

Surgical Phase Segmentation Using Deep Learning

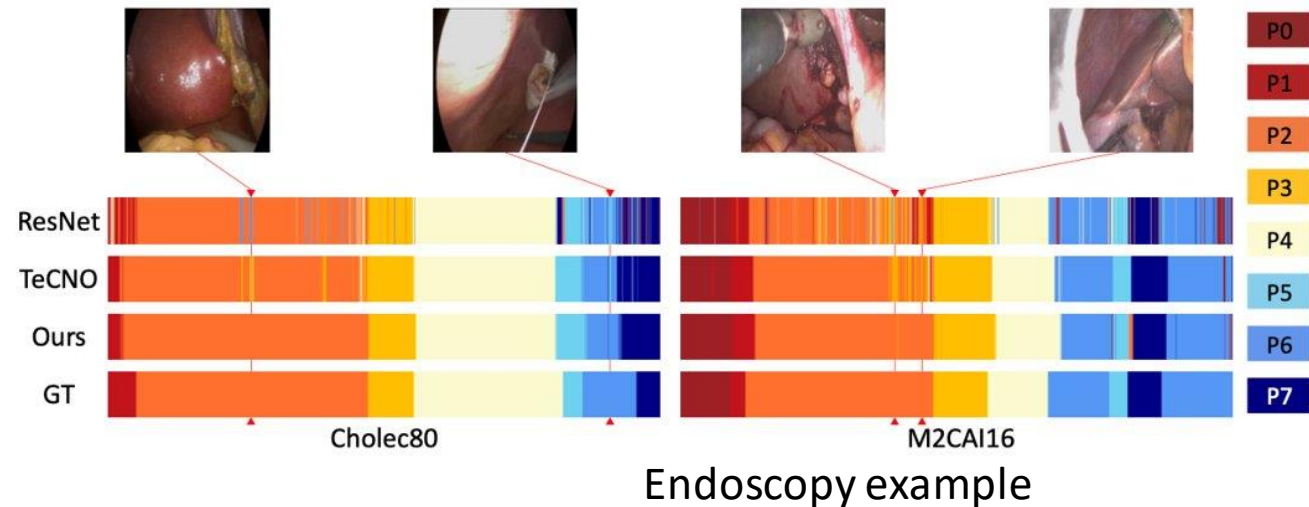
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Mentors: Max Li, Danielle Trakimas, Dr. Francis Creighton, Prof. Mathias
Unberath, Prof. Russ Taylor



Project Description

- Our Task: Mastoidectomy Surgical Video Segmentation
- Surgical Video Segmentation:
 - Online: Live Video Stream
 - Offline: Recorded

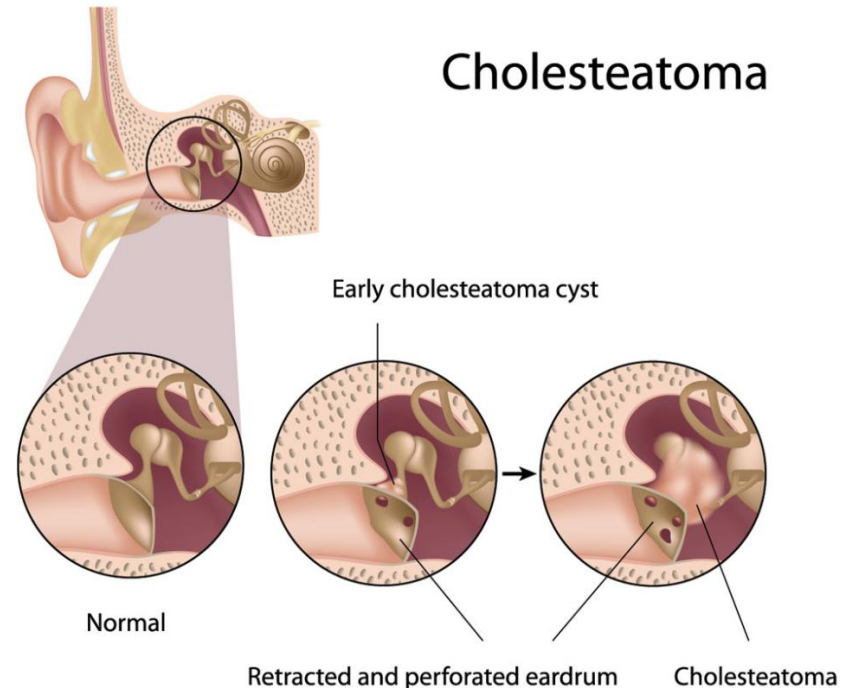
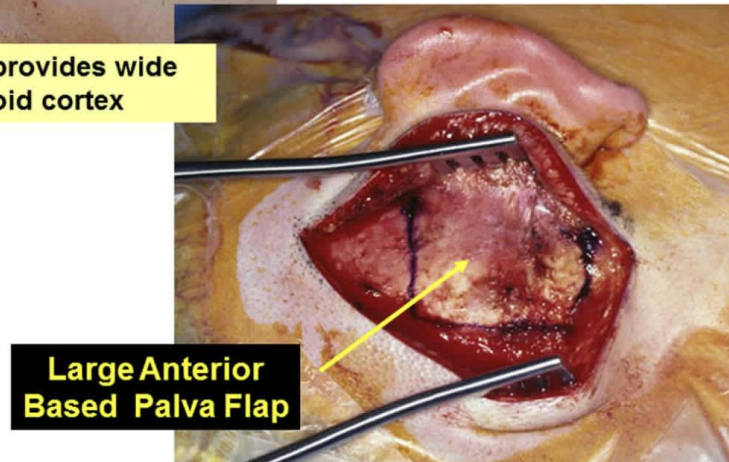


Mastoidectomy

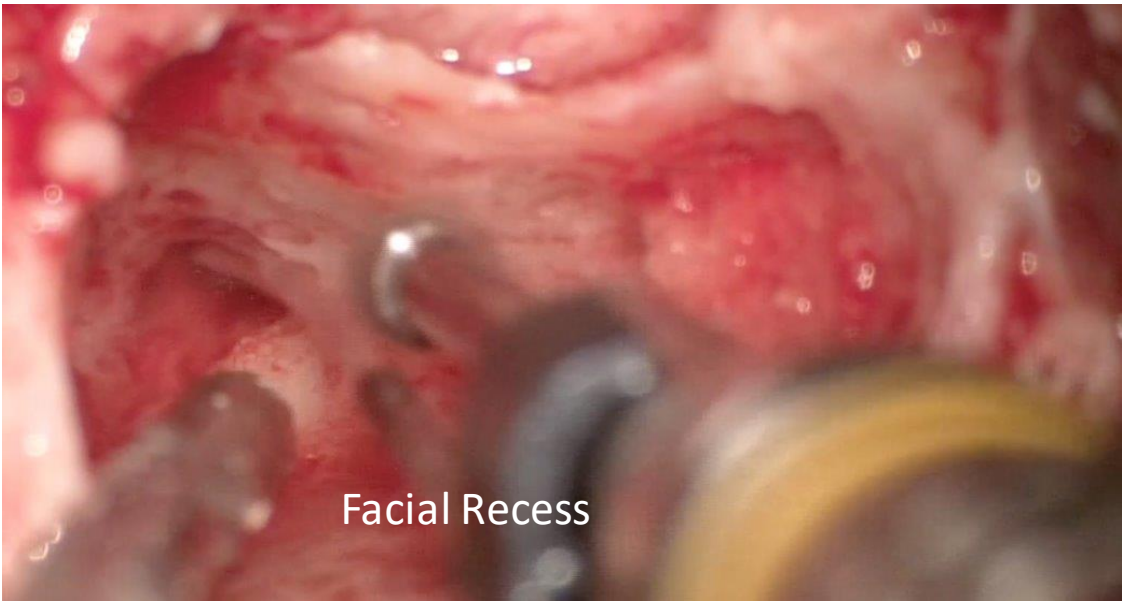
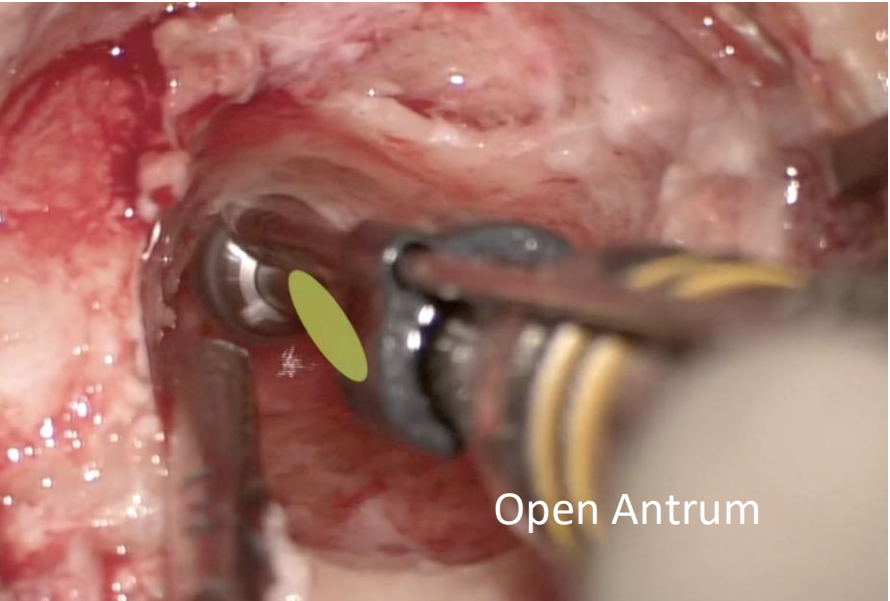
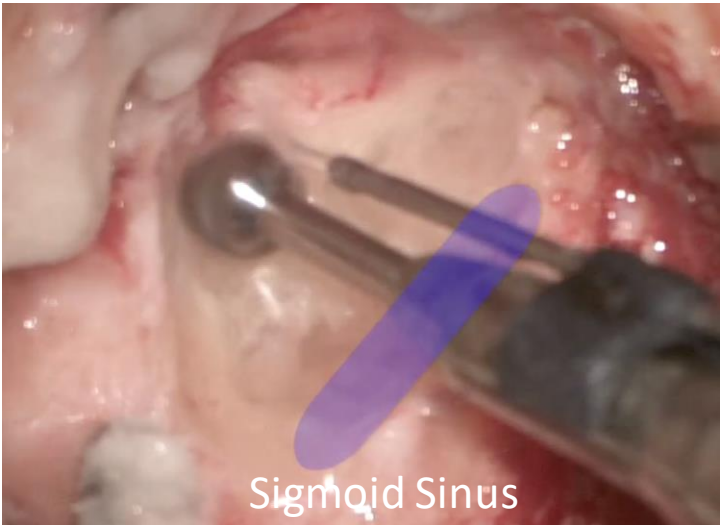
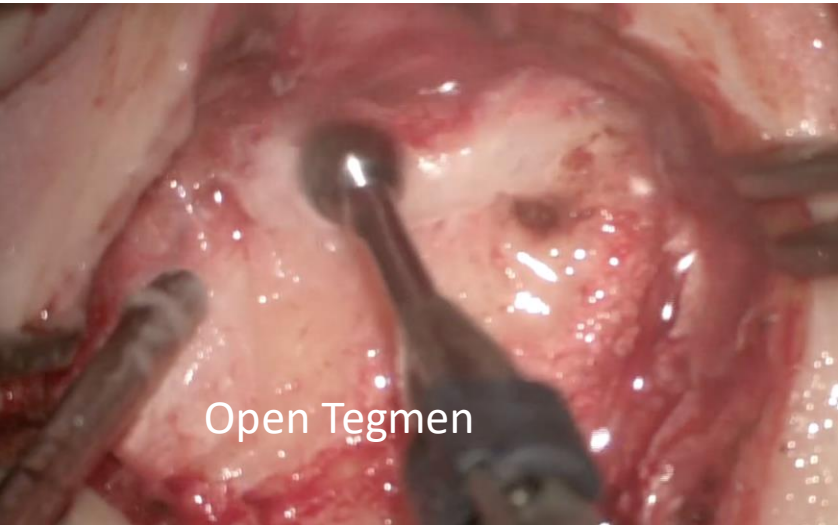
- A mastoidectomy is **surgery to remove cells in the hollow, air-filled spaces in the skull behind the ear within the mastoid bone.**
(Cochlear Implant, Cholesteatoma removal)



Mastoidectomy



Phases:



Technical Approaches

- Problem: Vision Based Automated video segmentation
- Feature Extraction
 - Spatial Feature Extraction
 - ResNet, EndoNet...
 - Temporal Feature Extraction
 - TCN...
- Feature Space Classification



Deliverables

- **Minimum: Existing DL Methods Benchmark**
 - Dataset
 - At least 3 methods
- **Expected: Improved DL Method**
 - 90% Accuracy (correct if segmentation error less than 1% of video length)
 - Algorithms & Code Documentation
- **Maximum: Conference paper**



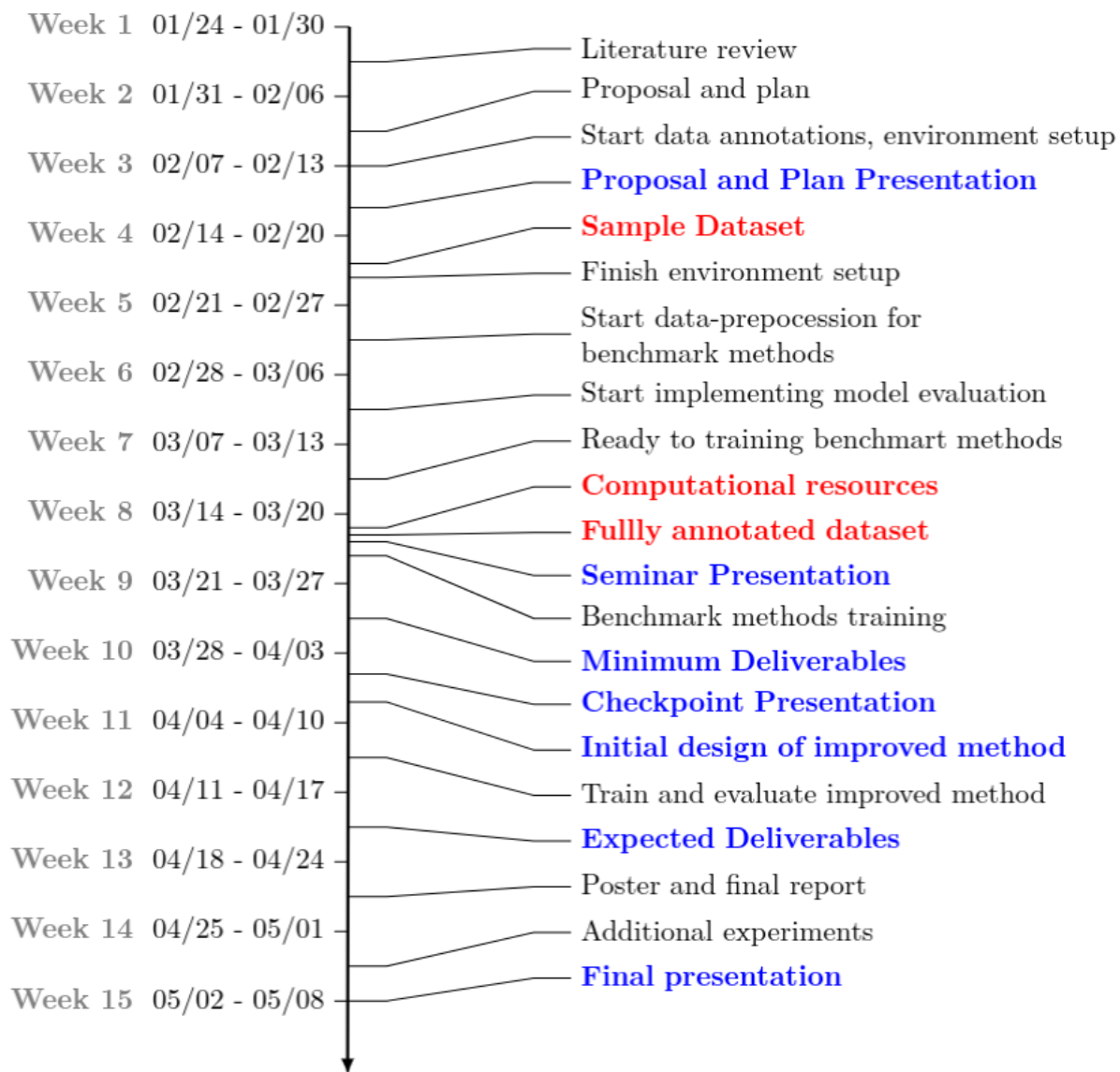
List of Dependencies & Plan for Resolving

Main Dependencies	Sub Dependencies	Contact	Expected Date	Status
Dataset	Data Generation	Dr. Danielle Trakimas	/	Ongoing
	Annotation Protocol	Dr. Danielle Trakimas	02/18	Finished Initial Protocol Ongoing
	Data Annotation	Dr. Danielle Trakimas	03/17	Ongoing
	IRB Training	Dr. Danielle Trakimas	02/11	Complete
Computational Resources	GPU	Prof. Mathias Unberath Max Li	02/18	Ongoing
	Server Remote Access	Anton Deguet Max Li	02/18	Ongoing
Existing Framework & Public Dataset	Framework	Prof. Mathias Unberath Max Li	02/11	Complete
	Laparoscopic Public Dataset (Cholec80)	Max Li	02/11	Complete
Clinical Advice	Clinical Advice	Dr. Danielle Trakimas	/	Ongoing

Milestones

Milestones	Expected Date
Proposal & Plan	02/10
Sample Dataset	02/20
Fully Annotated Dataset	03/17
Minimum Deliverables	03/27
Initial Network Design	03/30
Expected Deliverables	04/17
Final Presentation	05/02

Timeline



Blue entries: Milestones Red entries: Important Resolving Deadline

Management Plan

- Weekly meetings with mentors
- Communication on Slack
- Code management with Git
- Progress management with Gantt chart



Reading list

- [1] Andru Putra Twinanda, Sherif Shehata, Didier Mutter, Jacques Marescaux, Michel de Mathelin, and Nicolas Padoy. Endonet: A deep architecture for recognition tasks on laparoscopic videos. *CoRR*, abs/1602.03012, 2016.
- [2] Xiaojie Gao, Yueming Jin, Yong-Hao Long, Qi Dou, and Pheng-Ann Heng. Trans-svnet: Accurate phase recognition from surgical videos via hybrid embedding aggregation transformer. *CoRR*, abs/2103.09712, 2021.
- [3] Carly Garrow, Karl-Friedrich Kowalewski, Linhong Li, Martin Wagner, Mona Schmidt, Sandy Engelhardt, Daniel Hashimoto, Hannes Kenngott, Sebastian Bodenstedt, Stefanie Speidel, Beat Müller, and Felix Nickel. Machine learning for surgical phase recognition a systematic review. *Annals of Surgery*, Publish Ahead of Print, 11 2020.
- [4] Henry Lin, Izhak Shafran, David Yuh, and Gregory Hager. Towards automatic skill evaluation: Detection and segmentation of robot-assisted surgical motions. *Computer aided surgery : official journal of the International Society for Computer Aided Surgery*, 11:220–30, 10 2006.
- [5] Tobias Blum, Hubertus Feussner, and Nassir Navab. Modeling and segmentation of surgical workflow from laparoscopic video. volume 13, pages 400–7, 09 2010.
- [6] Joonmyeong Choi, Sungman Cho, Jong Chung, and Namkug Kim. Video recognition of simple mastoidectomy using convolutional neural nets: Detection and segmentation of surgical tools and anatomic regions. *Computer Methods and Programs in Biomedicine*, 208:106251, 06 2021.
- [7] Colin Lea, Joon Hyuck Choi, Austin Reiter, and G Hager. Surgical phase recognition: from instrumented ORs to hospitals around the world.
- [8] Manish Sahu, Angelika Szengel, Anirban Mukhopadhyay, and Stefan Zachow. Surgical phase recognition by learning phase transitions. *Current Directions in Biomedical Engineering*, 6(1):20200037, 2020.4
- [9] Lea, Colin, Austin Reiter, René Vidal, and Gregory D. Hager. "Segmental spatiotemporal cnns for fine-grained action segmentation." In *European Conference on Computer Vision*, pp. 36-52. Springer, Cham, 2016.
- [10] Jin, Yueming, Yonghao Long, Cheng Chen, Zixu Zhao, Qi Dou, and Pheng-Ann Heng. "Temporal memory relation network for workflow recognition from surgical video." *IEEE Transactions on Medical Imaging* 40, no. 7 (2021): 1911-1923.

