Optimal assembly sequence planning of fixture in a virtual environment

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ABSTRACT
Present day scenario in industry signifies the use of state of the art computer technology in the design, development and manufacturing of systems. Parametric designing techniques used which has profound impact on the reduction of design time. The aim of the paper is to discuss about the fixture design and assembly sequence in virtual environment. With the aid virtual assembly by computer simulation make the product designers to do design verification and nullify design effects and ergonomical errors in the design. Assembly sequence planning is part of a hierarchy of steps in assembly system design for manual, fixed automation, or programmable automation systems. In this paper we used Genetic algorithm for generating optimal fixture assembly (CAFDA) sequences.

Keywords: Fixture assembly, Genetic Algorithm, virtual assembly.

1. INTRODUCTION
Due to today’s heavy, growing competition environment, manufacturing companies have to develop and employ new emerging technologies to increase productivity, reduce production costs, improve product quality, and shorten lead time. A. Senthil kumar, A.Y.C Nee et al. [1] developed basic interactive fixture design functions across the internet. The main objective of this initial version is to demonstrate the feasibility of true 3D fixture design remotely over the internet implementing client server architecture. Guolin Duan [6] et al., described XML-based modular fixture graphs library including XML template, XML data producing, etc., and CAD data interface. Iain Boyle [8] in CAFxD methodology explained how the design experience is retrieved from design library and adapted to provide a new fixture design solution. Shu Huang Sun and Jahau Lewis Chen [13] explained a fixture design system based on case-based reasoning (CBR). During the last couple of decades the computers have been increasingly used to assist design activities. The beginnings of their application date back to the sixties of the last century, when they were first successfully used to control machine tools. This was followed by an expansion of their application in various domains of manufacturing engineering. Today, the emphasis is placed on the intelligent manufacturing systems which are able to solve problems without the use of an explicit and detailed algorithm or a mathematical interpretation of the problem. Virtual Reality (VR) has gained great attention during the past few years and is currently explored for practical uses in various industrial areas e.g., CAD, CAM, CAE, CIM, CAPP and computer simulation etc. Owing to the trend towards reducing lead time and human effort devoted to fixture planning, the computerization of fixture design is required. Virtual Reality crosses multiple domains and it is important that the related technologies develop synchronously to enable industrial applications of virtual assembly (Jezernik et.al [10]). It is envisioned that the distinction between CAD (Computer-Aided Design) and virtual reality systems will converge as new design systems will encompass features from each of the technologies.

2. PROBLEM DESCRIPTION
Planning the sequence of components (or parts) to be assembled during manufacturing is an important application problem for virtual environments for three main reasons. First, it is a highly visual problem. Second, a majority of assembly operations in factories (with the exception of simple pick-and-place operations) are still performed manually, because they are difficult to automate. Hence, it is an important problem involving human-machine interface. Third, there are a number of assembly operations which require dexterous operator training. Hence, it is also an important training problem.

3. PROPOSED METHODOLOGY
The primary objectives were to develop an interactive VR system entitled Computer Aided Fixture Design & Assembly System (CAFDA), which will allow fixture designers to complete the entire design process for modular fixtures within the Virtual Environment (VE) for instance: Fixture element selection, fixture layout design, assembly, analysis and so on. The main advantage of CAFDA is that the VR system has the capability of simulating the various physical behaviours for virtual fixture elements according to Newtonian physical laws, which will be taken into account throughout the fixture design and evaluation process.
4. GENETIC ALGORITHMS (GA)

Genetic algorithms (GAs) are adaptive search and optimization algorithms that mimic the principles of natural genetics. GAs are very different from traditional search and optimization methods used in engineering design problems. Because of their simplicity, ease of operation, minimal requirements and global perspective, GAs has been successfully used in a wide variety of problem domains. GAs was developed by John Holland of University of Michigan in 1965.

4.1 Assembly Modelling:

The first stage to search the assembly plans of a product is to have a good representation of the product. Most of the algorithms that deal with the assembly planning problem use a liaisons graph to model the product. Liaison: A relationship between two parts which are touching or effectively touching, whether physically attached or not. In Liaison graph, parts are dots, joints are lines. This is also called as “graph of connection”. The connections are defined by the pair of parts, which they connect. Therefore the precedence constraints are defined as an ordered list of connections, where every restricted connection is paired with its precedence connections. To calculate the feasible subassembly pairs out of the neighbour subassemblies, it needs to check whether the removed edges satisfy the precedence constraints or not. To generate the neighbouring subassembly pairs, it needs to remove certain connection (separation edges) of the original assembly.

4.2 Working Principle of GA

Genetic algorithms are search and optimization procedures that are motivated by the principles of natural genetics and natural selection. Some fundamental ideas of genetics are borrowed and used artificially to construct search algorithms that are robust and require minimal problem information. The working principles of GAs are very different from that of most of traditional optimization techniques. Here, we first describe the working principles of GAs. In order to use GA to solve the above problem, the variable $x$ is typically coded in
some string structures. Binary coded strings are mostly used. The length of the string is usually determined according to the accuracy of the solution desired. For example, if five bit binary strings are used to code the variable \( x \) then the string \((0 \ 0 \ 0 \ 0 \ 0)\) is decoded to the value \( x_{\min} \), the string \((1 \ 1 \ 1 \ 1 \ 1)\) is decoded to the value \( x_{\max} \) and any other string is decoded to a value in the range \((x_{\min}, x_{\max})\) uniquely.

It is worthwhile to mention here that with five bits in a string there could be only 2 or 32 different strings possible, because each bit position can take a value 0 or a 1. In practice, strings of size hundred or a few hundreds are common, recently a coding with string size equal to 16,384 has also been used. Thus with five bit strings used to code the variable \( x \), the accuracy between two consecutive strings is only \((X_{\max} - X_{\min})/32\). If more accuracy is desired, longer strings may be used. It is also noteworthy that as the string length increases the minimum possible accuracy in the solution increases exponentially. With a known coding, any string can be decoded to an \( x \) value, which can then be used to find the objective function value. The objective function is used to provide a measure of how individuals have performed in the problem domain. The objective function for the problem is to obtain an optimum or near-optimal assembly plans based on the minimization of the makespan (or) total assembly time for a given product. The objective function is defined as follows.

\[
C_t (AP) = \sum_{i=1}^{n} P_t (i)
\]

\( MS = \text{Min} \{ C_t \} \)

The fitness function is normally used to transform the objective function value in to a measure of relative fitness. Since the objective is a minimization problem, the objective function value itself is used as fitness function. The fitness function must be calculated for the initial set population and after performing genetic operation so as to evaluate the fitness for each string. The significance of evaluating the fitness value for each string provides information to decide whether the strings are carried for next iteration (generation) to obtain the desired result.

5. VIRTUAL ASSEMBLY:

The virtual assembly is defined as the process of mating the components of different shapes and sizes as per geometrical and modelling features of the components to make a sub-assemblies or a products in the Virtual environment that is with the help of Software like PRO E Wildfire 4.0, CATIA V5 R16 etc. To create real environment we have to use VIRTool software. Virtual assembly plays an important role in product
development cycle to analyse the Geometrical Dimensioning, Limits and Tolerances etc. before manufacturing the product in real time environment. It helps the designer to take decision upon the design and modification in virtually.

![Flow chart of proposed virtual assembly system](image)

Fig.4: Flow chart of proposed virtual assembly system

The virtual assembly system included an intelligent algorithm (GA) to enhance the effectiveness of the assembly task. The proposed intelligent assembly scheme allowed an operator to achieve the optimal assembly process by following an optimal assembly sequence. An experiment is planning to evaluate the effectiveness of the intelligent virtual assembly simulation and sequence guidance from the suggested optimal assembly results. The operators followed the following four main assembly steps:

1) Choosing a part,
2) Choosing a gripper,
3) Selecting the part, and
4) Assembling the part.

When performing the task, the operator used certain assistance features, such as the optimized sequence of parts with guidance for gripper selection and assembly orientation, and the optimized assembly path. The following steps used for Virtual Assembly System.

1. The operator simply selects the parts and performs the assembly tasks based on the results of the optimal assembly sequence.
2. The suggested assembly sequence affects the order of each part’s appearance in the VE.
3. After a part appears in the VE, the operator should choose a gripper.

The following behaviour link is used for constructing the fixture assembly

5.1 Creation of lapping fixture assembly in virtual environment:
Considering the complexity of the fixture geometry, the fixtures were built in CAD software solid works, Pro/Engineer® etc., The models were then exported in VRML file format. The use of Pro/Engineer® was limited to building individual components of the complete fixture assembly. The different attributes of the parts
such as colour, position in fixture assembly, and lighting effects in VRML world were given by using existing nodes in VRML specification. The animation of parts in the world was done using VRML. Navigating through the 3D VRML world is very simple. Getting acquainted with the VRML browser interface is in order. Following figure shows a sample VRML window.

Figure 5. The Behaviour Links and the Parameter Link (VIR Tool)

Fig: 6. lapping fixture assembly
Fig: 7. lapping fixture assembly .vrml (Solid works)

5.2 Designing modular fixtures consists of the following steps;
The system will have standard components under each section which can be selected and the fixture can be built. JavaScript will be used to obtain data from the user and build the fixture in a virtual world. It is required to build an interface between VRML and Java. Selecting proper tooling plates as per the size and orientation of the part Identify the features of the part over which the part will be located on the fixture. Select appropriate locating elements. Select appropriate mounting elements to build the basic structure of the fixture. Also select mounting elements to mount the locators onto the fixture base. Identify the purpose of fixturing, whether it is machining, grinding, lapping or inspection fixture. Also identify different forces acting on the fixture and work-piece so as to select the proper clamping.

6. CONCLUSION
The main aim of this Paper is to realize the optimal assembly sequence planning for fixtures using the interactive VR simulation (VIRTOOL Software) and provide the function of recording the animation for the process of Virtual fixture design and assembly. C programme is developed for the Optimal Fixture design and assembly sequence. The main contribution of this paper is considered as the research gap between VR and Fixture Design can be narrowed down by generating the appropriate visualization and 3D graphical representation for fixture elements during the process of optimal fixture design and assembly. In order to increase the efficiency of the manufacturing system as a whole, there is a logical requirement to integrate the information systems which support design decisions, and other systems which support enterprise management functions. The process of fixture design is not entirely synchronized with other design processes. Future approaches to fixture design methodology must be focused not only on CAD/CAM integration, but more importantly, on providing support for multidisciplinary through concurrent engineering paradigm.
REFERENCES:


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