Motion generate and control of Humanoid robot using Neural Oscillators

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Recently, Japan has a rapidly aging population and the reduction of labor population is an important issue. In 2020, the anticipated employment population will be more than two million persons the employment population. Especially, number of employees in tertiary sector of industry that worker productivity is low continues to increase year by year. To get stable labor force, it is important to grow labor productivity in tertiary sector of industry. According to the report anticipated robots market in future, it hugely expands the market scale of robots for tertiary sector of industry and decreases the market scale of robots for secondary sector of industry. Thus, we can know exactly what is expected of higher labor productivity in tertiary sector of industry, using robots. But there are little robots that can use in tertiary sector of industry at present, because almost robots are high cost and cannot work in various environments. Thus, in robotics, it is important to control robots autonomously and adaptively for changes in the environment and we expect to use robots in tertiary sector of industry.

It is available for humanoid robots to work in the environment that human beings live and do human tasks, because they are similar to human. Thus, it is available to use in multidiscipline and it is not necessary to newly build the infrastructure that they use. But we must realize their bipedal locomotion in various environments, using them for the described

previously purposes. Therefore, the main research of humanoid robotics is to realize bipedal locomotion in various actual environments.

Many humanoid researchers focus attention on biologically inspired control methods, to realize the described previously research. It is thought in general that the control system of relatively low level generates animal or human locomotion. The periodic motion includes locomotion is basically made up of rhythmic movements and the cooperative control between limbs. It is thought that rhythmic movements are generated by Central Pattern Generator (CPG) that exist at the spinal cord and that the cooperative control between limbs is realized by the network of CPG that exits at each limb. CPG generates rhythmic movements by the sustained input from high level nerve center of cerebellum and brain-stem and by the input from the periphery and by the input from the others CPG. The output of CPG is transmitted to the motor neuron of flexor and extensor through the interneuron.

Neural Oscillators are the method modeled CPGs that generate animal or human locomotion. The control methods used neural oscillators can adapt to changes environment and have robustness to environment perturbation. Therefore, there are many researches of humanoid robot locomotion system using neural oscillators, but there are few humanoid robots that walk in actual environment as of now. This reason is the parameters problem of neural oscillators. Neural Oscillators have many parameters that should be tuned, furthermore, it is necessary for these parameters to be retuned when the environment has changed greatly. However, there is not the explicit method to design the parameters of neural oscillators. Thus, using human experience, many researchers have designed these parameters as of now. This is one of the difficult problems that have to be resolved for realizing humanoid robots locomotion using neural oscillators.

In consideration of the above problem, we carried out investigation into three parts to realize humanoid robot locomotion using neural oscillators. Firstly, we researched about the method tuning the parameters of neural oscillators. In this research, we constructed the parameters adjusting system employed the heuristic parameters search. We tested the effectiveness of this system, to do computer simulations using a few simple dynamics models. As a result, we could demonstrate the effectiveness of the parame-

ters adjusting system that we constructed. Secondly, we researched about generating adaptive locomotion trajectories, to realize bipedal locomotion in various floor surface conditions. To generate locomotion trajectories, we used the phase generator network employing phase relation 's principle between neural oscillators. Phase generators generate phases that need to modify nominal trajectories using sensory feedbacks. Therefore, we could realize to generate locomotion trajectories in various floor surface conditions using the phase generator network. Finally, we researched about humanoid posture control system that had robustness to an unknown external force. We considered Humanoid robot model as one pendulum model, we attached the virtual spring and damper system coupled neural oscillators to this model and proposed the stable posture control system. We could demonstrate the effectiveness of this system using the foundational research results.