

Research Portfolio



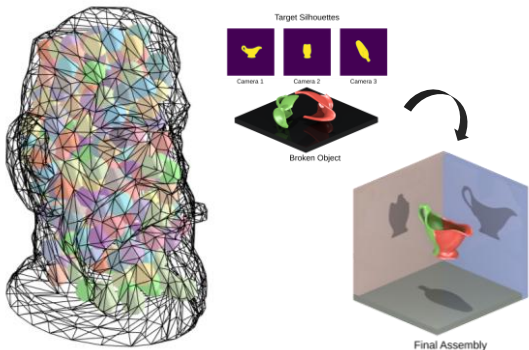
I am an incoming PhD student and NPGS Scholar at the School of Electrical and Electronic Engineering at NTU Singapore. I am currently pursuing a Master's degree in Computer Science and Engineering at IIT Gandhinagar, India. My master's research is focused on differentiable rendering and 3D shape analysis. Since March 2024, I have also been serving as a Project Fellow at the Computer Vision Imaging and Graphics Lab, IIT Gandhinagar. I have also been collaborating with the National Institute of Mental Health (NIMH), USA, on projects involving active animal cognition studies through Vision, AI & Pose estimation.

My Masters' Thesis

Shadow Guided Optimal Packing and Assembly of General 3D Shapes

Finalist at [Qualcomm Innovation Fellowship India 2024](#)

Drawing inspiration from 3D anamorphic art, I have developed a differentiable rendering based framework to optimize the packing of irregular objects within a predefined volume by leveraging the shadows they cast under illumination from multiple directions. I further expanded the framework for reassembly of fractured 3D objects.



My Publications

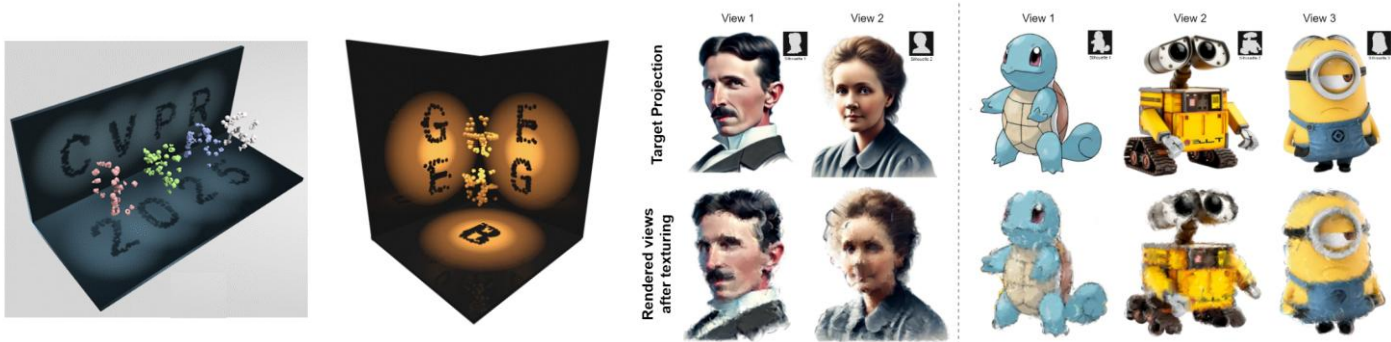
- RASP: Revisiting 3D Anamorphic Art for Shadow-Guided Packing of Irregular Objects**
Accepted in [CVPR 2025](#)
Soumyaratna Debnath, Ashish Tiwari, Kaustubh Sadekar and Shanmuganathan Raman
- ScribGen: Generating Scribble Art through Metaheuristics**
Published in [SIGGRAPH Asia 2024](#)
Soumyaratna Debnath, Ashish Tiwari and Shanmuganathan Raman
- L3D-Pose: Lifting Pose for 3D Avatars from a Single Camera in the Wild**
Accepted in International Conference on Acoustics, Speech, and Signal Processing ([ICASSP](#)) 2025
Soumyaratna Debnath, Harish Khatti, Shashikant Verma and Shanmuganathan Raman
- STEP: Simultaneous Tracking and Estimation of Pose for Animals and Humans**
Under proceedings of Transactions on Pattern Analysis and Machine Intelligence ([TPAMI](#))
Shashikant Verma, Harish Khatti, **Soumyaratna Debnath**, Yamuna S, Shanmuganathan Raman
- Modified Harris Hawk Optimization Algorithm for Multi-level Image Thresholding**
Published as a Chapter in Hybrid Computational Intelligent Systems
Soumyaratna Debnath, Abhirup Deb, Sourav De, Sandip Dey

RASP: Revisiting 3D Anamorphic Art for Shadow-Guided Packing of Irregular Objects

Soumyaratna Debnath, Ashish T, Kaustubh S, Shanmuganathan R

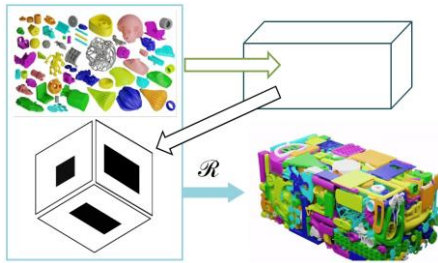
Finalist in the Qualcomm Innovation Fellowship India 2024-25

Accepted in CVPR 2025

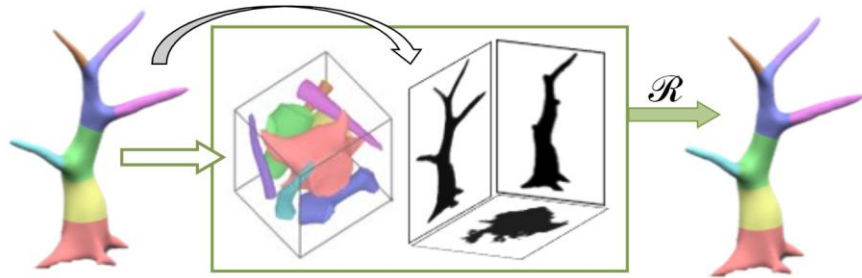


Project Description

- Introduces a differentiable rendering-based method for arranging 3D objects to produce K distinct shadows from K different viewing angles.
- Proposes a solution to the 3D packing problem using silhouette-based optimization.
- Extends the approach to address 3D part assembly problem.
- Offering a new perspective for 3D object manipulation.
- Potential applications in manufacturing, robotics, and 3D anamorphic arts.



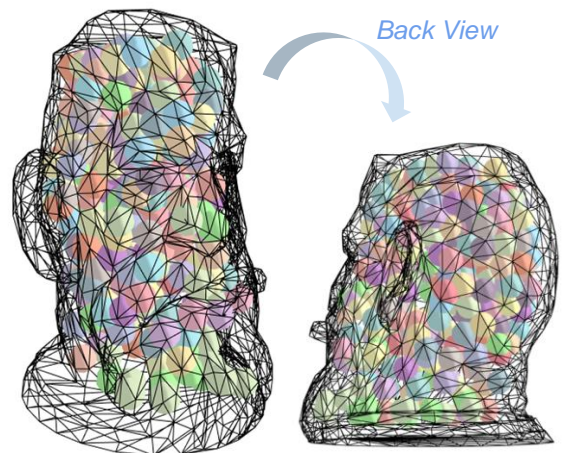
Proposed shadow guided optimal packing



Proposed shadow guided parts reassembly

Contributions

- We propose a differentiable-rendering-based framework to address irregular object packing with near-maximal occupancy and minimal inter-object spacing within the known bounding volume, drawing insights from 3D Anamorphic Art and Shadow Art.
- We develop a novel SDF-based formulation to handle inter-object intersections and object-container intersections along with image-based loss.
- We demonstrate that the proposed framework can also address part assembly without any explicit 3D ground truth supervision.
- We also show some interesting visual effects catering to multi-view anamorphic art.

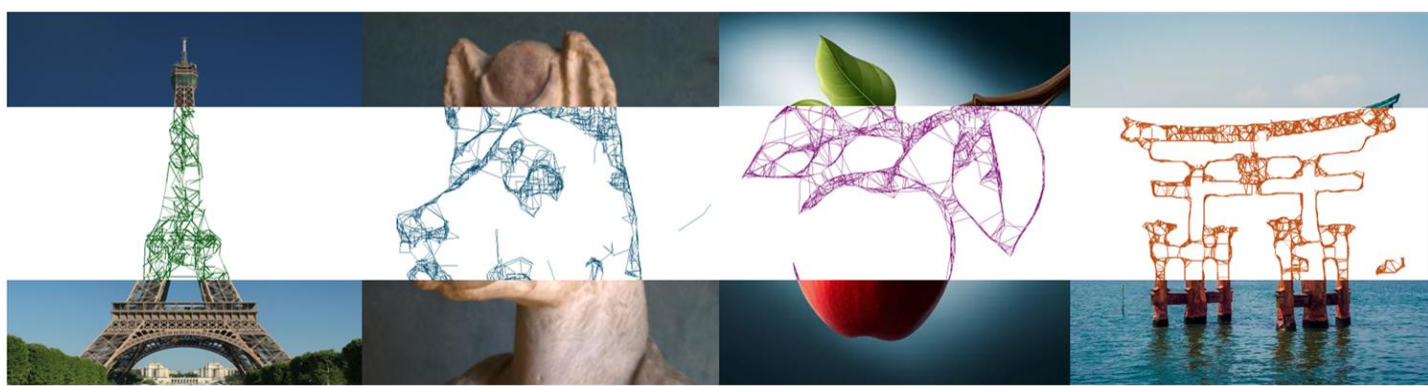


Results of packing of arbitrary shaped objects inside an arbitrary shaped container.

ScribGen: Generating Scribble Art Through Metaheuristics

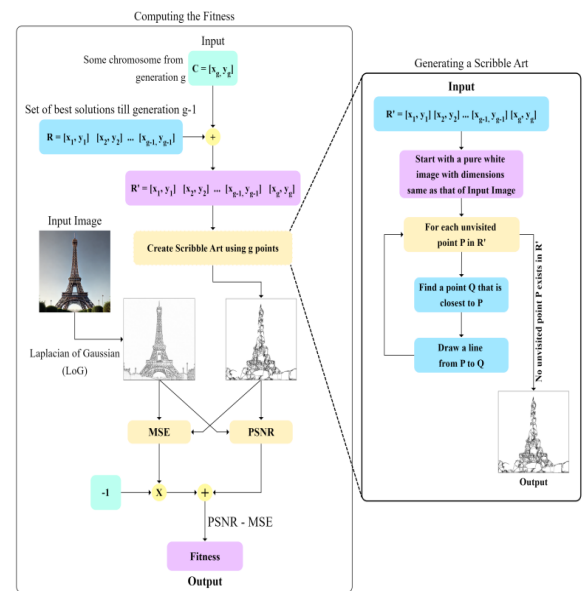
Soumyaratna Debnath, Ashish Tiwari, Shanmuganathan Raman

Published in SIGGRAPH Asia 2024

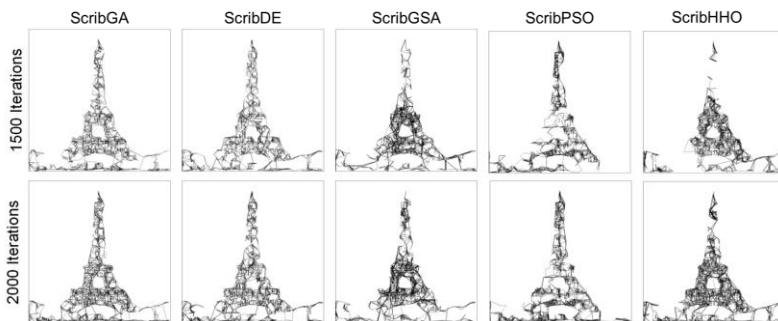


Scribble drawing as an optimization problem –

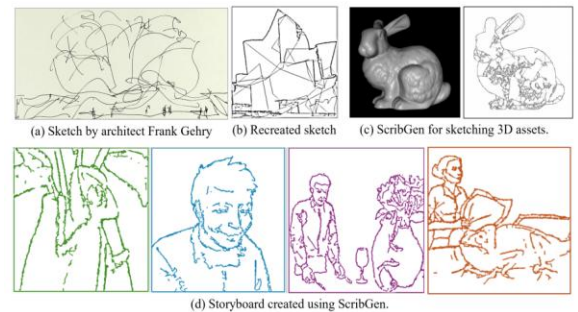
Generating digital scribble art is an interesting challenge where the goal is to turn a given image into art that looks like free-flowing scribbles while still keeping it recognizable and visually appealing. This task requires balancing randomness and order, with algorithms navigating many possible scribble patterns to find the best representation of the original image. We propose a novel approach to metaheuristic-based learning tailored specifically for scribble art generation where each solution in the underlying solution space consists of thousands of vertices or edges. We propose a progressive optimization method, where each iteration progressively adds the next best solution from a pool of possible solutions, represented by a 2D point that denotes a position in the image space (pixel). Thus, our objective is to identify a set of points within the image space that, when connected, form a visually compelling yet recognizable scribble drawing.



Methodology - Proposed ScribGen Algorithm



Scribbling results using different metaheuristic backbones



Applications of ScribGen

Project Description

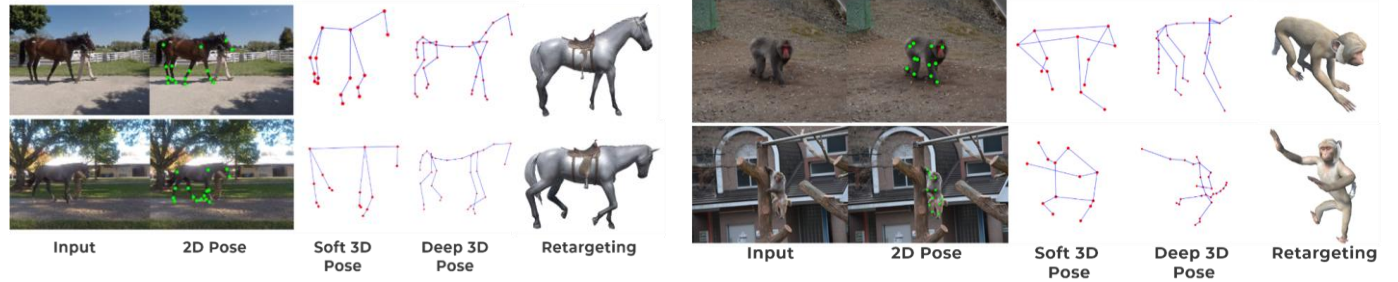
- We propose a novel approach using metaheuristics to generate scribble art from images.
- Alternative to traditional learning-based methods and no need for supervised training.
- Analysis of various metaheuristic algorithm backbones for producing scribble art.
- Quantitatively surpasses deep learning techniques in preserving visual similarity.
- Can serve as a data source for training deep learning models for sketch-to-image translation tasks

L3D-Pose: Lifting Pose for 3D Avatars from a Single Camera in the Wild

Soumyaratna Debnath, Shashikant V, Harish K, and Shanmuganathan R

In collaboration National Institute of Mental Health (NIMH), United States

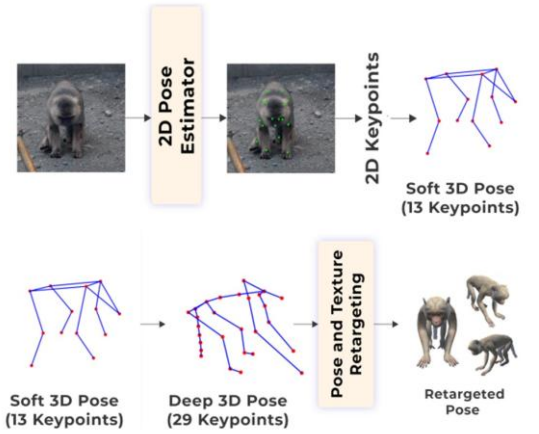
Accepted in ICASSP 2025



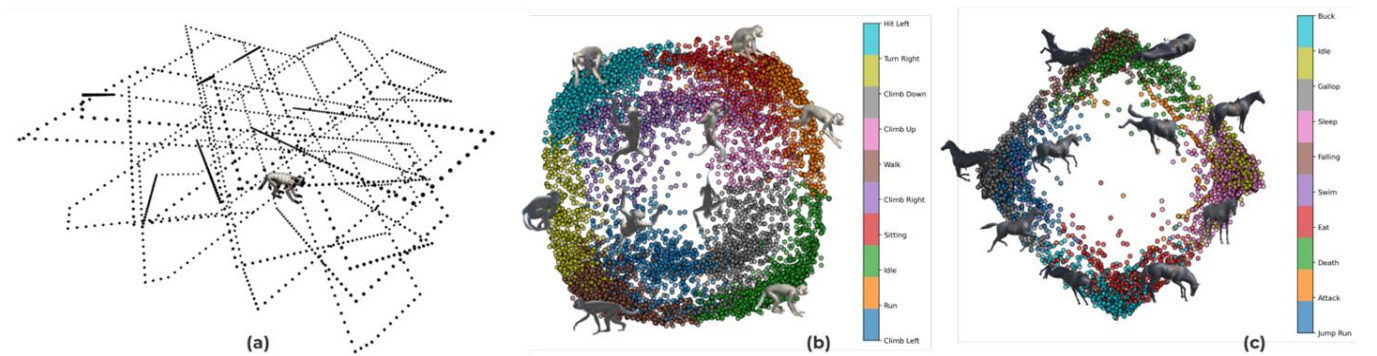
Lifting and retargeting of 3D Pose on rigged models obtained by the proposed framework

Contributions

- Proposes a hybrid approach to address the challenge of 3D pose estimation for animals by using rigged avatars and synthetic datasets to generate 3D annotations.
- Introduces an attention-based MLP network for lifting 2D poses to 3D
- Demonstrates effective lifting of 2D poses to 3D and motion retargeting from real-world settings onto avatars through experiments.
- Addresses the challenge of creating large 3D pose datasets for animals by leveraging synthetic data, improving applicability in various settings.



Proposed Methodology



Data acquisition setup and data analysis

Process flow of the proposed methodology

For a given natural image, we first use pre-trained 2D pose estimation techniques to obtain 2D keypoints in the image. Our attention-based simple MLP architecture, trained on a synthetic dataset, effectively lifts these normalised 2D keypoints into a partial soft 3D pose. We then match this partial 3D pose to the closest deep pose from a look-up table, which includes a diverse set of 3D poses derived from synthetic motion sequences. The Deep 3D Pose provides the necessary information to transfer the pose from the image onto an avatar model.

STEP: Simultaneous Tracking and Estimation of Pose for Animals and Humans

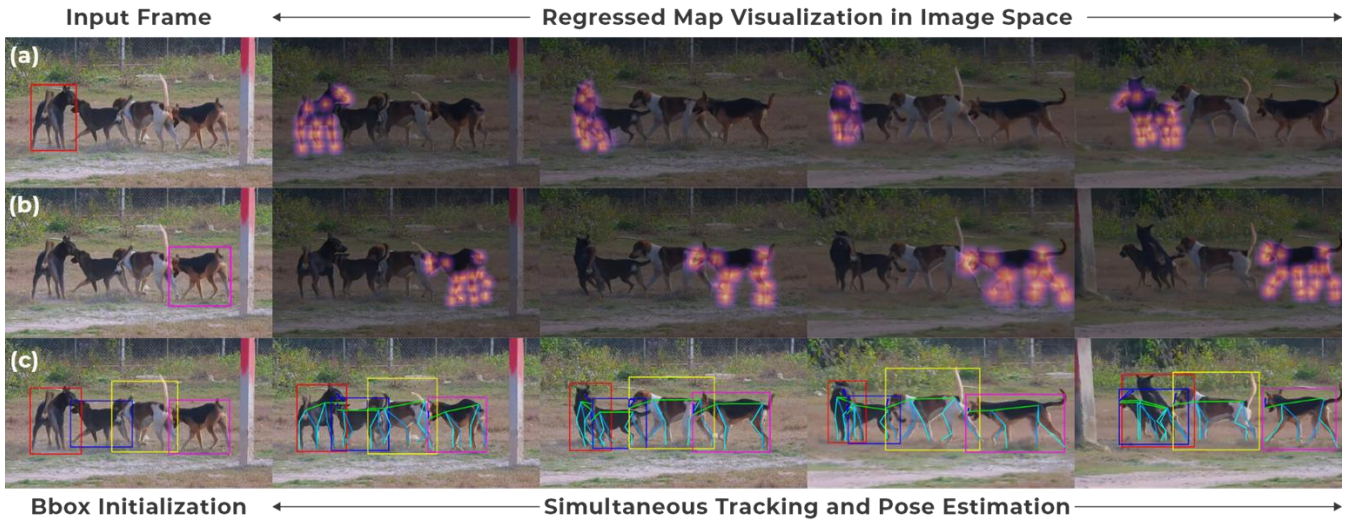
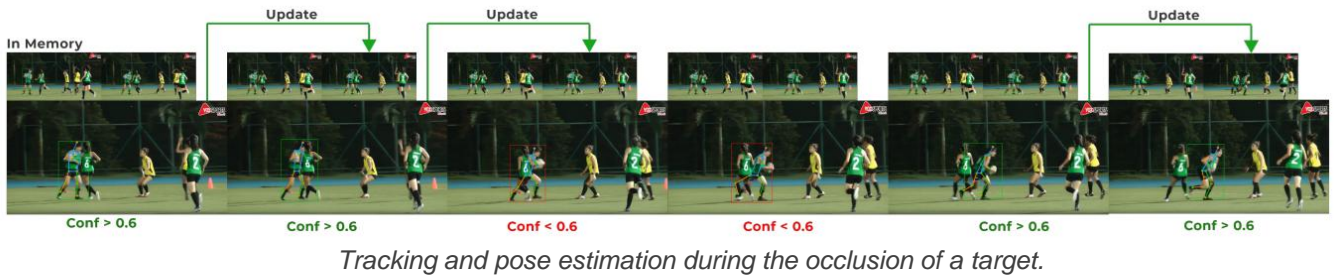
Shashikant V, Harish K, **Soumyaratna D**, Yamuna S and Shanmuganathan R

In collaboration National Institute of Mental Health (NIMH), United States

Currently Under Peer Review for TPAMI

Project Description

Inspired by the fact that the human brain exploits spatiotemporal continuity and performs concurrent localization and pose estimation despite the specialization of brain areas for form and motion processing, we introduce STEP, a novel framework utilizing Transformer-based discriminative model prediction for simultaneous tracking and estimation of pose across diverse animal species and humans. We train and validate our approach on datasets encompassing diverse species. Our experiments demonstrate superior results compared to existing methods.



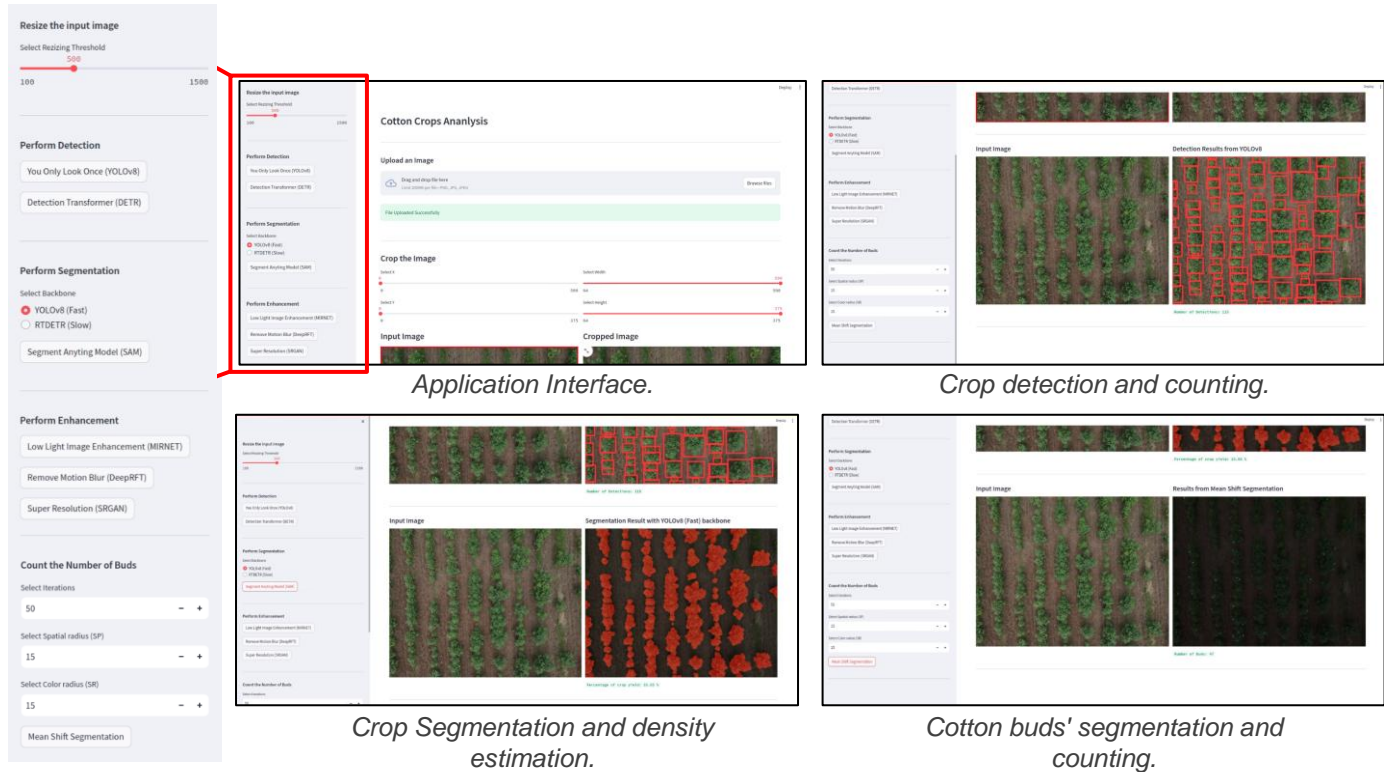
Contributions

- We conduct a comprehensive study on the pose estimation task within a discriminative model prediction framework. We utilize a Transformer-based model prediction module while simultaneously tracking the object of interest—an unexplored area in previous research.
- We develop a Gaussian Map Soft Prediction (GMSP) and Offset Map Regression Adapter (OMRA) module to precisely localize key points, ensuring both efficiency and accuracy in estimating pose key points.
- In the inference phase, we propose a confidence-based memory update of our tracker. This update integrates previous frame outputs to supervise and estimate subsequent outputs effectively. We showcase the effectiveness of our approach through a case study on Awaji Monkey Center (AMC) video streams.

Some Industrial Project on Real World Computer Vision Problems

1. UI Based Application for Analysis of Cotton Crops

In Association with L&T Technology Services (LTTS), Vadodra, India



2. IndAINagar - UI Based Application for Live Traffic Analysis

In Association with AI Centre of Excellence (AICoE) under the Ministry of Education, Govt. of India

[Demo Video \(Click to Play\)](#)

