COARSE-TO-FINE SEGMENTATION REFINEMENT AND MISSING SHAPE RECOVERY FOR HALIBUT FISH

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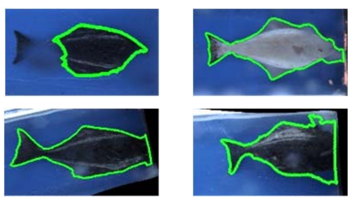
Abstract

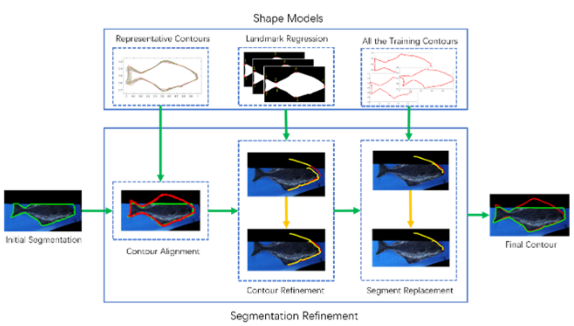
Image processing and analysis techniques have drawn increasing attention since they enable a non-extractive and non-lethal approach to fisheries survey. To measure the fish size and length accurately, a reliable segmentation result is required. However, there are two major challenges about the segmentation. One is that images may be blurred due to the spray of water on the camera lens, and the other is that some part of the fish body is out of the camera view. In this paper, we present an innovative and effective contour-based segmentation refinement and missing shape recovery method from an arbitrary initial segmentation. The refinement is processed from coarse level to fine level. At the coarse level, a weighted affine transform is estimated to align the entire fish contour of the initial segmentation with trained shape models. At the finer and finest levels, we iteratively refine the contour segments to represent the poorly segmented or shape missing image. The proposed method shows promising results on segmentation and length measurement for both water drop images and images with part of the fish out of the camera view.

Challenges in Length Estimation

- Water splash on camera lens
- Portion of fish is out of the view

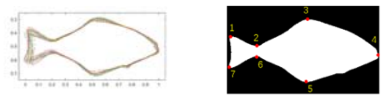


System Flowchart



PROPOSED COARSE-TO-FINE PROCESSES

- **Shape Models (Contour and Landmark Priors)**



Train

$$\hat{\mathbf{c}}_j(x) = \arg\min_{\mathbf{c}_j(x)} \|B_j \mathbf{c}_j(x) - \mathbf{v}_j(x)\|_2^2,$$

$$\hat{\mathbf{c}}_j(y) = \arg\min_{\mathbf{c}_j(y)} \|B_j \mathbf{c}_j(y) - \mathbf{v}_j(y)\|_2^2.$$

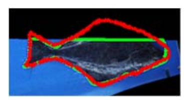
Test

$$\mathbf{v}_j^*(x) = \mathbf{b}_j^T \hat{\mathbf{c}}_j(x),$$

$$\mathbf{v}_j^*(y) = \mathbf{b}_j^T \hat{\mathbf{c}}_j(y).$$

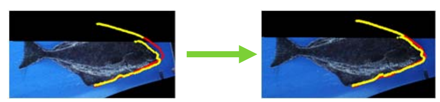
- **Contour Alignment (Coarse Level)**

Iterative weighted affine transform



$$\hat{\mathbf{h}} = \arg\min_{\mathbf{h}} \|W(A\mathbf{h} - \mathbf{p}^m)\|_2^2$$

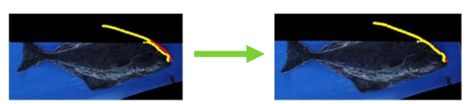
- **Contour Refinement (Finer Level)**



$$\hat{\mathbf{h}}_j = \arg\min_{\mathbf{h}_j}\{\|W_{j-1}(A_{j-1}\mathbf{h}_j - \tilde{\mathbf{p}}_{j-1})\|_2^2 + \|W_j(A_j\mathbf{h}_j - \tilde{\mathbf{p}}_j)\|_2^2 + \lambda \left\|(D_j\mathbf{h}_j - \mathbf{v}_j^*)\right\|_2^2\},$$

Affine Constraint   Landmark Prior

- **Contour Replacement (Finest Level)**



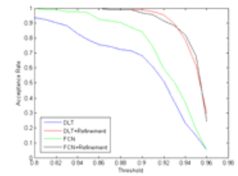
$$\hat{\mathbf{p}}_j^n = \arg\min_{\mathbf{p}_j^n} \left\|\mathbf{p}_j^n - \tilde{\mathbf{p}}_j\right\|_2^2$$

Experiments and Analysis

- **Water Drops**

TABLE I
Average IOU before and after Refinement

Method	Average IOU
DLT [2] (%)	89.65
FCN [3] (%)	92.35
DLT +Refinement (%)	95.04
FCN+ Refinement (%)	94.92

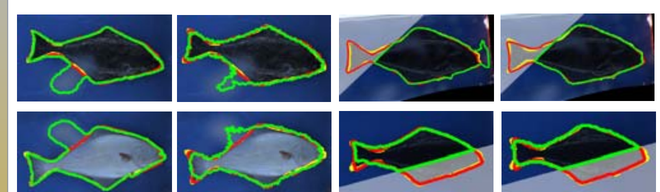


- **Missing Part Recovery**

TABLE II
Measurement of IOU and Length Error

Method	DLT+Refinement	FCN+Refinement
Average IOU (%)	87.81	89.28
Mean length error (%) [1]	4.86	4.07

- **Examples**



References

- [1] T.-W. Huang, J.-N. Hwang, and C. S. Rose. "Chute based automated fish length measurement and water drop detection." In Acoustics, Speech and Signal Processing (ICASSP), 2016 IEEE International Conference on, pp. 1906-1910. IEEE, 2016.
- [2] M.-C. Chuang, J.-N. Hwang, K. Williams, and R. Towler, “Automatic Fish Segmentation via Double Local Thresholding for Trawl-based Underwater Camera Systems,” IEEE International Conference on Image Processing, Sept. 2011.
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