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TrackSuite

Solution Brief

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PickNik's TrackSuite

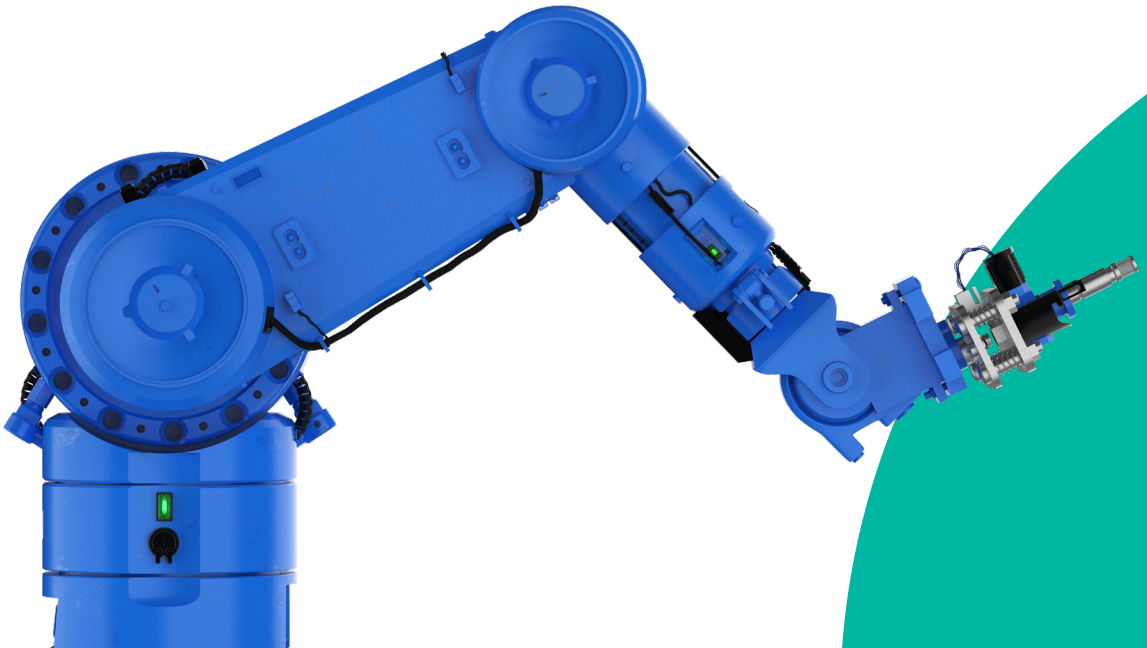
provides smooth kinetics for enhanced reliability & productivity and reduce wear & cost

Leading robotics motion smoothing library integrates seamlessly into ROS and proprietary systems

01 – ABSTRACT

Robotic arms and actuators are, for most applications, a robotic system's real-world interface. The real world can be tough on a robotic arm or actuator, too. Collisions, spills, joint damage, gear strain, fatigue stress and wear-and-tear all take their toll over time and can substantially reduce the lifespan of your robotic systems.

PickNik's **TrackSuite** smoothing interpolation management solution — consisting of both the **TrackPose** and **TrackJoint** libraries — can greatly extend the lifetime of your robot. TrackSuite further provides the jerk-limited trajectories that most industrial robots require (but which many path planning applications do not generate). TrackSuite also enables sensitive operation in dynamic, high-accuracy and fragile materials applications such as surgery, delicate operations (e.g. window washing or handling delicate items or breakables) and rapid conveyor belt pick and place.



As the smart add-on to a pre-existing robotics hardware and software solution, TrackSuite will prolong the life of your system, accelerate your team's productivity and increase your execution speed and cycle time.

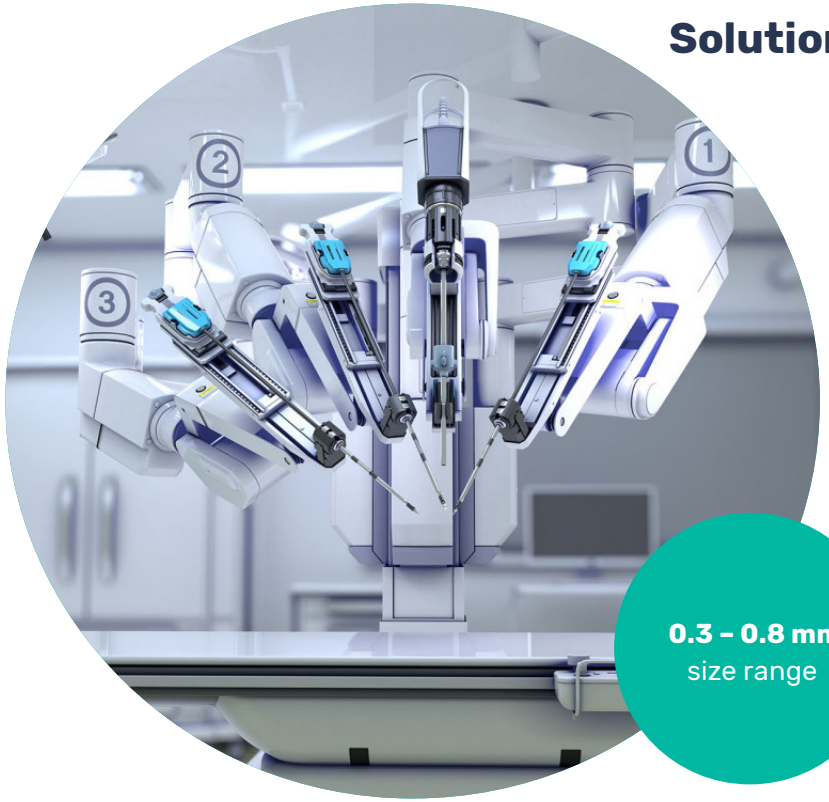
02 – INTRODUCTION

The real world is messy and noisy, while the virtual world of a robotics application is an abstract and idealized space. The robotic arm operates at the boundary between these two very different realities. If operated improperly — without management of joint interpolation and trajectory smoothing — your robotic system will not only wear out sooner (leading to unnecessary and expensive replacement and repair costs), it could also pose a safety hazard and become a source of dangerous collisions and costly downtime.

Lacking good interpolation and smoothing solutions, your robotic system will slow your teams down and increase your capital and operating expenses. You may not even be extracting the maximum value from your system, due to its perceived inability to handle high-precision applications. If there is noticeable vibration when your robot moves, **TrackSuite** can help.

Reasonably moderating robotic operating parameters can have an outsized impact on the lifetimes of those robots. For example, a recent engineering study of just a single component in many mechanical robotic systems (the ball screw drive, which translates rotation into linear motion with minimal friction) revealed...

> **...**
> **that the lifetime of this essential component alone can be nearly doubled via judicious restraints on the component's jerk, acceleration and velocity values.[1]**



However, motion interpolation and management is not just about reducing system wear-and-tear. In some use cases, motion interpolation and management is essential to the entire task. Many microsurgical procedures require accurate motions and incisions at the sub-millimeter scale. For instance, reconstructive surgery for patients with lymphedema (a lymph system swelling that often arises as a complication from breast cancer surgery) involves blood and lymphatic vessels in the 0.3 to 0.8 mm size range.[2] Even the most steady-handed surgeon would be challenged in that scenario **to ensure that jitter or tremor does not upset such a delicate procedure**. That is no judgment on any given surgeon either. Physiological tremor has long been known to be one of the main causes for microsurgical imprecision.[3] Which is why, in recent years, robot-assisted microsurgeries are increasing in number and effectiveness — from retinal to vascular to trans-oral to reconstructive procedures.[4]

03 – THE SOLUTION:
TRACKSUITE

PickNik's TrackSuite is the leading C++ motion interpolation library for both ROS and proprietary manipulators and actuators.[5] TrackSuite constitutes a crucial add-on component for some of the top industrial robotics solutions — demanding smoothed and jerk-limited trajectories that ROS software does not provide.

TrackSuite consists of a pair of realtime safe and fast robotic motion interpolation systems:

TrackPose + TrackJoint

See Fig. 1, the TrackSuite deployment diagram, for an illustration of this command flow.

Together, TrackSuite ensures a best-in-class deployment that ensures your robots':

- **reliability and robustness**
- **predictable behavior**
- **minimized wear-and-tear**
- **jerk-limited kinematics**
- **nearly time-optimal trajectories**

1. TRACKPOSE

filters six degrees-of-freedom Cartesian poses {x, y, z, roll, pitch, yaw} with minimum latency. Generated trajectories are within 10% of optimal. TrackPose sits between raw, noisy Cartesian commands and inverse kinematics (IK) applications like MoveIt, the jog_arm teleoperation package, or your proprietary IK solver.

+

2. TRACKJOINT

then smooths the non-jerk-limited joint commands coming out of IK or motion planning applications, providing smooth, jerk-limited joint commands with any number ofdegrees of freedom.

By contrast, open source interpolation libraries generate acceleration discontinuities, undesired oscillations, mechanical wear, unreliable deployment and updates, unsupported integration and haphazard customization options. Developing pose/joint interpolation and management software on one's own is potentially more treacherous still. (TrackSuite represents the culmination of a team of PhD roboticists devoting more than five person-years' development and testing.)

TrackSuite operates at up to thousands of cycles per second, providing one waypoint per controller timestep. End effector jerk, acceleration and velocity are all, with TrackSuite's smoothed trajectories, within each joint's safe operating parameters for minimal wear.

04 – REAL WORLD USE CASES

TrackSuite's smoothed trajectories enhance both productivity and viability of a wide range of industry applications, including:

ROBOTIC SURGERY

enhancing both teleoperation (e.g. from virtual reality surgical systems) and in-theater surgical robotics and enabling high-precision microsurgery procedures

FRAGILE OPERATIONS

from glass manufacturing and cleaning to agriculture (e.g. produce picking) to sensitive "cobotic" and safe robot-human work environments

HIGHLY DYNAMIC APPLICATIONS

including rapid assembly line or conveyor belt situations that demand high accuracy and fast response times

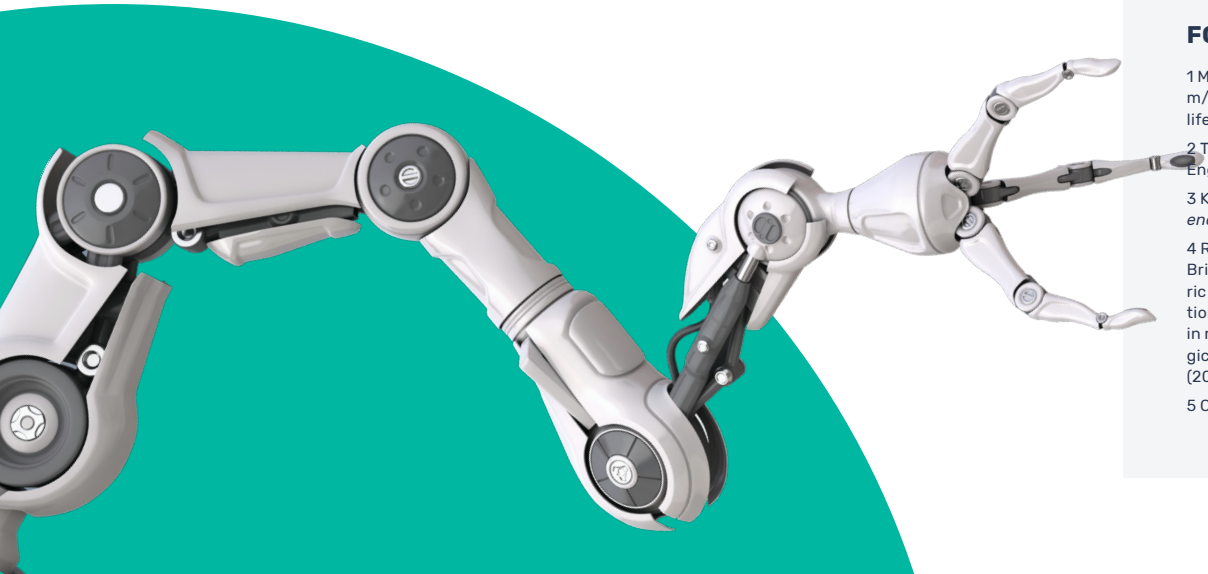
IMPROVING NOISY PERCEPTION DATA

Sensor noise, algorithmic limitations and poor calibration can each conspire to reduce safety, predictability and smooth operations of your robotic systems.

05 – DEPLOYMENT, SUPPORT & CONSULTING SERVICES

Installing TrackSuite into your existing robotics software library requires minimal effort. In most applications, no more than a few person-days from download to install to tuning to testing to up and running again to customization to testing to up and running again. The **TrackJoint** and **TrackSuite** interpolation library sits between a robot's low-level controller and the customer's robotics software code.

Some customers of course operate within a highly specialized parameter space or use an entourage of hardware and software with its own custom drivers and interconnects. In which case, **PickNik's** extensive experience (including its six PhD roboticists on staff) is also available for individualized **TrackSuite** consultations and support. Services include integrating motion planning systems, multi-system integration of **TrackJoint** / **TrackPose** and industry best practices on robotics implementation and use cases.



06 – CONCLUSION

Rapidly smoothed and reliably responsive robot motions are increasingly a baseline expectation of robotic operations today. Faster execution of paths boosts system efficiency and increases throughput. From industrial robots requiring jerk-limited trajectories to microsurgical robots mandating high-precision incisions to fragile materials handling and manufacturing environments to rapid conveyor belt responsiveness — all demand a robust and easily integrated suite of interpolation solutions. PickNik's TrackSuite (consisting of its TrackPose and TrackJoint robotic libraries) guarantees your robots' motions are safer and more predictable, with jerk-limited kinematics and reduced joint fatigue and hardware wear & tear. TrackSuite ensures your robots' behavior achieves nearly time-optimal trajectories while still prolonging the life of your hardware via smoother operation.

Complementing these pre-built solutions are a range of PickNik consulting services, integrating and optimizing trajectories for minimum material stress with maximum effectiveness and hardware longevity. Contact a PickNik representative to schedule a TrackSuite trial — and discover how custom trajectory interpolation and management can increase the effectiveness and productivity of your robotics applications today.

FOOTNOTES

1 Mauro et al demonstrate that moderating ball screw feed drive parameters {max. jerk (in m/s^3), max. acceleration (in m/s^2), max. velocity (in m/s)} from {1000, 9, 1.3} down to {600, 5,0.9} can, in their words, "almost double … the fatigue life." Stefano Mauro et al. Advances in Mechanical Engineering 2015. vol. 7(8) p. 7.

2 Theresa Sullivan Barger, "Robot Helps Doctors Perform Delicate Microsurgeries" ASME Alliance of Advanced MioMedical Engineering (Jan. 8, 2018) aabme.asme.org/posts/robot-helps-doctors-perform-delicate-microsurgeries

3 K.C. Veluvolu et al. "Adaptive Filtering of Physiological Tremor for Real-time Compensation" *Proceedings of the Conference on Robotics and Biomemetics (Feb. 21-26,-2009)*

4 Roizenblatt, Marina, et al. "Robot-assisted tremor control for performance enhancement of retinal microsurgeons." British Journal of Ophthalmology 103.8 (2019): 1195-1200; Guo,Shuxiang, et al. "A Novel Suppression Algorithm of Isometric Tremor for the Vascular Interventional Surgical Robot." 2018 13th World Congress on Intelligent Control and Automation (WCICA). IEEE, 2018; Tan, Youri, Philippe Liverneaux, and Jason KF Wong. "Current limitations of surgical robotics in reconstructive plastic microsurgery." Frontiers in surgery 5 (2018): 22; Chauhan, Manish, et al. "A robotic microsurgical forceps for transoral laser microsurgery." International journal of computer assisted radiology and surgery 14.2 (2019):321-333.

5 Contact PickNik for individual proprietary system compatibilities.

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