# Human detection and body posture recognition for human-robot collaborative applications

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## Introduction

Accurate and efficient human detection and body posture recognition are crucial factors that facilitate the safe and productive operation of collaborative robots in various domains: industrial manufacturing [1], healthcare, social environments, and agriculture. This work focuses on developing a human sensing framework that utilizes images from three-dimensional (3D) cameras mounted on a mobile robot that navigates in environments surrounded by human co-workers. An important feature of this system is scalability, which allows the human sensing framework to receive images from multiple cameras simultaneously as inputs without excessively increasing the computation cost. Furthermore, the system is utilized to accurately estimate the 3D human pose based on the two-dimensional (2D) pose data extracted from human body joints [2].

## Aim

- Designing an advanced and scalable vision-based human sensing framework using images captured from 3D cameras integrated on a mobile robot

## Objectives

- Developing a vision-based human sensing system that can effectively detect and track humans within the captured frames and extract information regarding body postures
- Developing a scalable vision-based human sensing system capable of utilizing images from multiple cameras as inputs
- Reconstructing the 3D pose of human body joints in real-world space based on their 2D representations

## Methodology

**1: Human sensing framework**

- Using Ultralytics YOLOv8 model [3] to generate bounding box detections of humans in Red Green Blue (RGB) images
- Maintaining continuity in the bounding boxes and tracking the individuals
- Extracting skeletons of humans from detected bounding boxes to infer human body postures

**2: Multi-Camera Fusion**

- Installing four cameras on the sides, front, and back of the mobile robot and capturing RGB images of the respective field of view from each camera
- Tiling the images from different cameras to obtain a comprehensive view from the resulting fused image and measuring the system's computational cost in the multi-camera setup

**3: 2D to 3D pose estimation**

- Extracting pixel coordinates of keypoints/joints from the skeleton of the humans and obtaining the depth values of each keypoint/joint from the depth images
- Estimating the 3D poses (x,y,z) using the 2D joint positions (x,y) and their corresponding depth information (z)
- Visualizing the final 3D pose by a human stick figure

## Results

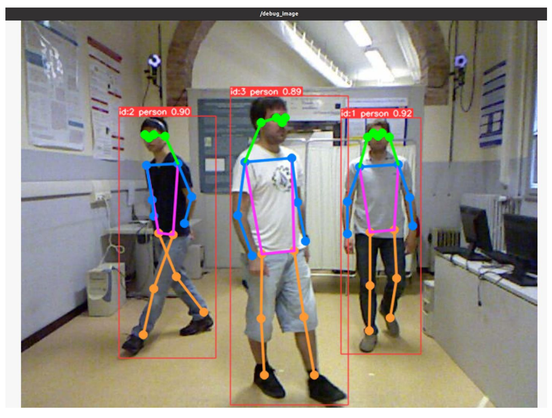


Figure 1: Human detection, tracking, and body pose estimation using Ultralytics YOLOv8 model on the dataset as ROS bags [4]

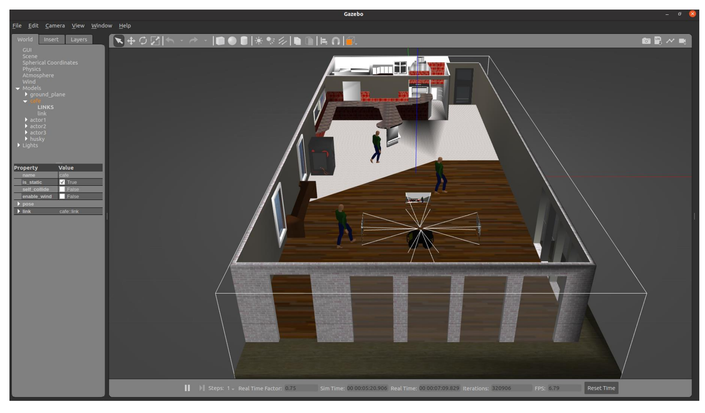


Figure 2: Gazebo simulation of the Husky mobile robot with the multi-camera setup and animated humans

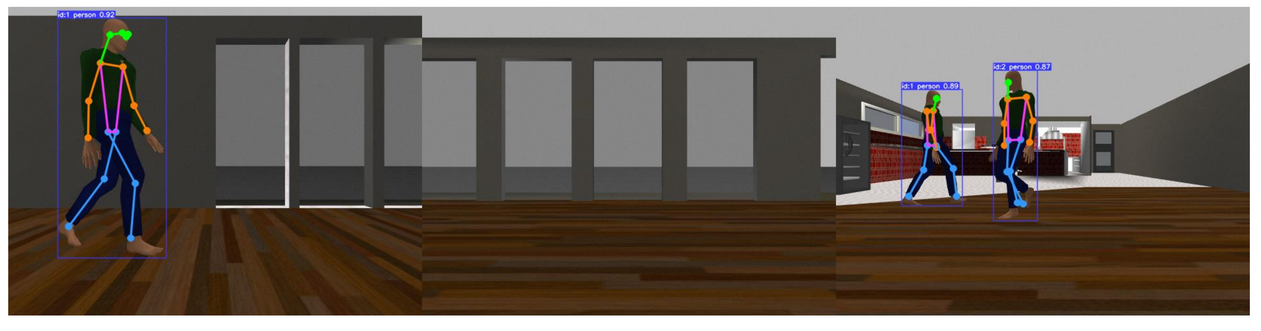


Figure 3: Fused image obtained from multiple cameras (front, right and left cameras)

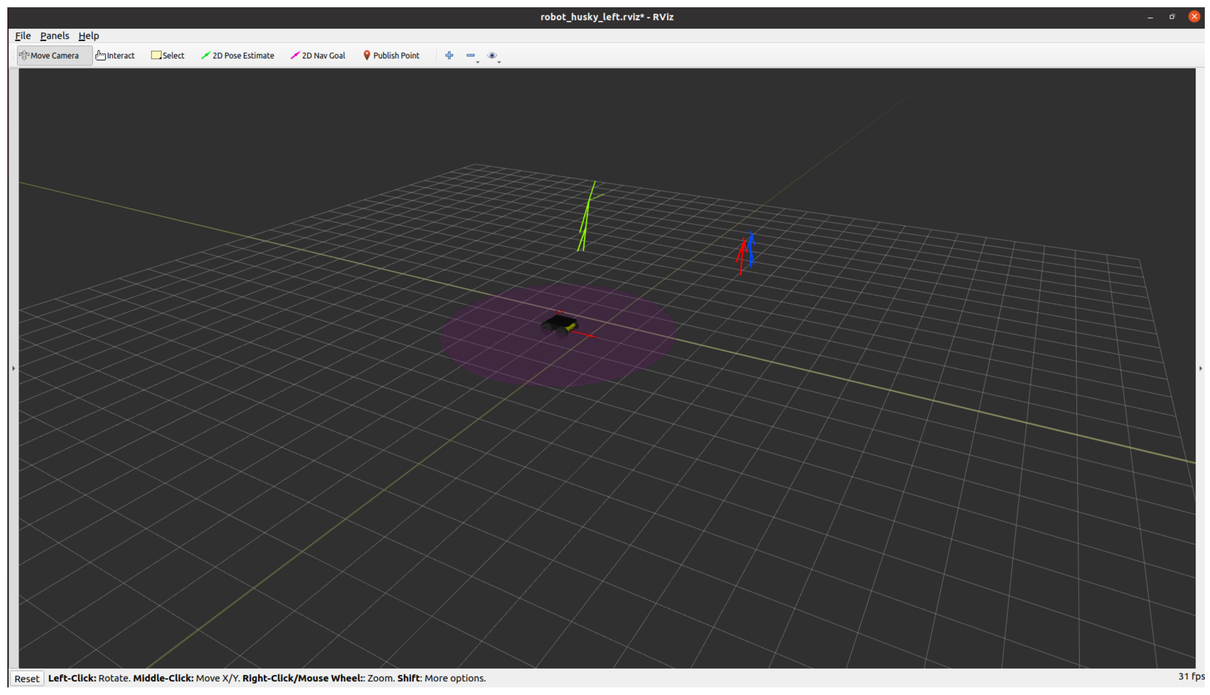


Figure 4: Reconstructing the 3D pose of body joints and visualizing them using human stick figures

## Future Work

Integrating a human-aware motion planning into the robot by using the 3D pose information of the humans in the environment

## References

[1] M. Zaccaria, M. Giorgini, R. Monica, and J. Aleotti, "Multi-robot multiple camera people detection and tracking in automated warehouses," in 2021 IEEE 19th International Conference on Industrial Informatics (INDIN), 2021
[2] C.H. Chen and D. Ramanan, "3D human pose estimation = 2D pose estimation + matching," 2017
[3] Ultralytics YOLOv8 Model
[4] M. Munaro and E. Menegatti, "Fast RGB-D people tracking for service robots," Autonomous Robots, 2014

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