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論 文 概 要

THESIS OUTLINE

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要約

Thesis Outline

This dissertation is focusing on the development of motion coordination between human and robotic swarm to achieve motion synchronization on the 2-D field, namely position and velocity synchronization. The objective of position synchronization is to lead all robots towards the human operator's desired position. On the other hand, the goal of velocity synchronization is to converge all robots to the same position and move together with the same velocity as the human operator's desired velocity. The essential problem in developing the coordination of human-robotic swarm is to guarantee the stability and the objectives in coordination with the human operator.

We first investigate the existing passivity-based architecture to interconnect human and robotic swarm to achieve the motion synchronization objectives by assuming the passivity of the human operator. In the violation of the human passivity assumption, we show that the stability can no longer be guaranteed. We then propose an architecture based on the interconnection of passivity-short systems which interconnects passive robotic swarm and the assumed passivity-short human operator. Additional virtual master robot and a feedback loop are introduced to ensure the human operator can cooperatively provide appropriate control with the given visual feedback information to ensure the motion synchronization. We presented the theoretical analysis of convergence that guarantee motion synchronization under a range of permissible gain in the architecture. Furthermore, the verification of the motion synchronization is demonstrated through simulations and experiments.

We next present a detailed analysis of the architecture on behalf of different gain settings in the architecture. Throughout the analysis, we show how the selection of the gains can affect how the human perceives the systems and provide a model-based prediction on how this will affect the degree of passivity-short of the human operator, which denoted as impact coefficient. Then, we present the results of the user study under different gain settings to verify the analysis and provide additional discussion based on the perceived workload. The user study verifies the existence of a trade-off between the clarity of information and the perceived workload of the human operator. Moreover, all participants' models fulfill the passivity-short assumption which demonstrates that the assumption is reasonable.

We also provide further development on the passivity-short-based architecture by presenting an alternative architecture through a change of calculation on the visual feedback information. Through convergence analysis, we show that alternative architecture provides relaxation of the gain condition to ensure motion synchronization. We then provide simulation-based analysis to compare both the original and alternative architectures. Additionally, we presented the user study comparing the two architectures.