IAPR ICPR 2020
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BP-net: deep learning-based superpixel segmentation for RGB-D image

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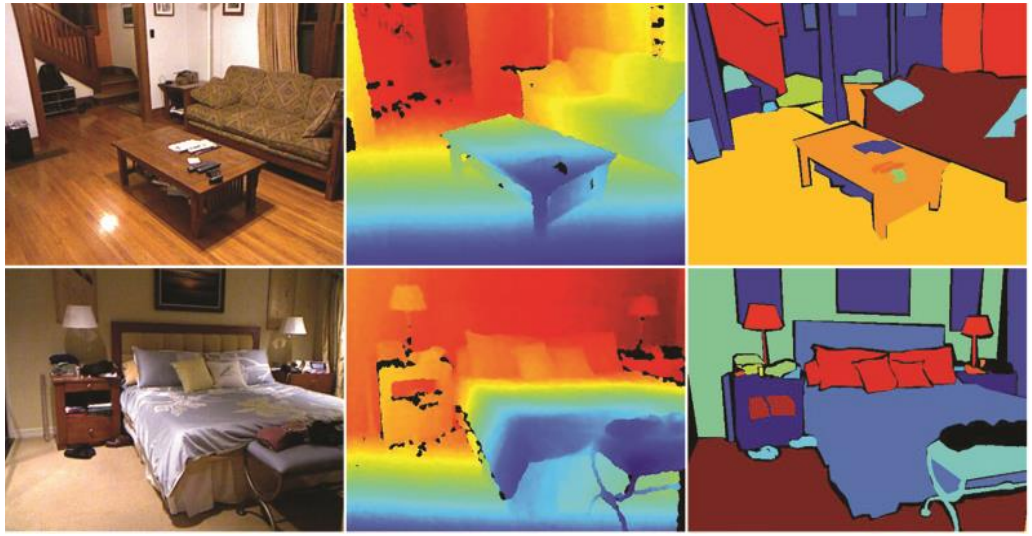
Superpixel

Pre-processing in vision applications
- Reducing the size of inputs
- Providing a meaningful image representation

- Boundary adherence
- Homogeneity within superpixel
- Regular shape

Microsoft Kinect, Intel RealSense, etc.



RGB Depth Segmentation GT

Call for superpixel algorithm for RGB-D image

Previous works

Superpixel Segmentation for RGB-D Image

① Depth-adaptive superpixels

② Voxel cloud connectivity segmentation

③ Superpixel segmentation based on weighted geodesic driven metric

④ Fast marker-controlled watershed superpixel

1) Hand-crafted feature

3)Unsatisfied seeds initialization

2)No constraint of regularity

Previous works

Superpixel Segmentation using Deep Neural Network

① Sampling superpixel network

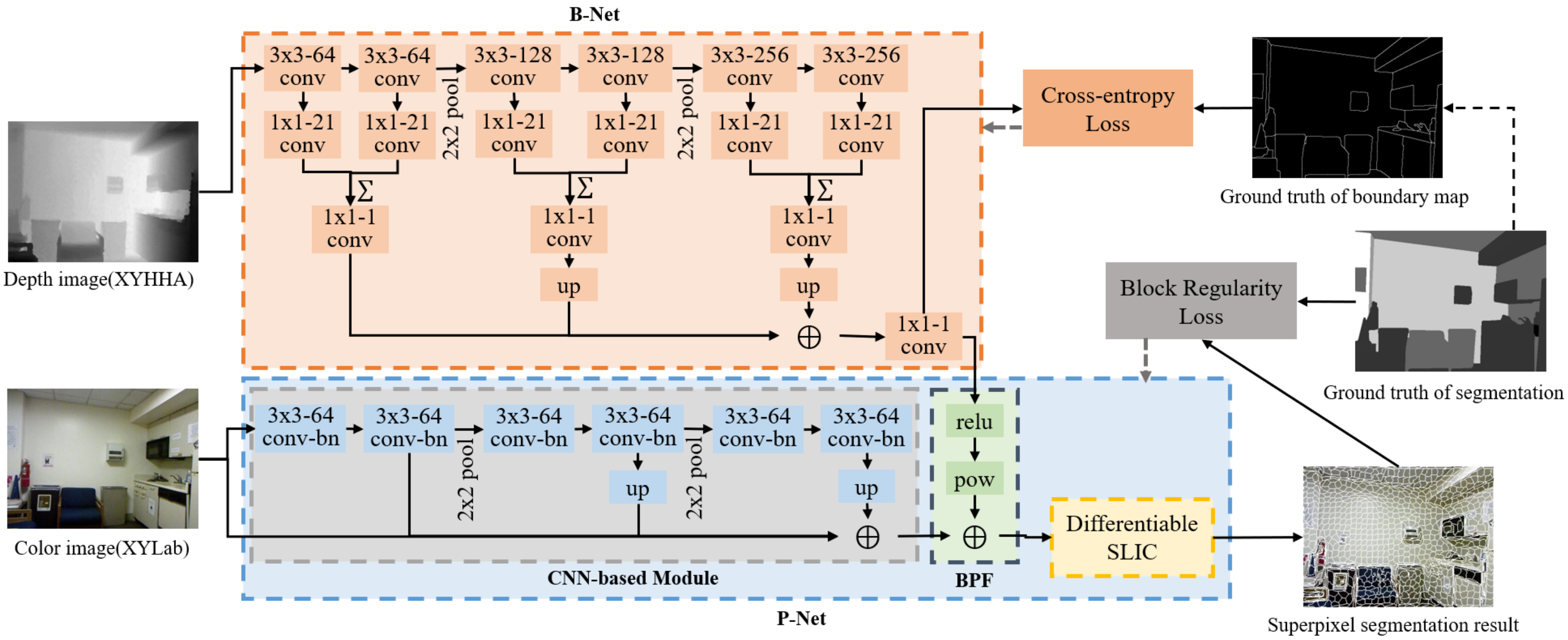
② Superpixel embedding network

RGB-D image

Cannot handle the depth information properly

Algorithm-Network architecture

BP-net



Algorithm-Loss function

Block regularity loss

Accuracy + Regularity

$$\mathrm{L}_{accuracy} = t_i \log a_i + (1 - t_i) \log(1 - a_i)$$

$$\mathrm{L}_{regularity} = 2 - r_i$$

r_i is the **regularity score**

$$SRC(S) = \left(\frac{|S|}{|CH|}\right) * \left(\sqrt{\frac{\min(\sigma_x, \sigma_y)}{\max(\sigma_x, \sigma_y)}}\right) * (|P(CH)|/|P(S)|)$$

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

Algorithm-Seeds initialization

Adaptive seeds initialization

The density of seeds $\rho(\Omega)$ is associated with region texture richness

Φ: maps pixels to 2-manifold $\mathcal{M}$ embedded in 4-dimensional combined spatial and color space

- Φ(x,y)=(x,y,grey(x,y),angle(x,y))

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

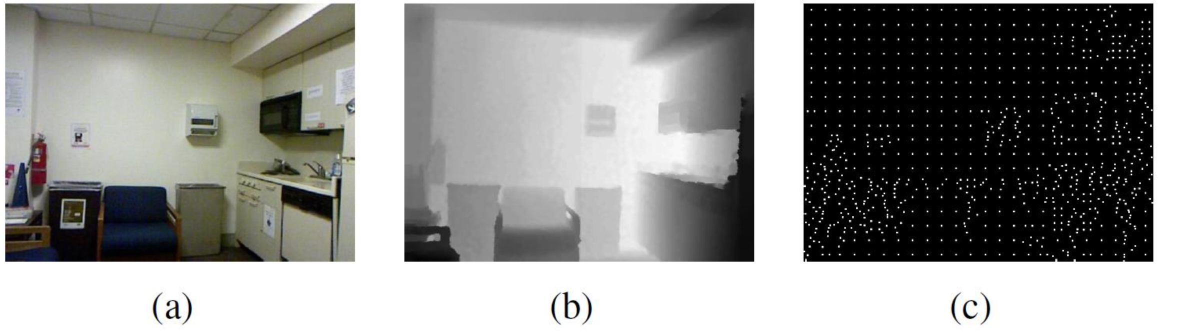
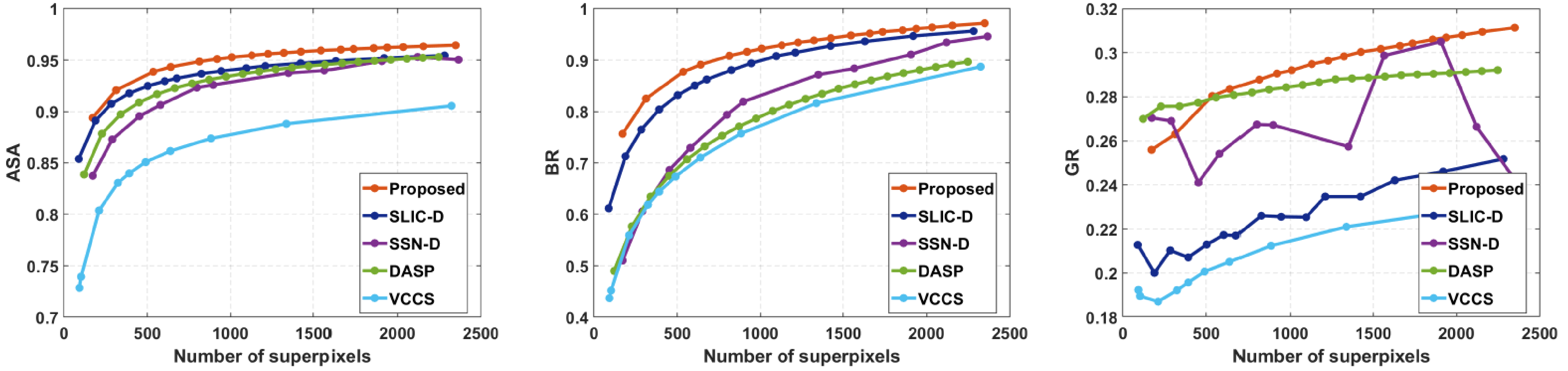


Fig. 2. Seeds initialization for an example image generated by the ASI. (a) The RGB image. (b) The depth image. (c) The result generated by the ASI with 800 seeds.

Experiment-Evaluation



(a) Achievable segmentation accuracy (b) Boundary recall (c) Global regularity measure

Fig. 3. Evaluation of four representative algorithms and our algorithm on the NYUD2 dataset.

Experiment-Ablation study

TABLE I
OUR ALGORITHM WITH SEVERAL ABLATION STUDIES ON THE NYUD2 DATASET.

	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%**

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Experiment-Sample result

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

Fig. 4. Sample superpixel segmentation results of our algorithm compared to the several state-of-the-art algorithms on the NYUD2 dataset.

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Thank you