康复工程新进展与新趋势

Advances and Trend in Rehabilitation Engineering

S12

主席：张　明

主席：季林红

2020 年 11 月 21 日　星期六　13:30-17:00		
时间	**演讲者姓名和单位**	**演讲题目**
13:30-14:00	**窦　豆** 国家自然科学基金委	康复医学面临的机遇与挑战
14:00-14:30	**张　明** 香港理工大学	3D 打印技术在康复辅具行业应用的机遇与挑战
14:30-15:00	**李增勇** 国家康复辅具中心	肢体运动功能障碍动态量化评估与智能康复训练系统研发
15:00-15:30	**季林红** 清华大学	冬残奥备战中的人机交互与辅助训练技术
15:30-16:00	**李光林** 中科院深圳先进技术研究院	智能灵巧假肢及快速适配技术研究进展
16:00-16:30	**蓝　宁** 上海交通大学	人体感知运动控制在神经运动康复中的转化应用
16:30-17:00	**樊瑜波** 北京航空航天大学	康复技术创新的相关科学问题

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3D 打印技术在康复辅具行业应用的机遇与挑战

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先进 3D 打印技术为假肢和矫形器领域带来了机遇，这主要因为大多数假肢和矫形器产品都是定制设计的。与传统的制造方法相比，3D 打印技术有可能大大减少材料浪费，缩短制造时间，允许复杂几何形状和可变材料特性的设计，并且减少基于手工技能操作的依赖。然而，在假肢和矫形临床中使用 3D 打印制造仍然存在着巨多挑战。从技术上讲，缺少一个系统技术能将患者信息收集，界面形状修改和调整，材料选择和打印等过程集成一起，从而制造出既能满足功能要求又能满足舒适性要求的假体或矫形器。另一个巨大的挑战是当前的假肢矫形师不喜欢改变传统的制造方法，或者说缺少一套系统允许假肢和矫形师将传统技术与 3D 制造集成在一起。本演讲将回顾 3D 打印技术在假体和矫形器制造中的应用现状，并讨论生物力学研究在产品评估及优化设计中的应用。目的是将先进的 3D 打印技术尽早用于康复辅具的临床，提供即能够满足功能性，舒适性和美观性要求的产品，同时保持成本竞争力。

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Dynamic Quantitative Evaluation of Motor Dysfunction and Development of Intelligent Rehabilitation Training System

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The advancement of 3D printing technology brings opportunities in the field of prosthetics and orthotics, because most prosthetic and orthotic products are custom-designed. Compared with traditional fabrication approach, 3D printing technology if implementing properly can greatly reduce material waste, shorten the fabrication time, allow the design with complicated geometry and variable material properties, and eliminate the need for most skill-based manual operations. However, challenges still exist in the realities to use 3D printing fabrication in prosthetic and orthotic clinics. Technically, there is a lack of a systematic technology integrated the procedures of patient information collection, interface shape modification and adjustment, material selection and printing into a package to fabricate a prosthesis or orthosis that can meet both functional and comfortable requirements. Another big challenge is the reluctant of the current clinicians in accepting the new technology in the field. This challenge arouses the new development of a design package to allow the prosthetists and orthotists to integrate traditional techniques with 3D fabrication technology. This presentation reviews the current state of application of 3D technologies in prosthesis and orthosis fabrication, and discusses optimal design using computational methods and biomechanical evaluations of product performance, including fabrication technologies, methodologies of design, materials feasibility and application, functional evaluation, and current challenges regarding these aspects. The overall efforts in the development of these technologies is that the products can satisfy the requirements of functionality, comfort, and aesthetics, while keeping the cost competitive.

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冬残奥备战中的人机交互与辅助训练技术

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2022 年冬季残疾人奥运会将在北京召开，为在本届冬残奥会上取得好成绩，在科技部冬奥专项的支持下，清华大学会同中国残疾人运动管理中心、上海体院、首都体院、体科所、运医所等科研单位联合承担了“冬残奥运动员运动表现提升的关键技术”项目。本演讲将系统介绍历届冬残奥会的数据、竞技项目、我国参加冬残奥会的历程和残奥体育项目分级规则。结合残疾人运动员（截肢、截瘫和儿麻等）的肢体肌力特征、专项竞赛特点和运动短板，系统开展了人机界面分析，可穿戴的数据实时采集和可视化，肌力不对称测试、专项训练比赛器材和竞赛模拟器等辅助器械技术的研究与设计，为个性化提升不同残疾特点运动员的运动竞技能力和弥补短板提供了重要科技支撑。

Man-Machine Interaction and Auxiliary Training Techniques in Preparation for the Winter Paralympics

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The 2022 Winter Paralympic Games will be held in Beijing. To achieve good records in this Winter Paralympic Games, with the support of the Winter Olympics Special Project of the Ministry of Science and Technology, Tsinghua University working with China Administration of Sports for Persons with Disabilities (CASPD), Shanghai University of Sport (SUS), Capital University of Physical Education and Sports (CUPES), China Institute of Sport Science (CISS) and China Institute of Sports Medicine (CISM), have jointly undertaken the project of “Key Techniques for Improving Sports Performance of Paralympic Athletes”. This speech will systematically introduce the data of the previous Winter Paralympics, sports events, the history of China’s participation in the Paralympics and the classification rules of Paralympic sports. Considering the limb muscle strength characteristics, special competition characteristics and sports shortcomings of disabled athletes (amputation, paraplegia, pediatric anesthesia, etc.), we has carried out man-machine interface analysis, wearable real-time data collection and visualization, muscle strength asymmetry test, The research and design of auxiliary equipment technologies such as special training and competition equipment and competition simulators provide important scientific and technological support for personalized promotion of athletes with different disability characteristics and making up for shortcomings.

康复技术创新的相关科学问题

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随着全球人口的逐渐老龄化以及非传染性疾病（包括慢性疾病）比例的上升，康复技术在人们生活中的重要性越来越显著。康复技术创新融汇了现代康复工程科技与现代康复医学，对于补偿和恢复患者身体功能、提高改善日常生活能力十分重要。本次演讲将主要围绕康复技术创新的相关科学问题，着重向大家介绍康复技术的科学机制，包括康复技术的生物力学和神经生理研究进展、康复评价和训练技术的科学原理。

Scientific Issues of Rehabilitation Technology Innovation

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With the gradual aging of the global population and the increase in the proportion of non-communicable diseases (including chronic diseases), rehabilitation technology is becoming more and more important in people's lives. Rehabilitation technology innovation integrates modern rehabilitation engineering technology and modern rehabilitation medicine, which is necessary for compensating and restoring patients' body functions and improving their life quality. This speech will mainly focus on the related scientific issues and mechanism of rehabilitation technology innovation, including the research progress in biomechanics and neurophysiology of rehabilitation technology, and scientific principles of rehabilitation evaluation and training techniques.

康复医学面临的机遇与挑战

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以“康复医学面临的机遇与挑战”为题，介绍近年来康复医学领域科学基金的申请与资助情况，与其他学科的比较分析，以及该领域的重要研究进展。

Opportunities and Challenges in Rehabilitation Medicine

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This paper introduces the funds application and funding in the field of rehabilitation medicine in recent years, and its comparative analysis with other disciplines. Moreover, the important research advances in rehabilitation medicine is also introduced.

智能灵巧假肢及快速适配技术研究进展

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为了提高假肢性能、加快其实用化进程，我国迫切需要上肢假肢智能控制、人机交互和快速适配等相关前沿技术的突破。研究可再现人体手臂灵巧运动和感觉功能的假肢设计、智能控制、临床评估及其适配技术对于重建人体上肢功能，科学适配假肢十分重要。本次演讲将为大家介绍上肢假肢的模块化仿生机械创成、假肢手少驱动下多关节协同运动的驱动策略、多源生物信息融合的多运动模式精确识别方法、假肢手接触信息解析及多模态感觉反馈的实现方法、基于力触觉信息的假肢手自适应闭环调控方法、满足上肢假肢快速适配的制作工艺及人机接口训练方法等多项关键技术。

Intelligent and Dexterous Prosthesis and Rapid Individualized Application Technology

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In order to improve the performance of prostheses and speed up their practical application, it urgently needs breakthroughs in cutting-edge technologies such as intelligent control, human-computer interaction, and rapid individualized application of upper limb prostheses in China. To reproduce the dexterous movement and sensory function of the human arm is significantly important for reconstructing upper limb function and scientific individualization of the prosthesis, with investigating prosthetic design, intelligent control, clinical evaluation and its individualized application technology. This presentation would introduce the key technologies such as: the innovation of bionic upper limb mechanism module, the actuation strategy of multi-joint coordinated motion with less prosthetic hand driven, the accurate recognition method of multi-motion based on multi-source biological information fusion, the realization method of prosthetic hand contact and multi-modal sensory feedback, the adaptive closed-loop control method of prosthetic hand with force and tactile information, the manufacturing process for the rapid individualized application of upper limb prosthesis, and the man-machine interface training method.

人体感知运动控制在神经运动康复中的转化应用

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进行神经运动康复训练，首先需要是神经科学家，然后是医生或工程师。前者提供人体感觉运动系统工作原理，后者需要结合不同病人的情况进行治疗或培训。这些对于工程师设计运动功能康复设备非常重要。本次演讲将着重于阐述将人类感觉运动系统和控制的认识转化为截肢、中风和帕金森病患者提供康复处方的实践。

Translating Human Sensorimotor Control to Neuromotor Rehabilitation

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To practice neuromotor rehabilitation, one needs to be a neuroscientist first, then be a physician or an engineer. The former affords understanding of human sensorimotor system and its operating principles; while the latter requires executing treatment or training in conjunction with the conditions of patients, which varies individually. It is particularly central for engineers, who designs apparatus to enable the undermined motor functions. In this talk, I shall focus on translating what know about human sensorimotor system and control into practice of delivering rehabilitation recipes to those with amputation, stroke and Parkinsonian disease.

肢体运动功能障碍动态量化评估与智能康复训练系统研发

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目前康复技术和产品缺乏中枢 - 外周多模态信息融合的动态评估手段和产品，运动训练与神经调控缺乏精准环路导向、协同优化。因此，迫切需要开发一套具有实时交互、反馈、评估与治疗一体化的自适应康复系统来惠及广大偏瘫患者。本项目聚焦肢体运动功能恢复的脑功能重塑变化特征及神经环路重建规律研究，重点突破康复训练中近红外神经活动与脑组织氧合代谢活动的同步监测、多靶点神经调控与运动训练协同增强康复、肢体运动生物力学特征动态匹配、动态量化评估反馈及能耗匹配的自适应调节与闭环控制以及基于增量人工神经网络的智能化康复训练处方等关键技术；研制一套上下肢综合康复训练系统与平台，具有刚柔混合结构，支持主动、被动、助动和抗阻运动，可上下肢单独和联动训练；支持多模态康复训练模式，具备多频段脑神经自适应反馈功能，能够实现近红外、运动、触力觉等多模态参数综合评价及在线交互、康复训练任务自适应匹配；进行系统临床验证并形成标准规范。

Dynamic Quantitative Evaluation of Motor Dysfunction and Development of Intelligent Rehabilitation Training System

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At present, rehabilitation technologies and products lack dynamic evaluation methods with the centra-peripheral multi-modal information. Additionally, rehabilitation training and neuromodulation therapy lack precise loop guidance and collaborative optimization. Therefore, there is an urgent need to develop an adaptive rehabilitation system, with the function of real-time interaction, feedback, evaluation and treatment, to benefit the patients with motor impairment. This project focuses on the characteristics of brain function reorganization changes and the law of neural circuit reconstruction during the recovery of motor function. It is aimed to break through the five key technologies, specifically, (1) synchronous monitoring of near-infrared neural activity and brain tissue oxygenation metabolic activity during the rehabilitation training; (2) synergistically enhance rehabilitation that combined the multi-target neuromodulation and exercise training; (3) dynamic matching of biomechanical characteristics of limb movement; (4) dynamic quantitative evaluation feedback and energy consumption matching system with adaptive adjustment and (5) closed-loop control and intelligent rehabilitation training prescription based on incremental artificial neural network. The main research of this project is to develop a comprehensive rehabilitation training system and platform for upper and lower limbs, which has a rigid-flexible hybrid structure, supports active, passive, assisted and resistive movement, and can train the upper and lower limbs individually and in conjunction. This system also supports multi-modal rehabilitation training paradigm. And it has a multi-band adaptive neurofeedback function, which can realize the comprehensive evaluation with multi-modal parameters such as near-infrared, motion, tactile sensation, online interaction, and adaptive matching of rehabilitation training tasks. At lastly, the project will conduct systematic clinical verification of the developed system and platform and form a standard specification.