AI Summer School 2025: Team Project

June 13, 2025

University of Pittsburgh

Introduction and Problem Statement:

Total Knee Arthroplasty (TKA) is a surgical procedure that replaces a damaged knee joint with a prosthetic implant. Precise implant placement is critical to ensure joint function, reduce complications, and optimize patient mobility after surgery. Artificial intelligence (AI) methods can assist in both pre-surgical planning and postoperative care by automatically analyzing radiographs.

In this team project, you will develop an AI localization system using YOLOv9 to automatically localize and classify the knee joint area on synthetic knee radiographs - both with and without TKA implants. This system aims to support clinicians by improving the precision and efficiency of TKA procedures.

The goal is not just to build a model - but to experience the entire medical AI pipeline: data understanding, annotation, model training, evaluation, and communication.

Good luck and have fun!

Team Creation:

In-Class: You will form groups of 2-3 students.
Remote: You will be assigned to breakout groups of 2-3 students.

Project Tasks

Task 1: Dataset Exploration

- Download the dataset from the GitHub repository.
- Visualize random samples.
- Verify image resolution and quality.
- Identify whether implants are present.
- Discuss any challenges that might affect annotation consistency.

Task 2: Inter-rater Agreement

- Download the AISummerSchool_2025_TeamProject-Interrater-Agreement-Set containing 15 images.
- Each team member will independently annotate these images using Roboflow. When completed export your annotations using the **PascalVOC format**
- Follow the provided annotation guidelines using LabelImg with the following two classes:
    - **KneeAP**: Native knee joint (no implant)
    - **TkaKneeAP**: Knee joint with TKA prosthesis

- Draw bounding boxes that tightly enclose the entire knee joint (including implant if present) following the annotation guidelines presented during the hands-on session
- After annotating:
    - Calculate the inter-rater agreement. Only one team member should do this, with each member should share their annotations with this member. Code to do this is provided in the project starter code notebook.
    - Calculate pairwise Intersection over Union (IoU) between team members' bounding boxes.
    - Compute the average inter-rater IoU for the group.
    - Review and discuss any low agreement cases to improve annotation consistency.
    - Reannotate **if necessary.** Aim for an IoU of 0.8 or greater.
- Provide the average inter-rater IoU and a few examples in your presentation.
- **For this step, use the CPU on Google Colab not the GPU. Google Colab only provides you with a GPU for a limited amount of time, and the time is used even when the GPU isn't being used.**

Task 3: Dataset Preparation

- Have one team member create a new project on Roboflow to contain the AISummerSchool_2025_TeamProjectDataset and add the other team members as Labelers
- Follow the provided annotation guidelines using LabelImg with the following two classes:
    - **KneeAP**: Native knee joint (no implant)
    - **TkaKneeAP**: Knee joint with TKA prosthesis
- Draw bounding boxes that tightly enclose the entire knee joint (including implant if present) following the annotation guidelines presented during the hands-on session.

Task 4: *Dataset Conversion*

- Export annotations into **YOLOv9 format**.
- Use the configuration demonstrated during the hands-on session.

Task 5: Model Training and Validation

- Enable the GPU for Google Colab
- Upload your final dataset to Google Colab for model training.
- Train a YOLOv9 detection model using your annotated dataset.
- Experiment with different:
    - Learning rates
    - Numbers of training epochs.
- Choose the best performing model from your experiments

Task 6: Model Evaluation

- Evaluate your best model on a test set:
    - Provide the mAP, Precision, and Recall (Hint: Ultralytics already provides these)
    - Compute average IoU for each class (KneeAP and TkaKneeAP).
    - Report the overall average IoU across both classes.
    - Select the model with the best performance.

- Provide two examples displaying the predicted bounding box and their confidence score

Task 7: Team Presentation

- Prepare a short team presentation that includes:
    - Background (1-2 slides)
    - Dataset Exploration & Inter-Rater Agreement (1-2 slides)
    - Dataset Preparation (1 slide)
    - Methods (1-2 slides)
    - Results (1-3 slides)
    - Conclusions & Future Extensions (1 slide)
- Presentation Schedule:
    - 11:30 AM - 12:00 PM
    - 1:00 PM - 2:15 PM
- Each team will have approximately 5 minutes.

Assistance:

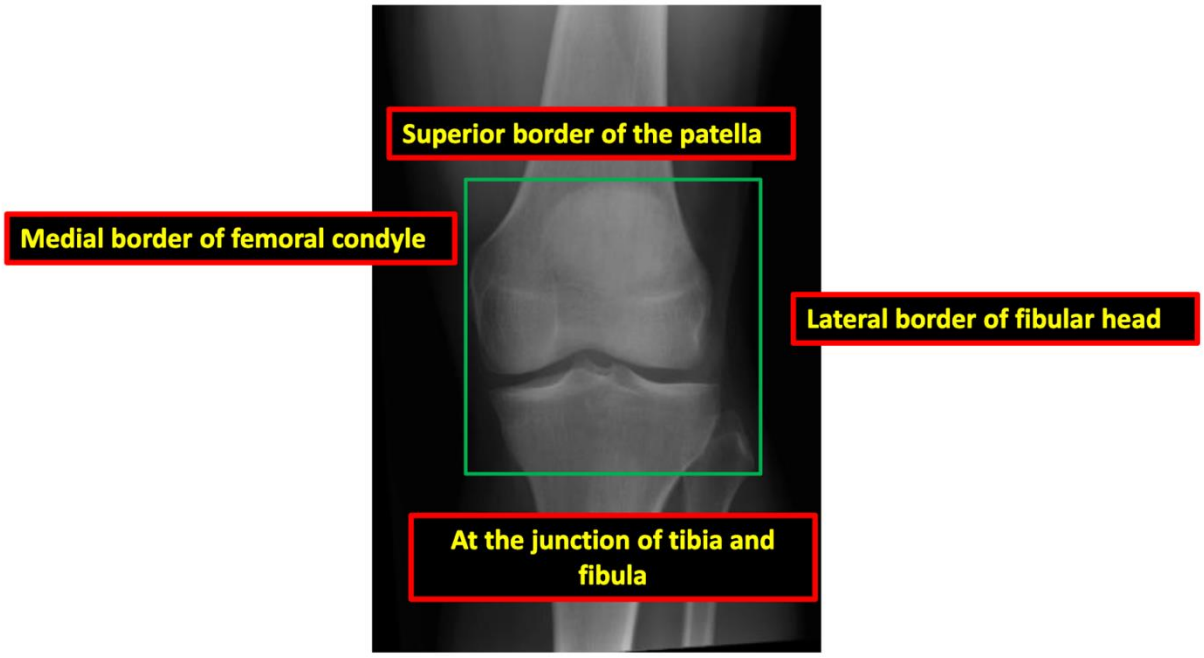
If you have questions at any time, please reach out to:

- Nick Littlefield
- Fengyi Gao

GitHub Repository:

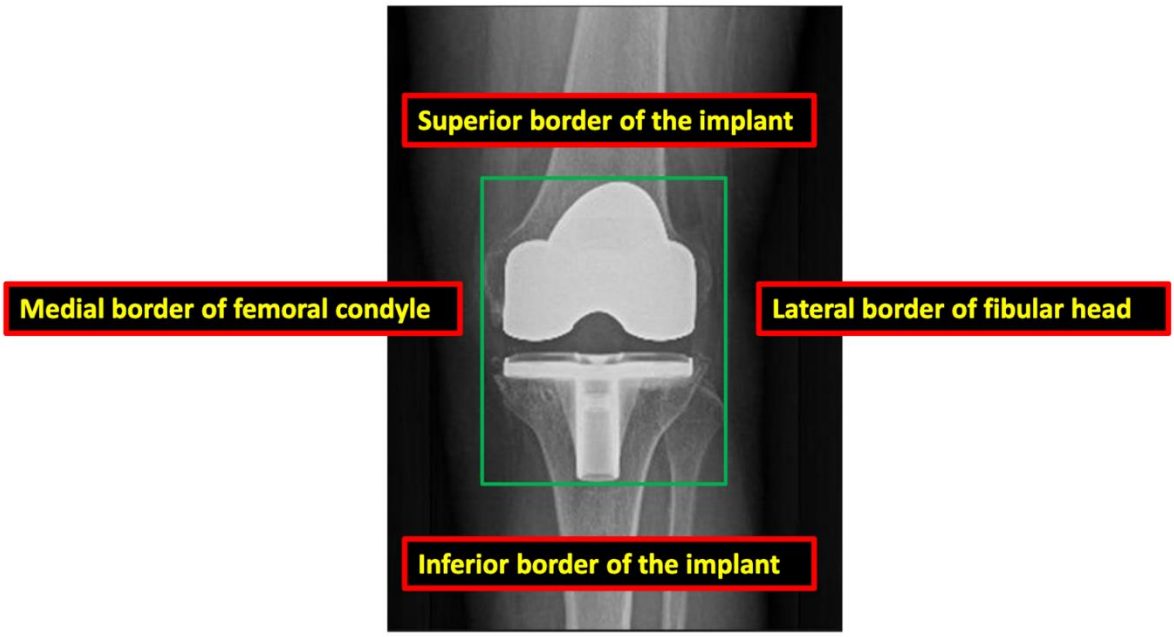
All datasets, guidelines, and example code will be available at:
https://github.com/pitthexai/AISummerSchoolinMedicalImagingInformatics

Annotation Guideline: KneeAP



https://opentja.github.io

Annotation Guideline: TkaKneeAP



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