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Proposal for Digitizing Objects through Its Three Views

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Abstract

The present research proposes a technique for capturing solid objects in the computer, which can be used to obtain from simple objects (cubes, pyramids, etc.) to very complex solids. The design of this technique focuses specifically on the capture of solid bodies through its three views, and projects to be a technique of easy use, which allows to know physical and mathematical magnitudes such as volume and surface of the solid with real values.

Keywords: 3D objects, image processing, CAD, view acquisition.

I. INTRODUCTION

In the current environment there are scanners that are physical devices which allow capturing images (photos, drawings, magazine covers, etc.), two-dimensional; however, there is a great absence for the capture of three-dimensional objects (screw, nut, cube, a box, etc.). This gap is being filled only by users trained in technical drawing [1], CAD tool handlers, who must perform a series of preliminary steps such as sketching the solid, taking dimensions, applying scales, and using sophisticated three-dimensional data collection devices such as sonic trackers, scanners [2], [3] and 3D object scanning apps [4]-[6], etc. etc. This leads to a loss of valuable time, taking into account the difficulty of the dimensions of the object, the graphic of the object may not be a faithful representation of it, due in many cases to the complexity of the object and its respective difficulty in the meticulous taking of its dimensions for its faithful representation.

Today's society demands faster and more practical drawing tools that can provide good quality graphics that are faithful representations of objects, without the need for extensive knowledge in professional drawing [7].

The graphic representation of a solid in three dimensions requires a deep knowledge of drawing methods and tools suitable for its transcription. Many scientific or technical processes need to know physical and mathematical magnitudes such as volume and surface of the solid, which are difficult to obtain, due to the complexity of the processes involved in its determination as irregularity of the object, impossibility of manipulation, ignorance of density [8].

In the technological environment, the software oriented to graphic manipulation is very deficient at the moment of making the drawing of a three-dimensional object, since the existing tools do not allow to make a direct transcription of the real object to the graphic software without the realization of the same one manually, this software generally known as computer aided design (CAD), offers powerful tools in the design of parts and mechanical drawings that are made producing profiles or more realistic productions [9], [10].

When the dimensions of an object have been specified to the computer system, designers can look at either side of the object to see what it will look like after construction. Experimental changes can be made freely because, unlike manual mechanical drawing, the CAD system quickly incorporates modifications into the object's display.

Electrical and Electronics Engineers work with CAD methods to design electronic circuits, using graphic symbols to represent various components, the designer can build a circuit by adding components in succession to the project. Designers of automobiles, aircraft, spacecraft and ships use CAD techniques in the design of various types of vehicles, wireframe traces are used to model components. Surface sections and surface constructions can be designed separately and put together to display the object as a whole. The technique used to produce visual displays from photographs or videos is called image processing [11]-[13]. Although computers are used with these displays, image processing methods differ from conventional computer graphics methods. In traditional computer graphics a computer is used to create the image. Image processing techniques, on the other hand, use a computer to digitize the shading and color models from an existing image [6].

Another technique for rendering three-dimensional objects is the display of stereoscopic views [14]-[16]. This method does not produce true three-dimensional images but provides a three-dimensional effect by presenting a different view to each eye of an observer. One way to achieve this is to display the two views of a scene on different halves of the screen. Each view is projected onto the screen from one viewing direction (left or right), where the user observes the screen through a pair of polarized glasses.

The development of a direct capture tool would produce a considerable saving of time in the transcription of the dimensions; since it would not be necessary to have previous knowledge in drawing techniques. The applicability or use of this software extends to different areas such as: machine design, architectural draughtsmen, physics, topography, engineering, advertising, geometry, etc. The absence of a means of systematized storage of physical objects not as two-dimensional images but as three-dimensional objects that possess real mathematical existence such as a spatial type matrix. That is why it is necessary to create this type of techniques, which represents a suitable tool for different types of users and at the same time that allows greater knowledge in the techniques of drawing and three-dimensional representation of objects.

II. METHODOLOGY

The following phases were carried out for the three-dimensional digitizing process:

- Conduct a study of the areas of interest.
- In each area select the necessary information that you want to convey to the user.
- Define the profile of the audience and the environment they are in.
- Abstract first the important characteristics of the knowledge and then go into details according to the types of users.

Study of the area of interest. It is intended to collect information from the area of interest in order to select and structure the knowledge. To collect the information has to do with the project: we went to private and public educational institutions with some kind of emphasis on graphic design, software distribution companies, Internet. They provided information concerning the different hardware and software devices existing in the market, technical and scientific aspects about professional graphic developments referring to three-dimensional objects, and some professionals of Architecture, Engineering and Graphic Design. Professionals in the area of mathematics were also consulted on concepts of spatial matrix management.

Audience Profile. Here it is necessary to know the current characteristics of the audience. And based on the information gathered, an analysis of the audience is made, to whom the application is addressed about their characteristics, needs and cognitive abilities or deficiencies that are found in the public and that can be solved with the development of the application.

This proposal is aimed at all types of people who want to perform, know, study, design or simply perform a technical drawing exercise that involves the development and visualization of a three-dimensional object, either through a display on the monitor or printer. This type of people can be divided into two levels such as: people with knowledge in computer science and people with knowledge in technical drawing.

Analysis of the Environment. This analysis aims to know in which environment the public develops and choose the best one. Corrective measures are established to create a suitable presentation environment to meet the objectives. The most suitable environments to implement the technique can be: Secondary Schools, to teach and practice the most relevant aspects of technical drawing and Euclidean geometry, another environment can also be an office or graphic design workstation, taking advantage of the ease and versatility in the graphic developments of objects.

The need to create a technique, which was able to digitize as a scanner a three-dimensional object for further manipulation and processing in areas such as three-dimensional visualization, cutting and separation processes, mathematical physical calculations to the solid, etc.. It was the result of a feasibility analysis of the project, and several factors were taken into account.

Within these factors, it was observed that in the current tools oriented to the graphic processing of three-dimensional objects, there was a large gap in devices or software, designed to represent them through external captures without the use of professional drawing techniques. Also the fact that the user could collect all the necessary information of the solid at the level of detail that he considered appropriate.

With this it was decided to make a proposal based on the creation of a technique that allows to present in a practical and friendly way all the various aspects involved in the representation of three-dimensional objects; such as views, depth lines, volume calculations, cutting processes, etc., which would be aimed at a general public among which may include engineers, architects, draftsmen, teachers, primary and secondary students, or anyone else interested based on the representation of solids already preconceived in 3D [17]. For the development we used tools of Graphic Design, Capture and Digitization of photographs and images, programming languages and application software. To carry out the link between all the previous resources, it is required the use of a versatile tool in the handling of programming objects. A POO language will be used, due to the characteristics and possibilities offered by its flexibility in the process of static matrices and optimal processing speeds for research.

III. RESULTS

The aspects that were taken into account for the creation of the proposal, were the complexity that means the creation or reconstruction of three-dimensional objects in the computer, subscribing to the storage and response time required by computer graphics, in the same way, obtaining a representation not only of the surface, but also of the solid context of the object.

The proposal is based on taking the three main orthogonal views of an object (trihedral projections) and taking as a basis the technique of technical drawing projections, the operation of three-dimensional matrices, and the creation of display and visualization processes, forming its corresponding solid. The three views are stored in two-dimensional matrices storing each point (pixel) of the view with their respective position and color, then obtain the binarization of these against the contrast color or background, and with the creation of these two-dimensional matrices make the orthogonal trihedral projection of each point to a three-dimensional matrix and its possible intersection with the different points of the remaining three-dimensional

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matrices, finally forming a multidimensional matrix of correspondence of the object.

Different algorithms will be applied to each matrix in order to create a virtual object of the solid, which could be understood, manipulated, modified and observed, despite the restrictions offered by the two-dimensional image of any computer monitor.

The processes elaborated to carry out the digitization and creation of a solidó are the following ones:

Three photographs are taken corresponding to the three trihedral views, with the help of the camera of a mobile device, at an equal distance from the reference frame, centering the lens with the center of the reference frame and perpendicular to the plane of the shot. The background plane must have a contrast color, which will serve as a base color to determine whether the pixel is part of the image or not (the contrast color is taken as a pixel outside the solid), in the realization of the photographic shot must be taken into account restrictions of brightness, transparency and opacity of the surface of the object, to avoid unwanted image points in the photographic shot. In this way three graphic format files of the three views are obtained, these formats can be BMP, JPG or GIF (Figure 1).

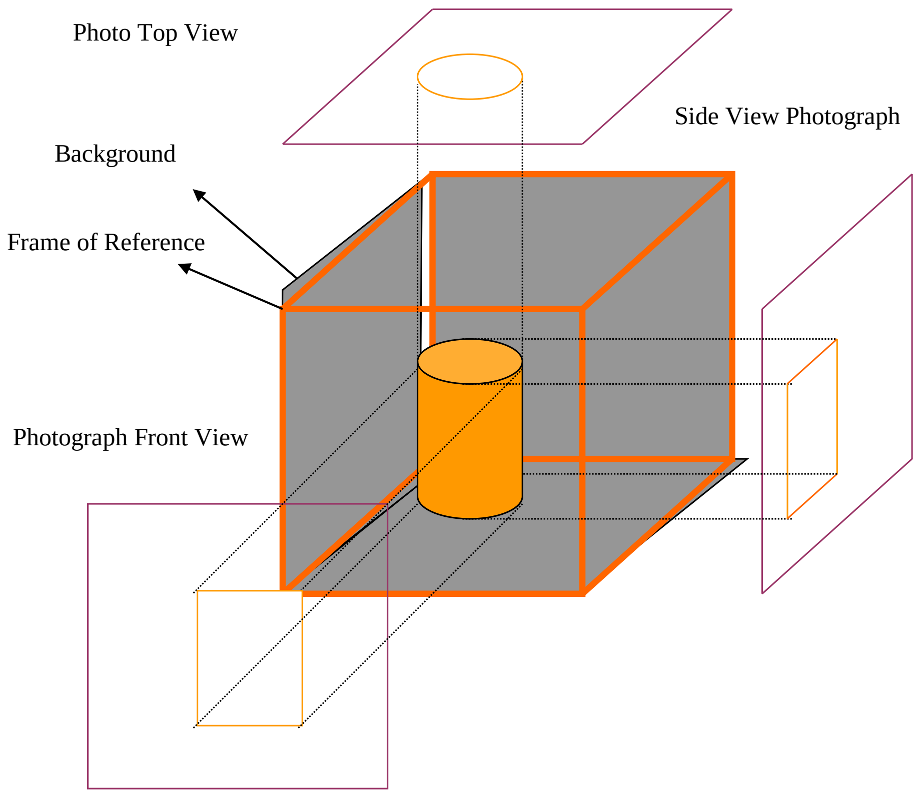

Fig. 1. Graphical capture.

The stored value of the pixel color is expressed in hexadecimal in a generic form like this: &H00AAVVVRR. The most significant byte is zero, and the next three bytes specify the color level Blue, Green and Red. This number is given by the RGB Function and the color palette implicit in the programming language.

A process called *boundary lines* is performed on the images displayed on the views, *this* process reads the maximum and minimum coordinates of the images contained in the *view* matrices, with these values orthogonal lines are projected to the neighboring views. These coordinates are obtained by performing a sequential path over the matrix until the first image values are determined. Once these are found, this coordinate is saved to be compared with the following ones and in this way determine which of them is the maximum or minimum found.

The *boundary lines* show the inconsistencies of alignment of the images with respect to the reference frames (Figure 2), this case would cause that the three-dimensional object formed is not a faithful reproduction of the desired object, this inconsistency is solved through the *ALIGNMENT*, where the boundary coordinates of the pattern image is taken (the one you choose: Front, side or top), and based on them performs an adjustment of the dimensions of the other missing views in order to match the *boundary lines* of these images with each other, which are necessary for a successful intersection of the faces of the object (Figure 3).

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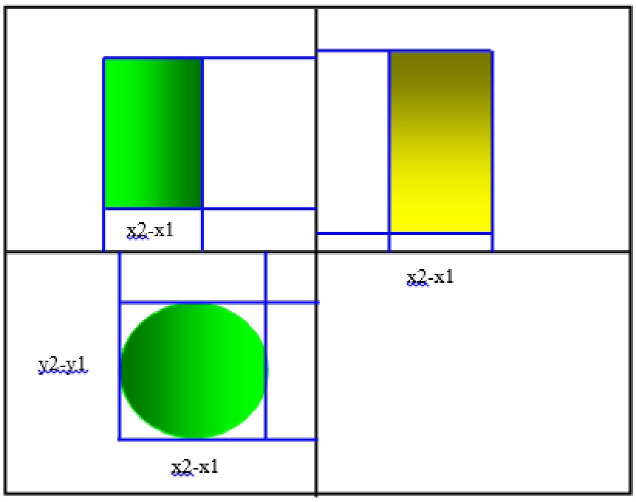

Fig. 2. Approximate representation of unaligned images

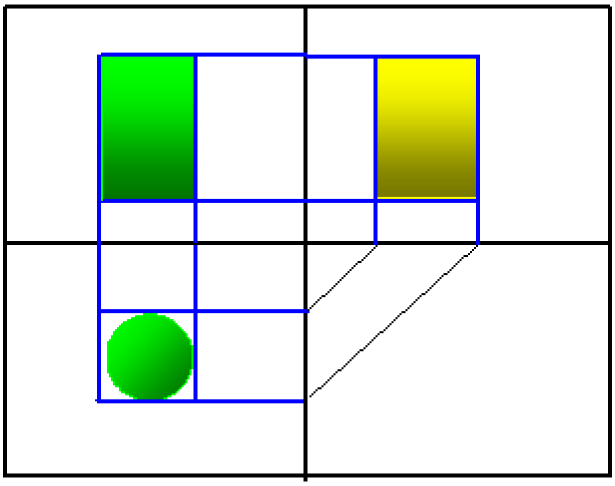

Fig. 3. Approximate representation of aligned images

To perform this alignment, the front image can be taken as a basis and then the following calculations are performed on the upper image:

Circle width = (x2-x1) of the front image *(x2-x1) of the top image, plus the new location depending on the x2, x1 coordinates of the front image.

Height of the circle = (y2-y1) of the top image * (x2-x1) of the side image, plus the new coordinate depending on y2, y1 of the side image.

The height of the side image is dimensioned in the same way.

The *edge* matrix is obtained by traversing the *view* matrix and first evaluating each point to determine whether it is background or image of the solid (this is obtained by comparing the value of the coordinate with the background color). Once this is evaluated, the status of the point with respect to its neighbors is determined, to be considered part of the *silhouette* of the image, it is only evaluated if one or more of its orthogonal neighbors is absent, the consideration of the non-orthogonal neighboring points is not considered because the orthogonal points present would make it part of the image content and not of the silhouette.

In order to obtain this result we will create matrices called ***view3d which are*** obtained taking as a base the ***view*** matrix, the missing magnitude is considered as follows: if it is the front ***view*** matrix that belongs to the plane (***x, y***) the missing magnitude will be ***z***, for the side view that belongs to the plane (***y, z***) the missing magnitude will be ***x***, and for the top view that belongs to the plane (***x, z***) the missing magnitude will be ***y.***

An evaluation of each point of the ***view*** matrix is made to know if it is part of the image of the solid, if so a copy of this value is made in each of the planes of the missing magnitude. For example if a point **p** of the front ***view*** matrix of coordinates (20, 30) has a color value of 23451 and belongs to the image of the solid, this value is copied to the ***3d view*** matrix in the same coordinate (20,30) but for each of the ***z-axis*** values (20, 30, z). Where the coordinate magnitude will have values from 0 to 130.

It can be seen that each figure or plan view has been converted into a solid keeping only the essence of the shape of each image (Figure 4).

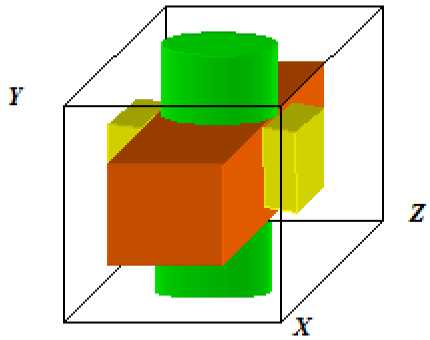

Fig. 4. Approximate representation of the solid intersection of the projections of each image.

To obtain the three-dimensional matrix of the solid, we take the three three-dimensional matrices ***Vistas3d***, and run them simultaneously to evaluate the coincidence of the three values in the same spatial coordinate, once the previous condition is fulfilled, this value is copied to a new three-dimensional matrix called ***solid*** in the same coordinate of coincidence.

Solid display modes

To obtain the wireframe display, we proceed to make the edges, but this time we do not apply it to the ***view*** matrix but we apply it to the planes that constitute the ***solid matrix***, doing this for each certain interval of planes that is defined by the user, to achieve a spacing between wires. The above procedure is performed for each of the two-dimensional planes.

To obtain the detail displays, the ***edge*** matrix is taken as a base and compared with each of the two-dimensional planes of the ***solid*** matrix, it is evaluated if the **edge** point coincides with a surface point of the solid, if this is so, the state of the neighboring points of the evaluated coordinate in this plane is determined. If the evaluated point meets some of the cases of consideration of a **detail** point**,** this coordinate is displayed

(Figure 5). The cases of consideration of a detail point, evaluate if this point is marked as an internal part of a straight line either in orthogonal or oblique directions. In which case it will be copied as part of an edge.

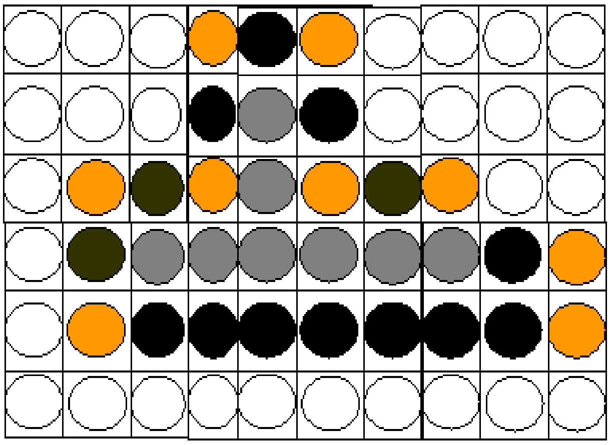

Fig. 5. Obtaining details, surface and solid.

Another case of consideration is to evaluate if the point is a corner that is its orthogonal neighbors are present, in which case the point is copied.

In the figure 6 with orange color have been marked the points considered of a plane as detail, the set of points of black and orange color are the points considered surface and in grey colors those that are considered part of the solid, the points that are not part neither of the surface nor of the solid in the image are represented without color.

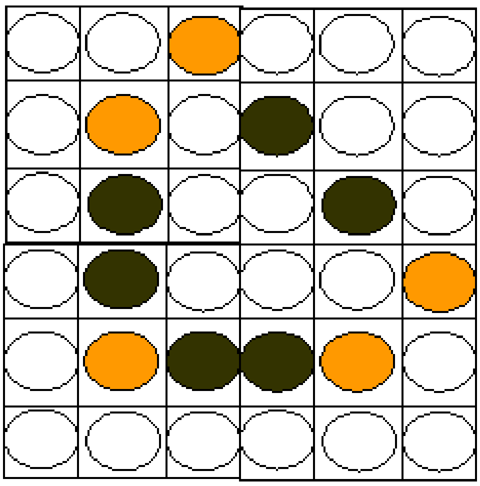

Fig 6. Detail points and hollow object surface.

The process of *painting solid* takes each of the two-dimensional matrices seen and is deployed on the surface of the three-dimensional matrix of solid, this is obtained by making a sweep of the coordinates of the matrix seen, and with this coordinate a path of the solid matrix is made until finding a point of surface of this to make its copying. So it consists of projecting the solid with its true colors, in the same way as in figure 7.

Fig. 7. Approximate representation of painted solid in its three axonometric views.

Another consideration in the object display mode, is to include the *Frame of Reference*, this can be created by displaying the lines of the frame cube of the size of the images, as an aid in the visualization of the solid in the position it was captured, as it will give the sensation of depth and location of the solid in space.

IV. CONCLUSIONS

Currently the elements that make up a three-dimensional development exercise are not entirely familiar to the community, for this reason it is necessary that the user has some basic knowledge not only in computing but also in technical drawing bases.

The application and its proper dissemination will contribute to deepen the knowledge and skills of technical drawing and graphic development to people related to the environment. At the same time it will promote the knowledge of three-dimensional structures by users only interested in these topics, such as students or inexperienced users in general.

The development of new graphic digitizing techniques is a totally interdisciplinary work, this means that partialized knowledge of three-dimensional structures alone cannot satisfy the needs of today's technological world, we are inclined to integrate different areas of knowledge such as: Systems Engineering, Graphic Design, Vectorial Mathematics, Physics, Abstract Reasoning, etc., so that together powerful alternative solutions are obtained.

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