Q1 - Model fine tuning

Fine-tuning a YOLO model for detecting medical anomalies in X-ray images means adapting an already trained YOLO model to perform well on a new task—identifying abnormalities in X-ray images. Here's a detailed and beginner-friendly explanation:

What is YOLO?

- YOLO (You Only Look Once) is a popular machine learning model used for object detection.
- It takes an image as input and identifies objects in the image by drawing boxes around them and assigning labels to each box.
- Imagine you're identifying apples, bananas, and oranges in a photo. YOLO finds each fruit, draws a box around it, and says what it is.

When we use YOLO for medical images, the goal is to identify medical issues (like fractures or tumors) in X-rays instead of apples and bananas.

Step 1: Understand the Pretrained Model

- A pretrained YOLO model has already learned to detect objects in general images (like animals, cars, or people) using a dataset called COCO.
- But X-ray images are different. Medical anomalies are subtle and not present in COCO data. That's why we need to *fine-tune* the model so it can detect these specific abnormalities.

Step 2: Gather and Prepare Your Data

1. **Collect Images**: Get lots of X-ray images. Some might show normal X-rays, while others might show abnormalities.
2. **Annotate the Images**:
   - Draw boxes around the abnormalities in the images.
   - Label each box with the type of abnormality (e.g., "fracture" or "tumor").
   - There are tools like **LabelImg** to help you draw these boxes on your computer.
3. **Organize the Data**:
   - Save the annotations in a format YOLO understands (e.g., `.txt` files alongside each image).
4. **Resize the Images**:
   - YOLO needs images of a specific size (e.g., 416x416 pixels). This resizing makes sure all images are the same size for the model.
5. **Augment the Data**:
   - Data augmentation means creating variations of your images to teach the model better. For example:
     - Flip the X-ray horizontally or vertically.
     - Slightly rotate the image.
     - Adjust brightness and contrast to simulate different scanning conditions.

Step 3: Modify the YOLO Model

- The pretrained YOLO model has a part that outputs labels like "cat" or "car."
- Replace this part with one that outputs your labels (like "fracture" or "tumor").
- This is like swapping the signboard of a store: Instead of selling fruits, the store now sells medical supplies.

Step 4: Train the Model

1. **What is Training?**
   - Training is when the model "looks" at your annotated X-rays, learns what the anomalies look like, and adjusts itself to make better predictions.
2. **How to Start?**
   - Use your prepared dataset.
   - Load the pretrained YOLO model, but tell it to focus on learning only about your data.
3. **Settings to Adjust (Hyperparameters):**
   - **Learning Rate**: Controls how fast the model updates itself while learning. Start with a small value like 0.0001 to avoid sudden wrong updates.
   - **Batch Size**: This is how many images the model looks at at once during training. A batch size of 16 or 32 is a good starting point.
   - **Number of Epochs**: One epoch means the model has looked at all the images in your dataset once. You might need 50–100 epochs for this task.
4. **Use Validation Data**:
   - Keep some X-rays aside (don't use them for training). After training, test the model on these images to see how well it performs.
5. **Monitor the Model's Progress**:
   - During training, the model calculates "loss," which tells you how wrong its predictions are.
   - A decreasing loss means the model is learning.

Step 5: Evaluate and Improve

1. **Test the Model**:
   - Use new X-rays to test the model's performance. Check:
     - Does it detect all abnormalities?
     - Does it avoid marking normal areas as abnormal?
2. **Metrics to Measure Performance**:
   - **Precision**: How many of the detected abnormalities are correct?
   - **Recall**: How many of the actual abnormalities were detected?
   - **mAP (mean Average Precision)**: A summary score that tells you how well the model is doing overall.
3. **Tweak Settings if Needed**:
   - Adjust the learning rate or batch size.
   - Train for more epochs if it's not learning enough or stop early if it's overfitting (memorizing instead of generalizing).

Step 6: Deploy the Model

1. **Set a Confidence Threshold**:
   - The model predicts anomalies with a "confidence score" (e.g., 85% sure it's a tumor). Decide a threshold (e.g., 50%) to filter predictions.
2. **Run the Model on Real Data**:
   - Feed new X-rays into the model. It will highlight areas with abnormalities and label them.
3. **Validate with Doctors**:
   - Have medical professionals check the results to ensure accuracy.

Important Tips

- **Patience**: Fine-tuning can take hours or even days, depending on your hardware.
- **Hardware**: Use a powerful computer with a GPU (Graphics Processing Unit). GPUs make training much faster.
- **Learning from Failures**: If the model misses abnormalities or makes many mistakes, look at the images it got wrong. This can give clues about what's missing in the training data.

By following these steps, you're teaching the YOLO model to "look" at X-rays and identify medical problems as a trained doctor would. Fine-tuning is a process of adapting a general-purpose tool to a specific and important task, like diagnosing medical conditions.