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Make Harmony Between Technology and Nature, and Your Mind will Fly Free as a Bird
*Young Researches and Scientist Paper / * Supervisor, Mentor*

ASSEMBLY/DISASSEMBLY PROCESS MODELING

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Abstract: *Assembly/Disassembly (A/D) simulations are important for improving designs and efficiency of product development processes. In order to get efficient simulation processes it is important to simulate all the possible relative movements between the components in a mechanical system. This is important both in the context of interactive simulation and in the context of immersive simulations. The authors are members in the project: "Assembly/Disassembly Process Modeling", project type: Research projects for stimulation of the founding/forming of young independent research teams, co-founded by CNCSIS. This paper contains some aspects regarding the methodology and the main proposed objectives for assembly / disassembly process modeling.*

Key words: *assembly, disassembly, simulation, contact, kinematic model*

1. INTRODUCTION

Assembly/Disassembly (A/D) simulation has been for a long time, the subject of many scientific contributions. To obtain an optimum A/D process, different methods are applied such as combining interference matrices of product components with connection matrices; special connection relations; disassembly sequence matrices and instability of sub-assemblies; changes of sub-assembly/disassembly direction or tools. Also, since the 90's we can mention some complex software for assembly analysis.

From a complementary point of view, for some A/D simulation approaches 3D shapes of components and/or assemblies are key elements (Brough et al., 2007). Path planning required for moving components into a complex environment strongly rely on the 3D shapes. Depending on the simulation purpose, these shapes can be either a polyhedron or a B-Rep NURBS model if the models come from a Computer Aided Design (CAD) software (Coma et al., 2003).

Focusing on simulations where contacts between components are of particular interest to characterize their relative mobility, prior works have shown that models fit into the following situation: apart from finite translations, all the possible movements are reduced to infinitesimal translations (Marcelino et al., 2003). Using this method, the range of movements is drastically truncated and the contacts between components are only partially described. In addition, the identification of the contacts between the components is generally interactive only, hence making A/D simulations very tedious and strongly reducing their *reality and usefulness*.

Also, the relative mobility of components is also a key element contributing to A/D simulations, especially if 3D component models are really contributing to simulations (Howard & Vance, 2007). In this case, they can be represented exactly for all types of functional surfaces (planes, cylinders, threads etc.) or approximated with infinitesimal translations only.

We note that almost all mechanical products are designed using one of the common CAD modellers. So far, we know that all these software are lacking of strong properties for assembly analysis. Even though CAD or Product Life Cycle Management (PLM) software can incorporate assembly modules enabling to define some mating conditions between components, these conditions are limited to the specification of some surface or axis' positions. This means that the surfaces really involved in these constraints are neither explicitly identified nor their location is really taken into account to make sure that they are effectively sharing some common areas. Therefore, the proposed constraints are more related to component positioning than to effective contact specification between components. This type of information is frequently not available when a product is transferred from one software environment to another one. Therefore the product representation is visually obtained and considered as satisfactory when all the components are simultaneously displayed. Also is important to define the contacts between components through a set of information intrinsic to the concept of contact and, in addition, a contact identification module must be integrated in an A/D simulation framework.

As a result, an A/D simulation framework should be able to manage the contacts in two different configurations: the static and kinematic ones. Knowing that A/D simulations based on VR approaches use polyhedral representation, we can mention that a few approaches have been developed for contacts finding using polyhedral models but the results are not always accurate and robust due to the local nature of the algorithms, which are sensitive to the triangle sizes (Liu & Tan, 2007). Especially when the input model of components come from CAD software, it is important to take advantage of the B-Rep NURBS description to strengthen the algorithms and obtain a more transparent access to the behavior of the assembly components in the simulation framework.

2. PROJECT MAIN OBJECTIVES

The main objective of the design and development process of products and systems is to meet the needs of users and consumers, while ensuring compliance with environmental legislation and profitability.

Modeling the Assembly/Disassembly (A/D) operations requires a lot of geometrical, kinematical and technological data and their synthesis in order to reduce the algorithmic complexity of the A/D process. An efficient simulation application should be able to simulate all the possible relative movements between the components at each stage of the A/D process. In this context, the first objective is to determine a way of describing the valid trajectories for A/D of the assembly components.

Interactive sequencing is a first category of applications needing models of component mobility. Having the ability to model translations, rotations and helical movements is mandatory to produce realistic component sequencing. Missing trajectories may discard solutions appearing as obvious from a user's point of view. In addition, having the ability to model the mobilities associated to partial contacts is also critical to avoid missing possible trajectories, hence a general purpose operator capable of characterizing a wide diversity of configurations is a key issue to improve the quality of simulations. Also, interfacing the mobility model with path finding algorithms is a mean to provide more realistic boundary conditions than just trajectory extreme points. Thus, another goal is to define a general purpose operator to evaluate (to combine) the family of trajectories for the assembly components.

Kinematic constraints reduce the number of free degrees of freedom, hence reducing the diversity of interferences as well as the computation time. In addition, immersive simulations require a capability to switch, in a transparent manner, from the kinematically constrained mode to the free mode so that the user's immersion is of high quality. To this end, input from position and force sensors available in a haptic environment must be used to identify constraints that need to stay consistent with the sensors, kinematic constraints must be transparently activated or deactivated in accordance with the user's movement and the diversity of kinematic constraints must be able to cope with the whole range of sensor data to avoid unrealistic changes between modes. As a result, another objective of this research is to characterize and use the mobility of elementary contacts between components (rotations, translations, helical movements) in order to define all the possible families of trajectories for extracting or inserting a component into a mechanism. We think that a new type of data structure for the assembly representation should be developed. This structure will offer a way for explicitly representation of the semantic information attached to a shape and it will create a link between two different representations of the same model: B-Rep NURBS and polyhedral.

The simulation of the A/D operations is currently a very important issue in order to determine, from the design phase of a product, the architecture of a mechanism, machine, robot or assembly tooling adapted to perform the operations in question. This is important both in the process of interactive simulations as in the context of immersive simulations (real-time). If some types of movements are omitted, the simulations may lose the main configurations and therefore they are no longer significant. In order to have a complete simulation, the simulation platform should be able to analyze a model and to detect all the contacts. One main objective addressed in the present project is to develop a simulation framework able to improve A/D simulation and its integration at various PLC stages. This framework will contain a contact identification module and a general combination operator.

Another important aspect is the fact that standard CAD programs are "part-centric" and, as a consequence, these software lack of strong properties for assembly analysis. In order to improve their functionality the research on modeling the process of assembly and disassembly, through the kinematic modeling of connections, could be integrates as a tool. More, each module of the proposed simulation platform could be integrated as add-on applications (or "wizards") in a CAD software like SolidWorks, SolidEdge or Catia V5.

3. PROJECT PROPOSED METHODOLOGY

In order to accomplish the project objectives the first step will be a critical analysis of the late A/D simulation researches in order to see the last advances in domain. The review of these papers will allow identifying new domain of interest where the proposed approach can be applied. Attention will be given especially to the new real-time simulation platforms, field where the companies from automotive and aeronautic industry have a strong interest lately.

The next step will be the theoretical part. In order to have a complete and fully automatic A/D simulation framework some theoretical concepts must be developed. The main objective is to explicitly describe the mobility of a component and/or the resulting mobility of a mechanical system. To accomplish that a mathematical model is needed; it should describe all the families of trajectories associated to the contacts from different components of a product. The compatibility between different contacts and the resulting mobility should be visually represented so a geometrical model should be developed.

Different shape representations are produced by Computer Aided Design (CAD) modellers. More, model variants are also produced by different CAD modellers even though they are quoted as standard format. In this context, the concepts for a new data structure must be described. This structure should offer a way for explicitly representation of the semantic information attached to a shape and a link between different representations of the same model.

The main purpose is to offer an intelligent tool to aid engineers in the design process. The proposed platform will offer the possibility to automatically identify contacts from a mechanical system, to compute the mobility of a component form an assembly, to determine the best sequence of mounting/dismounting of a product. This simulation software will be able to collaborate with standard CAD software and with real time simulation platforms; it will offer the possibility to export the models with the semantic information attached.

4. CONCLUSION

Regarding industrial benefits expected, our research brings response to identified industrial needs from companies like Dacia-Renault, Ford, EADS etc. related to simulation and modeling processes often present in the various phases of the PLC. The proposed simulation platform will provide an intelligent tool to aid engineers in the design process. In order to decrease the design time and the test costs, this platform will offer the possibility to automatically identify contacts from a mechanical system, to compute the mobility of a component form an assembly, to determine the best sequence of mounting/dismounting of a product. This simulation environment will be able to collaborate with standard CAD software and with real time simulation platforms. The main beneficiaries of the results of this project are companies from industry. Thus, the simulation platform could be used in any mechanical design department.

5. ACKNOWLEDGEMENTS

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