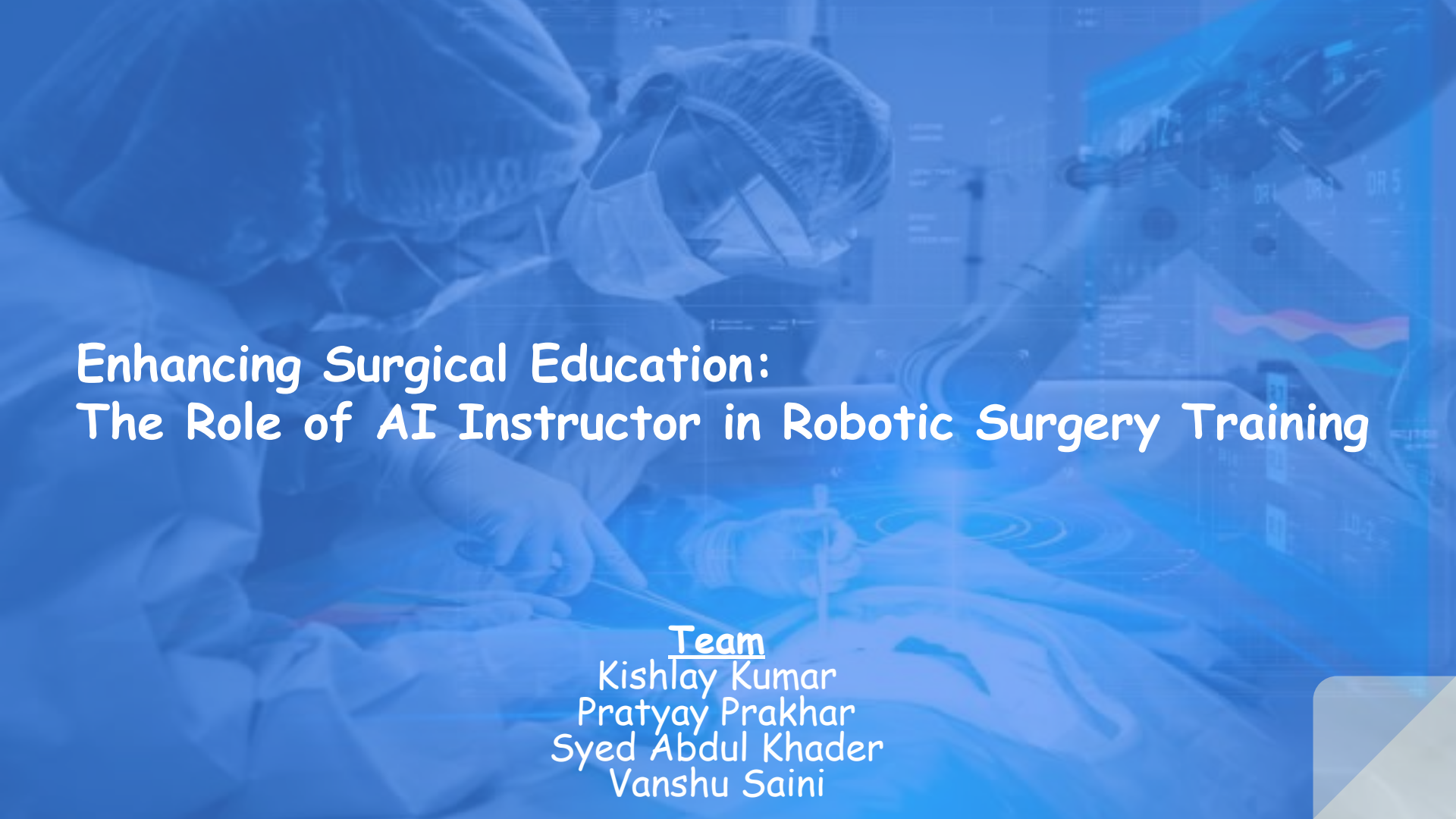
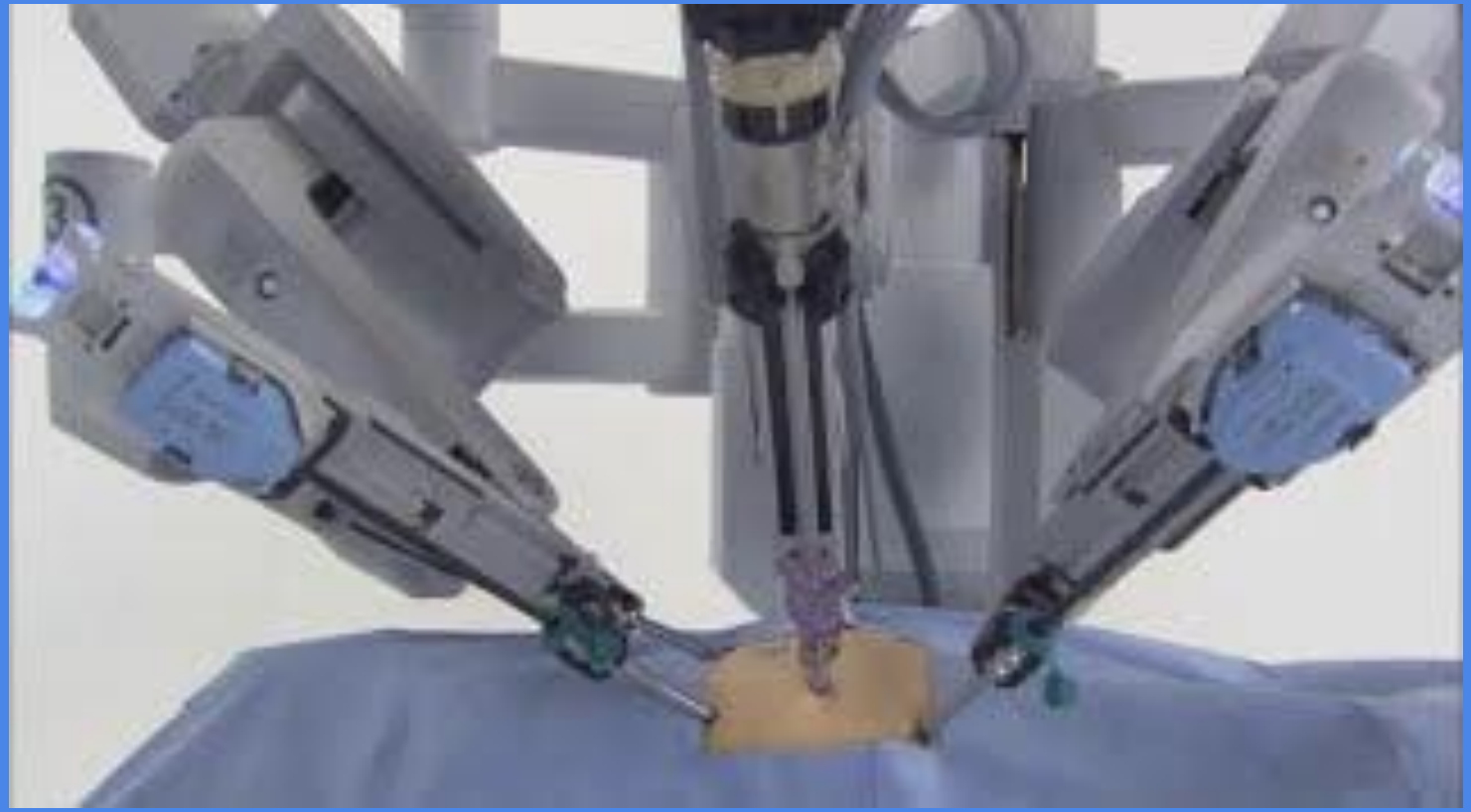


Enhancing Surgical Education: The Role of AI Instructor in Robotic Surgery Training

Team

Kishlay Kumar
Pratyay Prakhar
Syed Abdul Khader
Vanshu Saini

Robotic Surgery in Action



Challenge

Doctor's Presence

Auto Evaluation

Validated by a group of 4 esteemed doctors from

MGH 1811

HARVARD MEDICAL SCHOOL

Problem

Presence of Doctor required for training residents during simulated operations

Proposed Solution

Intelligent software system to accurately detect and identify arteries in real-time, enhancing surgical safety and training efficacy

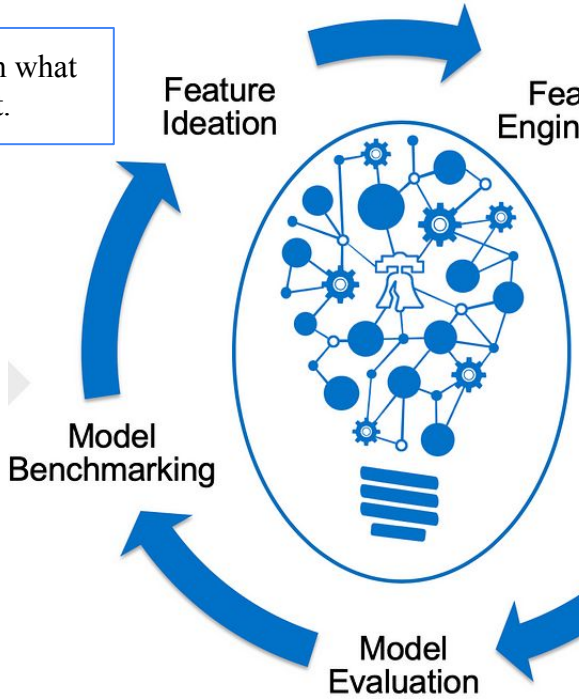
SCOPE
Thoracic Surgery & Educational Purpose

Hypothesis

The reliance on doctors' intervention during student's training can be eliminated while maintaining a high level of accuracy in artery identification.

APPROACH

AGILE ML CYCLE



Gathering data, ideating on what kind of data to collect.

Handling different features in the data. Extracting and combining features.

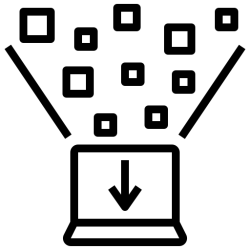
Training of model on the data.

Defining metrics, testing model on the defined metrics.

On the defined metric, compare different models.

Step 1: Data Collection & Annotation

Data Collection



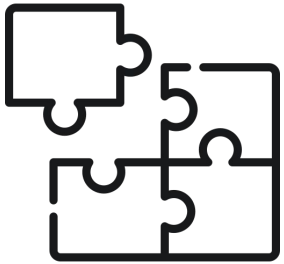
- There are no surgical video datasets labelled with anatomy like arteries and veins.
- We have data from twelve patients collected from the Thoracic Left Lower Lobe surgery.

Data Annotation

- Training data can be initially annotated using medical students' expertise.
- The entire video spans 1 hour 30 minutes, snippets for 1-5 minutes were taken from the video, where the arteries are exposed, and each frame was annotated.

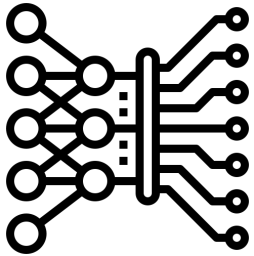
Step 2: Exploration and Research

Feature Extraction



- SIFT detector was used to extract interesting features from each frame and match them along the frames to track and segment the artery.
- This can be used as a baseline.

Model Training



- Off the shelf Mask-RCNN model was used to train for each frame on 80% of the data and remaining 20% for testing and validation.
- Using pre-trained backbone (ResNet50) with ImageNet weights, can give better results compared to training from scratch.

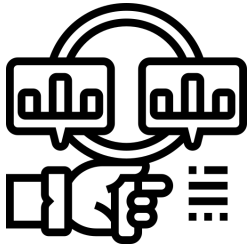
Step 3: Evaluation and Benchmarking

Model Evaluation

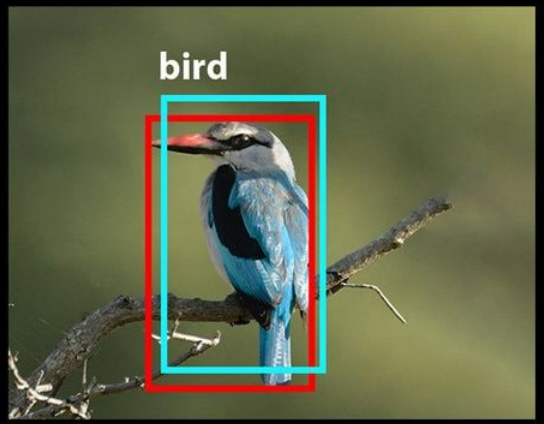
- To evaluate the model, Intersection over Union (IoU) metric can be used for both Object Detection and Segmentation.
- Generalizability over different patients and over different operation types can also also measured through IoU.

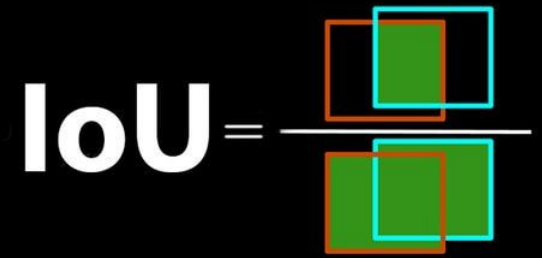
Model Benchmarking

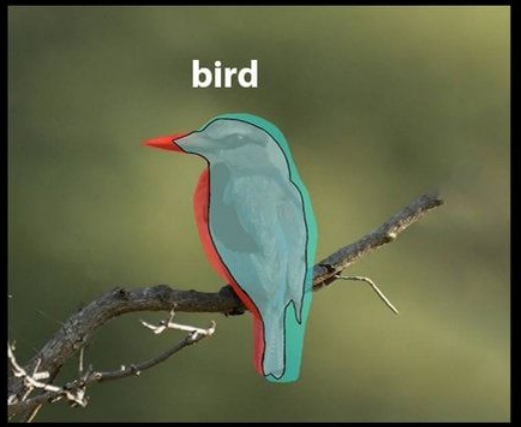
- After initial training, different hyper parameter tuning and heavy data augmentations was performed to improve the performance
- Another model, X-Mem which is capable of remembering the past frames in memory helping in better tracking performance was used.



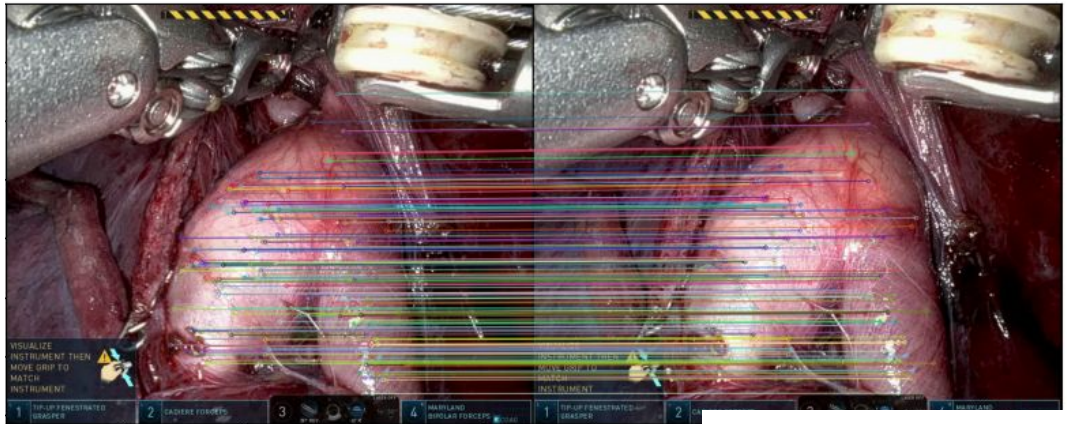
WHY IOU

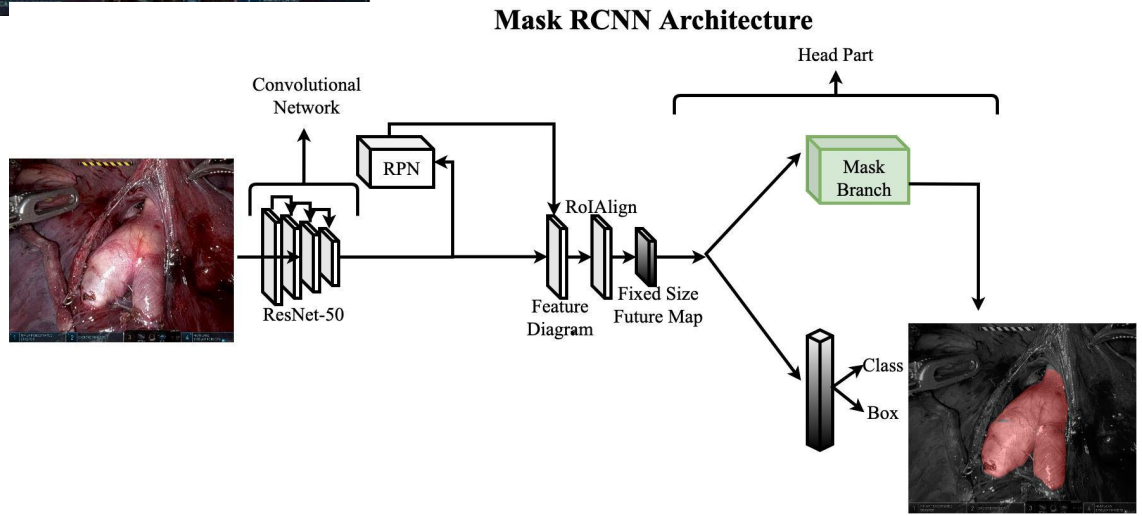


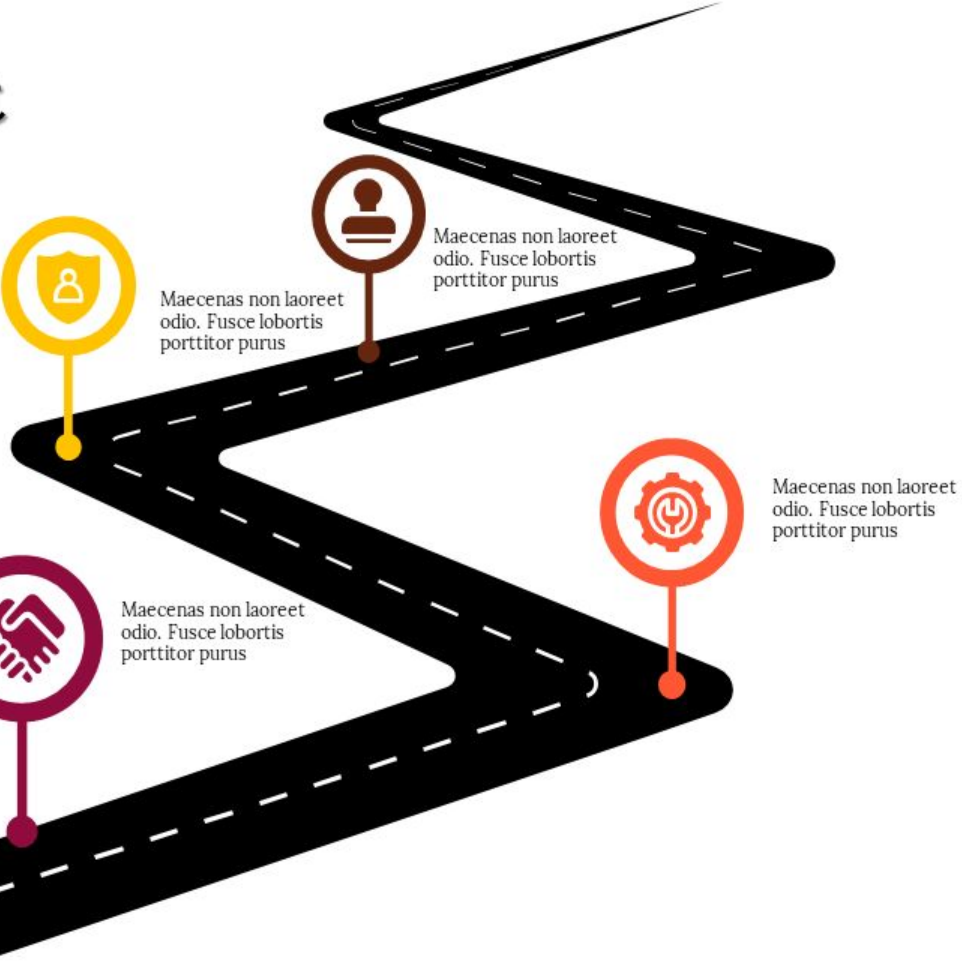




MODEL DETAILS







PRODUCT ROADMAP

SCRUM FRAMEWORK

Extremely agile 2 week-long sprint

Sprint Planning
Work to be accomplished in the upcoming sprint

Every second wednesday

Daily Standup
Updates on their progress, discuss any impediments

Everyday

Sprint Retrospective
Reflect on the recent sprint, identifies what went well and areas for improvement

Every second Thursday

Sprint Review
Showcase the completed work to stakeholders, gather feedback

Every second Tuesday

Tools

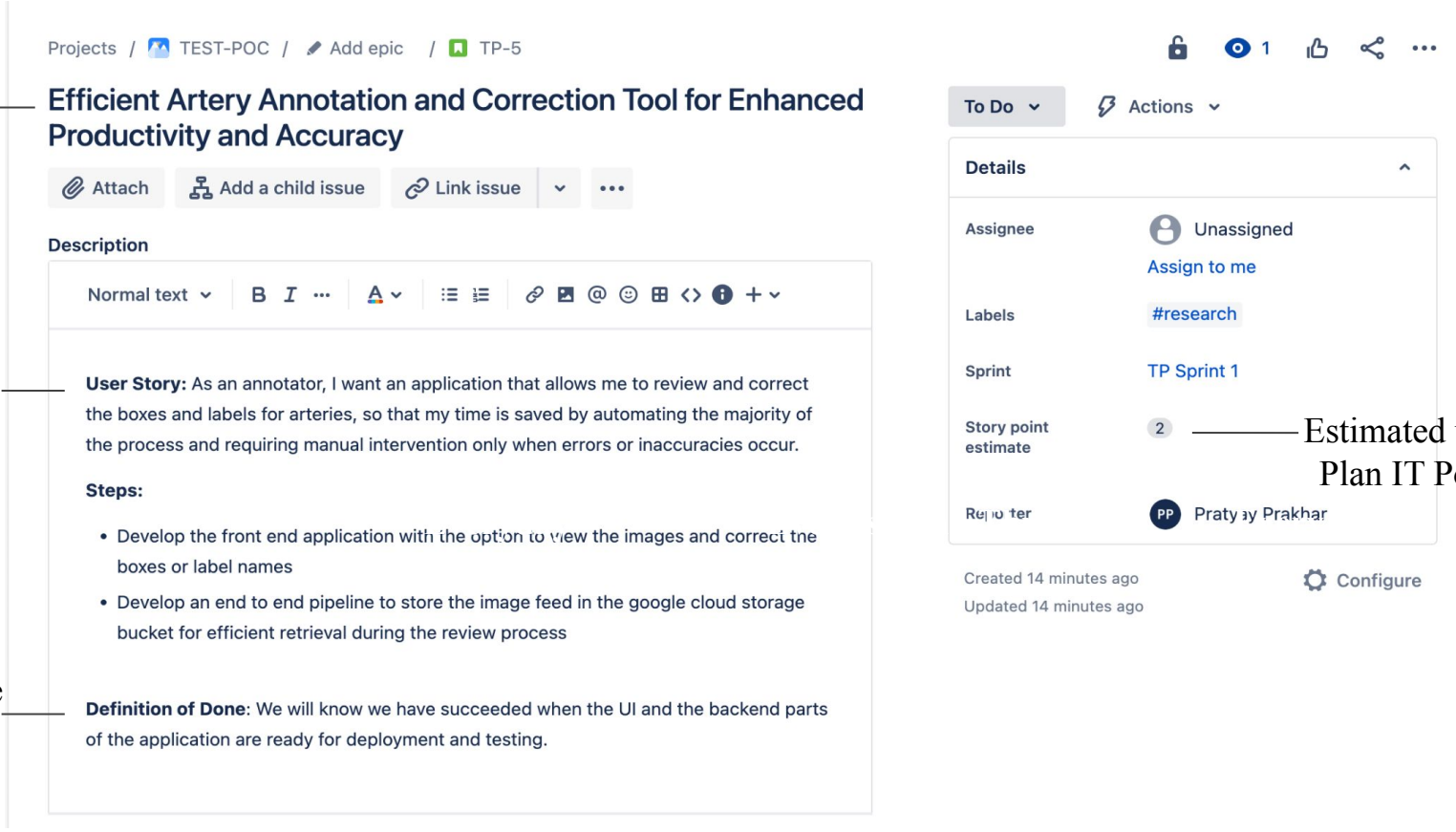
Jira Confluence

SAMPLE USER STORY

Outcome Focused

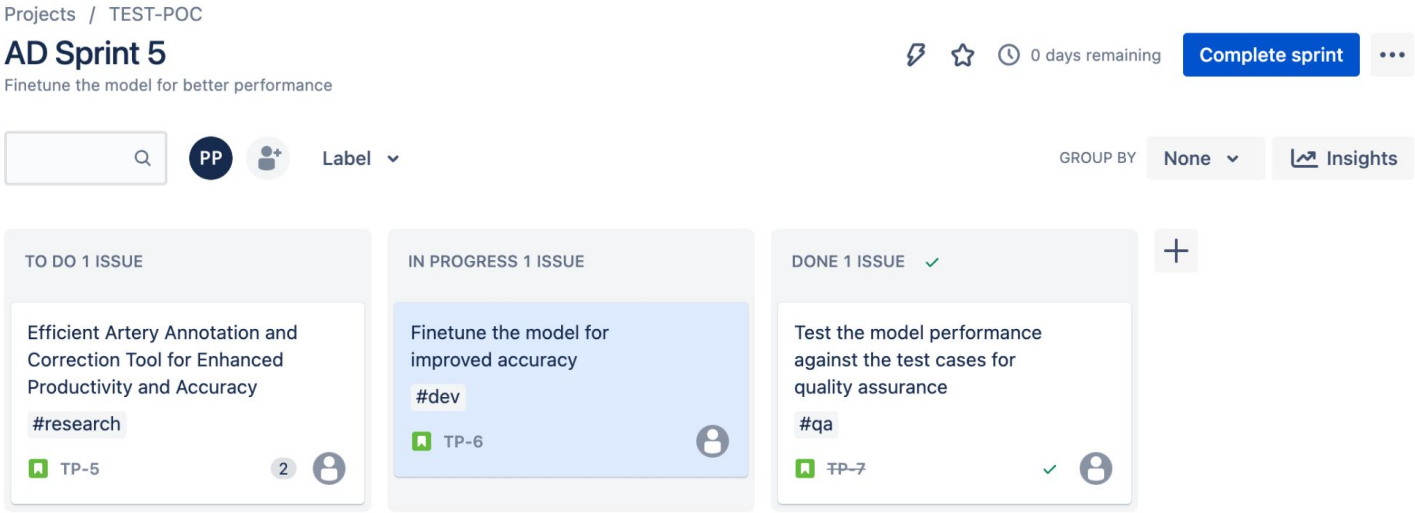
User Empathy

Acceptance Criteria



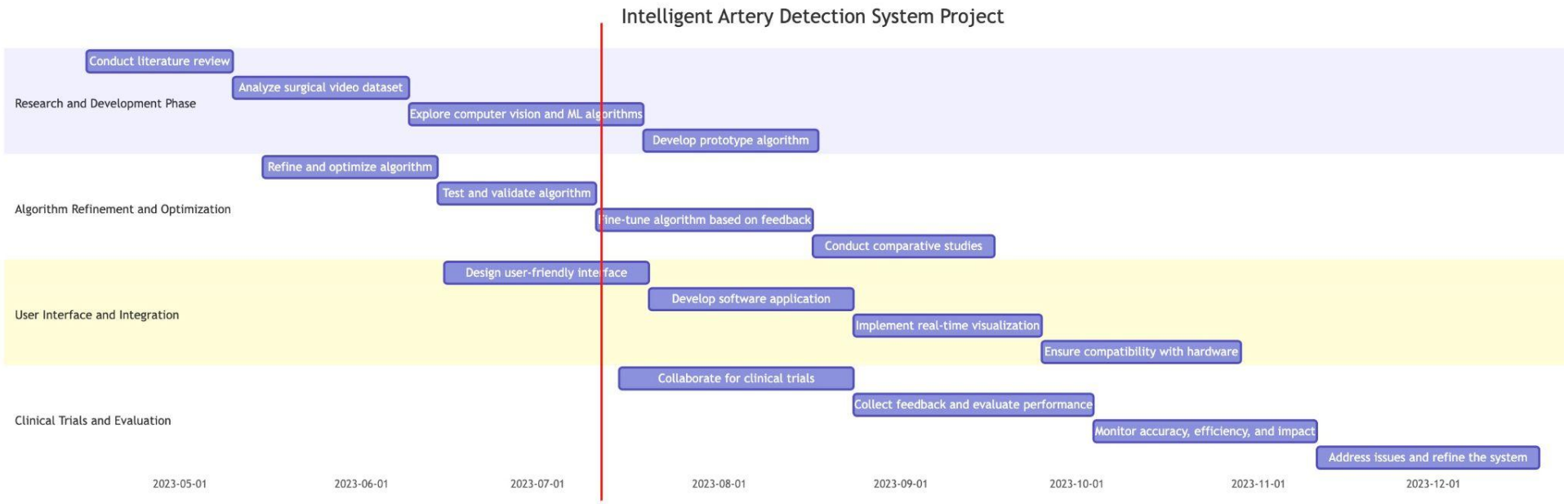
Estimated using Plan IT Poker

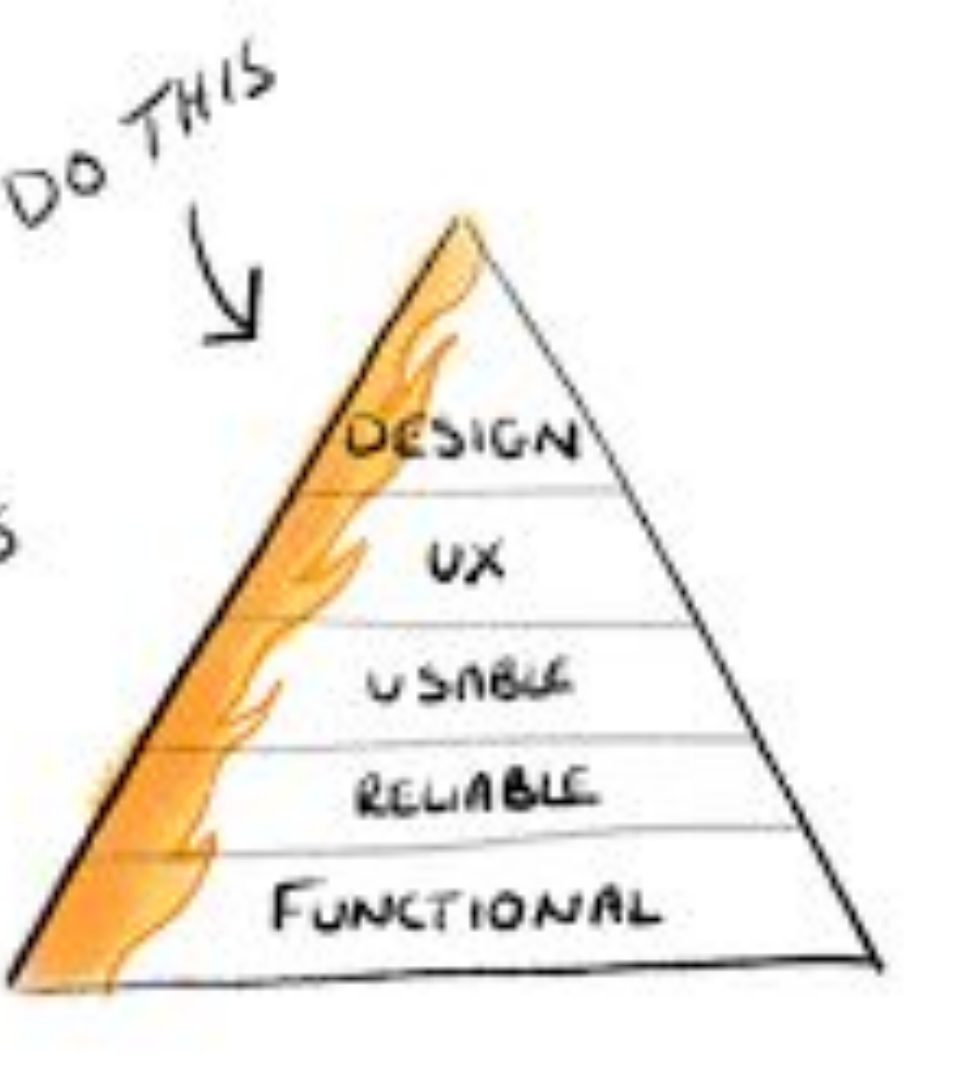
MANAGING SPRINTS



Backlog refinement to capture all the requirements and suggestions

PRODUCT ROADMAP





MVP

VIDEO DEMONSTRATION

Red Overlay

Wrong Predicted Part

Green Overlay

Correct prediction

(Prediction == Ground Truth)

Blue Overlay

Ground Truth

(not predicted by model)

MEASURING SUCCESS

METRICS

PRODUCT METRICS

- **Diagnosis Accuracy**, how accurately can the model predict and how well it aligns with expert doctors.
- **Adoption Rate,** among the doctors and medical institutions.

BUSINESS METRICS

- **Time saved by doctors**, which would be spent in training surgeons residents.
- **Change in Learning Experience**, the change in experience of students due to availability of constant supervision via automation.

AI-MVP

VALUE PROPOSITION

Our software empowers doctors with accurate artery detection during robotic thoracic surgeries, reducing complications, improving surgical efficiency, and enhancing training outcomes.

PERFORMANCE INDICATORS

Measure the accuracy of the trained model in correctly detecting arteries in the operation videos.
Assess the model's ability to generalize across different patients and operation types.
Measure the efficiency of the model during inference in real-time

ORGANIZATION

Mass General Hospital

DATA & TECHNOLOGY

Data – Annotated surgical data from twelve patients collected from the Thoracic Left Lower Lobe surgery.

Technologies – RCNN, SIFT, X-Mem

OPERATIONAL IMPLICATIONS

Improved surgical precision and reduced risk of complications

Streamlined Training Process and Standardized instruction for artery identification

Increased Efficiency in Surgical Workflow

AI LIFE CYCLE

1. Problem Definition
2. Data Collection and Annotation
3. Data Preprocessing and Exploration
4. Model Development and Training
5. Model Evaluation and Validation
6. Model Deployment and Integration
7. Monitoring and Iteration

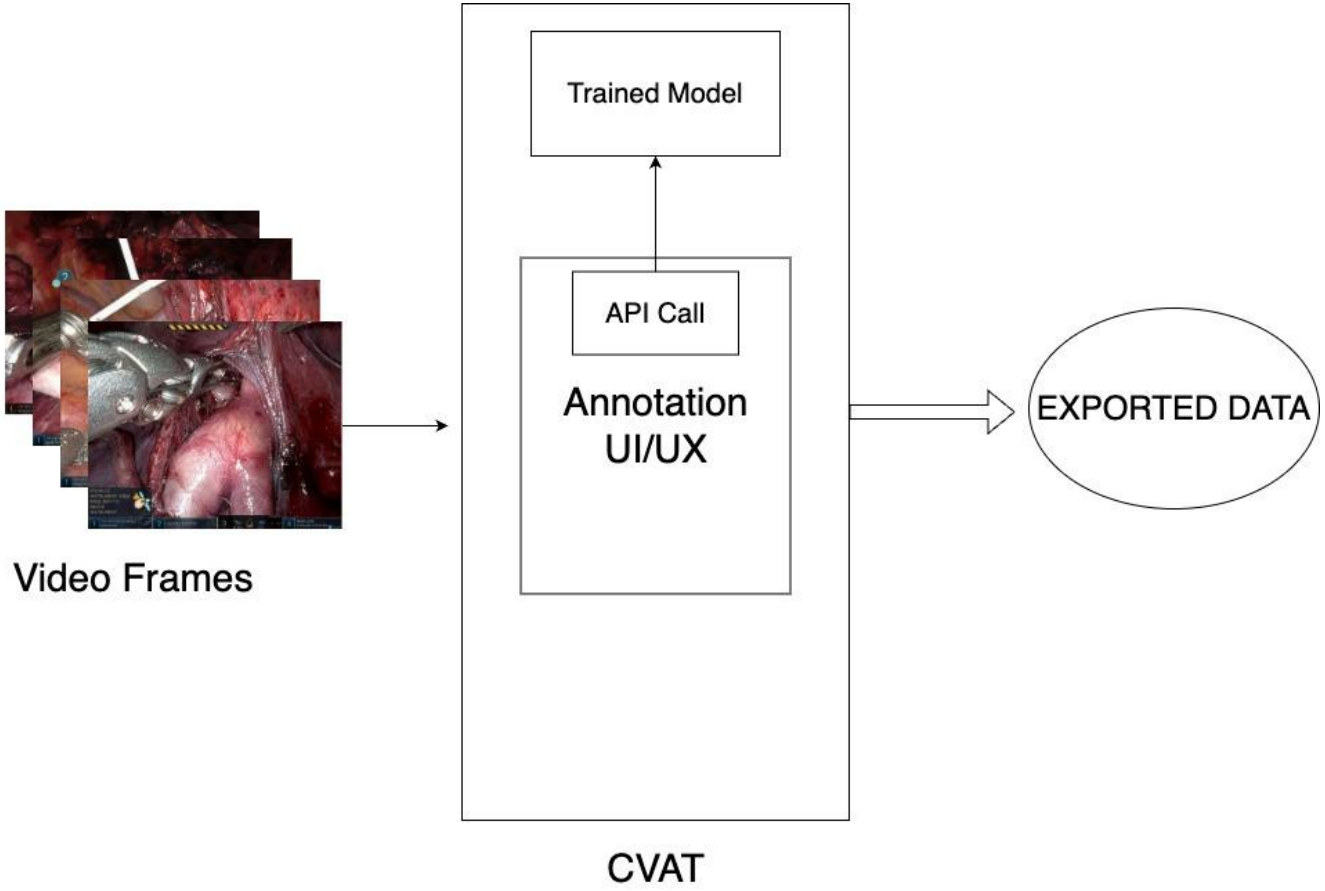
CURRENT AND FUTURE WORK

CURRENT RESULTS

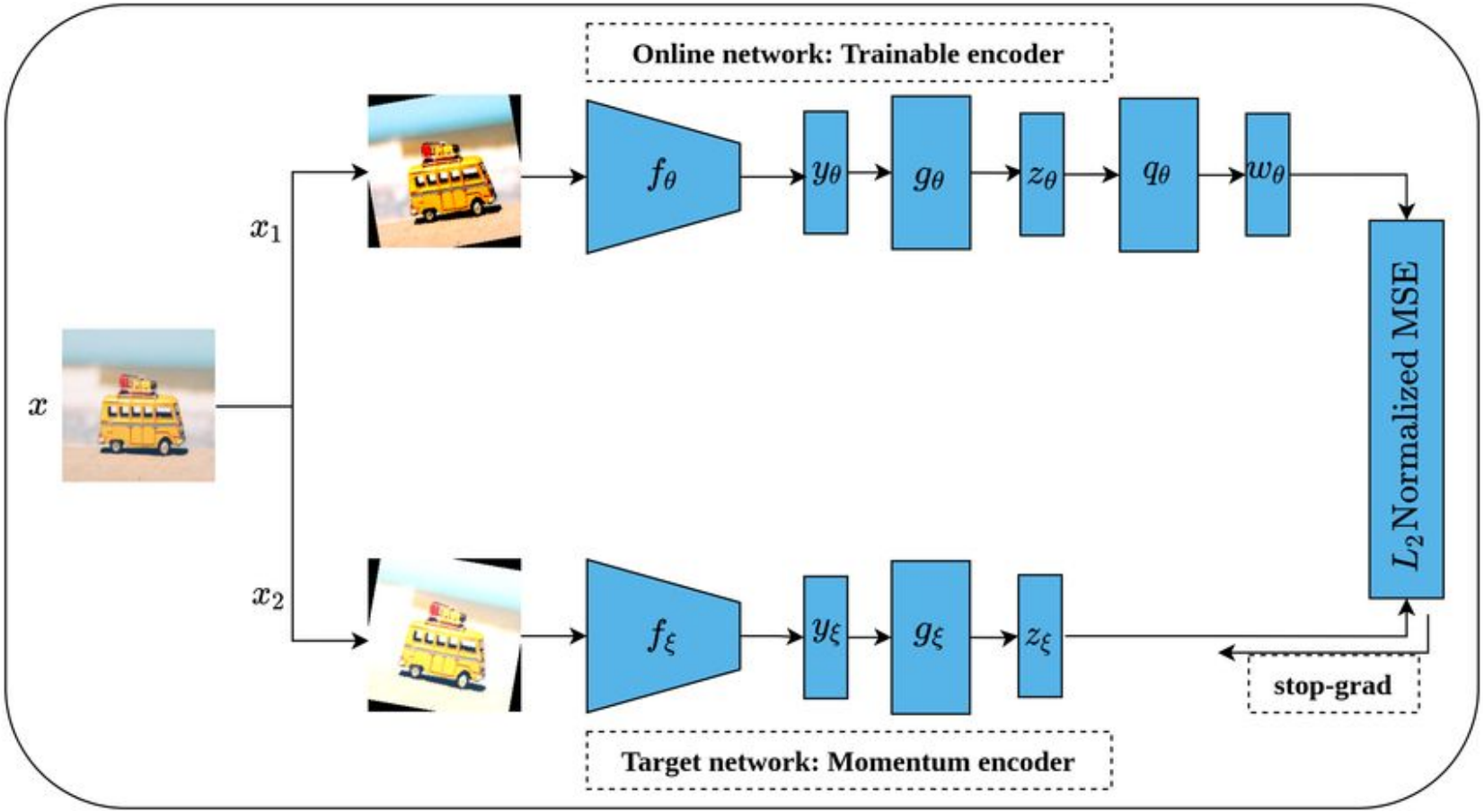
Model	Average IoU over all Patients
SIFT Tracking	7.1%
Mask-RCNN (Only 4 Patients Data)	22.6%
Mask-RCNN (without Data Augmentation)	43.01%
Mask-RCNN (with Data Augmentation)	**66.59%**
Pre-Trained X-Mem	**66.31%**
X-Mem (trained on our Data)	**71%***

** Prospective Results - Final Results yet to be confirmed*

ONGOING AND FUTURE WORK



ONGOING AND FUTURE WORK



THANK YOU