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## A REACTIVE JOGGER FOR TELEOPERATION AND CONTACT TASKS

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- Problem Statement
- Current Practice
- Solution: Reactive Jogger (jog\_arm package)
- Technical Challenges
  - Deterministic Control
  - Robust Singularity Handling
  - Robust to Input Signal Noise
  - Reduce Actuator Jerk
  - Support Multiple Manipulators
  - Safe Operation
- Package Links and Demonstrations

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# <u>Problem</u>: End-effector pose regulation to avoid damaging forces during contact tasks

High-frequency EEF pose regulation is necessary for:

- Efficient teleoperation with contact tasks or collision risks
- Support contact tasks during base motions
- Robust to uncertainties/errors in contact task descriptors such as Affordance Templates

#### Example contact tasks:

- Opening a sprung door
- Valve turning (double-block-and-bleed)
- Manipulating high voltage switches, circuit testing









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#### The jog\_arm package

- A Jacobian-based jogger
- Utilizes *ros-control* to support robotagnosticism





Simulated Motoman SIA5 U. Texas, 2019

HEBI Robot Adam Pettinger, U. Texas, 2019

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## Deterministic Control Rate

- Multi-threaded architecture
- Timeout for safety





## Singularity Handling

- "Look ahead" toward singularities with singular vectors
- Slow down if singularity is closer than a threshold



Universal Robots software does not handle singularities



*jog\_arm* singularity handling is configurable via yaml parameters



## Signal Filtering

- Configurable low-pass filter
  - Computationally efficient, does not overshoot
- Reduces noise and jerk to actuators
- Thanks @SansoneG and several other contributors





#### Jog multiple manipulators simultaneously

 Any number of arms can be jogged simultaneously with namespacing

<node name="right\_jog\_arm\_server" pkg="jog\_arm" type="jog\_arm\_server" output="screen">



• Average CPU load is ~20% per arm



### <u>A limitation for large industrial robots</u>

- Large industrial robots often require jerklimited commands
- Options:
  - <u>Reflexxes</u> (Google)
  - <u>TrackPose</u> (PickNik Robotics



KUKA Roboter GmbH, https://commons.wikimedia.org/wiki/File:Factory\_Automation\_Robotics\_Palettizing\_B read.jpg

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- Package Links and Demonstrations (non-contact/contact)



## Package availability (part of Movelt)

https://github.com/ros-planning/moveit/tree/master/moveit\_experimental/moveit\_jog\_arm

Tutorial <u>https://ros-planning.github.io/moveit\_tutorials/doc/arm\_jogging/arm\_jogging\_tutorial.html</u>

P. Fan, A. Pettinger, and A. Zelenak, U. Texas, 2019

![](_page_16_Picture_1.jpeg)

![](_page_16_Picture_2.jpeg)

![](_page_17_Picture_1.jpeg)

![](_page_17_Picture_2.jpeg)

Writing with a haptic pen with virtual fixtures Y. Su U. Canterbury, 2019

Controlling a UR5 intuitively with a tracker Y. Su, E. Sevestre U. Canterbury, 2019

Navigation Mode

![](_page_18_Picture_1.jpeg)