Orthopedics and AI: The next big thing

Pieter De Backer MD PhD

UroTech 2024 Vienna

25th January 2024

@pidebacker

“A.I. is like teenage sex:

Everyone speaks about it,

Nobody really knows how to do it,

Everyone thinks everyone else is doing it,

So everyone claims they are doing it.”

Professor Dan Ariely

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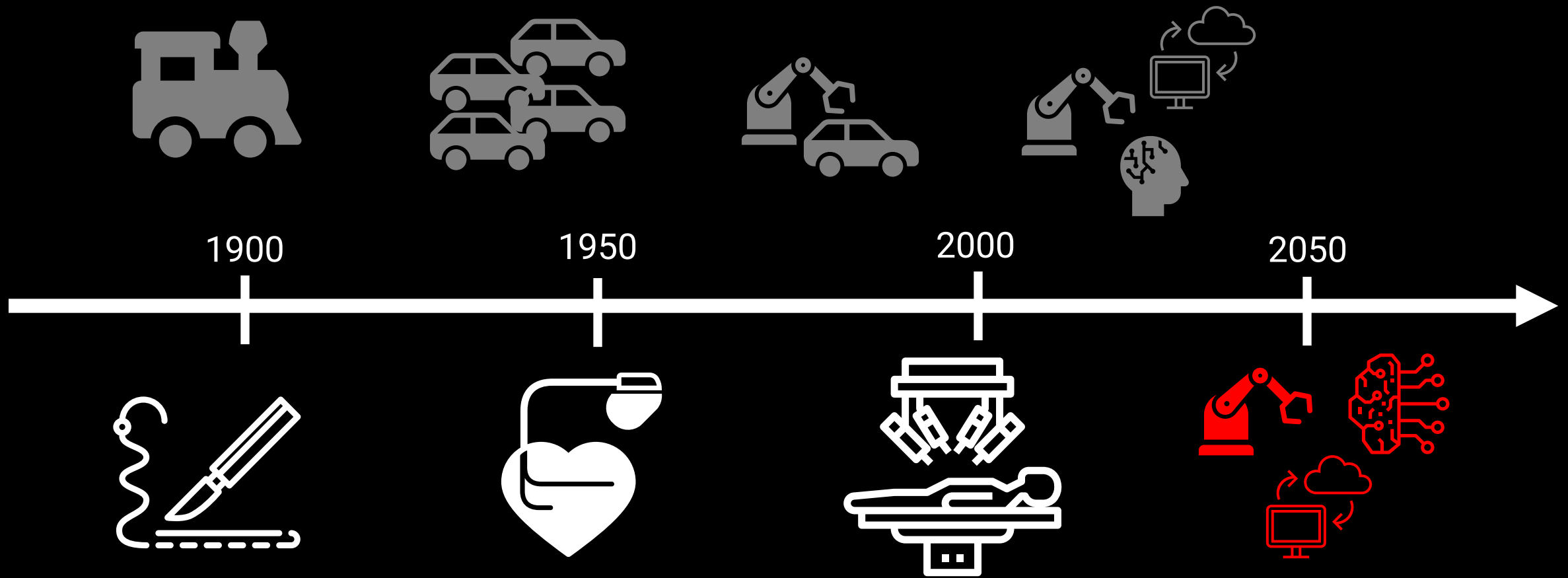
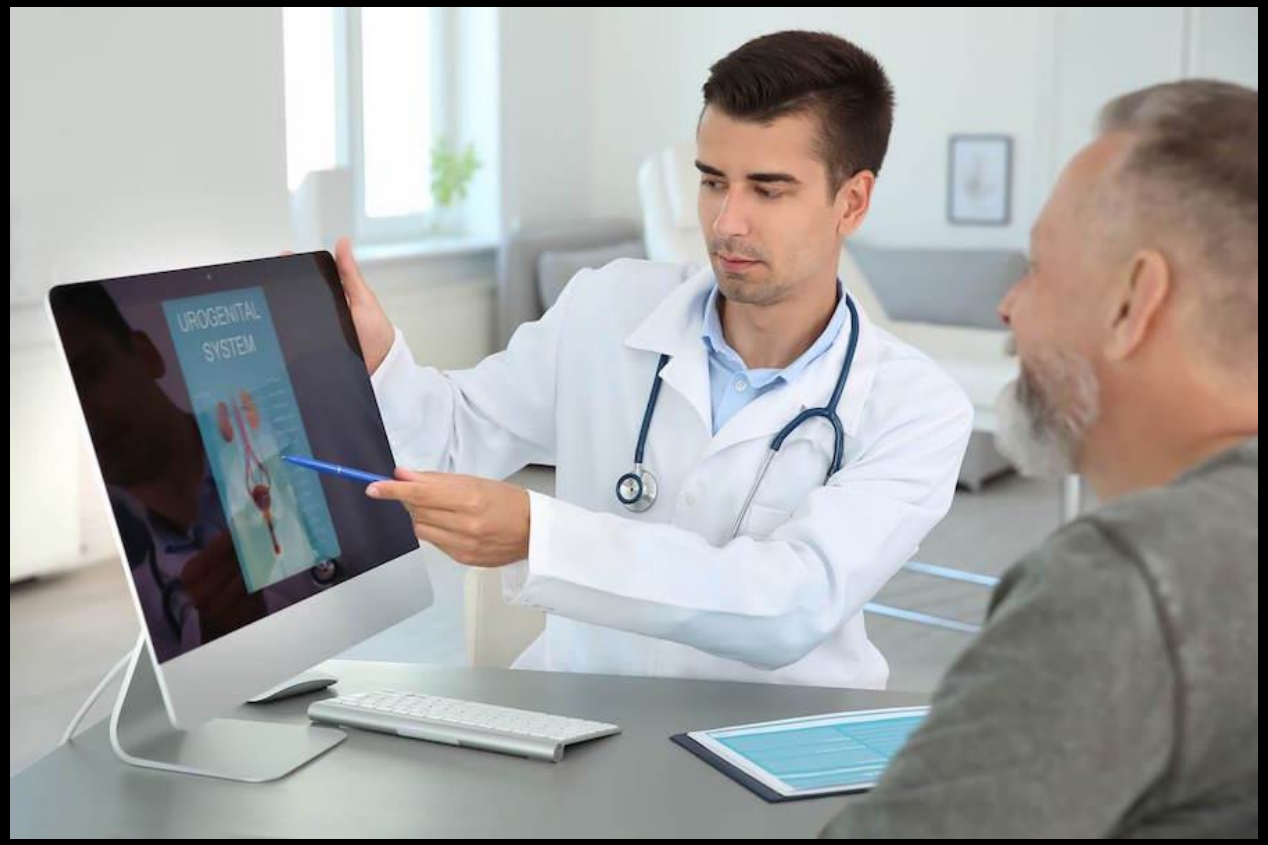
Surgical A.I. = Surgery 4.0.



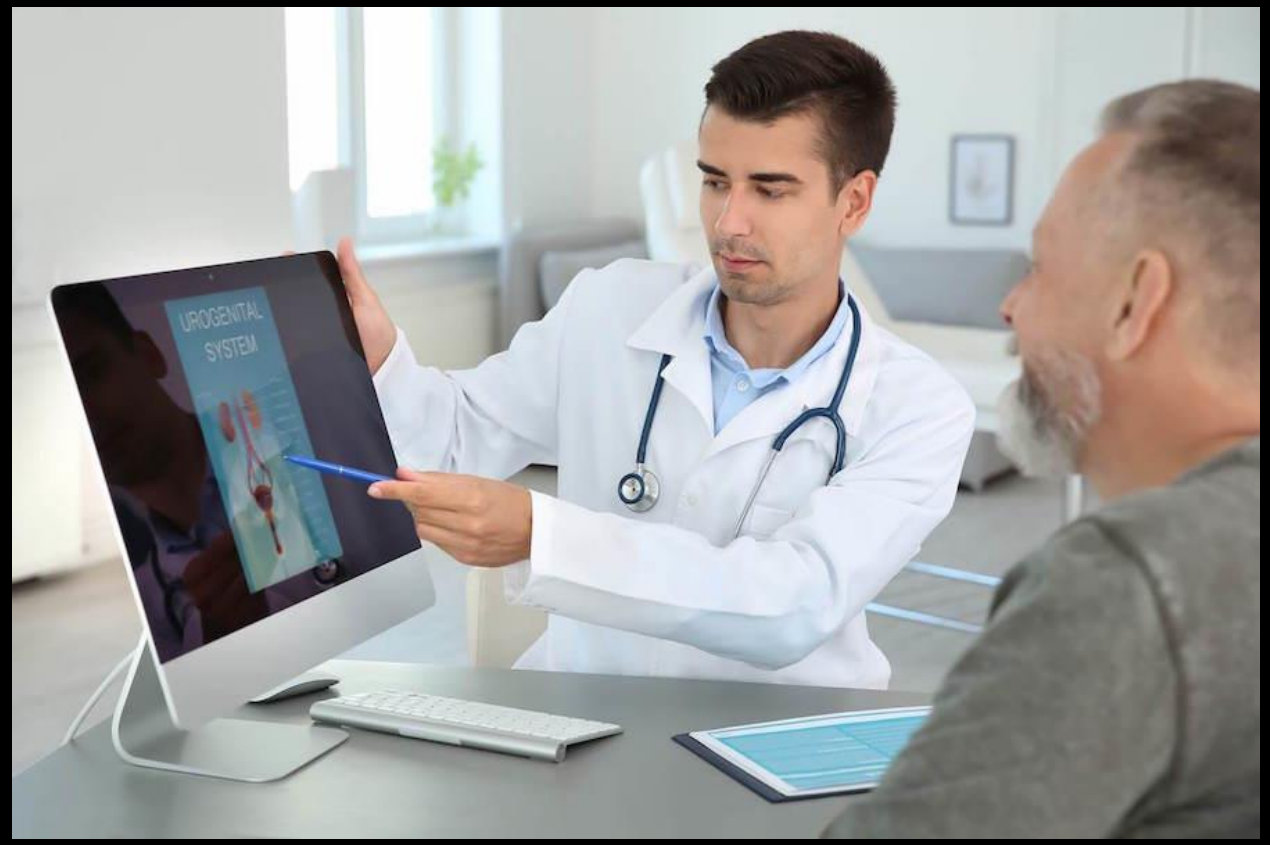
P De Backer, F Nickel – Role of Robotics as a key platform for digital advancements in surgery – 2024 British Journal of Surgery -- ©Noun Project

Surgery today



ORSI ACADEMY

Surgery today



SURGERY

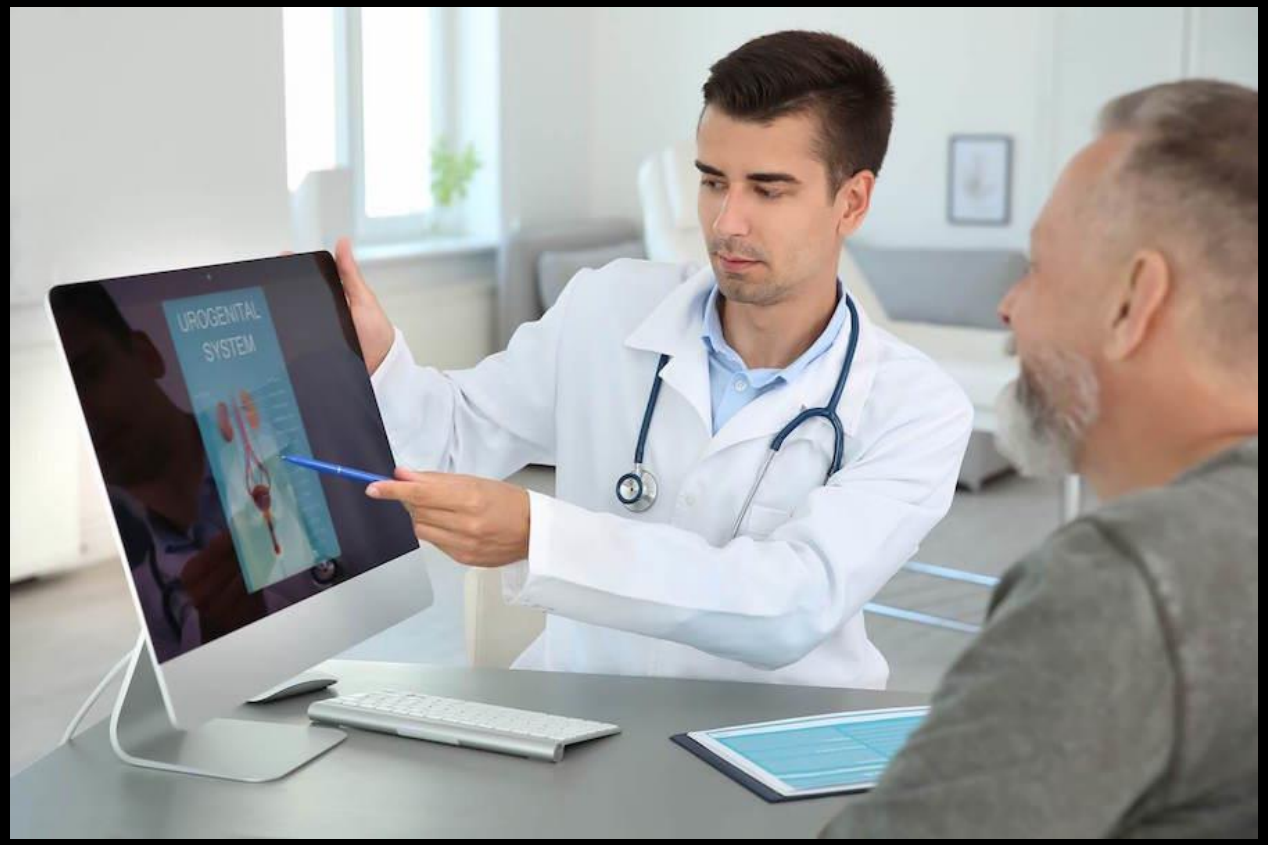
“Computer Vision”

ORSI ACADEMY

Surgery today

SURGERY

“Computer Vision”



OUTPATIENT CLINIC

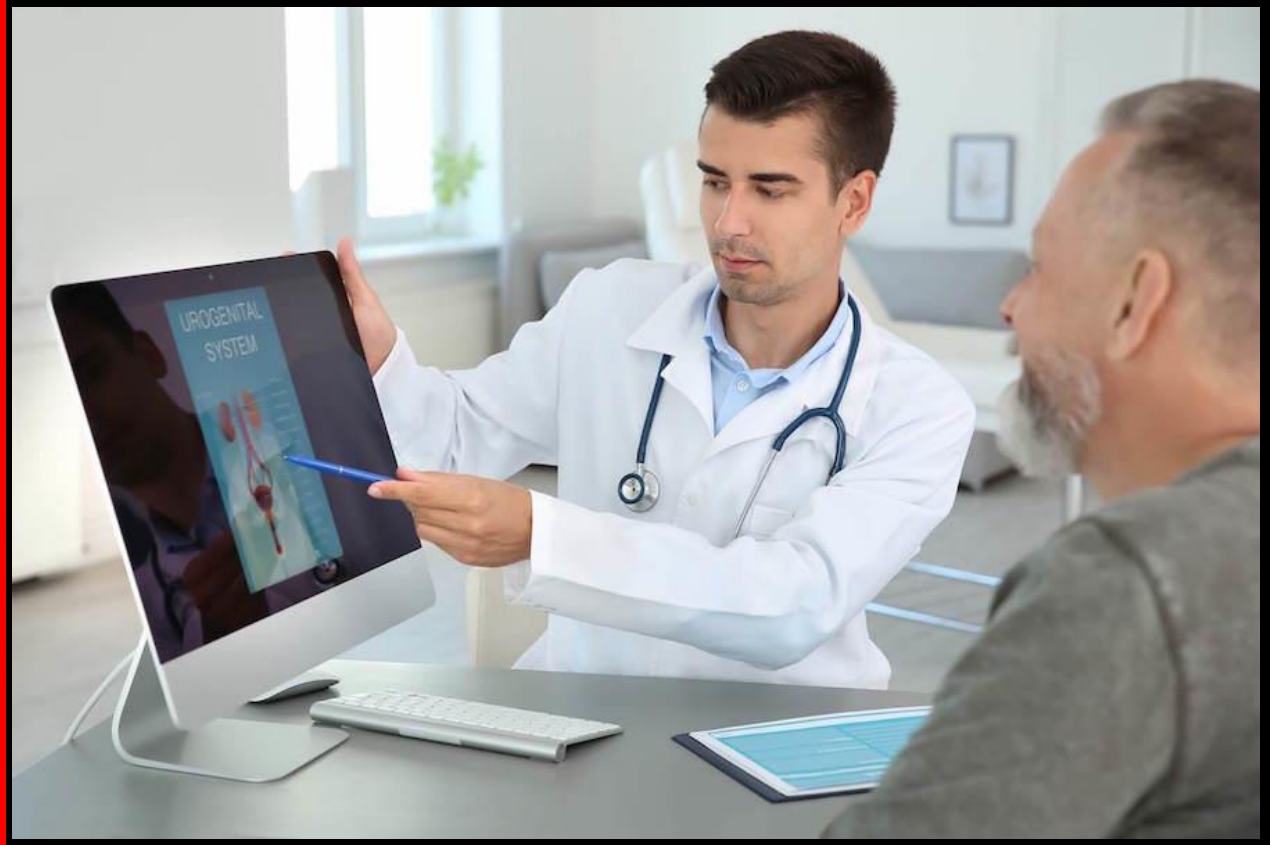
“Natural Language Processing”

ORSI ACADEMY

Surgery today

SURGERY

“Computer Vision”

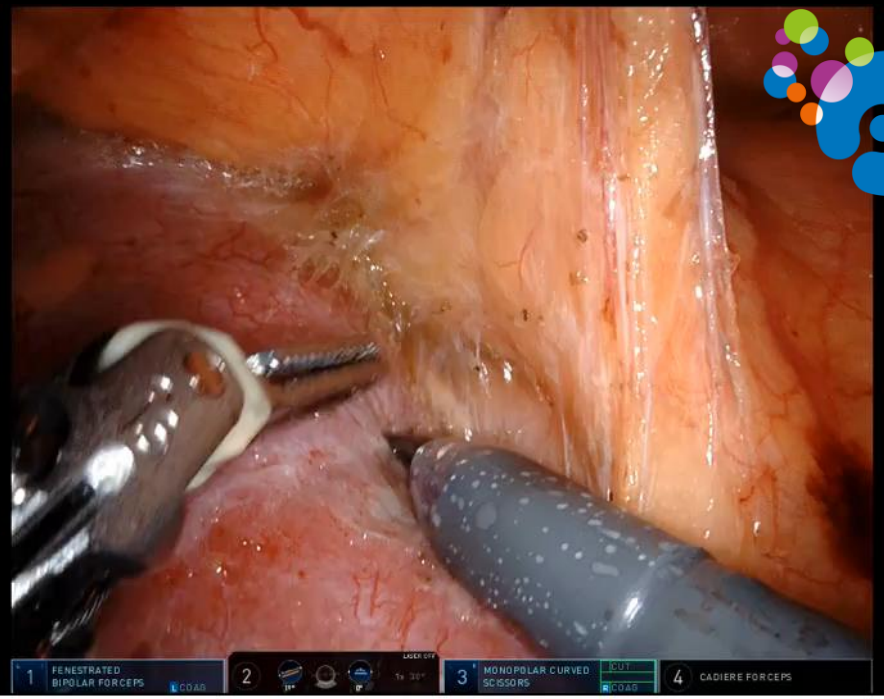


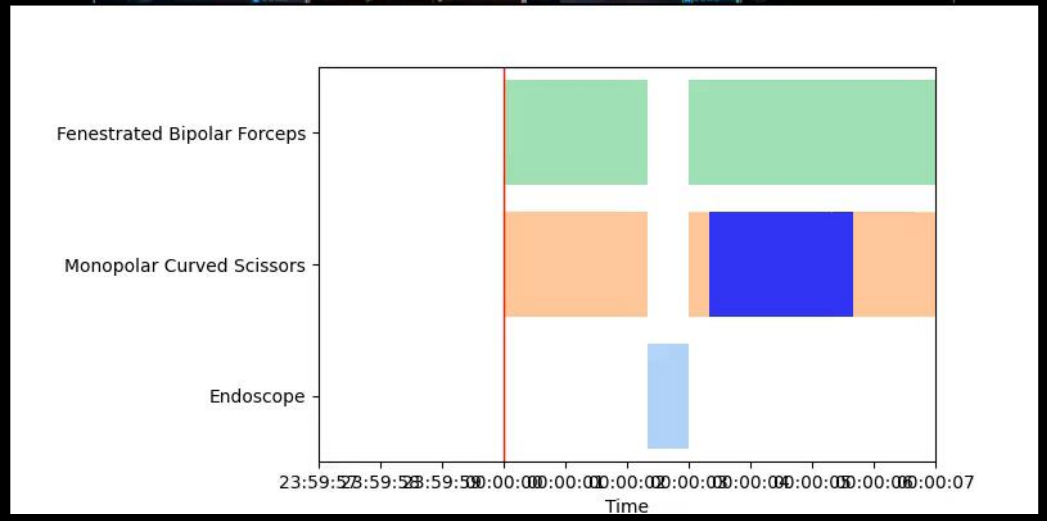
OUTPATIENT CLINIC

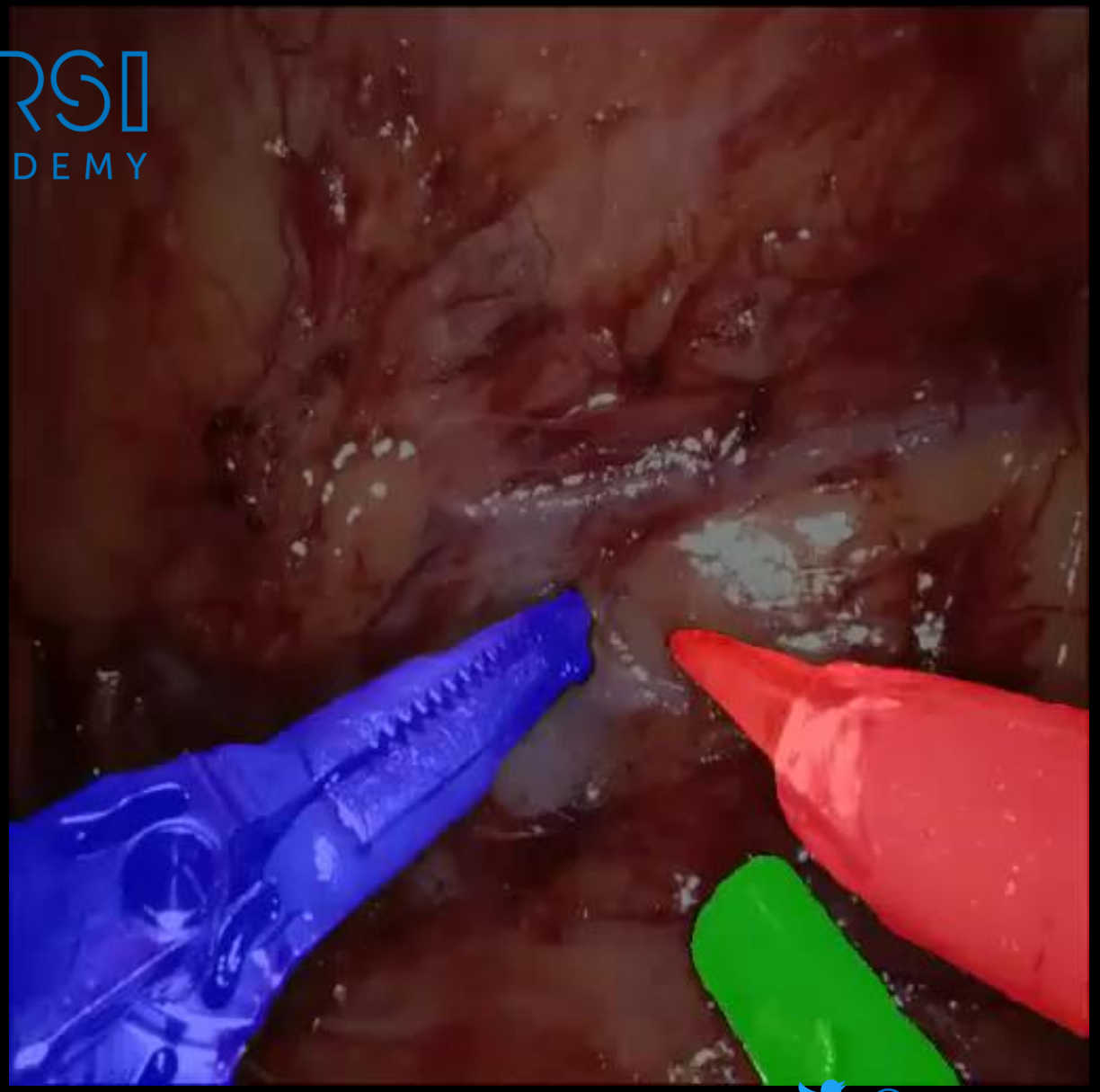
“Natural Language Processing”

ORSI ACADEMY

The basics: instrument tracking







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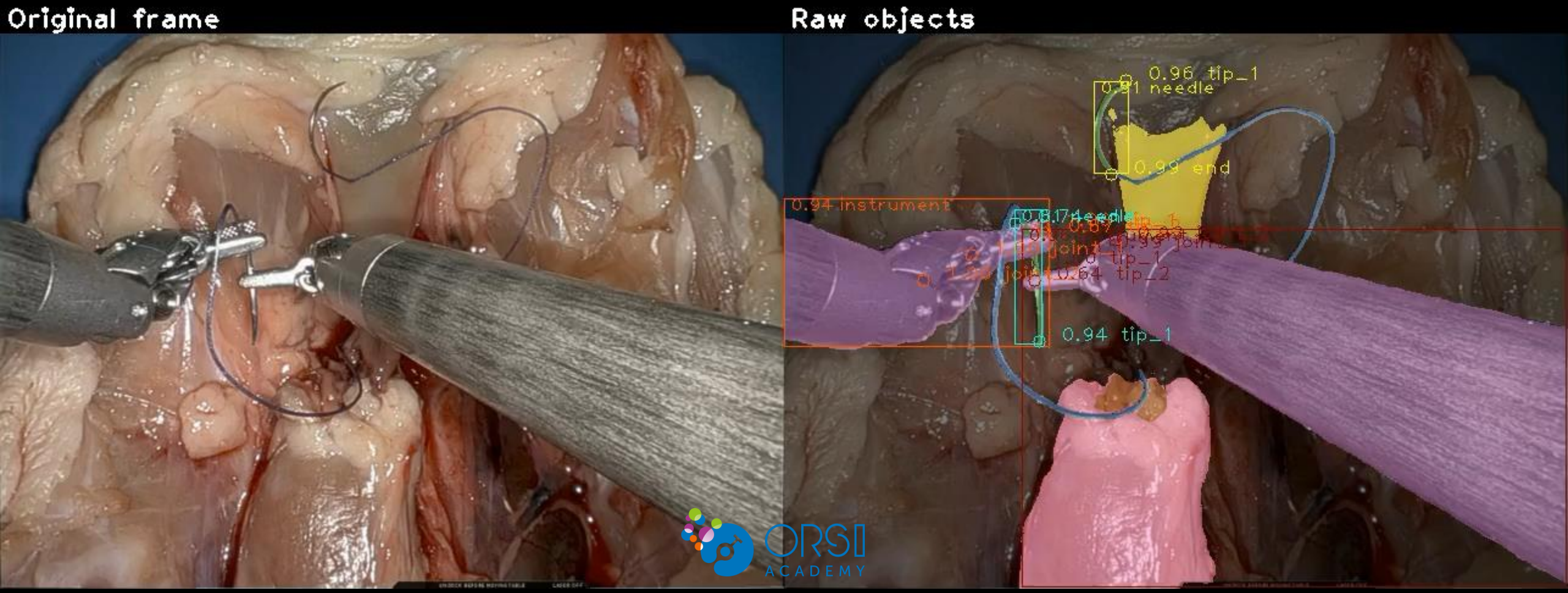
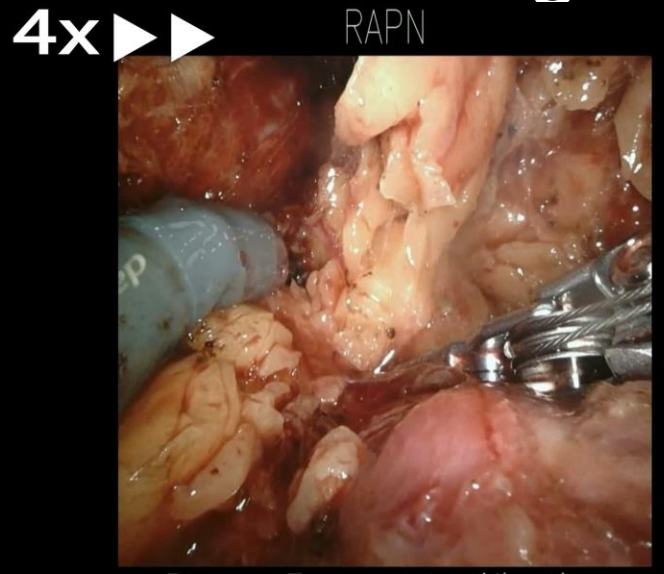
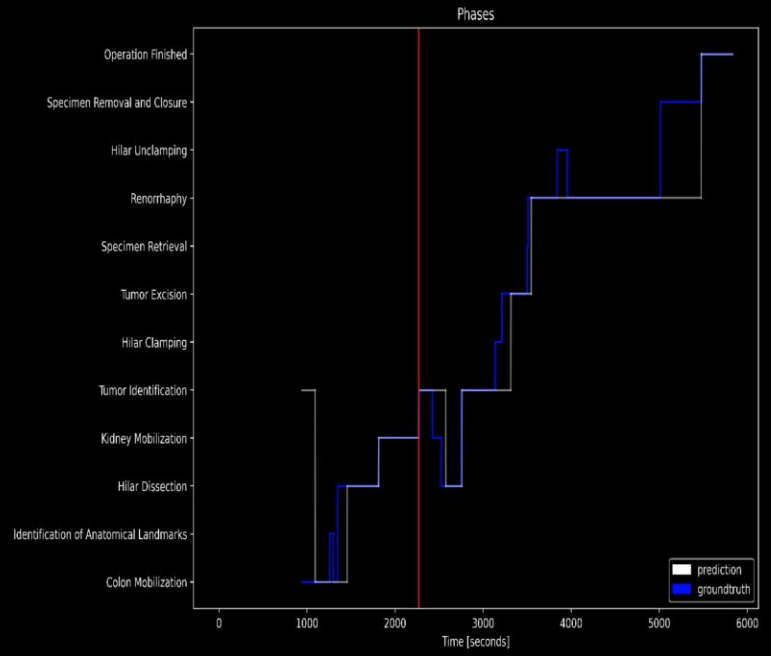
More advanced: Error detection



More advanced: surgical scene understanding

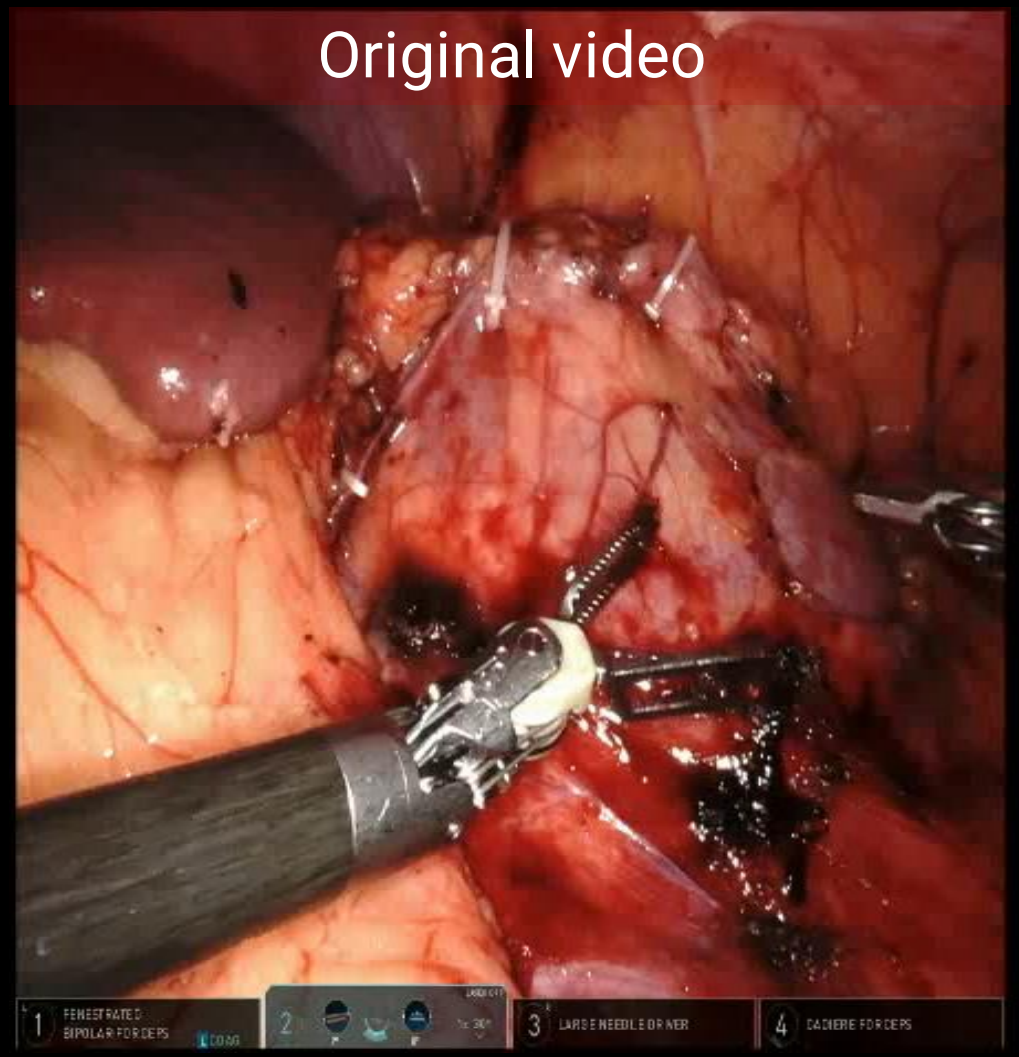




P. De Backer et al. - Surgical Phase Duration in Robot-Assisted Partial Nephrectomy: A surgical data science exploration for clinical relevance, MDPI Diagnostics 2023

Working real-time! E.g. **live** anonymization

Original video



A.I.

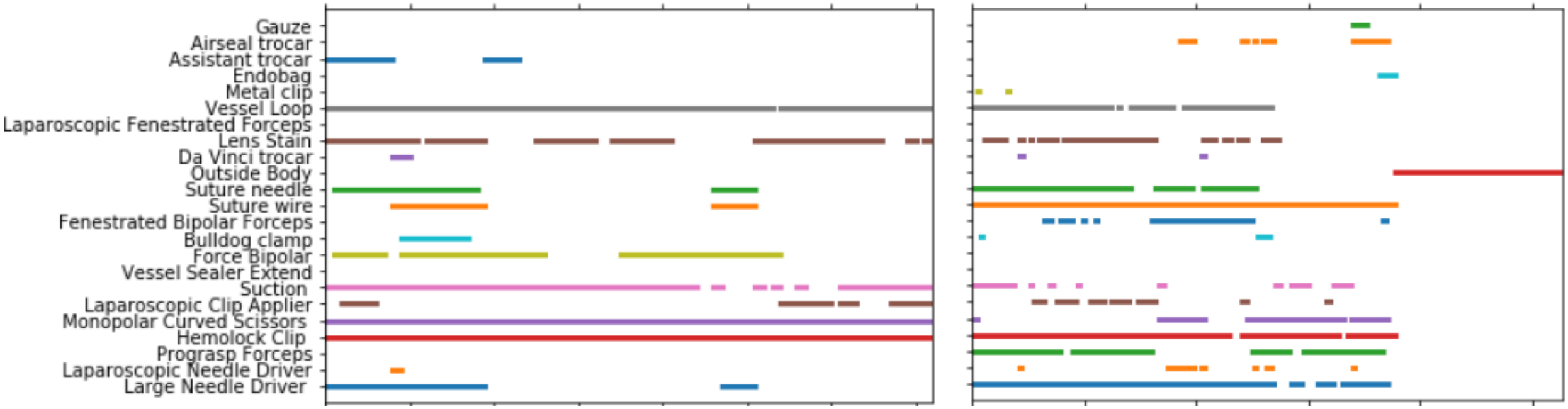
Anonymized video

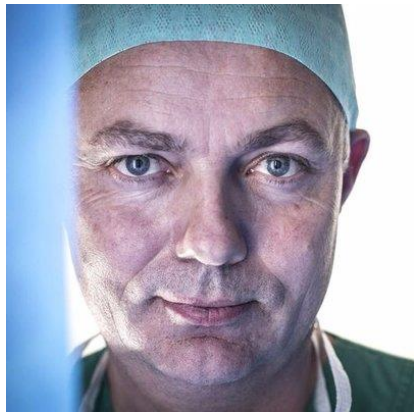
P De Backer et al - Privacy-proof Live Surgery Streaming: Development and Validation of a low-cost, Real-time Robotic Surgery Anonymization Algorithm
Annals of Surgery 2024; DOI: 10.1097/SLA.0000000000006245

Also in Orthopedics!

AI-ENHANCED

Surgical Data Science





Prof. Alex Mottrie – CEO Orsi

Surgical Trainee

AI & Automation

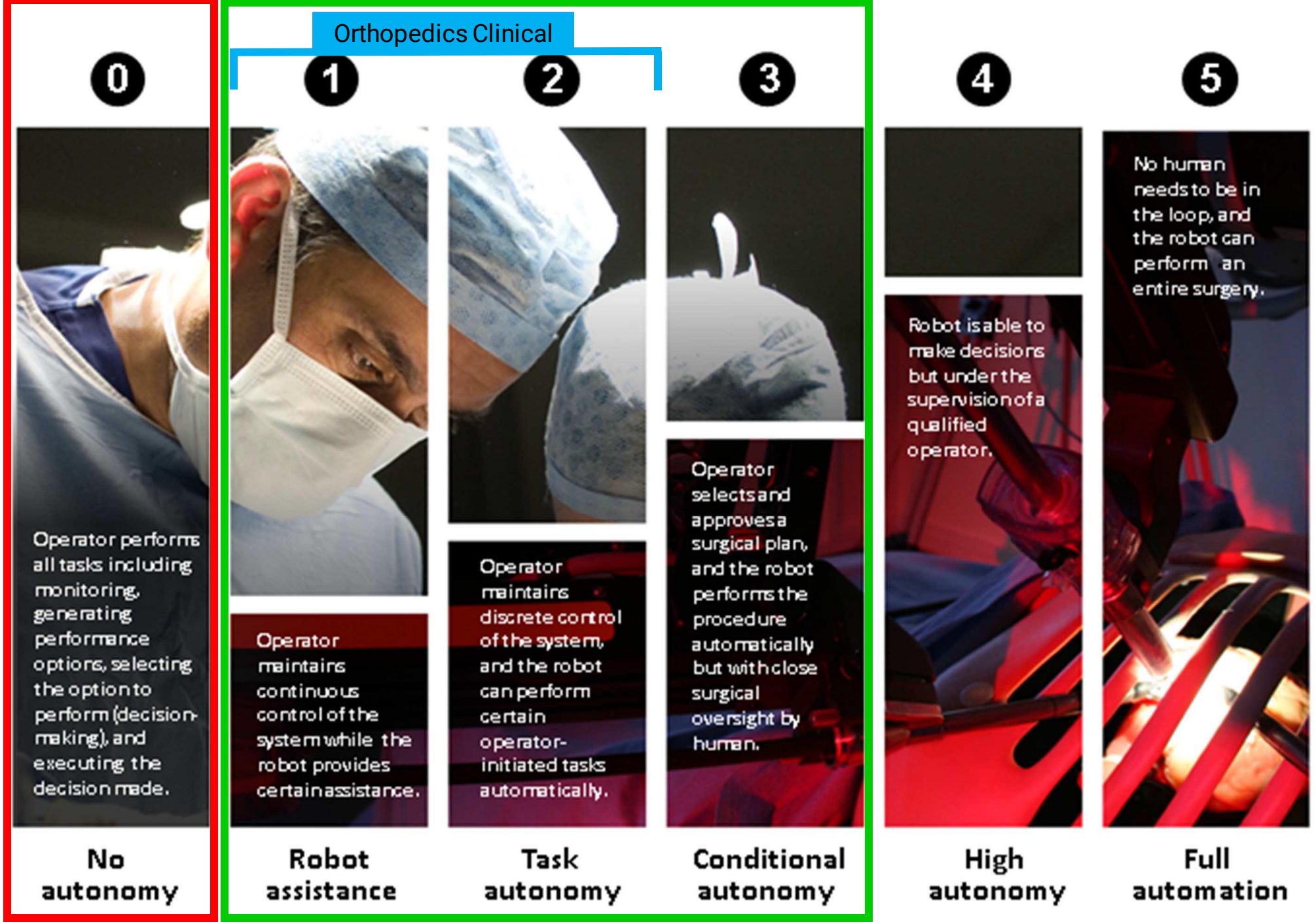
"Your robotic surgeon will see you now"

Yang et al - Medical robotics-Regulatory, ethical, and legal considerations for increasing levels of autonomy. *Science Robotics 2017*

Soft Tissue Clinical

Soft Tissue Research

Orthopedics Clinical



Yang et al - Medical robotics-Regulatory, ethical, and legal considerations for increasing levels of autonomy. *Science Robotics 2017*

Autonomous Suction to Clear the Surgical Field for Hemostasis using Image-based Blood Flow Detection

Florian Richter, Shihao Shen, Fei Liu, Jingbin Huang, Emily K. Funk,
Ryan K. Orosco, and Michael C. Yip
University of California San Diego

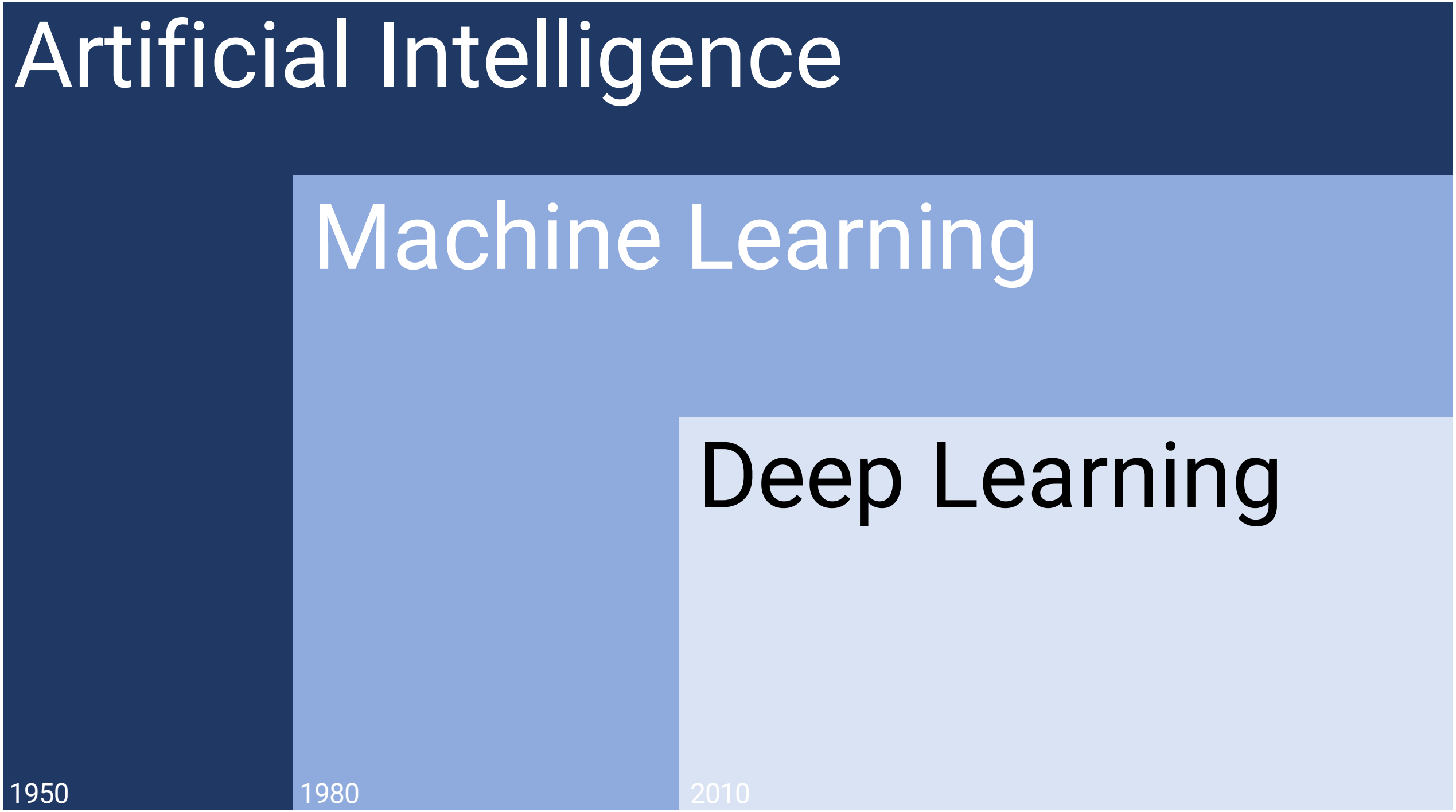
ARClab
UCSD advanced robotics and controls lab

UC San Diego

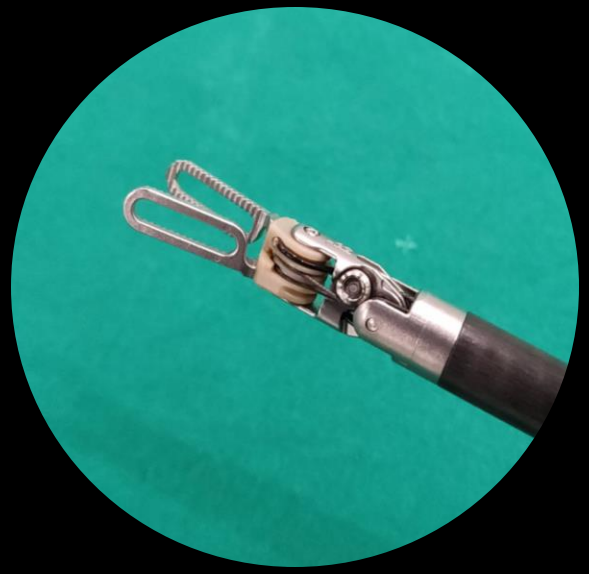
Richter, F. et al (2021). Autonomous Robotic Suction to Clear the Surgical Field for Hemostasis Using Image-Based Blood Flow Detection. IEEE Robotics and Automation Letters, 6(2), 1383–1390. https://doi.org/10.1109/LRA.2021.3056057

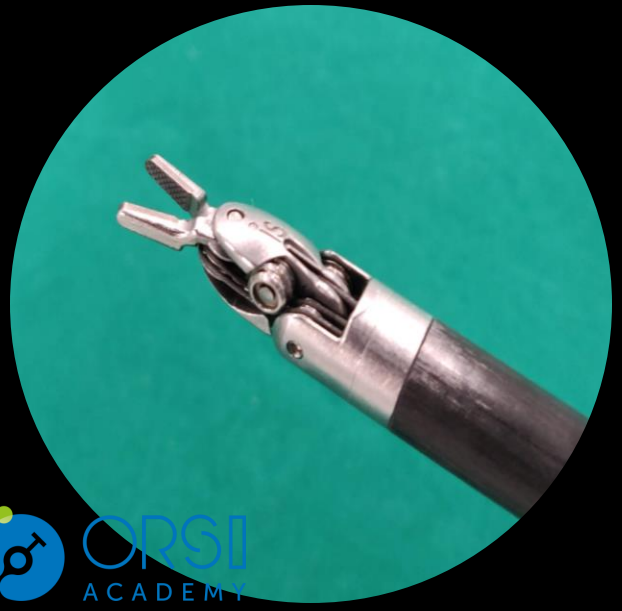
Orthopedics is leading the way!

How??


Artificial Intelligence
Machine Learning
Deep Learning
1950
1980
2010

Example: which instrument?





ORSI ACADEMY

Artificial Intelligence

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Artificial Intelligence

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If 10% of pixels are orange
Then monopolar curved scissors

ORSI ACADEMY

Artificial Intelligence

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If 10% of pixels are orange
Then monopolar curved scissors

ORSI ACADEMY

Artificial Intelligence

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If 10% of pixels are **orange**
Then monopolar curved scissors

No learning!
No real world data generalization!

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Artificial Intelligence

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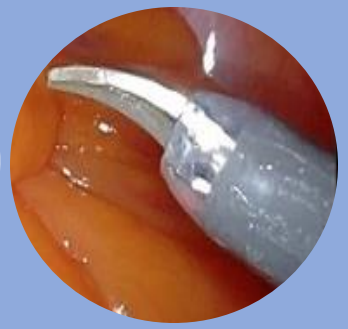
Machine Learning





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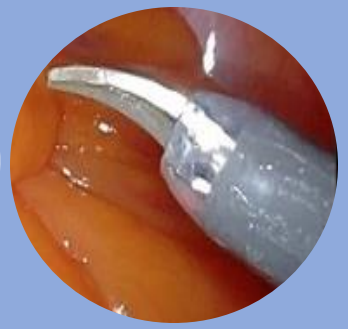
Artificial Intelligence

@pidebacker

Machine Learning





ORSI ACADEMY

Artificial Intelligence

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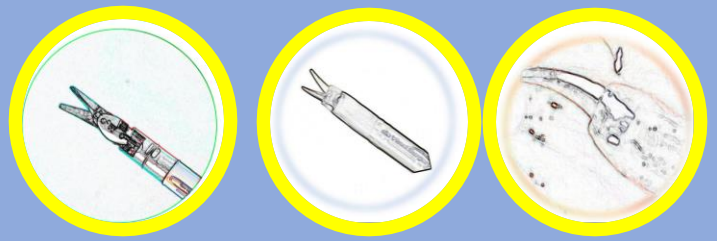
Machine Learning



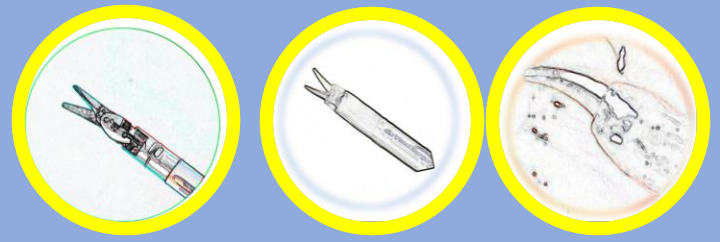
Detect edges - Number of triangles?

👷 **Feature engineering** 🤔

Artificial Intelligence

@pidebacker

Machine Learning



Detect edges - Number of triangles?

👷 Feature engineering 🤔

Amount of orange

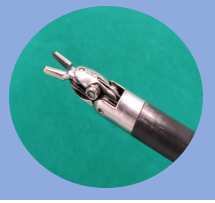
Ratio black/metal

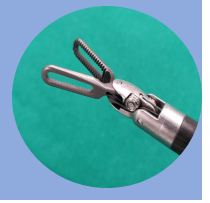
Scissor

Maryland

Needle driver

Cadiere



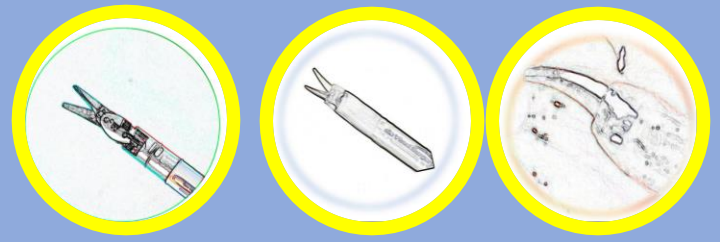


ORSI ACADEMY

Artificial Intelligence

@pidebacker

Machine Learning



Detect edges - Number of triangles?

> ??

< ??

Amount of orange

Ratio black/metal

> ??

< ??

> ??

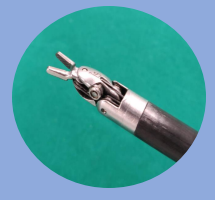
< ??

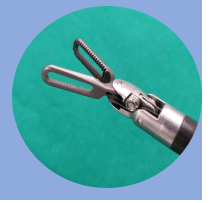
Scissor

Maryland

Needle driver

Cadiere





Feature engineering

ORSI ACADEMY

Artificial Intelligence

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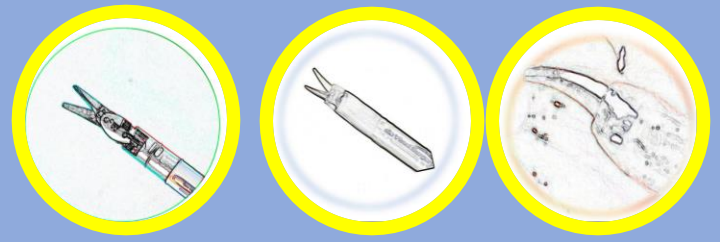
Machine Learning



Detect edges - Number of triangles?

> 2,36

< 2,36

Amount of orange

Ratio black/metal

> 9,7%

< 9,7%

> 0.8

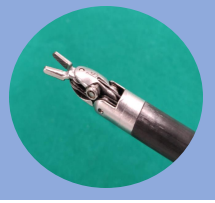
< 0.8

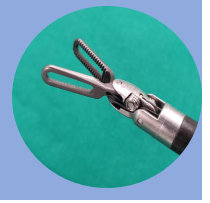
Scissor

Maryland

Needle driver

Cadiere





Feature engineering

Learn from the data
e.g. 1000 images

ORSI ACADEMY

Artificial Intelligence

@pidebacker

Machine Learning

Deep Learning

Let the algorithm learn by itself

Artificial Intelligence

@pidebacker

Machine Learning

Deep Learning

NO Feature engineering

Let the algorithm learn by itself

Artificial Intelligence

@pidebacker

Machine Learning

Deep Learning

Let the algorithm learn by itself

- ☑ Massive data input
- ☑
- ☑

Artificial Intelligence

@pidebacker

Machine Learning

Deep Learning

Let the algorithm learn by itself

- ☑ Massive data input
- ☑ Data representative for the problem
- ☑

Artificial Intelligence

@pidebacker

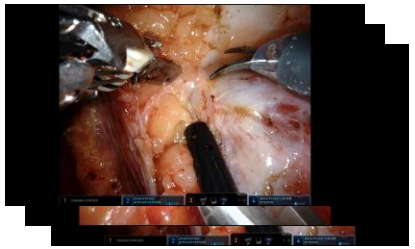
Machine Learning

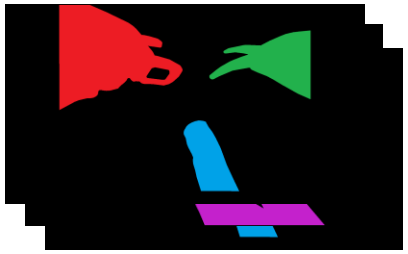
Deep Learning

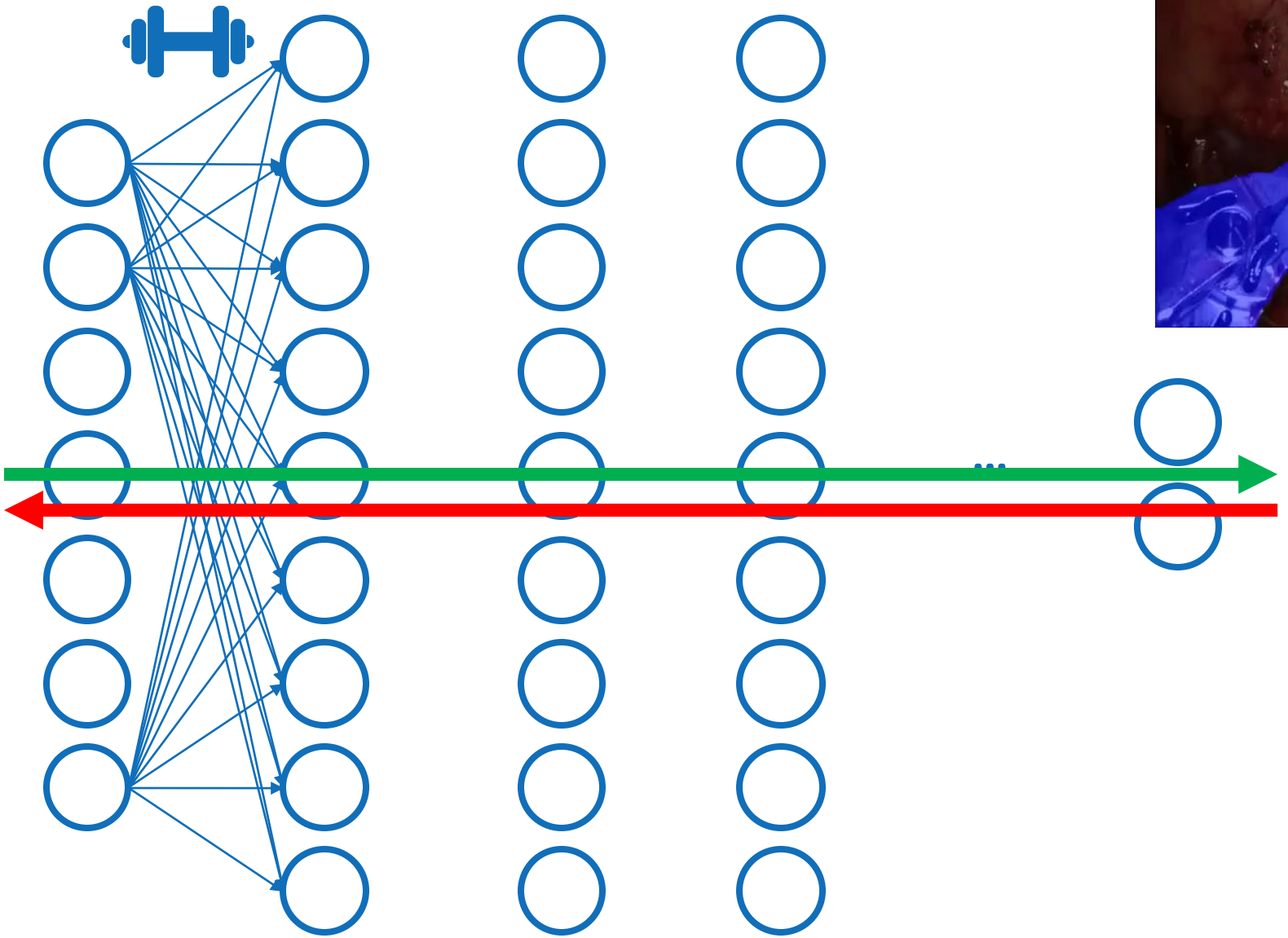
Let the algorithm learn by itself

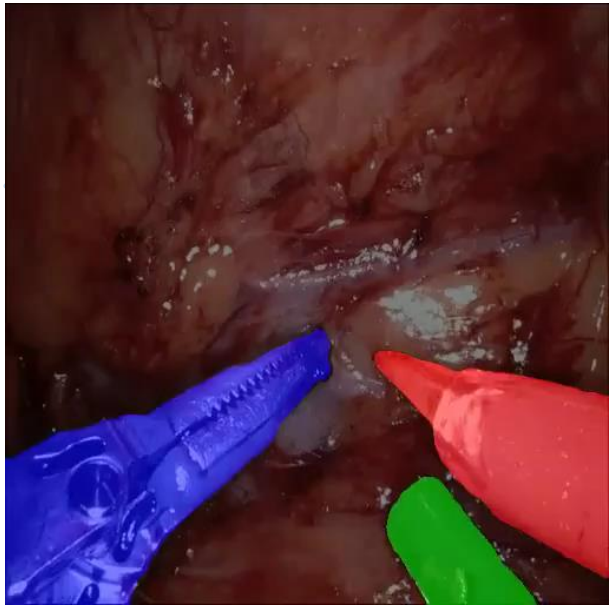
- ☑ Massive data input
- ☑ Data representative for the problem
- ☑ Look for things humans did not think of

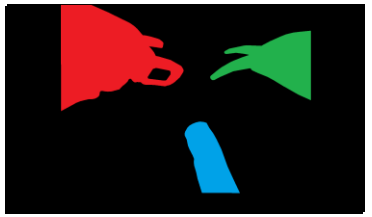
Deep Learning “Training”











ORSI ACADEMY

Deep Learning

Input image

Lowel level:
Lines and Edges

Mid level:
Shapes and Patterns

High level:
Components

Classifier

- Monopolar scissors 0,4%
- Prograps 3,3%
- Cadiere 93%
- Fenestrated Bipolar 3,3%

ORSI ACADEMY

Deep Learning

Input image

Monopolar scissors

0,4%

Prograps

3,3%

Cadiere

93%

Fenestrated Bipolar

3,3%

ORSI ACADEMY

Lowel level:
Lines and Edges

Mid level:
Shapes and Patterns

High level:
Components

Classifier

Neural Network

Input image

Eye

Monopolar scissors

0,4%

Prograps

3,3%

Cadiere

93%

Fenestrated Bipolar

3,3%

ORSI ACADEMY

Neural Network

Input image

Eye

Primary Cortex
Primitive Shapes

Monopolar scissors
0,4%

Prograps
3,3%

Cadiere
93%

Fenestrated Bipolar
3,3%

ORSI ACADEMY

Neural Network

@pidebacker

Input image

Eye

Primary Cortex
Primitive Shapes

Monopolar scissors
0,4%

Prograps
3,3%

Cadiere
93%

Fenestrated Bipolar
3,3%

Secondary Cortex
Abstract Thinking

ORSI ACADEMY

DEEP LEARNING WORKS IN

Video

Radiology

Text

DEEP LEARNING WORKS IN

Video

Radiology

3D planning

Text

Manual

No subparts…

DEEP LEARNING WORKS IN

Video

Radiology

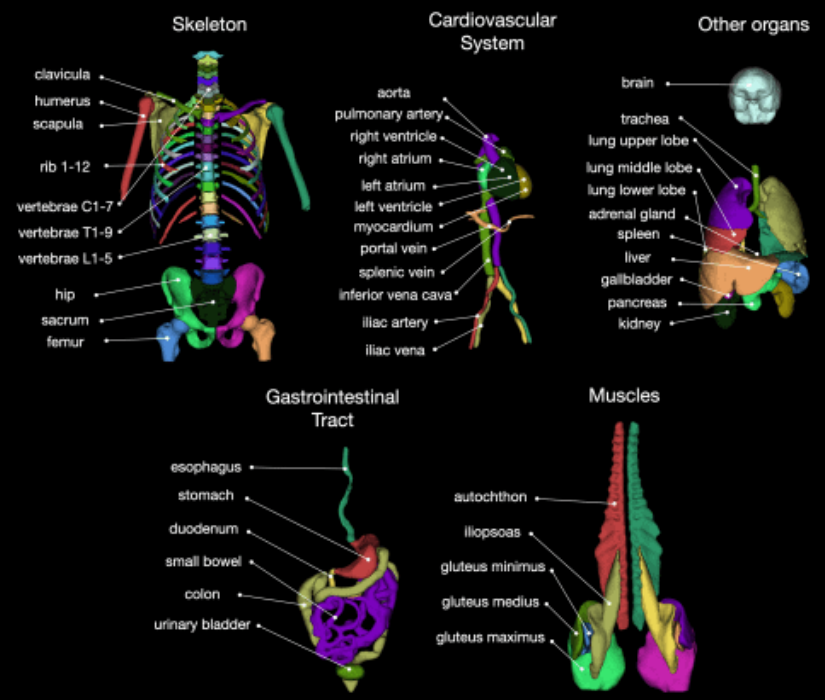
3D planning

Text

Manual

No subparts…

A.I.



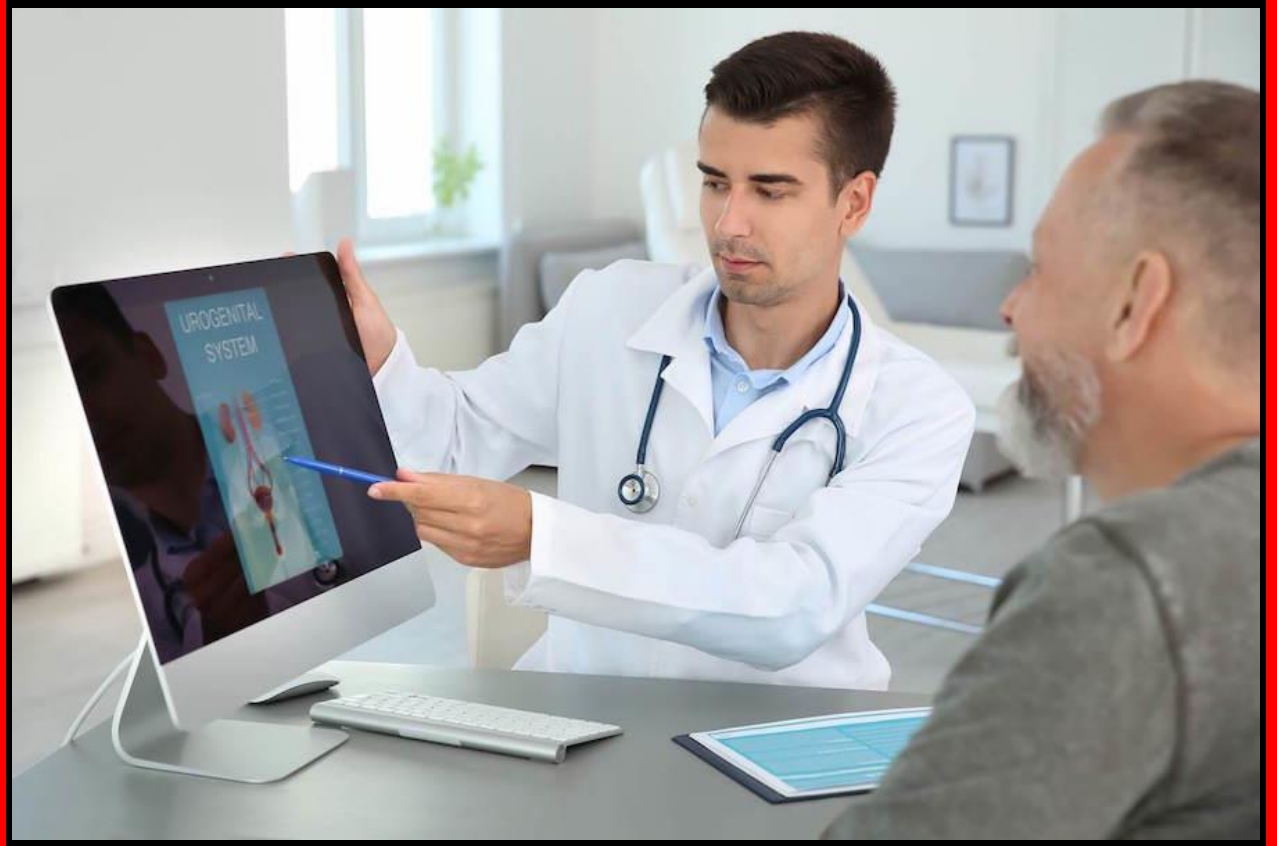
TotalSegmentator: Wasserthal et al, 2022

Personal project – Implementing on websites! 3D planning anywhere! Reach out if of interest!

Surgery today

SURGERY

“Computer Vision”

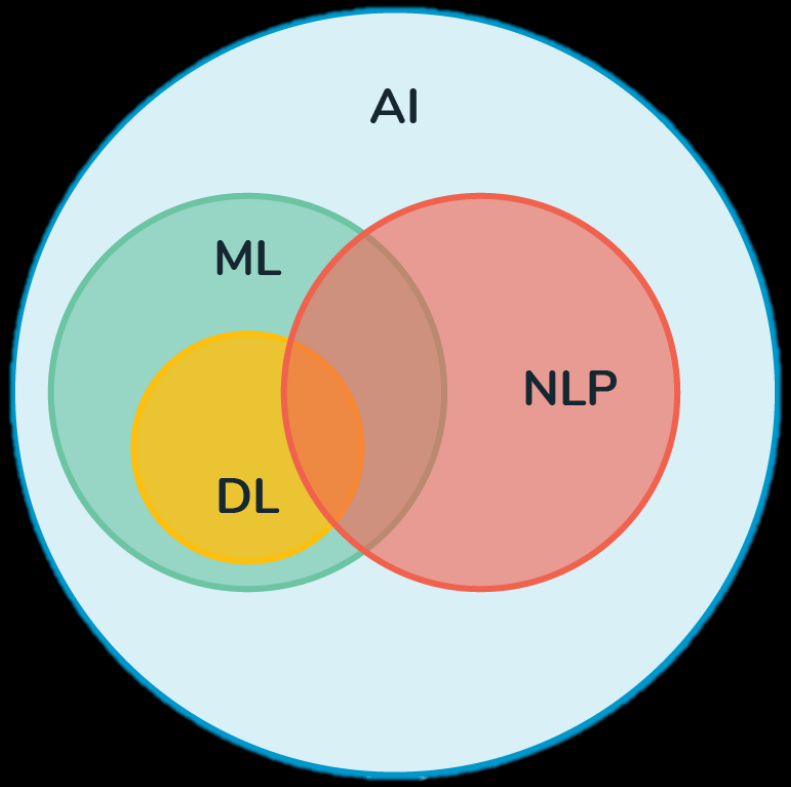


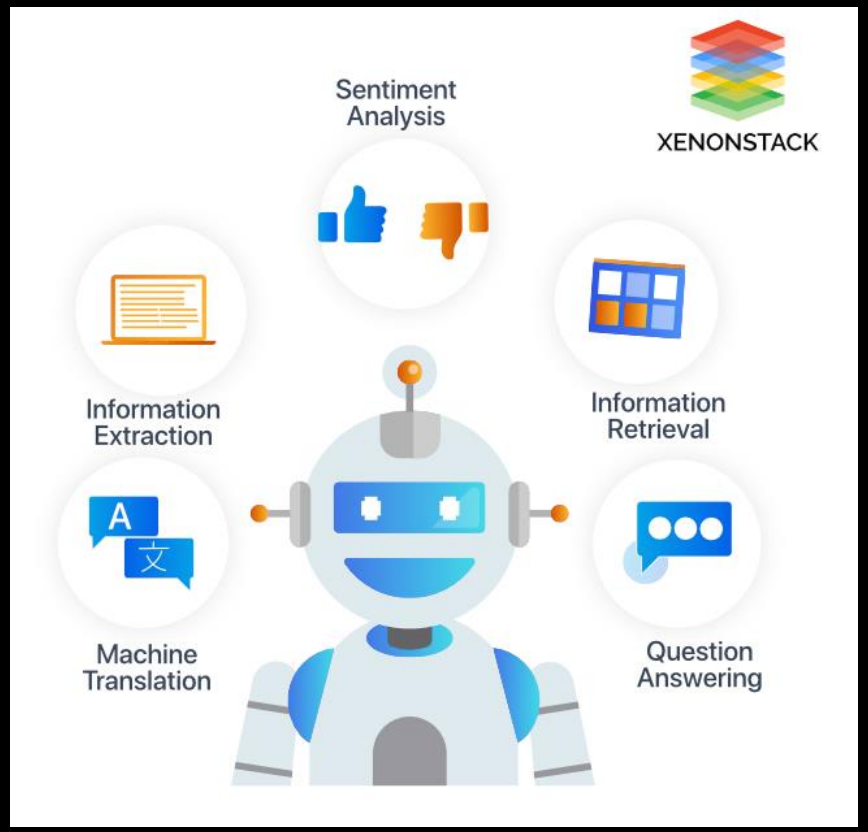
OUTPATIENT CLINIC

“Natural Language Processing”

NLP = Natural Language Processing

A.I. understanding text and speech like humans

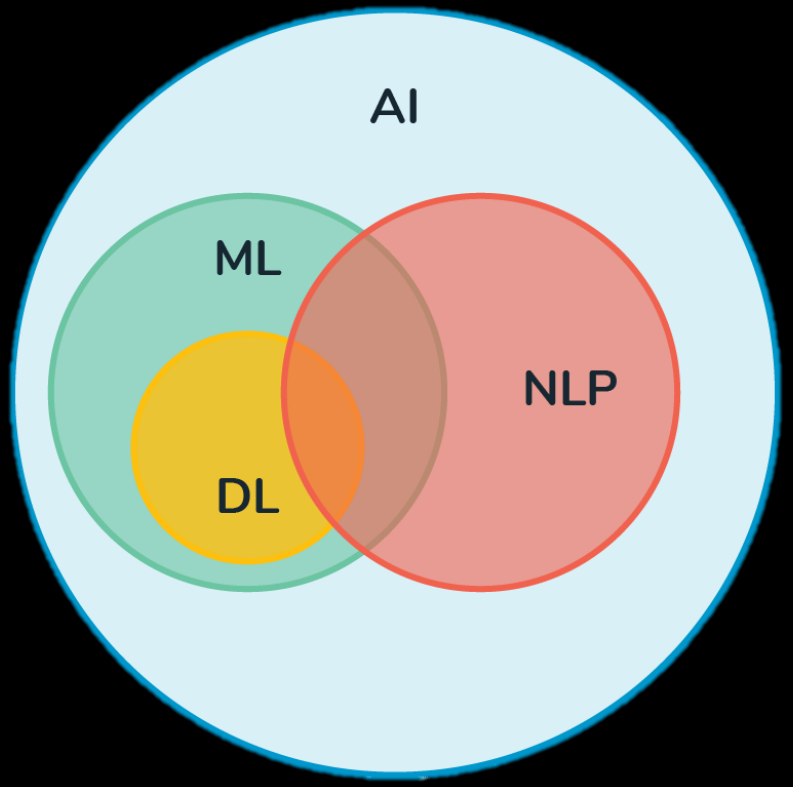


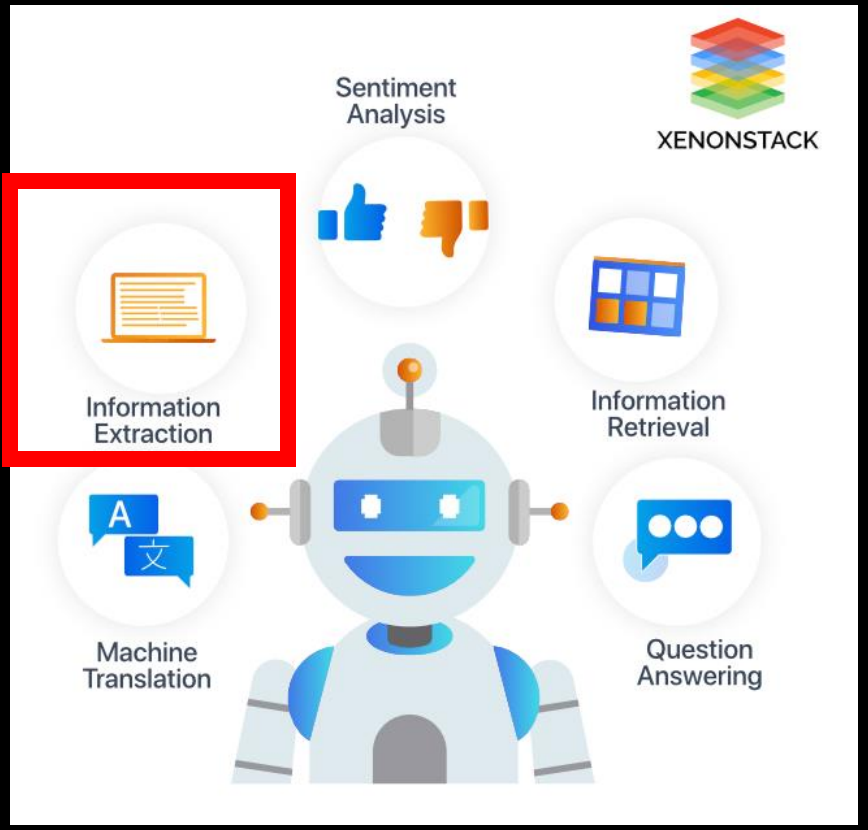


Sentisum.com / Xenonstack.com

NLP = Natural Language Processing

A.I. understanding text and speech like humans





Inova Fairfax Hospital Department of Medicine
Suggested Discharge Summary Format
(Modified from OU-Tulsa Department of Internal Medicine)

Patient Name:
Admission Date:
Discharge Date:
Attending Physician:
Dictating Physician:
Admitting Diagnosis:
Discharge Diagnosis:
Principal discharge diagnosis (reason for hospital stay after hospital assessment)
Other discharge diagnoses which were addressed during hospital stay (Complete list of active problems addressed during hospital stay)
Consultations: (name and specialty)
Procedures: (Name of procedure and concise description of results, only major studies)
Complications (for primary and other discharge diagnoses):
History and Hospital Course:
A concise summation of clinical course. Begins from time of admission with a brief summary (one paragraph) of key data from H&P. Then, use a problem-oriented approach by writing a separate paragraph for each problem title followed by a short synopsis of the evaluation, treatment and progress of each problem. Problems should match diagnosis above. Must describe to what the problem was attributed, the intervention(s) which occurred and the outcome.
Avoid a laundry list of lab values: For example, simply say, "Chest X-Ray was unremarkable; CBC, serum chemistries, were normal with the exception of elevated potassium of 6.3." Do include lab values that will be of use in clinic follow-up – e.g. HbA1C, lipid profile, TSH. Results of procedures documented under "procedures" can be referred to and do not need to be repeated.
Discharge plan:
Condition upon discharge:
Activity:
Diet:
Date of next appointment and physician who will see patient
Medications at discharge:
Do not simply state "resume home medications."
Issues to be addressed at follow-up:
History and Hospital Course:
A concise summation of clinical course. Begins from time of admission with a brief summary (one paragraph) of key data from H&P. Then, use a problem-oriented approach by writing a separate paragraph for each problem title followed by a short synopsis of the evaluation, treatment and progress of each problem. Problems should match diagnosis above. Must describe to what the problem was attributed, the intervention(s) which occurred and the outcome.
Avoid a laundry list of lab values: For example, simply say, "Chest X-Ray was unremarkable; CBC, serum chemistries, were normal with the exception of elevated potassium of 6.3." Do include lab values that will be of use in clinic follow-up – e.g. HbA1C, lipid profile, TSH. Results of procedures documented under "procedures" can be referred to and do not need to be repeated.
Discharge plan:
Condition upon discharge:
Activity:
Diet:
Date of next appointment and physician who will see patient
Medications at discharge:
Do not simply state "resume home medications."
Issues to be addressed at follow-up:
CC: Please instruct transcriber to cc all physicians who will follow up with the patient, especially the PCP.

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ChatGPT

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How does it learn to write as a surgeon?

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ChatGPT Input

“ChatGPT is a powerful natural _____ processing tool that is increasingly _____ in academic writing and research owing to its theoretically unlimited possible _____.”

Piazza P, …, Cacciamani GE; YAU; The Long but Necessary Journey Towards Optimization of the Cause-Effect Relationship Between Input and Output for Accountable Use of ChatGPT for Academic Purposes. Eur Urol Focus. 2023

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Desired Output

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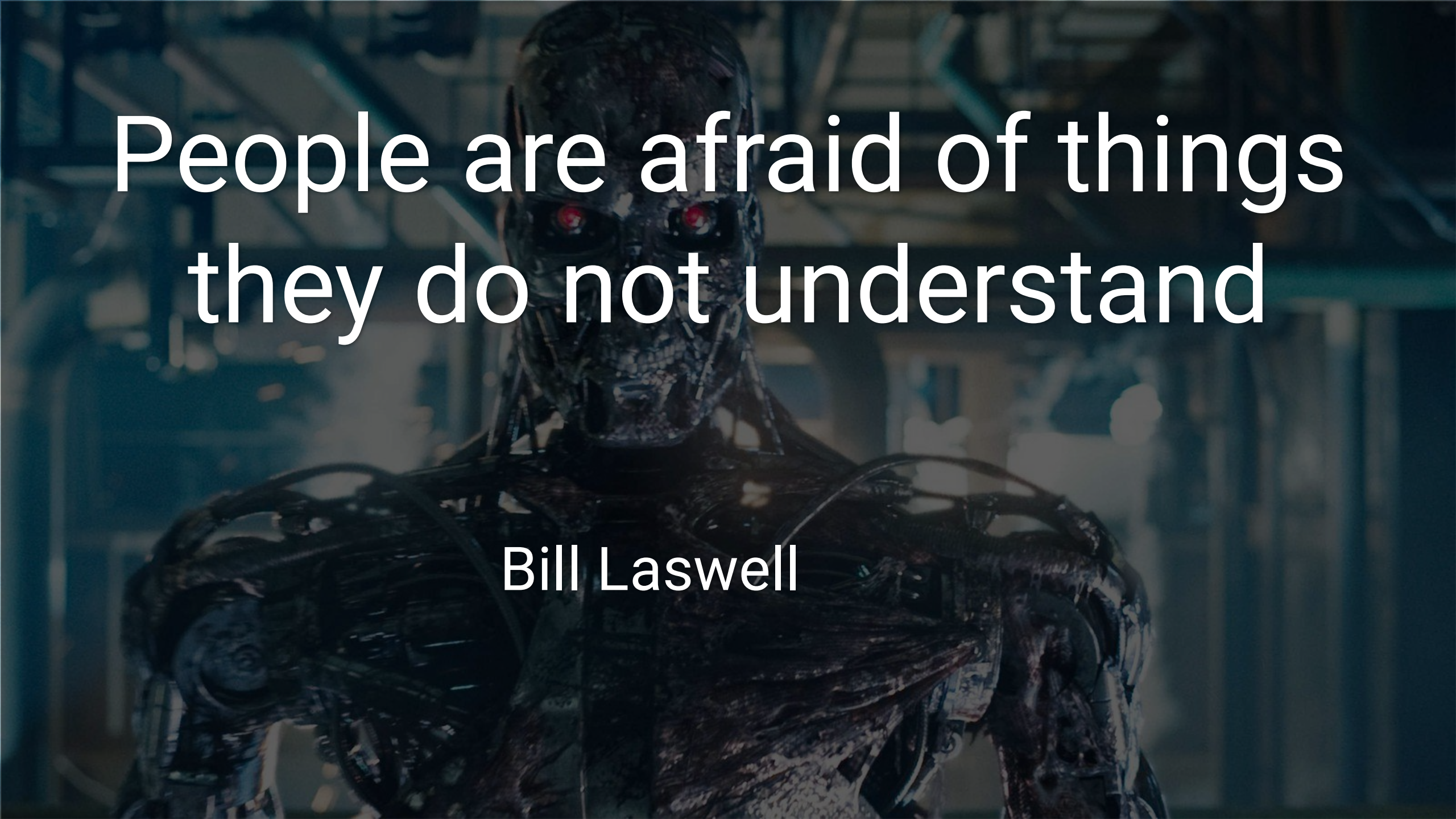
People are afraid of things they do not understand
Bill Laswell

Let’s get acquainted!

AI is an opportunity and not a threat!

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Thesis, fellowships AI in surgery,...

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