Graphical objects geometrical data handling inside DWG file

Author:

Vidmantas Nenorta, Kaunas University of Technology, Lithuania, vidmantas.nenorta@ktu.lt

Abstract — *The paper deals with required (necessary) data from technical drawing extraction, their recalculation in order to solve special nonstandard technical tasks. In order to extract necessary information from irregular objects, projection views, the drawing scan method based on temporary scanning ray passed through a drawing is proposed. Dependence to information necessary extract, geometric forms of graphical objects, temporary scanning ray moves through a drawing by linear or rotational motion. Some special technical solutions related with two surfaces intersection line determination and its presentation on development, data extraction from technical drawing for solid modeling are analyzed and shortly described. An appropriate methodology and algorithm are proposed and presented.*

Index Terms — *AutoLISP, CAD, DWG, DXF codes, graphical objects*

INTRODUCTION

Contemporary technical design works inconceivable without computer aided design systems (CAD). Their development and adaptation to special user requirements, learning process are relevant and very important. Competition between different software providers today is tremendous but more than half of the market is however covered by the four product life management (PLM) corporations: Autodesk, Dassault Systemes, Parametric technology and Unigraphics. Concerning two-dimensional (2D) drawing creation, Autodesk corporation software AutoCAD one of the most popular all over the world [1]. A lot of mechanical design corporations, institutes, business firms are working with that system. AutoCAD native vector image file format DWG stayed like a standard for storing two and three-dimensional (3D) data and metadata, that describes the content of the file related to the DXF (drawing exchange format) format, which is an ASCII version of DWG [2, 3]. Rightly prepared DWG file contains complete digital information concerning data of designed object. Handling the data located inside DWG file by DXF code analysis we can extract a lot of information concerning graphical objects and use it for special technical tasks solving. DXF code analysis allows determinate information concerning standard graphical objects created by AutoCAD or Mechanical Desktop (MD) systems. However some problems occurs when we attach with irregular shapes, when we try to determinate coordinates of the points located on a spline and other shapes with high accuracy, when we try extract 3D information from technical drawing projection views.

2D drawing, prepared by CAD system, contains complete digital information concerning data of designed object. So, rightly prepared drawing or set of drawings has information that the object represented can be built from it alone without additional information. This information is understandable for qualified engineers, workers i.e., to qualified human brain but not straightly for computer technique. It is not directly applicable for digital prototyping (3D parameterized objects creation) from 2D drawings, developments layout creation from it, surfaces intersection line on the development representation. Required data extraction from 2D design drawings allows user to solve special technical tasks automatically, to save drawing design and reconstruction time efficiently.

All investigations were employed with Mechanical Desktop system. This software built on the AutoCAD foundation. Files created by MD system have extension DWG.

STANDARD WAYS FOR GEOMETRICAL DATA EXTRACTION FROM 2D DRAWING

On a common case every piece of geometry inside AutoCAD. AutoCAD Mechanical (AM), MD systems is a distinct graphical object type. Most object types can take several forms. For example, polygons and rectangles are both polyline. All graphical objects inside DWG file are described according to appropriate rules.

The most suitable way for standard graphical objects (like line, polyline, arc, circle, ellipse) recognition, required data from it extraction – it is using internal database of AutoCAD, AM, MD system. All data concerning design drawing are presented by drawing exchange format (DXF) code. It provides an exact representation of the data in DWG format. The DXF format is a tagged data representation of all the information contained in an AutoCAD drawing file. Tagged data means that each data element in the file proceeded by an integer number that is called a group code. A group code's value indicates what type of data element follows. This value also indicates the meaning of a data element for given object type [3]. DXF code specifications from AutoCAD Release 13 are presented on Autodesk Web site http://usa.autodeskcom/adsk/sevlet/item?siteID=123112&id=12272454&linkID=10808853. Graphical objects, by its DXF codes analysis inside DWG file, recognition can be realized with AutoLISP programming language, as integral part

of MD software. For necessary data extraction from 2D drawing we can use standard AutoLISP functions like ENTLAST (returns the name of the last drawn object in the drawing), ENTNEXT (returns the name of next object in the drawing, if the function called with no arguments, it returns the name of the first nondeleted entity in the systems database), ENTSEL (prompts the user to select single object by specifying a point and returns the name of selected object and selection point coordinates), ENTGET (retrieves an object's definition data). Having object's definition data and employing AutoLISP list manipulation functions like ASSOC (searches for association list for an element andreturns association list entry), CAR (returns first element of a list), CDR (returns a list without the first element), NTH (returns the nth element of the list) and others [3] we can retrieve obtain data about interested graphical object.

The described way of graphical objects recognition does not allow find intermediate points of irregular forms like splines or splined polylines without additional mathematical recalculations. These graphical objects created by nonuniform rational B-spline (NURBS). A NURBS curve produces a smooth curve between control points. Sometimes it is very important to have data related with intermediate points of a smooth curve or curves jointed together, to determinate all the points located on the standard graphical object [2].

DATA FROM 2D DRAWING EXTRACTION USING TEMPORARY SCAN RAY

In order to determinate points coordinate located on any graphical object with required accuracy, method of temporary scanning ray is proposed (FIGURE 1, (A), (B)). The method of temporary scanning ray based on it's passing through an appropriate area of a technical (detail) drawing and trimming (or extending) it till intersection point with object of investigation. The end point of temporary scanning ray after trimming will coincide with the point located on object of investigation. Scanning ray end point's coordinate determination will allow extract information from selected graphical object. After point's coordinate determination, temporary scanning ray removes from a drawing, determinate data moves to an appropriate list and stores for the next necessary operations (mathematical or drafting) [5, 6].

Scanning ray length constant, user-defined and ensure intersection with object of investigation all the time during its movement by linear or rotational movement. The ray's rectilinear movement direction respectively x or y axis can be any. Ray's rotational center can be located anywhere. In the both cases we need to choose the most suitable solution in order to get the mostly correct information. It is defined by the shape of investigation object. As an example, portion of irregular curve (see FIGURE 1, (A)) can be investigated with the most accuracy by ray's with an oblique linear motion, whereas the movement parallel to this portion of irregular curve.

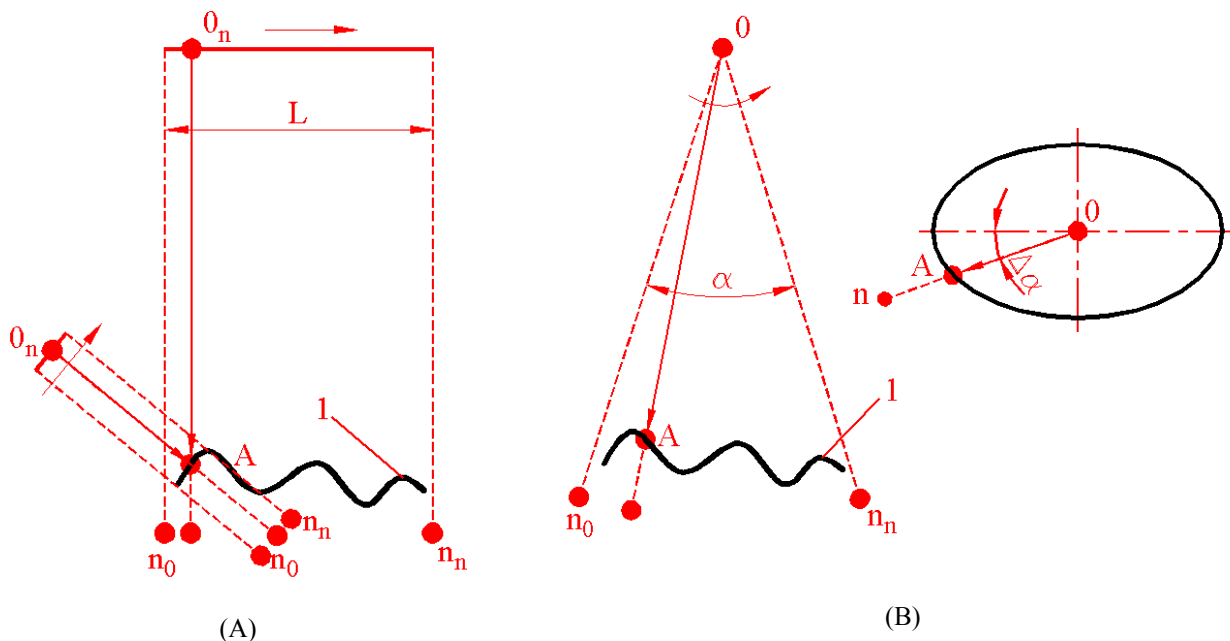(A)   (B)

FIGURE 1
TEMPORARY SCANNING RAY POSSIBLE MOVEMENT: (A) – LINEAR; (B) – ROTATIONAL

In the both cases scanning process executes at determinate interval with required accuracy $\Delta n = {L}/{n}$ for linear motion and $\Delta \alpha = {\alpha}/{n}$ for rotational motion, where Δn – linear discreet step in mm, L – scanning distance in mm, n – integer (number of scans), $\Delta \alpha$ – angular discreet step in radians, α – scanning angle in radians. Determination of endpoints coordinates, its' recalculation executes by extraction of the required data from CAD systems internal database using AutoLISP object-handling and list manipulation functions.

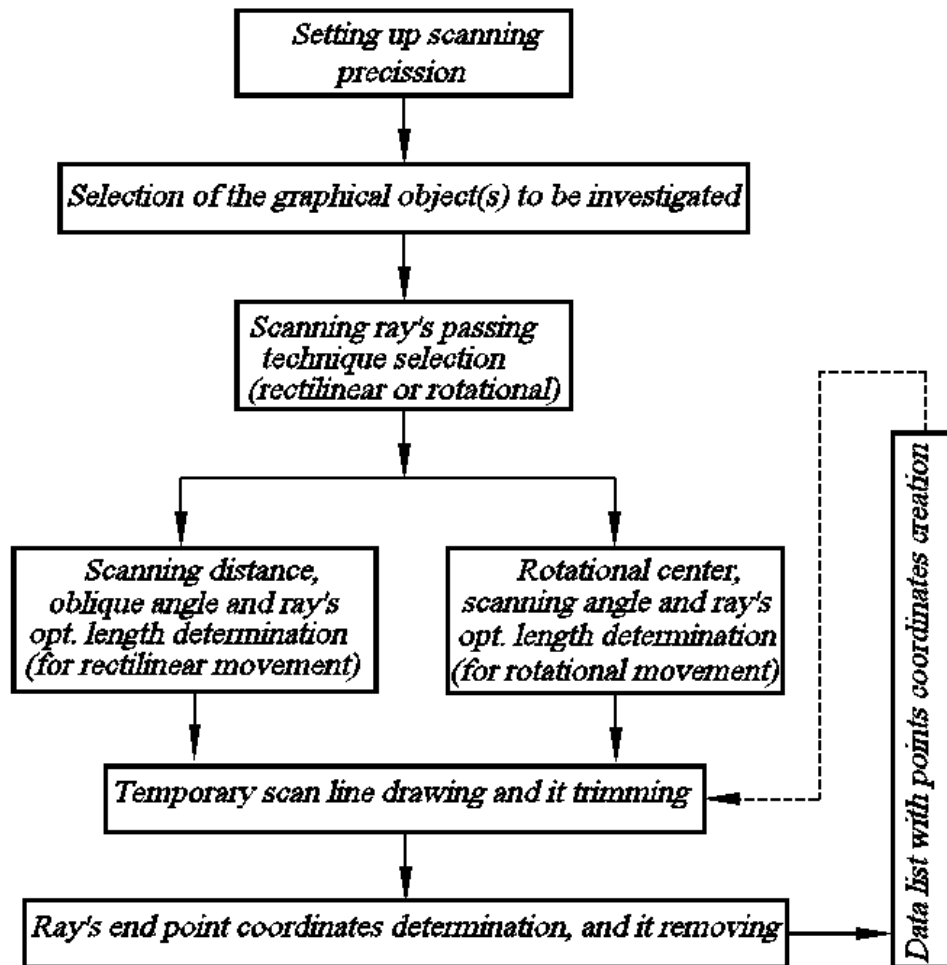The described problems solution algorithm presented in FIGURE 2

FIGURE 2
ALGORITHM FOR DATA LIST CREATION BY TEMPORARY SCAN RAY

Data list or lists with points coordinates located on investigated graphical object after appropriate recalculations can be used for different technical solutions.

EXAMPLES OF TECHNICAL SOLUTIONS SOLVED BY USING TEMPORARY SCAN RAY

Described data extraction from 2D drawing method is universal. Data lists can be used to development layout creation for developable and non-developable surfaces, for 2D drawing reconstruction into 3D parametrical part and etc. Some particular case for practical application of the proposed method presented below.

Modeling of the non-developable rotational surface development layout

Such kind of technical problems in the sheet metal industry can be solved by using Pilot3D, AutoPOL, and systems. They operate on data from 3D model. Pilot3D gives you an easy to unwrap or layout single (developable) or doubly curved surface. If a surface has too much double curvature, Pilot3d even gives you a way to subdivide the surface and unwrap the pieces [7]. AutoPOL for windows software application is built on the technology developed, for generating flat patterns from all kind of single curved models. It based on the ACIS solid modeling kernel and due to that, the SAT format is the core in the system. AutoPOL will also handle STEP, IGES and DXF files [8]. These software cannot be used for 2D drawings.

One section layout of non-developable rotational surface presented in FIGURE 3. Temporary scanning ray rotates about to ray's rotational center O. In order to find intermediate points of irregular form (see FIGURE. 3), scanning ray with length $R+\Delta R$ rotates about rotational centre O with discrete small steps equal to angle $\Delta\alpha$. On fixed position ray trim's till rotational surface boundary line. In our case ray shortens till segments OP_n'' length. Determinates point's P_n'' coordinates. Using this method you can determinate infinite number of points coordinates located on curved surface.

Length of nth arc $1'P_n'2'$ can be calculated according to equation: $L = 2\pi R_x / n_2$, where R_x – radius of cut on the point P_n'' in mm, generated by horizontal plane passed through point P_n''; n_2 – number of sections (in our drawing – 8 sections, see top view of the rotational surface).

After recalculations, cut's development layout with n scanned points (in our case – 100), will be drawn automatically respectively to randomly base point M, indicated on a drawing area of a screen. This shape can be printed or ploted directly at any scale factor or it can be used to transfer to a CNC (coputer numeric code) cutting machine program.
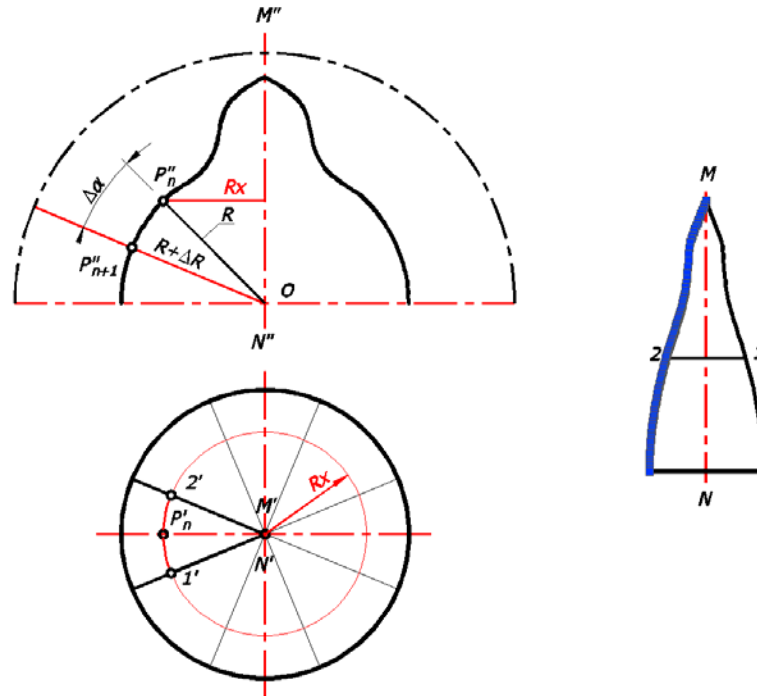

FIGURE 3
NON-DEVELOPABLE ROTATIONAL SURFACE INVESTIGATION SHEME AND DEVELOPMENT LAYOUT

Tree-dimensional data extraction from two-dimensional drawing

In FIGURE 4, (A), linear scanning ray passed through 2D drawing in order to extract 3D information.
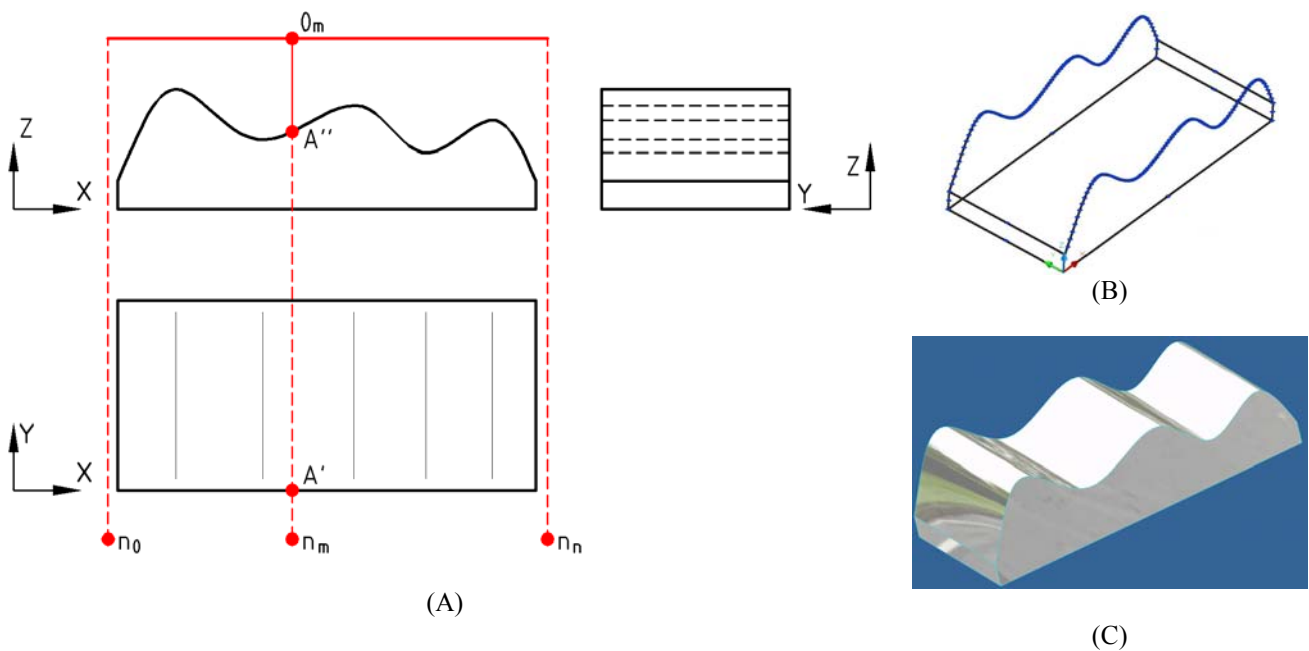

(A)

(B)

(C)

FIGURE 4
3D MODEL AUTOMATED DESIGN FROM 2D DRAWING: (A) – SCAN SCEME; (B) – MODEL

3D information concerning the point A can be determinate by trimming scanning ray twice. First time till point's A horizontal projection A′ (for *x, y* coordinates determination) and the second one – till its frontal projection A″ (for y, z coordinates determination). Having *x, y, z* points coordinates on the full (overall) length of graphical object you can, after an appropriate recalculations, construct 3D wireframe model (see FIGURE 4, (B)) and reconstruct it into solid (FIGURE 4, (C)). Number of scan points for irregular shape – 100. Generally, before scanning process, origin point of user coordinate system (UCS) should be superposed with datum surface and specific vertex.

3D wireframe model must be created on the free space of the technical drawing. So all designated (extracted) coordinates must be recalculated respectively to wireframe objects' forming base point with random user defined coordinates x_w, y_w, z_w. It can not coincide with UCS origin point noted before becouse new created object will close 2D views of the original drawing. Whereas the wireframe objects' forming point shifted to the free space of the drawing designated coordinates must be recalculated by means of the equations:

$$x_w = x_0 + \Delta x, \quad y_w = y_0 + \Delta y, \quad z_w = z ;$$

where Δx and Δy – alterations of an appropriate point coordinates relative to origin points of the coordinates, x_0, y_0 – UCS origin point coordinates.

CONCLUSIONS

- Temporary scan ray method allows extract unlimited number of points coordinates located on investigated graphical object and create it data lists;
- Created data lists can be used for special technical tasks solving: like surface development layout creation, 3D modeling process and others;
- Created methodology and AutoLISP programs fits for AutoCAD, AM, MD and other CAD systems built on the AutoCAD foundation;
- Investigation results are applied to learning process.

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