Title:
Kinetic Model Extraction from a Geometric Model

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Introduction:
As technology develops, the computer simulation is used a variety of fields including designing, executing and analyzing. Especially in the manufacturing industry, to increase the competitiveness, it is important that designing the product, process and resource. These designs depend on the computer simulation. Many parts of manufacturing industry depend on the computer simulation, from a product design to production, as computing ability increases and people requires better virtual environments like realistic than ever. This demand has resulted in the concept of a virtual factory (VF). It is necessary to construct digital models for all the physical and logical elements (entities and activities) of a real manufacturing system to implement a virtual factory [4]. If the digital model is not well implemented, we can't see the value in it. Accordingly, many algorithms have been developed about digital models.

The algorithm this paper proposed uses many algorithms including the contact detection, the collision detection and gauss map. There are related researches. Tomas Moller (1997) proposed the algorithm for the intersection between triangles, and Min-Ho kyung *et al.* (2011) did a research on the parallel computing of the GPU to fast detect the intersection between triangles. Asada *et al.* (1985) used the Jacobian matrix to model the fixture-work piece relationship in 3D space. Samuel R. buss (2009) did a research about the Jacobian transpose method, the pseudo inverse method and the damped least squares methods to implement inverse kinematic. Kang *et al.* (2003) proposed the concept of the geometric model and the kinetic model, this paper use this concept. Minsuk Ko *et al.* (2011) proposed an algorithm for the extract the kinetic model using concept of 'moment of inertia'.

Main Idea:
Figure 1 show the assembly geometric model that requires kinetic model in virtual factory. As the aforementioned assembly geometric model consists of rigid geometric parts, the joint of this model is made by contact of each part. To perform various works, all of geometric model have different shapes. Even though the shape of the geometric model is very complex, almost these geometric models have just two joints (revolute joint, prismatic joint). It is operated that many activity including assembly, welding, fixing and examination using these two joints in the virtual factory. To do so, it is necessary to go through three important steps: (1) detection of contact surface; and (2) identification of the contact surface of cylinder shape and creation of the center axis; (3) defining of the joint using the collision detection.

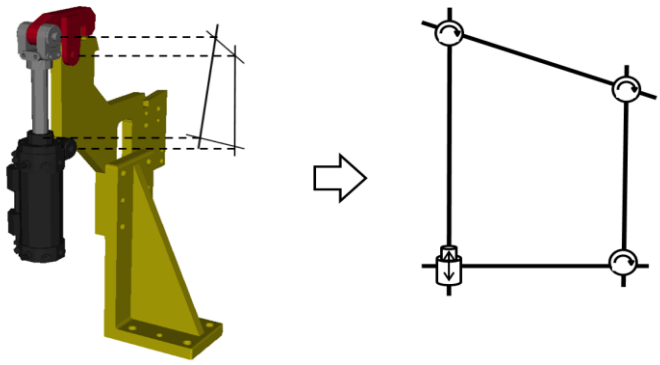

Fig. 1: Kinetic model extraction from a geometric model.

In the first and second step, as the method we've used to generate the center axis and to detect the contact shape of the cylinder shape by using the gauss map, this is the method to show the point on the gauss sphere that comes from the point on the surface consisted of a triangular net. If the circle shape is illustrated on the gauss sphere when a unit normal vector of triangles that obtained from the contact detection apply the gauss map, the contact surface of cylinder shape can be defined. The unit normal vector illustrates a point on the gauss sphere only in the contact flat surface. And we have to do cross product between normal vectors in order to generate the center axis. This vector is necessary to identify the type of joints and to define the motion of joints.

The third step is an algorithm to define the type of joints by using collision detection. This paper focuses aforementioned two joints including the revolute joint and the prismatic joint. As the revolute joint provides single-axis rotation function, this joint is a characteristic that has the fixed structure that does not rectilinear motion. On the other hand, the prismatic joint provides single-axis linear sliding movement function. This joint is a characteristic that does not collision when their do a rotary motion. That means if one of parts of the joint is moving in the center axis vector direction and reverse direction, when detect collision, the joint is the revolute joint, the prismatic joint otherwise. We can know whether it is collision through the distances between parts after moving. If the change of the distance between parts, this is collision. It is possible to extract the kinetic model from assembly geometric model using the proposed algorithm and to implement the motion of model using the center axis.

Conclusions:

To implement these models, we have to consider the geometric model and kinetic model for the physical concept and the logical concept in the virtual factory. To define the kinetic model, we have to select the contact surface and axis of the geometric model. Because it is inevitable that the product design frequent change in the manufacture industry, defining the kinetic model is a waste of time and money each time. This paper proposes an algorithm for the automated extract the kinetic model from the assembly geometric model to reduce waste. The proposed algorithm consists of three major steps: (1) contact detection; (2) identification of the contact surface of the cylinder shape and generation of the center axis of joints; and (3) definition of joints using collision detection. Both the OBB binary tree structure and parallel computing of the GPU increased the speed of detection of the contact surface, and we used the gauss map in order to identify the cylinder shape and generate the center axis. Most of joints including prismatic joint and revolute joint can operate because joints have the contact surface of the cylinder shape. And joints are defined using collision detection.

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