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微纳技术与精密机械

六足步行机器人的并联机械腿设计

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摘要： 将并联机构用于六足步行机器人的腿部结构,以拓展六足步行机器人的应用领域。提出了一种基于 (U+UPR)P+UPS机构的并联机械腿,并对机械腿进行了结构参数设计。首先,对腿部机构进行了运动学分析,推导出了腿部机构的位置反解方程和速度传递方程;分析了腿部机构的工作空间并绘制了工作空间三维图,定义了工作空间性能评价指标,绘制了结构参数与工作空间性能指标的关系曲线。然后,对腿部机构进行了运动灵活性分析并绘制了雅克比矩阵条件数分布图,定义了运动灵活性评价指标,绘制了结构参数与运动灵活性指标的关系曲线。最后,基于工作空间性能指标和运动灵活性指标,采用蒙特卡罗法进行了结构参数分析,选取了一组性能较好的结构参数并考虑加工和装配工艺性,设计了一种新型3自由度并联机械腿的虚拟样机,为六足步行机器人的进一步研究奠定了基础。

关键词： 并联机械腿　运动学分析　工作空间分析　性能评价指标　参数设计

Design of parallel mechanical leg of six-legged robot

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Abstract: A parallel mechanism was applied to the mechanical leg of a six-legged robot to expand the application areas of the six-legged robot. A new mechanical leg based on the (U+UPR)P+UPS parallel mechanism was proposed, and the structure parameters of the mechanical leg were designed. Firstly, the kinematics of leg mechanism was discussed, and the inverse position and velocity mapping equations were presented. Then, the workspace of the leg mechanism was discussed and a 3D map of the workspace was drawn. The performance evaluation index of workspace was defined and the relationship curve of the structure parameters and the evaluation index of workspace was given. Furthermore, the kinematics dexterity of the leg mechanism was analyzed, and the 3D map for condition numbers of Jacobian matrix was drawn. The performance evaluation index of kinematics dexterity was defined, and the relationship curve of the structure parameters and the index of kinematics dexterity were given. Finally, based on the indexes of workspace and kinematic dexterity, the structure parameters were analyzed by Monte Carlo method. A set of excellent structural parameters were proposed, and a 3-DOF mechanical leg was designed. These results lay the theoretical foundation for the further study of six-legged robots.

Keywords: parallel mechanical leg   kinematics analysis   workspace analysis   performance evaluation index parameter design

参考文献：

[1] WALDRON K J. Configuration design of the ASV. int [J]. *J. of Robotics Research*, 1984, 3(2): 37-48.
[2] 高云国, 张倩, 史亚莉. 无导轨高精度位移平台的结构设计 [J]. 光学 精密工程, 2009, 17(9): 2200-2205. GAO Y G, ZHANG Q, SHI Y L. Structure design of precise displacement platform without guiding apparatus [J]. *Opt. Precision Eng.*, 2009, 17(9): 2200-2205. (in Chinese)
[3] 刘金国, 王越超, 李斌, 等. 灾难救援机器人研究现状、关键性能及展望 [J]. 机械工程学报, 2006, 42(12): 1-12. LIU J G, WANG Y CH, LI B, *et al.*. Current research,key performances and future development of search and rescue robot [J]. *Chinese Journal of Mechanical Engineering*, 2006, 42(12): 1-12. (in Chinese)
[4] 黄远灿. 国内外军用机器人产业发展现状 [J]. 机器人技术与应用, 2009(2): 25-31. LIU J G. Domestic and foreign military robotics industry development status [J]. *Robot Technique and Applicationg*, 2009(2): 25-31. (in Chinese)
[5] ELENA G, MARIA A J. The evolution of robotics research [J]. *Robotics And Automation*, 2007, 3(10): 90-102.
[6] COLLINS C. Stiffness modeling and force distribution for the all-terrain hex-limbed extra-terrestrial explorer (ATHLETE) . *ASME 2007 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference, September*, 2007: 1-9.
[7] 崔冰艳, 金振林. 基于正交机构的机器人肩关节静力学分析与结构参数设计 [J]. 光学 精密工程, 2011, 19(1): 77-82. CUI B Y, JIN ZH L. Statics analysis and structure parameter design of robot shoulder joint based on orthogonal mechanism [J]. *Opt. Precision Eng.*, 2011, 19(1): 77-82. (in Chinese)
[8] 王炳一. 一种新型四足仿生机器人性能分析与仿真 .秦皇岛:燕山大学, 2011: 55-70. WANG B Y. *Simulation and Performance Analysis on New Type of Bionic Quadruped Robot* . Qinhuangdao: Yanshan University, 2011: 55-70. (in Chinese)
[9] 倪森. 基于2-UPS&UP并联结构腿的四足步行器设计 .秦皇岛:燕山大学, 2011: 35-70. NI S. *The Design of Quadruped Robot*

Based on 2-UPS&UP Parallel Mechanism Leg . Qinhuangdao: Yanshan University, 2011: 35-70. (in Chinese)

[10] 王洪波, 齐政彦, 胡正伟, 等. 并联腿机构在四足/两足可重组步行机器人中的应用 [J].机械工程学报, 2009,45(8): 24-30. WANG H B, QI Z X, HU Z W, *et al.*. Application of parallel leg mechanisms in quadruped/biped Reconfigurable walking robot [J]. *Journal of Mechanical Engineering*, 2009, 45(8): 24-30. (in Chinese)

[11] 王洪波, 徐桂玲, 张典范, 等. 助老助残四足/两足可重构并联腿步行机器人运动学建模与仿 真[J].燕山大学学报, 2010, 34(6): 508-515. WANG H B, XU G L, ZHANG D F, *et al.*. Kinematics modeling and simulation of quadruped/biped walking robot with parallel leg mechanism for the elderly and the disabled [J]. *Journal of Yanshan University*, 2010, 34(6): 508-515. (in Chinese)

[12] 黄真, 赵永生, 赵铁石. 高等空间机构学[M]. 北京:高等教育出版社, 2006: 277-283. HUANG Z, ZHAO Y S, ZHAO T S. *Advanced Spatial Mechanism* [M]. Beijing: Higher Education Press, 2006: 277-283. (in Chinese)

[13] 曾达幸, 黄真. 基于螺旋理论的转动解耦并联机构型综合 [J].中国科学(E辑), 2011, 41(5): 585-591. ZENG D X, HUANG ZH. Type synthesis of the rotationaldecoupledparallel mechanism based on screwtheory [J]. *Sci China Tech Sci*, 2011, 41(5): 585-591.

[14] 熊有伦. 机器人技术基础[M]. 武汉:华中科技大学出版社, 1996: 32-55 XIONG Y L. *The Basis of Roboticsy* [M]. Wuhan: Huazhong University of Science & Technology Press, 1996: 32-55 (in Chinese)

[15] JOHN J C. *Introduction to Robotics: Mechanics and Control* [M]. USA: Wesley Publishing Company, 1989: 117-119.

[16] 于靖军, 刘辛军, 丁希伦, 等. 机器人机构学的数学基础[M]. 北京:机械工业出版社, 2008: 11-12. YU J J, LIU X J, DING X L *et al.* *Mathematical foundations of robot mechanism* [M]. Beijing: Mechanical Industry Press, 2008: 11-12. (in Chinese)

[17] GOSSELIN C, ANGELES J. Global performance index for the kinematic optimization of robotic manipulators [J]. *Journal of Mechanisms, Transmissions, and Automation in Design*,1991,113(3):220-226.

[18] HUANG T, GOSSELIN C M, WHITEHOUSE D J, *et al.*. Analytic approach for optimal design of a type of spherical parallel manipulators using dexterous performance indices[J]. *IMechE Journal of Mechanical Engineering Science, Part C*, 2003, 217(2):203-207.

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