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A COMPARATIVE EVALUATION FOR MANUAL AND COMPUTER GRAPHICS BASED SYSTEM FOR NC PROGRAMMING

تقييم استخدام الكمبيوتر فى تصميم برامج ماكينات التحكم الرقمى بالمقارنة بالطرق اليدوية

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تعتبر مشكلة برمجة ماكينات التحكم الرقمى من المشكلات الهامة التى لاقت اهتمام واسع منذ ظهور هذا النوع من الماكينات ، وكثرت المحاولات لجعل هذه المشكلة اكثر سهولة . وبدأ استخدام الكمبيوتر فى تصميم هذه البرامج منذ الخمسينات بظهور لغة APT ومنذ ذلك الحين وكثير من الاعمال تناولت هذا الموضوع الى أن ظهر استخدام الكمبيوتر فى الرسم وامكانية استخدام البيانات المخزنة لاى رسم فى اعادة تنظيم هذه البيانات وتصميم برامج ماكينات التحكم الرقمى . والمعروف انه مازالت تستخدم الطريقة اليدوية فى تصميم برامج ماكينات التحكم الرقمى الى وقتنا الحاضر مما يؤدى الى استهلاك وقت الإنتاج وانخفاض الانتاجية وعدم الإستفادة من كفاءة مهندسى الإنتاج بالقدر الكافى . وقد قام الناشرون : فى بحث سابق) بتصميم نظام (AUTOGMC) هدفه تصميم برامج ماكينات التحكم الرقمى اوتوماتيكيا بالربط مع استخدام الكمبيوتر فى الرسم ، وفى هذا البحث الحالى ، يتم استعراض مقارنة بين هذا النظام وبين الطريقة اليدوية المستخدمة فى تصميم هذه البرامج .

وقد اظهرت النتائج التى اجريت على العديد من الاجزاء ، ان استخدام هذا النظام يوفر حوالى ٩٥ ٪ من الوقت المستخدم فى البرمجة اليدوية بالاضافة الى الدقة العالية الناتجة من هذا النظام مما يؤدى الى تخفيض وقت تحميل واعداد الماكينات وكذلك تخفيض استهلاك المواد المستخدمة فى التاكد من صحة البرنامج ، وهذا يقودنا بالطبع الى توفير عظيم فى التكاليف الكلية وزيادة الإنتاجية وجودة عالية فى المنتجات.

ABSTRACT

Part programming involves the planning and specifications of the sequence of processing steps to be performed on the NC. It also involves , although less directly , the preparatrion of the input medium by which the processing instructions are communicated to the machine. Manual part programmer spends a substantial amount of time preparing a part program. Usually using a number of sketches or drawings , derived from a design drawing , to describe raw material size , intermediate operation size and tool path. Every change of direction , intersection or blend point , requires time consuming and error prone calculations. Our previous work AUTOGMC system which generates automatic NC programs overcomes the NC manual programming problems. The work in hand , illustrates a comparative study between manual and Computer-Aided Part Programming (CAPP) with special reference to the economic point of view. This CAPP is the actual result from an integration system , the benefits of that are great , since data for each application does not have to be reentered , costly redefinition and reformating are eliminated. The investigation of this work has shown not less than 95% saving in time which in reality leads to a great saving in the total cost expanditure and no doubt more benefits should be expected i.e productivity , quality , etc. Thus one can say that fully integration for the Computer-Aided Engineering

INTRODUCTION

A part programmer studies the part drawing and the process chart and then prepares the control program on a standard form in the specified format. He spends a substantial amount of sketches or drawings ; derived from a design drawing , to describe raw material size , intermediate operation size and tool path. Every change of direction , intersection or blend point , requires time consuming and error prone calculations. The handwritten part program is prepared in a machine code peculiar to the particular machine tool and control system combination. Because the part program comprises a listing of letters and numbers , it is difficult to review. Therefore , there is further risk of mistakes arising from using the handwritten part program. Limitations of manual part programming can be summarized as : heavy use of man power resources , serious loss of machine productivity and the skill of the production engineer are not used effectivelly. Changes have occured over the years however to make the task of the manual part programmer less difficult. One of the very recent techniques is the AUTOGMC system developed by El-midany and El-baz [1] , which considered as a new approach for the industry. The developed system besides overcomming the manual programming problems , it is an automatic NC program for any profile component , the ability and flexbility of its higher performance are illustrated clearly through the complicated profiles components.

THE INTEGRATION CONCEPT IN CAE

Computer-Aided Engineering (CAE) can be defined as the integration of computer-aided design , analysis and manufacturing. This integration is used to improve manufacturing productivity in the industry. Needs and pressures in state-of-the art technologies , economics , human limitations , design and manufacturing complexity , computer developments and competition from abroad , serve to complicate the ability to meet this needs. The key to implement CAE is one integrated databases. The major problem in a system of linked databases is in the area of modifications , where changes in one database need to be automatically reflected in the other linked databases. This is clearly impossible when data is being converted from one database format to another database format and no connection is maintained in the data base. CIM is another abbreviation which has recently came into use. It standards for computer integrated manufacturing and means the integration by using computers in varius manufacturing areas such as NC , process planning , inspection , tools , and fixtures design , etc. Current production systems depends heavily on intermediate stages of human intervention , including design conceptualization , decision making , data communication , report documentation , etc. which if computer assisted can be efficient. If not so aided , then these stages as well as other mannedactivities become manpower intensive and tedius works. Such activites are usually relatively slow and economically inefficient when compared to the automated and/or computerised components of the operation. The benefits of integration are great. Since data for each application does not have to be re-entered , costly redifinition and reformatting are eliminated. Transcription errors are abbreviated as are lead times. Since the information is more accurate , product quality and reliability are inhansed integration improves the communications between manufacturing and engineering organisations. The useefulness of the CAD/CAM data base as CIM integrator is further enhanced if the data base is intelligent. For example a change in the product model which consider the heart of the CAD/CAM data base El-midany [2] should be reflected in other applications such as the manufacturing data required for NC machines.

PROBLEMS WITH MANUAL PROGRAMMING

1. Drawing both the required outline and the tool path of the machined part according to its radius by the traditional graphic metnod.
2. Analysis the drawing part into straight lines and arcs.
3. Determinethe tangential points between each sequental drawing elements.
4. The arcs which are found in more than one quadrant 90 must be subdivided into more than one arc , each subarc must not exceed one quadrant.
5. The straight line is determined by the coordinates of the initial and final points.
6. Each arc determined by the coordinates of the initial and final point and the coordinate of its centers.
7. With respect to the arcs , they are used more complicated analysis, the distance between the initial point and the center of each arc, alonge both X and Y axis must be calculated.
8. To ensure continous tool path. It is necessary to know the direction of the arc to be suitable with the desired machining sequence operation.
9. As the geometry of the workpiece needs separate cutting in certain position. The tool must do rapid return and the required position moves under the tool to complete the required cutting. Figure 1 illustrates the complete processing operations for the part drawing.

COMPUTER ASSISTED PART PROGRAMMING

Most parts machined on NC systems are considerably more complex.In the more complicated contouring applications , manual part programming becomes an extremely tedius task and subject to errors.In these instances it is much more appropriate to employ the high-speed digital computer to assist in the programming process. This trend began in the late 1950's with the development of the APT , many innovations have been made in NC languages and NC programming. Among these are the use of interactive graphics. Further innovations have been made in NC programming using the idea of interactive graphics. These innovations used different interactive graphic systems with other different programs. The main features of these innovations that the NC part programmer was the heart of these systms and they need a high profissional NC part programmer. So, with the tremendous advances made in NC programming over the last decades , it was not difficult to imagin that the entire logic of the part programming process will not be caputeured and feed to the computer. This would permit NC programming to be accomplished completly and automaically by the computer without human assistance.

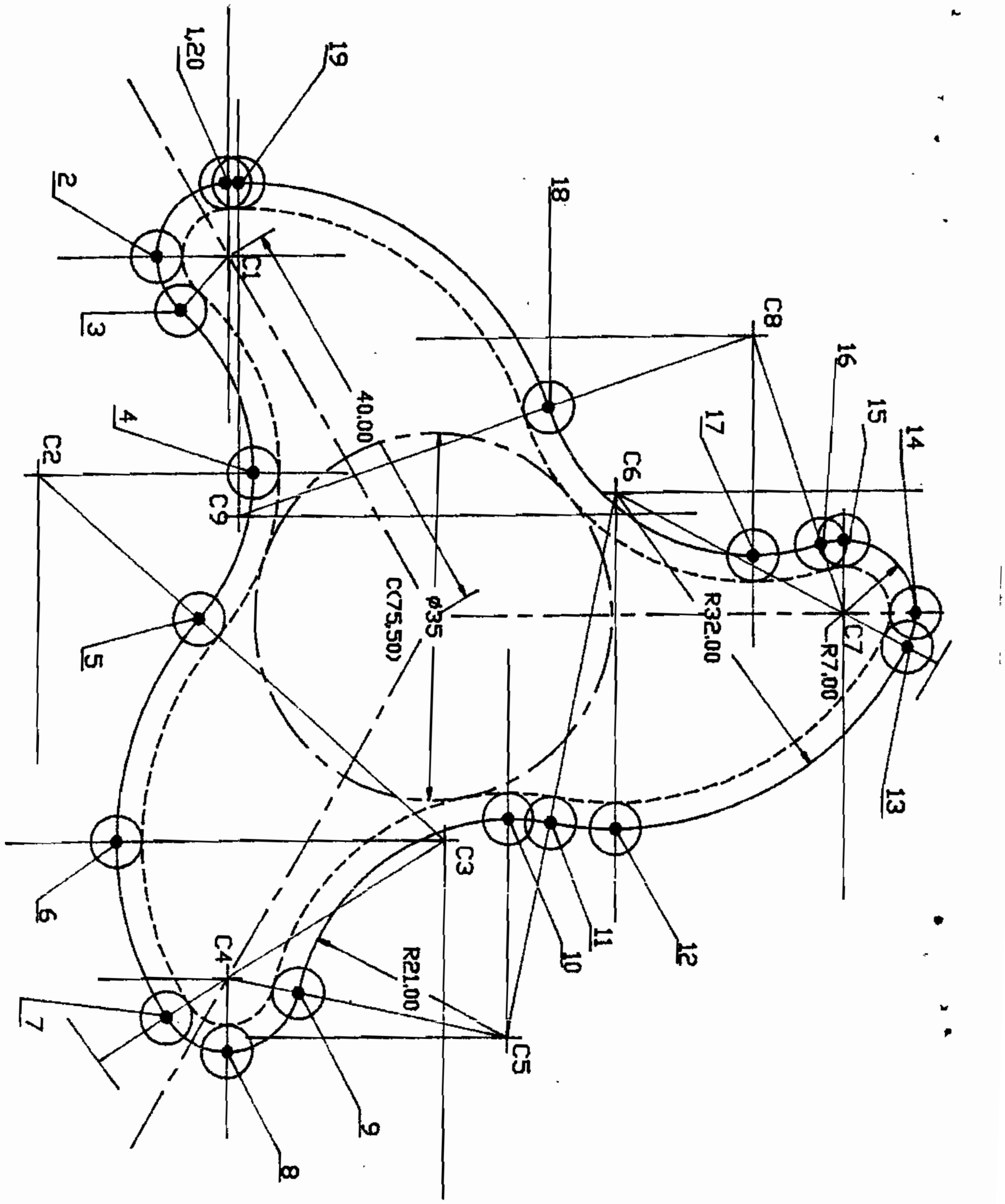

Fig 1. Processes required for analysing the part drawing.

AUTOMATIC GENERATION OF NC PROGRAMS FOR MILLING COMPONENTS

The developed AUTOGMC system [1] translates the exisiting information on the workpiece which previously drawn by the aid of AUTOCAD into data which can be used by dBASEIV to generate the complete commands for machining the workpiece. These functions include tool path , data ordering , operation sequence , miscellaneous and preparatory machine functions , as well as validation of the tooling process. The following examples (complete NC part programs for two different components) as illustrated in Figures 2&3 have been selected from different profilled components to show the complicity of the profile contour in case of milling. Figure 3 illustrates an ellipitical contour. Ellipses considered to be the most complicated profiles to produce on the NC milling machine. It is extremly difficult to prepare the NC part program by manual method , because it is necessary to divide the ellipse into a number of equiangular arcs. The problem is presented in calculating the coordinates of each arc and its centers and it should be noted that a curve drawn around , or inside , an ellipse and a constant distance from it , by manual method , is not itself an ellipse, Puckle and Arrowsmith [3] , and it cannot , therefore be used to define the path of the cutter center. This needs mathematical calculations to define the proper points required. Now , by the aid of AUTOGMC system [1] , it is easy to draw the ellipse , the cutter path and using the command "explode" to replace the ellipce to the simple entities (arcs). Then the user can complete the procedure to extract the NC program as hown in Figure 3.b.

JUSTIFICATION

The justification required for investment in AUTOGMC is best demonestrated by executing the part drawing shown in Figure 1. by the manual programming and by using AUTOGMC. This camparison is clearly appeared in the following , see Table 1.

Process	Time in min	
	Manual	AUTOGMC
. To develop the required drawing	120	10
. Prepare the NC part program	180	2
. Check & edit & effort	90	-
.Total manhour/part	390	12

From the above table the saving in the processing time is almost 95% which considered to be a tremendous acheivment. It is very clear to the production engineering sector that the turnover of the system would be great even if the ential expanditure is very high.

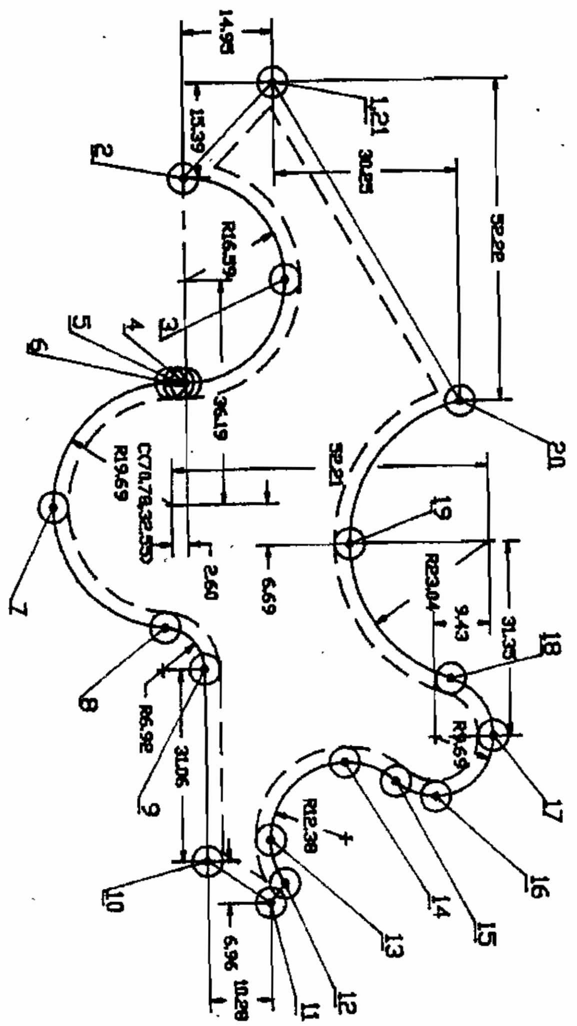

Fig 2.a Example 1.

Record#	G	M	X	Y	Z	I	J	F	S
1	90								
2	71								
3			0	0	5	10	5	1	
4		03							2000
5			2.62	50.16					
6	01				-2			100	
7	01		18.01	35.21				100	
8	02		34.60	51.74		16.58	0.055	100	
9	02		51.19	35.15		0.001	16.58	100	
10	02		51.14	33.97		16.59	0.004	100	
11	03		51.09	32.55		19.64	1.415	100	
12	03		70.78	12.86		19.69	0.004	100	
13	03		90.42	31.14		0.003	19.69	100	
14	02		97.32	37.56		6.903	0.493	100	
15	01		128.38	37.56				100	
16	01		135.34	47.84				100	
17	01		132.21	50.30				100	
18	02		125.07	48.03		7.139	10.10	100	
19	02		112.69	60.41		0.000	12.37	100	
20	02		115.96	68.78		12.38	0.003	100	
21	03		118.51	75.34		7.141	6.557	100	
22	03		108.82	85.03		9.691	0.002	100	
23	03		99.54	78.13		0.001	9.692	100	
24	02		77.47	61.72		22.06	6.634	100	
25	02		54.84	80.41		0.000	23.04	100	
26	01		2.62	50.16				100	
27					5				
28		05							
29		30							

Fig 2.b Complete program list for the part drawing shown in Fig 2.a.

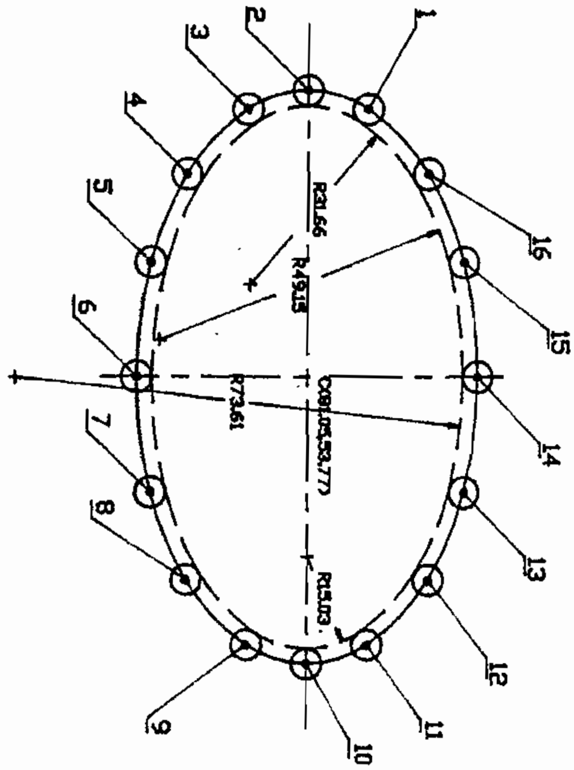

Fig 3.a Example 2.

Record#	G	M	X	Y	Z	I	J	F	S
1	90								
2	71								
3			0	0	5	10	5	1	
4		03							2000
5			34.77	53.77					
6	01				-2			100	
7	03		37.83	43.87		17.53	0.003	100	
8	03		48.33	33.94		28.19	19.27	100	
9	03		62.52	28.01		26.76	44.16	100	
10	03		81.05	25.72		18.52	73.81	100	
11	03		99.58	28.01		0.001	76.10	100	
12	03		113.77	33.94		12.57	50.09	100	
13	03		124.27	43.87		17.69	29.20	100	
14	03		127.33	53.77		14.47	9.896	100	
15	03		124.27	63.66		17.53	0.003	100	
16	03		113.77	73.60		28.19	19.27	100	
17	03		99.58	79.52		26.76	44.17	100	
18	03		81.05	81.81		18.53	73.81	100	
19	03		62.52	79.52		0.001	76.10	100	
20	03		48.33	73.60		12.57	50.09	100	
21	03		37.83	63.66		17.69	29.21	100	
22	03		34.77	53.77		14.47	9.893	100	
23					5				
24		05							
25		30							

Fig 3.b. Complete program list for the part drawing shown in Fig 3.a.

CONCLUSION

Part programmers are hard to find and hard to train. It often takes 24 , even 500 hours to prepare the part program for a component to be produced on the NC machine tool. One of the important questions to be asked to the NC user does this not limit the number of machine tools which can be purchased to increase machining productivity. Saving of processing time and total cost resulted from the automatic generation of the NC programs are very promoted. Our future goal is to design our own interface terminal to use any PC's computer directly with the machine tool control unit to feed the NC data directly to be excuted on the machine tool.

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