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BP-net: deep learning-based superpixel segmentation for RGB-D image

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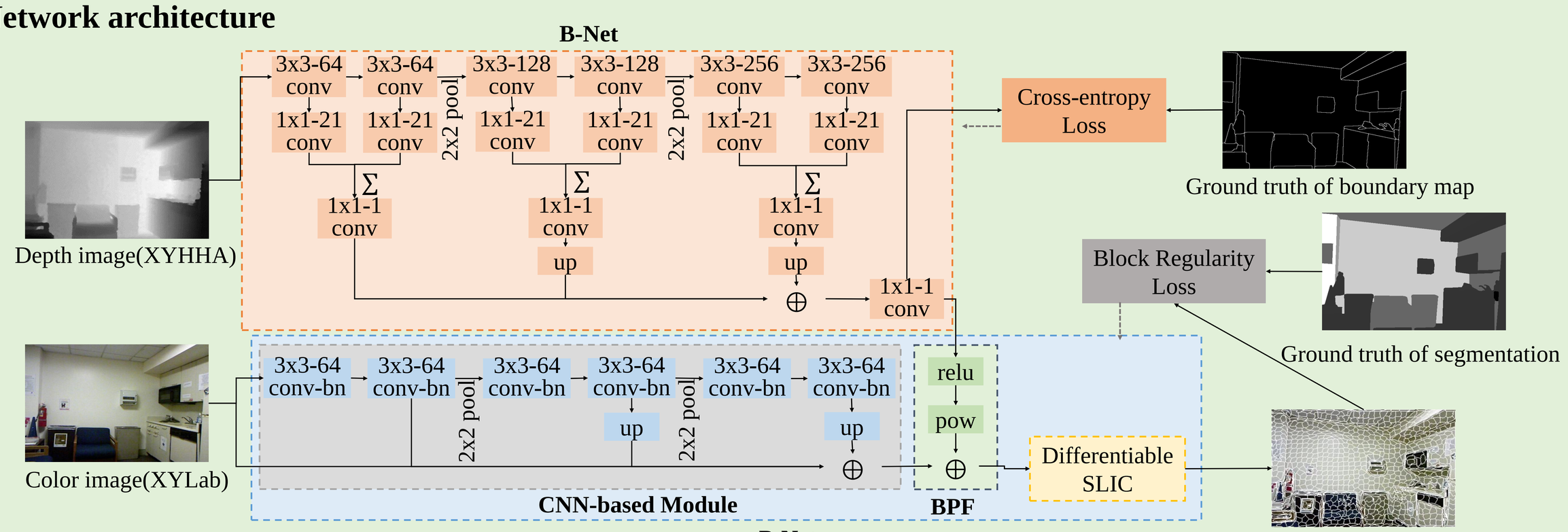
• Motivation

- Our BP-net is composed of boundary detection network that exploits geometry information from depth image, and pixel labeling network that extracts pixel features and generates reasonable superpixel for RGB-D image. A boundary pass filter in the BP-net is proposed to combines the edge information and pixel features and ensures superpixel adhere to geometry edges.
- The loss function in our BP-net combines accuracy and regularity term to learn the superpixel with high accuracy and regularity.
- The proposed seeds initialization can reduce the number of superpixels that cover multiple objects in the region of rich texture.

• Method

Network architecture



Block regularity loss

$$L_{BRL} = -\sum_{p_i \in I} \Big(\underbrace{(2 - r_i)}_{regularity\ term} * \underbrace{(t_i \log a_i + (1 - t_i)\log(1 - a_i))}_{accuracy\ term} \Big)$$

- r_i: $regularity\ score\ of\ the\ superpixel\ containing\ pixel\ i.$
- a_i: $predict\ label\ on\ pixel\ i.$
- t_i: $ground\ truth\ label\ on\ pixel\ i.$

Adaptive seeds initialization

The density of seeds is associated with region texture richness.

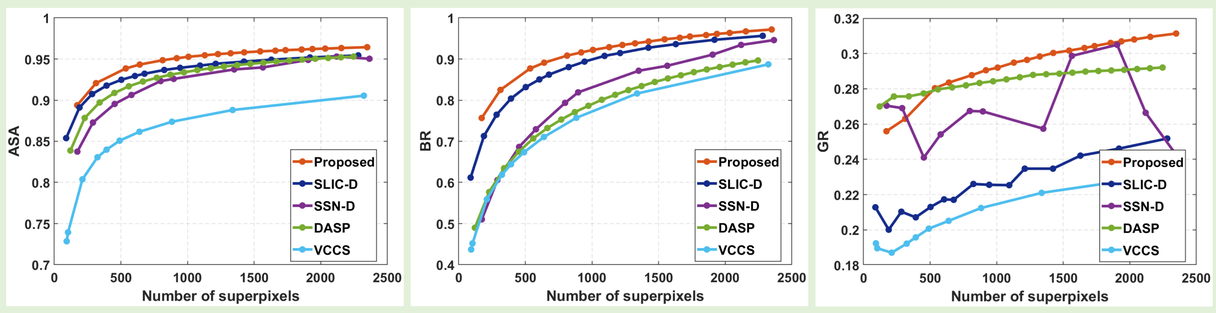
$$\rho(\Omega) \propto \frac{|\Phi(\Omega)|}{|\Omega|}$$

- $\rho(\Omega)$: the $density\ of\ seeds\ in\ region\ \Omega.$
- $\Phi(\Omega)$: $the\ corresponding\ region\ of\ \Omega\ in\ the\ combined\ spatial\ and\ color\ space.$
- $|\Omega|$: the size of region Ω.

(a) (b) (c)

(a) The RGB image. (b) The depth image. (c) The seeds initialization result by proposed adaptive seeds initialization with 800 seeds.

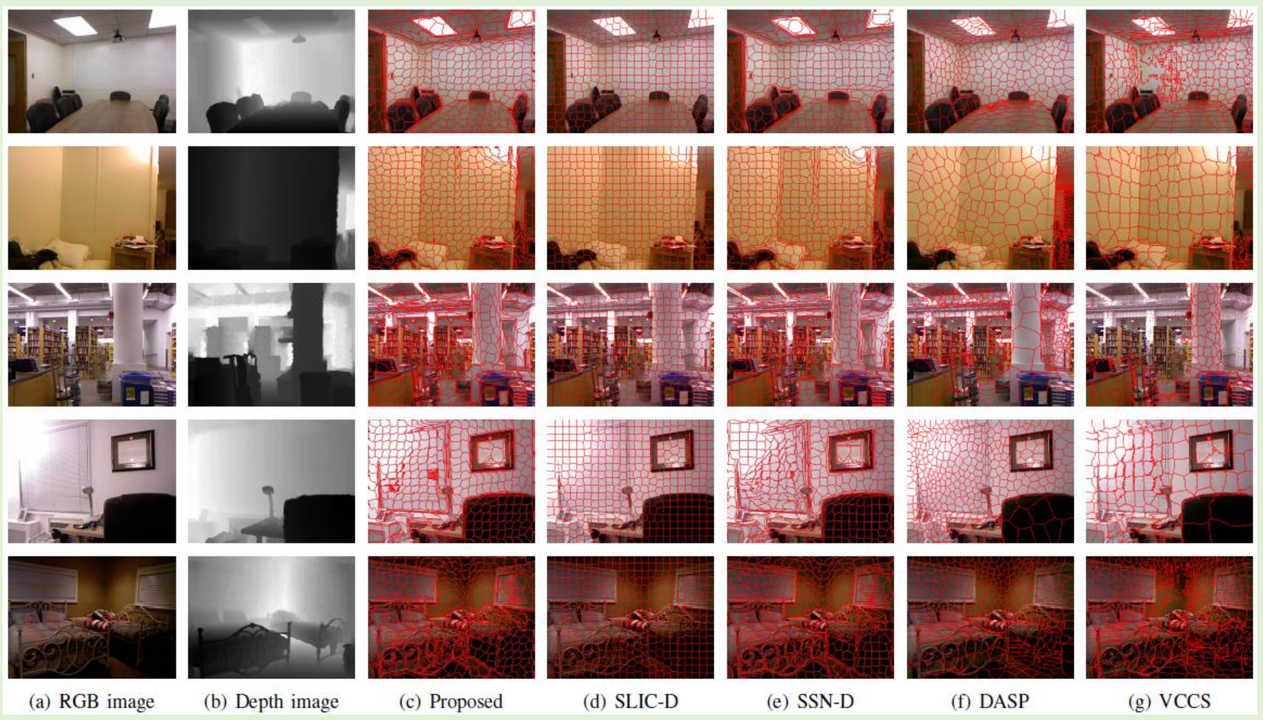
• Experiment



Evaluation with four representative algorithms.

	mean ASA	mean BR	mean GR
proposed w/o RT	**95.21%**	**92.65%**	21.44%
proposed w/o ASI	92.2%	91.51%	29.23%
proposed	95.09%	92.19%	**29.44%**

Ablation study: loss without regularity term (proposed w/o RT), without adaptive seeds initialization (proposed w/o ASI).



(a) RGB image (b) Depth image (c) Proposed (d) SLIC-D (e) SSN-D (f) DASP (g) VCCS