Boat Survey Using Photogrammetry Method

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Boat Survey Using Photogrammetry Method

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Abstract – *Lines plan drawings play a very important role in the fields of naval architecture and ship design. The drawings can be used for generating a three-dimensional (3D) surface model for ship hull and in performing many useful calculations such as ship hydrostatics, stability and powering. The survey process becomes very useful when dealing with ships or boats do not have proper lines plan drawings or in the absence of hull drawings. Various methods can be used to achieve the survey process such as laser and photogrammetry methods. Photogrammetry is used in case of inaccessibility or in which photogrammetry is the only possible way to be used. In this study, close range photogrammetry was used to survey the hull form of two boat models. The overall length of the first model is 0.71 m, while the length of the other one is 2.5 m. Commercial photogrammetry software was used for image processing to predict the lines of the two models. Moreover, the photogrammetry results of the large model have been exported into commercial naval architecture software to produce a fair hull surface model and to get the hydrostatic particulars for this model. Results obtained indicated that method developed was able to obtain good lines plans for the boat models.*

***Keywords**: Computational Fluid Dynamics, AUV, Resistance*

I. Introduction

Generally boat survey is a measurement method to obtain the geometry of a boat hull as well as its principal dimensions. Ship or boat stability calculations can be carried out directly once the geometry, principal dimensions and offset data of the lines have been determined.

Apart from stability analysis, through boat survey it is possible to obtain a 3D surface model for boat hull and determine boat characteristics from this model. Hull characteristics are very important because they have direct impact on boat speed, stability, strength, and efficiency [1].

Traditional boat builders normally produce boats using their own experience mixed with individual expertise and trial and error but very successful.

However, the traditional method to produce boats does not involve proper drawings. Without drawings, analyses such as calculations of stability, hydrostatics and prediction of vessel powering could not be done. Also, plans for additional work such as modification, repair, maintenance, will be difficult. Thus through boat survey is necessary to extract offset data from a boat and subsequently produce drawings.

There are two main approaches in boat survey. The first approach is a direct method which involves the use of manual devices such as measuring tape and a need for direct contact with boat hull all the time. The second approach is the indirect method which does not require any contact with boat hull all the time.

Methods that are classified as indirect methods may consist of laser scanning [2] and photogrammetry [3]-[4] methods.

Photogrammetry is defined as science, and art, of determining information about the position, size and shape of an object as a consequence of analyzing images recorded instead of by measuring directly [5]. In photogrammetry the position of a point normally defined by three dimensional coordinates system (x, y, z).

Meanwhile, the origin, scale, and orientation can be arbitrarily defined. There are two types of photogrammetry methods which are aerial photogrammetry [6] and close-range photogrammetry [7]. Aerial photogrammetry known as far range photogrammetry that used airplane for taking pictures of an object, generally the orientation is in a straight down manner. For close-range photogrammetry it is more on hand held camera or camera mounted on tripod and the orientation depending on the object. In addition the term of close range describe the object to be measure is less than about 100 meters.

The use of close range photogrammetry improves the precision of measurement, time consumption, equipment cost, and ease the manipulation if it is compared with direct method [8].

In this research work, the close range photogrammetry method has been used initially to obtain the lines of a small round-bilge fishing boat model having an overall length of 0.71 m to assess the effectiveness of the method.

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Once the method has shown some potential, a more comprehensive work has been carried out on larger chine-hulled boat model having a length of 2.5 m. The photogrammetry software PhotoModeler Pro 5 [9] was used in this study to obtain the hull lines of the two models from their images.

The results of the last model have been exported into the naval architecture software Maxsurf [10] to generate a fair hull surface and to perform the hydrostatic calculations for this model. Different comparisons have been made in this study to compare the photogrammetry results with the real data of the two models, to evaluate the capability of the photogrammetry method on surveying the hulls of the two boat models.

II. Implementation of Photogrammetry

II.1. Camera Calibration

In this study, Sony DSC-F828 DSLR (Digital Single-Lens Reflex) camera [11] with focal length of 7.1 mm, 8.0 Megapixels (3264 x 2488) resolution, 7x optical zoom and manual exposure control was used.

The camera was initially calibrated using control frame (Fig. 1). However, it required further on site calibration by setting up a calibration sheet (Fig. 2) on the floor. Eight images had been taken around the calibration sheet with 90o angle of separation and full field calibration was performed. Images then loaded into camera calibration program to determine the parameters of the used camera (Table I).

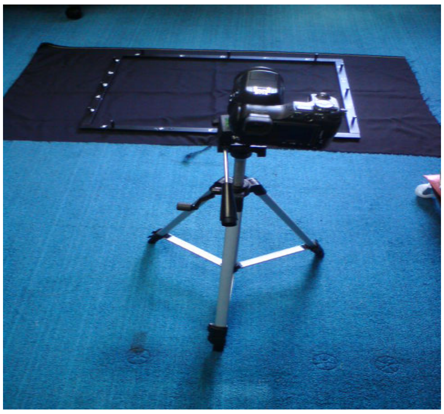

Fig. 1. Control frame used in camera calibration

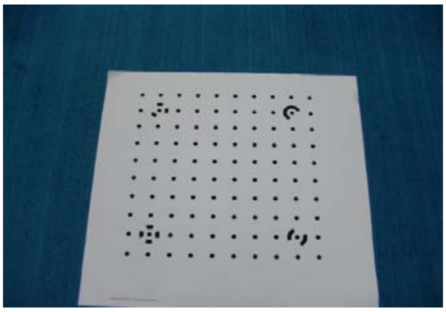

Fig. 2. Calibration Sheet used for in site calibration

TABLE I
THE RESULTS OF CAMERA CALIBRATION

Parameter	Symbol	Calibration value
Focal length	*f*	6.9563 mm
Format size	*W*	8.2039 mm
	H	6.1543 mm
Principle point	*X*	4.0788 mm
	Y	3.1153 mm
Radial distortion	*K1*	3.280 e-003
	K2	-3.749 e-005
	K3	0.000 e+000
Decentering distortion	*P1*	-1.530 e-004
	P2	5.294 e-005

II.2. Camera Calibration

Before photographing model, targets were placed on model hulls to enable the camera to capture the targets at three different angles. Retro reflective targets (Fig. 3) of diameter 5mm and 3mm were used for the small and large boat models respectively in this study. The selection of target size was based on the rules in [12]. T

argets have been distributed on the hulls of the two models so that the targets able to form the morphology of the models during data processing. Additionally, a scale bar of length of 57cm, an accuracy of ± 0.003 mm and markers on both ends was used with the small boat model to verify the accuracy of the survey work.

A camera tripod was used and attention was given to camera shutter speed, where it was found that decreasing the shutter speed produces images with better focal accuracy. Adjustment of shutter speed or aperture depends on the size of object going to be measured. In case of larger objects it is more appropriate to decrease shutter speed of the camera in order to avoid photograph from blurry.

Finally, the placement of camera or camera station should take into account during survey work. In this survey work, camera station had been arranged so that it was able to capture all side of the boat from forward to stern, and from port to starboard sides.

Fig. 3. Placement of retro reflective targets on model hull

II.3. Camera Calibration

After finishing the photographing process, the best images were taken in JPEG format and transferred to the photogrammetry software PhotoModeler Pro 5. The selected photographs were used for orientation and marking purposes. In the image processing stage, the photogrammetry software was able to extract all the coordinates represented by the markers that have been oriented. The marking process is critical part of images processing step in order to achieve high accuracy of measurement.

After completing images processing, the model can be viewed in 3D orientation and model data can be exported to Computer Aided Design software such as the ship design software, Maxsurf. In the previous program, data of the model can be read as a markers data in x,y,z, format which x represent longitudinal position, y represent offset and z represent height.

III. Results and Comparisons

III.1. Small Round-Bilge Boat Model

The photogrammetry method was applied to a small round-bilge fishing boat of length 0.71 m first, to determine how photogrammetry works on hull measurements.

Fig. 4 shows the preparation of the hull of the small boat model for the survey process. The retro-reflective targets of 5 mm diameter were used with this model, as can be seen from the previous figure.

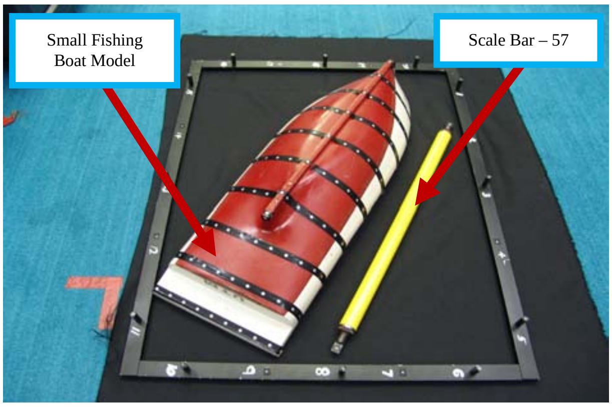

Fig. 4. Setup for small boat model scale survey

Fig. 5 shows the predicted lines for the hull of the small boat model after feeding the images to PhotoModeler Pro 5 software.

A comparison between tape measurements and photogrammetry measurements for the model main dimensions are presented in Table II.

TABLE II
ACCURACY OF PHOTOGRAMMETRY MEASUREMENTS FOR THE SMALL BOAT DIMENSIONS

Type of measurement	Tape (cm)	Photogrammetry (cm)	Diff. (cm)	Error %
Overall length	71.00	71.63	-0.63	0.88
Breadth	23.00	22.93	0.07	0.30
Depth	12.00	12.47	-0.47	3.91

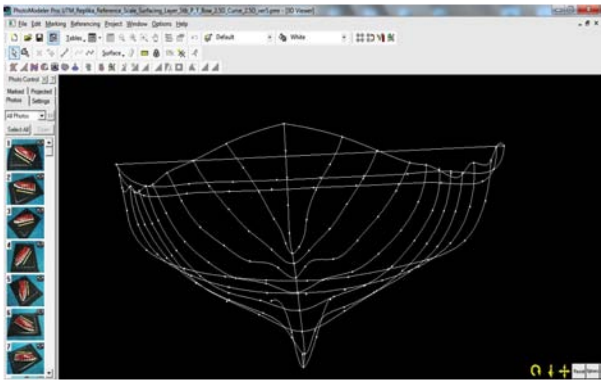

Fig. 5. Lines of small boat model obtained by photogrammetry method

III.2. Chine-Hulled Boat Model (MTL 060 Model)

The chine-hulled boat model MTL 060 (Fig. 6) was used in this study for the survey process, because of its good size and its chine hull form which gave good chance to test the ability of photogrammetry for surveying models and ships having similar hull forms.

The particulars of the model can be seen in Table III [13].

Fig. 6. Large boat model (MTL 060 model)

TABLE III
PRINCIPAL DIMENSIONS OF MTL 060 MODEL

Unit	Ship	Model
Scale Ratio	2.88	1.000
LOA (m)	7.20	2.5
LWL (m)	6.48	2.25
Beam (m)	1.64	0.57
Draught (m)	0.63	0.22
Displacement (tonne)	1.80	0.075
LCG (fwd amidship) (m)	0.97	0.34
LCB (fwd amidship) (m)	0.96	0.33

The hull of MTL 060 model was provided with retro reflective targets with a diameter of 3mm for each target.

The targets were placed at the hull line stations which have been marked earlier, as shown in Fig. 7. The placement of targets at only few hull stations was considered with this model, because the morphology of this boat model is not complex. Targets were distributed evenly at every station except at the hull chine where the sudden change in the hull shape led to closer distribution of targets.

In carrying out the survey work for MTL060 model, approximately over 700 targets have been used with this model.

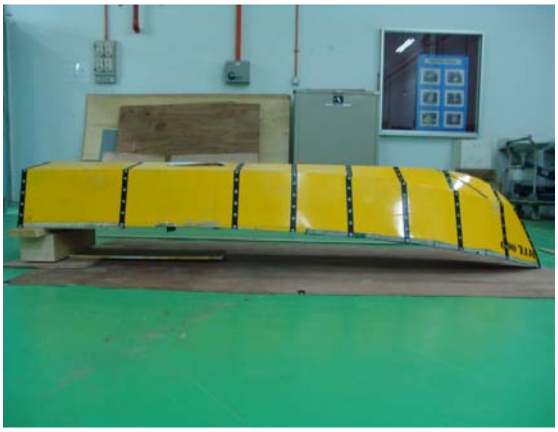

Fig. 7. MTL 060 model with retro reflective targets on its hull and ready for the photographing process

After multiple images for the same points on the model hull have been captured at different angles the images were processed by PhotoModeler Pro 5 software to generate the survey model, 3D model, by delineating lines of the model as well as the surfaces of the model based on oriented photograph of this model. The final result was the generation of the 3D hull surface model of MTL 060 boat model, as shown in Fig. 8.

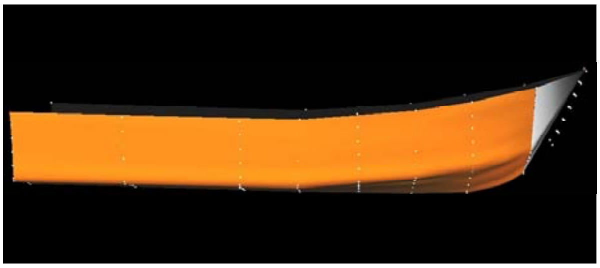

Fig. 8. The generated hull surface of model MTL 060 by photogrammetry software

TABLE IV
COMPARISON BETWEEN THE REAL AND THE PREDICTED MAIN DIMENSIONS OF THE LARGE BOAT MODEL (MLT 060 MODEL)

Model dimension	Model (cm)	Photogrammetry (cm)	Diff. (cm)	Error %
Overall length	71.00	71.63	-0.63	0.88
Breadth	23.00	22.93	0.07	0.30

The data of the predicted photogrammetry model was exported into program Maxsurf to produce a fair hull form and to calculate the hydrostatics of MTL 060 model, as shown in Fig. 9 and Table V.

Based on hydrostatic particulars comparison between the existing lines plan and photogrammetry, the results indicate the largest percent error was 3.01 %, which give good indication about the accuracy of predicted results. It is observed that the photogrammetry results show lesser mass and volumes displacements.

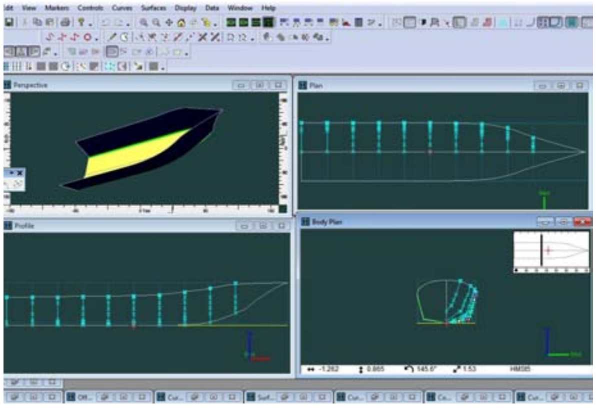

Fig. 9. Lines plan generated by program Maxsurf

TABLE V
COMPARISON BETWEEN HYDROSTATIC PARTICULARS OF MTL 060 MODEL

Hydrostatic particulars	Existing lines plan	Photogrammetry (cm)	Diff. (cm)	Error %
Disp.	0.0729 t	0.0707 t	0.0022	3.01
Volume (displaced)	0.0712 m^3	0.069 m^3	0.0022	3.01
KB	0.064 m	0.065 m	-0.001	1.56
Waterpl. Area	0.942 m^2	0.927 m^2	0.015	1.60
Wetted Area	1.153 m^2	1.137 m^2	0.016	1.39

The accuracy of the photogrammetry model can be assessed from the comparison between the real model main dimensions and the predicted dimensions, beside the comparison between the results of the predicted stations at the fore and aft with the data of the real stations at these locations, as can be seen from Table 4 and Figs. 10. On closer examination, it is found that although the measurements at most parts of the hulls are similar, the offsets near the Aft Perpendiculars and Forward Perpendiculars were not accurate. These are shown in Figs. 10(a) and 10(b).

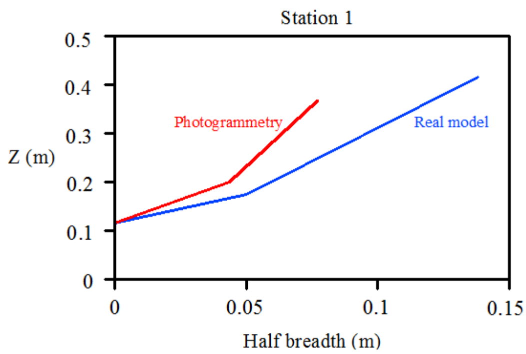

Fig. 10(a). Comparison between the real and the predicted lines of MLT 060 model at station 1 forward

The comparison between the main dimensions in Table IV show good agreement between the real and the predicted dimensions for MTL 060 model, while the comparison between the results at stations 1 and 10 show pronounced differences between the real and the predicted results as shown clearly in Figs. 10(a) and 10(b).

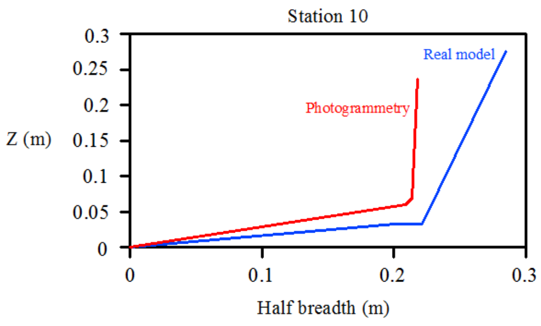

Fig. 10(b). Comparison between the real and the predicted lines of MLT 060 model at station 10 aft

These differences may arise from the need of more retro reflective targets on the model hull, beside the difference between the coordinates of the predicted photogrammetry model and the real model due to the variation between camera axis and the real model axis.

These in turn give rise to the discrepancies in hydrostatics data shown in Table V.

IV. Conclusion

In this research work the close range photogrammetry method was utilized for surveying the hull surface of the two different boat models. More attention was given to the results of the large model, MTL 060 model, because its shape and size which makes it near from a real boat.

The predicted main dimensions such as length and breadth from photogrammetry for the two models were compared well with the real dimensions. However, the detailed comparison for the hull lines at the two locations at fore and aft of the large boat model hull, show noticeable differences between the predicted and the real data. These main differences may lead to the requirement of using more retro reflective targets, more illumination in the survey location instead of using camera flash which gives sometimes noise towards the retro reflective targets, optimal placement for the models especially when there are sudden changes of model hull morphology.

Finally, this study represents a good step in ship and boat survey using close-range photogrammetry method, and in using the predicted results in useful purposes such as hull measurements and hydrostatic calculations.

References

[1] T. Brewer, *Understanding Boat Design*, 4th Edition, International Marine, 1994.
[2] C. Wang, *Laser Scanning, Theory and Applications*, InTech, 2011.
[3] L. Quan, *Image Based Modeling*, Springer, 2010.
[4] R. Alipour, F. Najarian H., Using Photo Digitizing Method to Investigating of Geometrical Integrity of Work Piece and Tool Wear Measurement, *International Review of Mechanical Engineering (IREME)*, Vol. 6, n. 6, pp. 780 – 784, 2010.
[5] K. Atkinson, *Close range photogrammetry and machine vision*, Whittles Publishing, 2001.
[6] Y. Egels, M. *Kasser*, *Digital Photogrammetry*, CRC Press, 2001.
[7] E. Davies, *Machine Vision: Theory, Algorithms, Practicalities*, 3rd Edition, Morgan Kaufmann, 2005.
[8] C. Ordóñez, B. Riveiro, P. Arias, J. Armesto, Application of Close Range Photogrammetry to Deck Measurement in Recreational Ship, *Sensors Journal*, Vol. 9, pp. 6991-7002, 2009.
[9] PhotoModeler web site available at: www.photomodeler.com (accessed in 29 October 2012).
[10] Maxsurf web site available at: www.formsys.com/maxsurf (accessed in 29 October 2012).
[11] Review of digital camera Sony DSC-F828 available at web site: www.dpreview.com/reviews/sonydscf828 (accessed in 29 October 2012).
[12] "Basics of photogrammetry" available at web site: www.geodetic.com/v-stars/what-is-photogrammetry.aspx (accessed in 29 October 2012).
[13] A. Hashim, *Roll reduction device for small fishing vessel*, Master Thesis, Universiti Teknologi Malaysia, Johor Bahru, Malaysia, 2010.

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