Semantic Understanding of Road Scene (Final)

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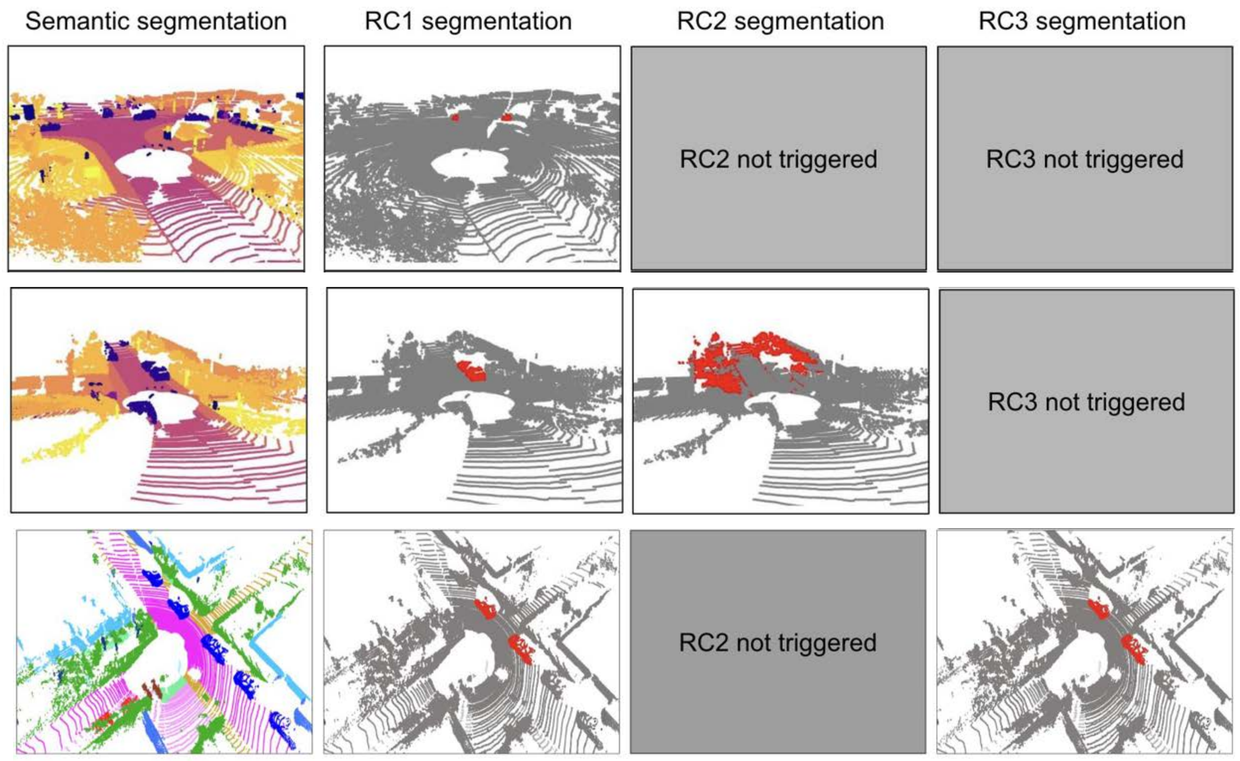
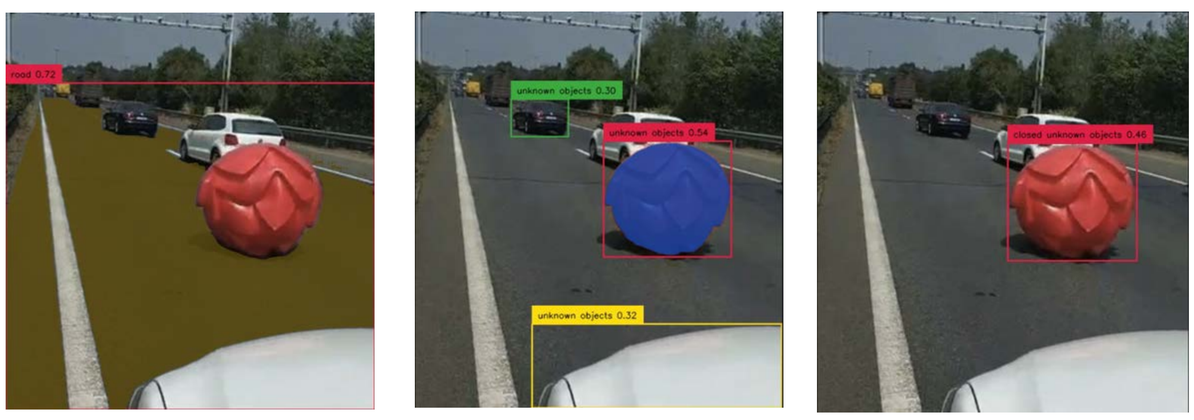
- **Goals - Enhance driving safety by understanding**
  - 1. Identifying Road Conditions(**RC**) via semantic understanding
    - Parsing expected and unexpected/rare RCs, objects, and layouts
  - 2. Identifying Rare RCs and Unknown/rare Objects
    - Discovering objects and assessing RCs by open-set models
- **Methods for Goal 1:**
  - Frame-wise RC identification and localization by 3D point-level semantic segmentation and object-level detection
    - Condition 1 - Objects On the Road (OOR)
    - Condition 2 - Rare/Undefined Objects on Road (ROR)
    - Condition 3 - Object in close 3D Proximity/ Distance



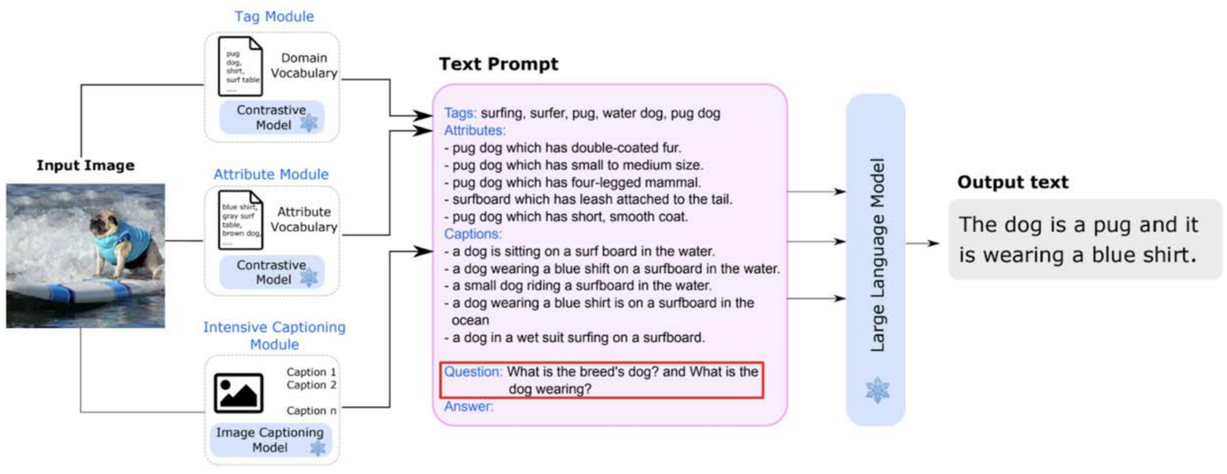
  - OOD detection (issue: may detect known objects as unknowns)

- **Methods for Goal 2 (Step 1):**
  - Road conditions based on 2D Open-set Perception
    - Conducting road segmentation and unknown objects bounding box detection and segmentation given text prompt

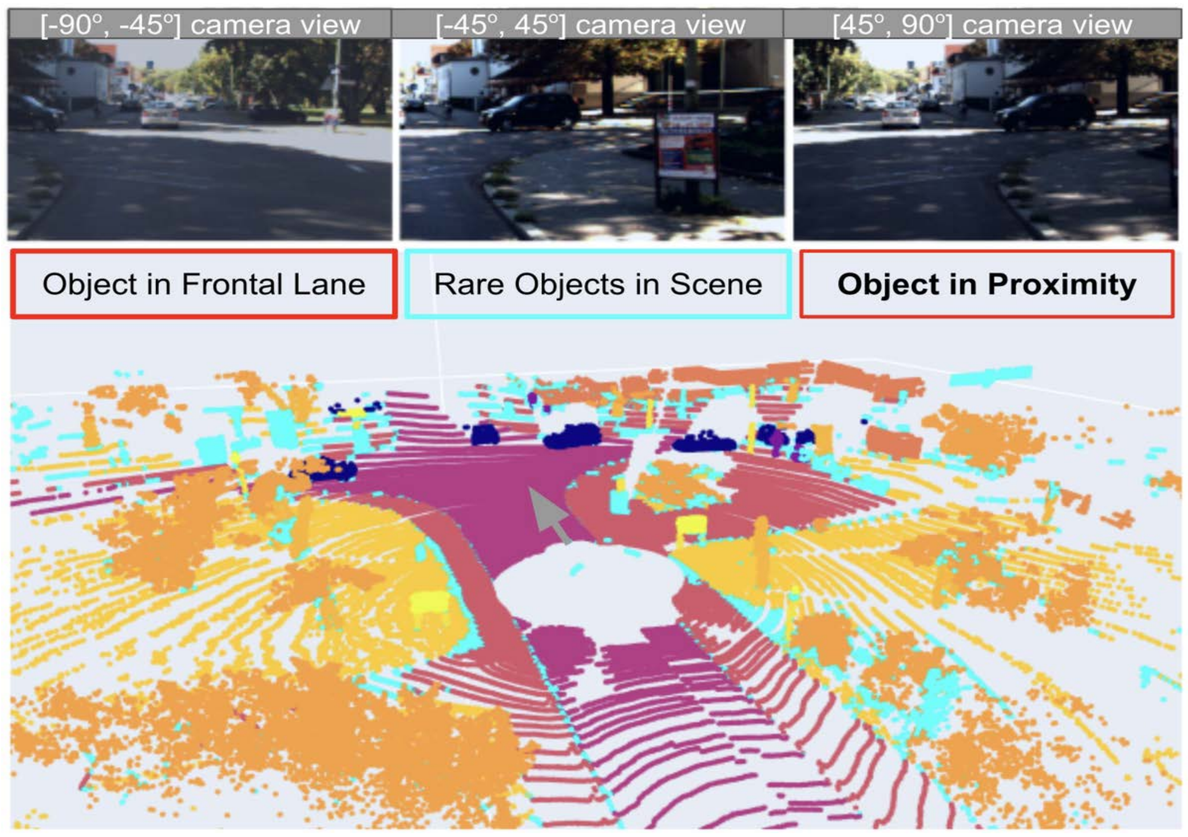
Prompt: Road | **Prompt: Unknown Object** | **Prompt: Closed unknown Object**



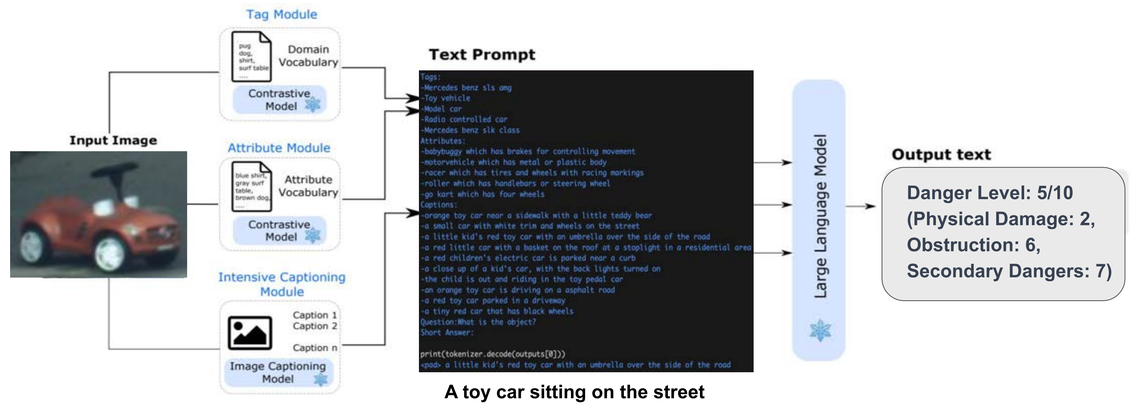
- **Methods for Goal 2 (Step 2):**
  - Road conditions based on 2D Openset Perception
    - Generating attributes from open-set detections



- **Demo: Close-set Road Conditions Understanding (Goal 1)**



- **Demo: Open-set Detections, Attributes and Danger Levels (Goal 2)**



- **Methods for Goal 2 (Step 3):**
  - Road conditions based on 2D Open-set Perception
    - From the attributes from unknown objects, we use ChatGPT to assess the dangerous level.

- **Physical Damage:**
  - Toy Car: Given that the toy car is small and lightweight, it's unlikely to cause significant physical damage to an autonomous vehicle. Running over a toy car would generally not harm the vehicle's mechanics, tires, or undercarriage.
  - Danger Score: 2 out of 10
- **Obstruction:**
  - Toy Car: An autonomous vehicle's sensors and cameras are designed to detect obstacles, including small ones. A toy car on the road could be detected as an obstruction. While the vehicle might be able to drive over it without harm, the autonomous vehicle's system might choose to stop or swerve to avoid it. The latter can be especially problematic if the vehicle swerves into an occupied lane or off the road.
  - Danger Score: 6 out of 10
- **Secondary Dangers:**
  - Toy Car: Secondary dangers refer to the potential hazards that arise as a consequence of the primary obstruction. If an autonomous vehicle stops or swerves to avoid the toy car, it could result in unexpected behavior that might confuse other drivers, potentially leading to accidents. Furthermore, human drivers might not anticipate the actions of the autonomous vehicle, leading to further complications.
  - Danger Score: 7 out of 10

Overall Danger Level: averaged scores in above criteria for an overall danger rating: (2 + 6 + 7) ÷ 3 = 5

Result: Danger Level: 5/10 (Physical Damage: 2, Obstruction: 6, Secondary Dangers: 7)

- **Summary:**
  - **Closed-Set / Point-Level Solution:**
    - Detecting and locating road conditions by **known** class **3D** points semantic segmentation
  - **Open-Set / Object-Level Solution:**
    - Detecting, descripting and assessing road condition from **Unknown** Object Caption tools: Grounded SAM, Lens and ChatGPT
  - **Future work:**
    - Open-set multi-modality 3D segmentation and danger level assessment