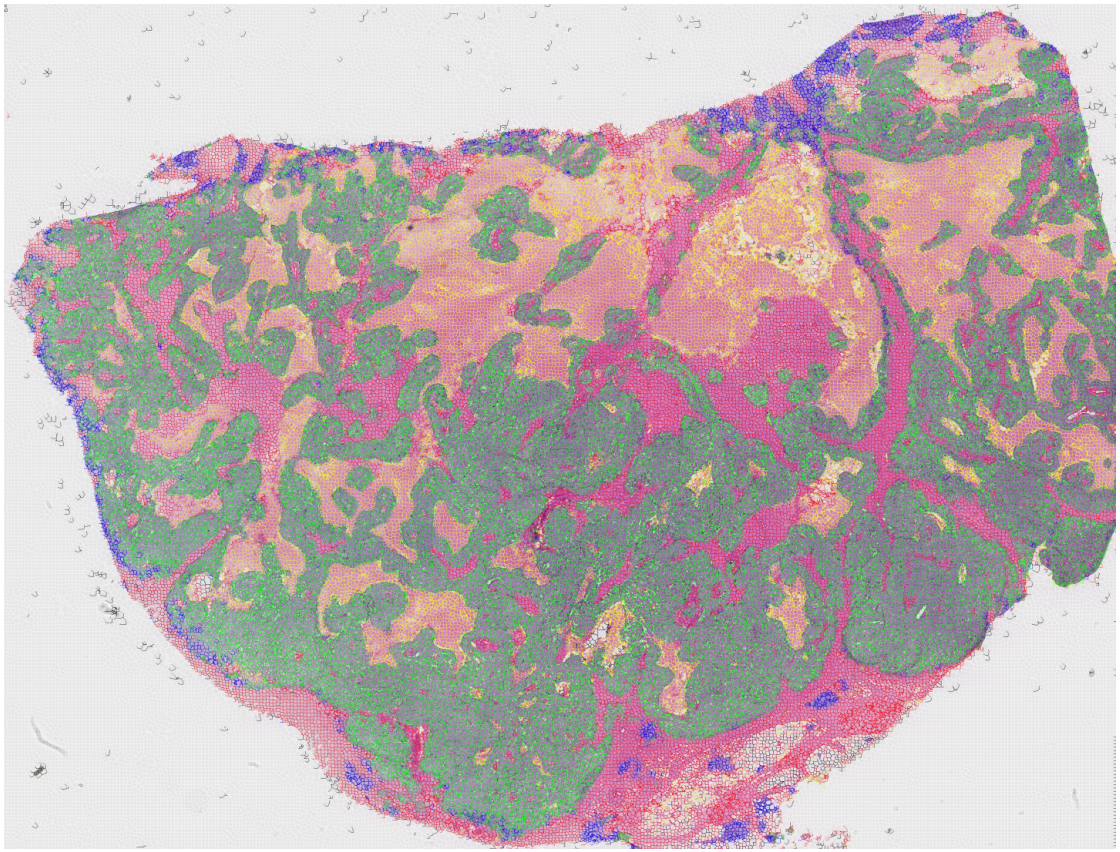


K. Zormpas-Petridis et al, Front. In Oncol. (2021)

Digital Pathology – Region / Tissue-level classification

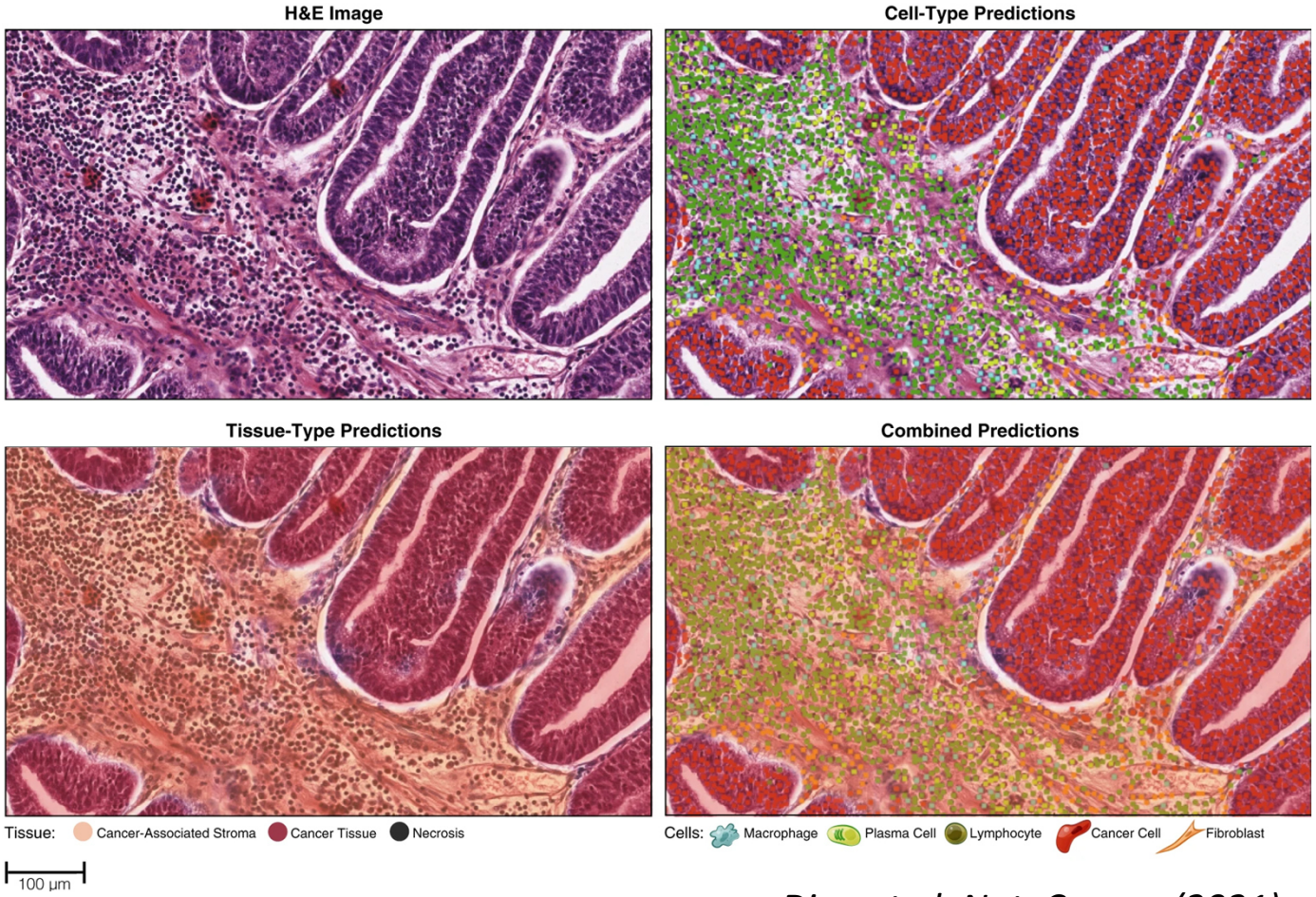
Triple-Negative Breast Cancer

- Tumour
- Stroma
- Necrosis
- Lymphocyte cluster
- Fat
- Background / white space



K. Zormpas-Petridis et al, Front. In Oncol. (2021)

Digital Pathology – Spatial statistics / Biological features extraction



Diao et al, Nat. Comm. (2021)

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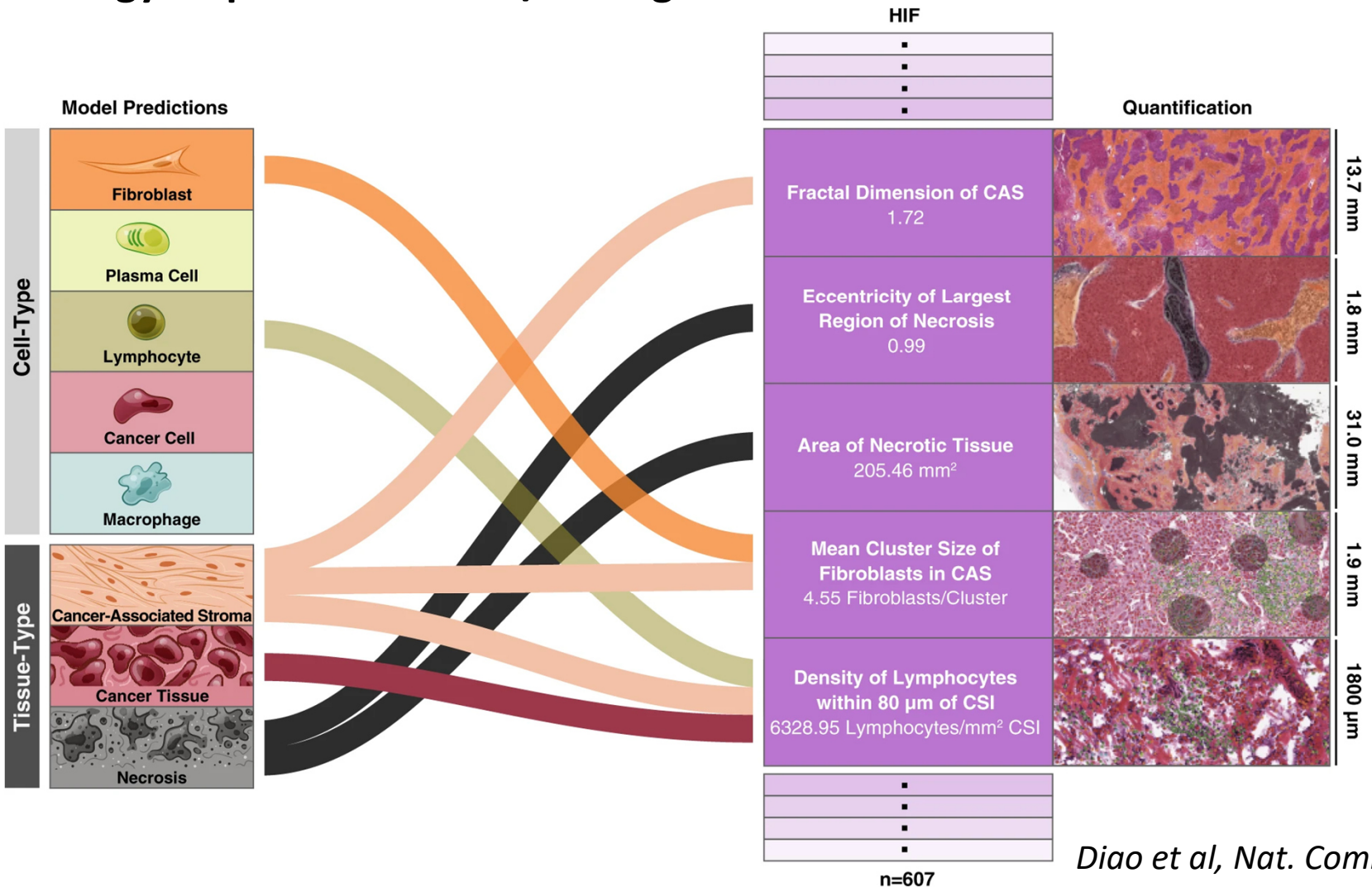
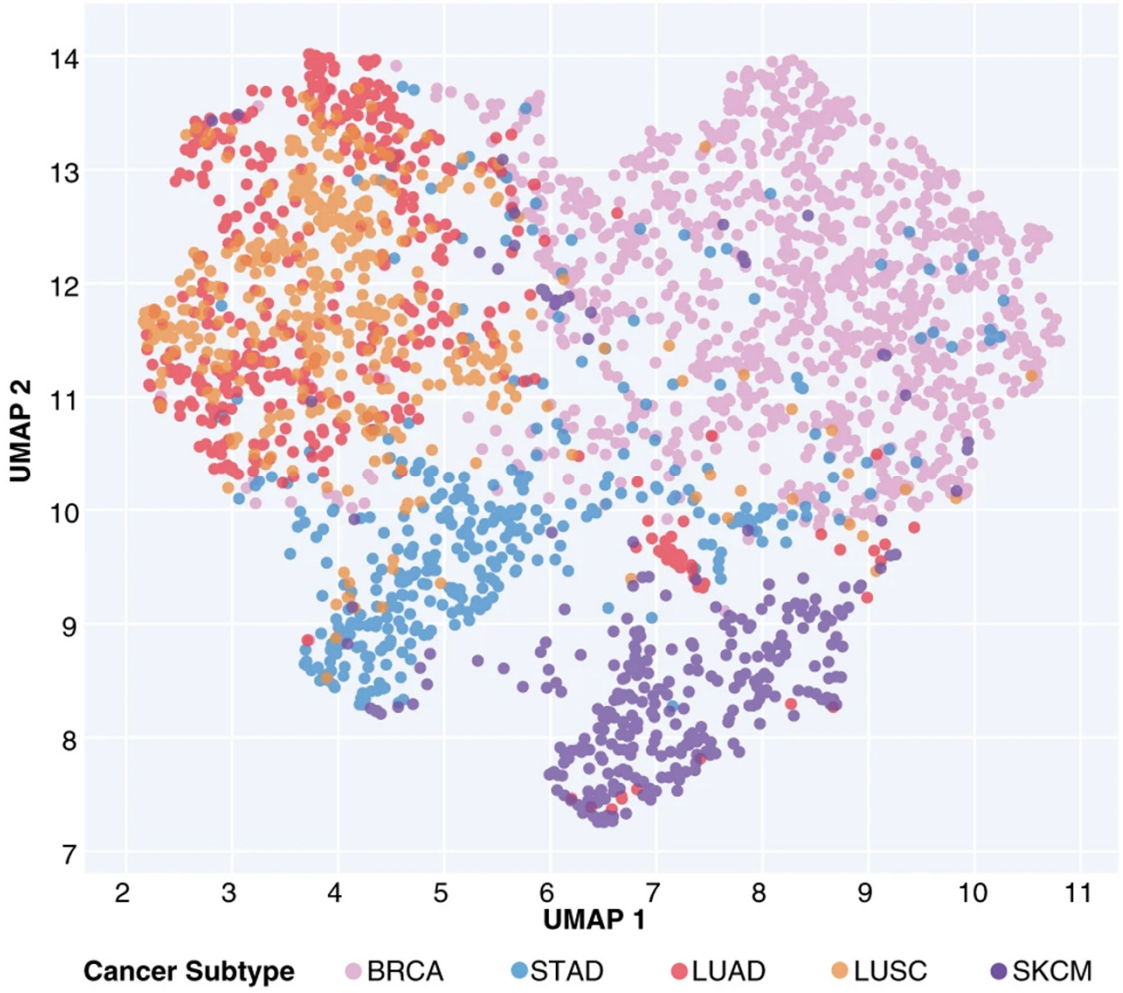


Diao et al, Nat. Comm. (2021)

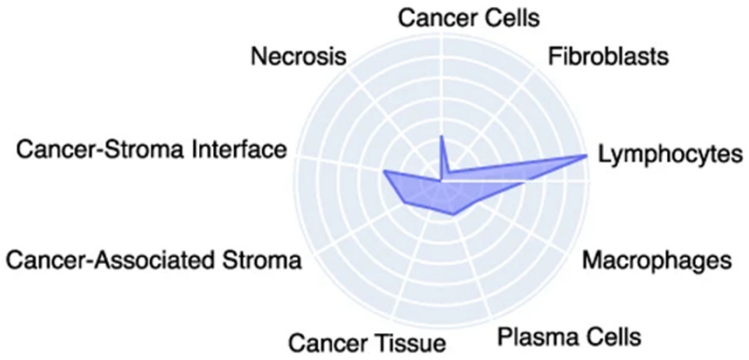
Digital Pathology – Applications: Mutation prediction



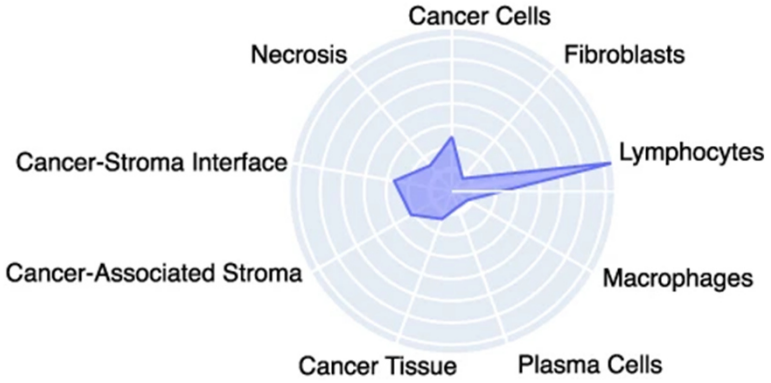
Diao et al, Nat. Comm. (2021)

Digital Pathology – Applications: Mutation prediction

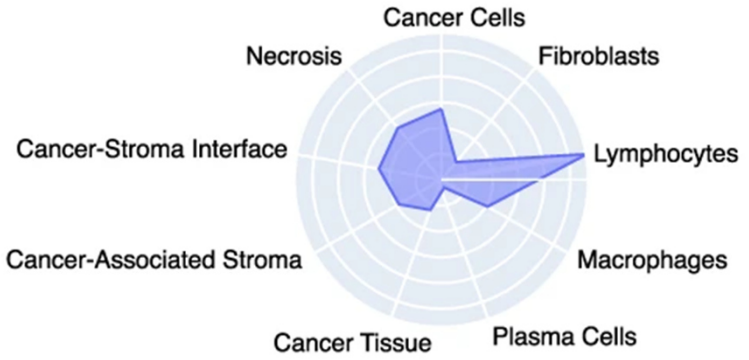
PD-1



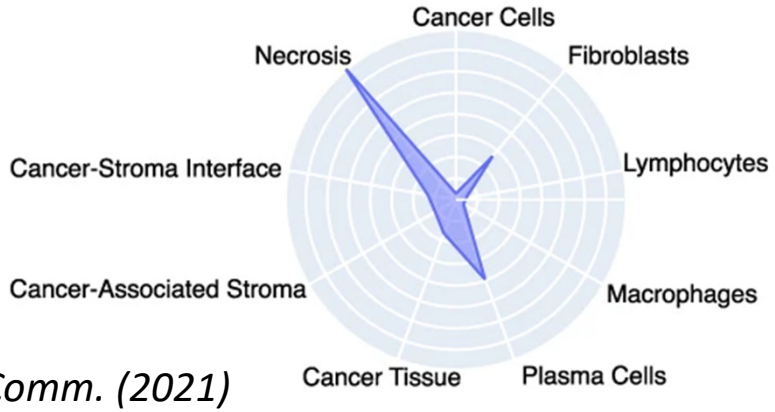
CTLA-4



PD-L1

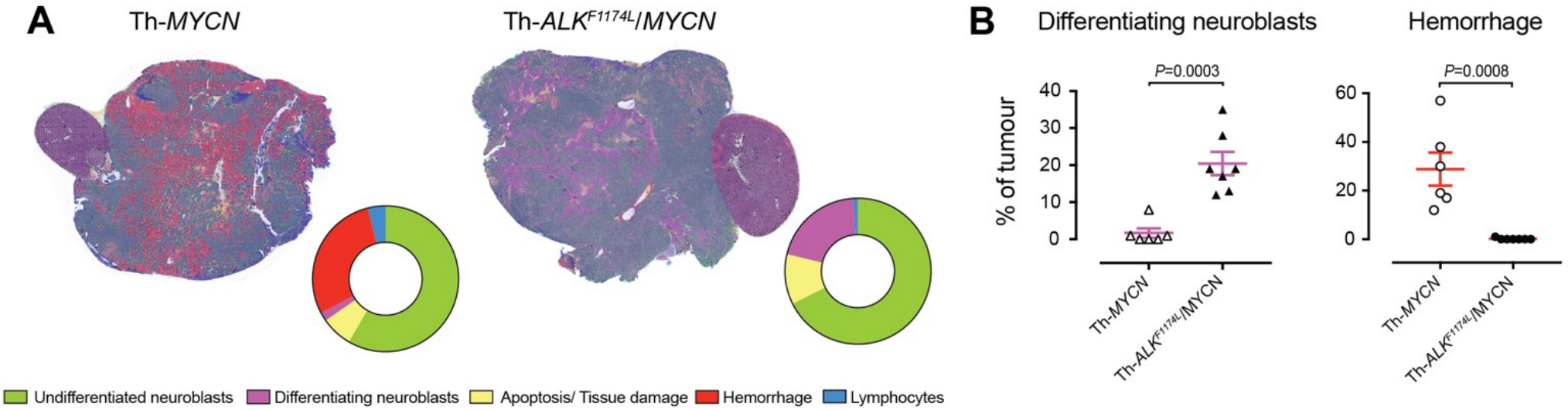


HRD



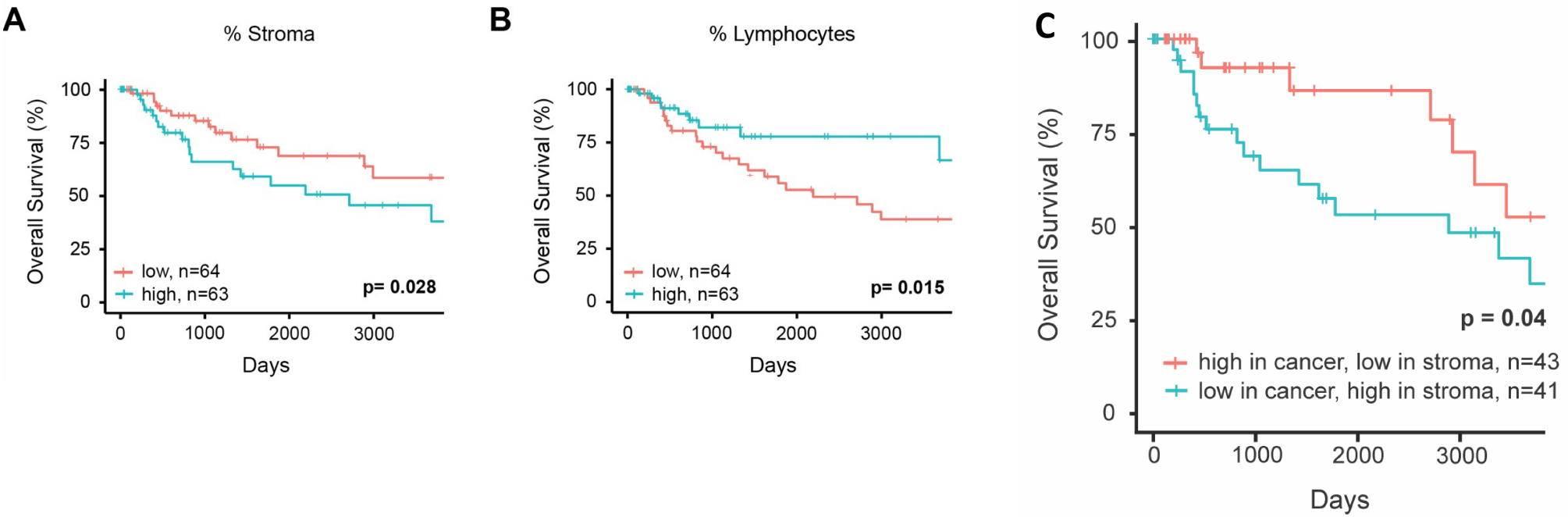
Diao et al, Nat. Comm. (2021)

Digital Pathology – Applications: Mutation prediction



K. Zormpas-Petridis et al, Front. In Oncol. (2021)

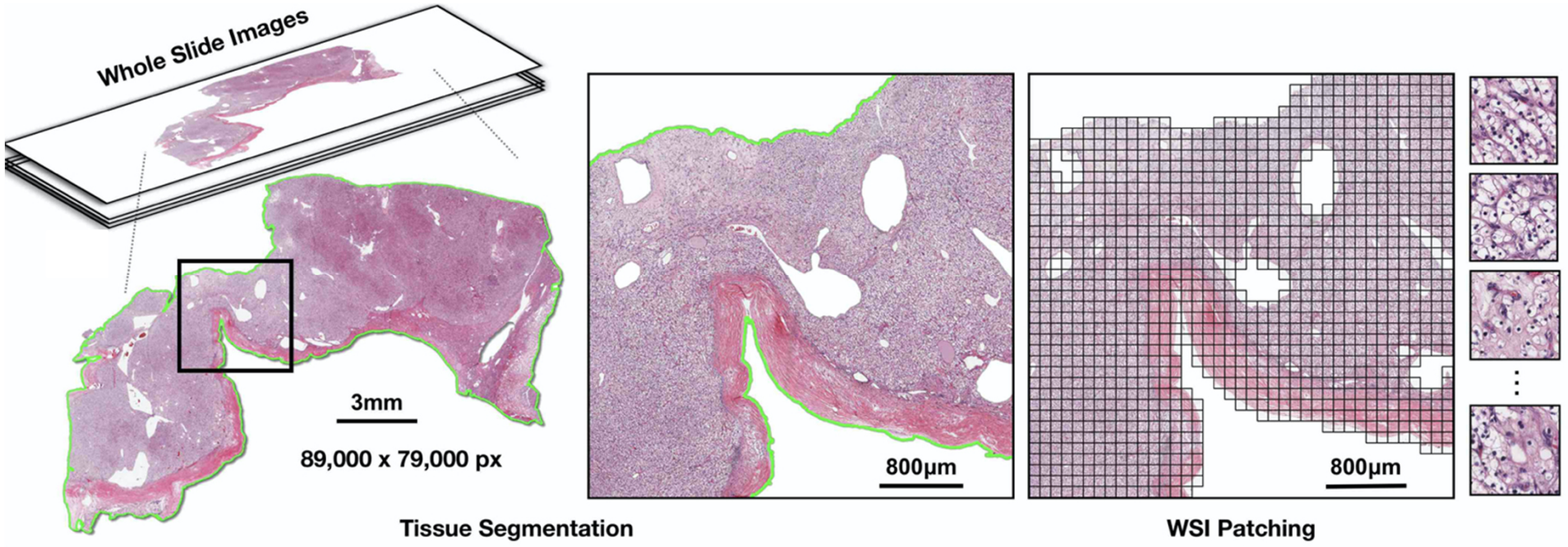
Digital Pathology – Applications: Survival prediction



K. Zormpas-Petridis et al, Front. In Oncol. (2019)
K. Zormpas-Petridis et al, COMPAY MICCAI (2018)

Digital Pathology – Fully deep learning-based pipeline

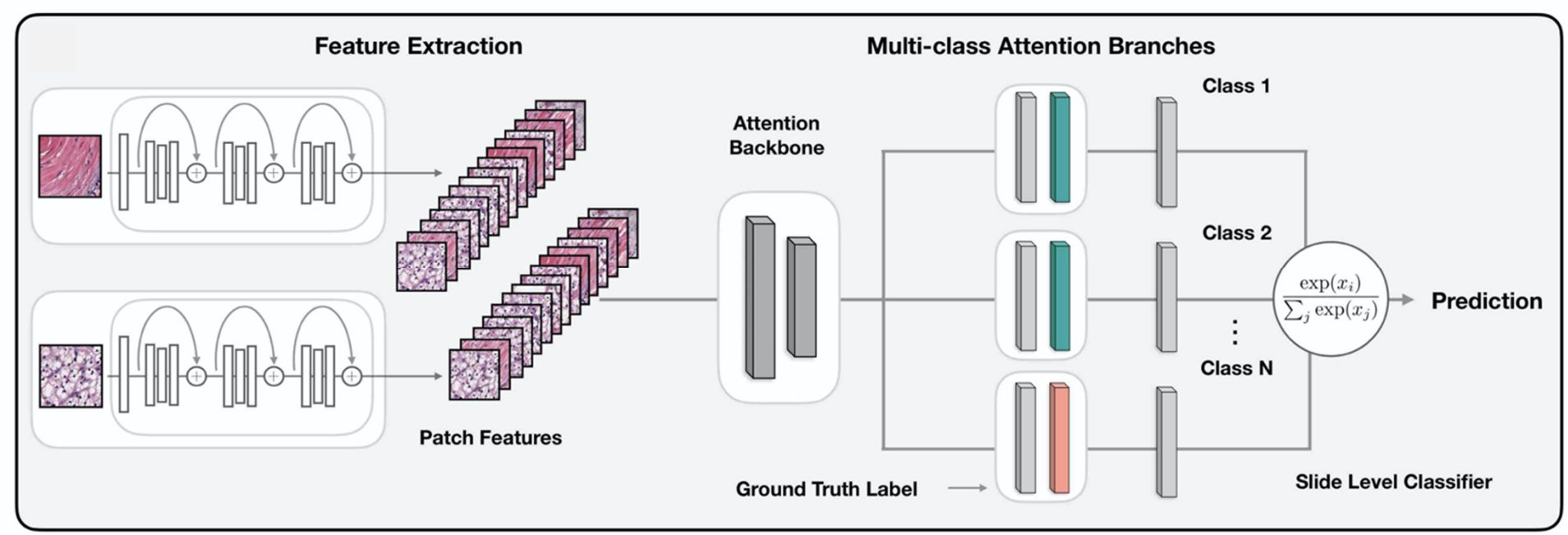
Attention mechanisms for interpretability



Lu et al, Nat. Biomed. Eng. (2021)

Digital Pathology – Fully deep learning-based pipeline

Attention mechanisms for interpretability



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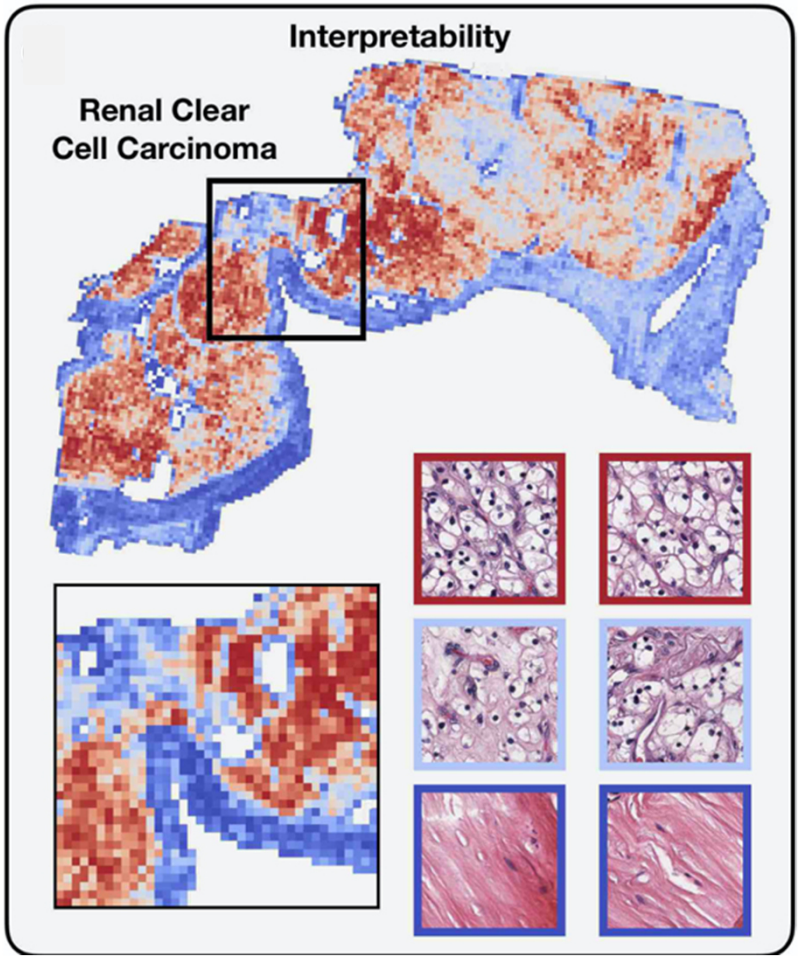
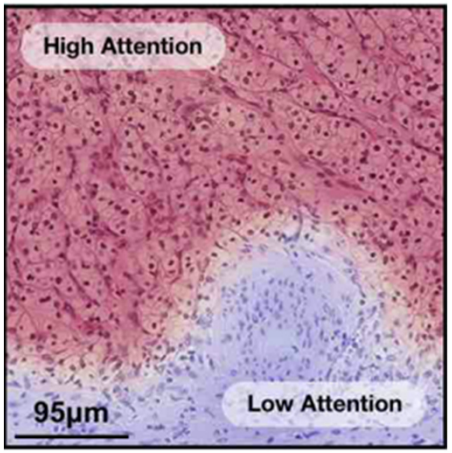
Digital Pathology – Fully deep learning-based pipeline

Attention mechanisms for interpretability



- Reverse engineering the biological mechanisms based on regions with high attention



Lu et al, Nat. Biomed. Eng. (2021)

Digital Pathology

Advantages

- Quantitative
- Reproducible
- Objective
- Novel biomarker discovery

Disadvantages

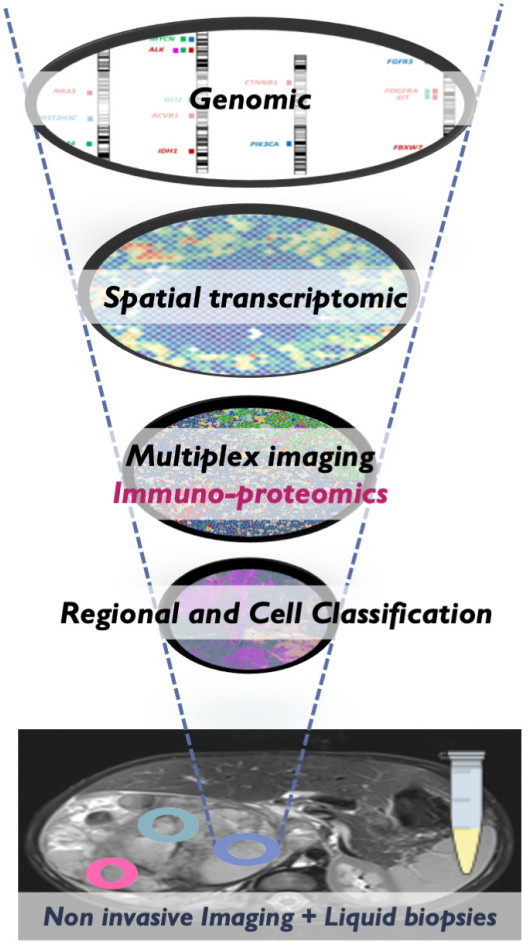
- Dependent on training dataset and current technology
- Need of extensive validation and optimization on new datasets
- Lack of full interpretability
- Long research time / difficult to adapt

Combination of medical data in a spatial manner

Types of medical data

- Genomic
- Transcriptomic
- Proteomics
- Histopathology
- Medical imaging

With the right understanding, digital pathology can be an invaluable tool to assist the pathologists



Courtesy of Dr. Yann Jamin