THE MODELLING AND 3D COMPUTER RECONSTRUCTION OF A SUNKEN U BOAT

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ABSTRACT:

UB-46 submarine of the German Navy mined and sunk on the 7 Th December 1915 in Turkish Coast of Black sea. Its wreck has been found in 1993 during excavations of an open coalmine at the coast of Kemerburgaz, a village of Istanbul at Black sea. The wreck is now exhibited in the Military Naval Museum. The modelling and Computer reconstruction of the U Boat are realized using the metrical digital photographs of the wreck and historical information's supplied by the archives. This realization will contain the necessary basic information's to obtain the physical reconstruction. Visualization techniques will serve to demonstrate the model of the U Boat.

1. INTRODUCTION

Today, the 3D reconstruction and visualization techniques became very popular and useful methods in the field of close range photogrammetry. The integration of Photogrammetric Methods and Computer Graphics has brought many tools and techniques and most important synergy out.

The presented paper is an integration of Photogrammetry and Computer graphics and uses digitised images and related control works with supplementary information provided by the archives. The end product of the data procession is the solid oriented surface structure. The output can be used through interfaces by CAD systems.

The wreck of the UB46 German submarine, which is the starting point of this paper, exhibited in the Military Naval Museum and consists of three parts. These three parts corresponds approximately to the half size of the UBoat. The other half part has not been found during the excavation. These three parts has been taken out without break out. They are carrying the surface characteristics of the UBoat. The aim of this project is to model the U Boat surface using the historical information by means of photogrammetric methods and to obtain the computer reconstruction with the help of visualization techniques. The modelling and Computer reconstruction of the U Boat are realized using the metrical digital photographs of the wreck and historical information's supplied by the archives. This realization will contain the necessary basic information's to obtain the physical reconstruction. Visualization techniques will serve to demonstrate the real model of the U Boat. In this paper an integrated work of the photogrammetric and historical information's on the U Boat wreck will be reported

1.1 The History and the Technical Specifications of the U boat UB 46

UB-46 was a coastal patrol submarine of the German Navy in the World War I and mined on the 7 Th December 1916 at Turkish Coast of Black Sea. It sank slowly with the tail first and from the country still survivor in the water was seen. With at the time the dominant rough sea, nobody could be saved.

The wreck of SM UB 46 was rediscovered after 77 years, at the beginning of September 1993 during excavations of an open coalmine at the coast of Kemerburgaz, a village of Istanbul at Black sea. The wreck is now exhibited in the Military Naval Museum. (Figure 1)

Figure 1. The wreck of UB46 Submarine

UB46 was a UBII type coastal submarine and build at the AG Weser Bremen Shipyard and was laid down in 4 September 1915. UB46 was commissioned to the Constantinople Flotilla and succeeded to sink 4 ships for a total of 8099 tons during its duty.

Figure 2. An Archive image of UB II Type Submarine

The Technical Information for UB46 from archives is as follows: (WWI U-Boat Types)

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Length (m)    36.13 oa,   27.13 ph
Beam (m)       4.36 oa,    3.85 ph
Height (m)     7.34
Range (miles/knots)  6650/5 sf,  45/5  sm
Speed  (knots) 9.15 sf, 5.81 sm
Torpedos        6
Mines           no
Max.Depth       ca. 50 m  (164 feet)
Crew            23 men
Power (hp)      284  sf,   280 sm
     sm=submerged  sf= surfaced     ph= pressure hull
              oa= overall   hp= horsepower
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2. PLANNING THE WORK

2.1 Photogrammetry

Object reconstruction consists besides determination of the geometry of surfaces the determination of **surface texture and colour** of the related object, so that we have a complete description of the object. The surface reconstruction of objects is today one of the main duties of digital photogrammetry. Photogrammetry derives the necessary measurements from the images, rather than measuring them directly. One of the most important advantages of photogrammetry is to provide automatic measurement possibilities through image matching techniques for the collection of the three dimensional coordinates of the points. After the photogrammetric processes visualization and computer graphics are needed for the 3D reconstruction process.

A typical example of photogrammetric surface measurement is the **acquisition of ground surfaces.** These surfaces are usually considered sufficiently well described by the capture of points in a grid (no discontinuities), other significant points such as peaks (discontinuities) and lines either as break-lines (discontinuities) or form-lines (no discontinuities). Area elements are derived from the captured basic elements "points" and "lines" by appropriate modelling.(Kraus,K.)

Photogrammetry is very powerful method to generate point clouds, which will be processed   for further processes such as visualization and graphics techniques.

2.2 Used Camera

In the first step of the project only the digital camera **Olympus Camedia C-4040** with the following characteristic was available. Images were acquired with this camera.

 CAMERA SPECIFICATIONS

- **Maximum image resolution:** 2272 x 1704

- **Maximum CCD resolution:** 4.14 megapixel

- **CCD size:** 2.54/4.57cm

- **Optical zoom:** 3x

- **Digital zoom:** 2.5x

- **Shutter speed range:** 1 to 1/800 sec

- **Focus range:** 7.1mm-21.3mm

2.3 Used Software

Photomodeller uses photogrammetry to recreate three-dimensional models. The user creates a project using Photo Modeller. Images are added to the project. The user indicates points on the images with the mouse. To recreate the model some points must appear in more than image. Next, the user creates triangles by connecting the previously created points. The obtained triangles form the surfaces of model. Photomodeller can save the recreated model in a variety of formats. (PhotoModeler Pro)

3. PHOTOGRAMMETRIC PROCESS

3.1 Images

Images were acquired with a Digital Camera using a tripod. 60 images are taken and all of them are used for the evaluation. The three wreck parts are located at the open part of the museum and there were trees around them. Therefore, the measurements are planned to select the best location and the optimum number of camera positions without being disturbed by the trees. The brightness and contrast setting are artificially changed to enhance the images.

3.2 Calibration

The focal length, sensor format size, principal point, and lens distortion parameters are obtained as the calibration result of each metric digital camera. The used camera Olympus Camedia C-4040 has a focus range from 7.1 to 21.3 mm. The calibration of the camera were performed using the fix focus of f= 7.1 mm. For this purpose the camera was calibrated on the test field using the Pictran Software. (Kulur,S.) The Photomodeller software contains a simple method to obtain the calibration parameters. The camera was calibrated once according to the instructions of the Photomodeller User manual.   Both calibration results are compared with each other and an adequate result has been obtained. The test field used for the calibration is as shown by Figure 3.
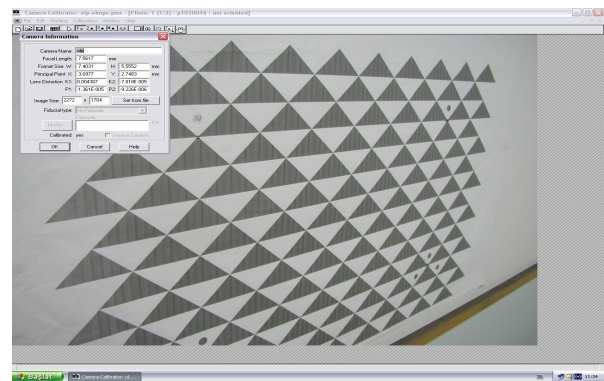

Figure 3. Test field for the calibration process.

3.3   3D Modelling of the Submarine Wreck

To obtain the model of the object same points, which describe the real surface of the submarine, on the different images of the wreck are measured and a point cloud was generated. Image measurements are performed with manual procedures. So we are able to define the surface with an appropriate method. The obtained surface was improved because of the irregularity of the wreck surface from the real submarine surface. For this purpose first grade polynomial surface fitting is applied to the point cloud to obtain a suitable surface model. Figure (4,5)
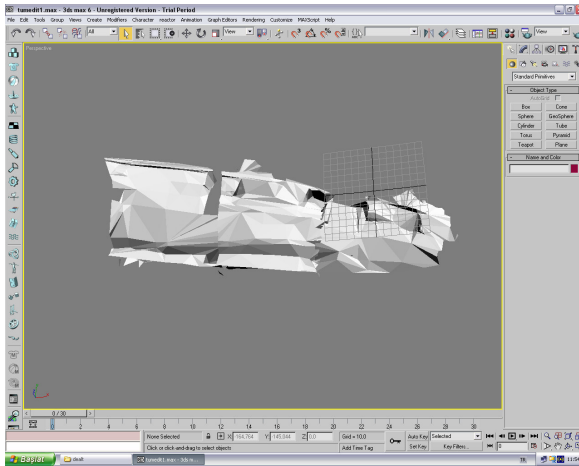
Figure 4. The wreck parts after being put together
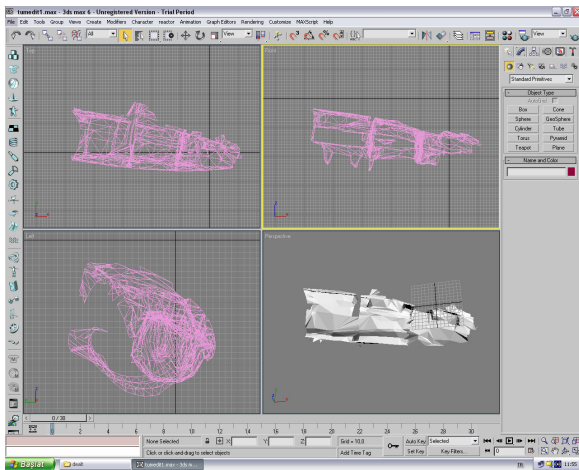
Figure 5. The Surface on the connected Wreck Parts

3.4 Design to Join the Missing Part of the Submarine using Archival Information

The technical information's for UB46 searched from archives are limited only with dimensions. There was only one archive image (Figure 2) and a sketch of the UB II Type (SMB46) showing only the upper part. (Figure 6) The sketch was displaying only the side section and had no scale. Using some proportions we obtained a scale for sketch. Using the archive image, the sketch, the photogrammetrically obtained surface

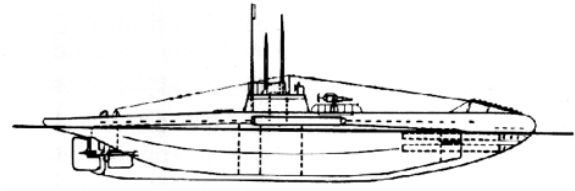and the known dimensions we tried to reconstruct the submarine in AutoCAD 2004.

Figure 6. Sketch of the UB II Type

For this purpose we transferred the surface model into the ACAD System. The first thing to do was to check the dimensions of the submarine. For this reason we compared the computed dimensions of the connected wreck surface model with those obtained from the image and sketch using known proportions of the submarine. (Williams, J.C) This check process realized only for the front part of the submarine. This part is approximately the third of the whole submarine. The reconstructed part was prolonged section-by-section using the surface model characteristics formed from the surface model. So we could reconstruct the body up to the tail part. The tail part of the submarine was designed only with the archive information's. (Figure 6) The 3D representation has to provide the interested researcher the right geometrical specifications of the object to analyse it. The obtained model can be loaded in a virtual reality system to provide navigation around the submarine model.

4. CONCLUSIONS

The paper describes the modelling and converting to digital form possibilities of a destroyed historical object. The spatial information about the object is collected by means of photogrammetric methods. The 3D creation, visualization and animation techniques are used to obtain reliable information's about the structure dimensions and geometrical shape of the UB 46 submarine, which was buried in the deepness of the history

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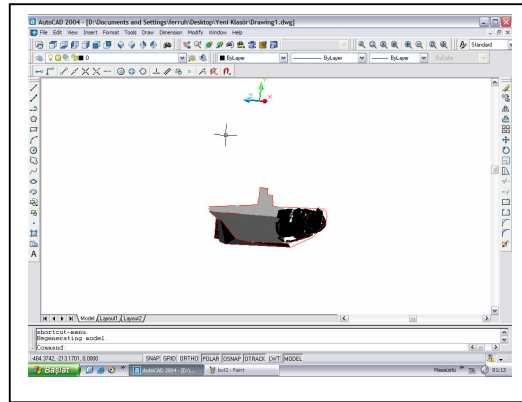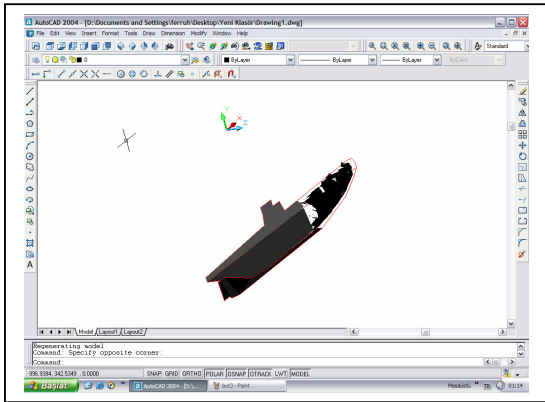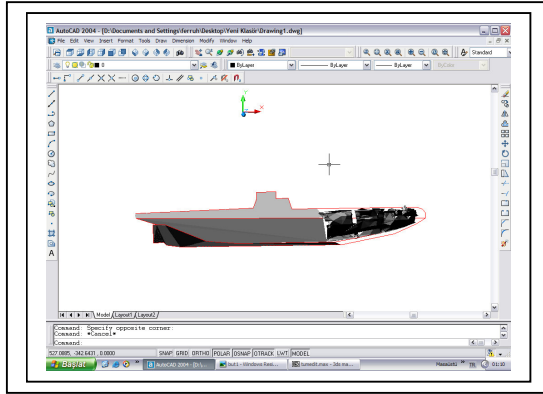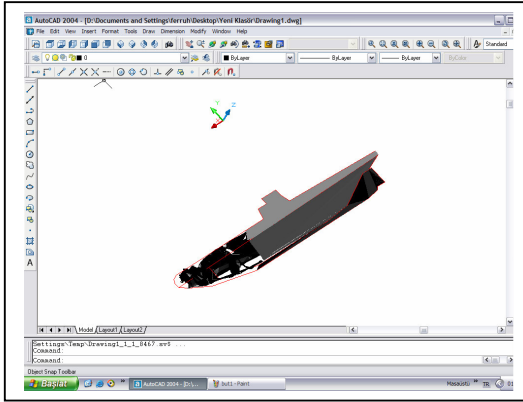Williams, J.C. Simple Photogrammetry, Academic Press, London, 1969

Figure 6. 3D AutoCAD Drawings of the reconstructed Submarine from different directions