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Development of K_Sim_Modeler for the dynamic solver including flexible parts

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Abstract*— There are many kinds of commercial dynamic solvers for kinematic and dynamic analysis. Some programs contain various functions including analysis of flexible parts, integration with controller, optimization tool and so on. While the general-purpose dynamic solvers are useful for analysis of the various mechanisms, the customized dynamic solver is useful for the development of the specific system. Therefore, we are developing the specialized dynamic solver for the solar cell substrate handling robot. The solar cell substrate handling robot has flexible parts which are called forks or hands and it is necessary to apply the vibration control algorithm for the flexible parts and the high speed motion of the robot. So the dynamic solver K-Sim is being customized for the solar cell substrate handling robot system. It includes the rigid body dynamics, the flexible body dynamics for the beam element and the control element. It is composed of three parts. The first one is the modeler part to input the system model and the system parameter, the second one is the analysis part to analyze the kinematic and dynamic characteristic from the data inputted in the modeler part and the last part is post-processor part to display the result and the animation. In the paper, we developed the K_Sim modeler using GUI as the pre-processor of the specialized dynamic solver for the solar cell substrate handling robot.

***Index Terms*—Dynamics solver, Modeler, K-Sim, Flexible body**

I. INTRODUCTION

There are many kinds of commercial dynamic solvers for kinematic analysis, dynamic analysis and various simulation. Some programs contain various functions including analysis of flexible parts, integration with controller, optimization tool and so on. While the general-purpose dynamic solvers are good for analysis of the various mechanisms, the customized dynamic solver is useful for the development of the specific system. Therefore, we are developing the specialized dynamic solver for the solar cell substrate handling robot. The solar cell substrate handling robot has flexible parts which are called forks or hands and it is necessary to apply the vibration control algorithm for the flexibility and the high speed of the system. So the dynamic solver K-Sim is being customized for the solar cell substrate handling robot system. It includes the rigid body dynamics, the flexible body dynamics for the beam element and the control element. It is composed of three parts. The first one is the modeler part to input the system model and the system parameter, the second one is the analysis part to analyze the kinematic and dynamic characteristic from the data inputted in the modeler part and the last part is post-processor part to display the result and the animation. In the paper, we developed the K_Sim modeler using GUI as the pre-processor of the specialized dynamic solver for the solar cell substrate handling robot.

II. THE MAIN FUNCTION OF MODELER

The main functions of the developed modeler are the followings.

(1) Inputting modeling component with GUI
- Body: Rigid, Flexible
-Joint: Fixed, Translational, Revolute, Spherical, Universal, Bracket
- Motion: Rotational, Translational
- Control: Sensor, Gain, Sum, DataIn, Saturation, Transfer Function, Differentiator
- Force: Force, Torque, spring, Bushing, Rotational Spring

(2) Connecting flow element represented as an arrow between components

(3) Inputting property for each modeling component

(4) Making an input file for K_Sim_Solver

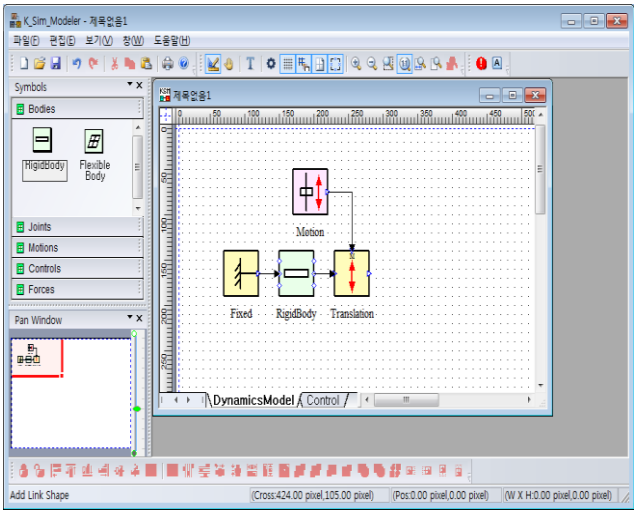

Fig. 1 Main program of the K_Sim_Modeler

III. MODELING COMPONENT

As mentioned above, there are many kinds of modeling components and they have their own symbol. Main components are classified into five categories as a body element, a joint element, a motion element, a control element and a force element. These five components are represented from table I to table V and each element has its own symbol as the table. There are a rigid body and a flexible body in the body element, a fixed joint, a translational joint, a revolute joint, a spherical joint, a universal joint and a bracket joint in

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the joint element, a rotational motion and a translational motion in the motion element, a rotational sensor, a translational sensor, a gain, a sum (two input), a sum (three input), a data in, a saturation, a integrator, a differentiator and a transfer function in the control element and a force, a torque, a spring, a bushing and a rotational spring in the force element .

Table I Body element

Body Symbol		Rigid Body
		Flexible Body

Table II Joint element

Joint Symbol		Fixed Joint
		Translational Joint
		Revolute Joint
		Spherical Joint
		Universal Joint
		Bracket Joint

Table III Motion element

Motion Symbol		Rotational Motion
		Translational Motion

Table IV Control element

Control Symbol		Rotational Sensor
		Translational Sensor
		Gain
		Sum (Two Input)
		Sum (Three Input)
		Data In
		Saturation
		Integrator
		Differentiator
		Transfer Function

Table V Force element

Force Symbol		Force
		Torque
		Spring
		Bushing
		Rotational Spring

IV. COMPONENT PROPERTY

There are five element categories and twenty five elements in K_Sim_Modeler as mentioned in the previous chapter. Each element has each property box according to the characteristic of each element. For example, a rigid body element has name, mass, inertia, body position, body angle and CAD file open in its property box and a flexible body element has element number, density, beam size, Young's modulus, Poisson's ratio, body position and material damping respectively. Two kinds of the property boxes are represented as Fig. 2 and Fig. 3. Figure 4 show an example of the joint property and Fig. 5 show an example of the sensor property.

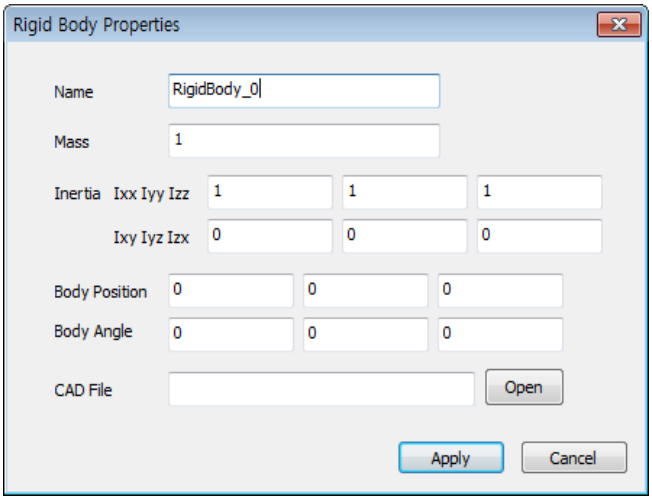

Fig. 2 Rigid body property

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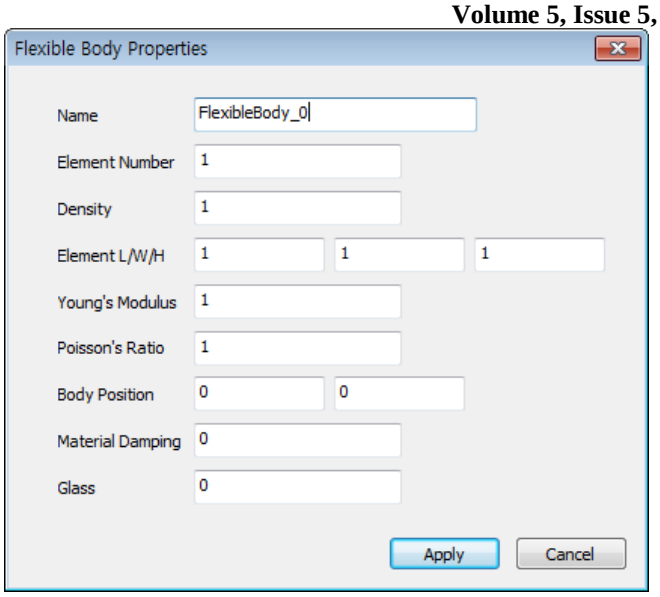

Fig. 3 Flexible body property

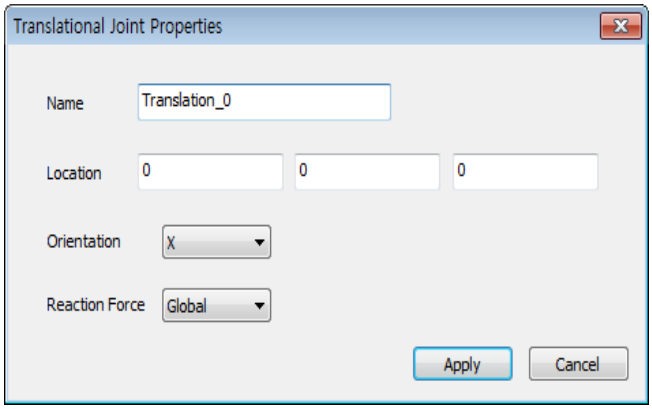

Fig. 4 Joint property

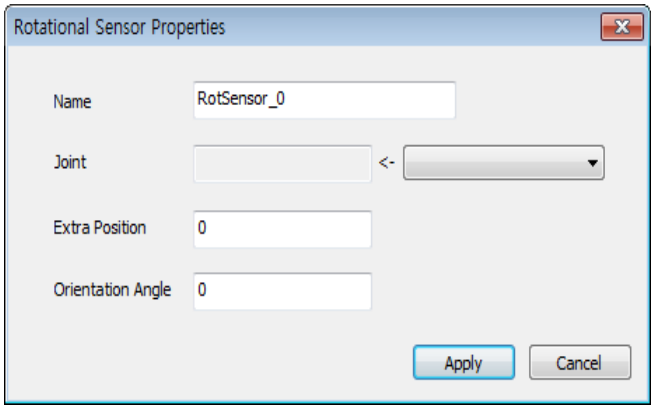

Fig. 5 Sensor property

V. MODELING OF THE SOLAR CELL ROBOT

The model of a solar cell substrate handling robot is constructed using the developed modeler with various customized elements for the solar cell robot. Figure 6 shows a template for dynamic analysis of only rigid bodies without control and Fig. 7 shows one for control.

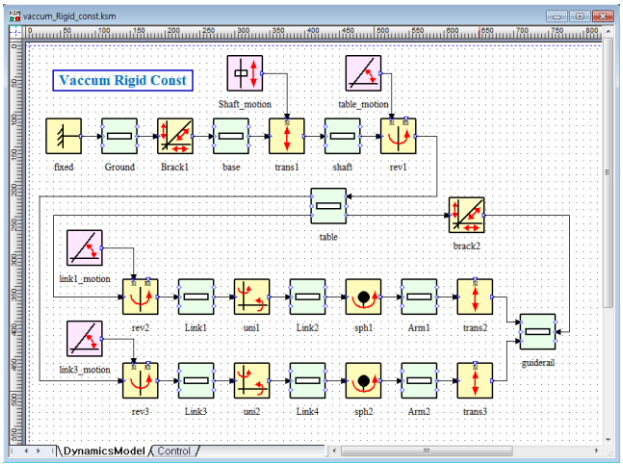

Fig. 6 Modeling of the solar cell substrate handling robot (Rigid body only, Dynamic analysis)

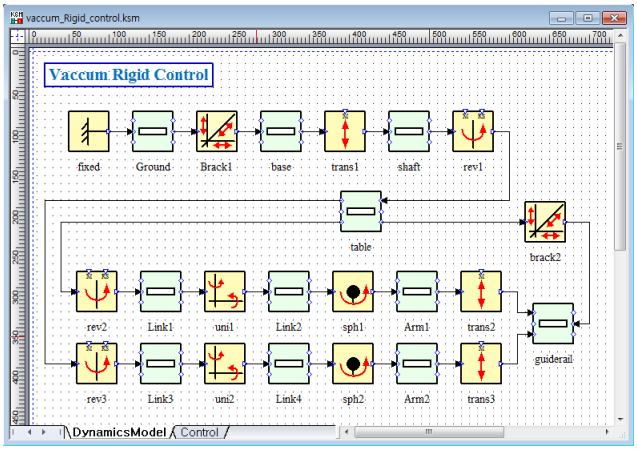

Fig. 7 Modeling of the solar cell substrate handling robot (Rigid body only, Control)

The template shown in Fig. 8 contains the flexible body and Fig. 9 shows an example of the control window.

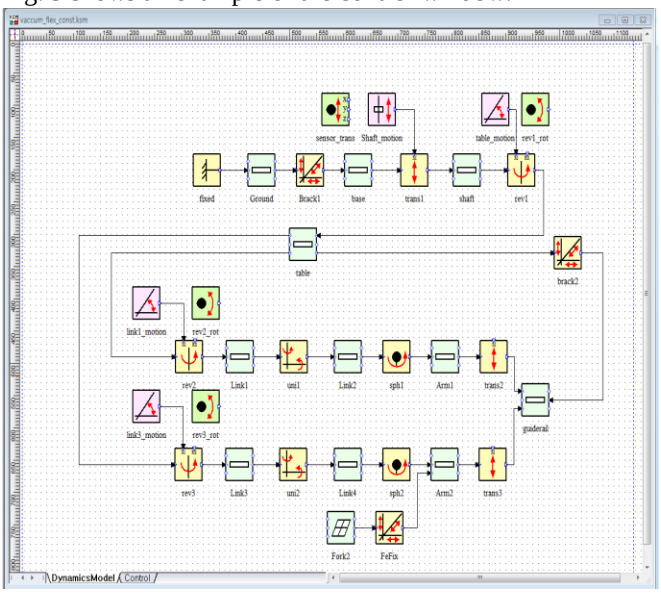

Fig. 8 Modeling of the solar cell substrate handling robot (Flexible body)

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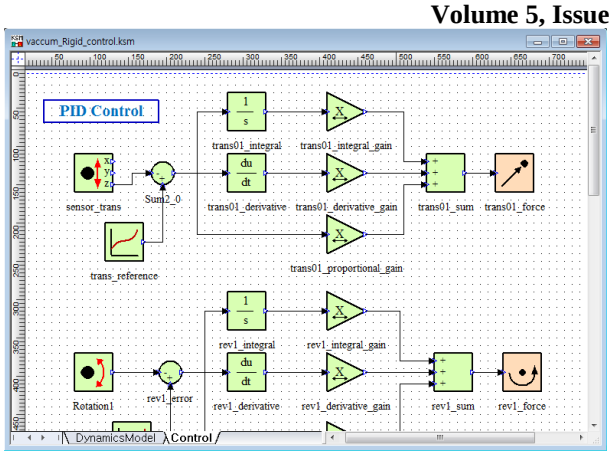

Fig. 9 An example of the control window

The modeling will be converted to an input file for K_Sim_Solver and can be used in the various simulations.

VI. CONCLUSION

We are developing the specialized dynamic solver for the solar cell substrate handling robot. The solar cell substrate handling robot has flexible parts which are called forks or hands and it is necessary to apply the vibration control algorithm for the flexibility and the high speed of the system. So the dynamic solver K-Sim is being customized for the solar cell substrate handling robot system. In the paper, we developed the K_Sim modeler using GUI as the pre-processor of the specialized dynamic solver for the solar cell substrate handling robot. The model of a solar cell substrate handling robot is constructed using the developed modeler. The modeling will be converted to an input file for K_Sim_Solver and can be used in the various simulations.

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AUTHOR BIOGRAPHY

Dong Il Park received a BS degree in Mechanical Engineering from Korea Advanced Institute of Science and Technology (KAIST) in 2000, a MS degree in Mechanical Engineering from KAIST in 2002 and a PhD degree from KAIST in 2006. He has been researching the robotics in Korea Institute of Machinery and Materials (KIMM) since 2006. His research fields are the design, control and application of robot manipulators and mobile robots.