Flexible Multi-Body Dynamics Analysis using Data Integrated Model Driven Simulation

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EXTENDED ABSTRACT

1 Introduction

Multi-Body Dynamics used to understand motion between rigid bodies has been expanded to Flexible Multi-Body Dynamics by integrating Finite Element Analysis. Consequently, Flexible Multi-Body Dynamics (FMBD) is becoming a powerful tool in order to analyze complex system composed of rigid bodies and flexible bodies. Based on these features, Flexible Multi-Body Dynamics can be useful for Digital Twin (DT) because of effective method converting a real complex system into a digital system.

In the perspective of effective use of Digital Twin, real-time analysis for complex systems should be accompanied. However, it is very difficult to analyze complex system with non-linearity and large degree of freedom in real time with current technology. Fast and robust analysis for Flexible Multi-Body Dynamics system is one of the main challenges that dynamics analysis software must overcome in the future. However, there are limits to existing analysis method based on the formulation of the governing equations of motion. In order to overcome these limitations, data-based analysis techniques using machine learning (ML) and artificial intelligence (AI) are being actively studied.

Since real-time system dynamics analysis is essential for expansion into various application fields such as digital twins, an effective method for the purpose of it is presented in this study. It is named 'Data Integrated Model Driven Simulation (DIMDS) technique, which is a combination of existing formalization technique for governing equations of motion and data-based techniques. It is expected that Flexible Multi-Body Dynamics models can be analyzed fast and effectively through presented technique.

2 Data Integrated Model Driven Simulation (DIMDS)

Fig. 1 shows a main concept of Data Integrated Model Driven Simulation (DIMDS) implemented in platform of commercial software RecurDyn.

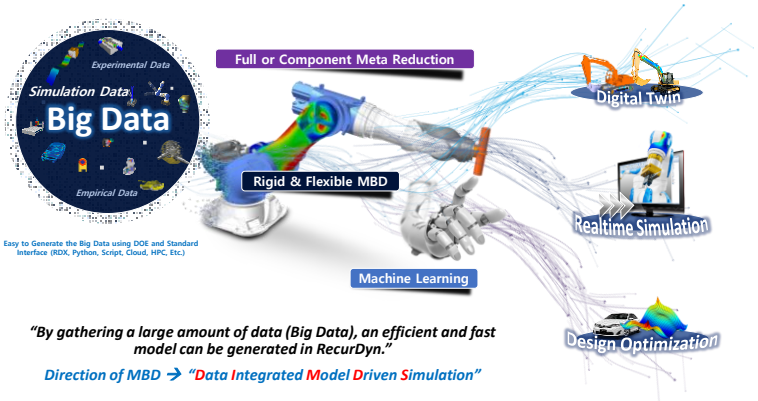

Figure 1: The Concept of DIMDS (Data Integrated Model Driven Simulation).

As shown in the Fig. 1, a lot of analysis data can be created using CAE software such as RecurDyn and those can be a source of big data. Such big data may be information on some components of the dynamics system or may be an upper-level system including the components. In this way, if Design of Experiments (DOE) is performed in the range of design variables for target parts or the whole system, the behavior of the system can be predicted based on the collected data from design of experiments. At the same time, a lot of time spent to get big data for numerous analysis cases can be saved by using distributed computing

system such as the cloud. Based on the DOE results, a meta model for a given component can be created or updated using various mathematical or machine learning techniques. Fig. 2 shows an example process making a meta model for spring model composed of lots of flexible elements.

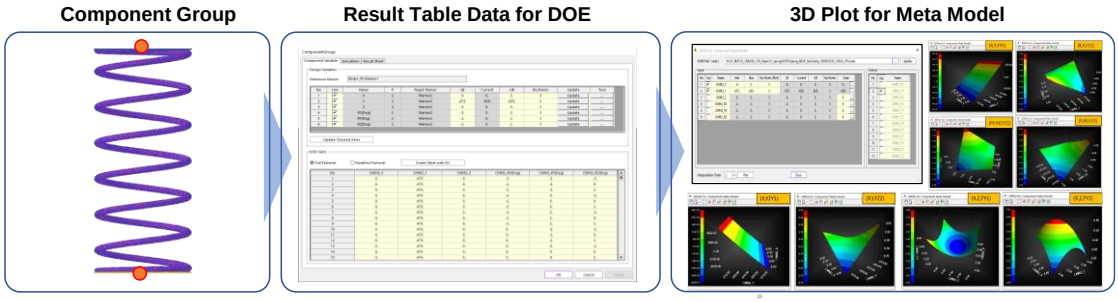

Figure 2: The process of DOE and meta model generation.

The meta model created in this way can be substituted for components in Flexible Multi-Body Dynamics model for faster and relatively similar analysis. In the case of using meta model instead of components composed of flexible bodies, various information such as stress and strain cannot be checked. However, the reaction forces of the part where the components are connected and the other results that need to be checked can be defined in advance and included in the meta model. Accordingly, the necessary results can be obtained even in the case of dynamic analysis using the meta model.

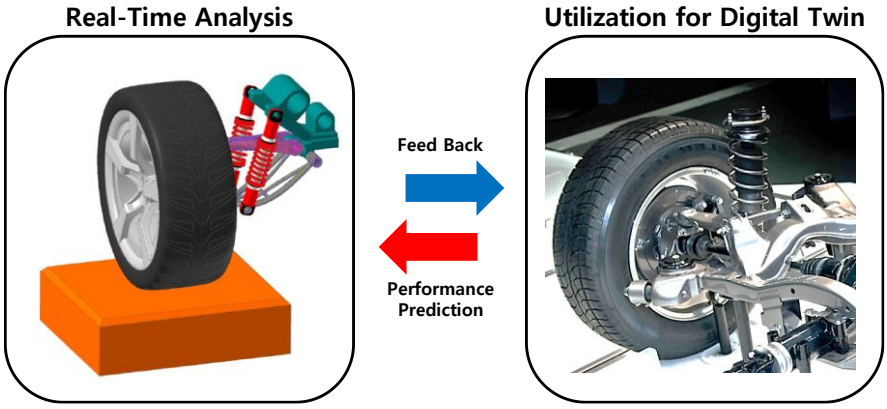

Figure 3: Realtime dynamic analysis model suing a meta model and the connection with a digital twin system.

As shown Fig. 3, If a component composed of flexible body is replaced with a meta model and analyzed by including it in the dynamics model, it will be possible to perform faster analysis in real time and utilize it for various Digital Twin connections. The method of enabling real-time dynamics analysis by systematizing this series of processes is called Data Integrated Model-Driven Simulation and this is the main subject of this study.

3 Conclusion

Recently, dynamics analysis has been expanded to the analysis of Flexible Multi-Body Dynamics systems including rigid bodies and flexible bodies, and real-time analysis is required for linkage with Digital Twin using dynamics analysis models. However, it is exceedingly difficult to perform real-time analysis of a flexible multi-body dynamics model with a large degree of freedom and complexity with nonlinearity. To overcome these problems, this study proposes a 'Data Integrated Model Driven Simulation' technique which is a combination of data based meta model and existing formalization technique of the equations of motion.

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