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Multi-body dynamics and Biomedical Engineering Development

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Abstract

Till now the relationship between biomedical and engineering is not perfect. And how to use the technology and theory of engineering into medical field becomes a hot topic all over the world. In this paper the development and trends of biomedical engineering and multi-body dynamics are discussed first. Then specific examples of medical devices and human security of biomedical engineering used multi-body dynamics are introduced. Then the multi-body dynamics used in bionic boom has been presented. Next the development suggestions between the two fields are proposed in future. All of this provides assistance for the study of medical field quantitative analysis.

Keywords:*Multi-Body dynamics, Biomedical engineering, Medical equipment, Development.*

1. Introduction

Biomedical engineering is younger than traditional biology, medical and engineering discipline. It only has been developing more than 30 years in China. It is also an interdisciplinary which has closed relationship with biology, medicine and engineering. One of the most special features is to use engineering methods into biomedical. Combine the engineering technology with medical can improve the medical equipment level and help to take care of patients better. One of the reasons is that bioengineering need to have the same expertise in the two fields of engineering and biology[1]. Multi-body dynamics is mainly applied to accuracy equipment movement and structure strength analysis of aerospace, engineering machinery, automobile, biology, port machinery and other precision device. In this condition these equipments can be seen as a number of objects connected by particular joints and achieve some specific movement, so the using of multi-body dynamics can reach the desired objectives correctly and conveniently.

2. Biomedical engineering Research Status

The research of biomedical engineering is extremely broad such as biological materials, biomechanics, biomedical image, physiological signal processing, 3D modeling, material information, image processing and system analysis. The applications of biomedical engineering are bio-compatible prostheses, medical devices, diagnostic equipment, MRI (Magnetic Resonance) and EEG (Electroencephalogram) imaging equipment and medical drugs[2]. The common used medical equipment are surgical robot (minimally invasive robotic boom), age reversal pulsed light, mole laser beam, test equipment X machine, magnetic resonance machine, pressure machine, treadmill, hearing aid[2]. And now the forefront units of biomedical engineering research all over the world are Johns Hopkins University, Georgia Institute of Technology，University of California-San Diego，University of Washington, Duke University, Boston University forefront and so on. In China Professor Lv Weixue has established the biomedical engineering research center in 1977 in Zhejiang University. The main research at that time was about biomedical medical instrument. Thereafter with the development of instrument technology more and more medical equipments and basic biological mechanisms are studied. Along with the medical information

development the medical computer software also has rapid development. Other units conducted similar studies in China are Tianjin University, Xi'an Jiao Tong University, Shanghai Jiao Tong University, Tsinghua University, Beihang University, Chongqing University, Southeast University, etc. Tsinghua University and Shanghai Jiaotong University biomedical engineering were founded in 1979. Southeast University and Xi'an Jiao Tong University had established the department respectively in 1984 and 1987.

The Ming Chuan University, Zhongyuan University Department of Biomedical Engineering, National Cheng Kung University, Centre College Biomedical Engineering Research Institute, Hongguang Science and Technology University in Taiwan have strong research capacity in biomedical engineering either.

3. Multi-Body dynamics Status

Multi-body dynamics has developed more than 60 years in engineering field. It mainly solves the mutual motion and force relationship between different bodies. Multi-body system is formed by series objects in a certain way and it commonly was found in many engineering fields, such as biological (animal or human), national defense industry, general machinery, aerospace, textile industry, transportation and so on. There is a large relative motion among the components generally. The topology and constraint are various and the force condition is more complicated. With the development of engineering， there are many problems to solve such as kinematics law, dynamics characteristic and motion control. So a new science branch has emerged and lots of research methods appeared one after another.

The research of multi-body dynamics began from the 1960s, the early studied object was mainly multi-rigid system. Wittenburg brought graph theory into the calculation of multi-body dynamics in 1977 which laid the foundation for the Lagrange method. Based on the finite element method and multi-body continuous system Schiehlen introduced the research of flexible multi-body dynamics in 1990. Shabana explained the multi-rigid body system dynamics and its numerical solution algorithm in 1994 and then put forward the absolute nodal coordinate method with high precision in the calculation of flexible body, which is a hotspot in this field today. After 1995, Rui Xiaoting in Nanjing University of Science and Technology improved the transfer matrix method of multi-body system, which brought about efficient and fast calculation of the multi-rigid body system dynamics. Bremer, Liu Yanzhu, Lu Lu, Hong Jiazhen, Huang Wenhu, Nikravesh, Bauchau O and other experts have made great contributions to this theory too. Till now how to solve the flexible body dynamics of multi body system has become a hot spot in the world[3-5].

4. Development Between Multi-Body Dynamics and Biomedical Engineering

From 1950s to now, biomedical engineering is relying on engineering theory and application. Medical device is an important branch of biomedical engineering[6]. Typical medical machinery such as elderly rehabilitation equipment, transfer table, multi boom probe hand; mechanical arm; artificial limb and so on[7-9]. The typical characteristics of these equipments are multi body system. The operation process requires high precision, accuracy and good stability. It is important to have precise calculation and motion control in order to achieve the requirements. The development of multi body dynamics makes it possible. Figure 1 is a mechanical boom and rehabilitation bed of medical equipment. The left is transfer equipment for patients who need to transfer form one place to another and the right one is for those who need ambulatory rehabilitation. In the design process it needs to take into account the multi boom deformation because it has significant influence to the accuracy motion and structure strength. Therefore in

order to achieve the expected effect the medical equipment it is need to use flexible multi-body kinematics and dynamics theory.

Figure 2 is a bionic robot boom. According to multi-body dynamics theory it can be divided into five components. No.1 is the base as seen in figure 2, and No. 2 is the support arm, No. 3 is the telescopic arm, No. 4 is the fore arm, No.5is the end effectors. The effectors designated location can be reached by the boom motion. In accordance with the flexible multi-body kinematics and dynamics theory the end effectors motion accuracy will be greatly improved which is good for equipment operation.

Figure 3 is the human body collision model and figure 4 is the man-machine integrated model in order to study the speed limit of human safety, which needs to build human and mechanism multi body dynamics model[7]. Thus the higher precision personnel operations safety and comfort can be carried out. It is possible to use a man to do the experiment at a low speed but it is not allowed at a high speed for the legal and moral reasons. So in reality it is impossible to use human to do some dangerous experiments thus it is important to study the multi-body dynamics model. It is convenient to modify the calculation boundary conditions of the model. Similar it needs to consider human body and machine as interaction system by multi-body system theory in the research of human comfort. Then the acceleration, velocity and displacement and the force of the system can be obtained.

Fig.1 Medical transportation device and rehabilitation bed.

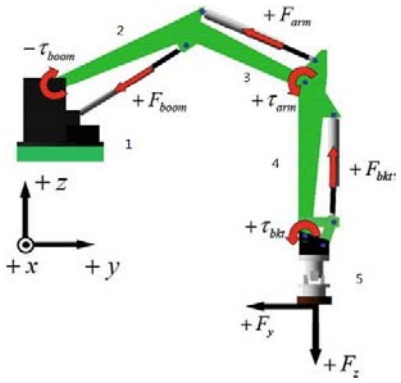

Fig.2 Bionic arm.

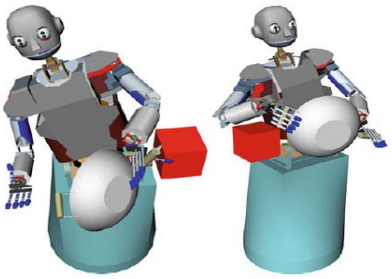

Fig.3 Human collision model.

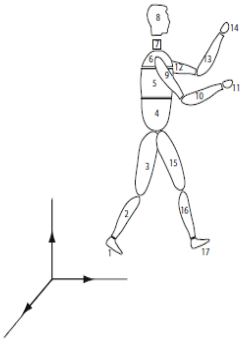

Fig.4 Man-machine comfort research multi-body model

According to the above examples it requires more and more motion accuracy and dynamics characteristics about biomedical engineering field such as medical transport equipment, bionic manipulator, human body model, and human model. Depend on its own technology it is unable to meet the growing structure strength and accuracy requirements. With the development of multi body dynamics it can satisfy the above requirements in biomedical engineering. Therefore the combination of the two disciplines will become more and more closely in the future.

5. Conclusion

So far the medical is no longer a separate subject and bio-medical engineering is not limited to the development of medical and biological range. Biomedical engineering technology is booming today but has not reached a mature stage and the multi-body dynamics is also in a rapid development stage. Use multi-body dynamics theory and technology can obtain precision, safety and structural strength requirements in biomedical engineering field. There are both theoretical research backgrounds and application objects of those two disciplines. At the same time it becomes the focus item between researchers and teachers from now on.

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