SUPPLEMENTARY MATERIAL

Automatic single fish detection from a commercial echosounder using YOLO v5 and its application to echosounder calibration

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Appendix A: Acoustic data pre-processing experiment

1. Acoustic echogram threshold setting

This paper takes the original acoustic data collected on June 4, 2021 as an example. The depth of the echogram was 30 meters andthe duration of the echogram was 30 minutes. The original acoustic data is displayed as an indexed image, shown in Figure A1.

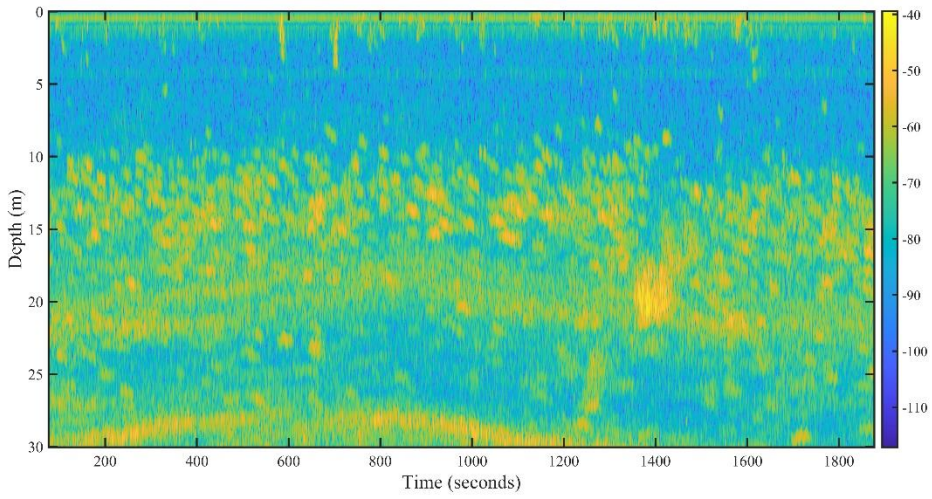

Figure A1. Original acoustic echogram

A fixed threshold method is used to remove the data outside the threshold in the echogram. According to the characteristics of pelagic fish acoustic scattering strength, the upper threshold was set at -20 dB andthe lower threshold set at -64 dB. The binary image obtained after threshold setting is shown in figure A2. In the binary image, the pixel within the threshold is 1 and the pixel outside the threshold is 0. The acoustic data after threshold processing is obtained by multiplying the numerical matrix of the binary image with the original acoustic data. The acoustic data after threshold processing is displayed in RGB indexed image format, which is shown in figure A3.

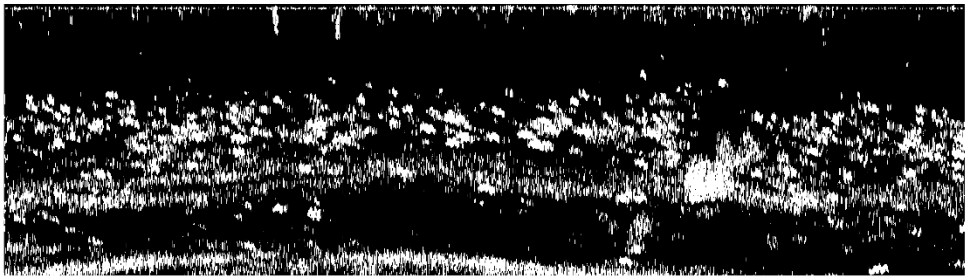

Figure A2. The binary image obtained after threshold setting.

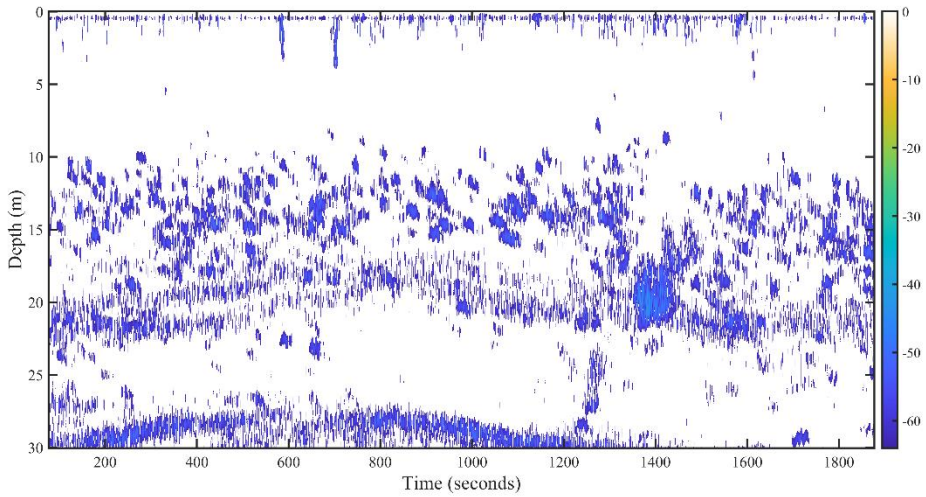

Figure A3. The indexed image obtained after threshold setting.

After threshold setting, the echo trace with lower echo intensity in the echogram is removed. Analyzing the distribution of the echo intensity in original acoustic data and threshold set acoustic data. The results showed that the upper quartile of echo intensity in the original acoustic data was -66.86 dB, the lower quartile was -82 dB, and the median was -74.22 dB.The Acoustic Data after threshold setting had an echo intensity

of -58.26 dB in the upper quartile, -62.60 dB in the lower quartile, and a median of -60.81 dB. The data distribution is shown in figure A4. The median echo intensity in the original acoustic data ranged from -70 dB to -80 dB, whereas the echo intensity in fish was usually above -70 dB, and most non-fish reverberations and noise were filtered by threshold processing.

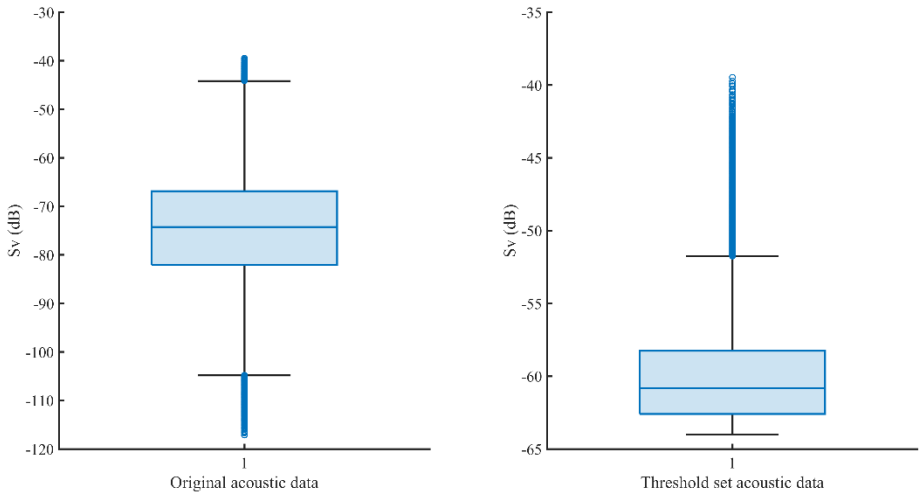

Figure A4. Comparison of echo intensity distribution between original acoustic data and threshold set acoustic data.

2. Median filter comparison with different window sizes

Pulse noise from acoustic data can be filtered out by median filter. The smaller the median filter window used; the more detail retained in the echogram. The filter effect of median filter with different window size are shown in figures A5, A6, A7. Distribution of echo intensity values in filtered images using three different median filter is shown in figure A8.

Figure A5. Binary image obtained by 3*3 Median filter.

Figure A6. Binary image obtained by 5*5 Median filter.

Figure A7. Binary image obtained by 7*7 Median filter.

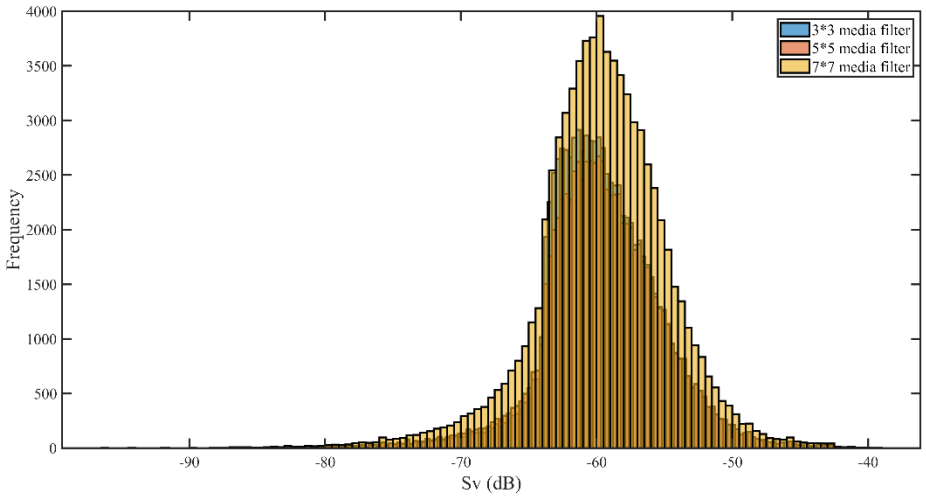

Figure A8. Distribution of echo intensity values in filtered images using three different median filter.

3. Edge detection

Canny edge detection algorithm is used to obtain the edge of each echo trace, so as to measure their morphological characteristics and echo intensity characteristics.

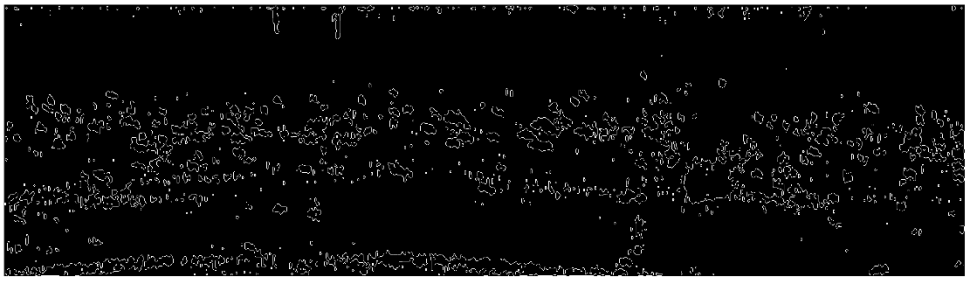

Figure A9. Detect the edge of echo trace using canny algorithm.

4. Preprocessing result

The original acoustic echogram was processed through fixed threshold setting, open and close operation, 3 * 3 Median filter, and edge detection to get the edge of echo trace. Used the layer overlay to get the echo intensity distribution in the region of each echo trace. Hence, the preprocessed acoustic data matrix was obtained and the grayscale image formed. The imagesc function was used to convert the grayscale image to an RGB indexed image. The resulting RGB acoustic image is shown in Figure A10.After preprocessing, the upper quartile of echo intensity was -57 dB, the lower quartile was -62.16 dB, and the median was 59.83 dB. The comparison with the echo intensity value of the original image is shown in Figure A11. By preprocessing the acoustic data, the echo traces could be identified with higher signal to noise ratio.

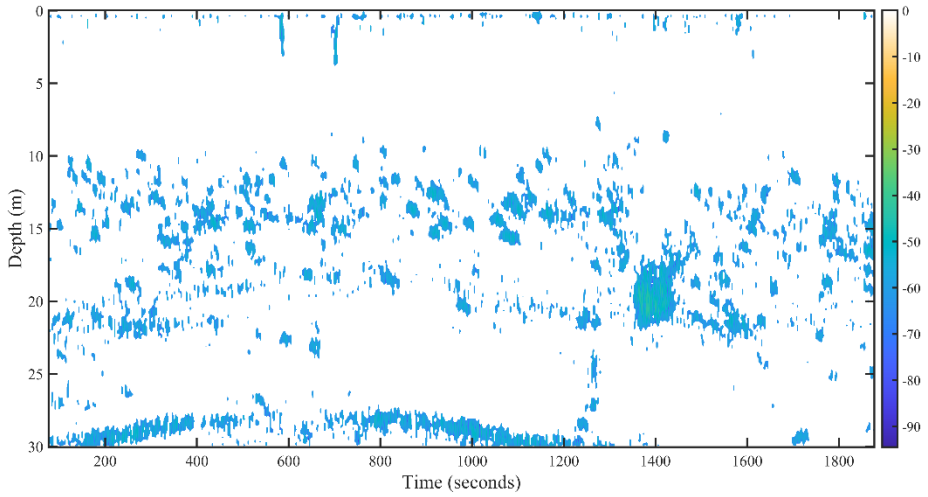

Figure A10. Acoustic echogram obtained after preprocessing

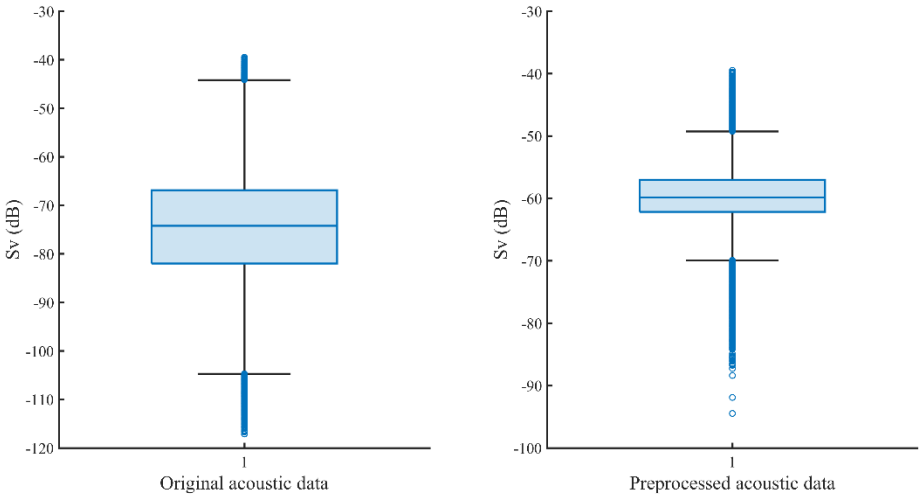

Figure A11. Comparison of echo intensity distribution before and after acoustic data processing

Appendix B: The mean speed, survey distance and horizontal resolution of acoustic survey in acoustic data

Table A1. The mean speed, survey distance and horizontal resolution of acoustic survey in acoustic data

Monitoring site	Jun 4	Jun 5	Jun 9	Jun 12	Jun 17	Jun 28	Jul 5
Mean speed (knot)	0.67	0.58	0.43	0.43	1.10	0.99	3.09
Survey distance (nmi)	4.71	4.09	2.99	3.00	7.72	6.95	21.69
Horizontal resolution (m)	0.35	0.31	0.22	0.22	0.58	0.52	1.63