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Research on Virtual Design and Simulation System of Characteristic Fruit Manipulator in Southern China

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Abstract. To study the characteristic fruit manipulator in southern China, architecture of fruit manipulator virtual design system was build by the use of modular technology. Parameterize the feature properties of picking manipulator, so the reusable parametric model was build. Based on the database technology, the knowledge base was build, including examples base, constraint rules and research status. Moreover, visualization 3D simulation of the processing of picking was realized under the virtual environment. Finally, through the development of experimental prototype, the virtual design system and its key technologies can be verified.

Introduction

Lichi and longan were the characteristic fruit in southern China, their cultivation area and production rank first in the world[1]. At present, their artificial harvesting lead the low efficiency and high cost. Mechanized harvesting can improve efficiency and reduce costs. But the existing simple fruit devices[2, 3] have the technical bottlenecks. They can only suitable for picking apples, pears, persimmons, apricots and other single fruit or the string-like fruit but little leaves, such as grape. The fruit which was string-like and intensive branches, such as lichi, can no be picked by such devices. Therefore, it is necessary to study the picking manipulator for the string-like fruit, such as lichi and longan.

The fruit like lichi, longan grow dense foliage, which was the obstacle when picking, and they are also prone to get mechanical damage. Therefore, when developing the picking manipulator, not only the picking mechanism and cutting mechanism must be researched, but also its flexible clamping and requirements of obstacle avoidance and anti-hook hanging. Using the virtual design technology, building the digital prototype, taking simulation experiment and used in the optimal design of physical structure, can improve the quality of design, shorten the development cycles and reduce development costs[4 -7].

In this paper, the parameter virtual design method and its picking simulation under virtual scenarios were studies. Then, a virtual design and simulation system of characteristic fruit manipulator in southern China was developed.

General Structure of Picking Manipulator Virtual Design and Simulation System

Characteristics of Picking Manipulator Virtual Design and Simulation System. Aiming at the drawbacks of artificial harvesting for litchi fruit, picking manipulator of characteristic fruit in southern China was developed by use of virtual simulation technology, which can overcome the shortcomings of existing picking mechanism. Because of the environment's complexity when picking the fruit of litchi and longan, it required to give full consideration to various factors for the design of system. Not only its model parameters of shear mechanism, blade geometry, the best cutting angle needed to be study, but also the relationship between the structure parameters and assembly errors of

bionic-oriented guiding mechanism and its obstacle avoidance and anti-hook hanging. The system's features include: First, on the basis of relevant mechanism's research, the optimal design comprehensive method was established by the amalgamation of design and simulation, and the simulation results was also been used in the optimal design of physical structure; Second, designing by parameterizing and modularizing, the problems of manipulator's optimum design was solved in the simulation and experiment; Third, through the faster computer aided design, it can be adapted to different harvesting requirements(different fruits, different harvesting methods, different harvesting environment, etc.).

General Scheme. The general goal of virtual design and simulation system of characteristic fruit in southern China was to build a computer-aided design system, which can realize faster parameters design and picking simulation. Taking the Pro/Engineer as the secondary development platform, the system control program was been written by the use of development language Visual C++. Net.

By connecting the physical layer, application layer and technology layers of system framework together, the unity of system modularity and model parameterization was realized ultimately. The general system structure was shown in Fig.1.

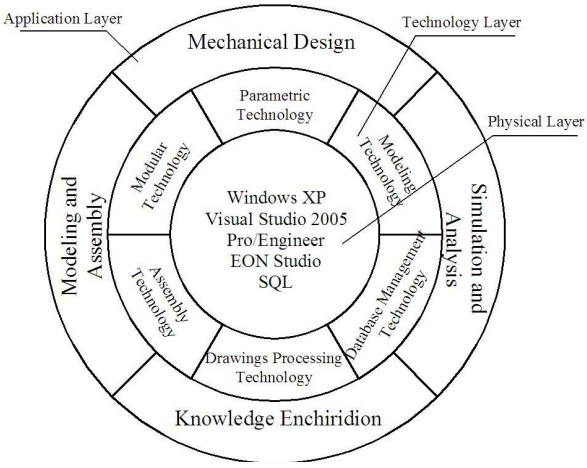

Fig.1 System General Structure

Functional Architecture. The digital system of fruit manipulator consisted of three main modules, including the picking manipulator mechanical design, simulation and analysis and knowledge enchiridion. The specific architecture was shown in Fig.2.

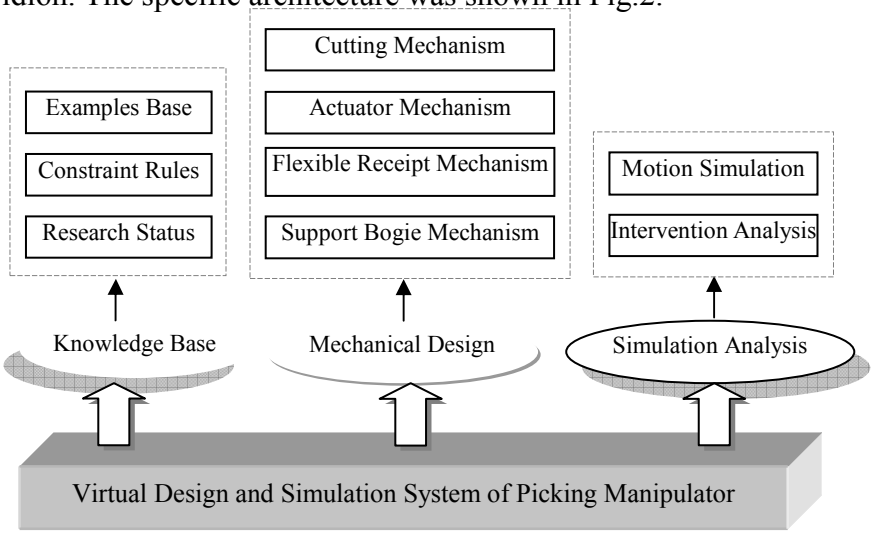

Fig.2 System Architecture Diagram

Among them, the mechanical design modules can be divided into cutting mechanism, actuator mechanism, flexible receipt mechanism and support bogie mechanism by function. The simulation and analysis modules mainly realize the visual simulation of the picking process and examine whether it meets the requirements of movement, then return the results to the users. Knowledge enchiridion

mixed the knowledge of mechanical characteristics, picking properties and others together, which provide design reference for the users. When users input their needs and design the parameters of parts, the system automatically generated the picking manipulator model, evaluated and checked the models. If user's design parameters didn't meet the constraints rules of knowledge base, it would return to the user for modifying until it met up. Finally, the system would automatically generate two-dimensional drawings and three-dimensional model. The workflow of system modules was shown in Fig.3.

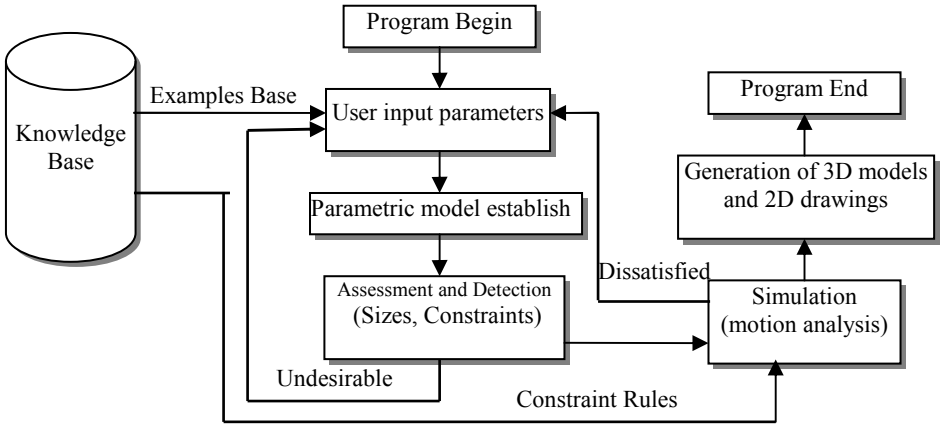

Fig.3 System Module Flowcharts

Key Technologies of System

Product Modular. Product modular, the product was divided into several parts (modules), each part had certain functionality. The final product can be finished through the permutation and combination of relevant modules[8]. The whole product life cycle of purchasing, logistics, manufacturing, and other resources can be simplified through product modular. Objective to picking manipulator modular was conversion of the assembly parameterize which the unit would be composed of scattered parts to the assembly parameterize which the unit would be composed of sub-assemblies (module), so the parameterize relationship of all the parts of picking manipulator was converted into the parameterize relationship of each module. The complex relationship of all the parts was converted to the relationship of the internal components and sub-assemblies. The assembly modular relationship of picking manipulator was shown in Fig.4.

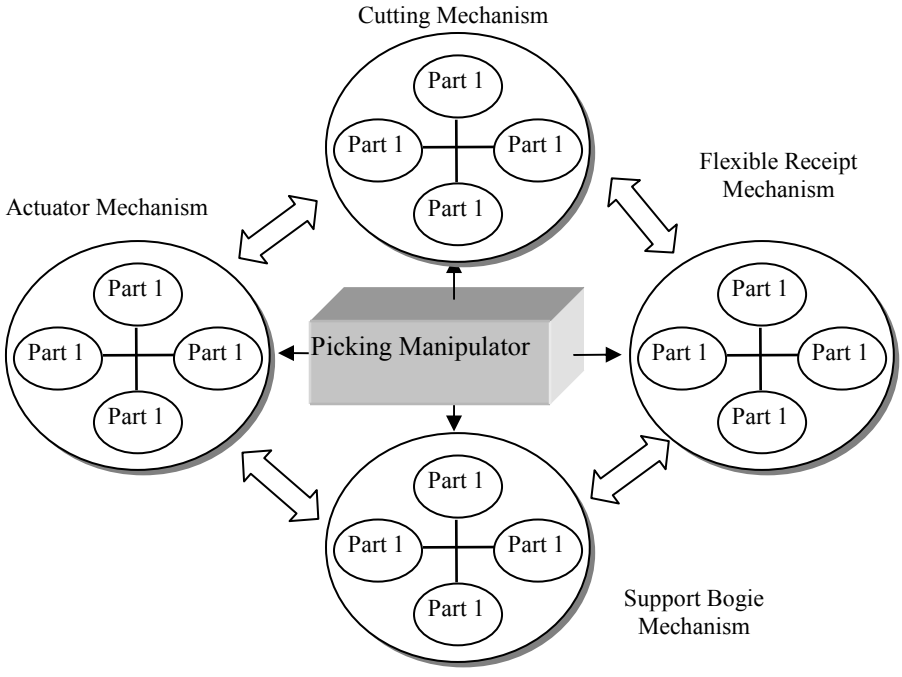

Fig.4 Modular Assembly Diagram of Picking Manipulator

Picking Manipulator Mechanism Design. Using the virtual faster design method to modularize and parameterize the picking manipulator according to the user's different needs can shorten the design cycle and enhance applicability. It can be divided into cutting mechanism, actuator mechanism, flexible receipt mechanism and support bogie mechanism concretely. To design the picking manipulator's mechanism was mainly to design the property parameters of its parts.

Taking the cutting mechanism for example, it needs to design the parts which it contained, including moving blade, fixed blade, connecting sleeve, connecting pins and other parts respectively when designing. Among them, moving blade contained the properties including material type, material allowable stress, moving blade's rotated angle, moving blade's thickness, moving blade's length and so on; Fixed blade contained the properties including material type, allowable stress, shear angle, fixed blade's thickness, fixed blade's length and so on; The properties of a connection sleeve contained material type, sleeve inner hole's diameter, sleeve thickness, sleeve height and so on. Other parts' design were similar to the design of cutting mechanism.

Construction and Query of Knowledge Base. Knowledge Base, which aimed at the needs of one field or multiple fields, was a structural knowledge in engineering. It was the aggregation which stored, organized, managed and used the interrelated knowledge by using some knowledge representation methods. According to the characteristics and property of knowledge base, the knowledge can be built up modular, easily operated and used organizational structure. In this system, the knowledge base consisted of examples base, constraint rules and research status. Design examples of common picking manipulator were stored in the examples base, and the users can choose it. And the constraints rules were mainly designed to check and judge the sizes parameters, performance parameters (strength and stiffness) and volume intervention of all parts. The research results were stored in the research status, including the research on the mechanical properties of litchi and longan, conditions of picking operations, and so on.

The knowledge base established must ensured that it can be easily modified and edited knowledge, while effectively accessed and searched for knowledge. When users enter their requirements, the system would query the knowledge base automatically to submit the general design scheme met to the users. Moreover, the uses also can carry out detailed design for each component. If the parameters users input was unreasonable (didn't meet the constraints or had some interferences), the system would hint the users by the form of dialog box and the users must modify it again.

Achievements of Virtual Design and Simulation System of Picking Manipulator

Establishment of Parametric Models. The main parts of picking manipulator included moving blade, fixed blade, main bar, handles, springs, and so on. According to modular technology described above, the picking manipulator can be divided into cutting mechanism, actuator mechanism, flexible receipt mechanism and support bogie mechanism. The structure size of each part must be optimized according to the operating environment and properties of picking object by users provided. The main drive sizes of components were set by users, and the rest driven sizes would obtain depending on their relationship equation and constraints. In Pro/E environment, using its own characteristic of feature-based modeling and parametric design, picking manipulator's parameter model was set up by the Boolean operations of stretch, rotate, holes, fillets and other. The parameters model of picking manipulator's fixed blade was shown in Fig.5.

Achievements of System. Pro/E can support the dynamic database connection technology. Depending on its development kit Pro/Toolkit, it can realize Visual C++. Net to control and visit Pro/E in security. Based on the ActiveX technology of VC, it can achieve the connection and communication between VC and Pro/E, EON by calling eDrawings.

Based on the technology mentioned above, in the platform of Microsoft Visual Studio 2005, virtual design and simulation system of characteristic fruit manipulator in southern China had been realized by using of Pro/Engineer's 3D modeling technology, EON's simulation capability and SQL's database management technology. The system interface diagram was shown in Fig.6, and physical prototype of picking manipulator was shown in Fig.7.

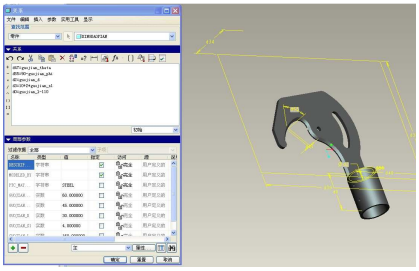

Fig.5 Parametric Model of Picking Manipulator's Fixed Blade

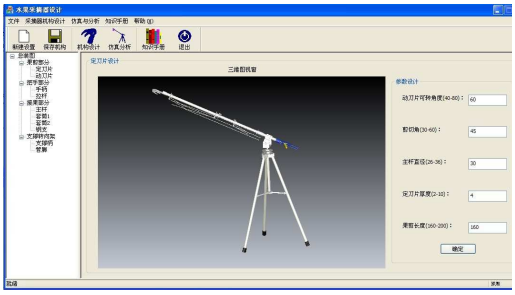

Fig.6 System Interface Diagram

Fig.7 Physical Prototype of Picking Manipulator

Conclusions

In this paper, modular, parametric modeling technology and virtual simulation technology were united to develop virtual design and simulation system of characteristic fruit manipulator in southern China. This system parameterized the properties of picking manipulator, and constructed the reusable structural component units, while it carried out the visual three-dimensional simulation of picking manipulator by using the EON simulation software. Moreover, it applied the database technology to build knowledge base for users to query relevant research data. Finally, through the development of physics prototypes, the system had been verified.

Acknowledgement

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