Automating Short-Term Insertion of Parts for Heterogeneous Robots Using a Control Basis Approach

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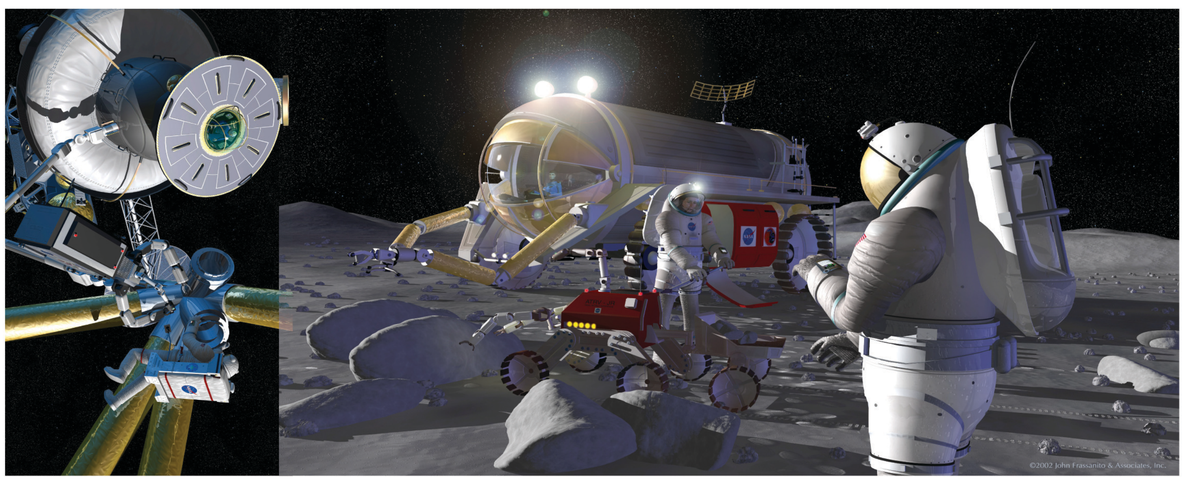
Introduction



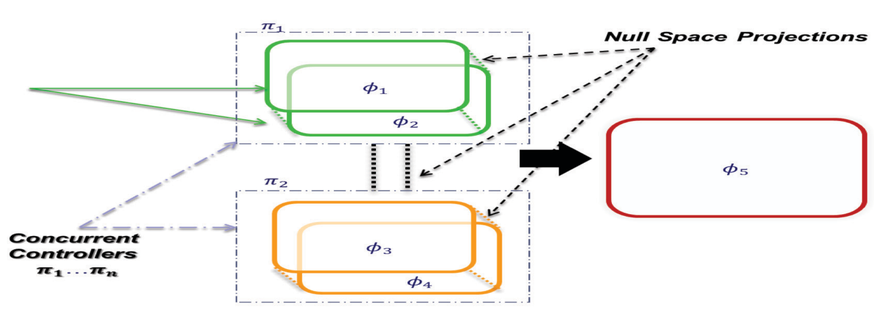
Space construction tasks will require that teams of heterogeneous robots work autonomsouly and reactively for low-level tedious tasks such as assembly tasks.

We studied how two robots of different morphologies can autonomously perform joint assembly using force sensing vunder two coordination schemes: “Push-Hold scheme”, and the “Push-Push scheme”.

Control Basis

We used a control basis framework and a multi-agent distributed architecture to bootstrap autonomous and reactive controllers.

The control basis builds a framework on top of the principles of nullspace behavioral control to decompose the control problem into a set of asymptotically stable primitve controllers that optimize many goald and execute instruction sets by running sequentially and concurrently.



Controllers

Three primitive controllers were combined in unique ways to produce three compound controllers. The graphic depicts how they are encoded in the push-hold scheme:

Pusher

Guarded Move Controller

Position

Moment

Compliant Insertion Controller

Moment

Force

Holder

Virtual Counter Balance Controller

Moment

- Force

Legend

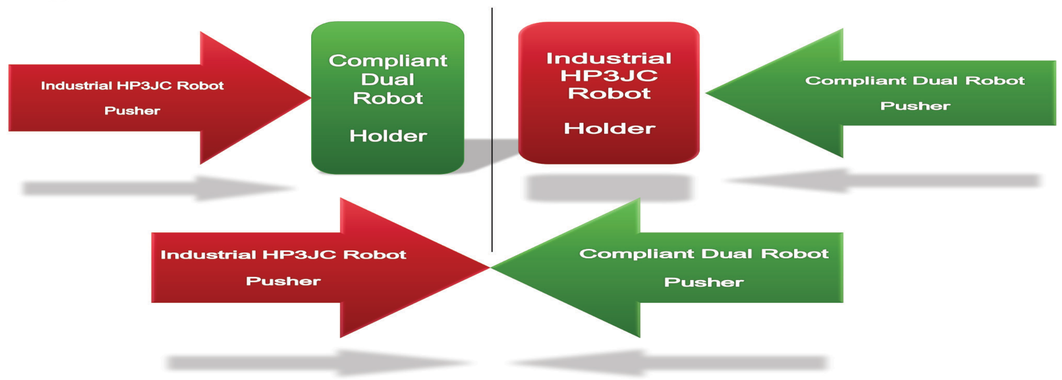
Concurrent Controller

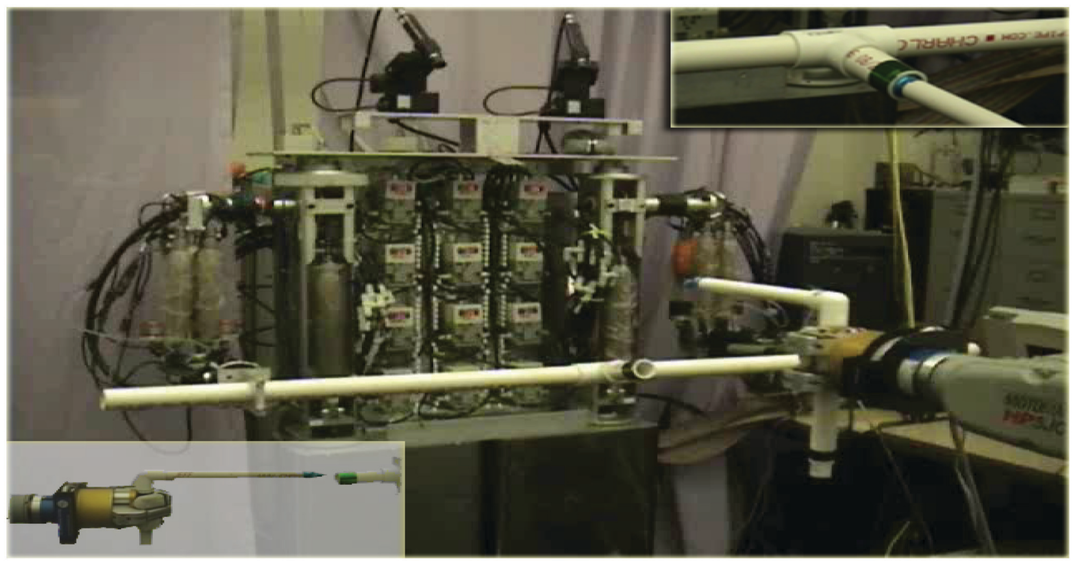
Primitive Controller

Nullspace Projection

Controller Transition

Experiments

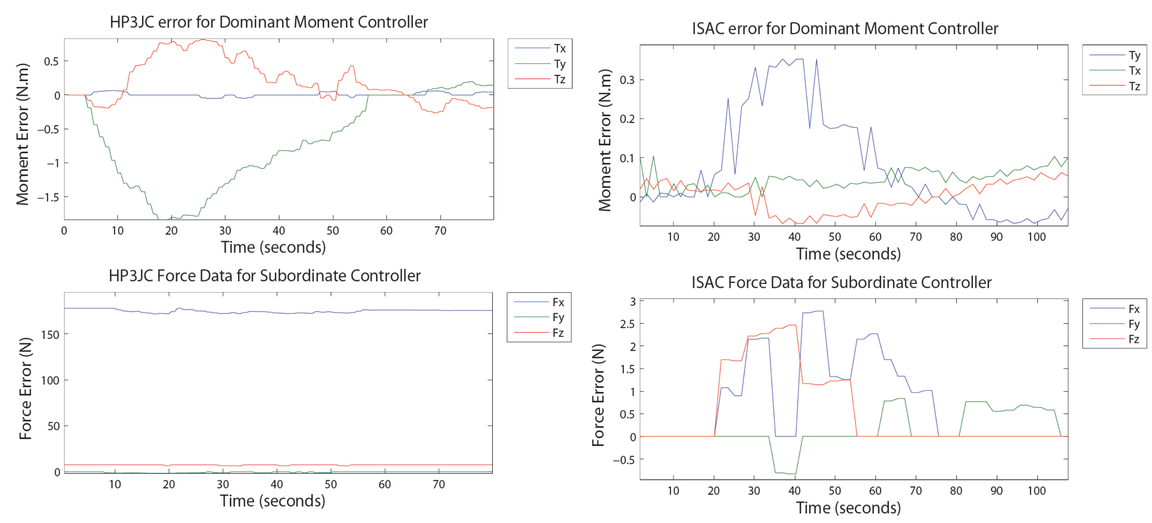




Overview of Experimental Setup

Results

In the push-push scheme, the dominant moment controllers minimized misalignments and drove moment errors to zero. Force controllers used their reference parameter to drive the insertion. Below, a jam situation, ISAC’s force reading goes to zero.



Moment residual and force residual readings for both the industrial HP3JC robot and the compliant dual armed ISAC robot in a push-push coordination scheme.

Conclusion

Higher levels of cooperation rendered faster and more reliable assemblies with higher contact forces. The study also revealed industrial robots are better pushers and compliant robots are better holders.