Evaluation of the Performance of a Human Following Robot Under Varying Illumination

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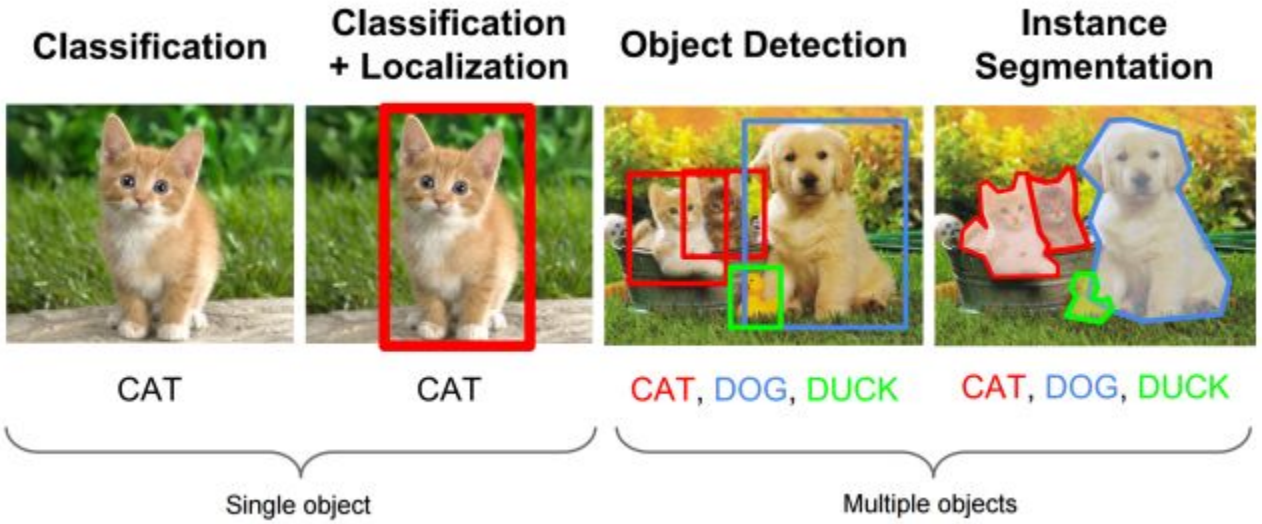
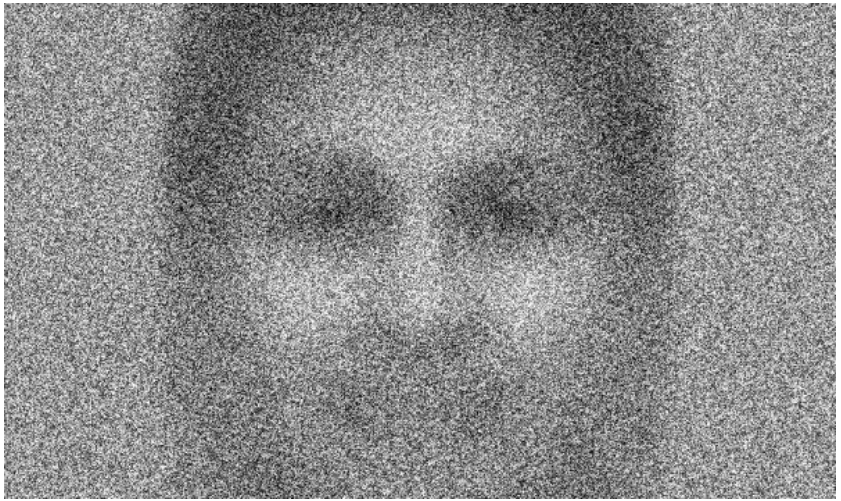
Introduction

Computer Vision



Obstacles in Computer Vision

- Illumination
- Noise in the scene
- Occlusion effect
- Pose variations



Problem statement

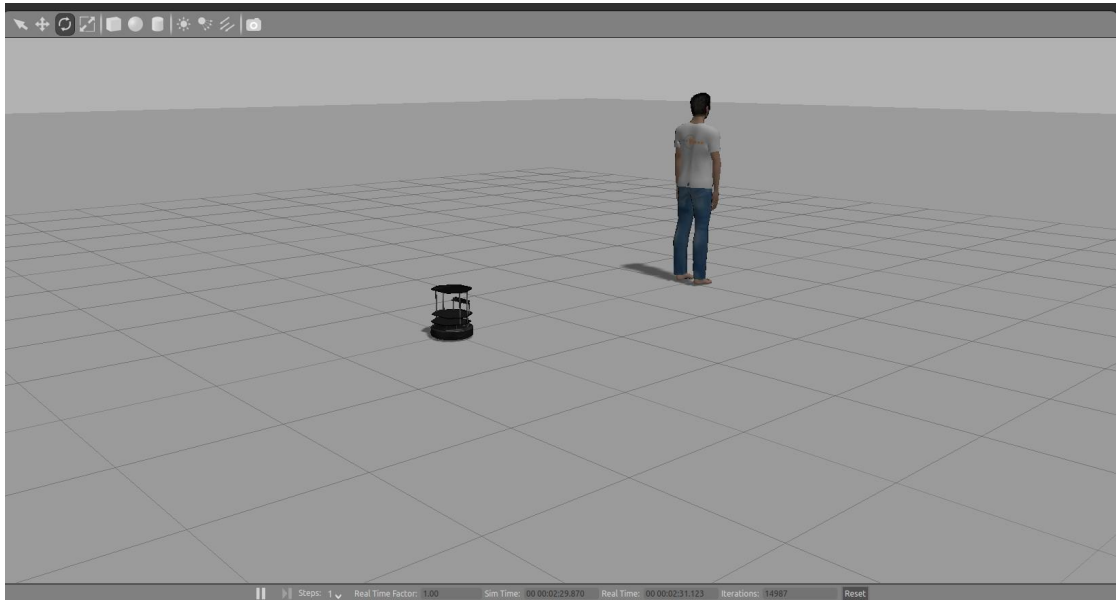
- An illumination variation may result in the tracking algorithm to lose the object in the scene.
- We propose a simulation of a robot which follows a human and observe its performance under varying illumination.

Simulation

Softwares Used

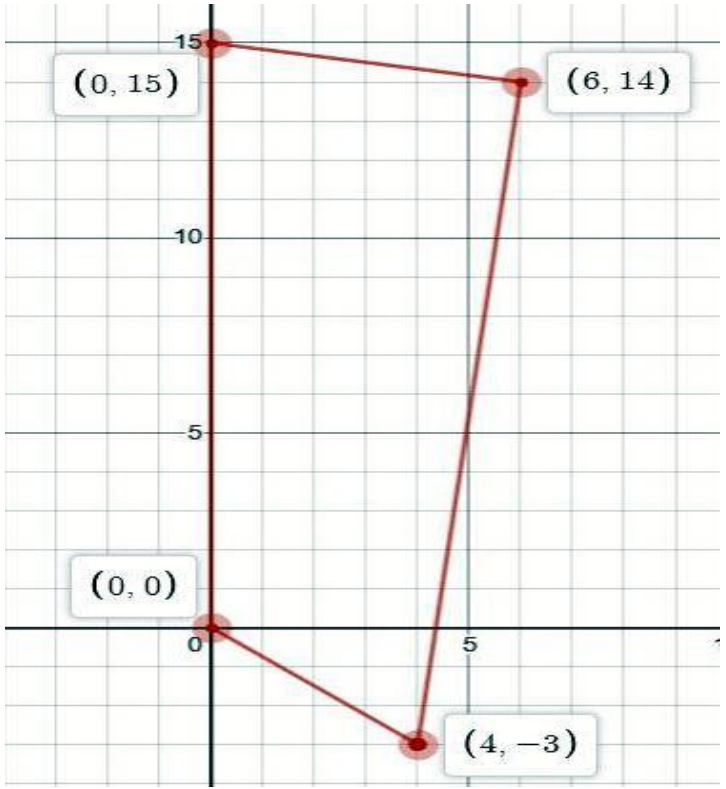
Setup of the Simulation

- No obstacles
- One human
- Constant pace
- Follows a trajectory



Trajectory

- Total distance : 48 units
- Straight lines
- Non-symmetric



Turtlebot 2.0

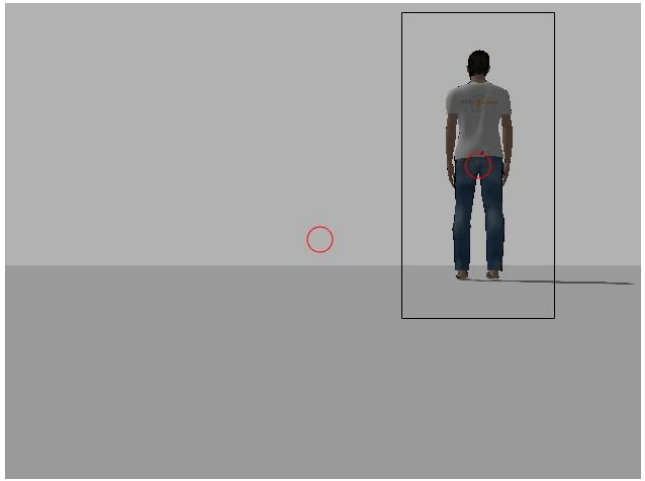
- Dimensions: 35.4 x 35.4 x 42.0 (cm)
- Kobuki base has two drive wheels and two passive wheels
- Kinect camera

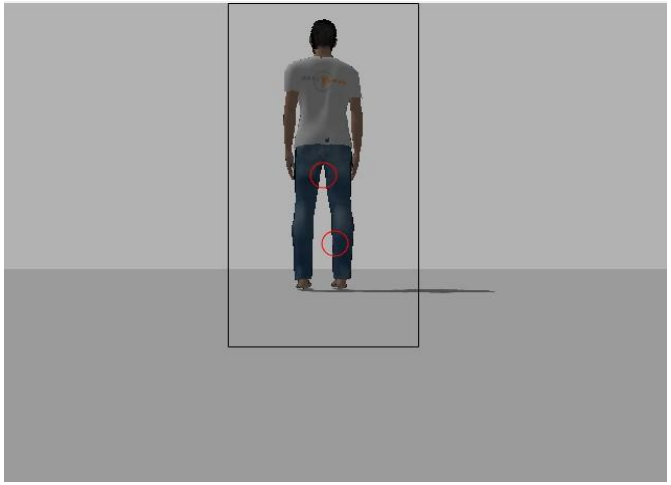
Microsoft Kinect Camera

- RGBD camera
- Horizontal and Vertical field of view : 57 & 43 (degrees)
- Effective range of detection : 0.5 to 6 metres
- 30 fps

Algorithm

- Kinect for capturing images
- Human was detected using a model that detects humans in an image using HOG features and a trained SVM classifier.
- Velocity commands were given to the turtlebot to align itself with the human.





Simulation

Analysis and Results

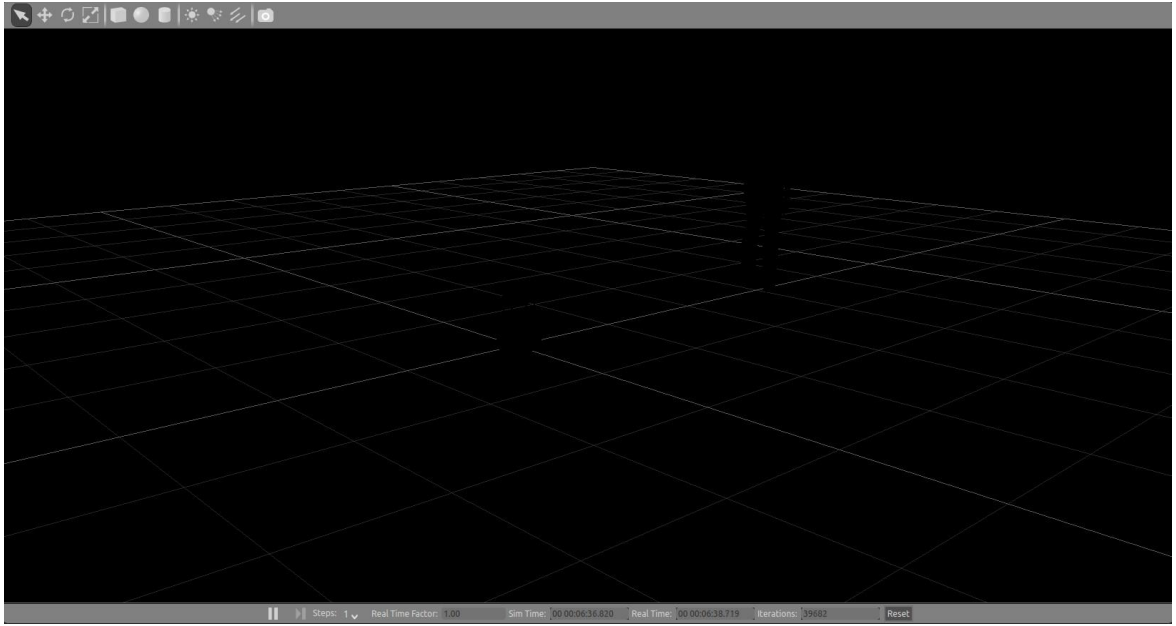
Performance Parameters

Miss-Count : It is the number of times the robot fails to predict the presence of a human during tracking. It is also the number of times the robot stops during tracking.

Distance covered: It is the distance covered by the robot during one iteration of the simulation.

Scenario 1

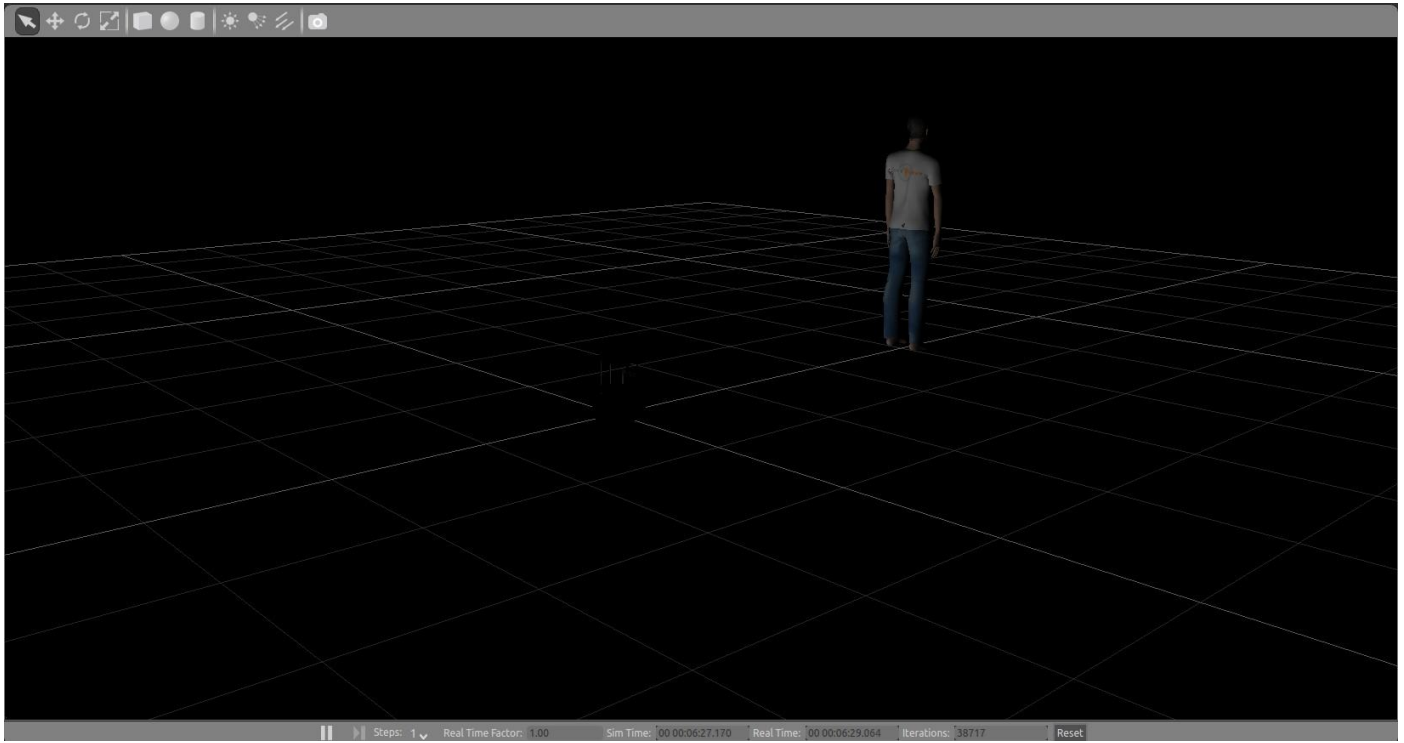
- We removed all the sources of light in this scenario.
- The bot could not find the human during this scenario and it failed to move.



Scenario 2

- All light sources were removed from the scene except a single point light.
- These light was kept at various locations in the environment and performance metrics such as miss-count and distance travelled were measured.
- In order to test how the the height of the light source affects the performance, the light source was kept at three different heights (on ground, height of human, 2x height of the human).

Scenario 2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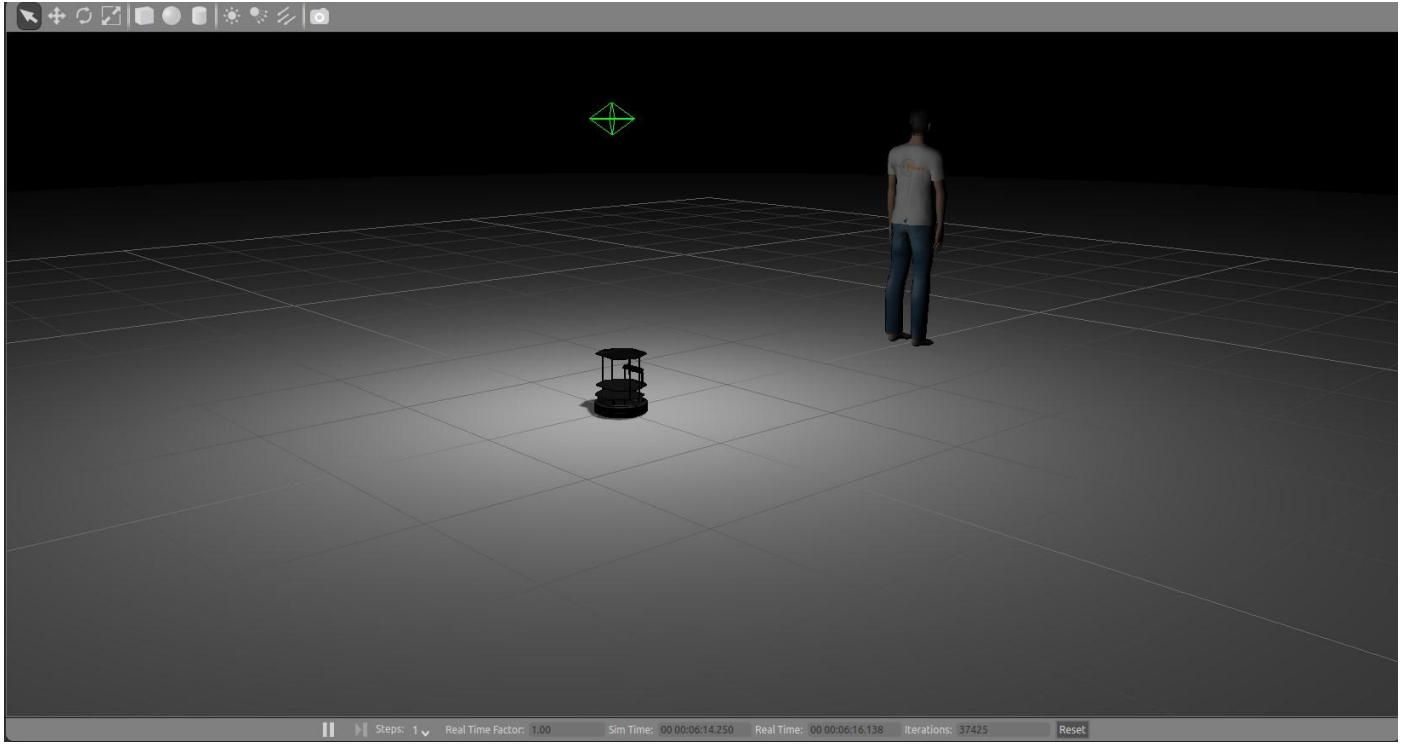
Real Time: 00 00:06:29.064
Iterations: 38717
Reset

Scenario 2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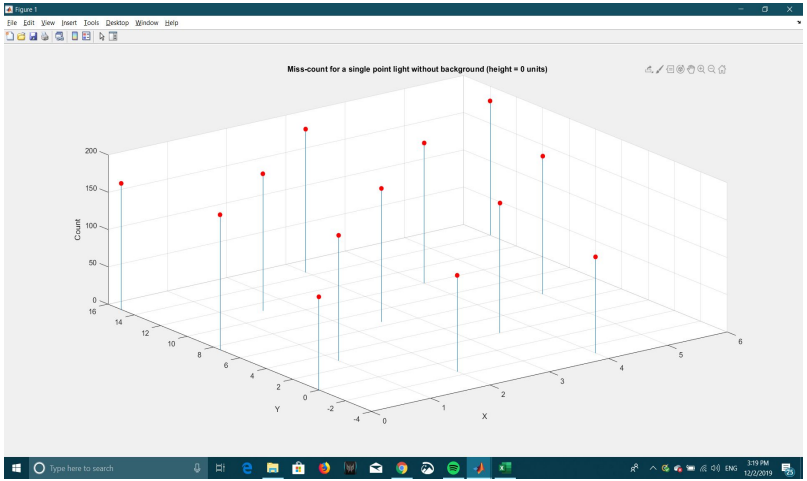
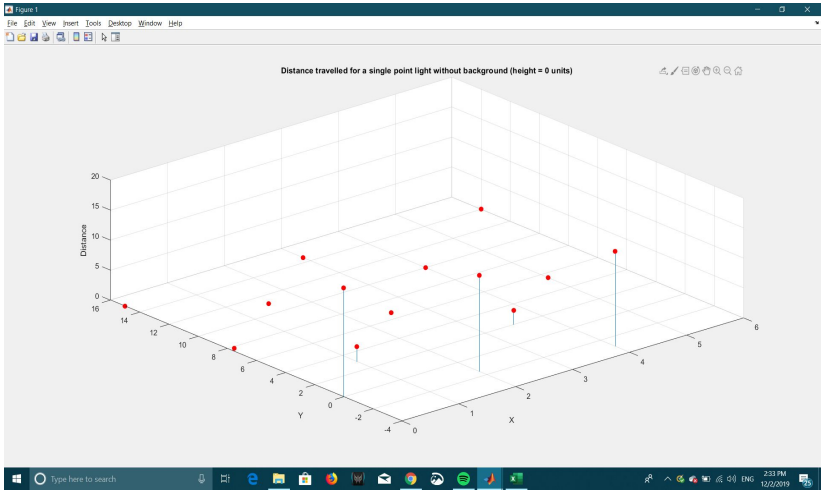
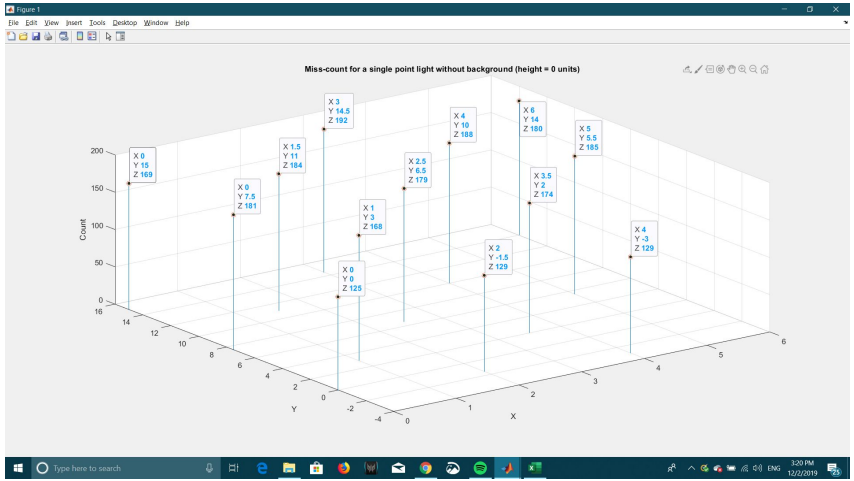
Reset

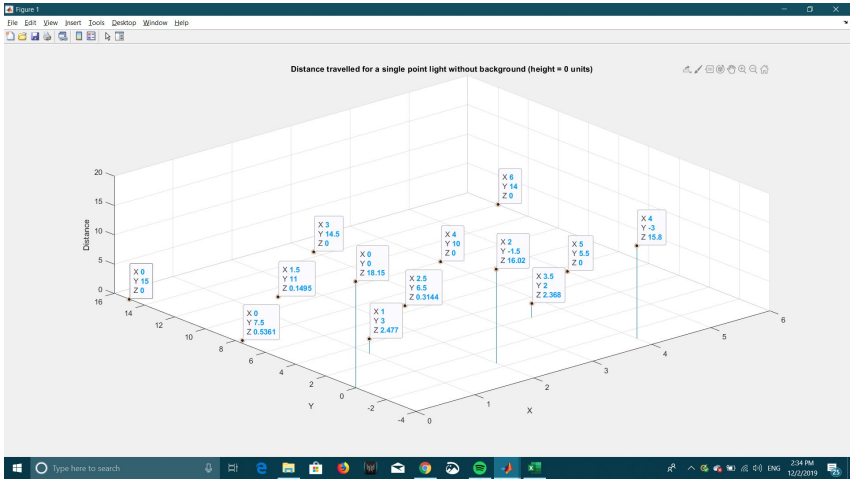
Results from scenario 2





Results from scenario 2





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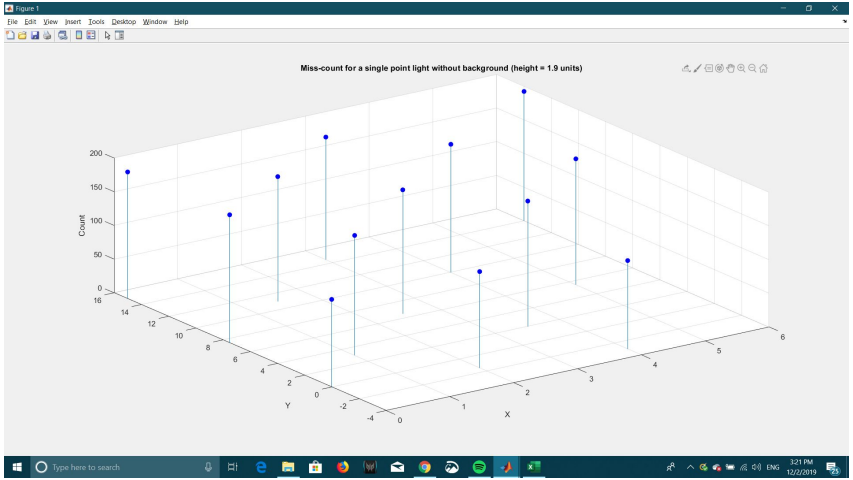

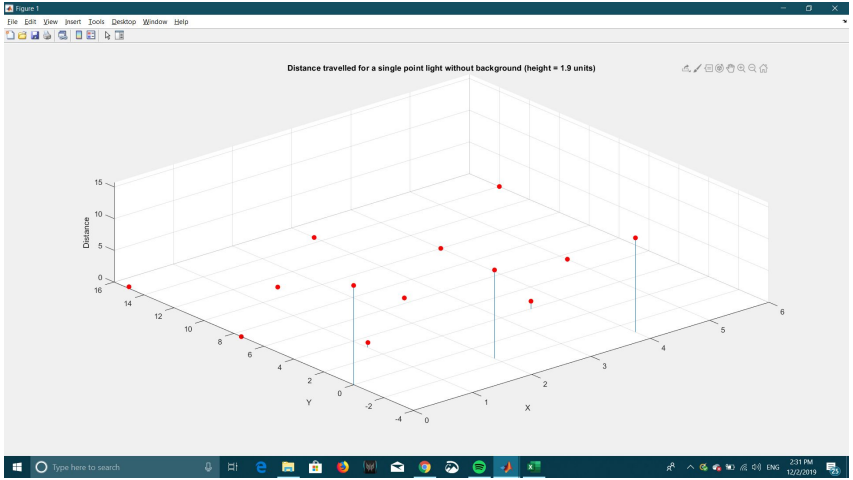

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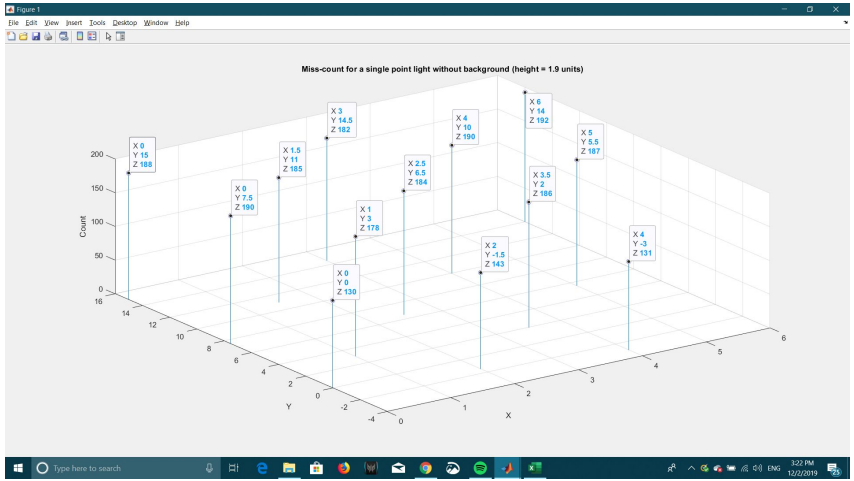
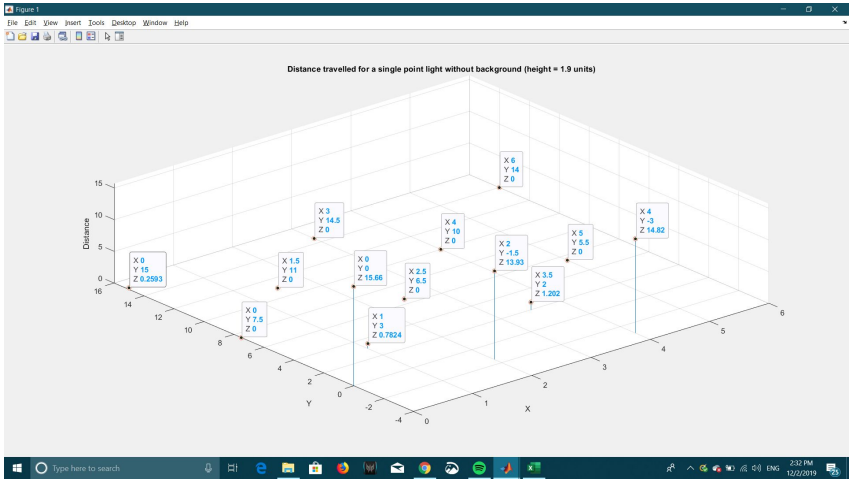
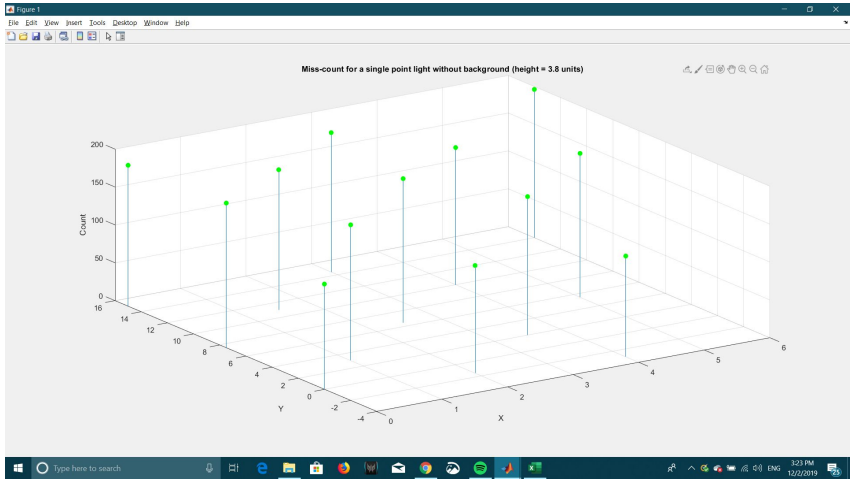
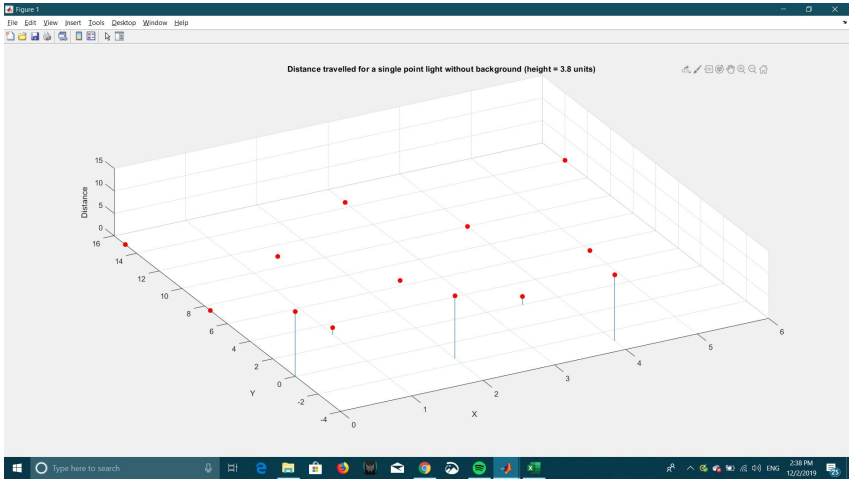


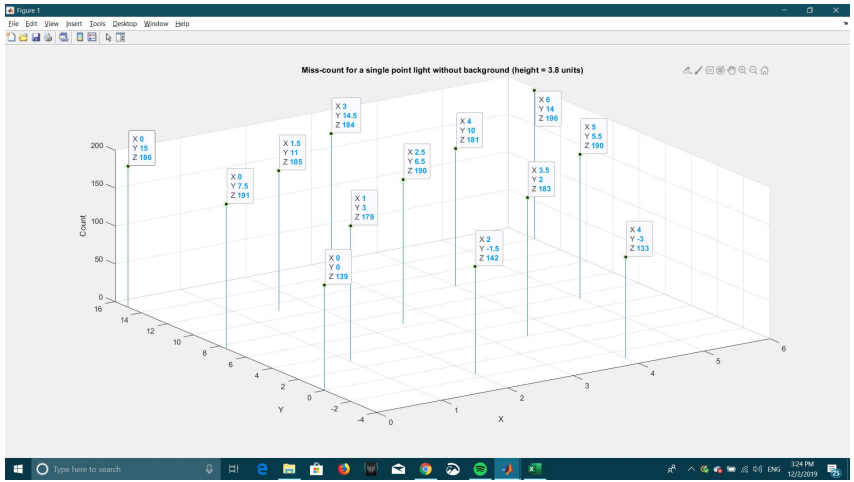


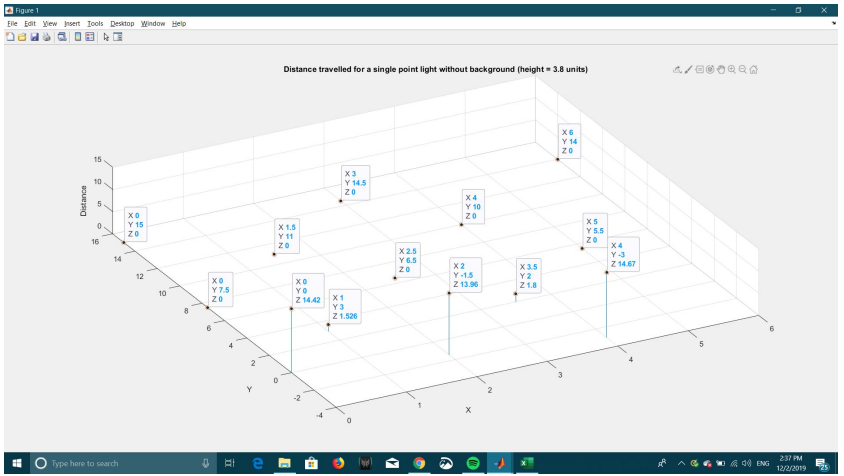
Results from scenario 2



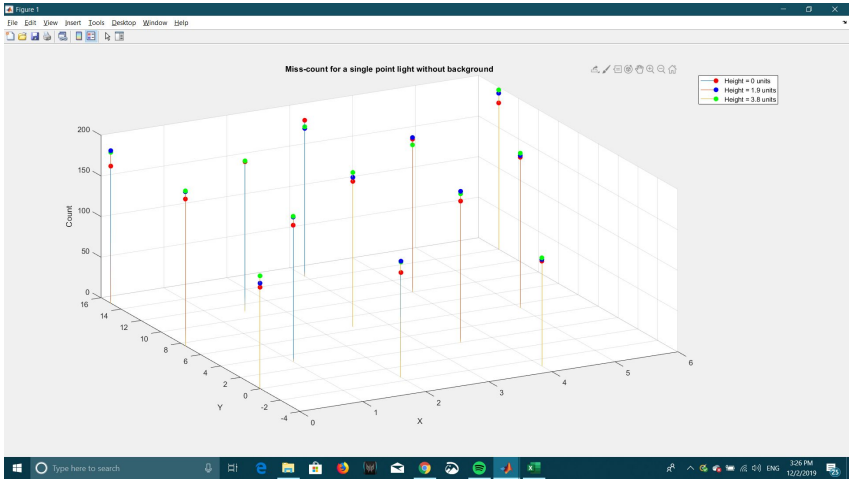


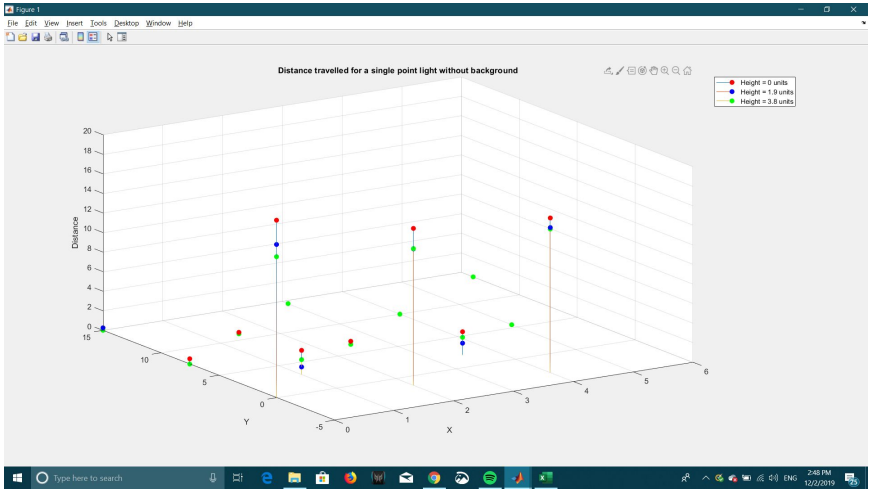
Results from scenario 2





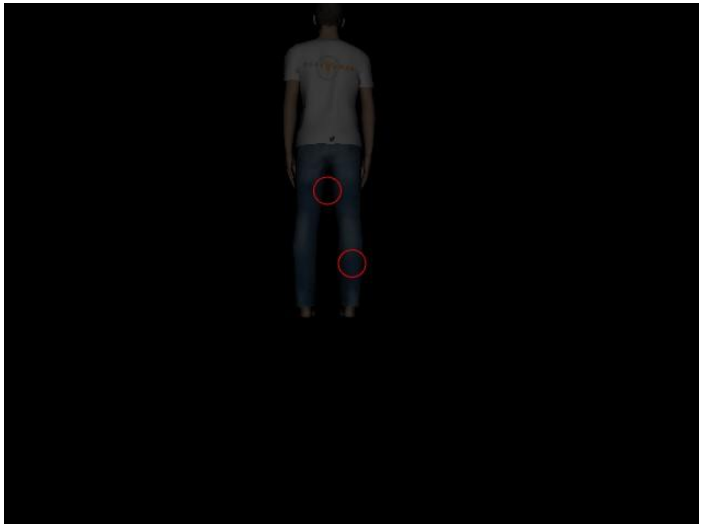
Results from scenario 2





Inference from scenario 2 results

- Whenever the light source illuminates the back of the human, the robot is able to follow the human.
- Whenever the light source is on the ground, the performance of the tracking is better than when the light source is at a height from the ground.



Simulation

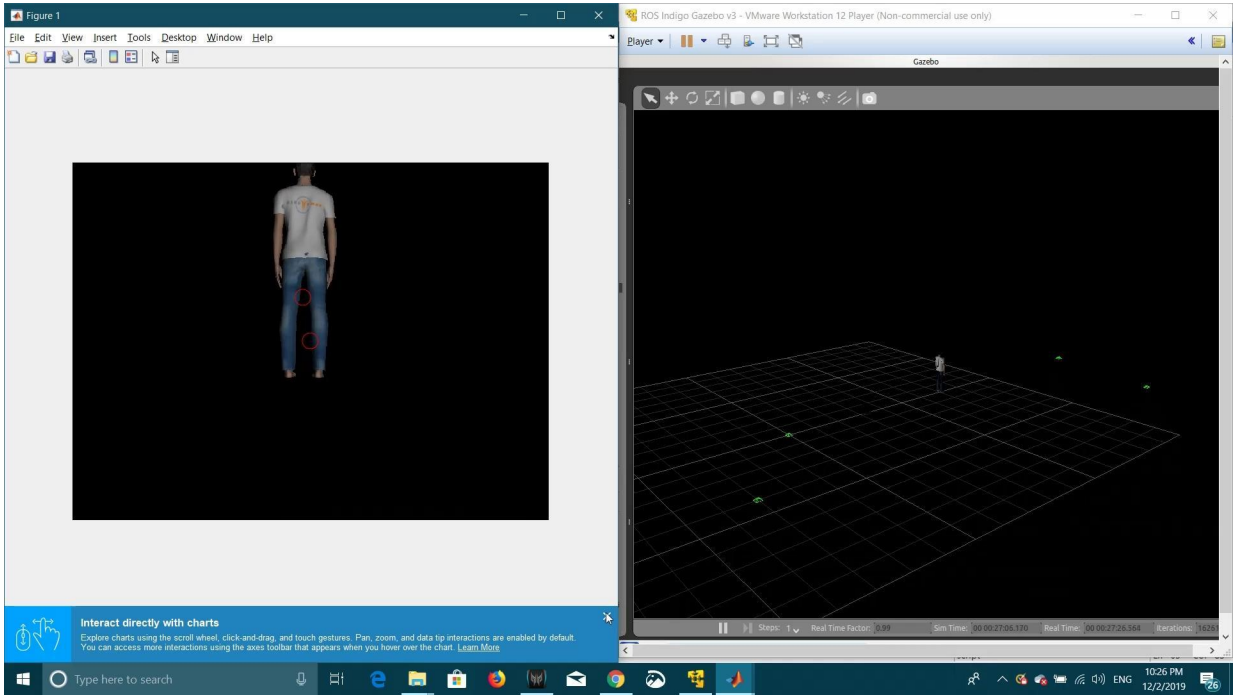


Figure 1
File Edit View Insert Tools Desktop Window Help
Interact directly with charts
Explore charts using the scroll wheel, click-and-drag, and touch gestures. Pan, zoom, and data tip interactions are enabled by default.
You can access more interactions using the axes toolbar that appears when you hover over the chart. Learn More
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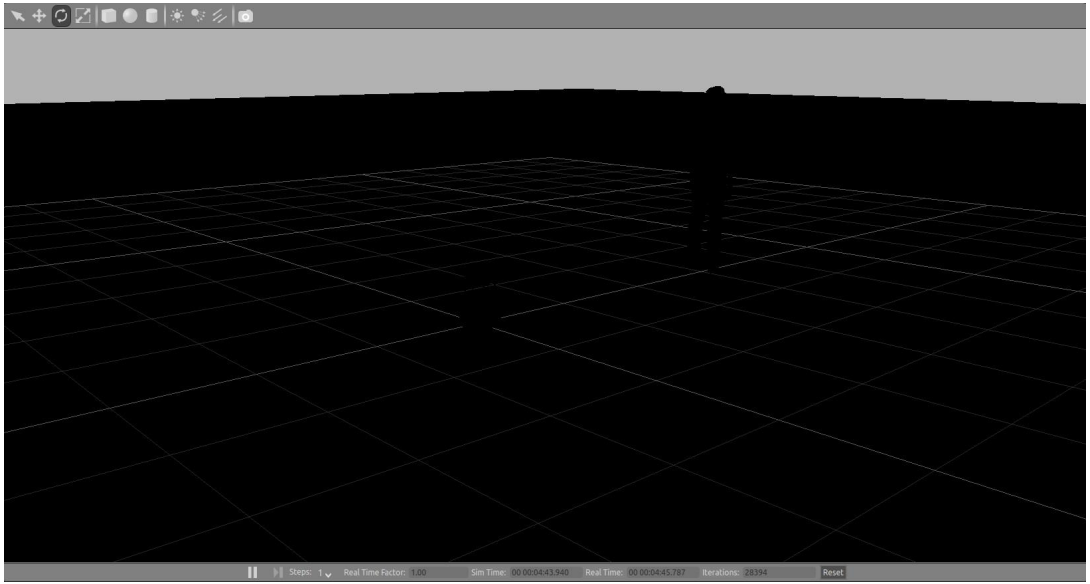
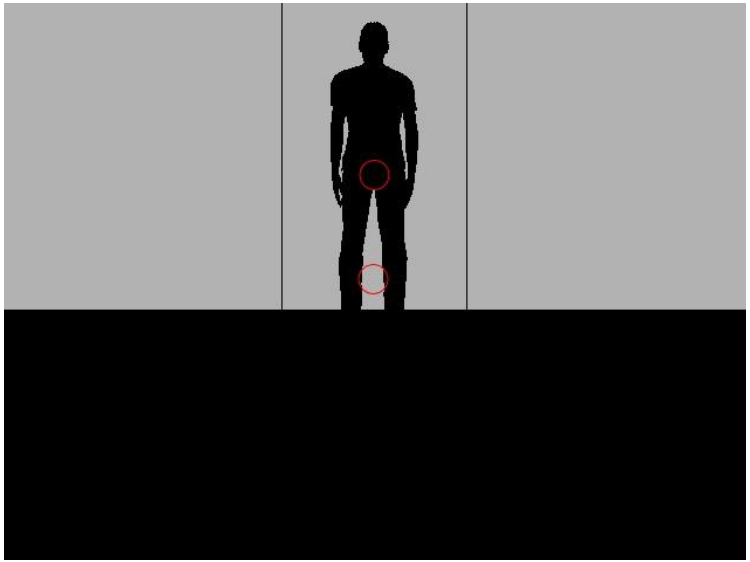
Scenario 3

- All the light sources were removed except for the background.
- The performance of the robot was evaluated based on the metrics such as distance travelled and miss-count.



Inference from scenario 3 results

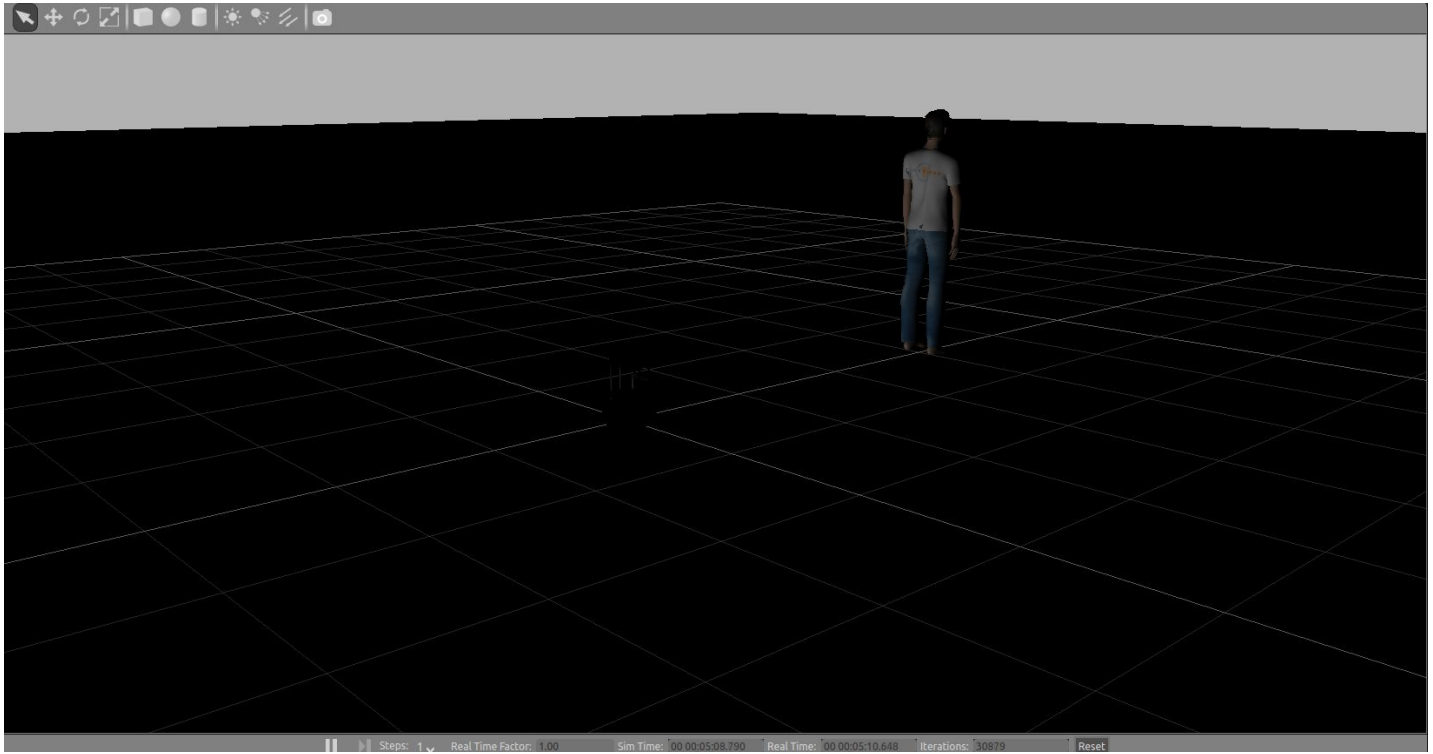
- In this scenario, the robot performs better than in the previous scenario (no background and single point source).
- The robot was able to complete the course by following the human with fewer loses in detections.
- Images of the human silhouettes aid in better detection.



Scenario 4

- All the light sources and the ambient light were removed except the background and a single point light source.
- The light source was placed at different locations at varying heights and the performance of the robot was evaluated.
- The performance metrics such as distance travelled and miss-count were used.

Scenario 4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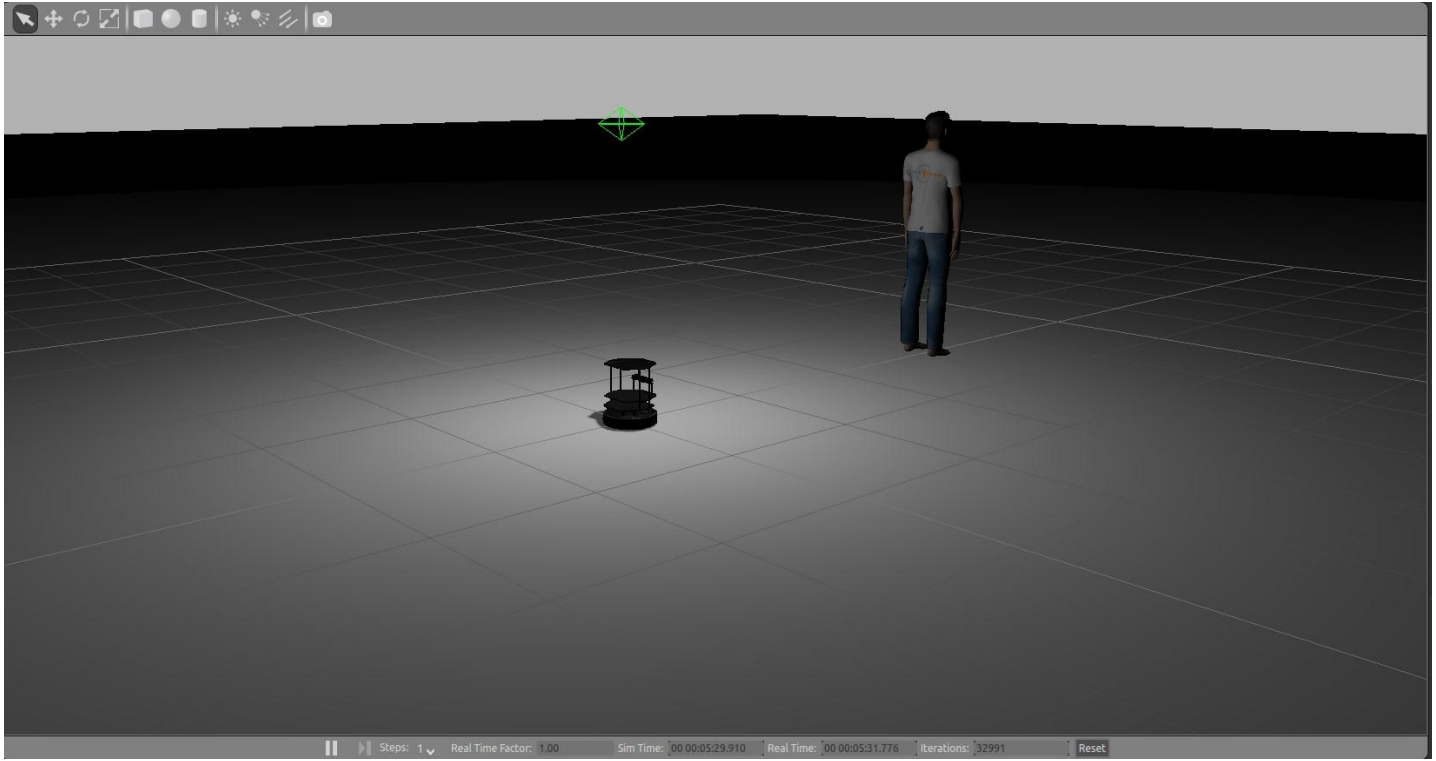
Real Time: 00 00:05:10.648
Iterations: 30879
Reset

Scenario 4


Steps: 1
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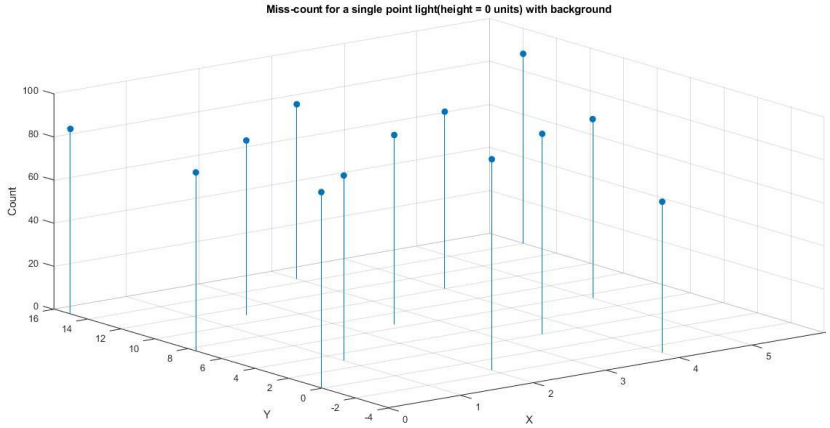
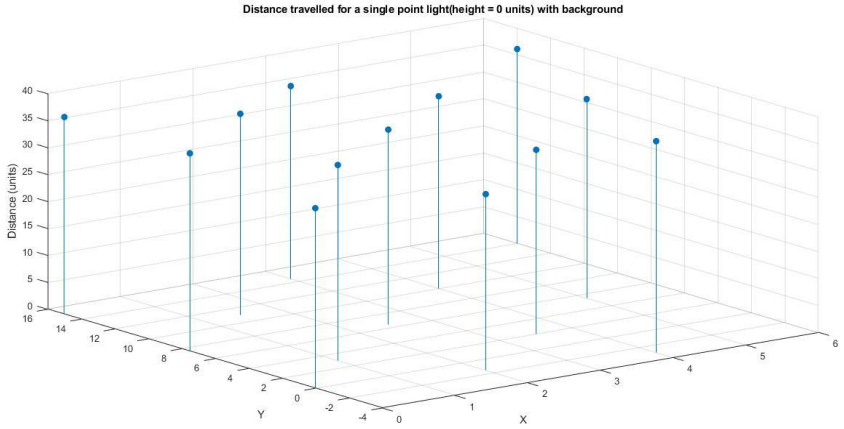
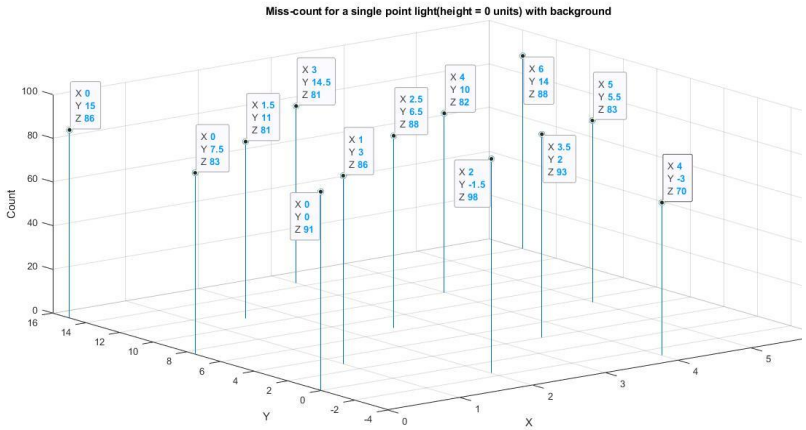
Sim Time: 00 00:05:29.910
Real Time: 00 00:05:31.776
Iterations: 32991
Reset

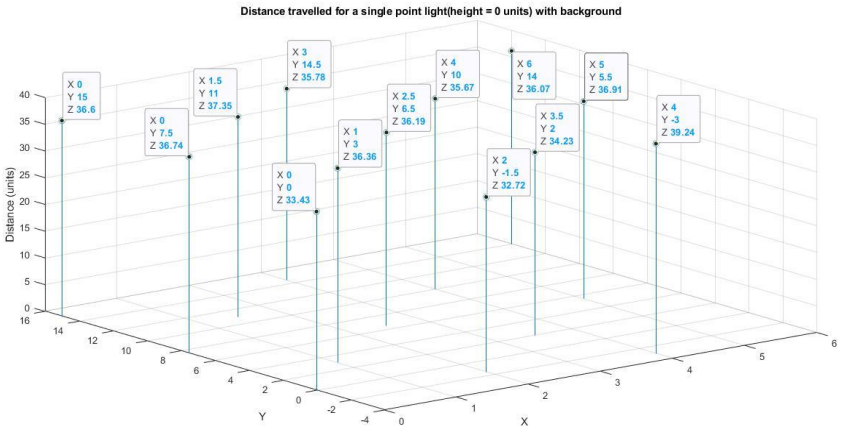
Results from Scenario 4



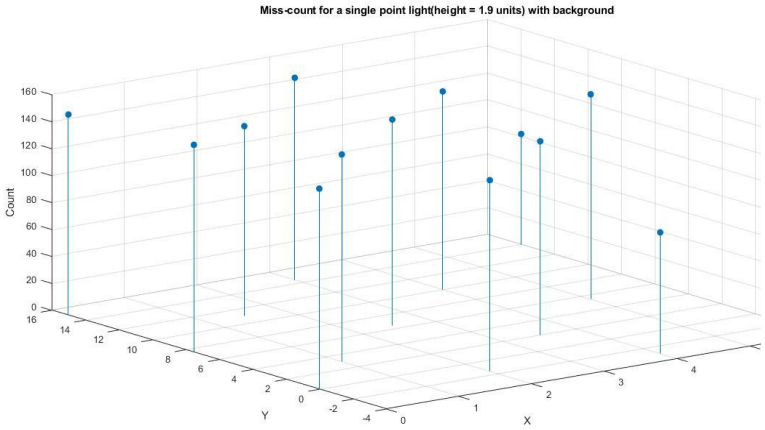


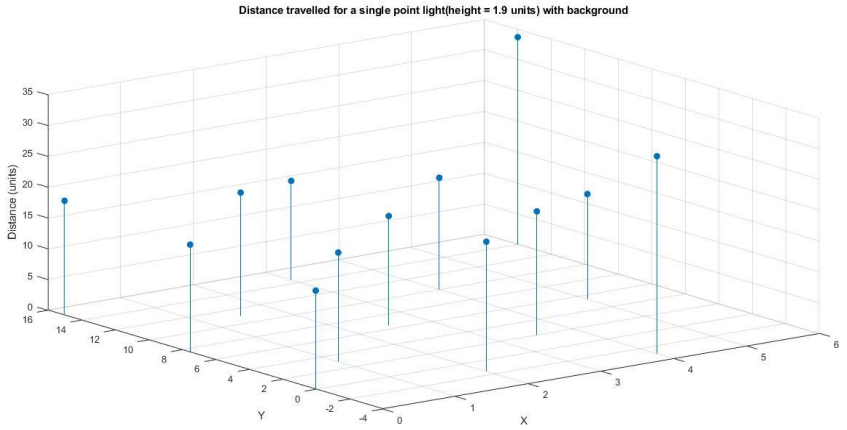
Results from Scenario 4



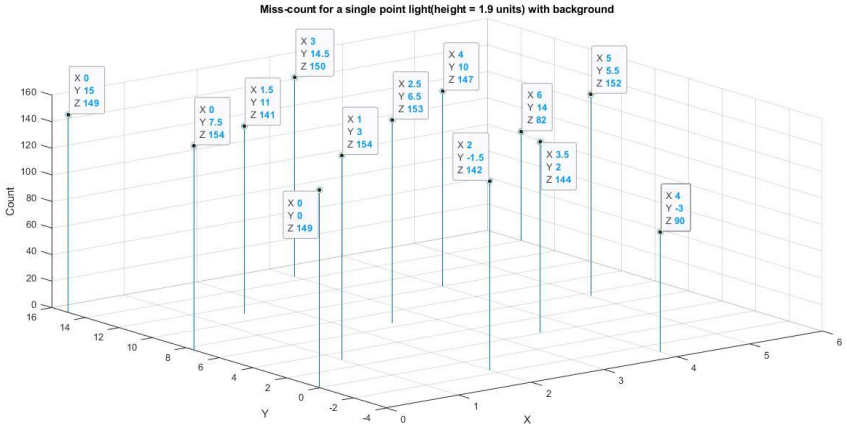


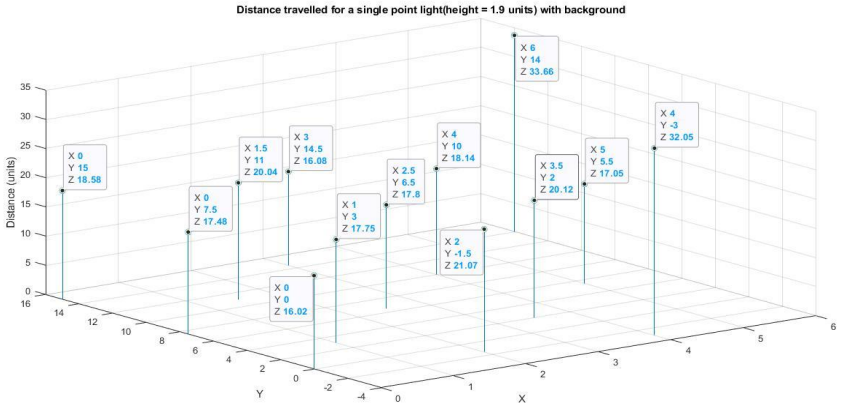
Results from Scenario 4



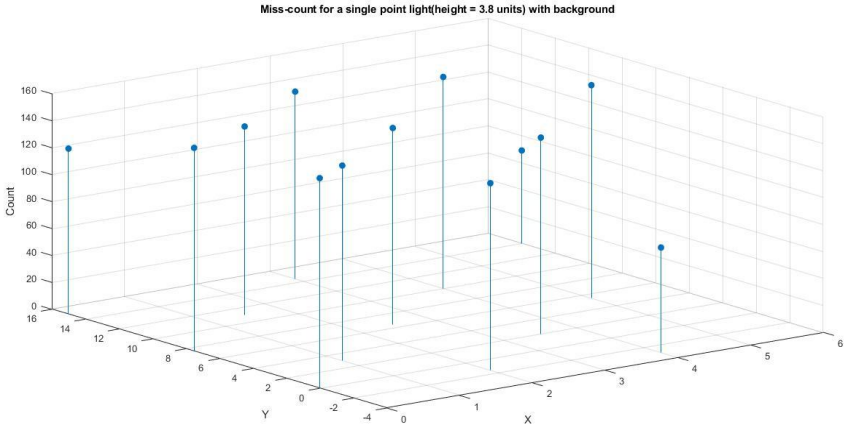


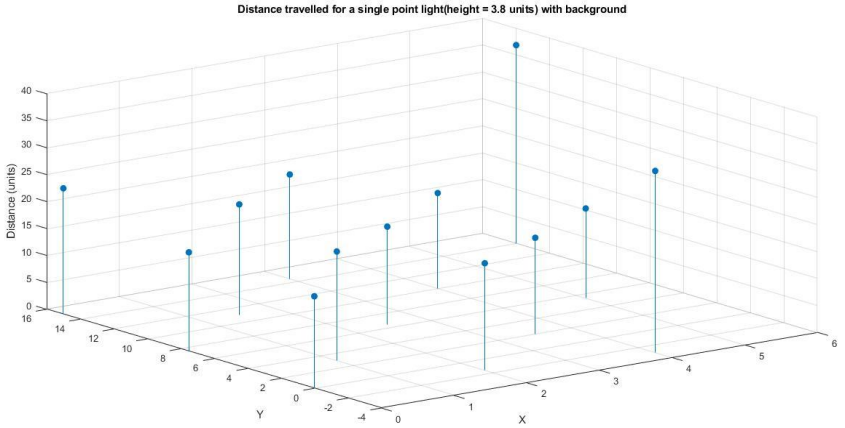
Results from Scenario 4



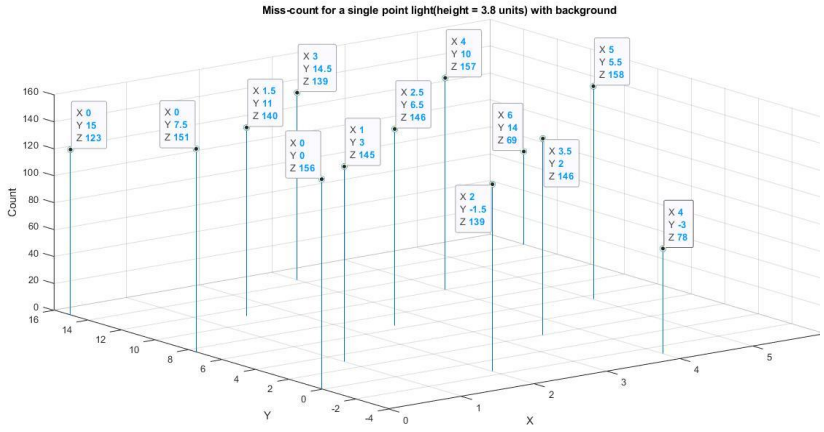


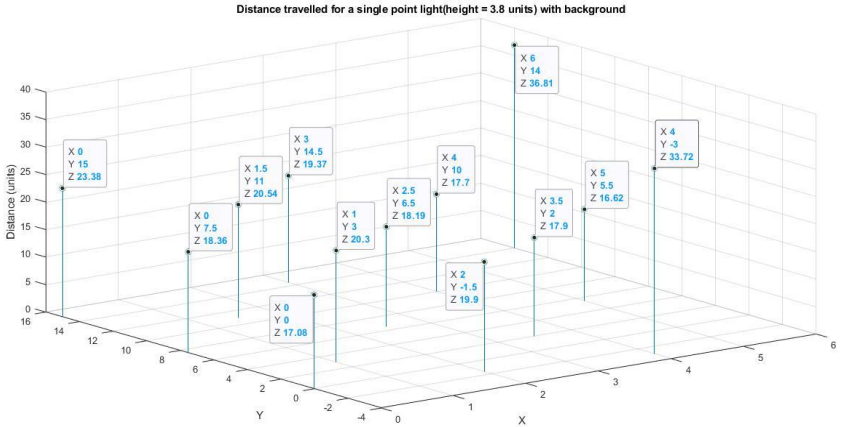
Results from Scenario 4



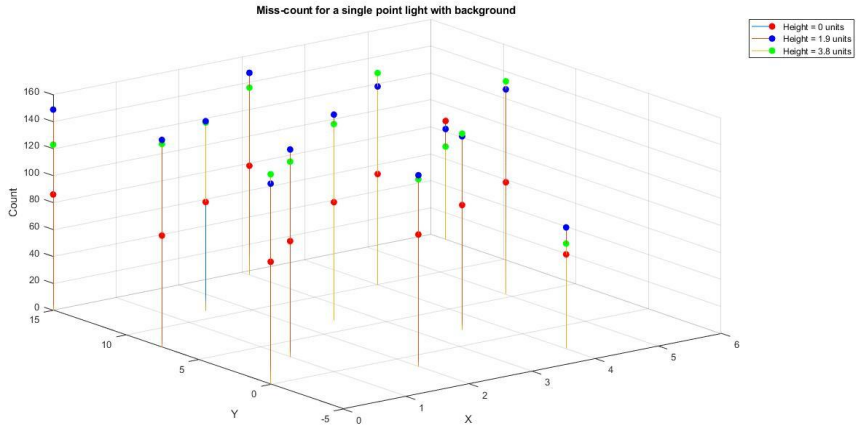


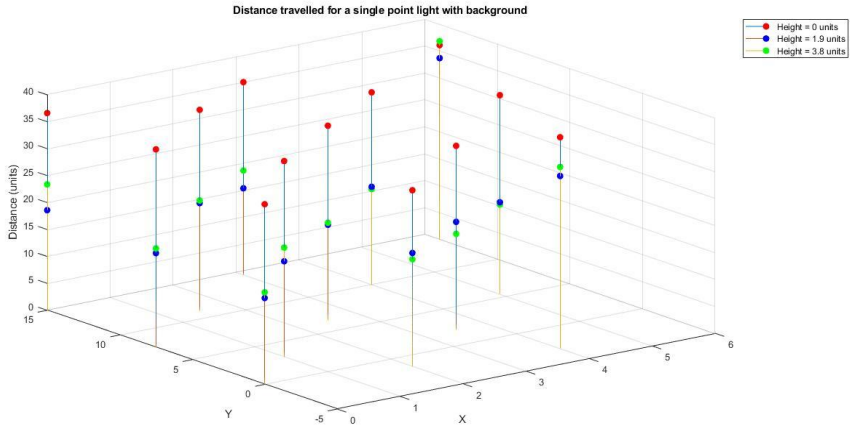
Results from Scenario 4





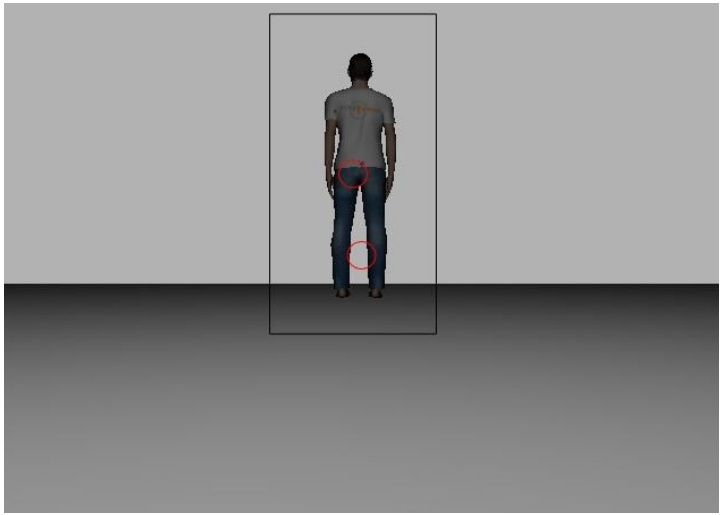
Results from Scenario 4





Inference from scenario 4

- The overall performance in this scenario is worse than in the previous scenario (only with the background light).
- The point light hinders the performance at two places where the turning angle is tight.
- Better performance is obtained when the point light source is placed at these turns.



Conclusion

- The robot tracks better when the frame obtained is well-illuminated by the light source.
- The performance increases when the light source is on the ground than at a height from the ground.
- The robot tracks better than usual when there is just background light illuminating the environment.
- This performance is reduced when any other kind of illumination is introduced in the environment.
- Lights have to be kept at difficult turns if there is ambient light reducing the performance.

Thank you.

Any Questions?