論文の内容の要旨

論文題目　Gait Pattern Generation and Stabilization for Humanoid Robot with Limited Resources Based on Coupled Oscillator Model

（リソース制約のあるヒューマノイドロボットのための結合振動子モデルに基づく歩行パターン生成と安定化）

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In this dissertation, we propose the walking method for small size humanoid robots.

A small size humanoid has limited system resources such as low computational power, poor quality of actuators and deficient sensors caused by its insufficient size and restricted production price. Accordingly, it is hard to apply previous works about biped walking of a full size humanoid robot which has sufficient system resources to a small size humanoid robot without modification.

Generally, the walking method based on dynamic analysis, requires high computational cost, and is vulnerable to the dynamic model error. On the other hand, the walking method based on biologically inspired model, requires complex parameter selection process by its large parameter space, and is vulnerable to environmental error.

Therefore, in this dissertation, combining both walking methods based on dynamic analysis and biologically inspired model, we propose new walking method for humanoid robots with limited system resources by designing gait pattern generator and walking stabilizer based on coupled oscillator model.

First, from observing human gaits, we define gait parameters and separate them into balance parameters and movement parameters. By the analysis of the coupled oscillator model, we can find out that the motion of the coupled oscillator implies that of a human gait. Based on this premise, we design the gait pattern generator which is consisted with the synthesis of motions for balance and movement. Then, through the trajectory simulation, we confirm that gait pattern is generated properly.

Second, we survey conditions for a stable walking. After that, we carried out ZMP simulations and dynamics simulations to select proper gait parameter values for a stable walking. By the ZMP simulations, we can find out that balance parameters can deal with the walking stability. With dynamics simulations, we can improve the walking stability by the adjustment of balance parameters.

Third, we design the walking stabilizer which is composed of the ankle angle controller and the trunk position controller, to achieve the stable walking for a real humanoid robot. We derive the dynamics model of the robot and the control method from simplified inverted pendulum model, and discuss about the effect of the designed walking stabilizer.

Fourth, we develop the small size humanoid robot for the experiment. We survey the requirements for the humanoid robot research platform and design the robot which has network based modular structure, the standard PC architecture, modularity and independency.

Finally, we conduct experiments to verify the proposed gait pattern generator and walking stabilizer on a real humanoid robot. From the stepping test and the walking test by the same gait parameter values determined in the dynamics simulation, we confirm that a robot can walk stably overcoming the model error. In addition, by the walking test on the shaking table, we verified that the robot can walk adaptively to

the environmental perturbation. Then, from the walking test with gait patterns generated by the vision processing routine for the ball tracking, we assured that the robot can walk variously.

Based on the method described above, we can confirm that the stable, adaptable and diverse biped walking for a small size humanoid realized by the proposed gait pattern generator and walking stabilizer.