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Underwater object detection by fusing features from different representations of sonar data

Key words: Underwater object detection; Sonar data representation; Feature fusion

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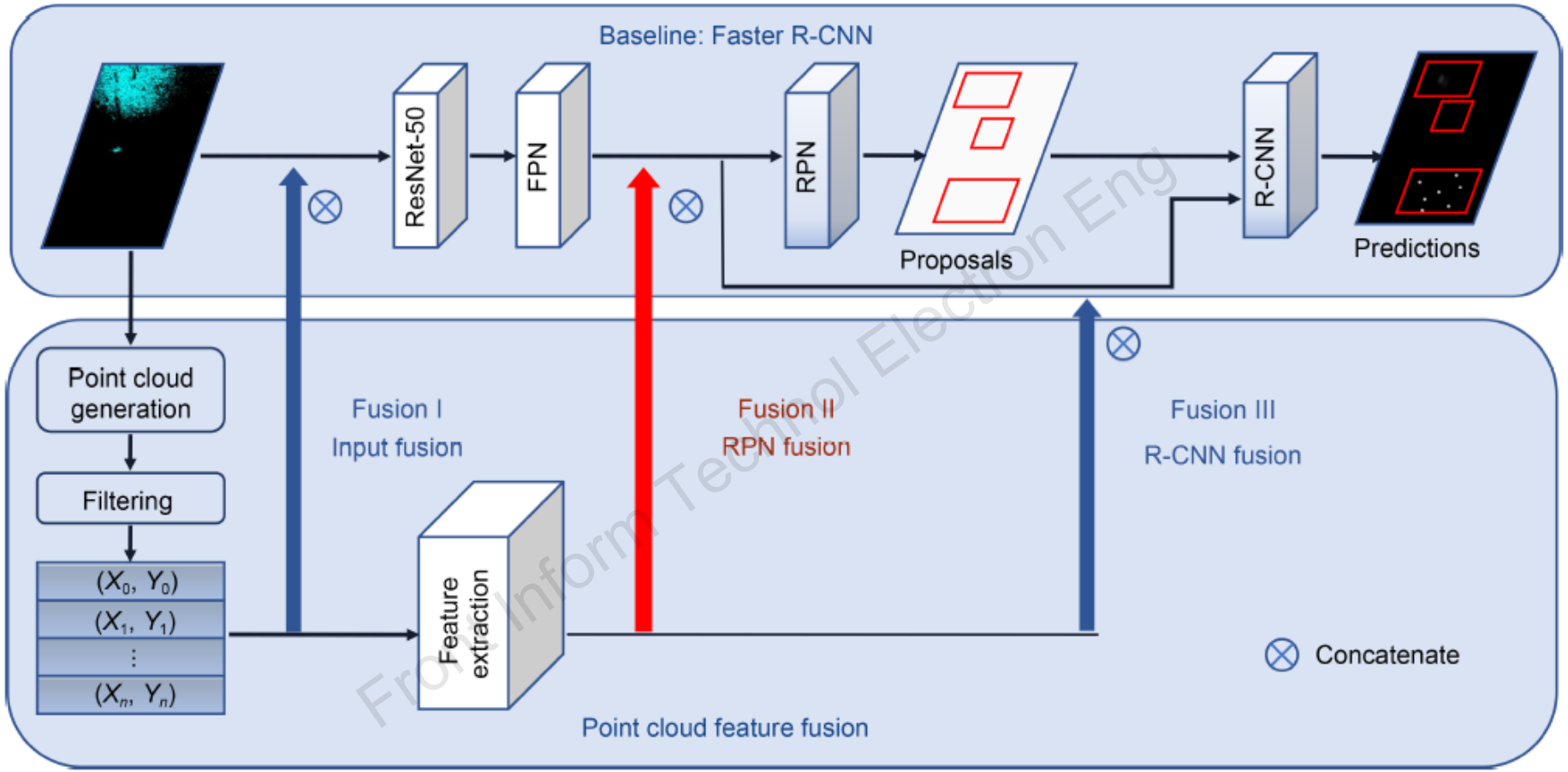
Motivation

- Underwater sonar images are low in resolution and high in noise. The accuracy of detection results is not good.
- Existing methods have focused mainly on improving the model structure and training procedure. The influence of sonar data representation on the detection results has seldom been investigated.
- Two kinds of distortion in sonar data are discussed, including projection distortion and representation distortion. The first is unrecoverable due to the limitation of sonar sensors, while the second is introduced by data representations. To reduce the influence of object distortion in sonar data, three sonar data representations are presented and analyzed.

Model structure



- Three strategies to fuse features from polar image and point cloud representations of sonar data are presented, including input fusion, fusing before region proposal network (RPN fusion), and fusing before the region of interest (ROI) pooling and ROI head of the R-CNN (R-CNN fusion).

Major results

1. mAP results of our model and related methods in underwater object detection

Table 4 Mean average precision of approaches without/with feature fusion

Representation	Mean average precision (%)					
	mAP@[.5, .95]	mAP@0.5	mAP@0.75	mAP(S)	mAP(M)	mAP(L)
Polar image*	50.8	93.8	49.7	18.5	51.0	45.5
Point cloud*	50.8	95.4	48.4	24.4	50.9	46.2
Input fusion#	51.8	95.6	50.0	24.4	51.8	48.7
RPN fusion#	**52.2**	**95.8**	**51.4**	**26.1**	**52.1**	**49.3**
R-CNN fusion#	51.5	94.3	50.5	24.4	51.6	47.5

Best results are in bold. * without feature fusion; # with feature fusion

Major results (Cont'd)

2. Average recall results of our model and related methods in underwater object detection

Table 8 Average recall of proposal generation without/with feature fusion

Representation	AR_{100}	AR_{300}	AR_{1000}	AR(S)	AR(M)	AR(L)
Polar image*	61.1%	61.1%	61.1%	24.4%	61.3%	61.4%
Point cloud*	60.8%	60.8%	60.8%	32.2%	61.0%	60.8%
Input fusion#	**61.7%**	**61.7%**	**61.7%**	32.2%	**61.7%**	**64.9%**
RPN fusion#	61.5%	61.5%	61.5%	**34.4%**	61.6%	62.4%

Best results are in bold. * without feature fusion; # with feature fusion

Conclusions

- A summary of different representations for sonar data is first presented, including polar image, Cartesian image, and point cloud.
- Three feature fusion strategies are presented in the framework to investigate the impacts of feature fusion on different components of the detection pipeline.
- A series of experiments are conducted on a public sonar dataset to demonstrate the effectiveness of our framework.

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