IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

A METHOD TO OBTAIN THE POSITION RELATION OF TWO POLYGONAL CONTOURS DEFINED BY PRIMITIVES IN THE SAME PLANE

Dora Florea*

*Department of Computer, Polytechnical University of Timisoara, Faculty of Automatich and Computer, Bul.Parvan nr.2, Timisoara,Romania

ABSTRACT

This paper presents an original method for determination position relation between two polygonal coplain contours used an original algorithm proposed by author for determination the position relation of a point with a contour. Determination of relation with a contour C of a point P: Relpoint {P,C}→{INTERIOR, EXTERIOR, BELONG TO VERTEX, BELONG TO CONTOUR} it make with add the predicative formulas. Also the algorithm which establish the position relation between two contours it presents with add the predicatives formulas.

KEYWORDS: Polygonal contour,relation of a point,relation of coplanar contours,predicatives formulas

INTRODUCTION

The problem of etablishing the position relation between the plane subfigures is required in the many matters of artificial intelligence [1],[3]. This paper has investigated the possibility of defining the relation between two closed coplaning polygonal contours and Dora Florea proposes an original algorithm for this. Starting from a possible relative position classification of two contours, the method presents in this paper is based on testing of predicative formulas, which first establish whether two contours cross, then whether they are external or internal and whether they are identical. The four last classes may by evidenced by the trouth value of predicative formulas relevant for each class, and for the relation of interior and exterior if necessary to establish the position of a point face to a contour.In the literature of speciality it know the algorithms for resolves the relation of a point with a polygon but this are not performed. So Sergiu Corlat[5] presents for resolves this problems two algorithm:

1)for determined the belongings of a point at a polygon by deviding in the triangles of a polygon and so can know if a point P is interior of a polygon

This algorithm is not performed because it necessary many subroutine for treatement the exception situations and to refer only the polygonal contour convex.

2) by number of intersections of horizontal segment with the polygon and so if the number of intersection is anstake the point is interior and the point is exterior if the number of intersection is stake. This algorithm it was presented and by Wiston[1]. But this algorithm has need of many subroutines for treatement the exception situations and this algorithm is not safe. Dora Florea in this paper proposes an original algorithm for establishing the position relation between a point and a contour based on the computation of the algebraic module sum S of the angle at which the point see the contour.This sum S is relevant for the classification of the point as related to the contour (internal,external,on the contour line, on a contour vertex) no other testing being necessary.The algorithm is safe and performed ,it can use in all the situations and for all the type of contour concave or convex , defined by primitives: segment of straight line, arc of circle, arc of ellipse, function or other primitives.

THEORETICAL CONSIDERATION

Let be C_1 and C_2 two closed polygonal contours defined by primitives in the same plane. They may be found in one of the four classes of possible relative distinct position referred to as INTERIOR,EXTERIOR,INTERSECTION (fig.1,fig.2,fig.3)or IDENTICAL. Let $D_1 = C_1 \cup Int\ C_1$ and $D_2 = C_2 \cup Int\ C_2$ the polygonal field determined by two closed polygonal contours and $M_1 = \{P_i \mid i=1,m\}$ and $M_2 = \{P_i | i=m+1,n\}$ the set of points for the definition of the primitives which belong to the contours C_1 and C_2. The function of position relationis defined by applying this relations:

RELPOZ:$\{C_1,C_2\}\rightarrow$, {INTERIOR,EXTERIOR,INTERSECTION,IDENTICAL}. (1)

RELPOZ:$\{C_1 , C_2\}$=INTERIOR ,
if $\{D_1 \backslash (IntC_1 \cap IntC_2)\}=C_1$ or $\{D_2 \backslash (IntC_1 \cap IntC_2)\}=C_2$

$\{C_1 , C_2\}$ =EXTERIOR ,
if $\{D_1 \backslash (IntC_1 \cap Int\ C_2)\}=D_1$ or $\{D_2 \backslash (IntC_1 \cap IntC_2)\}=D_2$

$\{C_1 , C_2\}$ =INTERSECTION ,
if $\{D_1\backslash(IntC_1 \cap Int\ C_2)\neq D_1$ and $\neq C_1\}$ or $\{D_2\backslash(IntC_1 \cap IntC_2)\neq D_2$ and $\neq C_2\}$

$\{C_1 , C_2\}$ =IDENTIC , if $D_1=D_2$

The relation (1) show that the function RELPOZ requires knowledge of interdependence which exists between the set of points defining the primitives of two contours and the existence or nonexistence of primitives intersection which belong to the contours. In fig.1 it show exemples of possible relations of interior between two contours C_1 and C_2 , in fig.2 it presents same position relations of exterior for two contours C_1 and C_2 and in fig.3 are three exemples for contours what are in relation of intersection.

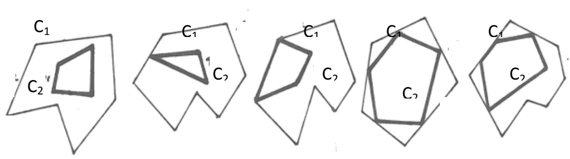


Fig. 1 Exemple of contours in relation INTERIOR : RELATION {C₁ , C₂}= INTERIOR

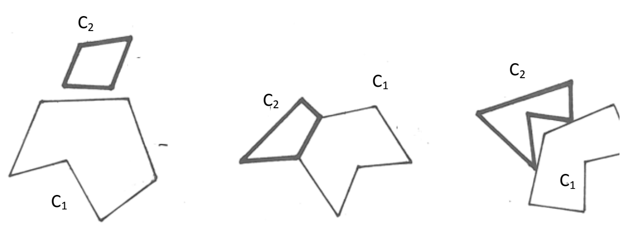


Fig.2 Exemple of contours in relation EXTERIOR : RELATION{C₁,C₂}=EXTERIOR

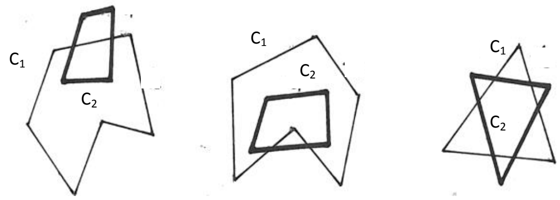


Fig.3 Exemple of contours in relation INTERSECTION : RELATION{C₁,C₂}=INTERSECTION

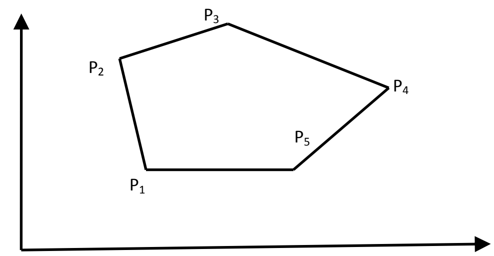


Fig.4 Contour polygonal C with vertex $P_1 \ldots P_5$

The algorithm proposed by Florea Dora for establishing the relation between the polygonal contours defined in the same plane considering as input data the points $P_{h,h=1..m-1},P_{k,k=m..n}$ (fig.4) which limit primitives of segment type generating closed polygons, requires as follows: Relation Pred1. (3) show if the contour C_1 is adjacent with the contour C_2 on the distance delimitated by the points P_{h1} and P_{h2} for the contour C_1 and the points P_{k1} and P_{k2} for the contour C_2 by testing if exist vertex of contours C_1 and C_2 identical or the angle coefficients is the same for primitives from contours C_1 and C_2.

Pred1.If $\exists P_{h,h\in h1\ldots h2}\equiv P_{k,k\in k1\ldots k2} \vee (y_h-y_{h+1})/(x_h-x_{h+1})\equiv(y_k-y_{k+1})/(x_k-x_{k+1})_{,h\in h1\ldots h2\ \ ,k\in k1\ldots k2}$
$\vdash C_{1,points\ Ph1\ ..\ Ph2}$ ADJACENT $C_{2,points\ Pk1\ ..\ Pk2}$

(3)

For precised if the contours C_1 and C_2 have common points , it used predicative formula Pred2, through testing if exist a point P_k for which the value of the function $f_{h,h+1,h\in 1..m-1}$ which defined a primitive is 0.

Pred2.If $\exists(f_{h,h+1}(P_k)=0)$ $_{where\ \ h\in 1..m,k\in m+1..n}\vdash C_1$WITH COMMON POINTS C_2

(4)

Determination of a possible intersection relation between the two contours shoud be made by testing the truth value of predicative formula Pred.3 (5). In the relation (5) the function which defines the straight line intersecting the points P_h,P_{h+1} has been noted $f_{h,h+1}$, the function which defines the straight line intersecting the points P_k,P_{k+1} has been noted $f_{k,k+1}$.

Pred3.If
$M_{hk}((x_{hk}\in((x_h,x_{h+1})\cap(x_k,x_{k+1}))\wedge y_{hk}\in((y_h,y_{h+1})\cap(y_k,y_{k+1})))$

where $M_{hk}=f_{h,h+1}\cap f_{k,k+1}$ and $_{h=1..m-1,k=m..n-1}\vdash$ C_1 INTERSECTION C_2

(5)

Etablishing of the position relation of INTERIOR or EXTERIOR possible between the contours C_1,C_2 is made by testing the truth value of the predicative formulas Pred4,Pred5,Pred6 expressed by (6),(7),(8). Predicative formula Pred4 establish the relation C_1 EXTERIOR C_2 if it detect a point P_h which belong to the domain D1 but not belong to the domain D_2.

Pred4. If ˥Pred3.$\wedge\exists(P_h\in D_1\wedge P_h\notin D_2)\vdash$ C_1 EXTERIOR C_2

(6)

The relation (7),(8) show that the contour C_1 INTERIOR C_2 or contour C_2 INTERIOR C_1 if it detect a point P_h which belong of contour C_1 or a point P_k which belong of cotour C_2 .

Pred5. If ˥Pred3.$\wedge$˥Pred4.$\wedge\exists$ ($P_h\in D_2\backslash C_2 \wedge P_h\in C_1$) $\vdash$ C_1 INTERIOR C_2

(7)

Pred6. If ˥Pred3.$\wedge$˥Pred4.$\wedge$˥Pred5.$\wedge\exists$ ($P_k \in D_1\backslash C_1\wedge P_k \in C_2$) $\vdash$ C_2 INTERIOR C_1

(8)

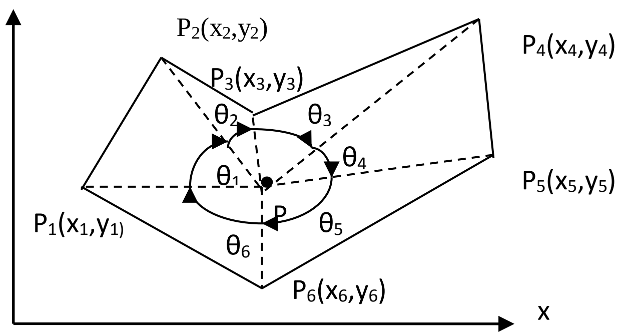
If the predicatives formulas Pred3 ,Pred4, Pred5,Pred6 are false ,than the contour C_1 is identical with contour C_2.

Pred7. If ˥Pred3.$\wedge$˥Pred4.$\wedge$˥Pred5.$\wedge$˥Pred6.$\vdash$ C_1 IDENTICAL C_2

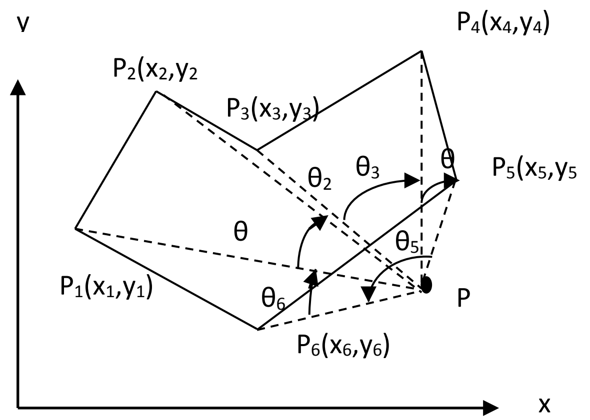
where $P_h\in M_1$ and $P_k \in M_2$

(9)

For establish the relations of interior or exterior contours defined in the same plane (6),(7),(8) it necessary to know the position relation of a single point belong of a contour. An algorithm for establishing the position of point as related to a contour: INTERIOR, EXTERIOR,BELONGS TO LINE of contour, BELONG TO THE VERTEX of a contour, respectively is necessary.The algorithm proposed in this paper by Dora Florea relies on knowledge of algebraic module value sum of the angles under which the contour *C* is observed from the point P for desided if the point is interior or exterior of the contour (Fig.4).



a) P interior point *C*



b) P exterior point *C*

Fig.5 Relative positions of the point P as related to contour C

Modul algebraic sum of the angles under which from the point P the contour observed is 360^0 , 0^0 for the case in which the point P is a) interior as related to the contour (Fig.5a), b) exterior to the contour(Fig.5b).Computation of the angle θ_i is made using the vector product P_v and the scalar product P_s of two vectors V_{PiP},V_{Pi+1P} ,which limited each primitive of the contour *C* and have their origin in the point P(x,y) :

$$\theta_i = sgn\,[(\overline{V_{P\iota P}} \times \overline{V_{P\iota+1P}})\cdot \bar{n}]\,arccos\,[\overline{V_{P\iota P}}\cdot \overline{V_{P\iota+1P}}]/[\,|\overline{V_{P\iota P}}|\,|\overline{V_{P\iota+1P}}|\,] \quad (10)$$

Where $\bar{n}$ is the unit normal vector $\bar{n}=\bar{r}\times\bar{J}$, n=vers $\overline{P_v} \perp (\overline{V_{P\iota P}},\overline{V_{P\iota+1P}})$ and $\overline{P_v} = \overline{V_{P\iota P}}\times\overline{V_{P\iota+1P}}$.
In the relation (10) the angle θ_i has the positive sign if the trihedral angle ($\overline{V_{P\iota P}}$,$\overline{V_{P\iota+1P}}$,$\overline{P_v}$) is direct.
In the relation (6),(7),(8) it's necessary to establish the position of one points $P_h \in M_1$ as related to the contour C_2. For this purpose one should computed the

y

directed angle $\theta_{i,i=m+1,n}$ determined by two consecutive points of contour C_2 and the point P_h used the relation (10). Algebraic module sum S of angles θ_i will define the relation of P_h as to the contour C_2 and the field D_2 by testing the formulas:

R1: If $S=\sum \theta_{i,i=m+1..n} = 360^0 \vdash P_h \in D_2 \backslash C_2$ or P_h INTERIOR C_2

(11)

R2: If $S=\sum \theta_{i,i=m+1..n} = 0^0 \vdash P_h \notin D_2$ or P_h EXTERIOR C_2

(12)

R3: $\neg R1 \wedge \neg R2 \wedge P_h \equiv P_k$, where $h \in \{1..m\}$ $k \in \{m+1..n\} \vdash P_h \in C_2$ or P_h BELONG TO VERTEX C_2

(13)

R4: $\neg R1 \wedge \neg R2 \wedge \neg R3 \vdash P_h$ BELONG TO C_2

(14)

If the sum of the angles $\theta_{i,i=m+1..n}$ is 360^0 ,the point P_h is interior of contour C_2 and if the sum of the angles $\theta_{i,i=m+1..n}$ is 0^0 ,the point P_h is exterior to contour C_2. If the formula R_1 and R_2 are negatives and P_h is identical with a vertex $P_{k,k\in m+1..n}$, the point P_h belong to a vertex of contour C_2.In the case false of rules R_1,R_2,R_3, the point P_h belong to the contour C_2.In order to find the relation in which are the points $P_k \in M_2$ as to C_1 , are should compute the directed angle $\theta_{i,i=1,m}$ determined by two consecutive points of the contour C_1 and the point P_k ,using the relation (10). Likewise the algebraic module of angles θ_i will determine the relation of P_k with the contour C_1 and the field D_1: P_k INTERIOR C_1 , P_k EXTERIOR C_1,P_k BELONG TO VERTEX C_1, P_k BELONG TO C_1 respectively .

CONCLUSION

Purpose of this paper is to offer an original method proposed by Dora Florea for determining the relation between two contours. This may lead to an algorithm involving high computation speed, redused memory and the elimination case which need a special treatment. The algorithm was tasted with a program wrote in Visual Basic language and the results was very good.

ACKNOWLEDGEMENTS

I take this opportunity to express my gratitude to the people who have been instrumental in the successful completion of this work.

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AUTHOR BIBLIOGRAPHY

Mis. Dr.Ing.Dora Florea
Myself working as Researcher in Politehnical University Timisoara, Romania