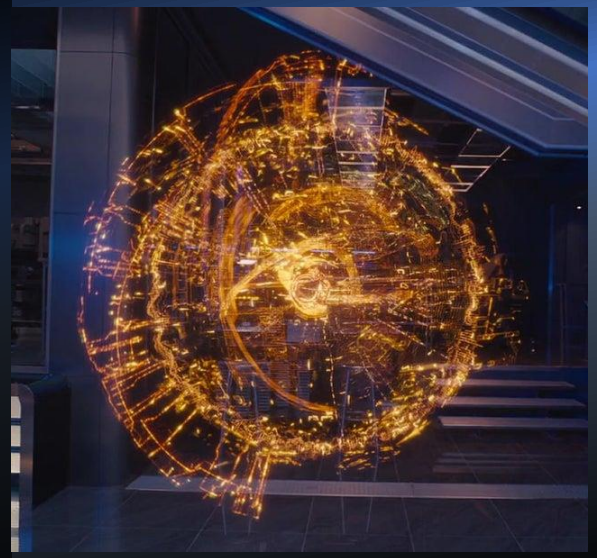
Computational Collective Surgical Consciousness



Intelligent Health 2022

Basel, Switzerland – September 8, 2022

Ozanan R. Meireles, MD, FACS

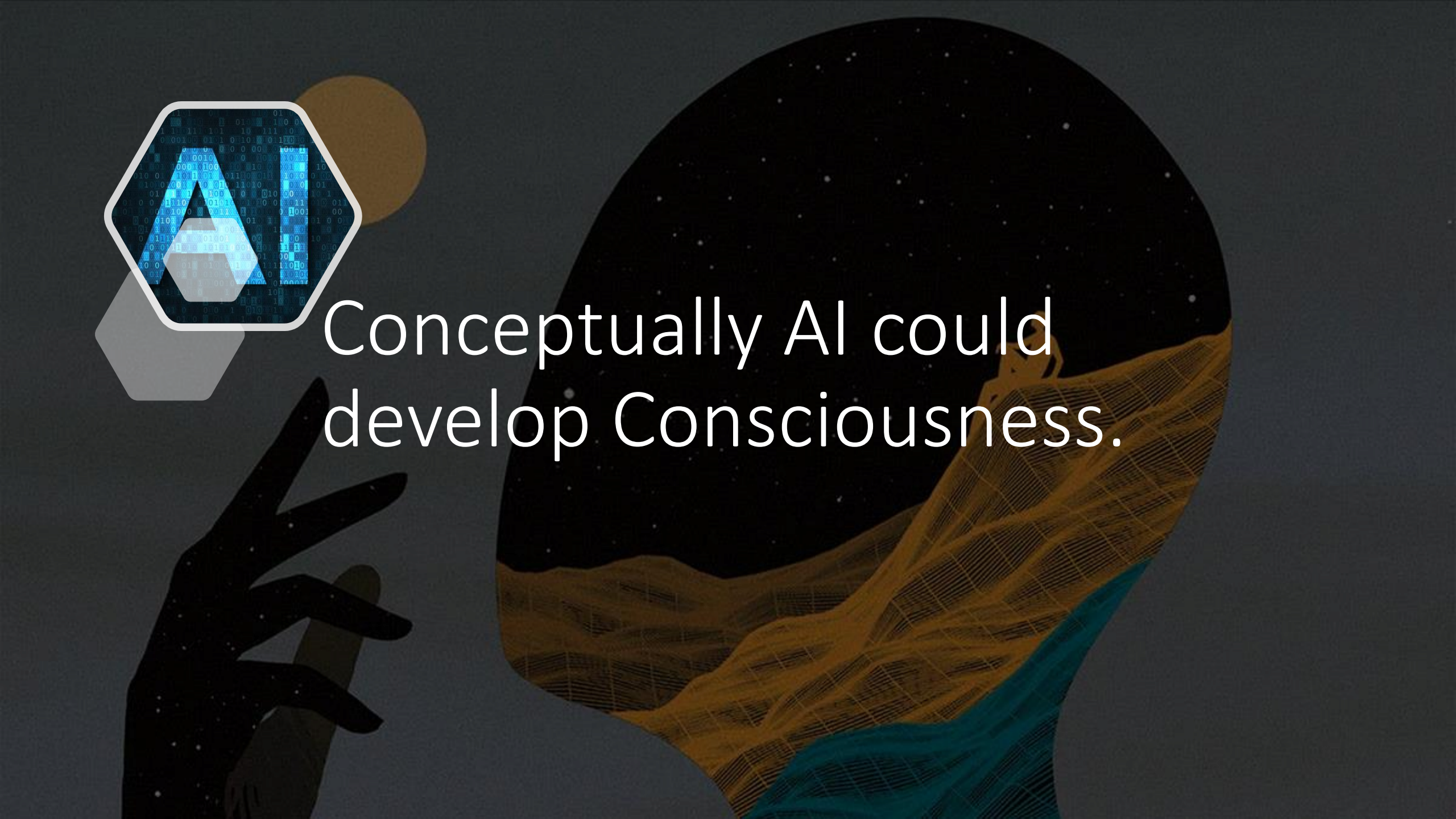
Assistant Professor of Surgery - Harvard Medical School

Massachusetts General Hospital

@MGHSAIIL @Oz_Meireles

MASSACHUSETTS GENERAL HOSPITAL

HARVARD MEDICAL SCHOOL



Conceptually AI could develop Consciousness.

Consciousness: The awareness of internal and external existence.

The state of being aware of and responsive to one's surroundings.

Collective Consciousness:

The set of shared beliefs, ideas, and moral attitudes which operate as a unifying force within society. In general, it does not refer to the specifically moral conscience, but to a shared understanding of social norms and concepts.

Collins Dictionary of Sociology, p93.

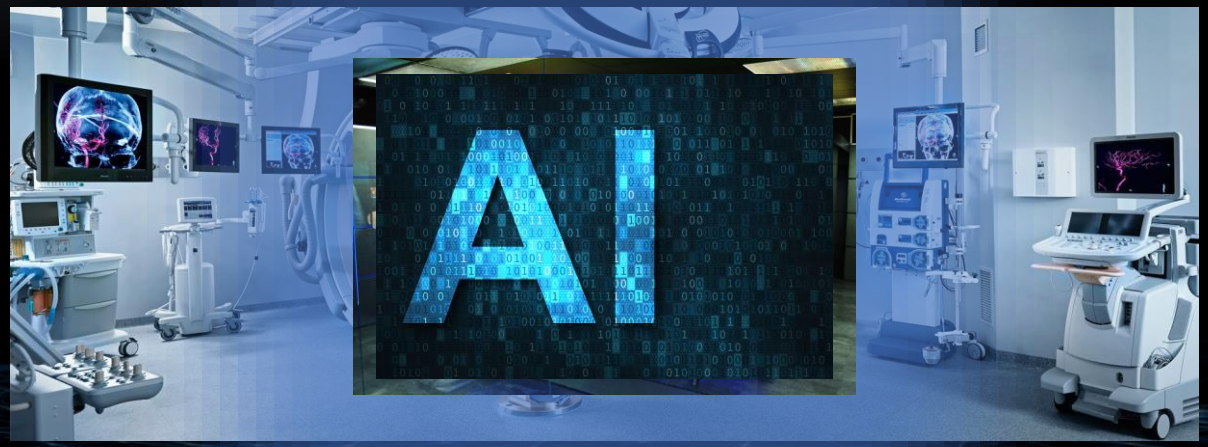
SURGERY

The oldest reports of surgical procedures are dated from 6,500 B.C. where archaeological findings in France reviewed human skulls with drilled holes due to Trepanation.

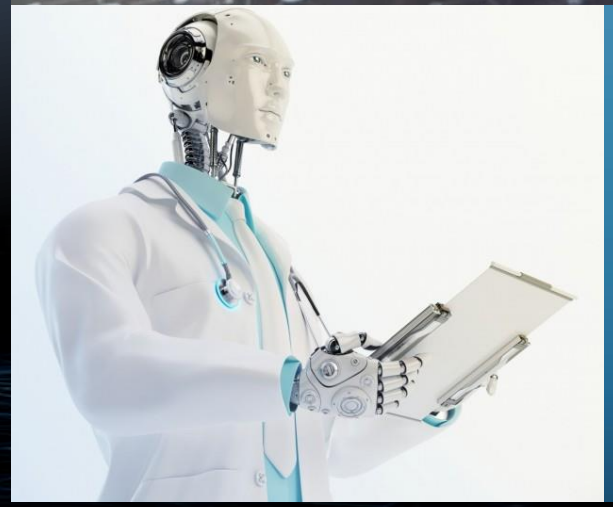
Modern surgery only started to be developed in the late 1800s

Surgical Revolutions (in last 200 years)

- General Anesthesia – 1840s
- Antiseptic Surgery – 1860s
- Endoscopic Procedures – 1960s
- Cognitive Computing – 2010s



What is happening in the Operating Room now ?



OR Data Generation

Hardware (instruments, Robotics)	Software (Data, Algorithms)	Human Operators (MD, RN, Biomed, IT,)	Telecom
Human (professional preparedness)	Economics (business plan)	Governance	Data ownership

Data sources and Analytics

EHR

Intra-operative data

Outcome registries

Scientific Research

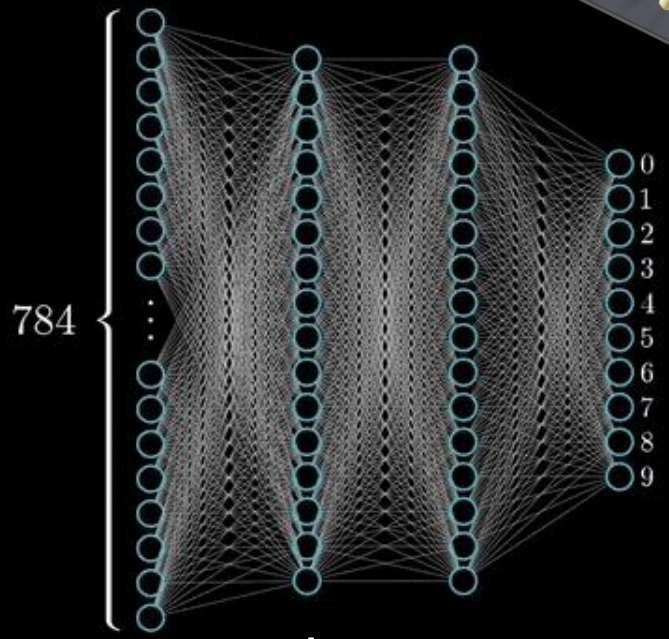
NLP

ML Big DATA mining

CV

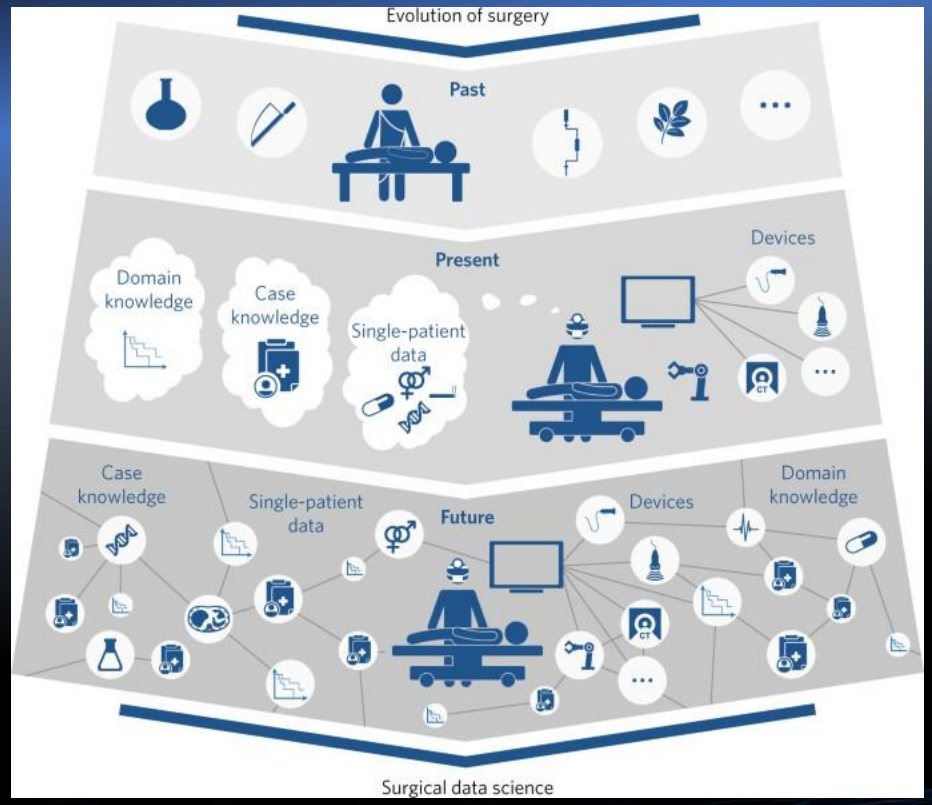
Video DATA

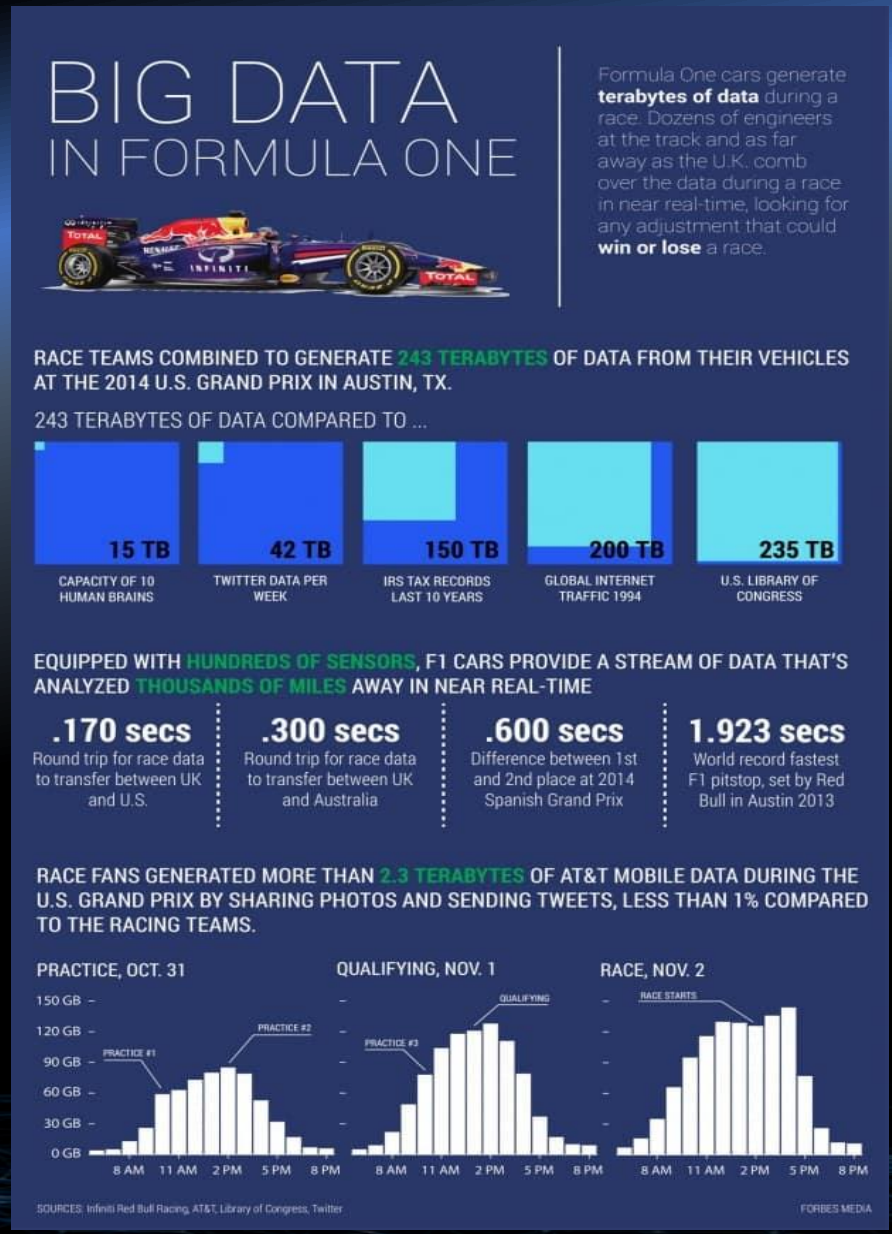
More computing power



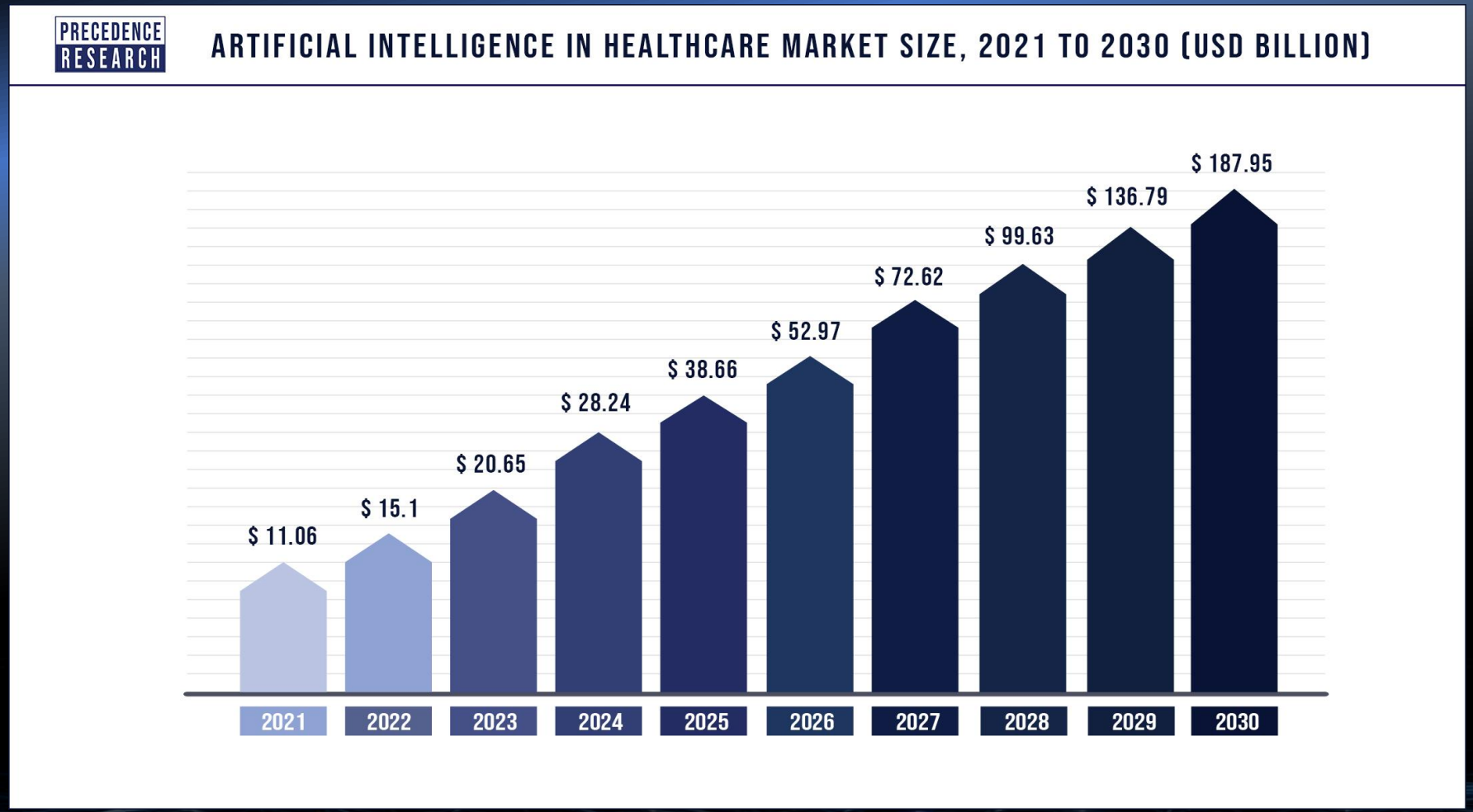
More powerful/efficient techniques

Large amount of DATA





The global market size of artificial intelligence in healthcare was estimated at US$ 11.06 billion in 2021 and is expected to surpass around US$ 187.95 billion by 2030, growing at a CAGR of 37% during the forecast period 2022 to 2030.



Precedence Research - Artificial Intelligence (AI) in Healthcare Market Size 2022-2030

Healthcare in 2065

Patient centred healthcare: Everything from diagnosis, drugs to devices will be custom designed to seamlessly integrate into a patient's daily life.

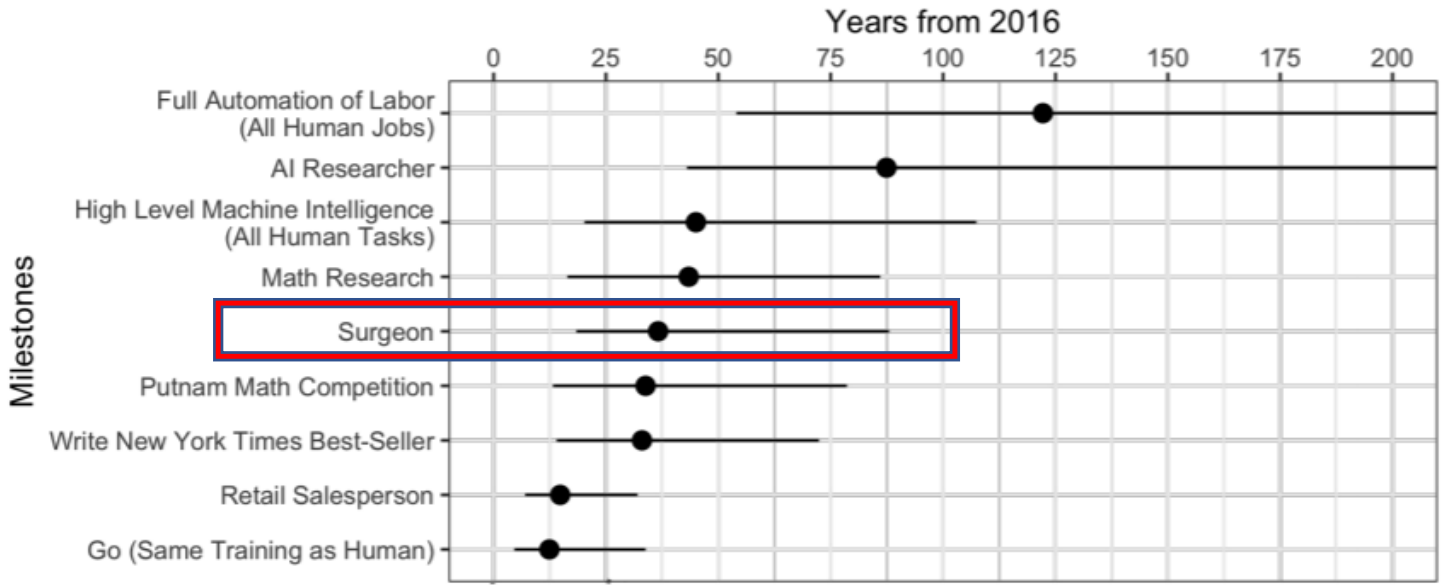
Wearables at the forefront: Always on and constantly collecting data, these peripherals are the basis of the medicalised quantified self.

Digitised and decentralised doctors: Improved connectivity and miniaturised diagnostic technology means accessibility and convenience for future medical consultations.

Rise of the machines: Medical robots and artificial intelligence create more efficient healthcare platforms that are powered by the insights of data analytics.

Evolved healthcare provision: Services will now be consumed continuously lending itself to a subscription based business model that focuses on high productivity and asset light strategies.

Researchers from Oxford University and Yale predict that all industries, including **healthcare**, could become significantly more reliant on machine intelligence by the middle of the century – and that machines may be able to automate all human jobs in less than 120 years



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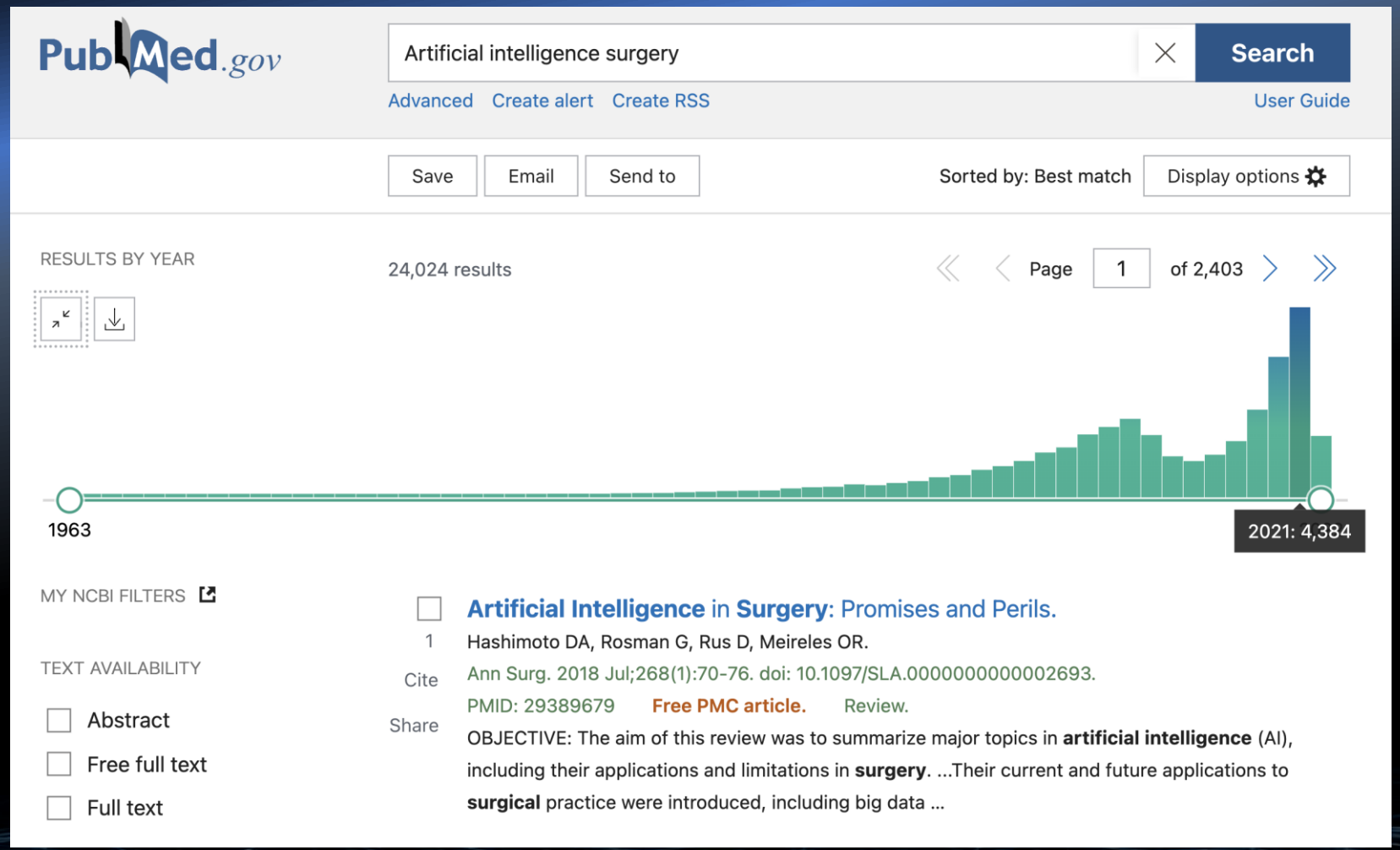
Scientific publications

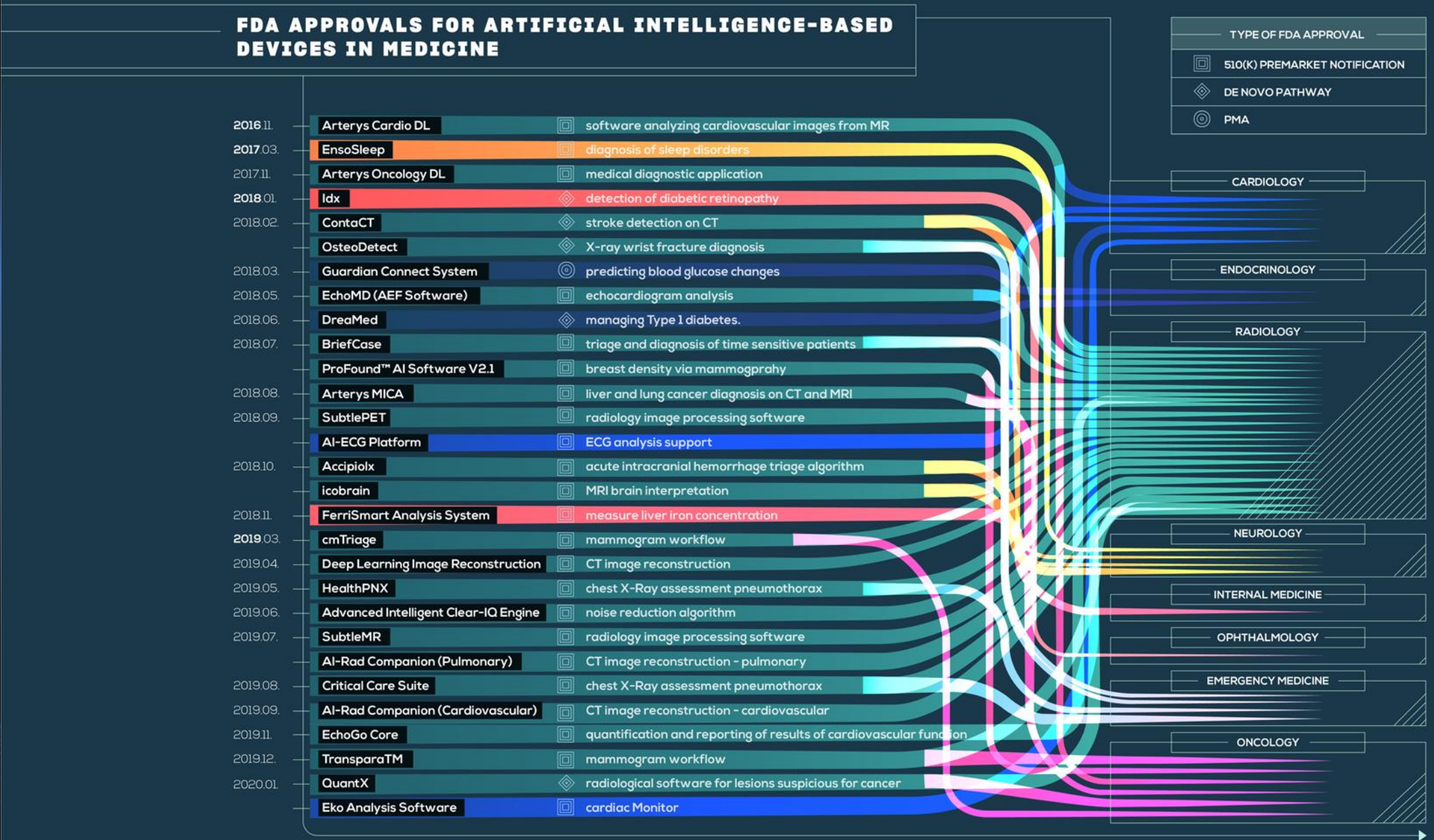
Search performed on April 17, 2022

PubMed_Timeline_Results_by_Year

Search query: Artificial intelligence surgery	
Year	Count
2022	1362
2021	4384
2020	3219
2019	1979
2018	1239
2017	919
2016	770
2015	882
2014	1381
2013	1762
2012	1573
2011	1396
2010	1091



FDA APPROVALS FOR ARTIFICIAL INTELLIGENCE-BASED DEVICES IN MEDICINE



AI + Big DATA = Cognitive Augmentation

Information, Guidance, and Intervention

Experimental Phase

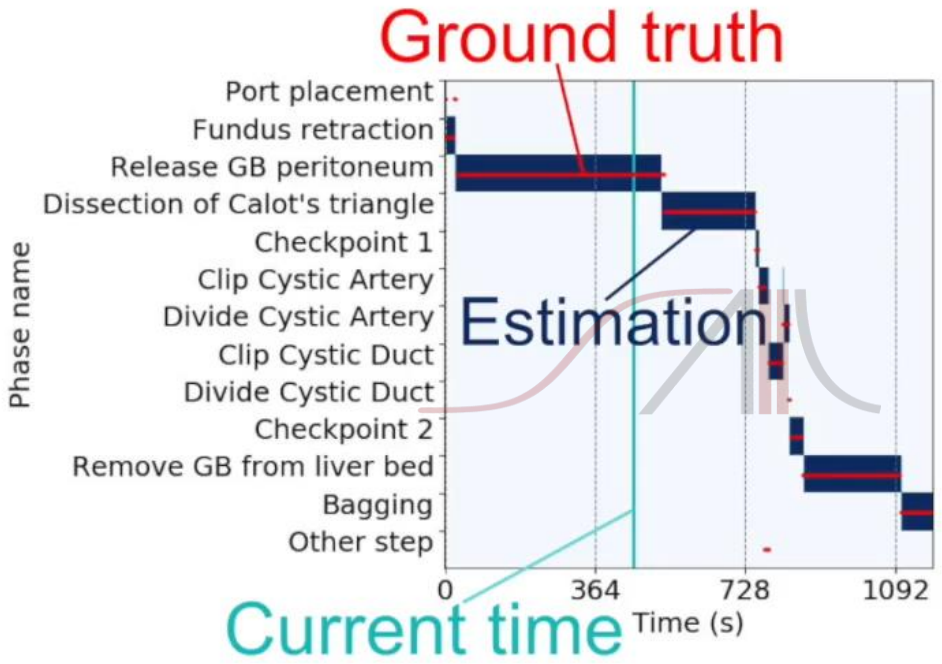
Research : Intraoperative decision support

- Shrinking data for surgical training
- Technique that reduces video files to one-tenth their initial size enables speedy analysis of laparoscopic procedures.

SAIIL – MGH – MIT

Experimental Phase

Real Time **Phase Detection**



GT: Release GB peritoneum
Estimate: Release GB peritoneum

Surgical Artificial Intelligence & Innovation Laboratory - Massachusetts General Hospital

Experimental Phase

Artificial intelligence prediction of cholecystectomy operative course from automated identification of gallbladder inflammation

Thomas M. Ward[1] · Daniel A. Hashimoto[1] · Yutong Ban[1,2] · Guy Rosman[1,2] · Ozanan R. Meireles[1]

What explains intra-operative variability in cholecystectomy?

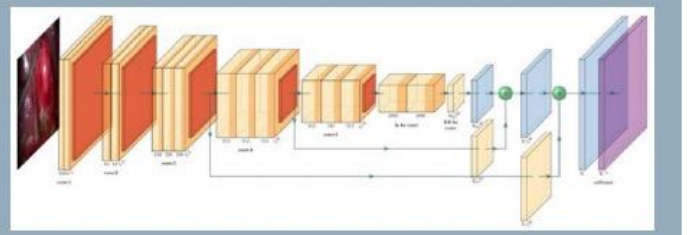
Surgeon + Inflammation

Bayesian Multilevel Models

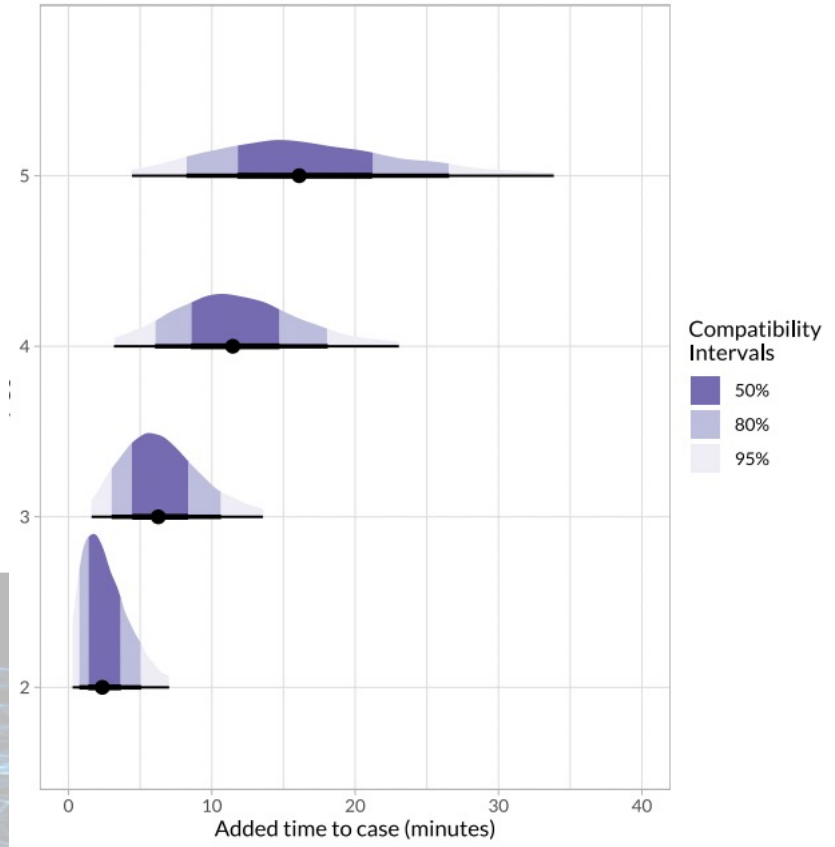
Gallbladder Injury	Duration	Critical View of Safety
Increased injury probability by 11%, and up to 28%, per case	Average 17, and up to 31.3, minutes added	No effect

Can computers reliably classify inflammation?

Convolutional Neural Network

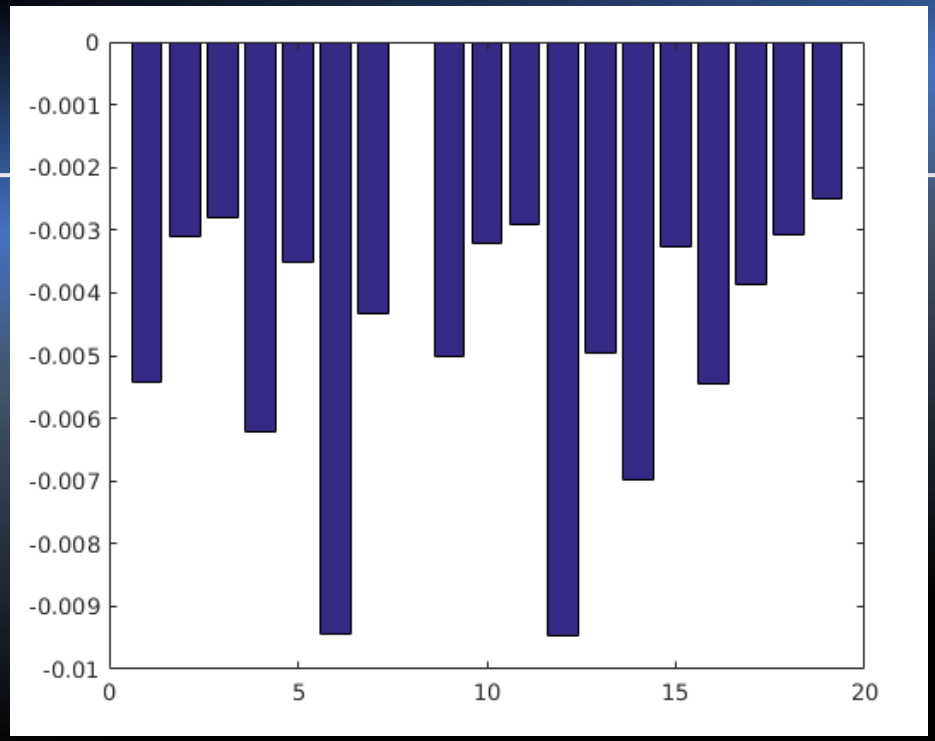


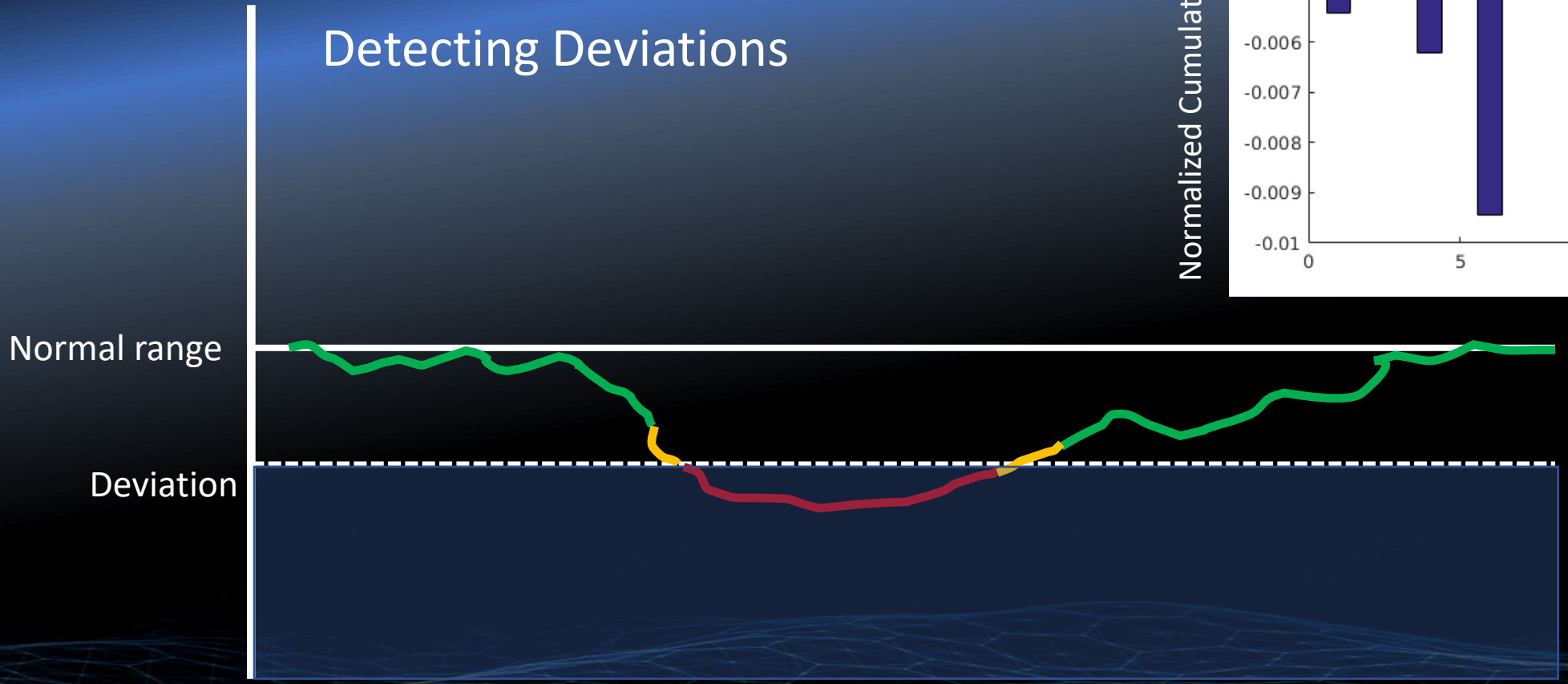
	Krippendoff's α	95% CI
AI Model	0.71	0.65-0.77
2nd Surgeon	0.82	0.75-0.87

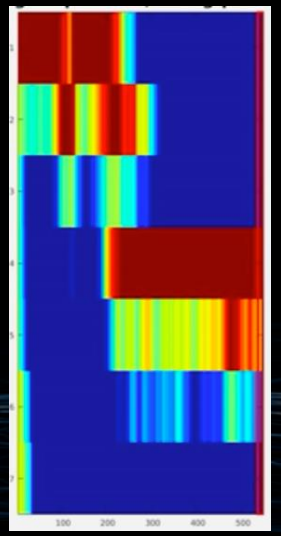


Analysis of intraoperative video

Experimental Phase

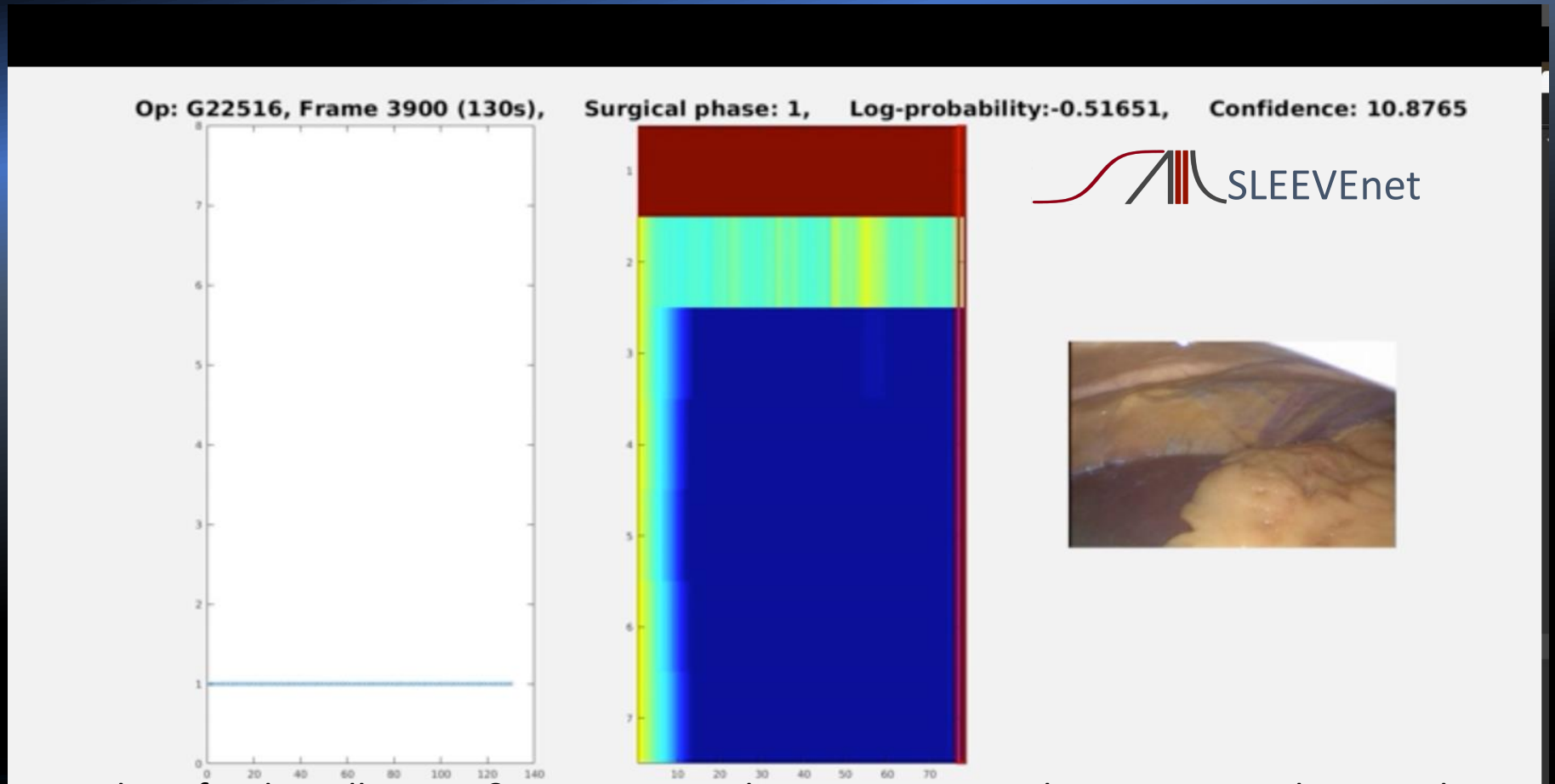






Experimental Phase

Deviation Analysis and Detection



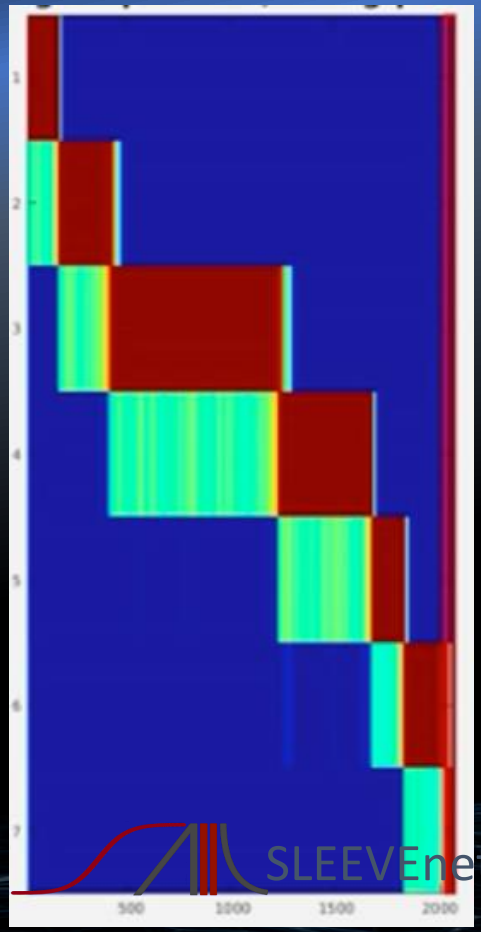
Surgical Artificial Intelligence & Innovation Laboratory - Massachusetts General Hospital


MGH
1811

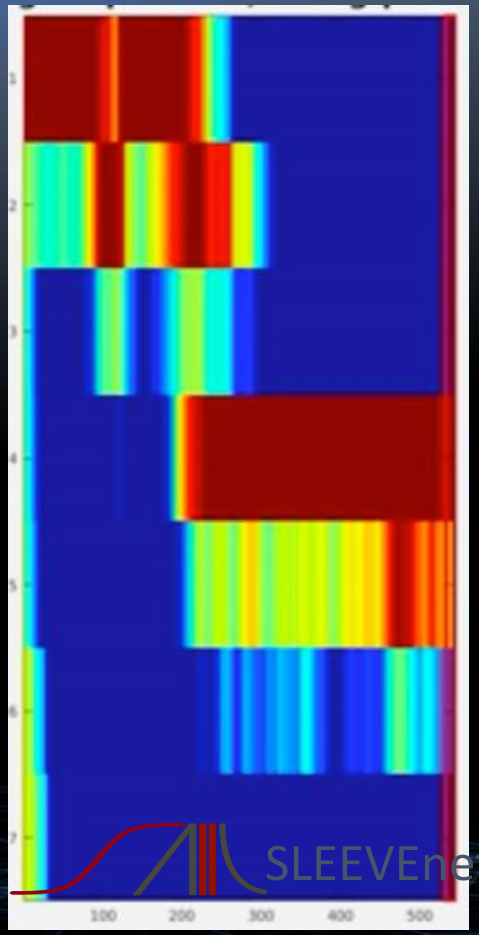

SLEEVEnet

Surgical Fingerprint – Sleeve Gastrectomy

Case A



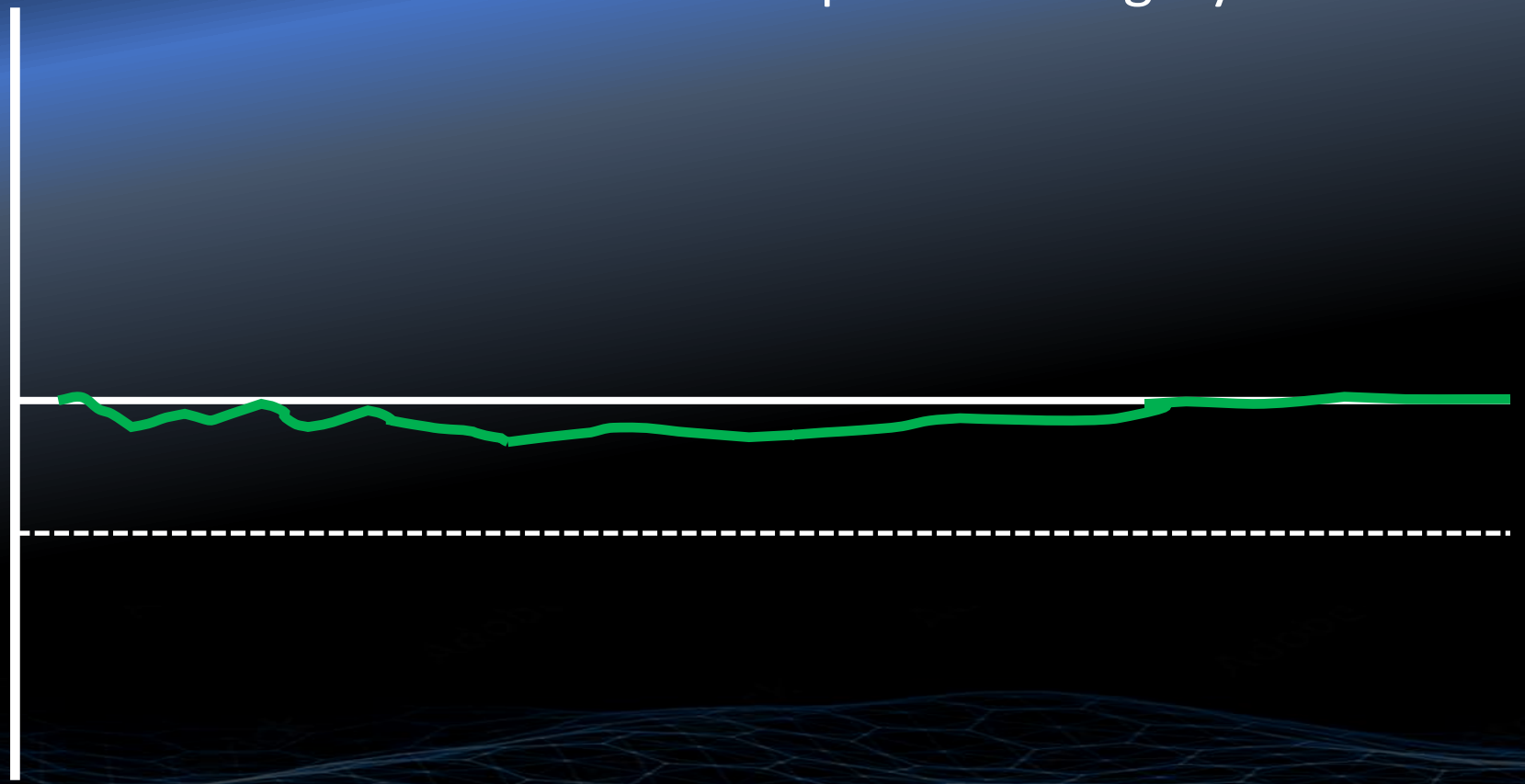
Case B

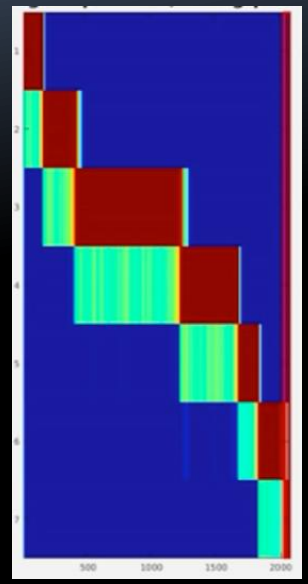


Analysis of intraoperative video

Experimental Phase

Case 1 – Uncomplicated Surgery

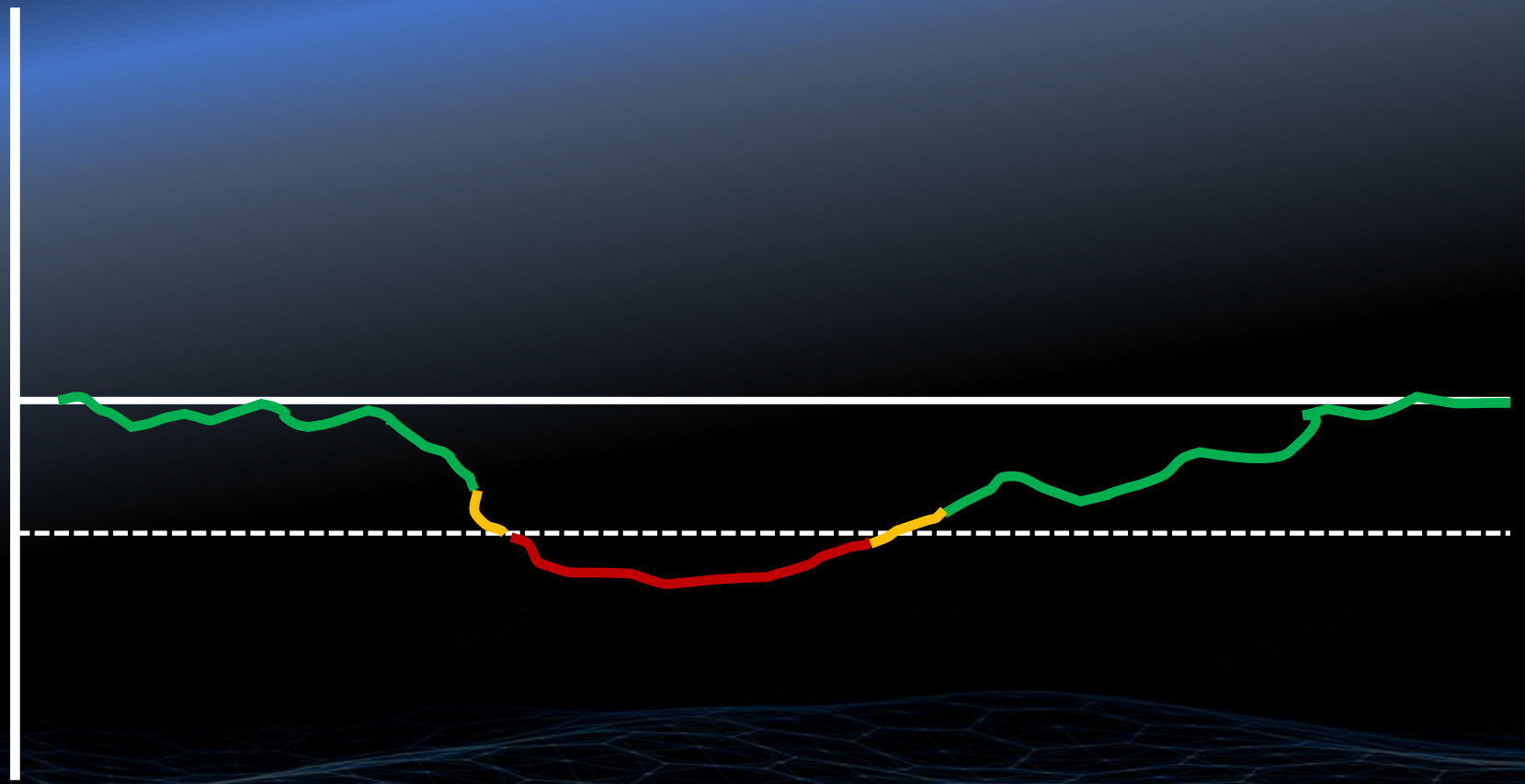


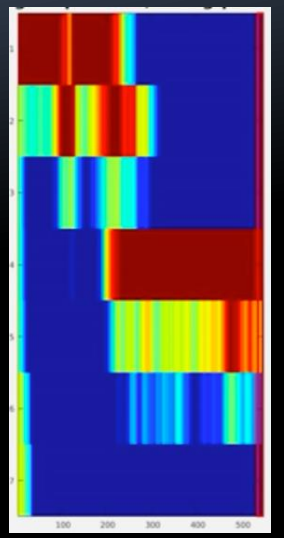


Analysis of intraoperative video

Experimental Phase

Case 2 – Detecting Complication





Potential applications

- **Attending notification system**
  - Notify attendings if the trainees are nearing critical portions of the operation.

- **Peer Review**
  - Augmented Morbidity and Mortality meetings
  - Board certification
  - Hospital credentialing and recredentialing

Potential applications

- **Tele-mentoring**
  - Establish automated communication link to human mentor when error is predicted or identified.
  - Battlefield and Rural Areas support, to medical staff who may not have the necessary specialty specific knowledge

Automation

AI and Mechanical Automation

Experimental Phase

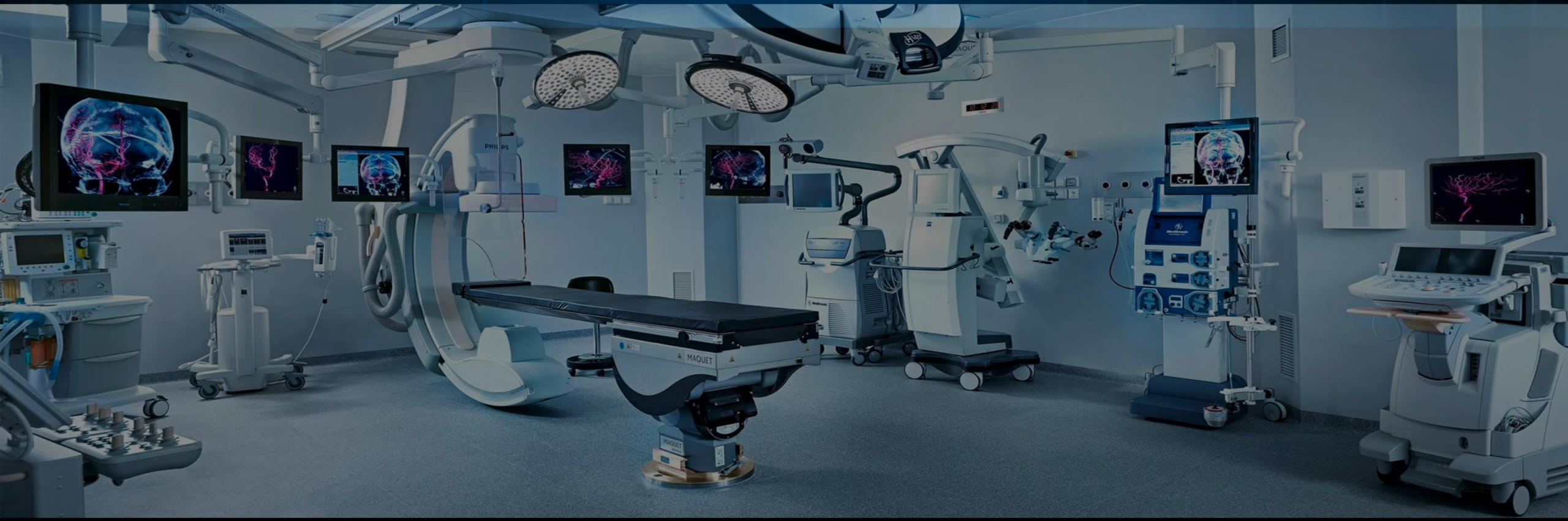
Berkeley
UNIVERSITY OF CALIFORNIA

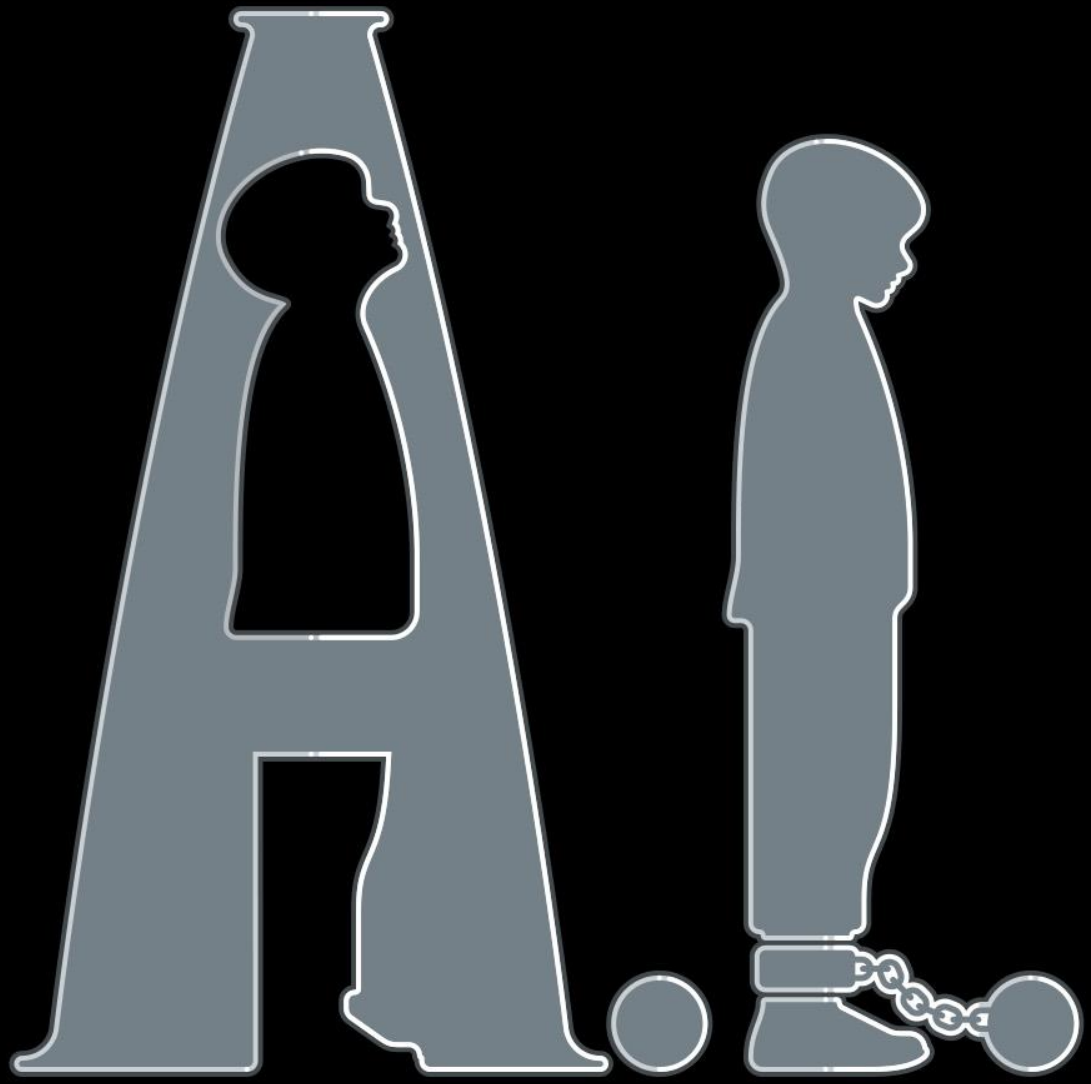
Ken Goldberg
Professor, Industrial Engineering and Operations Research
William S. Floyd Jr. Distinguished Chair in Engineering, UC Berkeley

MASSACHUSETTS GENERAL HOSPITAL

HARVARD MEDICAL SCHOOL

Basel, September 8, 2022



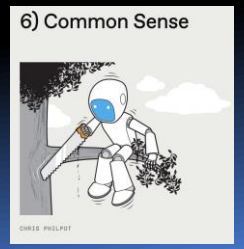

A.I.

Moravec's Paradox

- *"Robots find the difficult things easy and the easy things difficult"*

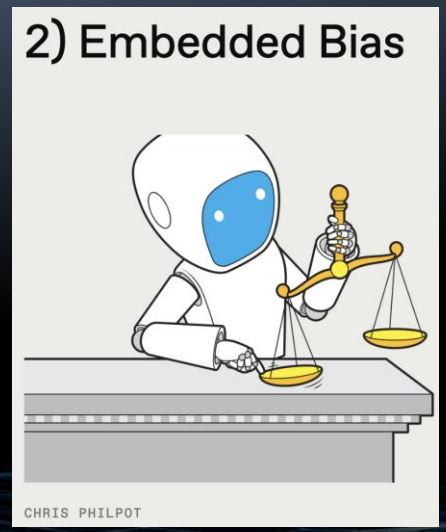
- "Contrary to traditional assumptions, high-level reasoning requires relatively little computation power, whereas low-level sensorimotor skills require enormous computational resources"

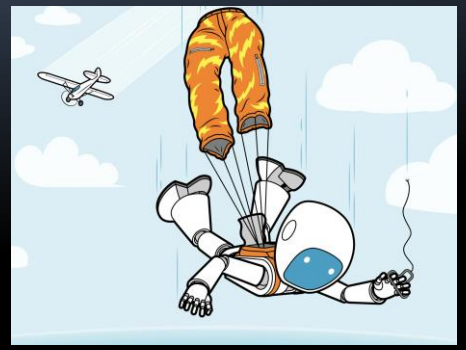
Potential Failures



7 REVEALING WAYS AI FAIL

IEEE Spectrum





- Brittleness
- Embedded Bias
- Catastrophic Forgetting
- Explainability
- Quantifying Uncertainty
- Common Sense
- Math

- https://spectrum.ieee.org/ai-failures

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Real life examples of AI Failures

HANDS ON THE WHEEL —

Another Tesla with Autopilot crashed into a stationary object—the driver is suing

Fail: Microsoft's AI Chatbot Corrupted by Twitter Trolls

Google Home outage hits users, '100 percent failure rate' reported

Apple's Face ID Defeated by a 3D Mask

IBM's Watson supercomputer recommended 'unsafe and incorrect' cancer treatments, internal documents show

Obstacles and Limitations

Data

- Limited access
- Limited annotation
- Regulation
- Systemic biases

Clinician

- Limited time
- Productivity pressure
- Culture

Researcher

- Limited exposure
- Innovation pressure

Industry

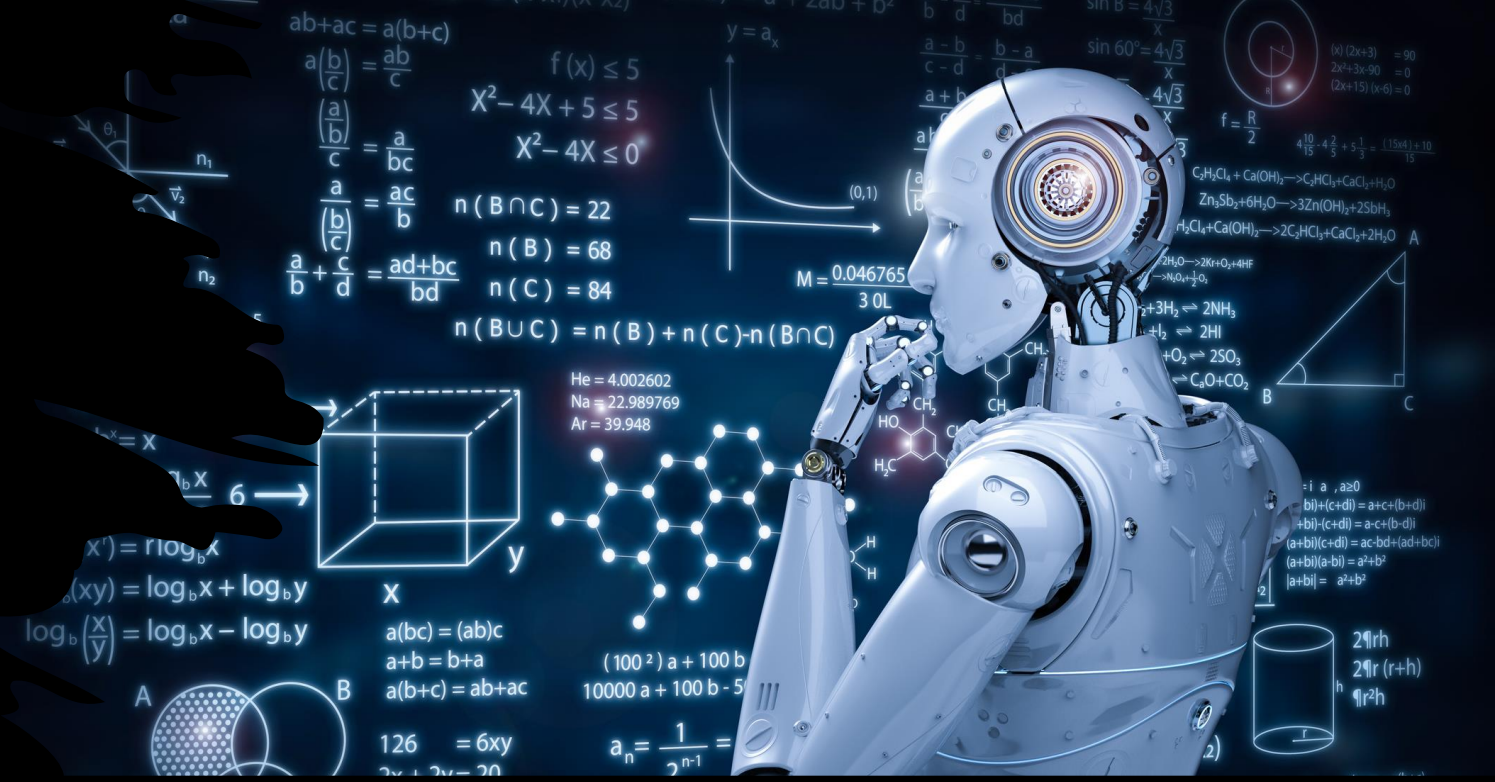
- Market pressure
- Culture

Patient

- Privacy
- Healthcare pressure
- Clinician relationship

Solution ?

sos



- Participate in the Development
- Be cognizant about:
  - Obstacles
  - Limitations
  - Hype

Surgical AI Development

Foundational Work

- Data
- Annotation
- Governance

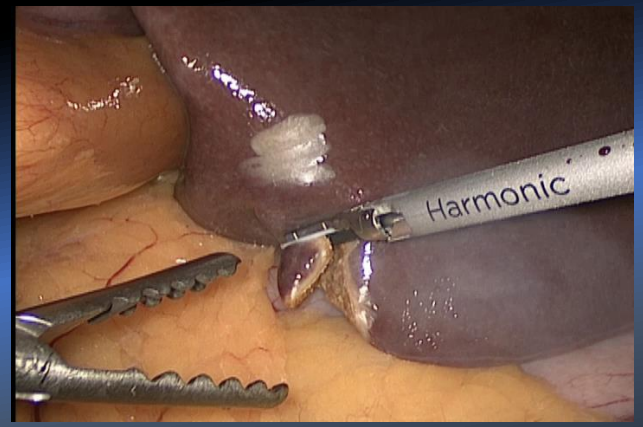
Structural Needs

- Video Data Acquisition Framework
- Management through data lifecycle

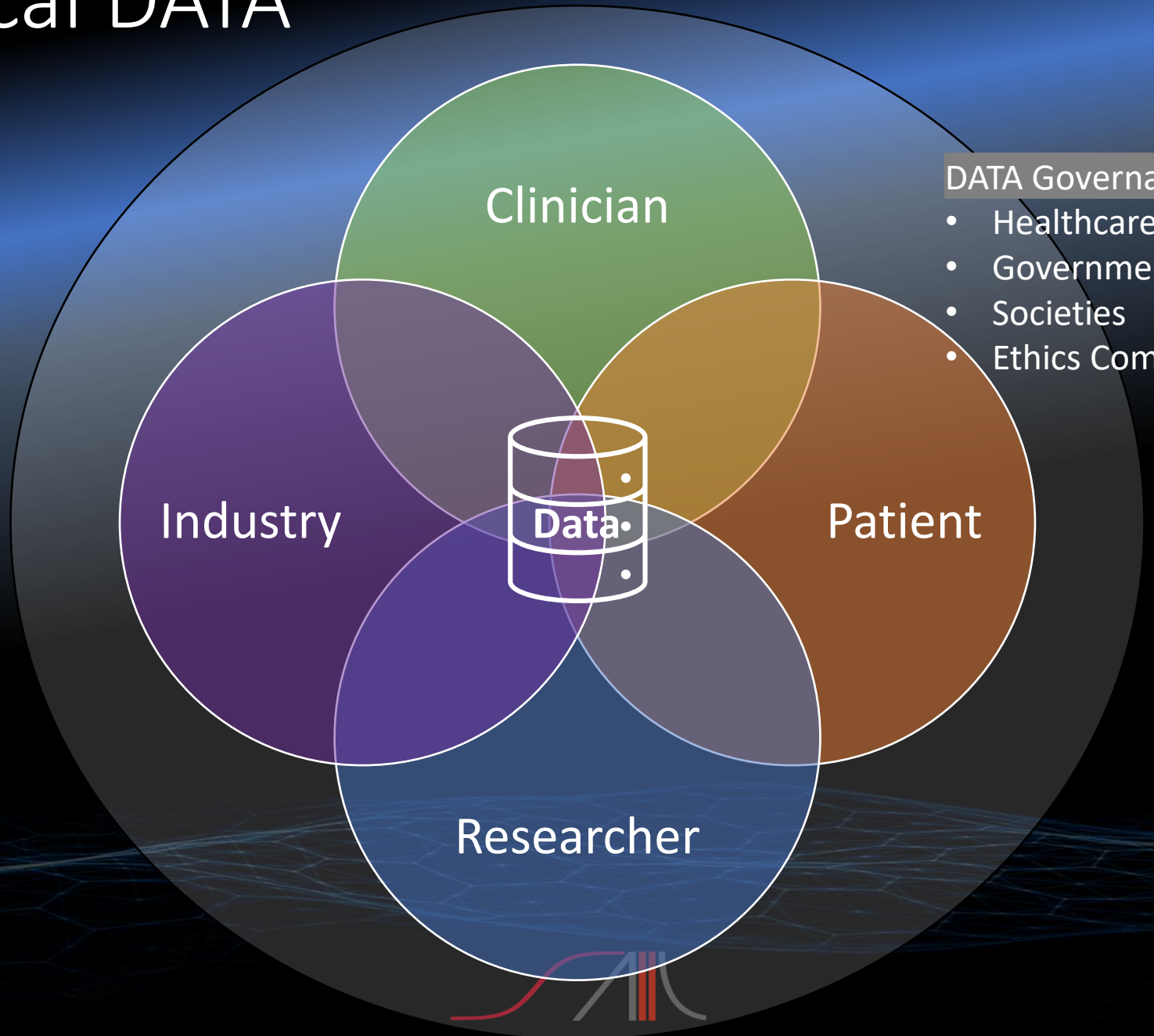
Knowledge Creation and Dissemination

- Scientific Research
- Education
- Cultural Transformation

DATA collection



Surgical DATA



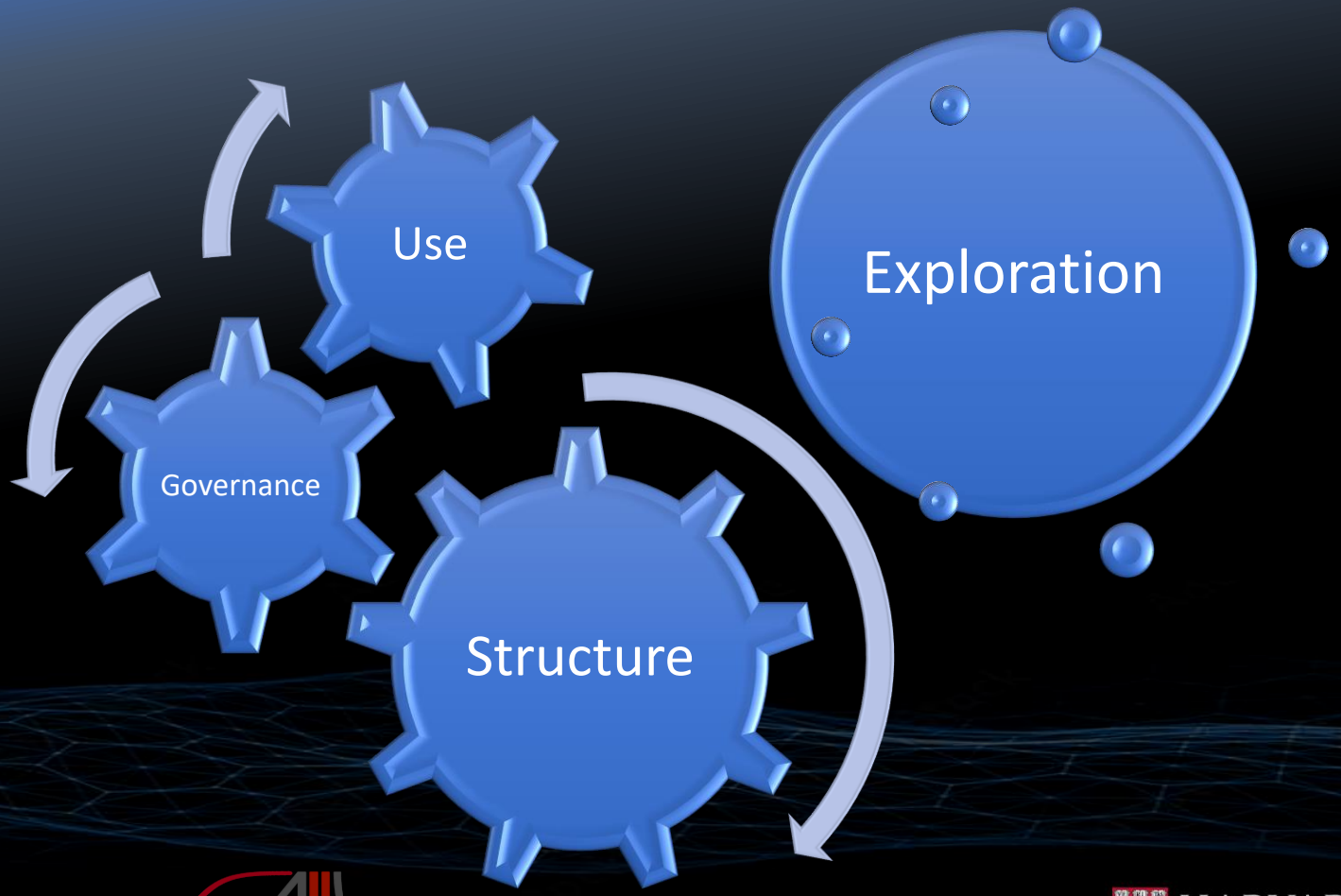
DATA Governance, Policies and Oversight

- Healthcare Systems
- Governments
- Societies
- Ethics Committees

DATA Use and Structure

Objective: Establish a framework for video data use in surgery to improve collaboration and proposed methods to structure the use of surgical video for clinical use, education, and research applications.

SAGES Surgical Video Data Summit 2021



Annotation Framework
Hierarchical Structure with Expandable Granularity

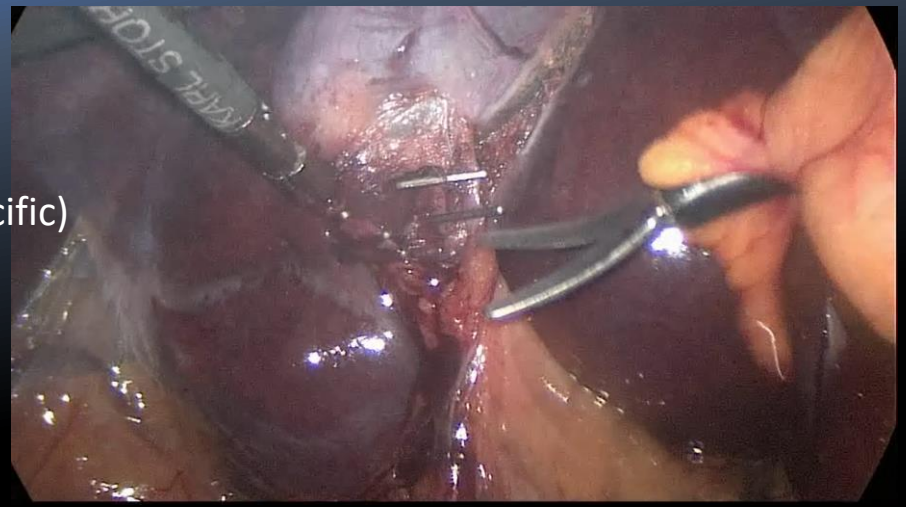
Temporal Events

Phase (generic)

Step (procedure- specific)

Task (generic)

Action (generic)



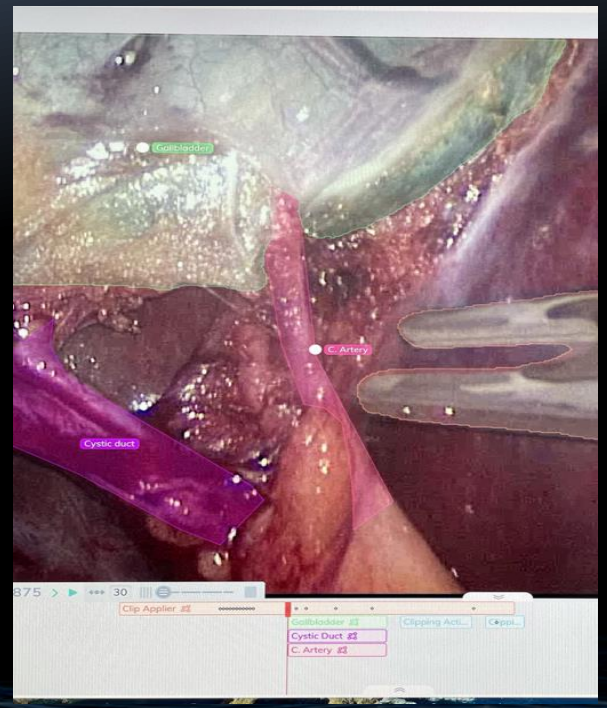
Spatial Events

Anatomic region

Specific anatomy

General anatomy

Tissue characteristics



Scientific efforts

Computer Vison Challenges

Multi-institutional collaborations

Standards for Publications

Academia and Industry partnership

Validation Studies

Promote Diversity

The Challenge | Donate Data | Annotation | Sponsorship | SAGES | Newsletter

Denver, USA • March 16, 2019

The Critical View of Safety Challenge

An initiative of the Society of American Gastrointestinal and Endoscopic Surgeons

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#SAGESAI

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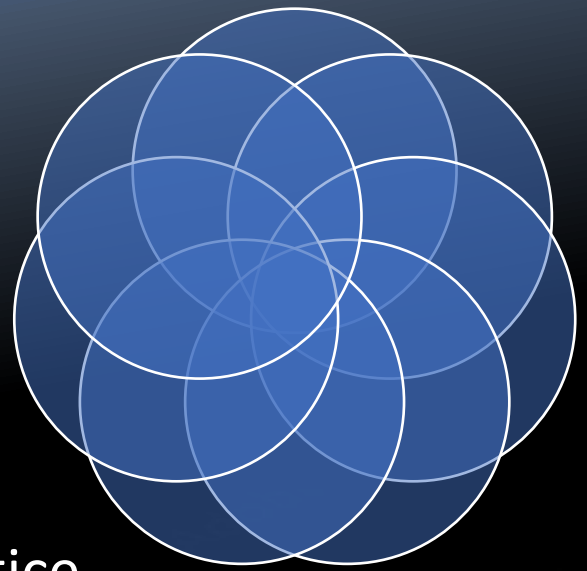
Surgical AI Governance

Regulations, Policies and Oversight

Surgeons

Patients

Government officials



Industry

Hospitals

Malpractice Insurance companies

Payers

2023

Surgical Operating System Framework

- Open Access Model to Promote Collaboration
- Standardization
  - Annotation
  - Data Structure
- Clear Policies and Regulations
- Transparency and Oversight
- Address Ownership Issues

Education and Training

Scientific Meetings

Dedicated Fellowships

e.g. SAIIL

Medical School Curriculum

Publications

Professional Preparation

- Computer science
- Ethics
- Programing
- Work force
- Training
- Credentialing
- Simulations

(36)

Cultural Transformation

SHARING DATA

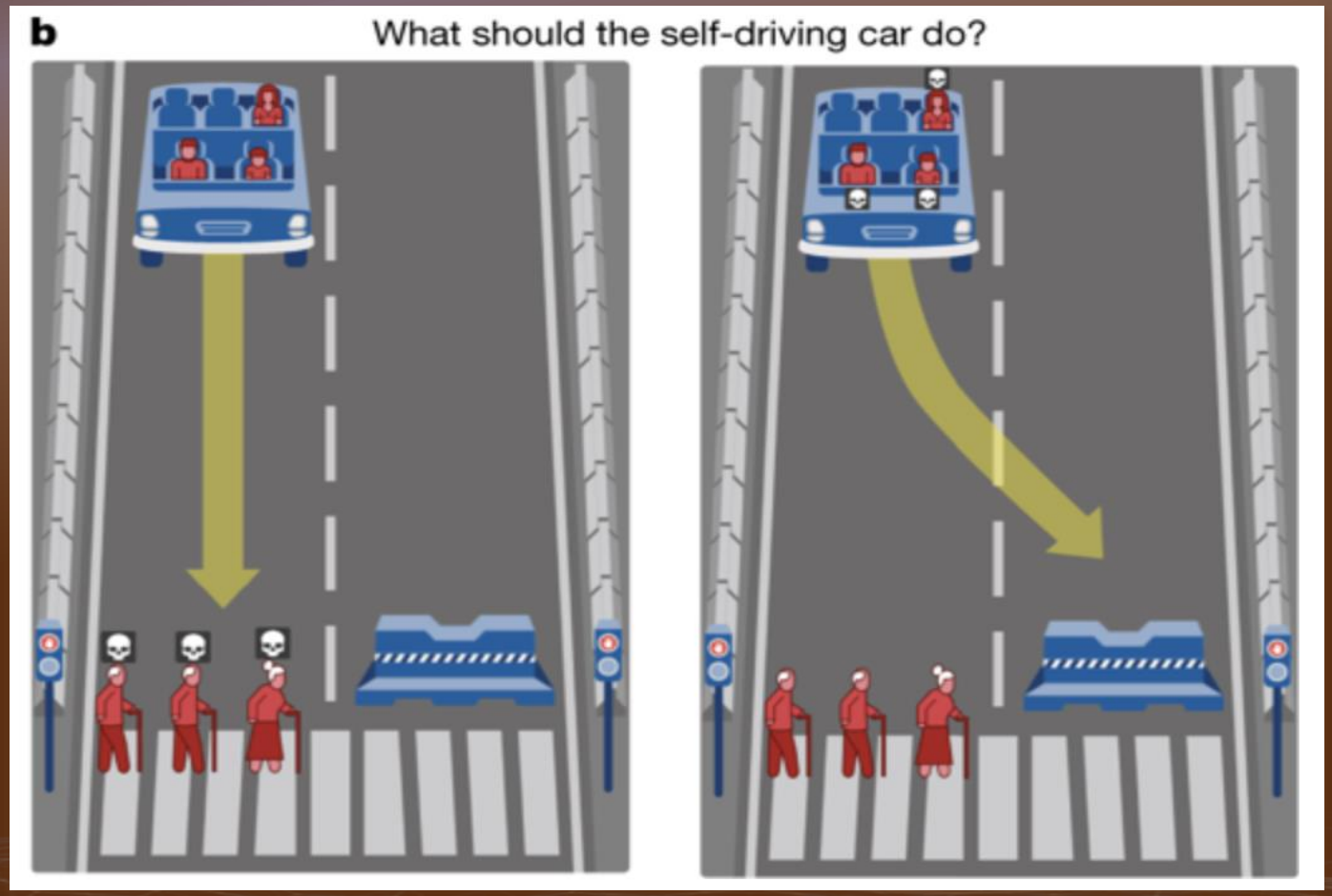
SHARING KNOWLEDGE

CULTURAL DIFFERENCES

Ethical considerations

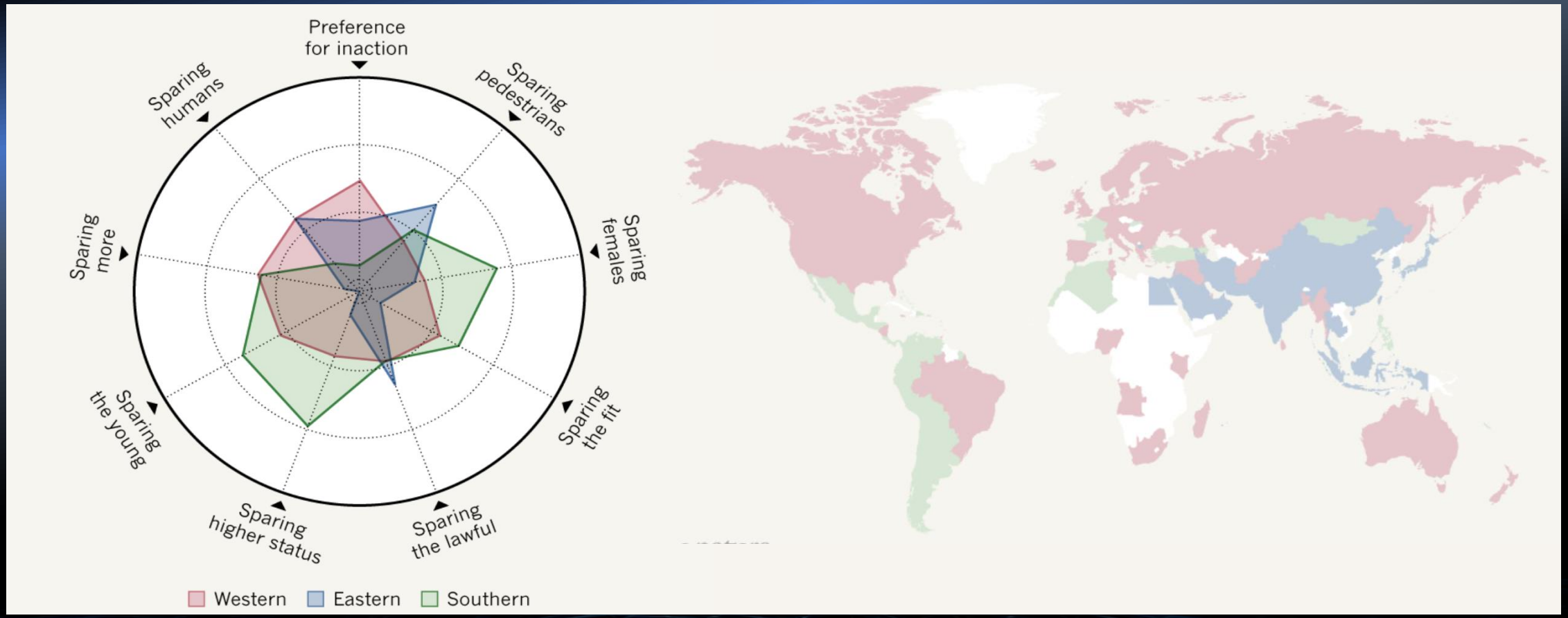
The Moral Machine

http://moralmachine.mit.edu



Awad et al. 2018. *Nature*

Ethical according to whom?



http://moralmachine.mit.edu

Other Considerations

Who owns the data?

Patient, Provider,
Hospital, Payor

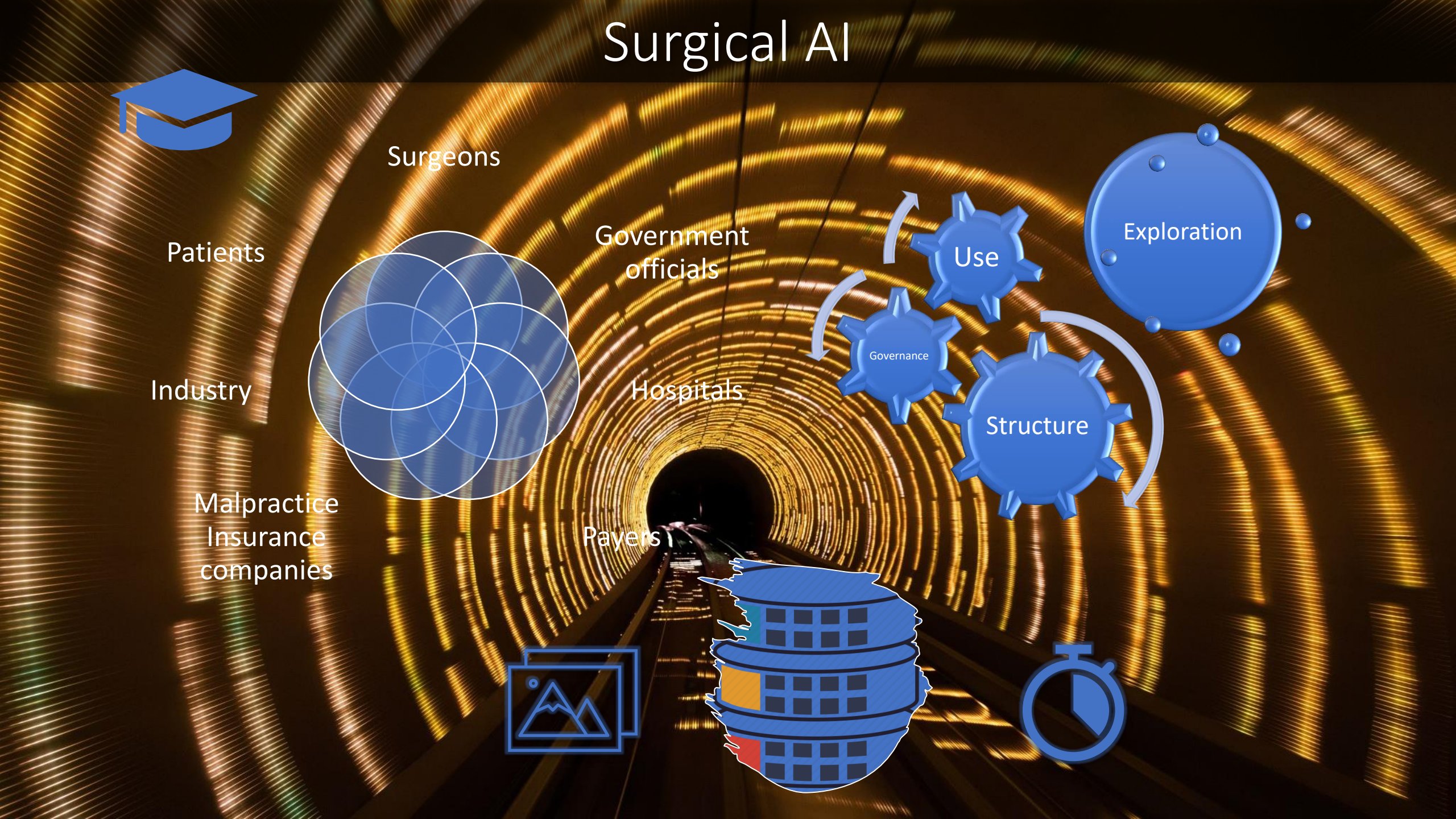
Who gets the credit?

Who gets the blame?

How do you explain AI-driven decisions to patients?

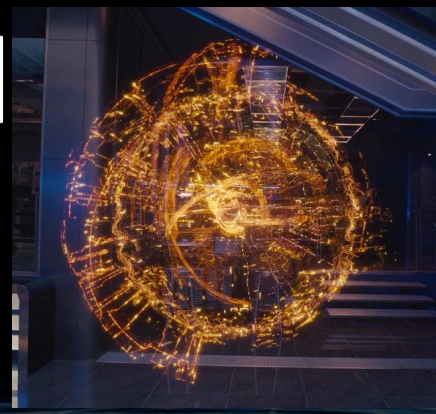
Can you challenge the decision ?

Surgical AI


Surgeons
Patients
Government officials
Industry
Hospitals
Malpractice Insurance companies
Payers
Use
Exploration
Governance
Structure

Sharing of global knowledge and resources utilization.

Computational Collective Surgical Consciousness



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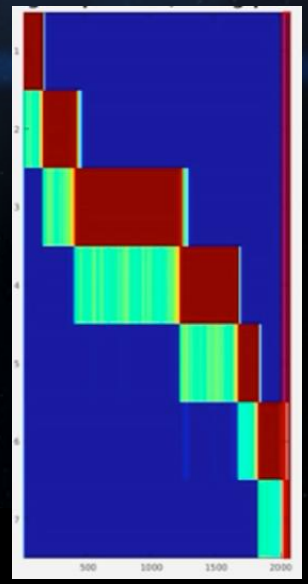
Analysis of intraoperative video *with Decision Support .*

Conceptual Phase

Case 3 – Preventing Complication



SAIIL Team

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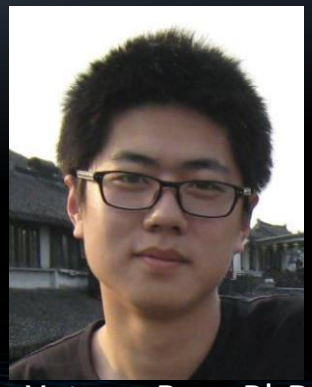
Brendan Brady
Project Manager



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