



# Unfolding the promise of digital pathology - Mixed reality and AI PoC applications in cancer diagnosis

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# Outline

## 1. Introduction

- Clinical (and digital!) pathology.
- The environment and organization @Karolinska
- Mixed reality and AI pathology diagnostic tools

## 2. Mixed Reality – Hololens4Pathology... and radiology.

## 3. AI for quantitative assessment of colorectal cancer liver metastases.

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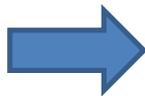
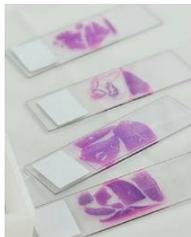
# Clinical pathology

- Became decisive for oncological care.
- Sub-specialization (diagnostic areas), advanced diagnostic methods.
- Only partly automated - mostly on the laboratory side.
- The results must be reproducible and evidence based - quality assurance and standardization.
- Cancer registers must be supplied with accurate data – public health planning.

# Environment and organization

- Karolinska University Hospital
  - One of the largest university hospitals in Europe (1340 beds, 1,6 million patient visits/year, 16000 employees).
- Function Area of Clinical Pathology and Cytology
  - 4 sites (Huddinge, Solna, Danderyd, Södersjukhuset).
  - 430 employees, 280 000 cases/year.
  - Nationally accredited laboratory and 5 diagnostic areas.
  - Digitalization in progress.

# Clinical pathology goes digital & computational



Better  
diagnosis

Improved  
value-based  
patient care

Optimize  
laboratory  
processes



# Mixed reality and AI pathology diagnostic tools

- Cancer projections are growing → Increasing number of probes.
- Surgical techniques and oncological treatments are improving (personalized medicine) → Increasing complexity and reporting requirements.
- Shortage of pathologists worldwide → Digital diagnostic tools our best chance!

# Mixed reality and AI pathology diagnostic tools

- Current state-of-the-art AI (deep learning) algorithms can match/compete with human experts in natural image classification, including medical field.

nature  
medicine

ARTICLES

<https://doi.org/10.1038/s41591-018-0107-6>

**Clinically applicable deep learning for diagnosis  
and referral in retinal disease**

De Fauw J et al.

# Mixed reality and AI pathology diagnostic tools

- **Integrated visualizations** – Pathology’s multimodal and cross-specialties (radiology-pathology).
- **Qualitative image analysis** – Automatic tumor detection.
- **Quantitative image analysis** – Computational pathology.

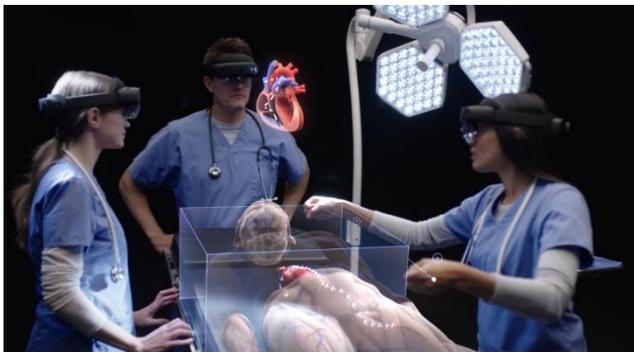


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# “Mixed reality” in medicine

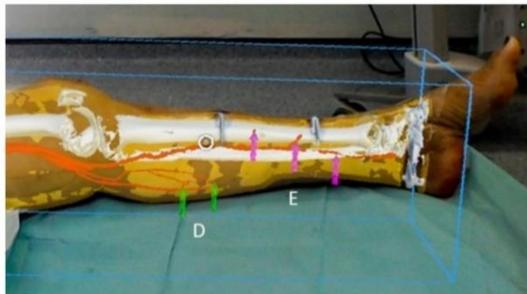
Medical education



Interventional radiology



Optimization of surgical procedures



Digital pathology

# Hololens4Pathology



- Project goals:
  - To develop a “mixed reality” PoC HoloLens application for a comprehensive **pathology workflow**.
  - To enable the **correlation** of preoperative **radiology** findings with the final **pathology** results.
- Aligning and synchronizing the visualization:
  - Radiology 3D organ reconstruction <> 2D images <> Pathology 3D organ scan <> Tissue slices <> (HE) Histology slides <> Immunohistochemical slides.

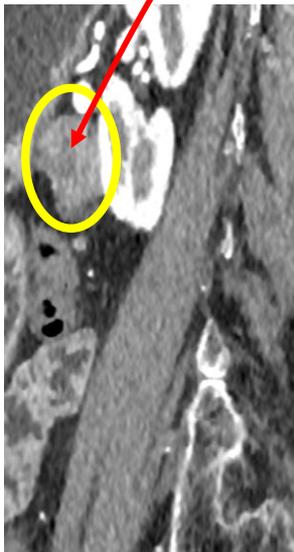
# Hololens4Pathology – Clinical values

- Better patient-centered care:
  - Integrating the visualization and analysis of multimodal diagnostic imaging (pathology-radiology).
  - Improving diagnosis of complex probes (major and extended surgeries, down-staged tumors).
  - Enriching the multidisciplinary team meeting.
    - Demonstration, analysis and decision-making.

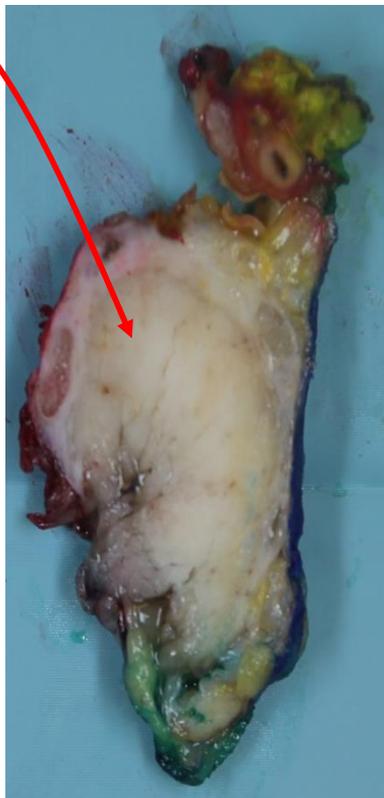
# Hololens4Pathology – Clinical values

- Better pathology:
  - Precise identification and diagnosis of the preoperative radiological findings.
- Better radiology:
  - Accurate feedback of the final pathology diagnosis (“gold standard”) for the preoperative radiological findings.

# Correlation radiology-pathology

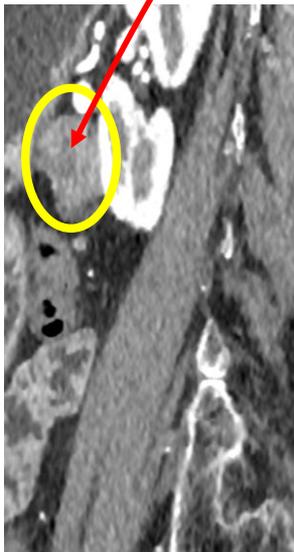


“Worrisome”  
radiology



Courtesy av Dr. Nikolaos Kartalis, Karolinska University Hospital

# Correlation radiology-pathology



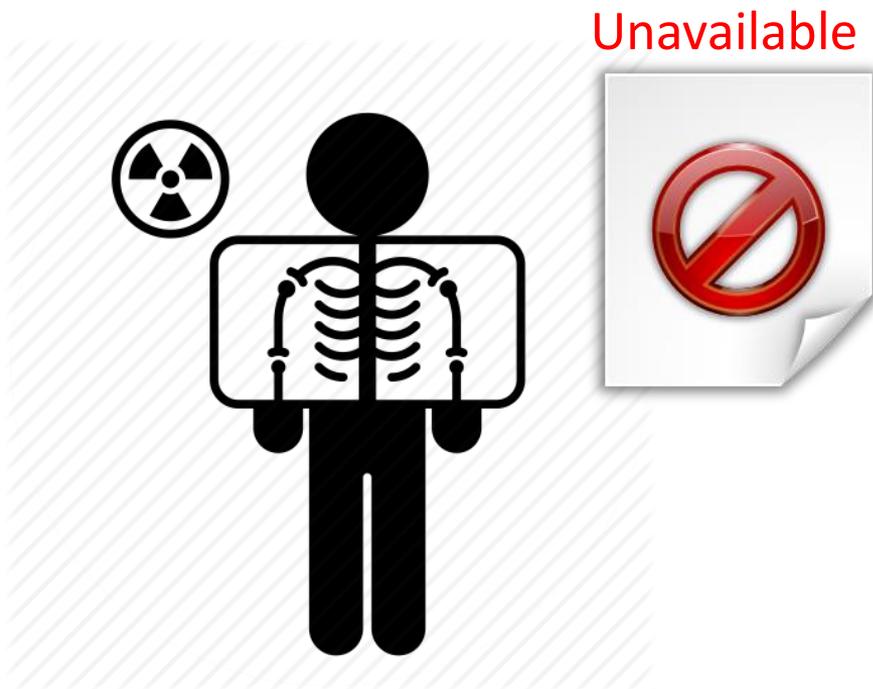
“Worrisome”  
radiology



Premalignant  
(benign)  
tumor

Courtesy av Dr. Nikolaos Kartalis, Karolinska University Hospital

# Current pathology workflow – Preoperative radiology imaging



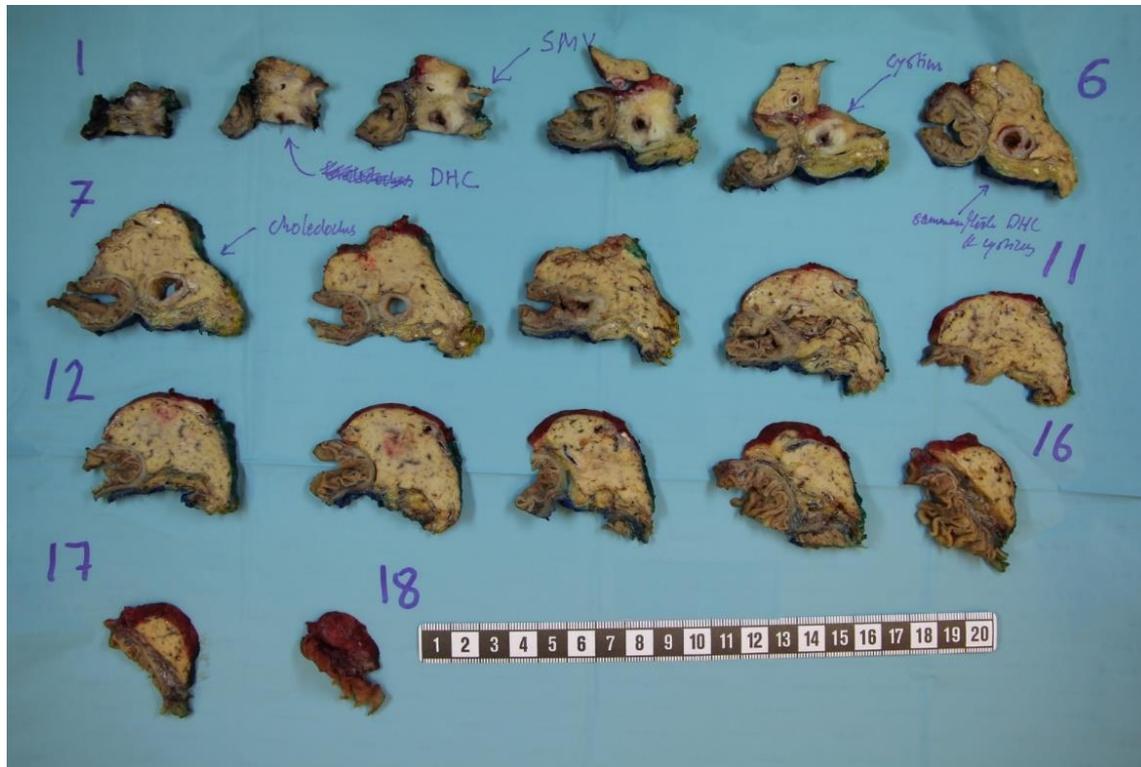
# Current pathology workflow – Macroscopic organ description

Pancreatic head resection



Poor detail, no 3D representation, lost during slicing

# Current pathology workflow – Macroscopic tissue slices



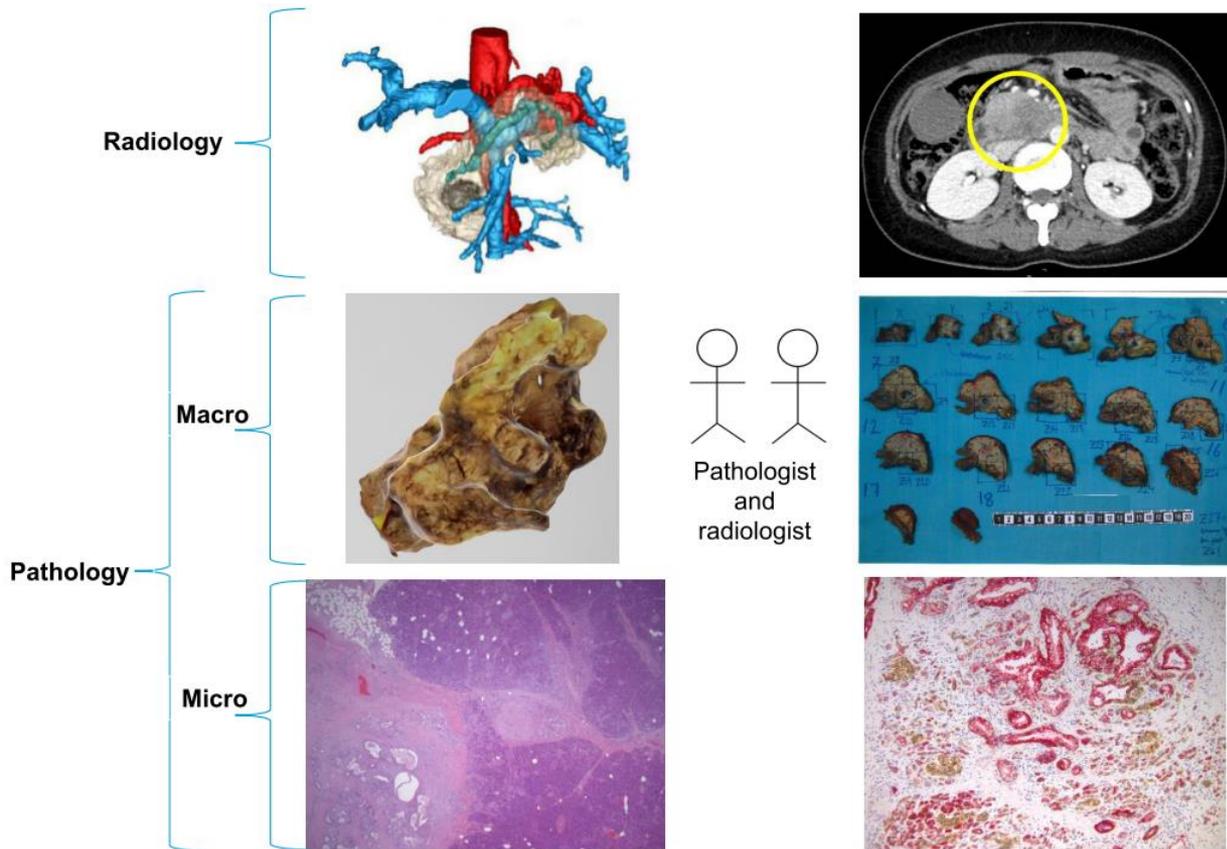
Organ is serially cut into 3-5 mm thick tissue slices, placed in order in a CT scan-like manner and photo documented.

# Current pathology workflow – Microscopic assessment



# Hololens4Pathology and Radiology -

Integrated, matched and synchronized visualization





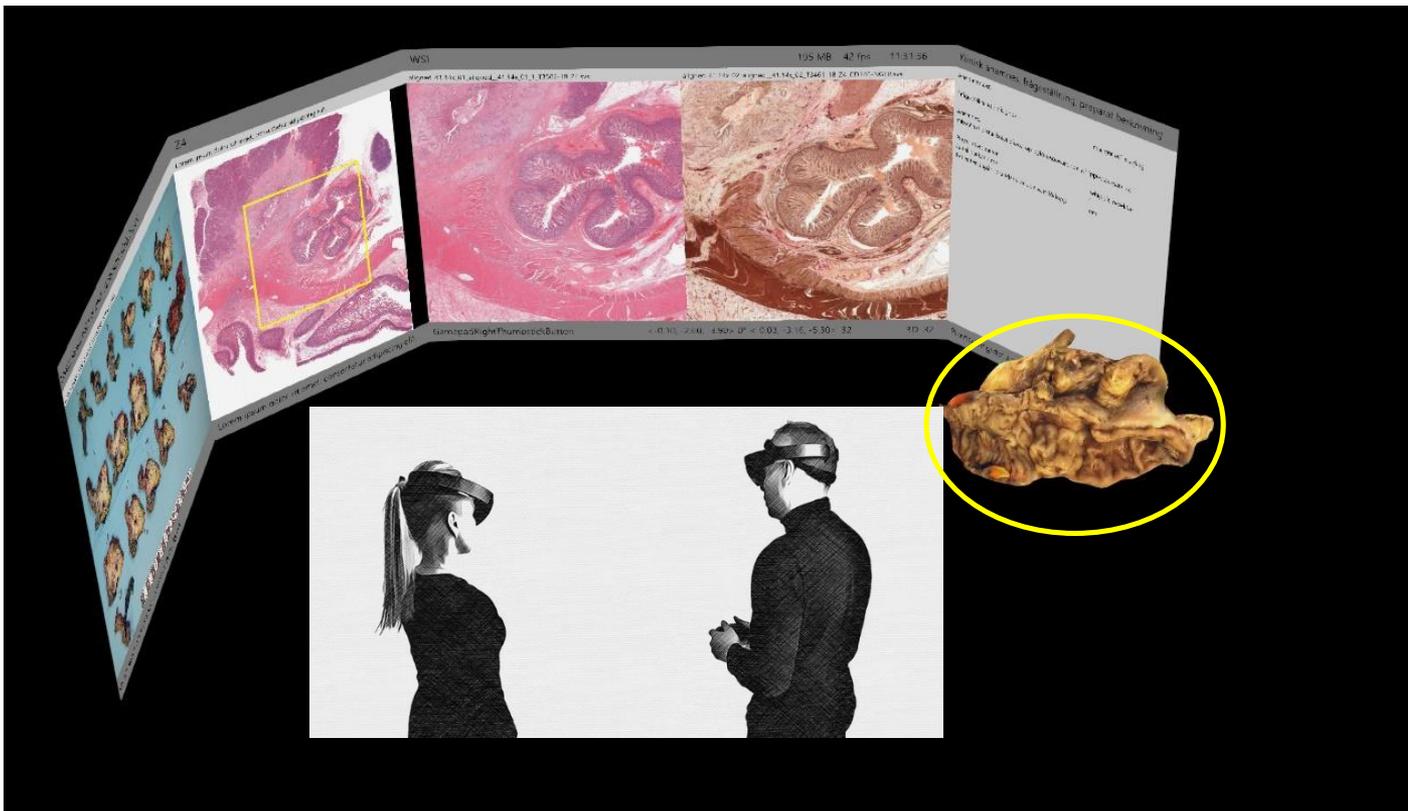
Hololens4Pathology

# Hololens4Pathology: 3D organ model



Right  
hemihepatectomy

# Hololens4Pathology: Integrated and synchronized visualization of pathology imaging



# Hololens4Pathology: Clinical information

2:42:15 Klinisk anamnes, frågeställning, preparat beskrivning

EAM.svs Anamnestext.

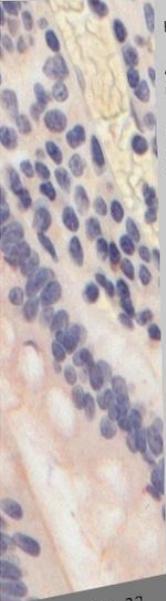
Frågeställning / diagnos: malignitet? staging

Anamnes:  
misstänkt distal kolangiöcc, op pylorusbevarande whipple.tacksam us.

Preparatets natur: whipple resektat

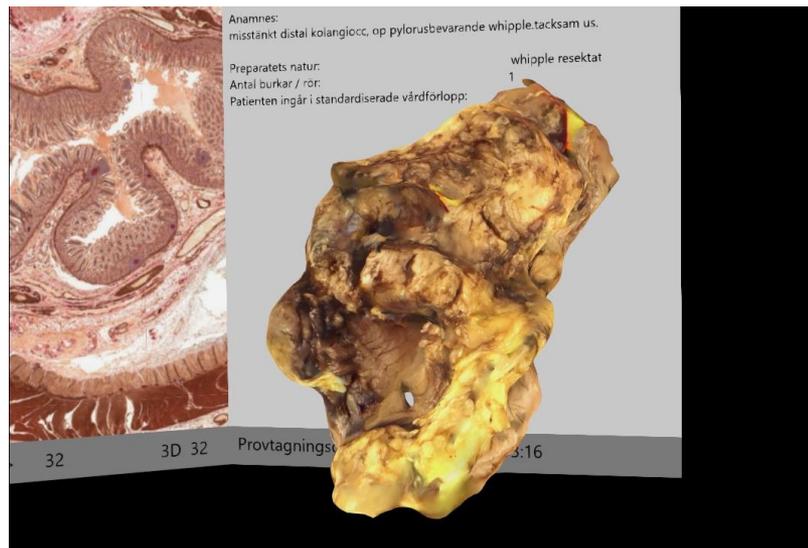
Antal burkar / rör: 1

Patienten ingår i standardiserade värdförlopp: nej

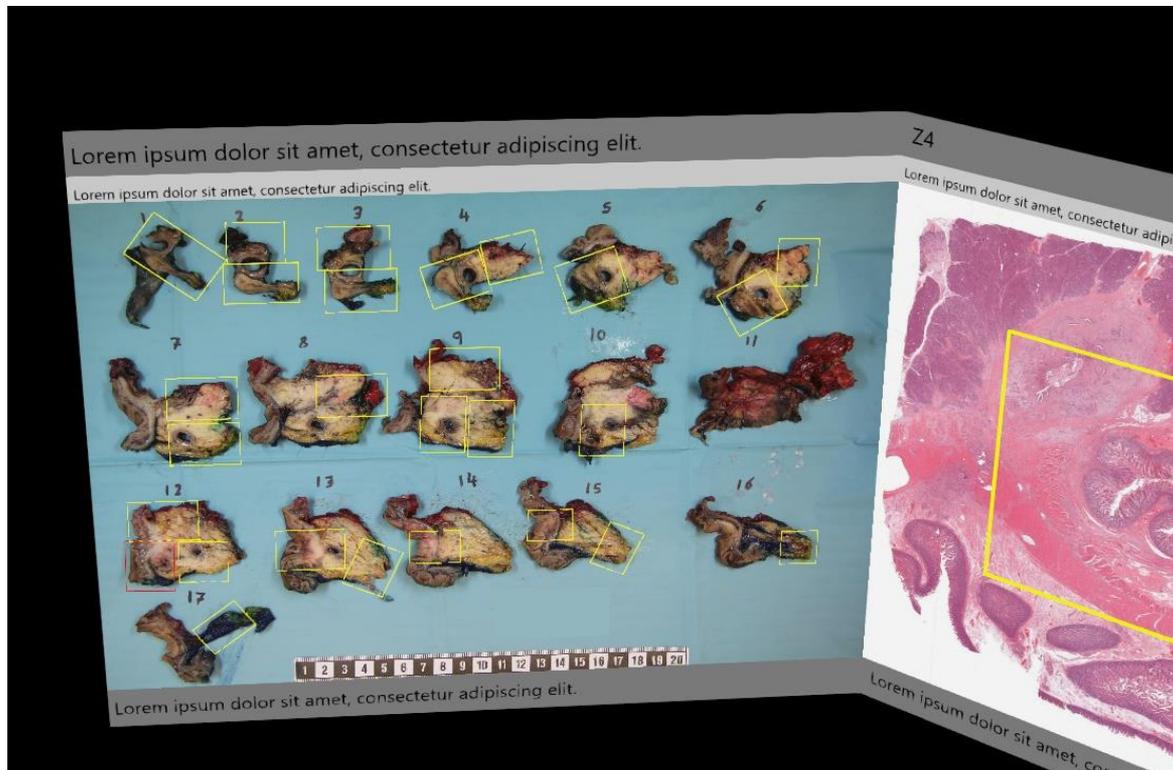


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# Hololens4Pathology: 3D organ model



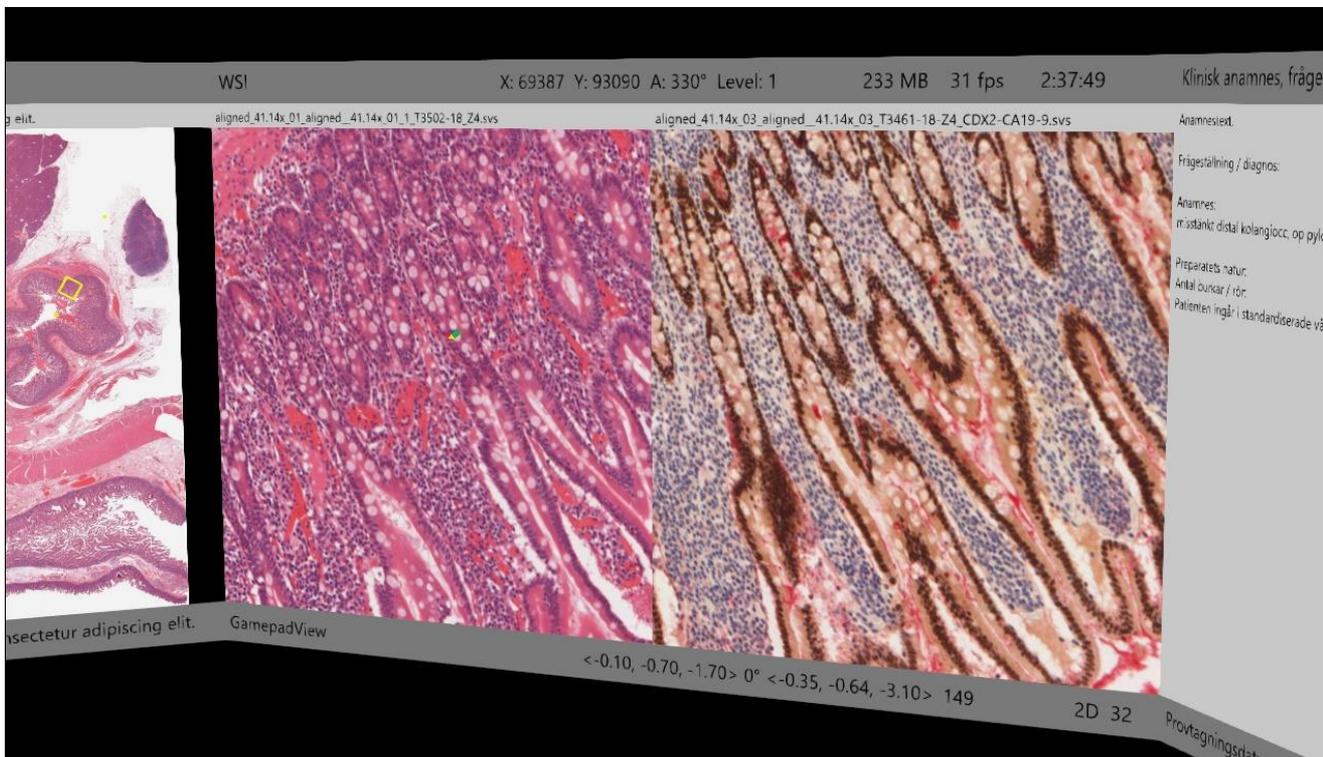
# Hololens4Pathology: Macroscopic tissue slices with mapping to histological images



# Hololens4Pathology: Synchronized visualization of histology images



# Hololens4Pathology: Synchronized visualization of multiple stainings





Hololens4Pathology

# Hololens4Pathology...and Radiology

WHAT'S  
NEXT



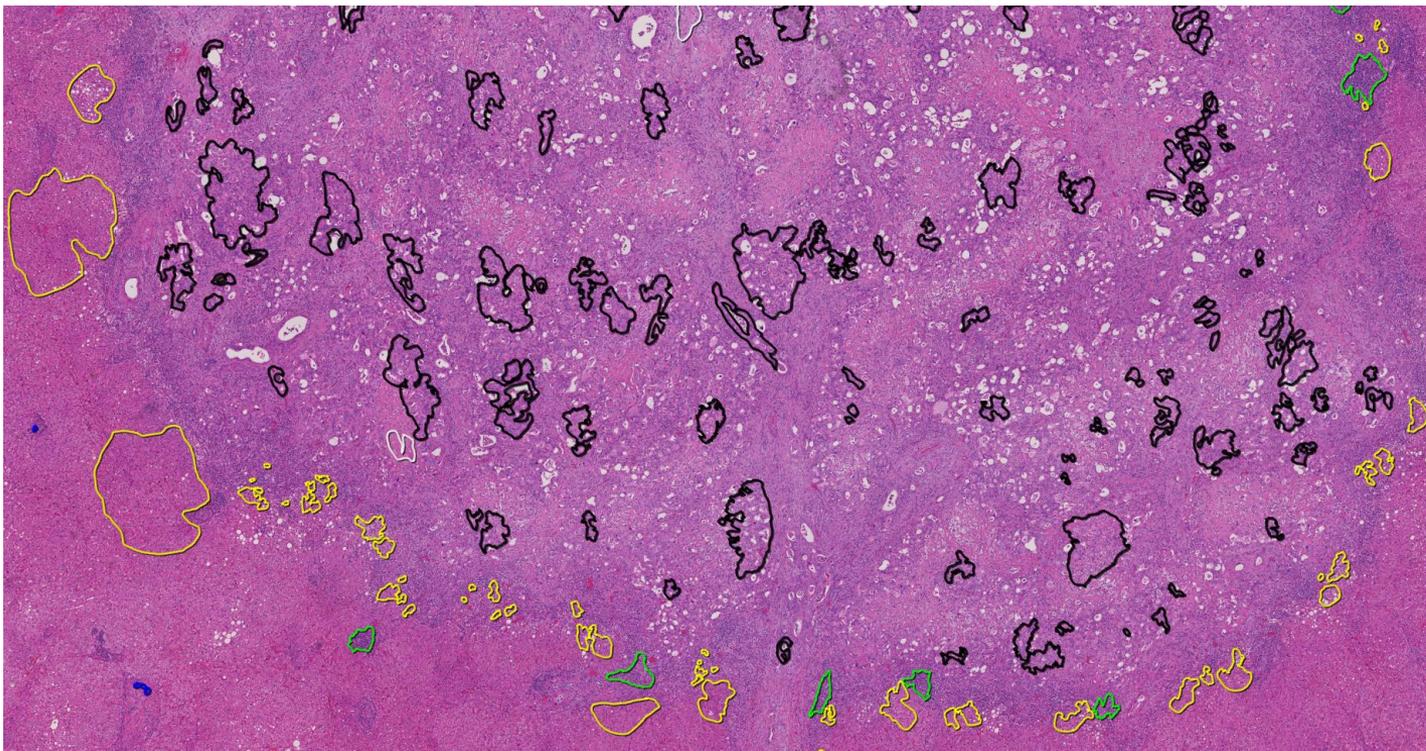
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# AI (deep learning) tool for quantitative analysis of colorectal liver metastases (CRLM)

- Clinically relevant parameters:
  - Grade of tumor regression after preoperative chemotherapy.
  - Histological growth patterns at the invasion front.
- Project outline:
  1. Creation of a large multi-class database of pathology annotations.
  2. Training of AI models.
  3. Evaluation of AI models for tissue detection, segmentation and quantification.

# CRLM - Multi-class annotation



T	Tumor	Black
N	Necrosis	Yellow
M	Mucin	Blue
MF	Macrophages	Purple
F	Fibrosis	White
H	Hepatocytes	Yellow
BD	Bile ducts	Blue
B	Blood	Red
I	Inflammation	Green

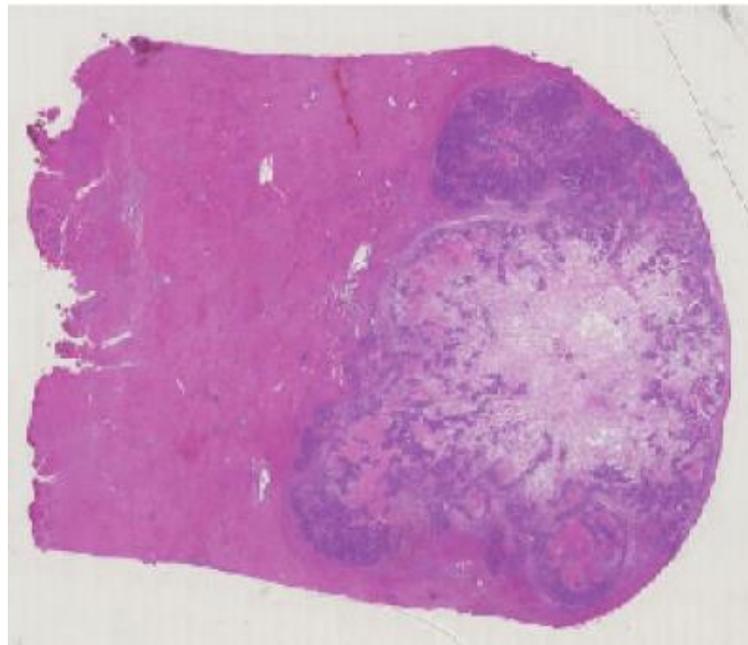
# Large database of high-quality pathology annotations of CRLM

- The dataset: 75 histology images (WSI), +17 000 annotations.
- Number of pathology annotations by class:

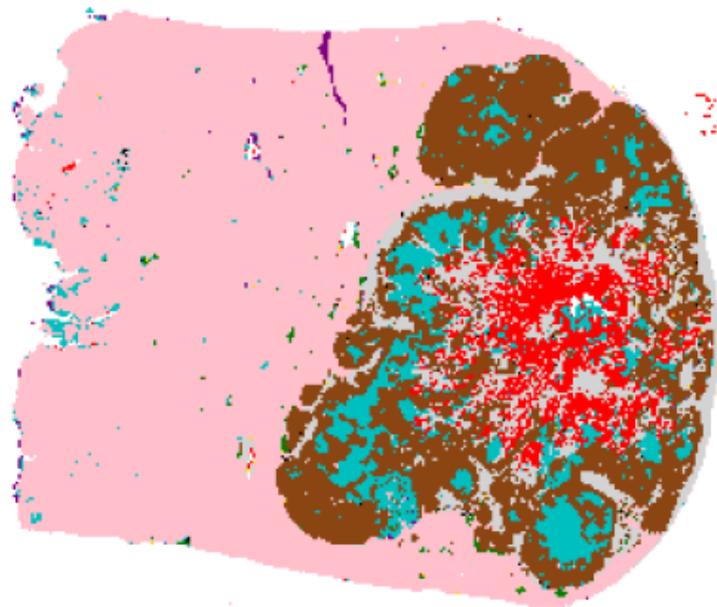
Tumor	6432
Necrosis	1112
Mucin	428
Macrophages	443
Fibrosis	2522
Hepatocytes	3148
Bile ducts	1636
Blood	296
Inflammation	1253

# AI (deep learning) model for quantitative analysis of CRLM - Results

Original

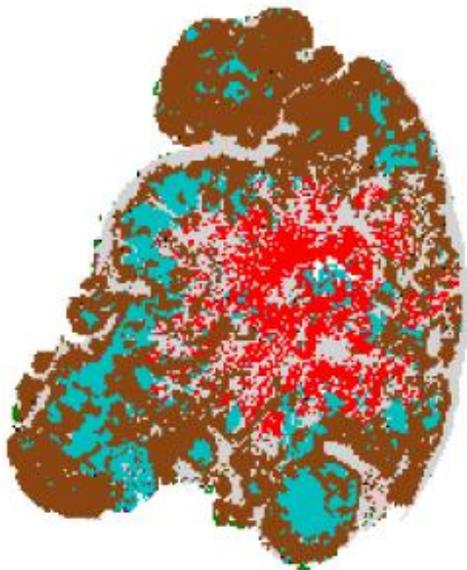


Whole slide segmentation results



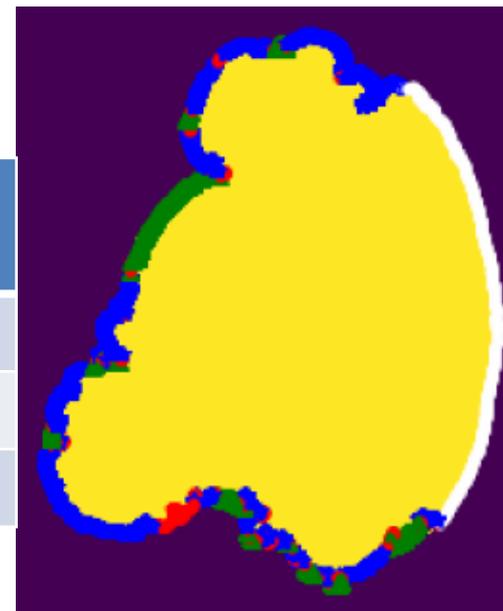
# AI (deep learning) model for quantitative analysis of CRLM - Results

Metastasis areas



Tissue components	%
Tumor	49
Necrosis	15
Fibrosis	21
Mucin	13

Histological growth patterns



Growth patterns	%
Replacement	60
Desmoplastic	19
Uncertain	21



# Conclusions

- Clinical pathology has become crucial for modern cancer diagnosis and care.
- Need for automated, computational and resource-optimizing digital diagnostic tools.
- Mixed reality enables unrivalled capabilities for integrated, multimodal and cross-specialties visualizations (rad-pat).
- AI-image analysis tools will empower pathologists to make diagnosis better, faster, more objective and computable.

# The team

- Clinical Pathology and Cytology: Mikael Björnstedt, Attila Szakos, László Székely, Béla Bozóky, Ozan Aricak. Nira Nirmalathas, Eduardo Fuente Martin
- Diagnostic radiology: Nikolaos Kartalis



- Lund Univ. Hospital: Danyil Kuznyecov



- Mathias Ekman, Eero Bragge, Zenodia Charpy, Bert Hoorne



- Anders Mertel (advisor)

- Tobias Bard, Jacob Broms



- Multimedia and Vision Research Group: Qianni Zhang, Zhaoyang Xu



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**SLL Innovation**

