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Comparison of the Classic Method of Hull Shape Assessment of a 5-Meter L5 Sailboat with the Photogrammetry Method

Abstract

This paper explores the comparison of two methods for assessing the hull shape of a 5-meter L5 sailboat. The classic way of obtaining the hull shape, involving manual measurements and traditional tools, is compared to the photogrammetry method, which relies on high-resolution photographs and software algorithms for analysis. Various aspects, including accuracy, speed, and practicality of both approaches, are analyzed in the study.

The results suggest that the photogrammetry method has significant advantages in terms of accuracy and speed of shape assessment compared to the classic method. Photogrammetry enables more precise and faster measurement of various sailplane shape parameters, reducing the need for manual interventions and human subjective assessments. Additionally, the photogrammetry method provides high-quality visual data that can be used for further analysis and simulations.

This paper suggests that the application of photogrammetry can enhance the process of obtaining the hull shape of 5-meter L5 sailboats, thereby increasing precision and efficiency in the field of engineering and design.

Keywords: sailboat hull shape, manual measurements, photogrammetry method

1. Introduction

The process of accurately measuring and recording the shape of a sailboat's hull is a critical aspect of ship design, marine technology, and ensuring environmental sustainability in the maritime sector. This paper explores a comprehensive methodology that utilizes photogrammetry, an innovative and efficient alternative to traditional measurement methods. By employing photogrammetry, which leverages advanced imaging techniques, it is possible to obtain highly precise measurements and shape descriptions, resulting in numerous advantages over conventional approaches.

The paper begins by detailing the preparation and tools required for the measurement process, emphasizing the need for precision, ingenuity, and creativity. It highlights the instruments used, such as chalk, wooden beams, meters, plumb bobs, ropes, and laser devices. The order of measurements and factors influencing it, including limited space and lighting conditions, are also discussed.

Subsequently, the paper delves into the steps for determining the transverse center of the sailboat. It explains the process of finding the sailboat's center, dividing it into two halves, and obtaining the Length Overall (LOA) measurement. This includes the use of a laser instrument, plumb bob, and marking stickers to ensure accurate center identification.

The introduction of an auxiliary frame, designed for facilitating measurements, is then explained. The frame allows for the determination of section positions and spacing, crucial for accurately representing the sailboat's shape. The positioning of sections on the LOA and their connection to the central rope are key elements of this phase.

The subsequent section focuses on the detailed process of reading points on individual sections, emphasizing the use of laser devices, rangefinders, and meters to obtain precise coordinates for each point on the sections. The paper emphasizes the importance of dissectioning points evenly to enhance visibility and accuracy.

The measurement of points on the stern mirror (R0) and bow stay (R10) is explored in the following section, which requires specific techniques and devices to obtain accurate measurements. These measurements are crucial for capturing the sailboat's shape comprehensively.

The paper also outlines the necessary steps to input the half-width dimensions of the sailboat into Rhinoceros, a 3D modeling software. This step is pivotal for accurately representing the sailboat's shape in a digital workspace.

To emphasize the advantages of the photogrammetric approach, the paper explains the modern methods of spatial recording of large objects, including 3D laser scanning, total station measurements, and software applications like Photomodeler and Rhino. It underscores the precision and efficiency gained through these technologies.

The subsequent sections elucidate the process of marking points on the hull model and camera calibration in Photomodeler. These steps highlight the need for accuracy and attention to detail during data collection, essential for achieving high-quality results.

The paper concludes by discussing the advantages and disadvantages of the photogrammetric method. While it offers speed, precision, and efficiency, the need for specific software subscriptions is acknowledged as a drawback. Overall, the photogrammetric approach holds immense promise for the field of ship design and marine technology, revolutionizing the way hull shapes are recorded and analysed.

2. Preparation before Measurement and Measuring Tools

To manually measure the sailboat's shape, tools and equipment that can be found in every household are needed. The following instruments were used to measure the sailboat's shape: chalk, wooden beam, meter, plumb bob, rope, scissors, adhesive tape, laser pointer, and marking stickers as seen in figure 1. The procedure and sequence of measuring the sailboat's shape may not necessarily be correct, as various factors influence the order of measurements, such as limited space, lighting in the room where the sailboat is located and the number of tools.

It requires a dose of ingenuity and creativity, as well as precision and patience to carry out the procedure as accurately and precisely as possible. To begin, it is necessary to clean the working area around the sailboat and possibly wipe away any dust accumulation from the sailboat for easier detection of the laser beam (the laser beam is later used for precise readings of the sections).

Figure 1: Measuring tools

3. Determining the Transverse Center of the Sailboat

Prior to measuring any sailboat component, the transverse centre of the sailboat should be determined. Since the sailboat is symmetric, measurements do not need to be taken on both sides from the center. The center of sailboat can be easily determined by measuring the narrowest part of center with a meter or a ruler and then center can be marked with chalk. The sailboat's maximum height at the stern is calculated for additional measurements using the center-marked point as a reference. The centre, where the sailboat is divided into two halves, is targeted by a laser instrument that emits a cross-shaped laser beam; this line corresponds to the chalk mark. This provides a visual division of the sailboat's transverse center as seen in figure 2. Due to the constant need for the laser device, a plumb bob is suspended from the highest point on the stern mirror, extending all the way to the ground. The spot where the plumb bob "falls" is marked on the ground with chalk, and the starting point of the rope is attached to the marked spot with adhesive tape. The process of finding the transverse center of the sailboat and determining the maximum height at the bow is repeated, and then the other end of the rope is led to the marked point on the ground. Eventually, a rope with its ends at the furthest points is obtained and stretched along the sailboat's centre. The length between these points represents the Length Overall. The ends of the rope also assist in drawing a reference frame around the sailboat.

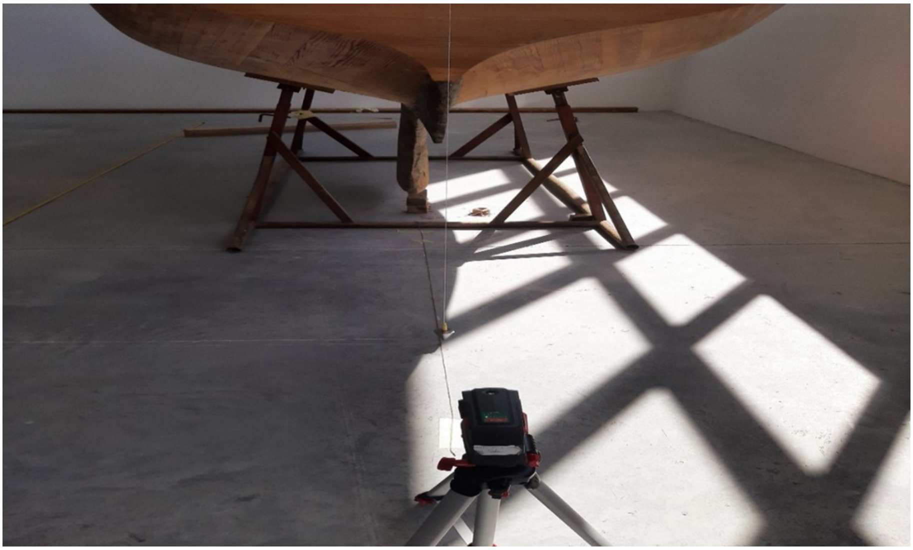


Figure 2: The process of determining the center of the sailboat widthwise

4. Auxiliary Frame

For easier measurements, a rectangular-shaped frame is drawn. A perpendicular line is precisely drawn to the furthest point of the Length Overall. A wooden beam is used for such precise drawing. The wooden beam is placed perpendicular to the furthest point, which is the "x-axis," using a construction protractor.

The beam serves as a ruler along which a randomly long line is drawn. The drawn perpendicular lines are then connected at the ends to create a rectangular frame. This obtained frame is used to determine the number of sections and their positions. To determine how far apart the sections are from each other and their positions, it is necessary to mark the stern and bow vertical lines with numbers 0 and 10 on the existing rectangular frame.

The length between the perpendicular lines is measured and then divided by the number of sections that make up the sailboat. Sections are marked from section 0 on the stern vertical line to section 10 on the bow vertical line as seen on figure 3. Once the position of each section on the LOA between the perpendicular lines is determined, a length is pulled to the rope for each section. Straight lines are drawn from the marked sections to the rope that was previously stretched along the center of the sailboat. The frame is now fully prepared and will facilitate further measurements.

Figure 3: Auxiliary frame

5. Reading Points on Individual Sections

A laser device is placed on the ground in front of the completed frame, perpendicular to the sailboat. The laser device is adjusted to follow the section, aligning the laser beam with the line representing the section's position on the sailboat. The first section to be measured on the sailboat is section 0.5, and the last section to be measured is section 9.5 because positions 0 and 10 are only points on the stern and bow.

Figure 4: Using measurement tools for point on the sections

The laser beam is now set on section 0.5, and the first point on section 0.5 will be the point on the keel, and its coordinates need to be determined. To determine the coordinates of the first point, a laser rangefinder, a meter, a laser device for tracking the section's plane, and marking stickers are required. The meter is used by placing it as close as possible to the drawn section on the ground, and then it is extended from the rope marking the center of the boat to the length between the stern and bow perpendicular lines marked on the ground as seen in figure 4.

To obtain the distance from the ground (height) and the distance from the center of the boat (width) for the first point, the laser rangefinder needs to be placed perpendicular to the point on the keel and directed towards the meter stretched on the ground. The laser beam needs to be aimed perpendicularly to the ground and as close to the meter as possible because the distance of the point's width will be shown on the meter itself, and the height will be displayed on the digital rangefinder. The height values obtained by the laser rangefinder and the distance from the center obtained by reading the meter are recorded on paper. To obtain the most accurate shape of the section, points on section 0.5 are chosen arbitrarily, but care should be taken not to have them too densely or sparsely dissectioned for easier visibility and accuracy. The last point on section 0.5 will be the connection between the left and right hulls at the bottom of the sailboat. The process is repeated up to section 9.5, where the starting point is also on the keel at the bow part of the sailboat, and the last point is on the connection between the left hull and upper deck. Ultimately, each point on each section is obtained. The values of the stern mirror at position R0 and the bow stay at position R10 still need to be read.

6. Reading Points on R0 and R10

In this measurement procedure, the values of the points on the stern mirror R0 are measured first. The stern mirror is not perpendicular to the waterline but at an angle that needs to be determined. The angle can be found in various ways, and in this procedure, a digital level was used, which was placed on the stern mirror and showed a reading of 12.3°. The readings of the points on the stern mirror are carried out by pulling a meter perpendicular to the marked center determined at the beginning of the measurement procedure, from the connection between the stern mirror and R0, and then determining the height from the ground to that point with a laser rangefinder. The points in height are determined arbitrarily, and it is important that they are not too dense or too sparsely dissectioned for easier visibility and accuracy as seen in figure 5. The bow stay located on R10 is measured in the same way as was used for the stern mirror. A meter is pulled from the point on the keel on section R9.5 all the way to the bow stay. After defining the distance of the bow stay point from the reference point on section R9.5, the height of that point is determined using a laser rangefinder. The process is repeated until all points on the bow stay R10 are defined.

Figure 5: Points on the bow staff and stern mirror

7. Inputting Half-Width Dimensions of the Sailboat in Rhinoceros

The values dissectioning the sailboat's shape recorded in a notebook need to be entered into a text editor of the user's choice. To have the programming language in Rhinoceros display the actual values of the sailboat's shape in the workspace, the order of values must be recorded in a specific order in the text editor. The X-coordinate of the section must be represented in the first column; consequently, this value must be constant for every section. The half-width Y, or the distance from the boat's centerline to the point, must be represented in the second column. The height of the point on the Z-axis, measured from the floor to that point, must be shown in the third column. In the text editor, the sections should be separated by one blank line and the recorded coordinates by one space. To begin modelling in Rhinoceros, the input file that contains the coordinates dissectioning the sailboat's shape, must be imported into Rhinoceros program.

8. Modern method of recording the shape of the ship's hull

There are several numerical methods of spatial recording of large objects, such as the photogrammetric method, the application of a 3D laser scanner and total station measurements.

The hull surveying process consists of a measuring device, auxiliary measuring devices, a pocket computer and a software package for processing the measured data.

The task of measurement is to record the shape of the ship with as many points as possible so that the shape is dissectioned as well as possible.

First, the position of the total station must be determined from which as many points as possible can be seen. It is not possible to measure from only one position. The measured values are recorded in a measurement file on the computer. The result of the measurement is a cloud of points with a defined spatial position of each point in relation to the origin of the coordinate system of the total station.

In this work were used computer programs Photomodeler and Rhinoceros.

Photomodeler is a software application that performs image-based modelling and close-range photogrammetry – producing 3D models and measurements from photographs. The software is used for close range photogrammetry, aerial photogrammetry and drone photogrammetry.

Rhinoceros (Rhino) is a 3D modelling program that can be used in many ways and for very different purposes. The geometry in the Rhino program is based on the NURBS mathematical model and produces mathematically precise representations of curves and free-form surfaces (unlike programs that use polygonal grids for surface approximations).

9. Marking points on the hull form model

This chapter will explain the procedure for marking points on the model of the ship's hull form, in the planes of the sections, in order to determine the spatial positions of the points using the photogrammetric method in order to dissection the hull form.

The hull model is placed on the scaffolding as can be seen in the figure 6. The space around the model must be tidy in a way suitable for later photography.

The hull model is indicated by points that follow the sections of the ship's hull. Depending on the required precision and complexity of the form, we adjust the required number of points and the marking method. The points can be marked manually or using suitable devices that laser project the plane of the sections onto the hull of the model. Points are marked by pasting previously prepared stickers.

Figure 6: Ship's hull model

In this case, points with a diameter of 50 mm were used, in accordance with the size of the model. The points can be additionally marked with numbers for easier navigation in different views, i.e., angles of photos in the later phase of digitizing the project. The final appearance of the marked model is shown in the figure 7.

Figure 7: Marked ship's hull model

10. Camera calibration in Photomodeler

Camera calibration is important for achieving accurate results in Photomodeler. The purpose of camera calibration is to determine the exact values such as focal length and lens distortion for your particular camera. While the techniques and procedures are similar, if the size of your modelled object is less than about a foot one should use a single calibration sheet. If the object is larger than a foot one should use the multi-sheet calibration [1].

The first thing one needs to do is create the calibration sheets (figure 8). Go to File, Print, Calibration Sheets and choose the multi sheet option. The target size can be adjusted so the smallest target should be at least 10 pixels across in any image. Print enough sheets to cover calibration area. The size of this area will depend on the focal length of the camera and the distance of the camera from the sheets.

The sheets to create a calibration area should be arranged, ensuring that the sheets are securely anchored to prevent any movement during the capture of photos. Even the slightest disturbance, such as a breeze caused by walking, can influence the positions of the targets and potentially disrupt the calibration process.

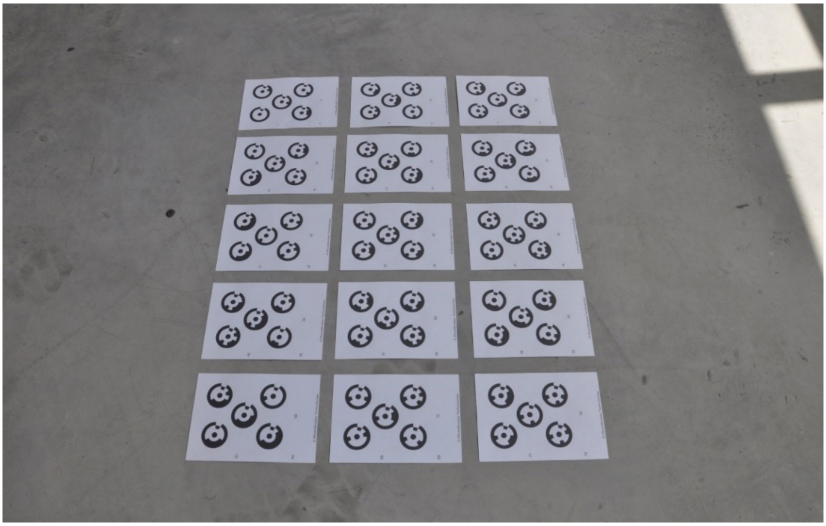
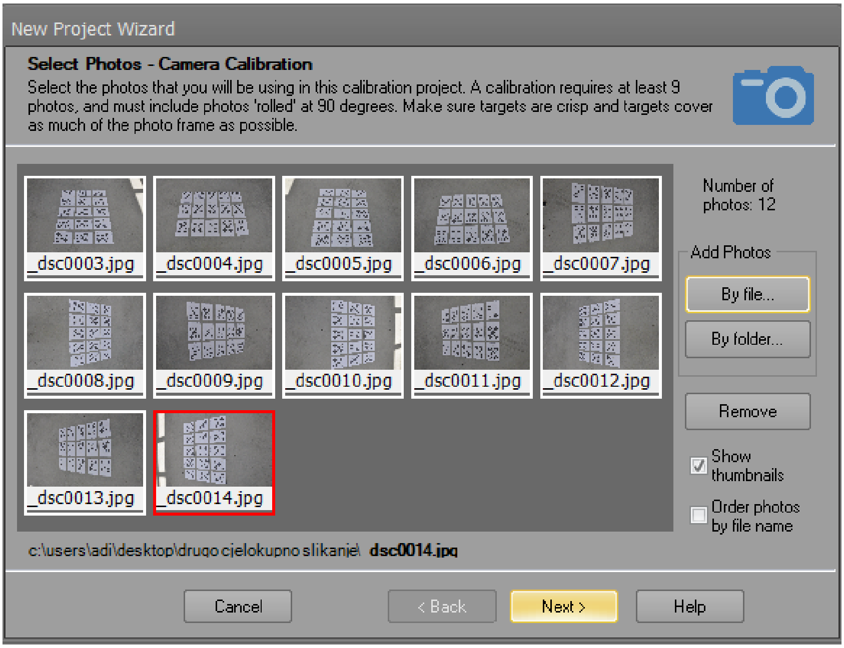


Figure 8: Example of imaging for camera calibration

A set of photos is taken from each side using a landscape orientation. All camera settings such as zoom resolution and image quality must be the same for all photos. In the calibration project sharpening and image stabilization or any other post processing operations should be turned off. Now, a portrait photo is taken meaning the camera is rotated 90 degrees to the right and then 90 degrees to the left. All targets must be in focus.

With a good set of images taken the image files can be transfer to a folder on computer and the calibration started. To start a calibration project, the New calibration is clicked and then Project option on the getting started dialog. One can navigate to the directory to save the images from the camera and add them all to the project (figure 9). A multi-sheet calibration is detected and one can hit Run to perform the calibration.



New Project Wizard

Select Photos - Camera Calibration

Select the photos that you will be using in this calibration project. A calibration requires at least 9 photos, and must include photos 'rolled' at 90 degrees. Make sure targets are crisp and targets cover as much of the photo frame as possible.

Number of photos: 12

☑ Show thumbnails

☐ Order photos by file name

c:\users\adi\desktop\drugo cjelokupno slikanje\ **dsc0014.jpg**

Figure 9: Inserting photos into the calibration project

First, auto marking detects the target points, then processing solves for the camera parameters.

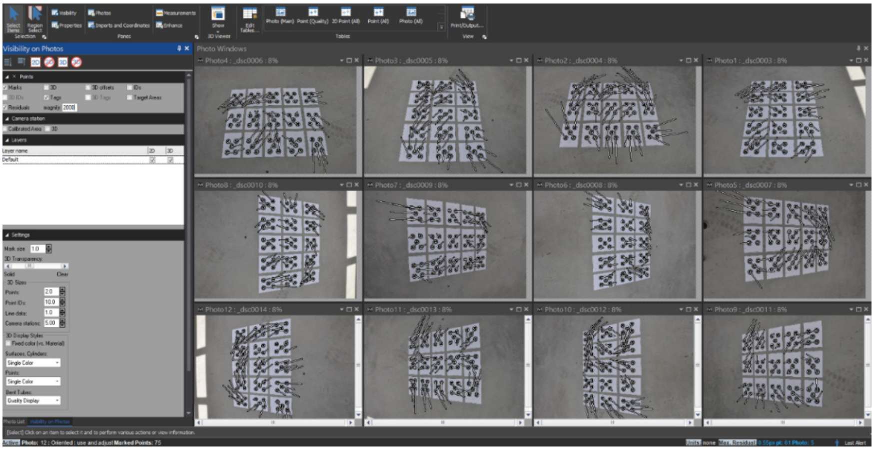
The final step is checking for high deviations or correlations. If one is found a parameter may automatically be removed as it is not having a beneficial effect on the project.

Next, a verification of the calibration results will be conducted by accessing the “Show report” option. Initially, attention will be directed to the section concerning issues and recommendations. Subsequently, the focus will shift to evaluating the calibration process by examining the total error. In the case of high-quality cameras with fixed lenses, the expected concluding value should be approximately 1 or lower. However, it is worth noting that for cameras equipped with zoom lenses, which are comparatively less stable, minor inconsistencies might result in a slightly higher total error. This increased error remains within acceptable limits for such cameras. In instances of substantially larger errors, potential issues related to the photographs, such as grid displacement between shots or blurred target points, should be investigated.

The quality section of the verification will be explored to assess the strength of the calibration. Initially, the point mark residuals will be examined. These residuals represent the disparities between the marked 2D point locations and their projected 3D counterparts. Of particular significance is the maximum residual, with a recommended threshold of under 1.5 pixels. In well-executed projects, all residuals should ideally be under 1 pixel, with lower values indicating a higher level of accuracy. Moreover, the overall root mean squared error for all pixels should ideally be under 0.5 in a well-organized project.

Upon completing the review, the camera calibration dialog will be closed, signifying the conclusion of the calibration process. Additionally, the option to include the camera in the camera library will be available. When importing photographs for a project, Photomodeler will utilize the data contained in the image header to automatically match the images with cameras stored in the library.

An alternative method for scrutinizing the results involves a thorough examination of the photographs and their corresponding marks. All images will be opened, and the residual display will be activated. Each marked point on the photographs will be associated with a black bar (figure 10) emanating from the marked point and extending in a particular direction. The point where the black bar terminates signifies the location that Photomodeler calculates for the marked point. In well-resolved projects, these mark residuals are typically minimal. To aid in detecting error patterns, the exaggeration factor will be increased to 2000 pixels, enlarging the size of the bars. An indication of a problematic pattern would involve all residual lines pointing uniformly in one direction, either toward the center or away from it. It is essential to ensure that error patterns on the bars exhibit a relatively random dissection, without concentrated patterns in specific areas of the photographs that could indicate potential issues.



☑ Marks ☐ 3D ☐ 3D offsets ☐ IDs
☐ 3D IDs ☑ Tags ☐ 3D Tags ☐ Target Areas
☑ Residuals magnify: 2000
☐ Calibrated Area ☐ 3D

Layer name	2D	3D
Default	☑	☑

Mark size: 1.0
3D Transparency: Solid Clear
3D Sizes
Points: 2.0
Point IDs: 10.0
Line data: 1.0
Camera stations: 5.00
3D Display Styles
☐ Fixed color (vs. Material)
Surfaces, Cylinders: Single Color
Points: Single Color
Bent Tubes: Quality Display

[Select] Click on an item to select it and to perform various actions or view information.

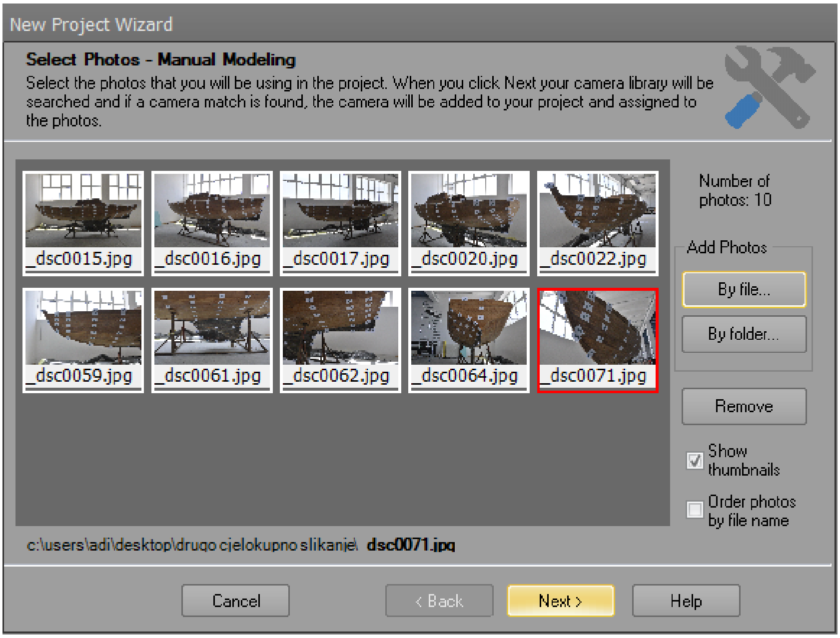
Active: Photo: 12 : Oriented : use and adjust Marked Points: 75 Units: none Max. Residual: 0.55px pt: 61 Photo: 5 Last Alert

Figure 10: Display of black bars indicating error patterns

A number of checks to review the calibration needs to be done. First, our final error number in the processing log was around 1. Second, in the status report the maximum residual is checked overall with some standard deviation numbers. Third, the residual errors in the market residual display are also checked to look for patterns.

11. Marking and reference of points on photographs

This guide will walk through the creation of a simple points-based project.


New Project Wizard

Select Photos - Manual Modeling

Select the photos that you will be using in the project. When you click Next your camera library will be searched and if a camera match is found, the camera will be added to your project and assigned to the photos.

Number of photos: 10

☑ Show thumbnails

☐ Order photos by file name

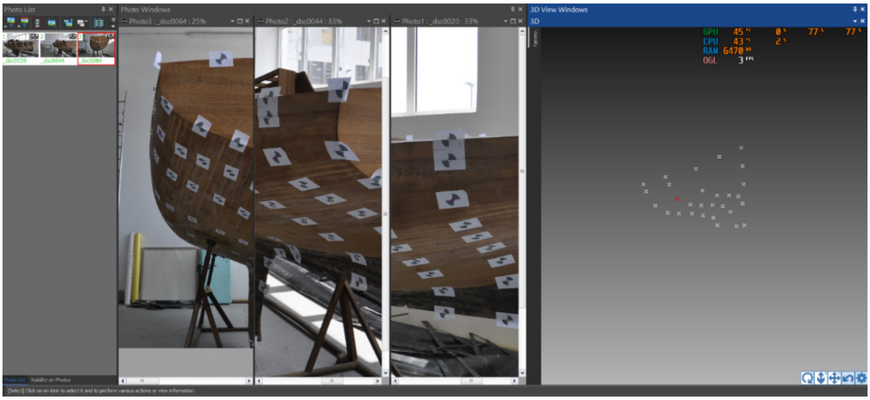
c:\users\adi\desktop\drugo cjelokupno slikanje\ **dsc0071.jpg**

Figure 11: Inserting photos into the project

The photos to be used in the project are selected (figure 11). After clicking "Next," Photomodeler identifies a matching calibrated camera, which had been utilized in the procedure explained in the preceding chapter. The first photo is accessed with a double-click, and then the transition to line mode is made to outline the sections or curves of the ship. Line mode allows the creation of lines between existing points or, in this case, the creation of points. Subsequently, the second photo, taken from a different angle, is opened, and the switch to referencing mode is executed. The first photo is activated, with all its points selected, designating it as the reference source. The photo becoming the reference source is indicated by a blue box around its edges.

Moving to the second photo, the location corresponding to the point highlighted in yellow is clicked. To assist in locating the source point, a rubber band line is drawn between the cursor and the yellow reference source point. A mark is generated and associated with the point on the first photo upon each click. The software automatically advances to the next point with each click. For enhanced accuracy, the option of zooming in to position these marks with greater precision is available. Upon reaching the minimum number of references, automatic processing is initiated, resolving the camera positions for both the first and second photos. This is indicated by the presence of the cameras on the thumbnails and in the title bar of the photo itself.

With the camera positions resolved, access to a 3D view allows observation of the outcomes (figure 12). Activating the camera stations enables visualization of where these positions have been determined. The process continues as additional points, references, and photos are incorporated. Upon opening the third photo, references are made to the points on the first photo. The project now contains sufficient data to orient the third photo. As the photo is now aligned, when marking the subsequent point, reference helper lines become visible.



[Select] Click on an item to select it and to perform various actions or view information.

Figure 12: *Display of a point in photographs and in 3D view*

This point is already marked on two other photos enabling to have two helper lines.

When the project is resolving accurately, the points' positions should closely align with the intersection of these lines as seen in figure 13. The subsequent point is designated in just one photo, resulting in a sole helper line. At this point, all the discernible points on the first photo have been cross-referenced with the second and third photos.

To assess the precision of the project, the remaining residuals are carefully monitored. Residuals represent the discrepancy, measured in pixels, between the marked point's location and its projected 3D position.

The largest residual in the project is displayed on the status bar, the lower this number, the better. Clicking the status bar will open the photo and select the point with the largest residual. This can be easily fixed by zooming in and dragging the point into its place.

One can review the residuals of all points in your project using a quality point table or using the project review pane and status icon to see metrics that are over defined thresholds. The obtained points of the finished model in Photomodeler are finally exported for use in other software.

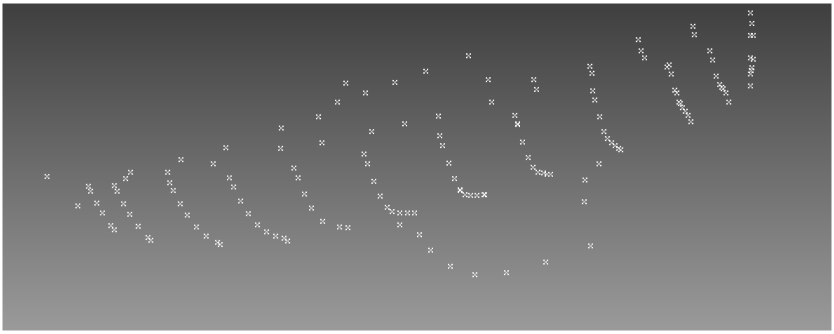


Figure 13: Cloud of measurement points

To export one can select File > Export > Export Model, and select the 3D DXF format for use in a cad program or another 3D package.

12. Modelling the form of the ship's hull

Using the acquired point positions, these points are imported into the relevant 3D modelling software, specifically Rhino in this instance, to initiate the modelling process. Employing the created points, plane curves are generated to delineate the sections, bow and stern frame, keel, superstructure, and other elements as seen in figure 14.

After the boundary conditions are defined, surfaces are defined to model the form of the hull. Also, the deviation of the created curves and surfaces from points obtained by taking a picture and creating in the photogrammetric software is controlled.

In the modelling software, one can also access the modelling of the superstructure and the outfitting of the ship.

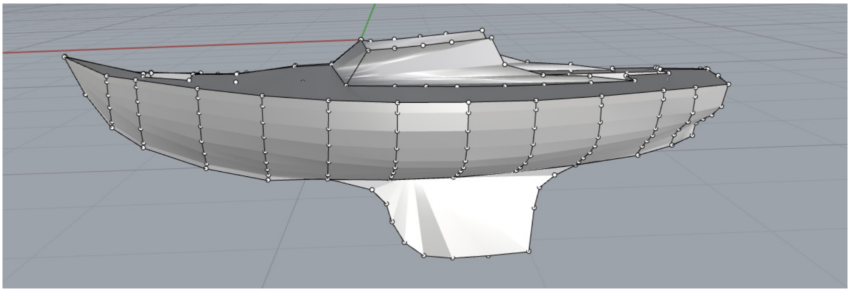


Figure 14: Smoothed view of the ship's hull form

13. Advantages and disadvantages of both procedures

The advantages and disadvantages of both methods can be summarized as follows:

13.1. Traditional Method

Advantages:

Proven and Established: The traditional method has been used for many years and is a well-established approach. Shipbuilders and naval architects are familiar with its techniques and tools.

Tangible Measurements: This method provides physical measurements with tools like meters, plumb bobs, and wooden beams. These measurements can be directly observed and recorded.

Low Initial Investment: The traditional method typically involves tools that are readily available and do not require a significant initial investment in specialized equipment or software.

Independence from Technology: Traditional measurements are not dependent on advanced technology, making them accessible in areas with limited access to high-tech solutions.

Disadvantages:

Labor-Intensive: The traditional method is often labor-intensive and time-consuming. It requires physical measurements and manual recording, which can be prone to human error.

Limited Precision: Achieving a high degree of precision with traditional tools can be challenging. Factors like lighting conditions and the measurement instruments themselves can affect accuracy.

Limited Data Processing: Traditional measurements may not easily lend themselves to digital processing and modelling. Transferring the recorded data to digital models can be cumbersome and may introduce errors.

Space and Mobility Limitations: The traditional method may be constrained by space limitations, especially when measuring large vessels. Additionally, mobility can be restricted when working in confined areas.

13.2. Photogrammetric Method

Advantages:

High Precision: Photogrammetry, when executed correctly, offers a high level of precision. It can capture detailed measurements, making it suitable for complex ship shapes.

Efficiency: Photogrammetry is generally more time-efficient than the traditional method. It allows for the simultaneous capture of numerous data points.

Digital Models: The data collected through photogrammetry can be directly used to create digital 3D models. This simplifies the transition from data collection to modelling.

Reduced Human Error: Automation in photogrammetry reduces the risk of human error during data collection, leading to more accurate results.

Non-Invasive: Unlike traditional methods that may require physical contact with the ship's hull, photogrammetry is non-invasive and does not risk damaging the vessel.

Disadvantages:

Specialized Equipment and Software: Implementing photogrammetry requires access to specific equipment such as digital cameras, laser devices, and software like Photomodeler and Rhino. This can entail additional costs.

Calibration Challenges: Accurate camera calibration is essential for the success of photogrammetry. Errors in calibration can result in inaccurate measurements.

Initial Learning Curve: Using photogrammetry effectively may require a learning curve, as individuals need to become proficient with the equipment and software. This can lead to delays in project initiation.

Environmental Factors: Photogrammetry can be sensitive to environmental factors such as lighting conditions and weather. For example, capturing data in low-light conditions or adverse weather may be challenging.

In summary, the photogrammetric method offers significant advantages in terms of precision, efficiency, and digital modeling capabilities, making it a promising choice for recording ship hull shapes [2] [3]. However, it does require an initial investment in equipment and software, along with careful attention to calibration and environmental conditions. Traditional methods, on the other hand, are tried and tested but may be less precise and more labor-intensive. The choice between the two methods depends on the specific needs of a project and the available resources [4].

14. Conclusion

In conclusion, the process of recording a ship's hull shape is a critical component of ship design, and it holds implications for the advancement of marine technology and environmental sustainability in the maritime sector. This paper has explored two primary methods for this purpose: the traditional approach and the photogrammetric method.

The traditional method, while well-established, is labor-intensive, relies on physical measurements, and may lack the precision required for complex ship shapes. On the other hand, the photogrammetric method offers advantages in terms of precision, efficiency, and the ability to create digital models. However, it necessitates specialized equipment and software, along with attention to calibration and environmental conditions.

The choice between these methods ultimately depends on project-specific needs, available resources, and the level of precision required. Both methods have their strengths and weaknesses, and it is vital to consider these factors when determining the most suitable approach for accurately capturing and modelling a ship's hull shape. As technology continues to advance, photogrammetry is emerging as a promising and efficient alternative, holding the potential to reshape the way hull shapes are recorded and analysed in the maritime industry.

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