

Novel Approach to Automatically Generate Feasible Assembly Sequence

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Abstract

Today the assembly sequence for the items is regularly completed manually and its definition, typically, is extremely extravagant, not ensuring ideal arrangements. Gathering arrangement arranging utilizing a business framework regularly depends on a master assembly sequence organizer, and it is dominantly done manually. The difficulties to consequently produce gathering arrangements utilizing CAD models lie as a part of smart thinking and investigation of the displayed assembly information. This work displays a programmed approach expected to characterize gathering sequences, based on the data containing the mates, obstruction and the volume information existing among the parts, which is acquired by the assembly CAD model of the item. This paper exhibits a framework that can examine and use assembly information accessible from a CAD model to produce gathering arrangements. The framework likewise considers client input as a kind of assembly obligation. The framework is equipped for creating a set of positioned attainable assembly arrangement plans for an administrator to assess. A matrix approach has been embraced to process the data held from a CAD model. Obstruction and volume studies are completed amid the formation of assembly sequence plans.

Keywords: Assembly, Mates, CAD model, Obstruction

1. Introduction

Assembly sequencing assumes a key part in the vital and operational parts of integrative item plan and creation arranging. Mechanical items are regularly mind boggling and made out of numerous segments. In view of this, an item regularly has numerous Assembly sequence plans. A portion of the Assembly arrangements are more productive and better than others. Together with the way of the current outline practice and globalization, there is a need to have the capacity to automatically generate proficient Assembly succession plans. In any case, there are no business frameworks that can automatically generate achievable Assembly sequence plans. Manual Assembly sequence planning practically speaking is dependent on

experienced assembly organizers. Assembly organizers will be obliged to see all the capacities and all the particular points of interest of a product. Besides, products are normally designed at the same time by numerous design groups concentrating on distinctive parts of the design. This sort of design practices is made conceivable through the utilization of Computer Aided Design (CAD) systems. Any postponements or adjustments to Assembly arrangement planning after the fruition of product design could prompt expensive changes for amendment. It is remarkable that in the previous two decades, explore in computer aided design helped gathering sequencing and planning has expanded essentially. There has been a decent measure of exertion done on the era of gathering succession plans. Then again, the data needed to deliver

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Assembly sequences is not generally promptly accessible. Rather, it is generally subject to human aptitude. More or less 70% of the assembling expenses decided at the design and planning stages¹. Accordingly, it is gainful to anticipate viable gathering arrangement plans at the planning stage. An Assembly sequence influences (a) expenses that are identified with the time period in which the product can be fabricated, (b) the set-up of the sequential construction system and (c) the gathering assets needed.

The destination of the methodology to gathering arrangement era is point by point in this paper. The system created can remove significant information utilizing data that is now installed inside a CAD system and to utilize this information to guide Assembly arrangement generation

2. Literature Review

Research advances have been made in both theory and practice of assembly sequencing as shown by the emergence of new assembly planning systems. Frederic Demoly, proposed the system highlights a novel calculation focused around a numerical model coordinating limit conditions identified with DFA principles, designing choices for assembly sequence and the product definition². Luiz S Homen de Mello, This change prompts a decomposition approach in which the issue of dismantling one gathering is decomposed into unique sub issues, each being to dismantle one subassembly³. Daniel F Baldwin, proposed to create gather grouping by utilizing dismantling method and assess the arrangement by utilizing strength, fixturing, introduction, refixturing and reorientation number, and consideration of great states are considered to highlight desirable or undesirable groupings⁴. Jungwoon Yoon, developed a savvy virtual gathering framework in which an ideal get together calculation is utilized to permit haptic collaborations amid virtual gathering operations which provides ideal ways for haptic direction and a get together grouping of the parts to be gathered⁵. S J Hu developed the gathering succession based the item assortment and then broke down the part of operational multifaceted nature and human administrators in gathering frameworks⁶. Y Wang and J H Liu proposed a disorderly molecule swarm advancement (CPSO) methodology to create the ideal or close ideal gathering groupings of items. Six sorts of get together process stipulations influencing the gathering expense are contemplated focused around which the enhancement of the succession is completed⁷.

3. Methodology

The aim of this paper is to find the assembly sequence. In any assembly the sequence in which it is assembled, in the same sequence it has to be disassembled, this approach used in this paper. Various information required for deciding the assembly sequence is extracted from the CAD assembly file. This information is stored in respective matrices. The information required is relationships between all parts of the assembly, secondly the volume of each part and some user input. User input required is the direction in which each part is going to be assembled. In this approach we are eliminating all the fasteners like nut, bolt, screws, rivets or any adhesives used for joining two parts since its designer choice how to join to parts by using necessary fastener. Hence fastener need not be considered in the assembly sequence.

3.1 Working of Algorithm

Algorithm shown in Figure 3 is developed for generating a feasible assembly sequence. First all the required information is extracted from the CAD file and the respective matrices are formulated with the help of some user inputs.

Step 1: Extraction of all information and storing in various matrixes

1) Formation of mate matrix

From the CAD assembly through API all the mates present in the assembly are extracted and stored in a database as shown in Figure 1⁸. Using this database mate matrix is formed which gives relationship information between all the parts Table 5. Number 1 denotes there is a mate between parts A and parts B, number 0 denotes that there is no mate between the two parts. Diagonal elements are crossed marked as there cannot be any mate for any part with itself.

2) Formation of Volume matrix

While assembling care has to be taken that the parts remain stable. For these purpose bigger parts having larger volume has to be assembled first. Based on the volume of individual parts a ranking is provided by extracting the volume of each part from the CAD file and stored in the form of a sequence as listed in the table 2. Then a comparative study is done between two parts. Here number 1 denotes that part A is having a greater volume then B and number 0 denotes that part B is having a smaller volume then B this is indicated in Table 3.

```

[File = I:\cranehooknew\Final.SLDASM
Mates
--
Coincident20"
...
Coincident20"
--
Type = 0"
AlignFlag = 0"
CanBeFlipped = False"
...
Component = pulley-1"
MateEntType = 1"
(x,y,z) = (0.186460207984886, 0.560655296117742, 6.51343217279855E-03)"
(i,j,k) = (-1, -3.55870217016525E-17, -3.90093997095358E-16)"
Radius 1 = 0"
Radius 2 = 0"
...
Coincident20"
--
Type = 0"
AlignFlag = 0"
CanBeFlipped = False"
...
Component = bush1-1"
MateEntType = 1"
(x,y,z) = (0.119586032784304, 0.560655296117742, 6.51343217279855E-03)"
(i,j,k) = (-1, 0, 0)"
Radius 1 = 0"
Radius 2 = 0"
...

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Figure 1. Data Base.

3) User input

User will have to define in which direction the parts are going to be assembled that is along X, Y or Z. This input data is collected and stored in user input matrix as shown in Table 4. In this approach we are assuming that all the parts can be assembled in 3 principle axis that is X, Y and Z and no inclined parts.

Step 2: Generation of assembly sequence

Disassembly sequence is found using the obstruction test and the opposite will give the assembly sequence. First of all the parts will be checked for obstruction and the parts which do not collide while disassembling will be selected. Each part will be checked for obstruction in the direction in which it is going to be assembled as specified by the user. If 'N' parts passes this obstruction test one will be selected based on the weightage given to the volume and mates of the corresponding part. One point weightage is given to mates it has with other parts and two points to the volume of that part. Using equation 1 scores of each part is calculated. Where X is rank based on mate matrix and Y is rank based on volume matrix. The part having least number will be assembled last and hence that part will be disassembled first. This part forms the base part of the algorithm. Next the part which is related to the selected part is checked for obstruction and if 'N' parts

pass the obstruction test, again the same scoring procedure is repeated to select one part. This procedure is repeated till all the parts are selected. The inverse of the disassembly sequence will give the assembly sequence. The reason for selecting part with lesser volume last in the assembly sequence is to take care of stability of the product while assembling. Parts with more weight or volume are advised to assemble first⁹.

A. Implementation with an Example

Crane hook assembly shown in Figure 2 and Figure 4 is taken as an example and the algorithm is implemented on it to find the possible assembly sequence. All the parts of the assembly are listed in Table 1.

All the required information is extracted from the CAD file and stored in the corresponding matrices. Then the obstruction test is done by selecting one part at a time. As seen in the Figure 7 we cannot disassemble pulley before cover plate-1, it clearly shows obstruction of the pulley with cover plate-1. Only cover plate can be disassembled first before the pulley as shown in Figure 6. Hence Cover plate becomes the base part that is the part to be assembled at the end. Two parts passes the obstruction test, in this case both this parts are similar and has same score calculated using numbers of mates and volume of the part, any one part can be cho-

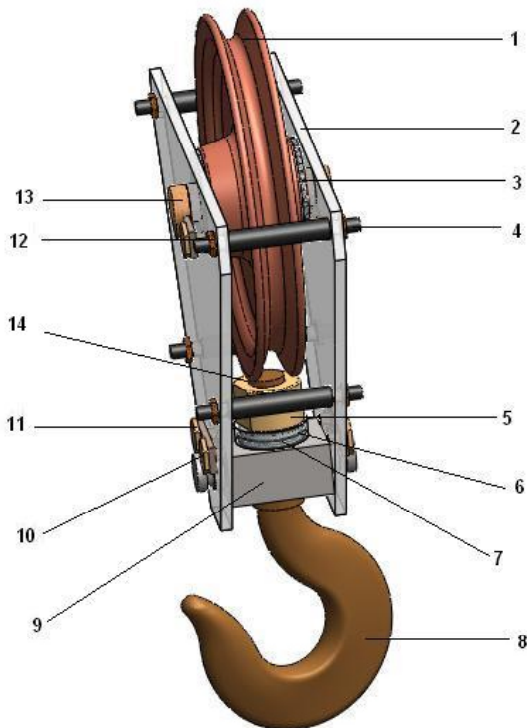
Hook
Cross Head Block
Thrust Bearing
Dust Cover
Pulley
Pulley Pin
Bush-2
Bush-1
Cover Plate-2
Lock Plate-4
Lock Plate -3
Cover Plate-1
Lock Plate-2
Lock Plate-1



Assembly sequence



Disassembly Sequence



sen in such condition. Out of the remaining parts, the parts which are having mates with the selected part are checked for obstruction test. The part which clears the obstruction test is selected next for disassembly. This

Table 1. List of Parts in the Assembly

SLNO	PART
1	PULLEY
2	COVER PLATE
3	BUSH
4	DISTANCE BOLT
5	NUT
6	DUST COVER
7	THRUST BEARING
8	HOOK
9	CROSS HEAD BLOCK
10	LOCK PLATE
11	HEX SCREW
12	NUT M20
13	PULLEY PIN
14	SPLIT PIN

Based on the Volume Analysis the Following Sequence of Parts is generated:

Table 2. Sequence of Volume

PART	RANK
Hook	1
Pulley	2
Cross Head Block	3
Thrust Bearing	4
Cover Plate	5
Pulley Pin	6
Bush	7
Lock Plate	8
Dust Cover	9

Table 3. Comparative study

	Hook	Pulley
Hook	x	1
Pulley	0	x

process is repeated till all the parts are selected; the inverse of this gives the assembly sequence. The assembly sequence generated after the implementation of the algorithm is:

Assembly Matrix

Table 4. User Input Data

Part Name	Direction to be assembled
Hook	Y
Cross Head Block	Y
Thrust Bearing	Y
Dust Cover	Y
Pulley	X
Pulley Pin	X
Bush-1	X
Bush-2	X
Cover plate-2	X
Lock Plate-4	Z
Lock Plate-3	Z
Cover Plate-1	X
Lock Plate-2	Z
Lock Plate-1	Z

4. Conclusion

In this paper new algorithm to automatically generate assembly sequence has been developed. A matrix based approach is used to generate the assembly sequence. A system automatically extracts the information about the assembly from the CAD file. This information like obstruction of parts while disassembling, mates between various parts and volume of each part is analyzed and the assembly sequence is generated. A systematic system is implemented with the use of matrices to store this information. First matrix is the mate matrix containing relationship information, second is the volume matrix containing volume of each part, and third is the obstruction matrix containing the obstruction test result and fourth matrix stores the user inputs containing the information about the assembly direction. Output of the system is an assembly sequence plan. This will reduce time and money which is required for planning the assembly sequence and also reduce human interference. Implementation of this system will surely increase the productivity of any manufacturing industry.

Table 5. Mate Matrix

	Hook	Cross Head	Thrust Bearing	Dust Cover	Pulley	Pulley Pin	Bush-1	Bush-2	Cover plate-2	Lock Plate-	Lock Plate-	Cover Plate-	Lock Plate-	Lock Plate-
Hook	X	1	0	0	0	0	0	0	0	0	0	0	0	0
Cross Head Block	1	X	1	1	0	0	0	0	1	1	0	1	1	0
Thrust Bearing	0	1	X	1	0	0	0	0	0	0	0	0	0	0
Dust Cover	0	1	1	X	0	0	0	0	0	0	0	0	0	0
Pulley	0	0	0	0	X	1	1	1	0	0	0	0	0	0
Pulley Pin	0	0	0	0	1	X	1	1	0	0	0	0	0	0
Bush-1	0	0	0	0	1	1	X	1	0	0	0	1	0	1
Bush-2	0	0	0	0	1	1	1	X	1	0	1	0	0	0
CoverPlate-2	0	1	0	0	0	0	0	1	X	1	1	0	0	0
Lock Plate-4	0	1	0	0	0	0	0	0	1	X	0	0	0	0
Lock Plate-3	0	0	0	0	0	0	0	1	1	0	X	0	0	0
CoverPlate-1	0	1	0	0	0	0	1	0	0	0	0	X	1	1
Lock Plate-2	0	1	0	0	0	0	0	0	0	0	0	1	X	0
Lock Plate-1	0	0	0	0	0	0	1	0	0	0	0	1	0	X

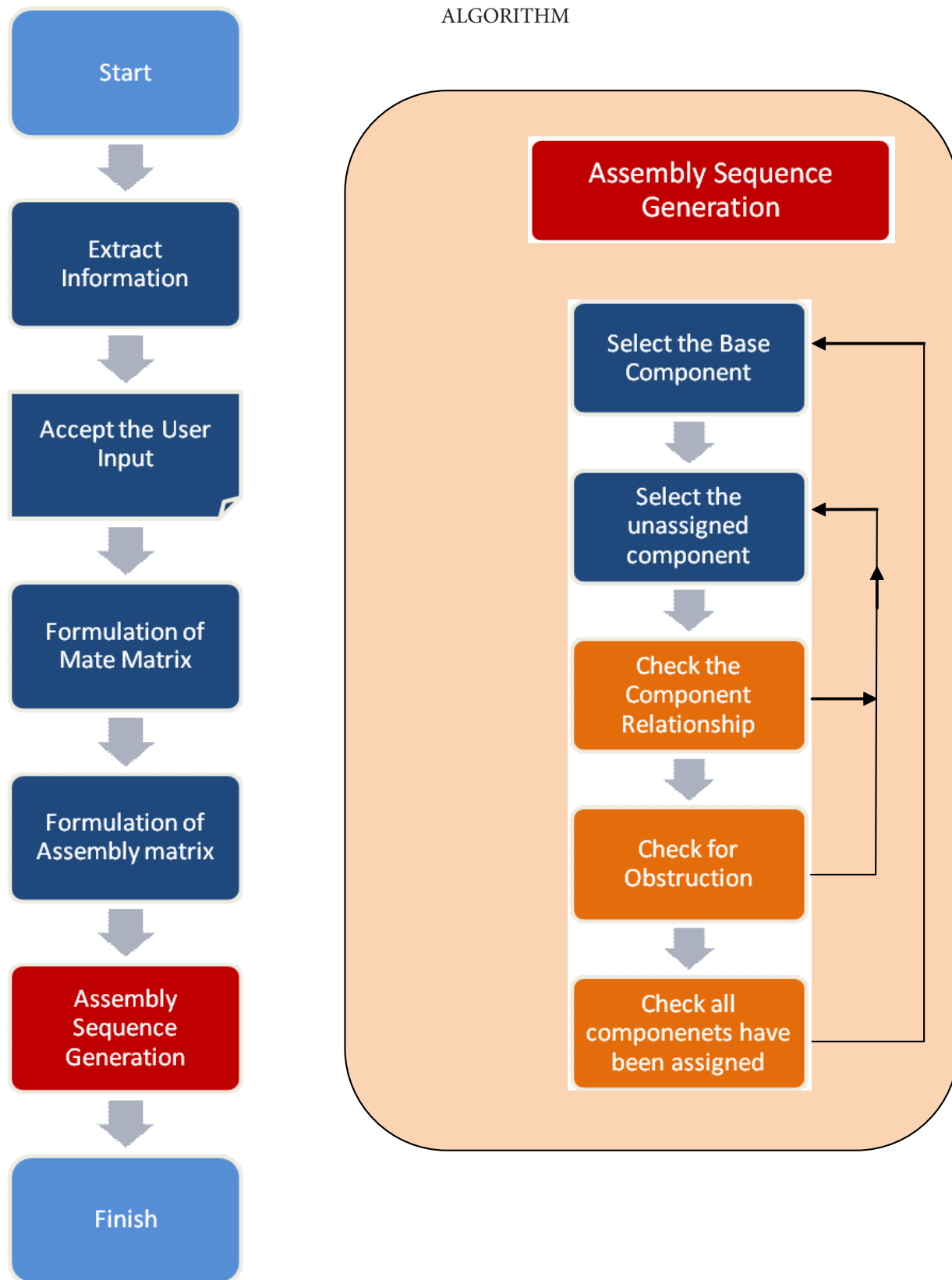


Figure 3. Schematic representation of Algorithm.

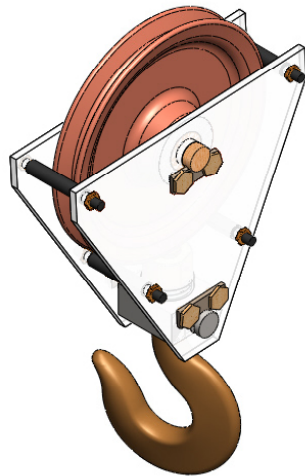


Figure 4. Crane Hook Assembly

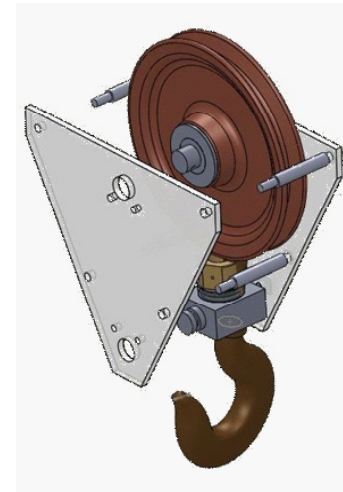


Figure 6. Obstruction Test (Cover plate removed first)

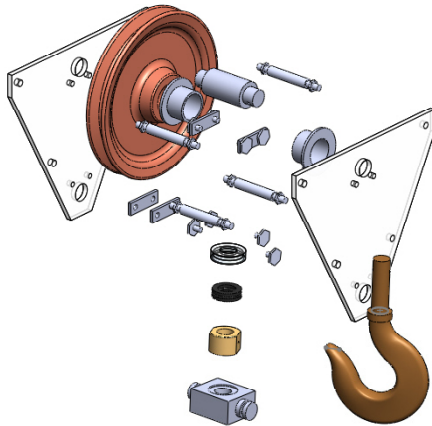


Figure 5. Crane Hook Exploded

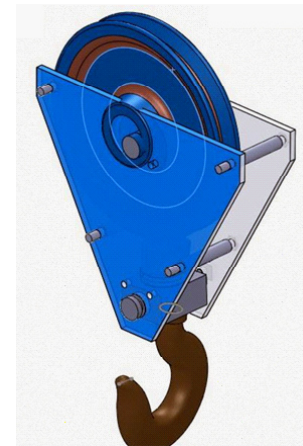


Figure 7. Obstruction Test (pulley removed first)

5. References

1. Nevins JL, Whitney DE. Concurrent design of product and processes. New York: McGraw-Hill; 1989.
2. Demoly AN, Xiu-TianY. An assembly oriented design framework for product structure engineering and assembly sequence planning. Journal of Robotics and Computer-Integrated Manufacturing. 2011; 27:33–46.
3. Luiz S, Homen de Mello. Assembly sequence Planning. Journal of Robotics and Computer integrated manufacturing. 1990.
4. Baldwin DE, Whitney DE. An Integrated Computer Aid for Generating and Evaluating Assembly Sequences for Mechanical Products. IEEE transactions on robotics and automation. 1991 Feb; 7(1).
5. Jungwon Y. Assembly simulations in virtual environments with optimized haptic path and sequence. Journal of Robotics and Computer-Integrated Manufacturing. 2011; 27:306–17.
6. Hu SJ. Assembly system design and operations for product variety. Journal of Manufacturing Technology. 2011; 60:715–33.

7. Wang Y, Liu JH. Chaotic particle swarm optimization for assembly sequence planning. *Journal of Robotics and Computer-Integrated Manufacturing*. 2010; 26:212–22.
8. Mathew AT, Kossambe I, Kavlekar A, et.al. Automatic Identification of Sub Assembly in an Assembly. *International Journal of Applied Engineering Research*. 2013; 8(17). ISSN 0973-4562.
9. Mathew AT, Rao CSP. A Novel Method of Using API to Generate Liaison Relationships from an Assembly. *Journal of Software Engineering & Applications*. 2010; 3:167–75.