Humans & AI - on the Road and in the Operating Room

A Contrastive Outlook

Guy Rosman

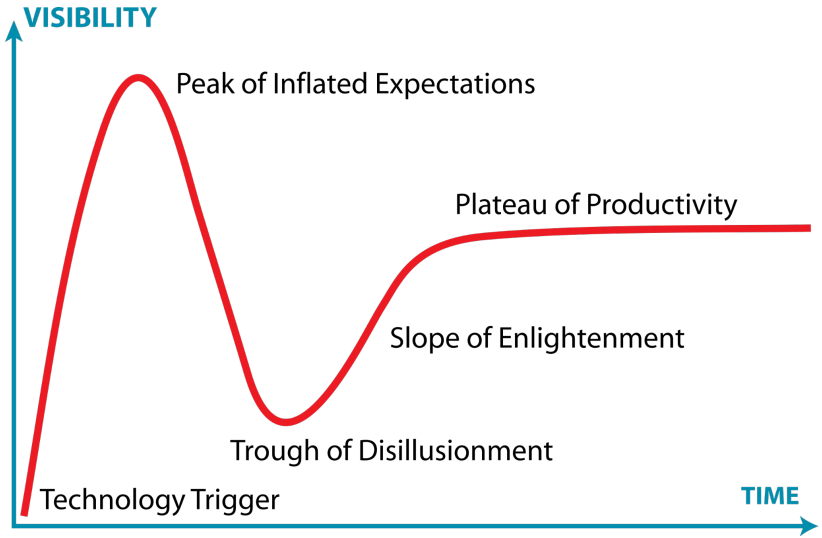
Research - Domains (behavior)

	Driving 	Minimally Invasive Surgical 
Data	Perception results from from LiDAR, Cameras, localization	Surgical video Robot kinematics
State space	Vehicle state, control signals	phases, action triplets, tasks, *
Ego agent	Driver	Surgeon
Machine role	Drive, Share-control, Warn	Assistive
Annotation	Useful	Crucial
Observability	Pretty good	Partial

* SAGES consensus recommendations on an annotation framework for surgical video, Surg. Endoscopy, 2022

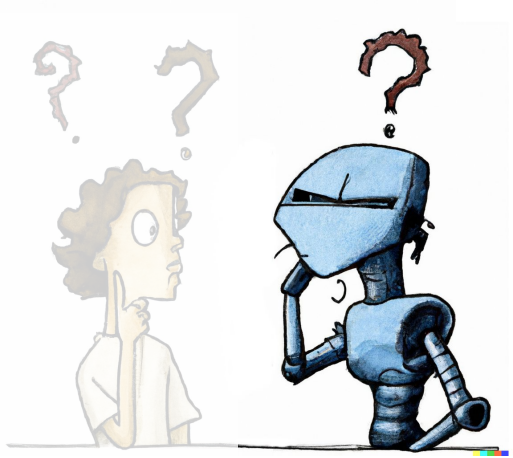
AI Winters

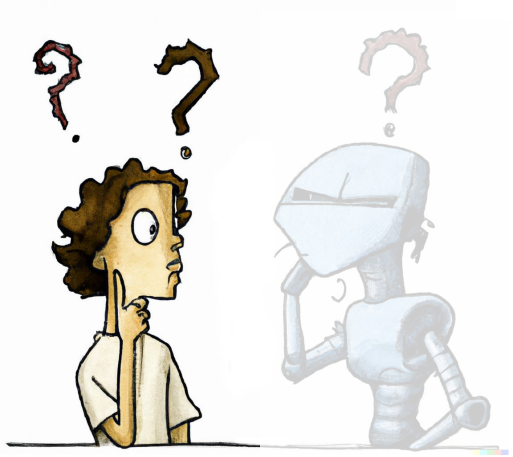
- Winter I (60-70s)
  - ALPAC report, Lighthill report
  - CMU SUR project
  - DARPA focus shift towards mission-guided
- Winter II (80-90s)
  - LISP machines
  - Lack of progress on symbolic AI
  - DARPA Strategic Computing project
- Instance of hype curve
- Autonomous driving?
- What's different this time?
  - The fallback is better
  - In some domains, commercially viable



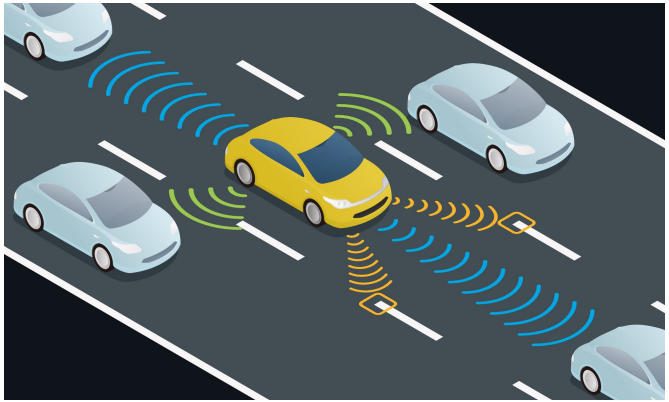
Human-Centric AI

- How AI affects humans?
  - Fairness & ethics
  - Social implications
  - Economy implications
- How humans can interact with AI?
  - Explainability
  - Interfaces,
  - Cooperation
  - Co-adaptation



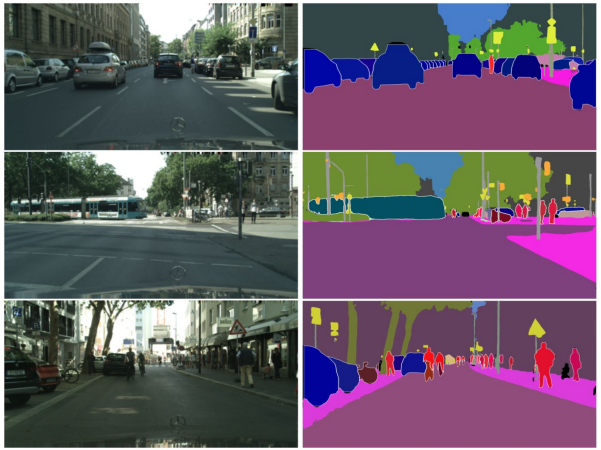


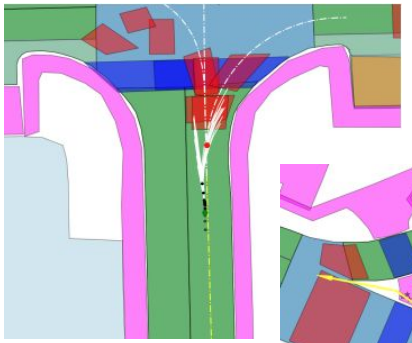
AI on the Road

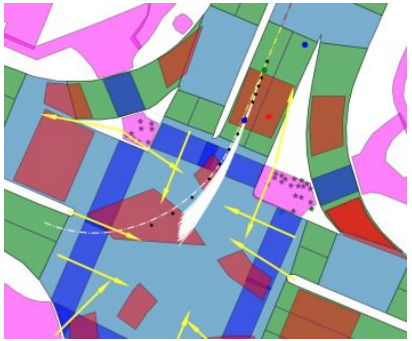


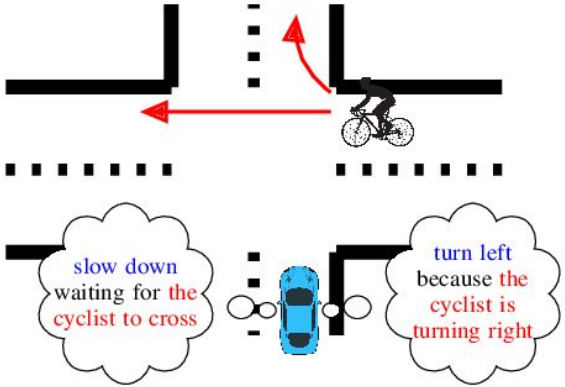
AI on the Road

- Understanding the environment
- Understanding people
- Interacting with people
  - Driver
  - Other road users



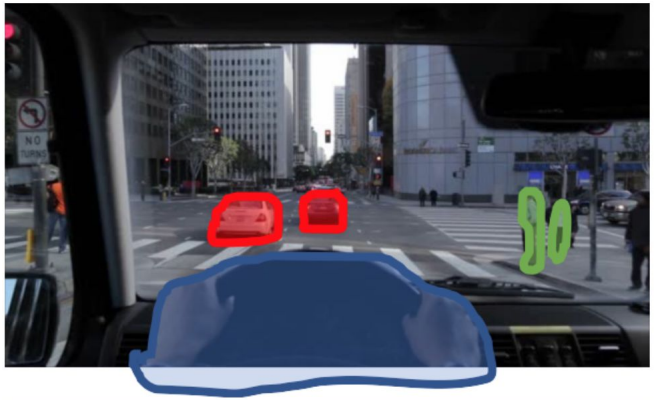


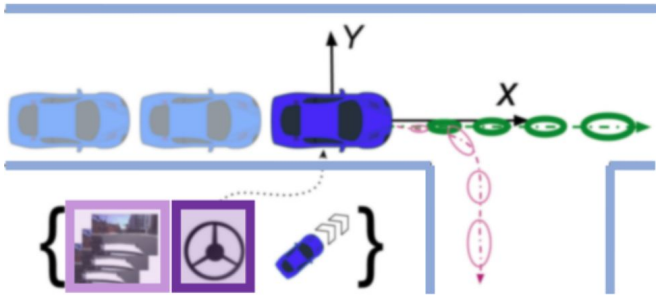




Behavior Prediction

- Includes
  - **The car you're driving**, **External cars**
  - **Not just cars**
- Conditioned on all past inputs
  - Past trajectory, Map, Sensors
  - Vehicle data
- Data-driven

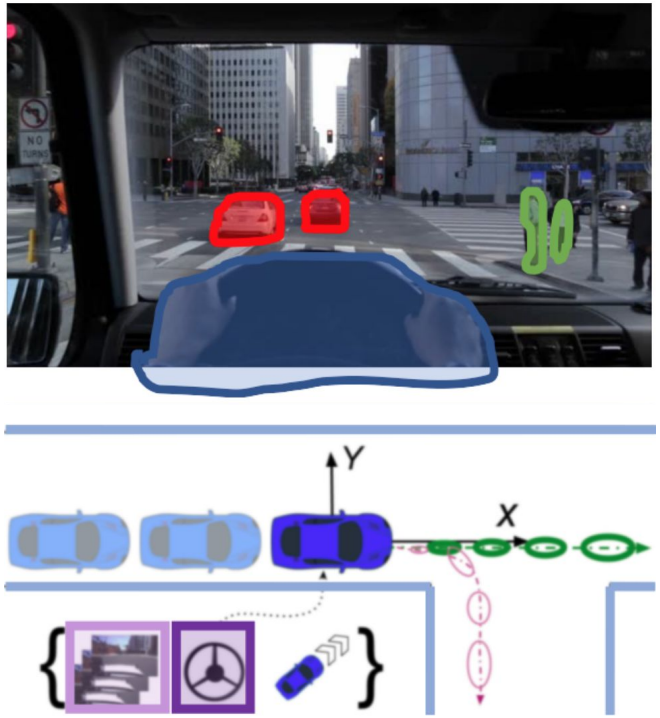




Uncertainty-Aware Driver Trajectory Prediction at Urban Intersections, X. Huang, S.G. McGill, B.C. Williams, L. Fletcher, G. Rosman, ICRA 2019
TIP: Task-Informed Motion Prediction for Intelligent Vehicles, X. Huang, G. Rosman, A. Jasour, S.G. McGill, J.J. Leonard, B.C. Williams, IROS 2022
Vehicle Trajectory Prediction Using Generative Adversarial Network With Temporal Logic Syntax Tree Features. X. Li, G. Rosman, I. Gilitschenski, C-I Vasile, J. A. DeCastro, S. Karaman, D. Rus, RA-L, 2021

Behavior Prediction

- Includes
  - The car you're driving, External cars
  - Not just cars
- Conditioned on all past inputs
  - **Past trajectory**, **Map**, **Sensors**
  - **Vehicle data**
- Data-driven

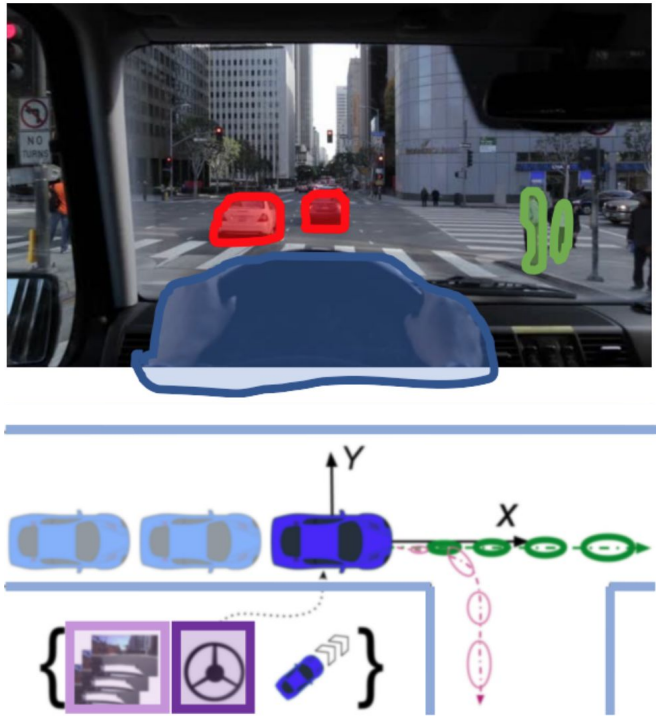


Deep Context Maps: Agent Trajectory Prediction Using Location-Specific Latent Maps, I. Gilitschenski, G. Rosman, A. Gupta, S. Karaman, D. Rus, RA-L, 2020
Driving Through Ghosts: Behavioral Cloning with False Positives, A. Bühler, A. Gaidon, A. Cramariuc, R. Ambrus, G. Rosman, W. Burgard, IROS 2020

Behavior Prediction

Patterns

- Inductive Biases
- What is legal?
- What is good?
- What is normal?
- What is abnormal?

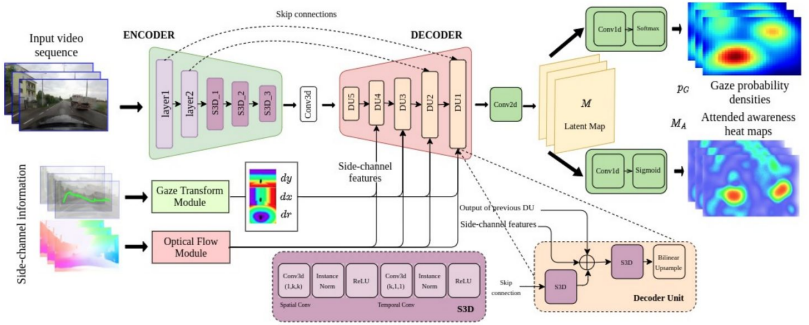


DiversityGAN: Diversity-Aware Vehicle Motion Prediction via Latent Semantic Sampling, X. Huang, S.G. McGill, J.A. DeCastro, L. Fletcher, J.J. Leonard, B.C. Williams, G. Rosman, RA-L, 2020
Vehicle Trajectory Prediction Using Generative Adversarial Network With Temporal Logic Syntax Tree Features. X. Li, G. Rosman, I. Gilitschenski, C-I Vasile, J. A. DeCastro, S. Karaman, D. Rus, RA-L, 2021
Trajectory Prediction with Linguistic Representations, Y-L. Kuo, X. Huang, A. Barbu, S.G. McGill, B. Katz, J.J. Leonard, G. Rosman, ICRA 2022

Driver Understanding

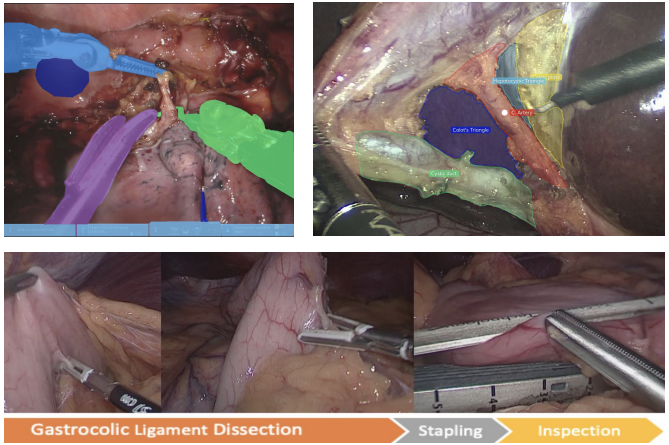
Given a rough estimate of where the driver is looking

- What they are looking at?
- What have they attended to?



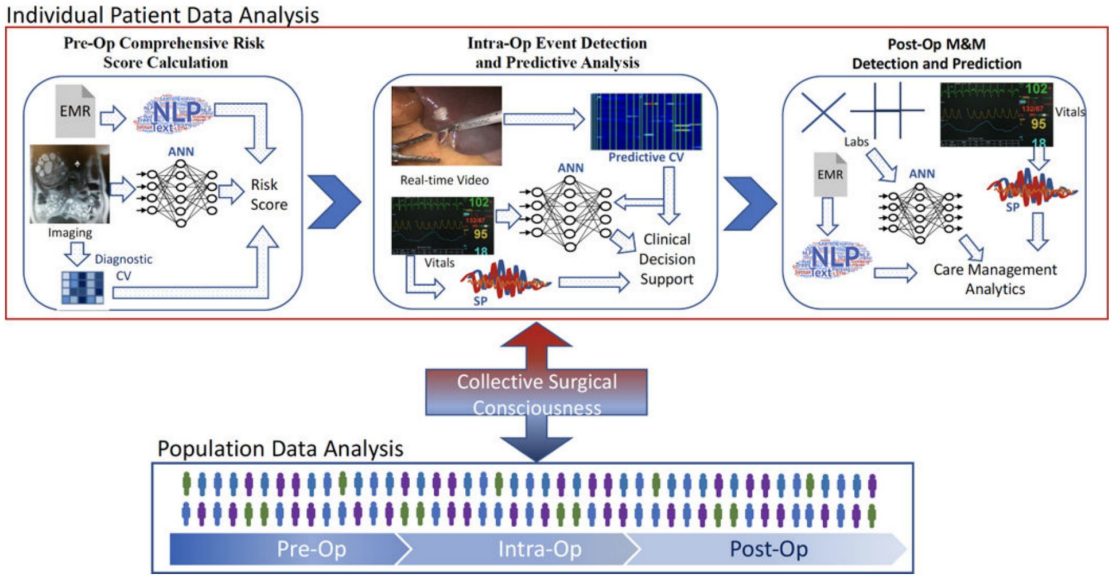
MAAD: A Model and Dataset for "Attended Awareness" in Driving, D. Gopinath, G. Rosman, S. Stent, K. Terahata, L. Fletcher, B. Argall, J.J. Leonard, ICCV workshops 2021

Surgical AI



Surgical AI

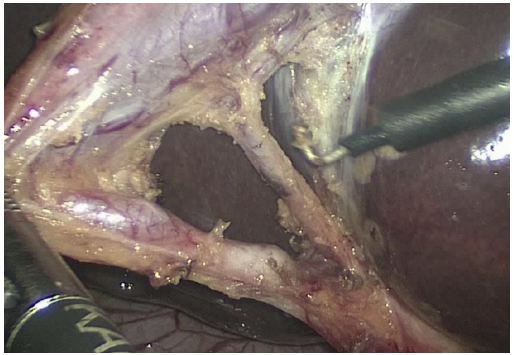
- Still far from the vision of data-driven medicine
- Mixture of best practices and initial AI situational awareness



Artificial Intelligence in Surgery: Promises and Perils, D.A. Hashimoto, G. Rosman, D. Rus, O.R. Meireles, Ann. Surg., 2018

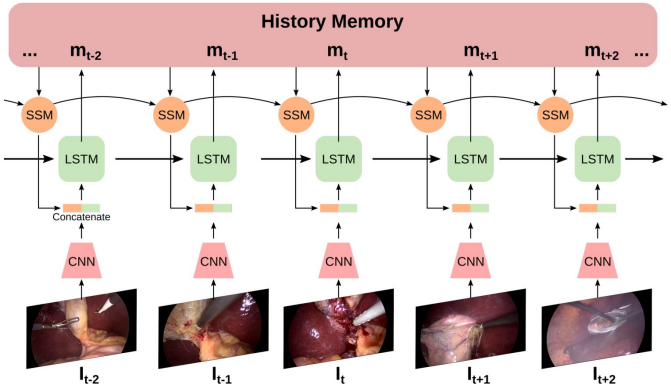
AI and Minimally Invasive Surgery

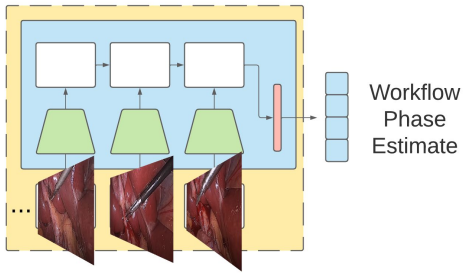
- Field of view defines the surgeon's observations - *the information is there*
- Field of view very partial - partial observability
  - Stateful reasoning over the timeline - long term context
  - Consider reasoning about polyps in colonoscopy
  - EMR as the context
- Specific taxonomy and labels set.
  - Parkland grading scale, critical view of safety in lap-chole's
  - Tools, actions, tissues, tasks, phases,..



AI and Minimally Invasive Surgery

- Situation Awareness
  - Which phase, task, action,.. are we at?
  - What do we see - tools, tissues,..
  - What are the temporal, spatial patterns?



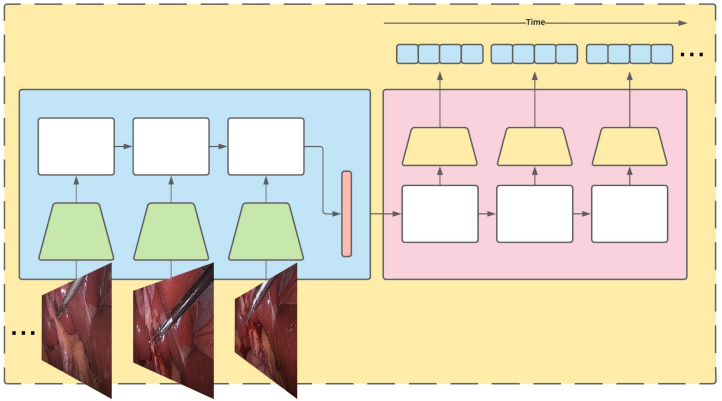


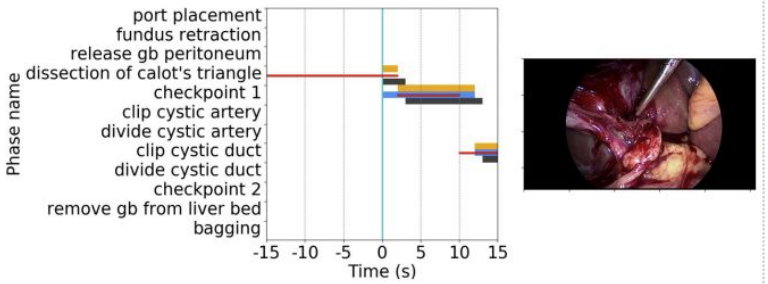
Computer Vision Analysis of Intraoperative Video: Automated Recognition of Operative Steps in Laparoscopic Sleeve Gastrectomy, D.A. Hashimoto, G. Rosman, E.R. Witkowski, C. Stafford, A.J. Navarrete-Welton, D.W. Rattner, K.D. Lillemoe, D.L. Rus, O.R. Meireles, Ann. Surg., 2020
Automated operative phase identification in peroral endoscopic myotomy, T.M. Ward, D.A. Hashimoto, Y. Ban, D.W. Rattner, H. Inoue, K.D. Lillemoe, D.L. Rus, G. Rosman, O.R. Meireles, Surg. Endo., 2020
Aggregating Long-Term Context for Learning Surgical Workflows, Y. Ban , G. Rosman, T.W. Ward, D.A. Hashimoto, T. Kondo, O.R. Meireles, D. Rus, ICRA, 2021

AI and Minimally Invasive Surgery

Prediction - what is going to happen?

- Remaining surgical time
- Next phases and transitions





Artificial intelligence prediction of cholecystectomy operative course from automated identification of gallbladder inflammation, T.M. Ward, D.A. Hashimoto, Y. Ban, G. Rosman & O.R. Meireles, Surg. Endo., 2022

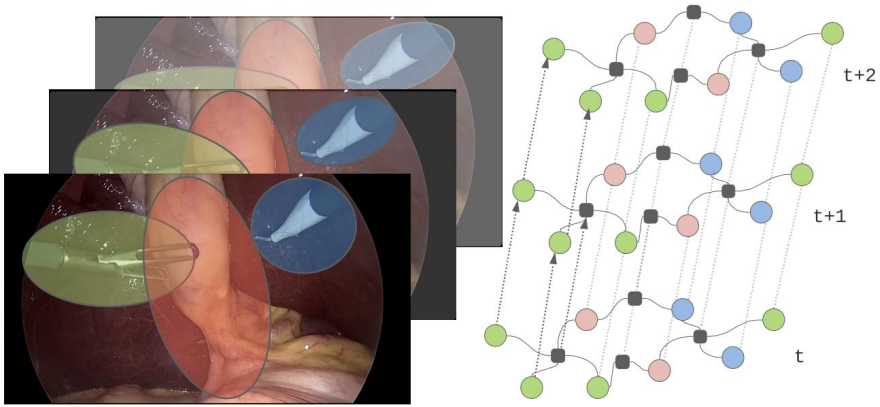
SUPR-GAN: SUrgical PRediction GAN for Event Anticipation in Laparoscopic and Robotic Surgery, Y. Ban, G. Rosman, J.A. Eckhoff, T.M. Ward, D.A. Hashimoto, T. Kondo, H. Iwaki, O.R. Meireles, D. Rus, RA-L, 2022

Explainable Surgical AI

How do we understand surgical videos?

- What semantic entities we have?
- How they relate?
- Can we extract them? Can we use them?

Can we build an extensible AI framework to capture that structure?



Concept Graph Neural Networks for Surgical Video Understanding, Y. Ban, J.A. Eckhoff, T.M. Ward, D.A. Hashimoto, O.R. Meireles, D. Rus, G. Rosman, Arxiv, 2022

Outlook

- Several exciting avenues for impact
- Depends a lot on the human context
- Several emerging technological trends,

  each with its own limitation

- How we use data matters

  on capabilities; on societal impact

“We tend to overestimate the effect of a technology in the short run and underestimate the effect in the long run”

(Roy Amara)