LMI-based design of Variable Impedance Controllers from User Demonstrations and Preferences

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Implementation details

Controller design process has been carried out within MATLAB environment using R2022a version on an Intel Core i7-8700K CPU @3.70GHz×12 with a NVIDIA Corporation GeForce GT 730 GPU.

1) H-GP model generation: Using the available GP implementation in MATLAB, we consider for the H-GP model generation as convergence criterion an improvement between iterations below 5% w.r.t the difference between the two noise prediction means. Thus, for the validation experiment, using a set of 10 taught position trajectories consisting on 240 samples each (i.e. a sampling time of 0.02[s]), the method takes (on average) 9 iterations to converge, which corresponds to an average time of 45.136[s] (for each DoF).

2) Controller solution search: The *off-the-shelf* Bayesian Optimisation Algorithm from MATLAB has been used as the solution-search method. For convergence criterion, we have considered $\epsilon = 0.01$ (below 1% for the fitness range $[0,1]$) and $N_{\text{iter}} = 75$. The LMI problem has been formulated through the YALMIP toolbox [1] (release $2018-10-12$), and solved with the semi-definite programming algorithms provided by MOSEK [2](version 9.3.10). Thus (on average) each iteration takes 1.737[s] from which the generation of the LMI constraints 0.028[s] (1.6%), the execution through YALMIP 0.0570[s] (3.28%) and MOSEK solver 0.005[s] (0.3%). This means that a problem setting that requires 250 iterations for convergence will take approx 7.3[min]. The average number of iterations until convergence for all the User Preferences and Designs used in the validation are included in Table I.

User Pref. / Design	I	II	III	IV
A	167	170	263	419
B	229	208	322	576
C	156	157	272	504
D	180	176	415	630

TABLE I
NUMBER OF ITERATIONS UNTIL CONVERGENCE FOR EACH USER PREFERENCE - LMI DESIGN COMBINATION.

[1]YALMIP toolbox : https://yalmip.github.io/
[2]MOSEK software: https://www.mosek.com