4.4　生体機構を取り入れた運動制御

鉛直方向の負荷変動に対応する２足歩行の運動制御 −生体の筋構造の考慮の有無による相違の評価−

Walking Motion Control of Biped Robotic Legs Inspired by Human Muscle Model for Adapting Variation of Vertical Load

Emre Duman

Research on biologically inspired robots is advancing nowadays. Researhers observe mechanical properties and dynamic motions of many biological objects and such observations are used in order to implement on some robotic systems which can have similar characteristics. Many industrial robots and humanoid robots such as ASIMO, AIBO, QRIO are conventional type robots. Conventional humanoid robots and biological subjects differ in their mechanisms and control strategy. Biological subjects have musculoskeletal systems that can drive two joints at the same time while conventional robots use one joint drive mechanisms. Biological objects use their monoarticular and biarticular muscles in order to move their limbs and they have nearly perfect coordination of those muscles while jumping, landing, biped walking, running, etc. Muscle mechanism makes it easier to exert more force at the tip and the distribution of forces can be varied based on each activation of muscles. In this research, a biped robotic leg which is inspired by human leg muscle model is taken into account and walking behaviour of the leg in the existance of an external force is analised. Details of the mathematical modeling for such biologically inspired robotic leg is explained and simulation results for joint torque generation for different situations, especially in case of an vertical external force are presented. It has been shown that human has rational mechanism for output force control at the tip by taking the advantage of cooperative actuation of monoarticular and biarticular muscles. Especially, the magnitude of force is bigger in the direction from the fixed joint to the end effector. Human use this advantage for carrying a heavy body and also for jumping, walking and rejection of external forces. Additionally, using biarticular muscle improves the self-stability of the robotic leg by transfering energy between two adjacent joints. Dynamic motion is theorotically derived by taking mass, inertia, link lengths and gravity into account. Walking for robotic leg is formulated for both legs, one is when leg is carrying the body and react to external force, other is when leg is not in contact with the ground and taking one step forward. Joint torques are distributed to individual muscles by using a method called 2-norm which is used to calculate the efficient way of distribution of 2 values into 3. As for muscle model, a spring-damper system is considered so that flexibility can be achieved and, DC motor is used as actuator to tighten and loosen the muscle. Wires are used in order to transfer rotational motion into translational motion. Each muscle is controlled by a DC motor after calculating the necessary displacements of each muscles.

生体機構の単・二関節筋駆動に基づく二足歩行ロボットの運動制御

河邊 貴之

従来のロボット工学においては、一つの関節を一つのアクチュエータで駆動する単関節駆動が主流であった。一方で、ヒトをはじめとする生体においては、二つの関節にまたがりそれらを同時に駆動する二関節筋が存在することが指摘されており、応用が期待されている。

本研究においては、二関節筋等の生体の仕組みを取り入れることで、より簡単な制御則で曲げ伸ばしの基本動作が実現されることを利用した、ヒトの二足歩行メカニズムの解析とその応用を目指している。単・二関節筋同時駆動による伸縮運動とエネルギー効率に優れた受動的歩行に着目し、両脚の伸縮運動に基づく推進力によって、より自然で簡単な歩行制御が実現できることを提案した。

Motion control of a biped robot taking advantages of mono- and bi-articular muscles of a human

Takayuki Kawabe

In the conventional robotics motion control, each single joint was driven by each single actuator. On the other hand, human beings have bi-articular muscles which can drive two adjacent joints simultaneously. It is expected that bi-articular muscles system is applied to robotic motion control.

In our research, we introduced human body mechanisms for biped walking robot to find out and develop human like walking motions. And we proposed mono- and bi-articular muscle motion control system is suitable for dynamics based walking which has high degree of energy efficiency and confirmed this walking motion which is based on propulsive force generated by a leg stretching motion.