様式Form

論 文 内 容 の 要 旨
Abstract of Dissertation

氏　名Name　川合 勇輔

Recently, the aging population is increasing, besides, the worker population is decreasing. For such problems, to improve the quality of life, demands of the human support system are increasing in industrial as well as non-industrial fields. The back drivability, the robustness of environmental stiffness variation, and stable contact are required for stable environment interaction. However, force control that satisfies three targets has not been proposed. In the dissertation, the back-forward drivable torsion torque control is proposed for the stable environment interaction that satisfies the above issues.

The contribution of the dissertation is summarized as follows.

Chapter 1 describes the issues for stable environment interaction and discusses the environmental interaction control for solving each issue.

Chapter 2 discusses force control for environment interaction and its issues. First, back-forward drivability is defined for environment interaction. This chapter introduces acceleration-based force control and discusses ideal back drivability in the single-inertia and two-inertia systems for human interaction. In addition, the force control approach considering environmental dynamics is considered for environment interaction and problems against environmental stiffness variation are discussed using robust stability analysis. To overcome the above problems, the back-forward drivable torsion torque control is proposed and target back-forward drivability in the proposed approach is discussed for human and environmental interactions.

Chapter 3 describes proposed high back-forward drivable torsion torque control focusing on back forward drivability for human interaction. Proposed back-forward drivable torsion torque control achieves the back-forward drivability on acceleration dimension and vibration suppression is also achieved. As a result, smooth human-robot interaction is realized.

Chapter 4 describes the proposed high-robust force control based on back-forward drivable torsion torque control using ERRC against the environmental stiffness variation. ERRC is constructed based on torque-velocity duality. The RRC which is proposed in position/velocity controls is also able to be applied by using ERRC for force control.
The resonance ratio in force control using ERRC is determined as $\sqrt{5}$ and it is same as that in position/velocity control. In robust stability analysis, the proposed load-side torque control shows that it is robust against the environmental stiffness variation.

Chapter 5 describes stable contact realization using force impulse based on the back-forward drivable torsion torque control. The force impulse controller has transformed form I-P torque controller in the back-forward drivable torsion torque control, as indicated in Chapter3. The ERRC is constructed based on the two-spring system focusing on the torque-velocity duality and is applied to improve the robustness against environmental stiffness variation, as indicated in

Chapter 4. Stable contact motion is realized based on force impulse control that combined the back-forward drivable torsion torque control and the ERRC.

Chapter 6 summarizes contribution of each proposed approach against some issues for environment interaction and indicates the future tasks.

In this thesis, the back-forward drivable torsion torque control is proposed focusing on back-forward drivability on the acceleration dimension and is established for environment interaction including human operation as well as various contact objects. The proposed approach is engineeringly and industrial effective for environment interaction.