Machine-to-Machine Learning for Search and Rescue Missions

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Problem

SAR environments are dynamic, uncertain, and time-critical

Robots must handle:

- Obstructed objects
- Similar-looking objects (disambiguation)
- Changes in scene and viewing perspective

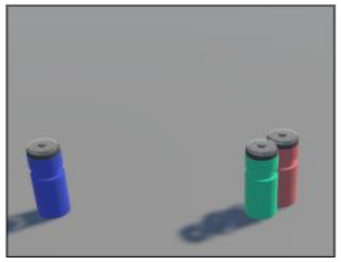
Current systems lack efficient knowledge sharing

Objectives

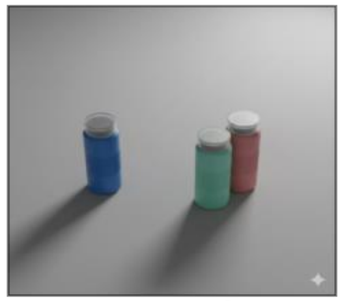
Enable LLMs to:

1. Generate accurate text-based scene descriptions
2. Build shared memory system across robots
3. Analyze scenes given textual descriptions and updated images to identify changes

JSON Description Accuracy



Original Image

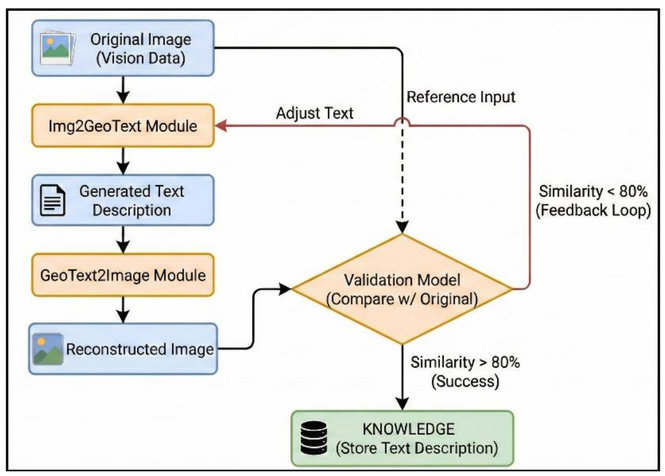


Reconstructed Image

```
{
  "Object_1": {
    "Object Name": "Cylindrical Water Bottle",
    "Color": "Solid Cobalt Blue",
    "Shape": "Tall cylinder with a diagonal textured grip band in the center and a flat, translucent grey cap",
    "Orientation": "Strictly upright, vertical",
    "Position": "Lower left side of the frame",
    "Surrounding": "Isolated on a plain grey surface; casting a long, soft-edged shadow toward the bottom-left corner"
  },
  "Object_2": {
    "Object Name": "Cylindrical Water Bottle",
    "Color": "Seafoam Green",
    "Shape": "Tall cylinder with a diagonal textured grip band in the center and a flat, translucent grey cap",
    "Orientation": "Strictly upright, vertical",
    "Position": "Lower right side of the frame, positioned directly in front of the red bottle",
    "Surrounding": "Obscuring the left half of the red bottle behind it; shadow merges with the red bottle's shadow toward the bottom-left"
  },
  "Object_3": {
    "Object Name": "Cylindrical Water Bottle",
    "Color": "Muted Rose Red",
    "Shape": "Tall cylinder with a diagonal textured grip band in the center and a flat, translucent grey cap",
    "Orientation": "Strictly upright, vertical",
    "Position": "Lower right side, tucked behind the green bottle",
    "Surrounding": "Only the right side and the top cap are visible; it is partially hidden behind the green bottle's right shoulder"
  },
  "Environment_and_Perspective": {
    "Background": "Seamless, uniform matte medium-grey floor and wall with no visible horizon line",
    "Lighting": "Single strong light source from the top-right corner, creating soft shadows that fall toward the bottom-left",
    "Camera Angle": "High-angle perspective looking down at a 45-degree angle, making the circular tops of the caps clearly visible"
  }
}
```

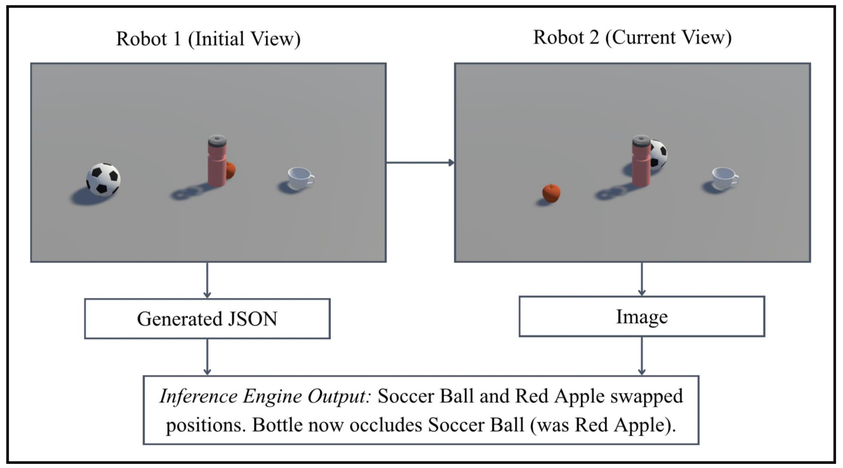
Textual Description

JSON Generation



Iterative process of JSON generation to ensure described image is comparable to original image provided.

Inference Testing



Positional change inference between Robot 1's initial view and Robot 2's current observation

Results & Conclusion

Test Scene	# Tests	Success (%)	Failure Reason
Color Change	20	100%	N/A
Position Change	20	90%	Object mapping and correspondence
View Angle Change	20	75%	Spatial visualization and inconsistent perspective scaling
View Angle and Position Change	20	60%	Combined distortion and scene complexity

Results show strong accuracy in change detection and knowledge sharing, with up to 100% success in simple scenarios. Performance drops in complex spatial and viewpoint changes, indicating areas for improvement.