An Intelligent Strategy for Automated Assembly Sequence Planning While Considering DFA Concept

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Abstract

Recent advancement in Design For Assembly (DFA) has driven product designers towards minimizing the number of parts in a product so as to reduce the assembly efforts and cost. Many industries are using the DFA concept on their own and there is no particular method or automation to apply the DFA concept for the products. However, there is also no particular method to develop assembly sequence along with applying the DFA concept for the industrial products. In manufacturing, 30% of time consumption is only due to assembly operation as compared to the remaining processes in manufacturing. By application of DFA concept to the products, not only we can reduce the time of the assembly but also we can reduce the manufacturing part number also. As the part number reduces in the assembly, manufacturing cost of the parts and assembly of the parts also drastically reduces. There exists many Computer Aided Design (CAD) based and Artificial Intelligence (AI) based methods to obtain the optimum feasible assembly sequence for the reduced number of parts obtained from the DFA concept. In this research, a novel method is implemented to automate the assembly sequence planning with the help of AI techniques along with the DFA concept. The proposed methodology has been implemented to an industrial product in order to validate the assembly sequence.

Keywords: Design for Assembly, Assembly Sequence Generation and Artificial Intelligence.

1. Introduction

DFA plays a key role in manufacturing industry to minimize assembly cost by modifying the product topology by reducing the number of parts in the assembly [1-2]. DFA simplifies the design and reduces the number of parts in the assembly because assembly is one of the major cost contribution operation in the manufacturing industries.

To overcome the said problem, researchers have worked towards implementation of knowledge based methods. As these methods consume lot of computational time due to huge search space for products with more number of parts [3-5]. In the last decades, several focused on AI techniques have been implemented to avoid huge search space problem in assembly sequence planning. Though these approaches are successful to certain extent the major limitation with these approaches is local optimal solution.

In most of the AI techniques, the input supplied to the process is generated manually, which is also time consuming. Hence computer aided methods have been evolved to extract such information through various Computer Aided Design (CAD) exchanging data formats [6-11]. Graphical methods are used for testing the geometrical feasibility in the early stages. These methods uses advanced CAD based assembly attribute extraction to reduce the human error and minimize the computational time.

Besides liaison and geometrical feasibility predicates, stability and mechanical feasibility are two essential assembly predicates to yield the appropriate results. The computer aided extraction of stability was discussed by several researchers [12-15]. These methods so far existed fails to obtain the optimal assembly sequence along with DFA concept.

In this research an automated method is implemented to generate optimal assembly sequence along with the DFA concept. The application of DFA concept leads to reduce in the levels of the assembly by which time of the assembly as well as cost of assembly of the parts reduces.

2. Role of Assembly Predicates in Applying the DFA concept and to Obtain the Optimum Assembly Sequence for the Industrial Products

A valid optimum assembly sequence generation for the modified topology of the products can be generated by the assembly predicates for practical possibility in physical environment. In the present research work, different types of assembly predicates are used to generate the modified topology for given assembly and to obtain the optimal assembly sequence by reducing the cost and time of the assembly and manufacturing.

1. Liaison information.
2. Material information
3. Relative motion information
4. Functionality information

These predicates are used for DFA concept

5. Stability information
6. Geometric feasibility information
7. Mechanical feasibility information

These predicates are used for obtaining optimal assembly sequence

3. Optimal Assembly Sequence Generation through General Search based DFA Method

The developed method initially generates the random sequence for the designed product in CAD environment. The generated random sequence is checked by DFA predicates, satisfying these criteria a new assembly will be generated with reduced number of levels. The reduced levels of the assembly sequence is then send to evaluate the fitness. This process will continue till termination criteria satisfies. The optimum assembly sequence obtained from this method is having the modified topology with reduced levels of the assembly sequence. As the assembly sequence is of reduced levels the cost of manufacturing and time of the assembly reduces. To validate the proposed methodology, an industrial product (Machine frame) with 16 parts has been considered which is shown in the Figure 1.

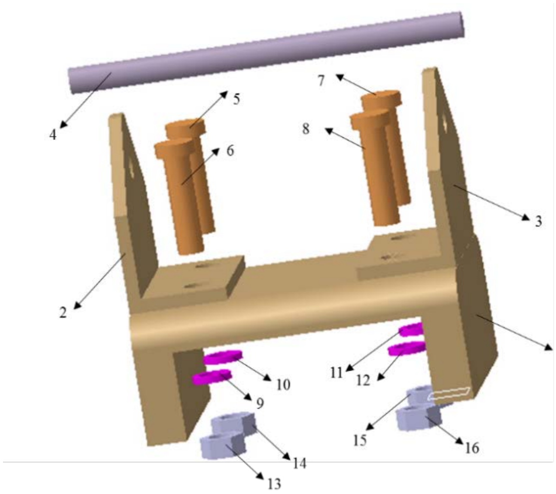

Figure 1 Machine Frame Assembly

1: Base 2 &3: L shaped frames 4: Rod 5, 6, 7&8: Bolts 9, 10, 11&12: Washers 13, 14, 15&16: Nuts

The detailed methodology is explained with the flow chart in Figure 2.

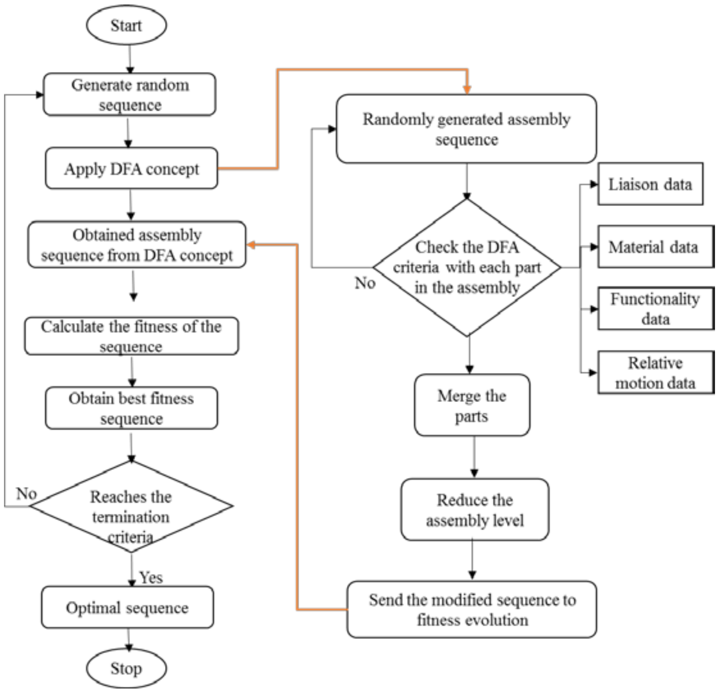

Figure 2 Detailed flowchart of intelligence strategy based DFA method

3.1 Generation of optimal assembly sequence for modified topology machine frame

The modified topology obtained from the DFA concept with reduced levels of the assembly sequence is sent to evaluate the fitness to obtain the optimum assembly sequence. The modified topology of the machine frame is shown in the Figure 3.

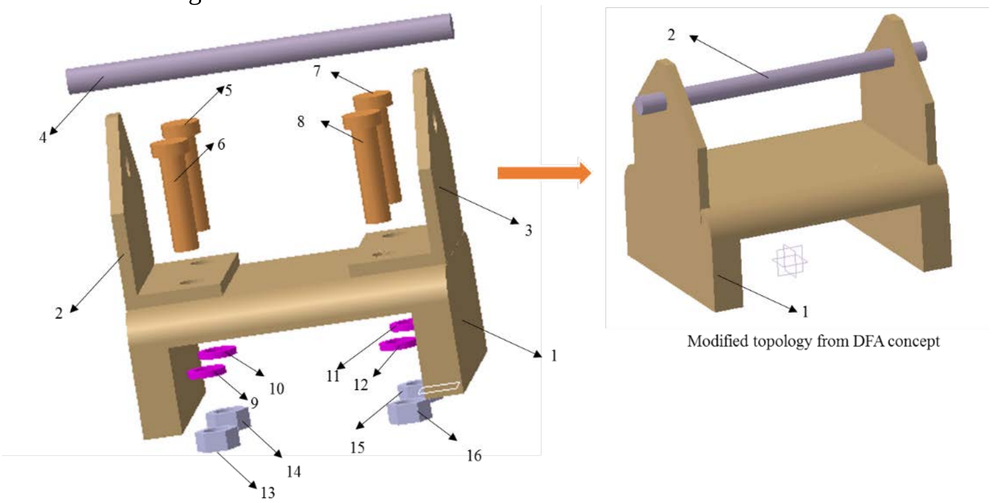

Figure 3: Modified topology of the machine frame

After application of the DFA concept the 16 part (12 bolts and nuts) machine frame is modified into 2-part machine frame. The optimal assembly sequence for the 2-part machine frame assembly is:
The sequences are: **1-2 or 2-1**

Conclusions

A novel strategy is proposed along with design for assembly for automated optimal assembly sequence planning on industrial products. In this methodology an optimum assembly sequence with modified topology by reducing number of assembly levels has been achieved. This methodology merges the parts those satisfies the DFA predicates, by which cost of the manufacturing and as well as the time and cost of the assembly drastically reduces. The proposed method successfully results in optimal assembly sequence with modified topology along with satisfying all the assembly predicates. As this method is automated, there is no need of human intervention and there by human error is completely eradicated. This automated method reduces the number of parts of the assembly there by reduces the levels of the assembly sequence and thus lot time is saved and speed of manufacturing occurs.

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