

# THE COORDINATE TRANSFORMATIONS METHOD COMBINED WITH AUTOLISP TO THE ARCHIMEDEAN SPIRAL REPRESENTATION IN AUTOCAD

**Sorin Cristian ALBU**

“Petru Maior” University of Tîrgu Mureș  
Nicolae Iorga Street, no. 1, 540088 Tîrgu Mureș, Romania  
sorin.albu@ing.upm.ro

## Abstract

*The purpose of this paper is to make the geometric model to the Archimedean spiral, curve often used in practice. Although it is a widely used, in AutoCAD there is no command with which to represent the Archimedean spiral. The method used for determining the mathematical relationships that define the spiral is the coordinate transformation, and for the calculation of the points which define it, is use AutoLISP, representation being made in AutoCAD. The result of this work is to develop an AutoLISP program which can represent the Archimedean spiral, presented a method that can be applied to the representation of any curves used in the technique.*

**Key words:** Archimedean spiral, coordinate transformation, worm type ZA, coordinate system, spiral step.

## 1. Introduction

The behind of the teeth mills it processed after Archimedean spiral [1]. The intersection between a worm type ZA and a plane perpendicular to the symmetry axis of the worm is an Archimedean spiral [2], [12], [13]. Some cam profile is executed after the Archimedean spiral, spiral arcs are wrapped most of the times after the spiral Archimedean. Thus, being a common curve using in practice is warranted numeric and geometric modeling of Archimedean spiral.

The Archimedean spiral is a plane curve named after Greek mathematician Archimedes defined as the locus of points that correspond to the positions of a point in time which deviates from a fixed point (origin) with constant speed along a line which rotates around the origin with constant angular velocity [16]. The straight line can rotate in two ways, counterclockwise and obtain left spiral and in a clockwise direction when we get straight spiral. The two spirals are mirrored.

To determine the parametric equations of the spiral will use the method of coordinate transformations [3], [4], [7]-[15], and to represent it in AutoCAD [5] will design a program in AutoLISP [6]. The working method used can be applied to the representation of any curves from plane or in space such as evolving, cycloid, cylinder propeller, cone propeller and others curves.

## 2. Determination of the parametric equations of the spiral using coordinate transformations

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In the first phase it represents straight line ( $d_2$ ) in its original position and a point P in origin. Attaches the point, around which rotate line ( $d_2$ ) clockwise, orthogonal coordinate system  $S_1$  whose axes are  $X_1Y_1O_1$ , and the point P who walking on right ( $d_2$ ) coordinate system  $S_2$  with axes  $X_2Y_2O_2$  like in fig.1.

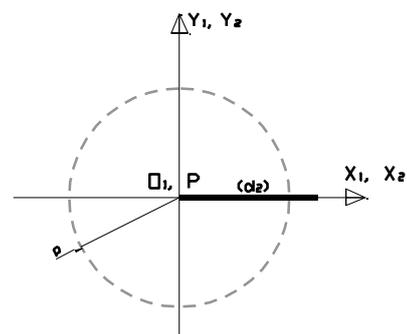


Fig. 1: Representation of the line ( $d_2$ ) and of the point P in initial position

On the straight line will move with constant velocity point P so that of the rotation of the line with an angle equal to  $360^\circ$  point P move a distance equal to the spiral step  $p$ .

It represents the straight line ( $d_2$ ) rotated by an angle  $\varphi$  and coordinate systems attached to the point around which it rotates right, namely the point moving with constant speed on the straight, as shown in fig. 2.

The coordinates of the point P into the  $S_1$  system are seeking. Coordinate transformation in symbolic matrix form is as follows:

$$r_1 = M_{1,2} * r_2 \quad (1)$$

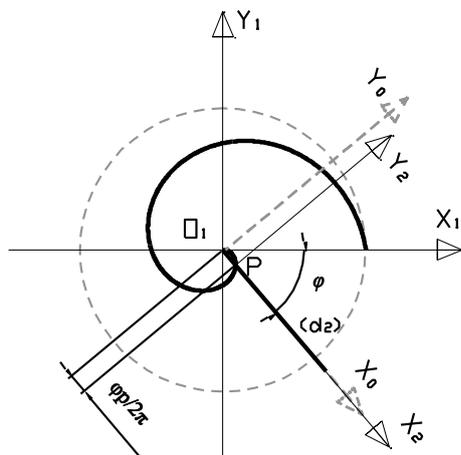


Fig. 2: Representation of the straight line ( $d_2$ ) and of the point P in displaced position

$r_1$  - single-column matrix of the homogeneous coordinates of the point P in system  $S_1$ ;  
 $r_2$  - single-column matrix of the homogeneous coordinates of the point P in system  $S_2$ ;  
 $M_{1,2}$  - transformation matrix from the system  $S_2$  to the system  $S_1$ ;

Coordinate transformation write in extended form will be:

$$\begin{bmatrix} x_1 \\ y_1 \\ 1 \end{bmatrix} = \begin{bmatrix} \cos x_1 x_2 & \cos x_1 y_2 & x_{12} \\ \cos y_1 x_2 & \cos y_1 y_2 & y_{12} \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x_2 \\ y_2 \\ 1 \end{bmatrix} \quad (2)$$

It knows the position of the point P in system  $S_1$  and the position of system  $S_2$  in system  $S_1$ .

$$\begin{bmatrix} x_1 \\ y_1 \\ 1 \end{bmatrix} = \begin{bmatrix} \cos \varphi & \sin \varphi & \varphi \frac{p}{2\pi} \cos \varphi \\ -\sin \varphi & \cos \varphi & -\varphi \frac{p}{2\pi} \sin \varphi \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \quad (3)$$

Making calculations, obtain the parametric equations of trajectory of the point P in system  $S_1$ , respectively Archimedean spiral equations, relation (4).

$$\begin{cases} x_1(\varphi) = \varphi * \frac{p}{2\pi} * \cos \varphi \\ y_1(\varphi) = -\varphi * \frac{p}{2\pi} * \sin \varphi \end{cases} \quad (4)$$

Where:  $\varphi$ - parameter of the spiral;  $p$  – spiral step.

### 3. Program designed to represent the spiral of Archimedes and his running in AutoCAD

To represent the spiral in AutoCAD has been written a program in AutoLISP. Logical scheme is presented in fig. 3.

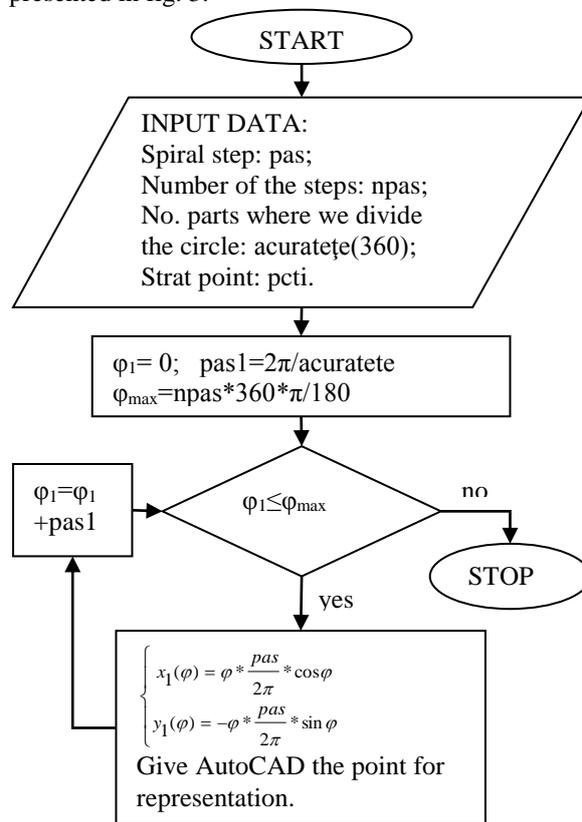


Fig. 3: Logical scheme of designed program

And the designed program is presented in the following:

```
; representation of the left Archimedean spiral when
we know the spiral step
(defun c:sparh ()
  (setvar "cmdecho" 0)
  (setvar "blipmode" 0)
  (setq pas (getreal "\nEnter spiral step(40): "))
  (setq npas (getreal "En\ter the number of the
step:"))
  (setq acuratețe (getreal "Ent\er No. parts
where we divide the circle(360):"))
  (setq pcti (getpoint "Enter\ the strat
point(centrul cercului): "))
  (command "color" 5)
  (command "circle" pcti pas)
  (command "color" 7)
  (command "line" (list (- (car pcti) pas 20)
(cadr pcti) (caddr pcti))
(list (+ (car pcti) pas 20) (cadr
pcti) (caddr pcti)) "" )
(command "line" (list (car pcti) (- (cadr pcti)
pas 20) (caddr pcti))
```

```

)
(list (car pcti) (+ (cadr
pcti) pas 20) (caddr pcti)) "" )
(command "color" 5)
(command "ucs" "m" pcti)
(setq fim (* npas 360 (/ pi 180)))
(setq pas1 (/ (* 2 pi) acuratete))
(setq fi 0) ; conturul pentru fi
(command "pline")
(while (<= fi1 fim)
  (setq x1 (* fi1 (/ pas (* pi 2)) (cos fi1)))
  (setq y1 (* -1 fi1 (/ pas (* pi 2)) (sin fi1)))
  (command (list x1 y1))
  (setq fi1 (+ fi1 pas1))
)
(command "")

```

The spiral is represented in AutoCAD with the help of the command named *pline* [5] which creates a 2D polyline. AutoLISP provides points belonging to the curve based on the mathematical relationship (4) obtained by the method of coordinate transformations. For representation in AutoCAD to spiral proceed as follows:

a. On the menu Manage select the option Visual LISP Editor fig. 4.

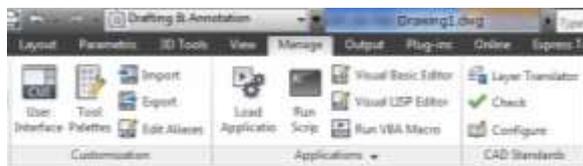


Fig. 4: Menu Manage from AutoCAD

b. In opened window enter the presented program, fig.5.

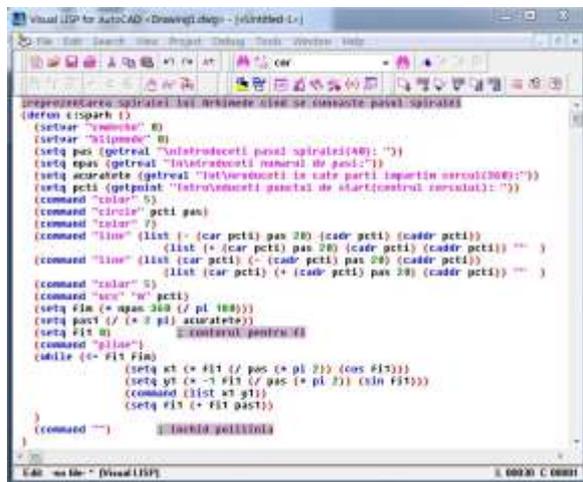


Fig. 5: Window Visual Lisp

c. The program written in AutoCAD-site editor is saved fig.6.

d. On the menu Manage select the option Load Application fig.4.

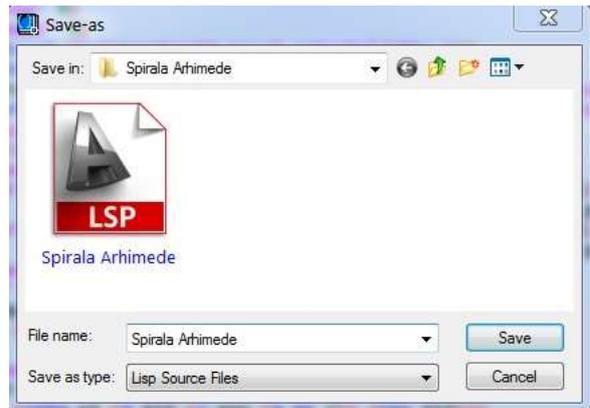


Fig. 6: Window open to the file saving

e. In the dialog box appeared, fig.7, load the program saved in step c selecting the saved file, followed by pressing the Load button. If your program is correct, in the bottom of the dialog box displays the message: "Spirala Arhimede.LSP successfully loaded".

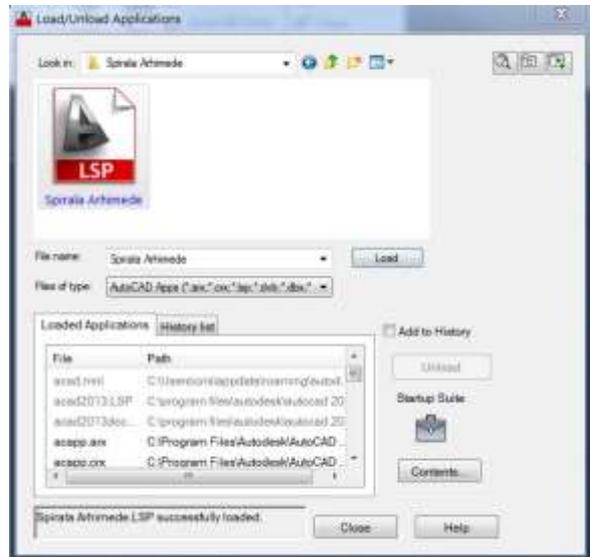


Fig. 7: Loading the saved program

f. To launch the program, from the command prompt command of AutoCAD write the program name, *sparh* in this case. Press the ENTER key, then enter the requisite data. To the final will be represented the Archimedean spiral corresponding data entered.

Using the method of coordinate transformation parametric equations of the curves can be determined, after which using a lightweight program to master as it is AutoLISP can be represented any curve.

#### 4. Archimedean spiral representation corresponding to a 40 mm step

In the following is represented the spiral with a pitch of 40 mm. Enter the data into the program designed according to table 1.

Table 1. Input data

Characteristics of Archimedean spiral	Value
Spiral step [mm]	40
Number of the steps [Natural number]	2
No. parts where we divide the circle (360) [Natural number]	360

As a result of running the programme designed obtain the coordinates of points belonging to spiral from fig. 8:

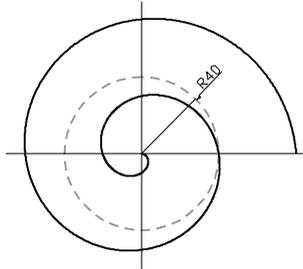


Fig. 8: Archimedean spiral from left sense (reduced scale)

## 5. Conclusions

Using the method of coordinate transformation can be obtained parametric equations of the curve you want to represent, and using AutoLISP is obtained the points belonging to the curve. These points are provided to AutoCAD, where using a simple command as *pline*, it is represented the desired curve.

Using the method of coordinate transformations combined with AutoLISP obtain an efficient method of representing scatter any curve that conforms to some rules.

The result of this work is a program which can represent through points, Archimedean spiral when know her step.

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