南通大学

专业技术五级及以下岗位申报表

申报人姓名：陈峰

申报岗位等级：专业技术五级

所在一级学科：控制科学与工程

现聘岗位等级：专业技术七级

填表时间：2019年5月5日

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6. 所在一级学科参照2018年4月国务院学位委员会、教育部印发的《学位授予和人才培养学科目录》填写。

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申报人签名：陈峰

2019年 5月 5日

一、 基本情况

姓名	陈峰	性别	男	民族	汉	籍贯	安徽肥西
出生年月	197705	政治面貌	中共党员		来校工作年月	200706	
健康状况	健康	联系电话	18761796396		邮箱	hardwk@163.com	
所在一级学科	控制科学与工程				申报专业技术岗位等级	五级	
现聘专业技术职务及聘任时间（转评专业技术职务分行填写）			副教授，20100807				
是否遵纪守法，具有良好的品行和职业道德，具有良好的学术声誉、学术道德和合作精神						是	

二、 年度考核情况

任现职以来，各年度综合考核是否均为合格及以上			
近三年年度考核情况	2016 年	2017 年	2018 年
	合格	优	优

三、教学工作情况

1.任现职以来，年度教学质量考核优秀次数（注明年份）			
2.近三年教学质量考核情况	2016 年	2017 年	2018 年
	优	优	优

四、任现职以来业绩

1. 教师荣誉（申报条件附表条款 1）

获得时间	称号名称	授予部门

2.人才称号（申报条件附表条款 2）

获得时间	称号名称	授予部门
√ 2016	“六大人才高峰”高层次人才项目：高端装备产业	江苏省委组织部

3.团队建设（申报条件附表条款 3）

获得时间	团队名称	本人角色	批准部门

4.教学平台、公共服务平台负责人（申报条件附表条款 4）

获得时间	平台名称	本人角色	批准部门

5.专业建设负责人（申报条件附表条款 5）

获得时间	专业建设名称	本人角色	批准部门

6.学科、科研平台负责人（申报条件附表条款 6）

获得时间	平台名称	本人角色	批准部门

7.教学成果奖（申报条件附表条款 7）

获得时间	奖项级别	奖项等级	本人排名	评奖部门

8.自然科研成果奖（申报条件附表条款 8）

获得时间	奖项名称	奖项等级	本人排名	评奖部门

9.专利奖（申报条件附表条款 9）

获得时间	奖项名称	奖项等级	本人排名	评奖部门

10.指导学生（申报条件附表条款 10）

获得时间	奖项名称	奖项等级	本人排名	评奖部门

11.科研项目（申报条件附表条款 11）

起止时间	项目名称	立项单位	项目级别	本人角色
2011/01-2013/12	可穿戴型颈部助力并联机器人技术研究	国家自然科学基金委员会	国家自然科学青年基金	主持人
2015/07-2018/06	可穿戴型助力机器人柔性双模混合研究	江苏省科技厅	江苏省自然科学基金项目	主持人

12.教学项目（申报条件附表条款 12 内容）

起止时间	项目名称	立项单位	项目级别	本人角色
				主持人

13.论文、论著、专利类（申报条件附表条款 13）

论文题目	发表刊物（卷/期）	本人角色	期刊级别（或分区）

专著名称	出版社	字数（本人撰写字数）	出版时间	折算论文篇数

发明专利授权名称（转让情况）	本人角色	授权时间（转让时间）	折算论文篇数
一种手指康复训练装置	第一发明人	201601	
可穿戴型颈部助力并联机器人	第一发明人	201207	

合计论文篇数（含折算）：_______篇
自然科学论文___篇（其中中科院 JCR 三区及以上论文__篇；人文社科论文___篇;期刊级别按附表条件表述，如 SCI、EI、三区；CSSCI、SSCI、《高等学校文科学术文摘》转载等；ESI 学科排名前 1%或学科潜力值超过 0.5%的主要贡献者情况说明：________________

____

14.课程资源建设（申报条件附表条款 14）

获得时间	课程资源建设名称	本人角色	批准部门

15.标准制定（申报条件附表条款 15）

颁布时间	制定标准名称	本人角色	标准颁布主体

五、符合申报岗位条件情况

对照《南通大学电气工程学院2019年基础岗位新增聘用办法》，本人认为符合条件为：

聘任 副高 （副高、中级）专业技术职务满 8 年，具备附表 1 中所列的第 2 、7、11 、___、___、___项条件，以及附表___中所列的第___、___、___、___、___项条件。

六、学院意见

经评审，　　　　同志拟聘为专业技术　　　级岗位。

电气工程学院岗位聘用工作小组组长签字：

年　　月　　日

姓　　名　陈　峰

性　　别　男

出生年月　1977.05

工作单位　南通大学

编　　号　10010416

经　江苏省高校教师高级专业技术资格评审委员会于2010年 8月7 日评审，陈　峰已具备副教授　　　　资格。

发证机关：

二○一○年　八月　七日

“六大人才高峰”第十三批高层次人才选拔培养资助方案
（高层次人才项目：高端装备产业）

项目编号	项目名称	项目承担单位	项目承担人	资助类型
GDZB-005	超高频段通信装备传输理论与技术研究	东南大学	许威	C
GDZB-006	光伏系统智能运维机器人关键技术	河海大学	丁坤	C
GDZB-009	精密电主轴用五自由度集成化磁悬浮电机关键基础理论及运行控制	淮阴工学院	张涛	C
GDZB-011	大口径光学非球面或自由曲面加工中基于夏克哈特曼波前传感器的面形检测技术研究	江南大学	胡立发	C
GDZB-014	紫外光诱导自由基一体化脱硫脱硝脱汞的关键技术及装置研究	江苏大学	刘杨先	C
GDZB-016	设施栽培作物营养亏缺的叶片组分二维分布诊断技术及装备研究	江苏大学	石吉勇	C
GDZB-017	高空化性能高可靠性舰船用盐水泵关键技术研究及应用	江苏大学	王勇	C
GDZB-018	基于多次快扫的飞秒激光双光子加工技术及其三维纳米光子器件	江苏大学	王正岭	C
GDZB-019	激光定域辐照的电沉积3D打印制造技术	江苏大学	张朝阳	C
GDZB-021	船用水下结构检测与清污机器人ROV研发与产业化	江苏科技大学	陈伟	C
GDZB-027	高参数换热设备管子-管板柔性连接性能与以胀代焊技术研究	江苏省特种设备安全监督检验研究院	马歆	B
GDZB-032	盐析两相流理论及熔盐泵内部流动和外特性研究	南京工业大学	邵春雷	C
GDZB-033	大型盾构主轴承可靠性增长关键技术与试验装备	南京工业大学	王华	C
GDZB-034	面向三维打印仿生功能性零件建模技术	南京航空航天大学	戴宁	C
GDZB-040	用于运载工具减震降噪的磁流变弹性体器件研制与开发	南京理工大学	王文举	C
GDZB-044	康复机器人研究	南通大学	陈峰	C
GDZB-052	超声波振动与冲击耦合高效破岩系统研究	中国矿业大学	王旭锋	C
GDZB-056	大输液智能灯检机器人	南京海果智能科技有限公司	屈桢深	C
GDZB-059	储罐底板全自动漏磁检测机器人的研制及工程应用	南京市锅炉压力容器检验研究院	梁斌	C

61060101－3839－4

国家自然科学基金资助项目批准通知

南通大学　陈峰同志：

根据《国家自然科学基金条例》的规定和专家评审意见，国家自然科学基金委员会决定资助您的申请项目。请您登录科学基金项目管理 ISIS 网络信息系统（https://isis.nsfc.gov.cn），获取《国家自然科学基金资助项目研究计划书》（以下简称计划书）。您登录该系统的用户名和密码以电子邮件方式发送至您在申请书中填写的电子邮箱。

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国家自然科学基金委员会

信息科学部

2010 年 8 月 18 日

附：批准意见表（见背面）

江 苏 省 科 技 项 目 合 同

计 划 类 别 基础研究计划（自然科学基金）--面上研究项目

项 目 编 号 BK20151273

项 目 名 称 可穿戴型助力机器人柔性双模混合控制研究

项 目 类 别 ______

起 止 年 限 2015 年 7 月 至 2018 年 6 月

项目负责人 陈 峰 电话及手机 18761796396 0513-85012601

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项目主管部门 南通市科学技术局

江 苏 省 科 学 技 术 厅

二〇一五年

八、签订合同各方

甲方：

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项目主管处室负责人（签字）

项目主管处室经办人

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项目负责人（签字）

公 章

开户银行、帐号

2015年 9月 7日

丙方：

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公 章

年 月 日

南 通 市 科 技 项 目 合 同

计 划 类 别 2015 G应用基础研究计划 工业创新

项 目 编 号 GY12015015

项 目 名 称 NBT800重载码坯机器人系统研究与开发

项 目 类 别 应用基础研究-工业创新

起 止 年 限 2015 年 10 月 2017 年 09 月

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承 担 单 位 南通大学

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项目主管部门 南通大学

南 通 市 科 学 技 术 局

二〇一四年一月制

证书号第[illegible]号

发明专利证书

发明名称：[illegible]

发明人：[illegible]

专利号：ZL 2011 1 [illegible]

专利申请日：2011年04月27日

专利权人：南通大学

授权公告日：2012年07月25日

[illegible]

局长 田力普

中华人民共和国国家知识产权局

2012年07月25日

第1页（共1页）

证书号第[illegible]号

发明专利证书

发明名称：[illegible]

发明人：[illegible]

专利号：ZL 201[illegible]

专利申请日：2013年10月15日

专利权人：南通大学

授权公告日：2016年07月06日

[illegible]

局长 申长雨

中华人民共和国国家知识产权局

2016年07月06日

第1页（共1页）

软体机器人的分类与加工制造研究

Research on the Classification and Processing Manufacturing of Soft Robots

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（南通大学电气工程学院[1]，江苏 南通　226019；常州先进制造技术研究所[2]，江苏 常州　213164）

摘　要：对软体机器人的分类和加工制造等问题进行了调查研究。软体机器人可以分为有缆驱动式软体机器人和无缆驱动式软体机器人，其采用电活性聚合物、聚合凝胶等作为致动器。软体机器人的制造包括柔软本体制造、柔性致动器制造和可伸展电子电路制造，采用了形状沉积法、智能微结构等新型制造方法。软体机器人是仿生机器人研究的延续，也是一种新兴的机器人，对它的研究才刚刚起步，在未来的研究中将面临更多的挑战。

关键词：软体机器人　仿生机器人　驱动方式　电活性聚合物　智能材料

中图分类号：TP242　　　**文献标志码**：A

Abstract: The classification and manufacturing processes of the soft robots are researched and investigated. Basically, there are two categories of soft robots, i. e., the cable driven soft robot and the wireless driven soft robot; while the actuators are using electro-active polymer (EAP) and polymer gel, etc. The manufacturing of the soft robots includes three parts, i. e., flexible body fabrication, flexible actuator fabrication, and stretchable electronic circuit fabrication; novel manufacturing methods such as shape deposition and smart microstrurture are applied. Soft robot is the continuation of the research on biomimetic robot, and it is an emerging robot, its research has just started, and will face more challenges in the future.

Keywords: Soft robot　Biomimetic robot　Driving mode　Electro-active polymer　Smart materials

0　引言

传统机器人的刚性结构限制了其与环境相互作用的能力。如传统的机器人使用刚性连接，并采用末端执行器操作对象，其通常分量重且昂贵，能执行的动作类型有限，在非结构化和高度拥挤的环境中常会遇到困难。然而各种动植物在复杂的运动中却表现出了其柔性结构。如章鱼触手和大象的鼻子，它们的肌肉结构属于典型的肌肉性静水骨骼结构，通过加压渗透可以改变其形状。研究人员根据生物学特征而设计和构建的软体机器人，可在混乱或者非结构化的环境中，利用其软结构和冗余自由度来完成微妙的工作。

近年来，随着仿生技术的快速发展，越来越多的研究人员开始关注仿生软体机器人的研究。该机器人具有传统机器人所无法媲美的柔软性能，能够根据环境状况而灵活改变自身形状，对工作空间狭小及非结构化环境具有独特的适应能力，这使得软体机器人的应用极为广泛。

本文将对软体机器人的一些现状进行分析并指出未来发展的趋势。

1　软体机器人分类

仿生软体机器人主要由弹性基础材料构成，依靠自身形状在空间上的连续变化来实现运动，理论上具有无限多自由度[1]。软体机器人分类情况说明如下。

① 根据用途的不同，可以将软体机器人分为：工业机器人、特种机器人或者是陆地机器人、水下机器人和地外探险机器人。

② 根据驱动方式的不同，可以将软体机器人分为：物理驱动式软体机器人和化学驱动式软体机器人。

③ 根据结构类型的不同，可以将软体机器人分为：静水骨骼结构软体机器人、肌肉性静水骨骼结构软体机器人以及其他结构软体机器人。

④ 根据受控方式的不同，可以将软体机器人分为：点位控制型软体机器人和连续控制型机器人。

⑤ 根据能量供给方式的不同，可以将当前的软体机器人分为：有缆驱动和无缆驱动式软体机器人。有缆驱动式软体机器人和无缆驱动式软体机器人特性比较如表 1 所示。

下面着重介绍有缆驱动式软体机器人和无缆驱动式软体机器人。

国家自然科学基金资助项目（编号：61105111、61005054）。

修改稿收到日期：2013-09-25。

第一作者尤小丹（1988-），女，现为南通大学控制理论与控制工程专业在读硕士研究生；主要从事仿生机器人的研究。

Proceedings of 2016 IEEE
International Conference on Mechatronics and Automation
August 7 - 10, Harbin, China

Residual Power Spectrum Analysis in the Application of EEG De-noising

Yongtao Wan , Feng Chen , Zhixiang Huo
School of Electrical Engineering
Nantong University
Nantong,Jiangsu Province, China
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Abstract – **Electroencephalogram (EEG) reflects the physiological rhythms of brain. It has been widely used to diagnose mental disease and infer the intention of human from the Brain Computer Interface (BCI) system. Compared with other signals, it is so weak that it can be contaminated easily. In this paper, we intend to introduce a new method, orthogonal test, which is used to select the appropriate combination of mother wavelet, threshold strategy and decomposition level in wavelet transform to remove noises from EEG signal. To measure the effect of de-noising, we not only use traditional de-noising evaluate criteria, namely signal to noise ratio (SNR), root mean square error (RMSE), but also lead to a new and intuitive method, residual power spectrum (RPS), assessing the de-noising work. Correlative experimental results showing the eoif3 wavelet function, Rigorous Sure threshold and 3 levels decomposition have the best performance.**

Index Terms* – *Orthogonal test. RPS. EEG. De-noising.

I. INTRODUCTION

Electroencephalogram (EEG) is the recording of electrophysiological brain activity along the scalp. It has been widely used in studying brain function and pathological brain mechanisms because of its high temporal resolution, non-invasiveness, low cost and suitability for long-term monitoring [1-6], such as post-stroke dementia [7], epilepsy which is the second most common neurological disorder [8-11]. It is also applied in brain computer interface (BCI) system and performance enhancement or rehabilitation ranging from sports sciences to neurofeedback training [12]. Generally, the amplitude of clinical EEG is around 10-200 μv and the frequency range is from 1 to 100 Hz. According to frequency range, they can be mainly classified into four rhythms, namely Delta ( ), Theta ( ), Alpha ( ) and Beta ( ). Their briefly information has been shown in table1.

Table 1

Type	Frequency(Hz)	Amplitude(μv)
Delta(δ)	1-3	20-200
Theta(θ)	4-7	100-150
Alpha(α)	8-13	20-100
Beta(β)	13-30	5-20

Moreover, when we are in the awakening status and focus on something, brain often appears a frequency higher than beta waves, the frequency is 30-80 Hz, but its amplitude range is uncertain. And during sleep, it can also appear some more special waveforms in brain, such as the hump wave, sigma (σ) wave, lambda (λ) wave, mu (μ) wave, etc. Through the above analysis, we can learn that EEG is diversity and weakness. So it is easily contaminated by other physiological signals such as electromyogram (EMG), electrooculogram (EOG) and space electromagnetic noises during the acquisition process [13]. Those artifacts will confuse the original EEG signal and make the further analysis more difficult. So how to eliminate the noise and extract useful information from EEG is a great challenge.

In the current study, wavelet threshold de-noising has been regarded as an effective method to solve it. And there are many theses stating the relative theory. However, it does exist greater arbitrariness when we select the appropriate mother wavelet function, threshold strategy and decomposition level. So this paper will introduce a new method, orthogonal test, to select wavelet transform relevant parameters. It will provide a better and scientific way to quickly identify the optimal combination of parameters. In addition, normal de-noising criteria, like signal to noise ratio (SNR), root mean square error (RMSE), peak signal to noise ratio (PSNR), usually neglect the frequency information of residual. In this paper, we will propose a new method: residual power spectrum analysis. Through the analysis of residual power spectrum, filtered frequency information can be displayed. Compared with the normally evaluative criteria, the residual power spectrum is more intuitive. It can be used as a supplement when those normal evaluating criteria are similar and difficult to be selected in EEG de-noising process. In this paper, Epoc headset device of Emotiv systems is used for EEG acquisition as shown in Fig.1.

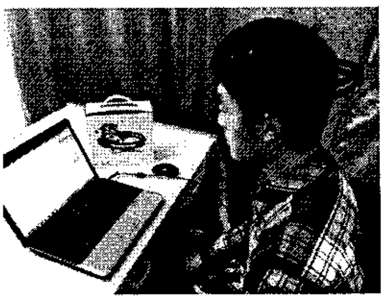

Fig.1 EEG acquisition from author using Epoc.

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Design of the arm-wrestling robot's force acquisition system based on Qt

Zhixiang Huo, Feng Chen, Yongtao Wang

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基于 HCSP 和模糊熵的脑电信号分类

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摘 要：针对共同空间模式特征提取算法（CSP）不能对频域信息进行处理，且在导联数较少的情况下应用效果不佳的问题，提出将希尔伯特-黄变换（HHT）与 CSP 相结合的算法。在原始脑电信号经过经验模态分解（EMD）后，提取每个导联的前三阶固有模态函数（IMF）及其组合重构信号，利用 CSP 特征提取，获取 2 维特征，联合计算信号的自回归模型参数（AR）和模糊熵组成融合特征向量，采用线性判别分类器对提取的特征进行分类。对第二届 BCI 竞赛提供的数据使用该方法进行特征提取，训练集和测试集分类准确率分别达到 90%、88.6%，验证了该算法可有效改善运动想象辨识效果。

关键词：脑电信号；共同空间模式；希尔伯特-黄变换；自回归模型；模糊熵；特征提取

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Classification of EEG signal based on HCSP and fuzzy entropy

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Abstract: The common spatial pattern feature extraction algorithm (CSP) can not deal with the frequency domain information and the poor effects of application exist in the case of a small number of leads, a method combining Hilbert-Huang transform (HHT) with CSP was proposed. The first three intrinsic mode functions (IMF) and the reconstructed signal of each lead were extracted after the empirical mode decomposition (EMD) of the original electroencephalogram (EEG). CSP was used to obtain the two-dimensional feature vector. the autoregressive model parameters (AR) and fuzzy entropy of the EEG were calculated to constitute the feature vectors. The extracted features were classified. The data provided by the second BCI competition and the proposed method for feature extraction were used. Results of experiments show the classification accuracies of 90% and 88.6% are achieved for the training set and test set. The method can affect the motion recognition greatly.

Key words: electroencephalogram; common spatial pattern; Hilbert-Huang transform; autoregressive model; fuzzy entropy; feature extraction

0 引 言

脑-机接口（brain-computer interface, BCI）[1] 通过分析由运动想象产生的脑电信号就能读取人脑发出的动作指令，从而替代大脑神经与人体肌肉直接与外部设备建立连接通道，帮助肢体活动受限的人操作和控制一些辅助设备。然而由于脑电信号自身固有的非线性和非平稳性，这给脑电信号特征提取与识别带来了巨大的挑战，同时也是运动想象 BCI 技术一直处于实验室阶段，不能走入实际应用的主要原因[2]。

目前，研究人员已提出多种运动想象脑电信号的特征提取[3-7]方法。其中小波变换和小波包变换都是基于傅里叶变换的特征提取算法，不能在时域和频域同时具有较高的分辨率。共同空间模式提取的特征缺乏相关的频域信息，且需要大量的电极，无法应用到少通道信号中[8]。希尔伯特-黄变换在时域和频域都具有很高的分辨率，但是在 EMD 分解后需要人为选取 IMF 分量，由此可能导致重构信号混入噪声或丢失对分类有用的信息[9]。针对上述特征提取方法中的缺陷，提出了希尔伯特-黄变换与共同空间模式相结合（HCSP）的方法，结合自购实验装置 EPOC，对表征手部运动想象脑电特征的 C3、C4、CZ 三通道分别进行经验模态分解，选取分类效果最明显的前三阶 IMF 及其

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Classification of EEG signal based on HCSP and Fuzzy entropy

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Abstract—**According to the problem that the common spatial pattern feature extraction algorithm (CSP) are unable to deal with the frequency domain information, and the application effect is not so good in the case of less lead number ,an algorithm which combine the Hilbert Huang transform (HHT)with CSP is proposed. After the original EEG signal passes empirical mode decomposition (EMD),we can extract the first three order intrinsic mode function(IMF) of each lead and its reconstruction signal, and we can obtain two-dimensional feature from this signal through CSP feature extraction, meanwhile, calculate the Autoregressive model parameters and fuzzy entropy to form the fusion feature vector .Finally, use linear classifier to classify the extracted features. The data provided by the second BCI competition are extracted by this method, and the accuracy of the training set and test set is achieved by 90% and 88.6% respectively. It is proved that the algorithm can effectively improve the effect of recognition.**

Keywords- electroencephalogram;common spatial pattern; Hilbert-Huang Transform;autoregressive model;fuzzy entropy; Feature extraction

I. INTRODUCTION

In recent years, Brain-computer Interface (BCI) has become a hot spot in the field of rehabilitation engineering and biomedical Engineering. The research and development of BCI will greatly enriched the content of the brain cognitive science and neural informatics. We could recognize human activities by analysing the EEG signals[1].In this way ,BCI may create a new communication channel between the brain and an output device , it may convert action or language instructions directly into signals ,which can drive an external device instead of the normal output pathways of nerves and muscles. However, the non-stationary and nonlinear characteristic of EEG makes a tremendous challenge for feature extraction. It is the reason why the BCI technology is still in the laboratory stage and can't be used in the practical application[2].

So far, researchers have presented a variety of feature extraction algorithms, Please refer to the literature [3-7]. Wavelet transform and wavelet packet transform[3] are both based on Fourier transform, which can't have higher resolution in time domain and frequency domain at the same time. The feature extracted from the common spatial pattern lacks the relevant frequency domain information and requires a large number of electrodes[4], so it can't be applied into the less channel signal. Hilbert huang transform has a high resolution in both the time domain and the frequency domain[5], but it is need to select the IMF component artificially after the EMD, which may results in the reconstructed signal mixing with noise and losing useful information. According to the defects of the above feature extraction algorithms, a method combining HHT with CSP is proposed. By selecting the three channels (C3, C4, and CZ) which characterize the motor imagery of the hand, and then apply the empirical modal decomposition of each channel respectively. We extract the first three IMF and the reconstructed signal of each lead composed of 15-dimensional signal. We can obtain the instantaneous amplitude by Hilbert transform and extract the feature through the way of CSP[6], the Autoregressive model parameters (AR) and fuzzy entropy of the EEG were calculated to constitute the feature vectors. This paper employs the data provided in BCI competition 2003, the Hilbert Huang transform, CSP and the proposed method are used to extract the features, and then classify them through linear classifier. Using the method proposed in this paper, the classification accuracy is 5 percentage points higher than that of HHT alone and 15 percentage points higher than that of CSP alone, The classification results show that this method could avoid the uncertain factors brought by the IMF, It can also reduce the number of leads and increase the relevant frequency domain information, so this method can extract more effective feature.

II. EEG FEATURE EXTRACTION METHOD

A. Introduction of HHT

Recently, Hilbert-huang transform is a major breakthrough in the field of signal processing, Since the late 90s, it has been widely used in seismic data, climate data, voice signals, image signals and other data analysis, this method has good resolutions on both time and frequency domain, so it is applicable in nonlinear and non-stationary signal processing. HHT is divided into two parts[5]: 1) empirical mode decomposition (EMD); 2) Hilbert spectral analysis (HSA).

EMD is the first step in Hilbert Huang transform and also the most important step in the feature extraction, a complex multi-component signal can be decomposed into some simple components through EMD. The upper and lower envelope of these simple components must be symmetrical along the timeline at any time, and the

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机器人三关节运动跟踪路径定位滑模控制

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摘要:为了提高空间三关节机器人轨迹跟踪控制性能,提出一种基于低通滤波器的滑模控制方法。传统滑模控制响应速度快,对系统参数摄动和外部扰动等不确定因素具有不变性,可保证系统的渐进稳定性,但其缺点是控制本身会引起系统较强的抖振,造成跟踪精度较差。因此在传统的滑模控制方法中引入低通滤波器,则保证了轨迹跟踪误差的快速收敛,同时实现控制器输出信号的平滑,有效的减弱了抖振。系统的稳定性通过李亚普诺夫定理证明。通过对空间三关节机器人进行仿真,结果表明在存在模型误差和外部扰动的情况下,提出的方法能有效提高关节机器人跟踪控制性能,同时可以较好的消弱系统抖振。

关键词:机器人;滑模控制;低通滤波器;抖振
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Sliding Mode Control for Robot Three Joint Motion Tracking Path Location

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ABSTRACT: In order to improve the trajectory tracking control performance of three-links spatial robot, a new sliding mode control method with low-pass filter is proposed. Due to fast response speed and invariant to system parameter perturbation and external disturbance uncertainties, traditional sliding mode control can assure the asymptotic stability of the system, but its disadvantage is that the control itself may cause strong system chattering which results in poor tracking accuracy. Therefore, a low pass filter was introduced on base of the traditional sliding mode control method. The control law can guarantee fast convergence of trajectory tracking error as well as actualizing the smoothness of the output signal of the controller, and thereby the chattering was weakened effectively. The stability of the system was proved by Lyapunov theorem. Finally the simulation was carried out for a three-links spatial robot, the simulation results show that the proposed method is effective to improve the robot tracking control performance in the presence of model error and external disturbance and to weaken the chattering better.

KEYWORDS: Robot; Sliding model control; Low-pass filter(LPF); Chattering

1 引言

多关节机器人也称作为机械臂、机械手,从运动几何学的角度看,是指一端与基础固定的一系列具有空间运动能力的刚体的连接组合[1]。多关节机器人在现代工业应用中占据主体地位。然而多关节机器人是一个十分复杂的多输入多输出非线性系统,具有时变性、强耦合性和非线性等动力学特性,因而控制起来十分复杂。尤其是由于机器人结构参数的不确定性、作业环境干扰的不确定性及结构共振模式的不确定性等因素的存在,将导致机器人动力学模型存在建模误差和模型的不确定,这些不确定性因素的存在都有可能造成系统的不稳定[2-4]。对机器人的控制主要是对其各关节或末端执行器的位置进行控制,使其能够以期望的动态品质跟踪给定的轨迹或稳定在给定的位置上,即轨迹跟踪控制或位置控制。针对不确定性机器人的先进控制策略主要有三类:滑模控制、自适应控制和鲁棒控制。

滑模控制[5](Sliding Mode Control, SMC)本质上是一类特殊的非线性控制,因具有强鲁棒性、无需精确建模和专门解耦而成为一种有效的控制方法。可以对含有多种不确定性干扰和摄动的多关节机器人实现较好的控制。但研究表明其控制器的输出存在严重的抖振现象,这并不利于控制器的物理实现和工程应用。国内外许多学者针对滑模控制抗抖振问题进行了大量的研究,从不同角度提出了很多解决方法。目前较为典型的几种方法有[6]:滤波方法、观测器方法、切换增益方法、模糊方法、神经网络方法和遗传算法优化方

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Sliding Mode Control of Three-links Spatial Robot Based on Low-pass Filter

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Abstract—**In order to improve the trajectory tracking control performance of three-links spatial robot, a new sliding mode control method with low-pass filter is proposed in this paper. Due to Fast response speed and invariant to system parameter perturbation and external disturbance uncertainties, traditional sliding mode control can assure the asymptotic stability of the system, but its disadvantage is that the control itself will cause system strong chattering. Therefore, low pass filter is introduced on base of the traditional sliding mode control method, the control law can guarantee fast convergence of trajectory tracking error as well as robustness for external disturbanees and parameter uncertainties. The stability of the system is proved by Lyapunov theorem. Finally the simulation is carried out for the three-links spatial robot, the simulation results show that the proposed method is effective to improve the robot tracking control performance in the presence of model error and external disturbance, and weaken the chattering to a certain extent.**

Keywords-robot; sliding model control; low-pass filter; chattering

I. INTRODUCTION

Multi link robot, also known as the manipulator, from the perspective of motion geometry, refers to the end and the base of a series of fixed space with the ability to connect the rigid body [1]. Multi link robot occupies the main position in modern industrial application. However, multi link robot is a very complex multi input and multi output nonlinear system, which is characterized by time-varying, strong coupling and nonlinear dynamics. Especially due to the uncertainty of the structural parameters, the uncertainty of robot working environment disturbance and the uncertainty of structural resonance mode, will lead to modeling errors of dynamic model of robot, these uncertainties are all likely to cause system instability [2, 3]. Control of the robot means to control the position of link or the end-effector to track a given trajectory or stable in a given position with expected dynamic quality, that is the trajectory tracking control or position control. There are three kinds of advanced control strategies for uncertain robots: sliding mode control, robust control and adaptive control.

Sliding Mode Control (SMC)is a special kind of nonlinear control. It is an effective control method because of its strong robustness, no need of accurate modeling and special decoupling. It can be used to control the multi link robot with many kinds of uncertainties and disturbances. However, the study shows that the output of the controller has serious chattering phenomenon, which is not conducive to the physical realization and engineering application of the controller. At present, there are several typical methods[4], such as filtering method, observer method, switching gain method, fuzzy method, neural network method and genetic algorithm optimization method. The adaptive sliding mode controller based on disturbance observer is designed to eliminate chattering phenomenon in traditional sliding mode control in reference [5], and the tracking error is close to zero. In reference [6], actualize the switching gain of sliding mode controller of permanent magnet synchronous motor (PMSM)real-time tuning with the combination of gain scheduling and adaptive, achieve the gain scheduling of switching gain coefficient in the range of allowable boundary, weakens the chattering and improves control performance. The reference [7] presents a radial basis function neural network sliding mode control method, the control scheme using global sliding surface, the nonlinear mapping ability of neural network and the characteristics of sliding mode control are combined, weaken the chattering of sliding mode control, and ensure the robustness of the system.

In this paper, a sliding mode controller based on the low-pass filter is proposed to replace the traditional sliding mode controller for three link robot. The experimental results show that the link trajectory tracking performance of the three link robot has good dynamic quality, the tracking error is asymptotically, stable and closed to zero, furthermore weaken the chattering phenomenon in a certain extent.

II. DYNAMIC MODEL OF THREE-LINKS ROBOT

The dynamic equation of the three link robot is established based on Lagrange kinematics:

$$H(q)\ddot{q}+C(q,\dot{q})\dot{q}+G(q)+d(q,\dot{q},\ddot{q},t)=\tau \qquad (1)$$

Where, q , $\dot{q}$ and $\ddot{q}$ are the angular displacement (position), angular velocity and angular acceleration of each link of robot; τ represent control moment; $H(q)$ represent inertia matrix; $C(q,\dot{q})$ is the Coriolis force and centripetal force; $G(q)$ corresponds to gravity; $d(q,\dot{q},\ddot{q},t)$ includes modeling uncertainties, friction torque and external disturbance torque.

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六维腕力传感器非线性正解耦方法设计*

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摘 要：多维力传感器利用其多个转换单元完成测量加载于其结构上未知负载的作用效果,解耦是其设计的重要组成部分。针对传统静态线性解耦方法的不足,试图将传统线性解耦方程扩展为多项式结构,受其多元高次方式通解形式的启发,构造了一种多项式非线性静态正解耦方程,该方法无需传统线性解耦方法中的曲线拟合、逆解,不依赖以系统是线性为前提,且方程可以扩展成任意结构的多项式。实验结果表明:该方法能降低输出耦合误差。

关键词：六维力传感器；耦合误差；线性解耦；非线性正解耦

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Design of nonlinear directly decoupling method for six-axis wrist force sensor*

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Abstract: A multi-axis force sensor is a device in which several simple transducers measure the effects of unknown loads on the mechanical structure, decoupling is an important part for its design. Aiming at shortcomings of traditional static linear decoupling method, attempt to extend the traditional linear decoupling equation to polynomial structure, inspired by the general form of the inverse solution to polynomial, a nonlinear polynomial static directly decoupling equation is established, the method does not need curve fitting and inverse solution in traditional linear decoupling method, and does not depend on the precondition that the relationship between input and output is assumed to be linear behavior, and it can be expanded easily to produce any polynomial type required. The experimental results show that the method can reduce significantly output coupling error.

Key words: six-axis force sensor; coupling error; linear decoupling; nonlinear directly decoupling

0 引 言

多维力传感器是智能机器人重要组成部分,已广泛应用于机器人和遥控操作领域,获取力的变化方向和强度大小是其主要任务。对臂-环境交互的感知能力是机器人由单一的重复行为转变为针对未知环境或任务具有一定自主决策能力的智能体系[1]。多维力传感器应用在可穿戴型助力机器人系统,用于获取人-机交互信息[2];针对目前常用手写设备信息获取不全面问题,基于多维力传感器设计的笔交互设备能获取手写全力信息[3]。另外,广泛应用于灵巧手的多维指力传感器[4],使手指实现智能抓取成为现实。

对于多维力传感器而言,一旦受力,弹性体在各个方向上均会产生形变,从而导致各向输出,即使是理想的输入也会产生不期望的结果——耦合误差。解耦方法通常被用来提高输出精确度,避免因耦合误差而引起系统误动作。利用最小二乘法所构建的静态线性解耦方法常应用于工程解耦中[5~8],其解耦效果的好坏主要依赖于传感器的结构设计、加工工艺等的优劣,该方法的主要优点是便于实现逆解。但在实际应用中,静态线性解耦并不十分理想,其原因在于传感器的输入-输出关系并非是理想的线性关系。为此,有研究人员提出用分段线性化法,因其计算时间太长而无法应用于工程实际中[9]。借鉴风洞天平非线性标定方法,理论上利用多次非线性拟合手段,实现非线性解耦[8],仿真已证明其可行性。近年来,智能计算被广泛应用于多维力传感器解耦与误差补偿中,借助其良好的非线性逼近能力和自学习能力,通过神经网络和支持向量机等方法重新构建多维力传感器输入-输出关系或进行非线性校正及

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Autonomous Decision-making for Human-Robot Hybrid System Based on FRF

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Keywords: WPAL. Interaction Force. FRF.

Abstract: This paper demonstrates a concept of walking power assist leg (WPAL), which is designed for enhancing strength and endurance during walking. Using D-H method, the kinematics of WPAL is investigated theoretically. The reasonability of fundamental design is verified by the simulation results. To make the system work smoothly and provide power assist for operator, the robot must understand the operator's intention. In this paper, the floor reaction force (FRF) information has been used to complete the intention prejudgment of its operator's leg movement. The method of prejudgment and FRF information acquisition system are designed. The experimental results also indicate the feasibility of FRF system.

Introduction

In 1970s, Miomır Vukobratović has introduced the concept of the power assist exoskeleton robot [1]. However, it was not paid attention by more researchers and scholars. Today, trends in robotics research are changing from industrial applications to non-industrial applications, such as service robots, medical robots, humanoid robots, personal robots and so on. Human ability to perform physical tasks is limited not only by intelligence, but also by physical strength.

The main goals of power assist robot can be categorized into two fields: direct power assist, which aims to provide power to specific location of user's body such as HAL, RoboKnee, and indirect power assist, which aim to share tasks with operator, such as BLEEX. After Hardiman I [2] was reported, the system has received much more attention and with the progress of robotics and computer technology, the system has been developed quickly. University of California, Berkley, has designed a system called the BLEEX [3], which has more than 40 sensors and hydraulic actuators, and helps lighten the load for soldier or worker. RoboKnee [4] has been designed by the company Yobotics. It was a single knee powered walking device. Wakayama University had designed a wearable power assist suit [5] to support the elbow, shoulder, hip and knee motion, powered by pneumatic actuators, sEMG was used as trigger, joint torques were approximated with statics calculation by using the human model. HAL [6] of Tsukuba University was a lightweight power assist device. Its actuators were DC motors at the knee and hip. They used sEMG electrodes on human's leg muscles to estimate human inner force. Tohoku University developed a wearable antigravity muscles support system for supporting physically weak person's daily activities [7]. The joint support moments were designed based on a part of the gravity term of the necessary joint moment derived by human approximated model.

This paper is to develop a power assist system which not only amplifies strength of human legs and enhances endurance during walking, but also avoids interfering with the its operator walking freely. It is using mechanism to save human power during walking based on autonomous decision-making through human-robot interaction information measured from the sensors system. And, force control method will be designed to regulate the power assist robot. The system can be further improved to provide stronger adaptability, enhanced performance and efficiency. The structure of the WPAL [8] is shown in Fig.1.

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Non-invasive EEG based Mental State Identification Using Nonlinear Combination

Feng Chen, Yunyi Jia and Ning Xi

***Abstract*—Non-invasive EEGs are very useful in human-machine integration development and medical diagnosis. Mental state, especially mental fatigue, is one of the main causes of the tragic accidents. In order to prevent accidents caused by mental fatigue, it is crucial to identify such mental state. Based on the mental state, the human-machine systems would obtain beneficial effects for reducing their accident rate. Using non-invasive EEG recordings, the features of EEG are extracted based on nonlinear combination among EEG four frequency components. The index of mental state can be represented by a polynomial equation. The method is more flexible and provides a quantitative analysis way to acquire the more accurate mental state. The effectiveness of the method is well demonstrated through experimental results.**

I. Introduction

THE method to study EEG, whether conventional cognitive neuroscience or affective, would be useful in human-robot hybrid control (i.e., "thinking" can make the operational robots work not by manual control or the wearable power assist robot work smoothly), clinical diagnosis and other fields. EEG is very helpful in diagnosis of epilepsy, coma, stroke, sleep disorders, and even brain death. EEG is the spontaneous and rhythmic electrical activity of brain cells from electrode arrays. EEG is the scalp electroencephalogram in general. In fact, it is actually diagram between scalp potential difference and time. The recoding of scalp EEG is obtained by placing electrodes on the scalp.

The idea of distinguish mental state using EEG is not new. In fact, EEG recording device and recording technique has been greatly improved, from the original only 1 or 2 channels to the following 6 channels, 8 channels. Now, 16 channels, 32 channels and 64 channels are commonly used to study and diagnose clinical diseases and injuries in the body. In this paper, Emotiv EPOC Neruoheadset shown in Fig.1, which has 14 channels (plus CMS/DRL references, P3/P4 locations) and 0.2-45Hz bandwidth, is applied to record EEG. The device mainly uses non-invasive detection methods. Before using this device, the 16 electrode recesses must be fitted with

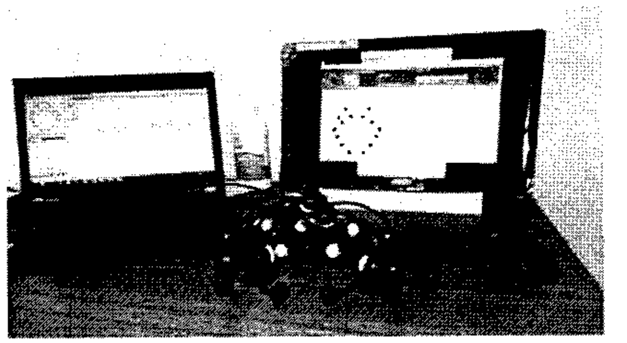

Fig.1 Emotive Epoc Headset

moist felt pads, wet them with saline solution, to reduce impendence. It can capture user brainwave signals. After being converted to digital form, the data are wirelessly transmitted to the USB receivers. And then the user's thoughts, feelings and emotions are analyzed based on EEG recordings. After cognitive training, the simple user's conscious intent can be discerned in virtual object, such as push, pull, left, right, up and down. The relationship between the index of mental state and operating level can be further gone into. In recent years, some researchers are trying to acquire the mental state [1], mental control [2] and pathological analysis [3] through EEG. Efficiency and performance can be declined during fatigue when people who persist in continuing the current activity invariably. With the information of EEG, we have developed an adaptive controller for teleoperator [4, 5] and an on-line skill method in the teleoperattion [6], so the telerobotic operations could be optimized [7]. And, many incidents and accidents are related to mental fatigue [8]. Driver fatigue is a major risk for road safely as it is associated with decreased concentration, increased reaction time and increased error rate [9]. Therefore, the mental state is one of important index of safe working.

Mental fatigue is a complex phenomenon that makes people lack of concentration or feel asleep in either short or long periods of time [10]. Some methods for indicators of mental fatigue were developed [4-6, 11-13]. Currently, three main fatigue countermeasure methods are distinguished, which are subjective self-report, divided-attention steering simulator and physiological measures such as eye movement, facial movement, heart activity and brain wave activity [14]. Although, several methods to study brain activity exist, which are Functional Magnetic Resonance, Positron Emission Tomography, Nuclear Magnetic Resonance Spectroscopy, Near-infrared Spectroscopy and Event-related optical signal, EEG perhaps is the most promising. It has shown that the changes in brain activity can been measured during fatigue have been documented.

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下肢助力机器人动力学分析与应用*****☆

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Dynamics analysis and application of the rehabilitation power assist robot for the leg

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Abstract

BACKGROUND: In 2005, the successful production of lower extremity rehabilitation robot system can co-promote the delivery of leg movement through the central control system as well as the gait and attitude control system so as to restore lower limb function.

OBJECTIVE: To perform the mechanical analysis of the rehabilitation power assist robot.

METHODS: Power assist exoskeleton is a complicated dynamical system composed of many joints and links, and it is a MIMO. Power assist robot dynamics is about the movement-force relationship, and its results of simulation are used to optimize the system. Through motion information perception, the rehabilitation power assist robot provides power for wearer hip joint to accomplish motion of flexion/extension, abduction/adduction and internal rotation/external rotation.

RESULTS AND CONCLUSION: The dynamical equation is used to realize the hybrid control. The practitioner can fully completed functional recovery action, with promotion of practicer limb strength and action proficiency, the system gradually reduces the power support until the recovery.

Chen F, Tang M, Ma WG, Liu XF. Dynamics analysis and application of the rehabilitation power assist robot for the leg.Zhongguo Zuzhi Gongcheng Yanjiu yu Linchuang Kangfu. 2011;15(30): 5518-5521. [http://www.crter.cn http://en.zglckf.com]

摘要

背景： 2005 年成功研制出下肢康复机器人系统，该机器人通过中心控制系统和步态、姿态控制系统互相协调，带动下肢各种运动，从而达到恢复下肢功能的目的。

目的： 对下肢康复助力机器人做动力学分析。

方法： 该系统为一个复杂的动力系统，由多个关节和多个连杆组成，具有多个输入和多个输出，分析其运动和作用力之间的关系。通过运动信息感知网，实现机器人系统主动为使用者提供完成髋关节屈/伸、旋内/旋外及外展/内收功能恢复动作的助力支持。

结果与结论： 利用动力学方程完成人-机混合系统的控制，减小人体感受的运动强度，使练习者能充分完成功能恢复动作，随着康复者下肢力量的加强和动作的熟练程度的提高，通过改变系统控制参数，系统会逐步减少对其动力支持，直到康复。

关键词： 助力机器人；动力学；拉格朗日方程；下肢；康复
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0 引言

研发的可穿戴型下肢助力机器相当于一个辅助器，有被动式和主动式两种工作模式。被动式主要实现下肢康复训练功能，通过对下肢康复训练运动的解析，康复训练/助力装置与练习者的腰部结合在一起，利用路径规划，使机器人实现对患者的康复训练。通过给予适当的助力，使练习者能充分完成训练动作，随着康复者腰部力量的加强和动作的熟练程度的提高，系统逐步减少对其的帮助，直到完全康复；主动式主要是根据人体运动信息为下肢提供动力援助的。

运动治疗是物理治疗的核心部分，是根据疾病的特点，患者的临床表现及功能状况借助治疗器械，手法操作以及患者自身的参与，通过主动或被动的方式来改善局部或整体功能，提高身体素质的一种治疗方法。

自从20世纪60年代初期出现了第一台康复机器人CASE以后，直到70年代中期，对康复机器人技术的研究才开始发展起来。康复机器人可细分为康复训练型和辅助型两种。康复训练机器人的主要功能是帮助患者完成各种运动功能恢复训练，如手臂运动、下肢运动、脊椎运动等；辅助型康复机器人主要用来部分补偿老年人或残疾人弱化的机体功能。部分国外康复机器人见表1[1-10]。

在国内，清华大学在国家“863”计划支持下，从2000起即开展了机器人辅助神经康复的研究，研制一种上肢康复设备UECM，可以在平面内进行两个自由度的运行训练。哈尔滨工程大学在国家自然科学基金的资助下，于2005年成功研制出下肢康复机器人系统，该机器人通过中

可穿戴型下肢助力机器人控制分析

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摘 要:对可穿戴型助力机器人控制策略进行分析.根据研究目的及人体结构和功能的特殊性和复杂性,通过将人体下肢作适当简化及必要的假设,提出基于骨-肌肉功能模型的下肢助力机器人控制方法,该方法通过对骨-肌肉模型中的弹性系数和阻尼系数的调节能为人体下肢运动提供助力支持.同时,通过人-机间交互力信息实现人体下肢的运动预判.

关键词:助力机器人;肌肉功能模型;运动预判
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Control analysis for the wearable power assist robot for leg

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Abstract: In this paper, the control strategy for the wearable power assist robot for leg (WPAL) was introduced. Considering the purpose of research, the structure complexity and the function particularity of the human body, this paper proposed a control strategy for WPAL based on an imitated bone-muscle function model through the proper simplified and indispensable hypothesis. And through adjusting the muscle function model cofficients of spring and damp, we could change the time of power assist phase, namely, change the percentage of power assist. And, through the interaction force between the user's leg and the robot's, the user's movement could be judged in advance.

Key words: power assist robot; muscular function model; movement pattern prejudgement

利用机器增强人类肌肉的力量和感知能力,同时保留人的灵活性和直接操作的感觉是机器人研究领域之一.人体的所有运动都与力及其控制有关,助力系统利用特定装置给人提供一定的力补偿,降低人自身能量的消耗,或是对那些有异样运动行为的人提供治疗或矫形.

根据助力对象的不同,可穿戴型助力机器人[1-7]可分为两类:1)直接式:直接给使用者提供动力,如下肢助力、背部助力及上肢助力等,这种情况下,助力装置的运动需超前于人体相应的运动.2)间接式:分担使用者的劳动负荷,诸如背负的重物、搬运的货物等,从而达到减轻使用者劳动强度的目的,这种模式需要机器与使用者同步运动.

由于助力装置基本是刚性体,整体柔顺性差,这样人与装置运动时会造成不协调与不自然,这便涉

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Study on Mobile Robot Navigation Based on Strategy of Blind Man Finding Way

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Abstract –**The main task of a mobile robot is to perform navigation and orientation. In this paper, a navigation method for three-wheel mobile robot is introduced based on interactive force information. The interaction force information between mobile robot and wall or unknown obstacle comes from the robot end effector, which may be a multi-DOF manipulator with force sensors or an antenna using the elastomeric material. Considering complexity of the structural, difficulty of the system control and the low-efficiency of this method, the system can obtain collision information using multi-dimension force sensors fixed on mobile robot body. Its aim is to complete the survey, self-localization and the path programming, and it is a good supplement to existing navigation methods such as the image, light, electromagnetism, sound. The experimental results indicate the validity of this method using interactive information to estimate relative position/orientation to an unknown object.**

Index Terms* - *Blind man finding way. Contact interaction. Mobile robot.

I. INTRODUCTION

Mobile robot is an intelligent system which includes environment apperception, dynamic decision-making and planning, behaviour controlling and execution and etc. According to the sensor information obtained, the robot neatly adjusts its own work state to adapt the environment to finish the work. During moving process, mobile robot often solves the following three problems [1, 2]: 1 Where? 2 where to go? 3 How about to go? The first problem is the orientation and tracking problem of navigation. The second and the third problem is the path planning problem. Due to the navigation devices, mobile robot doesn't lose direction during walking and doesn't collide with other obstacles, and finally reaches the destination smoothly. At present, many navigation methods are applied to mobile robot, such as magnetic navigation, visual navigation, inertial navigation, voice navigation, light reflecting navigation and global positioning system. Some mobile robots are shown in table 1[3-8].

Table 1 Mobile robot

Type	Sensors	Circumstance
Pioneer	Sonar, Electronic compass, visual system, laser sensor	Known or unknown environment
NavLab-5	Visual sensor, differential GPS, gyro	Unknown highway environmental
OXFORD SERIES	Laser range finder, sonar, odometer	Known or unknown factory environment
SOJOURNER	Sonar, odometer	surface of Mars environment
ROBIN	laser sensor, Tactile sensor, ultrasonic sensors	Unknown artificial environment
ANFM	Camera, infrared detector, ultrasonic sensors, GPS	Known or unknown natural environment
QRIO	Camera, sonic sensor	Known natural environment
Spirit	Camera, odometer	unknown natural environment
ASIMO	Camera, gyro	Known or unknown natural environment

In our country, the study on mobile robot began in the 8th five-year plan. Many universities jointly developed military mobile robot 7B.B and THMR-V [9]. The National University of Defence Technology has designed a system called CITAVT [10]. Jilin University has designed several mobile robots such as JUTIV, AGV, explosion-proof robot and Climber [11]. An omni-direction visual navigation system has been designed by institute of automation, Chinese academy. Harbin industrial university developed the guide robot. Some others are not described here.

According to the existing navigation methods, mobile robot depends on the application of image, light, sound, electromagnetic principles. But any kind of method has its own limitations. For example, light condition is necessary for the visual navigation. Magnetic navigation holds in a certain area and cannot complete simple obstacle-avoidance action. In this paper, a method of mobile robot navigation is introduced based on blind man tracing wall, insect exploring object using antenna and the force characteristic of objects contacting [12]. The interaction force information between mobile robot and wall or obstacle comes from the robot antenna, which maybe a multi-DOF manipulator with force sensors or the elastomeric material. The method based on interactive force [13] is not subjected strictly to light and environment. This method can finish detection, ego orientation and local path planning, and it is a good supplement to existing methods motioned above. Meanwhile, consider the table 1, the mobile robot navigation sensors are not a single class sensor, namely a variety of navigation methods are synthetically applied to a mobile robot. Along with the mobile robot applications widening, and navigation method of study and development of mobile robot intensified, the mobile robot has better application prospect.

In this paper, the strategy of blind man finding way is shown in the next section. In section III, the navigation method based on interactive force information is analysed. And then, the experimental results and the future work are depicted in section IV.