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SAMPLE ABSTRACT

Transparency Improvement of EBA Using Smith Predictor for Bilateral Teleoperation with Variable Time Delays

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**Purpose**:This research aims at the improvement of transparency in Bilateral Teleoperation in the presence of variable time delays. The stability of Bilateral Teleoperation has already been guaranteed by robustly EBA (Energy-bounding Algorithm). However, the issues of magnitude reduction and phase delay of feedback force by using EBA with increasing time delay is addressed. In this regard, Predictive control approach is applied with EBA to improve the transparency in the presence of variable time delays with uncertainties in the slave device parameter.

**Materials and Methods**: Smith predictor is the popular approach that is applied in bilateral teleoperation in the presence of time delays. The approach requires accurate estimate of slave plant and environment model. If the estimate is accurate then time delay effect can be completely compensated. In this view, Smith Predictor with EBA is applied to achieve the transparent force reflection. The simulations are done using Matlab/Simulink.

**Results**: **1**. The simulations for the transparent force reflection show the feasibility of proposed scheme. **2.** Smith Predictor predicts the slave states on the master site and thus avoids the use of delayed information as far as force tracking is concerned. **3.** The significant magnitude and phase improvement are observed in case of both accurate and uncertain slave dynamics realization. **4.** With the constant and variable time delays, both free and contact motion show enhanced performance and system keeps stability via EBA.

**Conclusion:** The proposed algorithm shows its feasibility in the presence of variable time delays (500ms RTT up to 25% variation). The transparent force reflection is observed via simulation results in the presence of uncertainties of slave damping up to 50%.