1. YOLOv5 Architecture and Image detection Techniques

You Only Look Once is an object detections framework that can be used to perform real time detection. YOLO has many models including the one that has been integrated into this project YOLOv5 i.e. version 5.

Key components of YOLOv5

* The main body of the framework has been designed using the *new CSP-Darknet 53* structure a heavy modification from the previous iteration of this model
* Connecting the head to the body it uses a *SPFF New and CSP-PAN* structure, and it also known as the neck of the project
* The head in the end is that final part which is responsible for providing the end output. YOLOv5 uses the head of its previous iteration the YOLOv3 model
  1. The model has been trained using two classes derived from the used dataset namely “crop” and “weed”. The customization used by YOLOv5 is done using the YAML configuration which allows it to focus only on the classes that are needed to execute the project and improve performance
  2. The model also sets the epochs (number of times the batch has been processed) to 100 and the batch size (number of samples processed) to 16 which allows for smoother gradient curves updates and more epochs ensure model convergence
  3. The uses transfer learning which is a ML task that uses knowledge gained from one task to help improve the related task. Transfer learning by YOLOv5 is done by using a pre-trained model and adjusting it to the custom dataset.

1. Data annotation and Preprocessing
   1. Images in the output are annotated with bounding boxes around the objects “weed” and “crop” with its coordinates, confidence score(how certain the model is of the objects true nature) and a label indicating what is a crop and weed.
   2. Flipping and Rotation to help the model generalize different orientation

Scaling and cropping which makes the model accustomed to size variations in crops and weeds

* 1. Colour Jittering which compensates for different images that have been taken under different lighting conditions

1. Deployment Architecture: Flask API for backend Inference
   1. The Flask API framework includes an endpoint that is used to handle POST requests. The users input the image via the frontend, which is then processed by the YOLOv5 model and returns coordinates, confidence scores and detection labels
   2. Once the model provides its predictions and output the user input the results are saved as an image and JSON file, which the frontend uses to display what has been detected.
   3. The Flask endpoint has also been customized and improved for better error handling, file management and most importantly CORS(cross-origin resource sharing) which allows for seamless connection between frontend and backend
2. Front end Interface for user interaction
   1. The front end has been designed using the trinity of HTML, Javascript and CSS which allows the user to select an image, which is previewed and uploaded. The image is then analyzed and the front end retrieves the results from the server, displaying it for the user
   2. The Front end offers real time analysis, error messages for wrong inputs and a responsive and interactive User interface for ease of use

Future scope

1. Automated Image Capturing using UAVs: To streamline data capturing our future scope involves using the best of technology in drones and UAVs which will capture images of the field drawing their own boundaries and limits in real time. This allows us to capture high resolution images that will gather critical data without any laboured intervention
2. The next goal we aim to achieve is create a 3D, well defined model of the field using these large scale images. The model will offer a precise, spatially accurate representation of the field giving the users a close up as well as birds eye view of the field in digital format
3. The next step is to use the 3D model and display each plant and weed using distinct colours like red for weed and green for plants. This colour coded approach will ease the task of locating and identifying weeds from the large fields
4. In the last step we aim to help the farmers navigate the field to find and eradicate the weeds in order using a standardized coordinates system, that will accurately track plant location, support management strategies and potentially automate treatment solutions based on exact coordinates