RICE: Refining Instance Masks in Cluttered Environments with Graph Neural Networks

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PROBLEM

> Robots need the capability to reason about unseen object instances in unstructured environments, e.g. households or work spaces.

> Can a robot detect and segment unseen objects from a single RGB-D image?

Motivation

> State-of-the-art methods tend to fail in highly cluttered scenes.

UOIS-Net-3D [1]

UCN [2]

> Can we sample refinement operations such as splits and merges to improve upon these segmentations?

Broader Impact

> Solving this fundamental robotic perception problem opens up potential for downstream robotics applications.

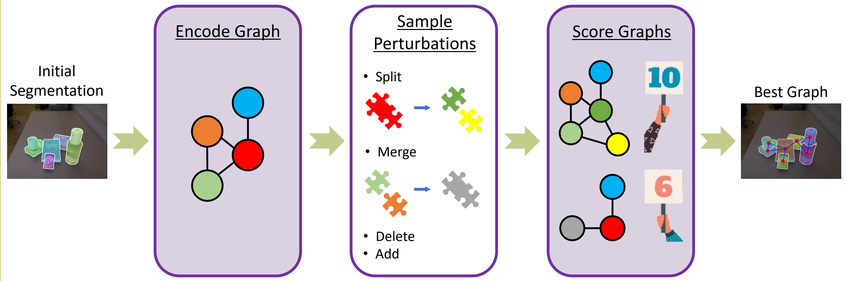
> For example, healthcare robots may need to clear a table of unknown objects in order to assist doctors in hospitals so they can focus on the patient.

> Rearranging unseen objects can allow robots to clean rooms in households or organize surgical tools at a doctor's convenience.

[1] Xie et al. "Unseen Object Instance Segmentation for Robotic Environments. T-RO, 2021.
[2] Xiang et al. "Learning RGB-D Feature Embeddings for Unseen Object Instance Segmentation". CoRL, 2020.

METHOD

RICE: System Overview



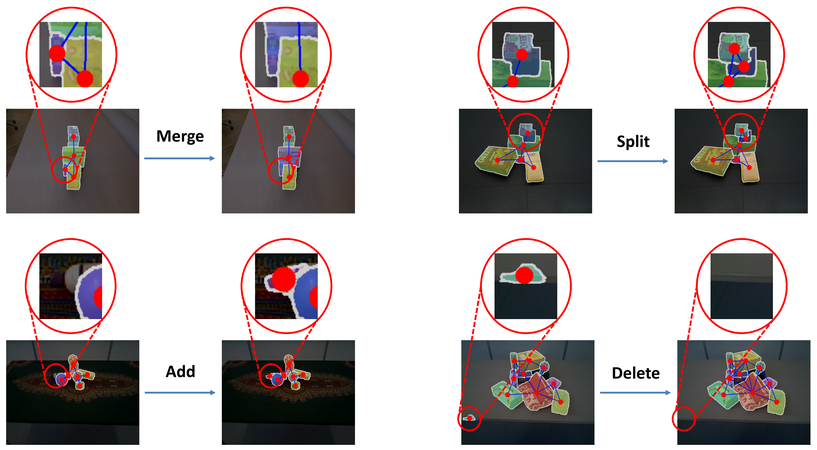
> Input: initial segmentation masks from external method (e.g. [1, 2]).

> Output: A refined segmentation.

Sampling Operations

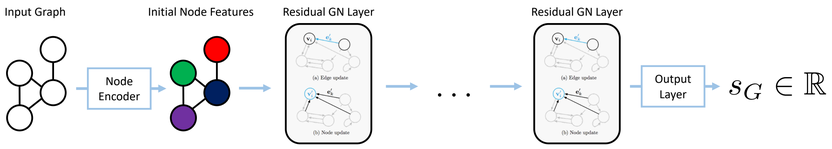
> Four sampling operations: merge, split, add, delete.

> Learn deep networks to suggest smart perturbations.



Graph Neural Network

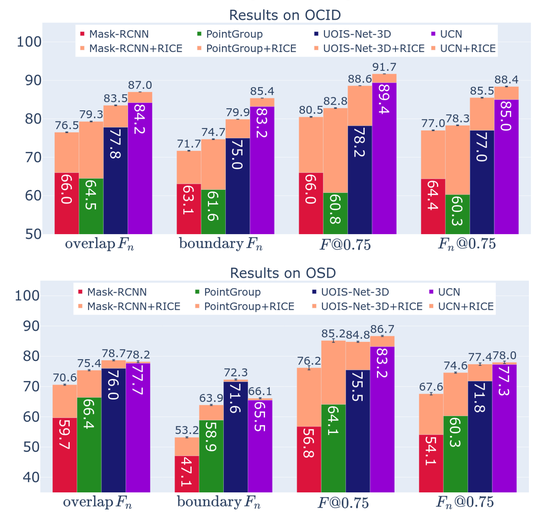
> Score the graphs with a learned graph neural network.



EXPERIMENTS

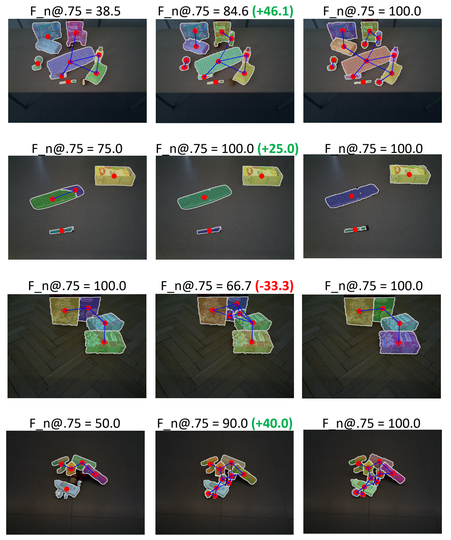
Quantitative Results

> State-of-the-art results when applied to previous methods.



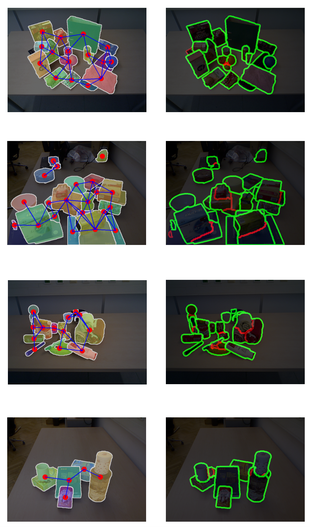
Qualitative Results

> Example refinements:



> Contour Uncertainty:

Red denotes uncertainty



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