EPFL Design Project – SIE 2023

nature counts FOUNDATION

Use of stereoscopic cameras to extract information on individual fish

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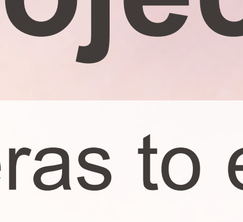
Objectives

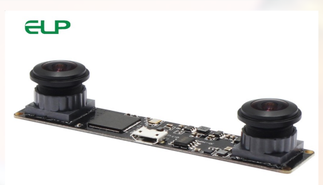
Fish size measurement is an important and frequent operation for aquaculture or market purposes. Monitoring the size distribution of female fish can provide important insights into the overall health and sustainability of the population. The objectives of this paper are:

- Propose a stereoscopic fisheye cameras method by Opencv to measure the fish size
- Evaluate the suitability and accuracy of this method



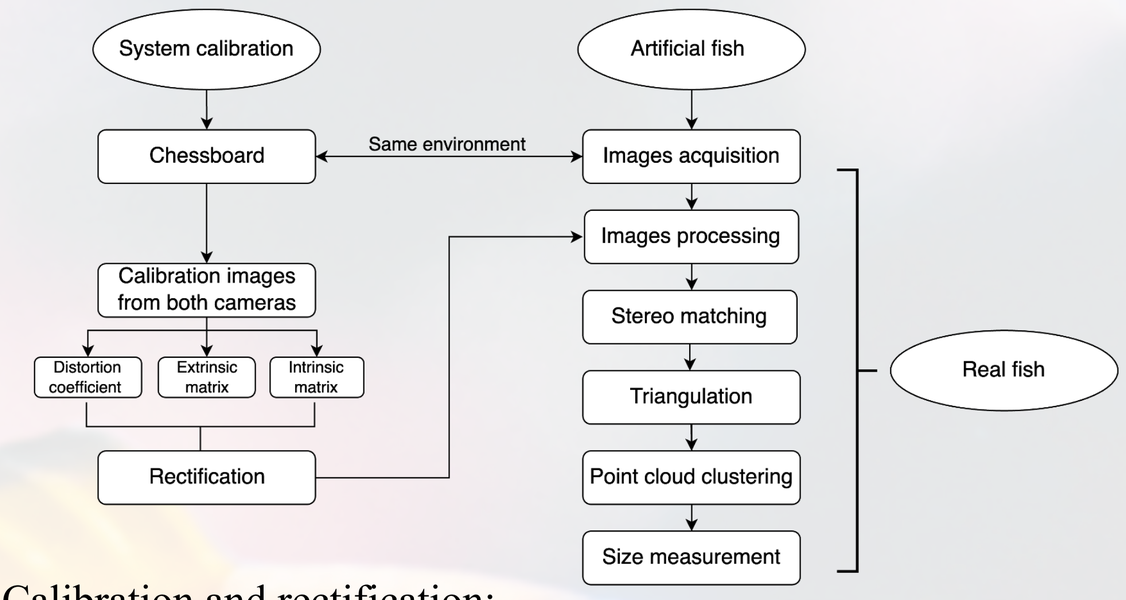
Experiments

- Cameras: (a) Dual fisheye cameras ELP-960P2CAM-LC1100 with 6cm baseline; (b) Images are captured from video



- Experiments: (a) Test objects: a blue carton, a red Cola can bottle and an artificial fish; (b) Environment:: cameras were mounted on the glass in Rolex; (c) Placing distance: 15-20, 20-25, 25-30 cm away from the lens

Methodology

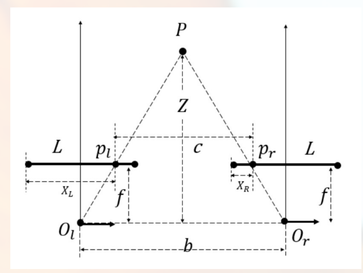


1. Calibration and rectification: obtain the cameras parameter and correct distortion.
2. Stereo matching: find keypoints of the target objects by ORB (select) and SIFT.
3. Triangulation: obtain the object depth.

$$Z = {fb}/{d}$$

$$X = {b}/{d}\,(u - c_x)$$

$$Y = {b}/{d}\,(v - c_y)$$



4. Outliers Rejection : identify target objects
5. Size measurement: find the the maximum and minimum values of keypoints in the x-axis direction

$$Length = \sqrt{\Delta x_{max}^2 + \Delta z_{correspond}^2}$$

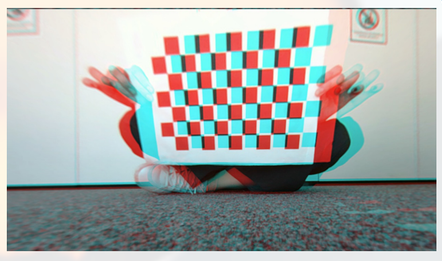
6. Accuracy evaluation: calibration and size measurement

Results

Calibration and rectification

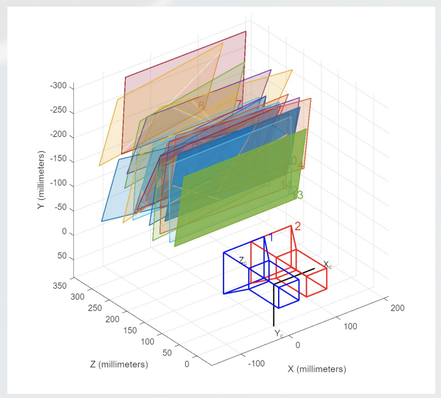
- Intrinsic parameters

	Intrinsic matrix(K, unit: pixel)	Distortion coefficients(D)
Left camera	$\begin{pmatrix} 419.84 & -1.31 & 662.82 \\ 0 & 417.91 & 510.35 \\ 0 & 0 & 1 \end{pmatrix}$	$\begin{pmatrix} -0.05 \\ 0.06 \\ -0.07 \\ 0.03 \end{pmatrix}$
Right camera	$\begin{pmatrix} 422.20 & -1.04 & 688.48 \\ 0 & 421.59 & 517.99 \\ 0 & 0 & 1 \end{pmatrix}$	$\begin{pmatrix} -0.03 \\ 0.002 \\ -0.03 \\ 0.02 \end{pmatrix}$



- Extrinsic parameters

Rotation matrix(R)	Translation vector(T)
$\begin{pmatrix} 1.000 & 0.003 & -0.007 \\ -0.003 & 1.000 & 0.004 \\ 0.007 & -0.004 & 1.000 \end{pmatrix}$	$\begin{pmatrix} -1.823 \\ -0.015 \\ 0.055 \end{pmatrix}$

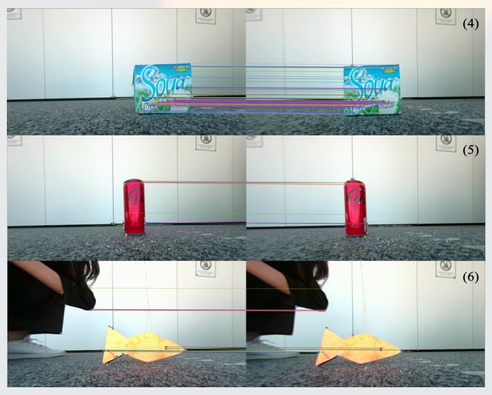


- Reprojection error

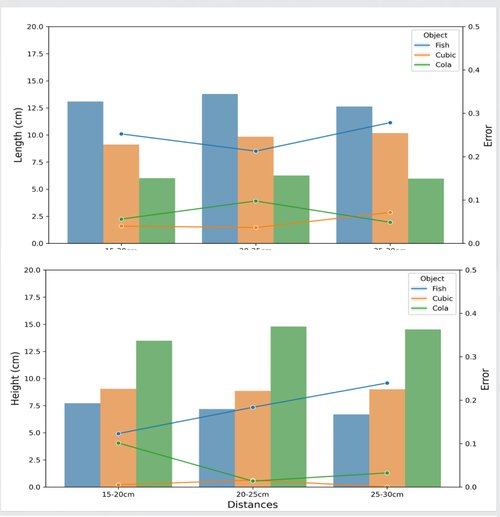
	Left camera	Right camera	Stereo system
RMS(unit: pixel)	0.59	0.60	0.61

Size measurement

- Stereo matching



- Calculated size and errors



Cubic and cola have satisfactory accuracy, while the accuracy of fish was unexpected.

Object	Distance range(cm)	Measured length(cm)	Mean measured length(cm)	Actual length(cm)	Relative length error	Mean relative length error
Fish	15 - 20	13.08	13.17	17.50	0.25	0.25
	20 - 25	13.78			0.21	
	25 - 30	12.63			0.28	
Cube	15 - 20	9.12	9.72	9.50	0.04	0.05
	20 - 25	9.85			0.04	
	25 - 30	10.18			0.07	
Cola	15 - 20	6.02	6.08	5.70	0.06	0.07
	20 - 25	6.26			0.10	
	25 - 30	5.98			0.05	

Conclusion

A method for object size measurement using stereoscopic cameras is proposed.

- Reprojection errors of the stereo camera system are satisfied with all RMSE lower than 1 pixel
- The accuracy of height measurement is greater than length measurement
- The cube and cola size measurements are more accurate
- There is a large error in the measurement of the length and height of the fish model, where the mean error values are 25% and 18% respectively
- The inaccuracy of fish size measurement may originate from the unrecognized keypoints of the target object and incorrect match during stereo matching process.