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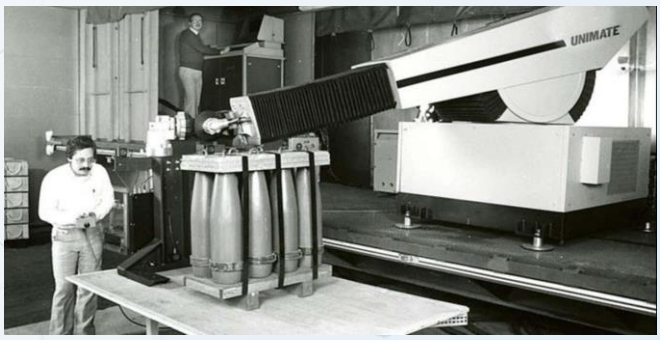
Intelligent automation: Working smartR with MoveIt

The history of robotic manipulators

Unimation was introduced almost 70 years ago as the first industrial robotic arm. The first prototype sold to General Motors started a revolution in efficiency in the automotive industry.

Nowadays, the manipulators available in a large variety in the market are stronger, faster, and more reliable than its predecessor from decades ago.



All the processes have been optimized, bringing down the cost and time it takes to deploy a robotic automation application.

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As a result, robotic automation has become an essential component of many industries, from manufacturing to healthcare. Its ever-increasing demand is justified by the numerous opportunities for the development of sophisticated applications.

Current challenges

Despite all the progress, getting a robot to move the way you want is not yet a trivial thing to do. There are still some intrinsic challenges to this field that require a considerable amount of engineering effort.

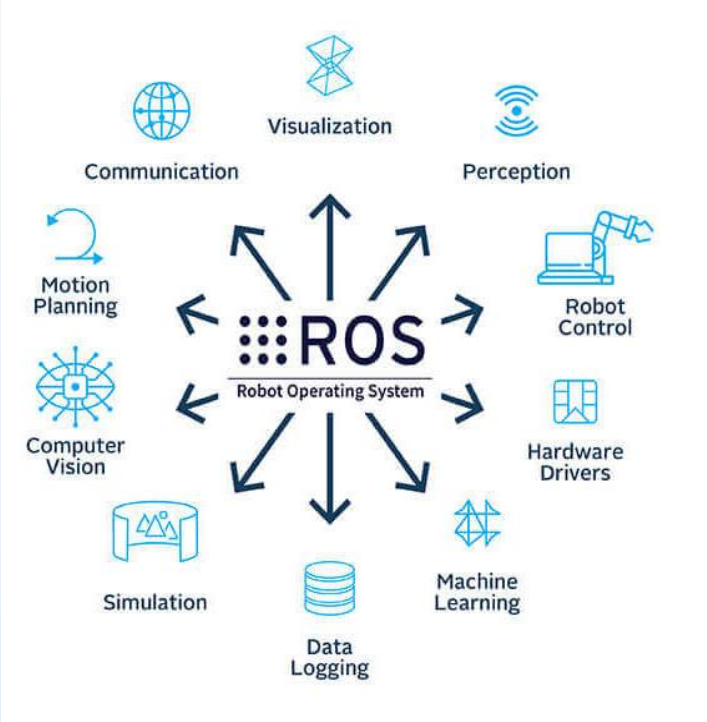
After defining the task to be accomplished and the robotic arm and other hardware components needed, comes the application-specific phase where custom instructions must be given to the robot so it can execute the desired movement.

These instructions are a sequence of movements to be performed by the robotic arm motors to execute the task at hand. The commands can be recorded by moving the robot to several desired waypoints that will be played back later. Alternatively, it is generally also possible to describe a sequence of poses with X, Y, Z, and orientation coordinates with respect to a frame. Those coordinates will later be converted using inverse kinematics to find the target position for each motor of the manipulator at each instant in time. Using a sequence of poses is the most common approach for complex and dynamic projects.

There are several ways of describing the desired robot motion, each method has its pros and cons.

Standard automation refers to using vendor-specific tools, like the teach pendant, the scripting language, and the offline programming suites to tell the robot what it should do.

A very interesting alternative to that, especially for complex projects which may involve unstructured environments, is using the Robot Operating System (ROS), which is an open-source platform for building robotic systems that has become increasingly popular in recent years. MoveIt is a framework within ROS that provides advanced motion planning and manipulation capabilities for robotic arms.



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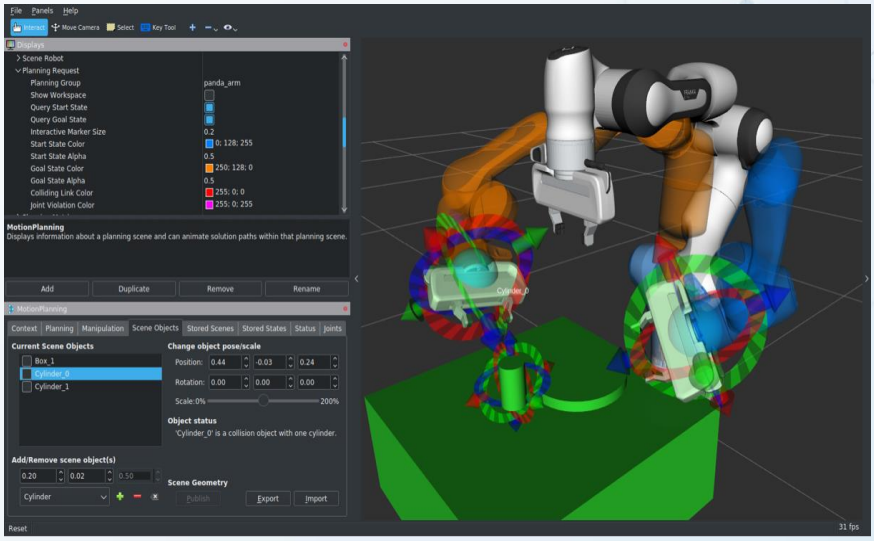
What is MoveIt?

“MoveIt is a motion planning framework that reduces the barrier to entry complex robotic software by leveraging open-source robot-agnostic work.” Robert Haschke

The premier open-source robotics platform for building commercial manipulation applications, MoveIt is a software framework that uses AI to enable robots to reason about its environment and plan optimal motion and task solutions for any robot manipulator. It is used by hundreds of startups, research labs, and large corporations, like NASA, Google, and Microsoft, to effectively develop custom automation solutions featuring robots.



Why use MoveIt?

The smartR AI intelligent automation team primarily works with MoveIt and ROS, rather than the more traditional standard robotic automation application, such as the Fanuc robotic arm with their software.

When looking at how these two systems function, the controllers are basically the same, as are the effectors. However, the difference with MoveIt and ROS is that the environment is inputted, allowing robots to have the ability to understand and find their way around their environment using AI.

The Benefits of MoveIt

- MoveIt and ROS are open-source and community-driven, which means it has a large community of developers and users contributing to the maintenance and development of new capabilities. This results in a robust and constantly evolving platform with cutting-edge algorithms and features.
- ROS is like a hub where the community add support to different sensors, controllers, planners, and actuators from a large variety of providers, making it easy and inexpensive to integrate technologies across vendors.
- MoveIt is designed to be robot agnostic. This means that they can work with any robot manipulator, regardless of its manufacturer or model. This is a significant

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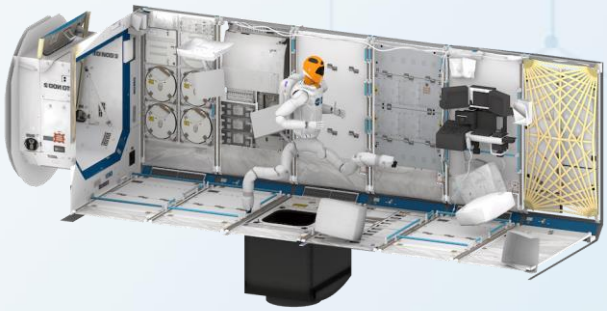
advantage over proprietary robotic automation systems, which are often limited to specific robot vendors.

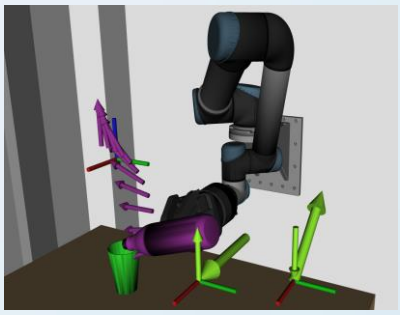
- MoveIt provides a simple user interface for configuring the software to work with any robot environment. This is done through the MoveIt Setup Assistant, which allows you to provide the robot model in URDF format from your favorite CAD program, and the assistant takes care of the rest, making it easy for even non-experts to get started with the software.

- Out-of-the box visual demonstrations in Rviz, ROS 3D interactive visualizer, allow users experimentation with various planning algorithms around obstacles. Execution on physical hardware is just a click away.

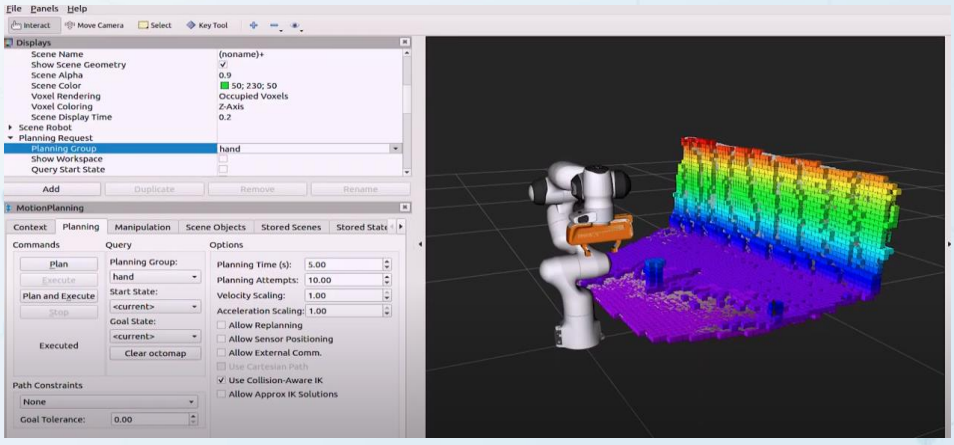
- Development and testing cycles can be sped up by leveraging a full physics-based simulator with MoveIt. The combination of the Gazebo simulator, ROS Control, and MoveIt make up a powerful robotics development platform.



- MoveIt provides a wide range of capabilities, including advanced motion planning, collision avoidance, and manipulation. The MoveIt Task Constructor can plan arbitrarily complex tasks with multiple intermediate subtasks ideal for pick-and-place applications, where tasks can be broken down into basic planning stages that are solved in parallel to ensure a valid plan for the entire task.



- MoveIt constructs a 3D representation of its environment out of a combination of static and dynamic elements. Through perception system integrations, such as the Octomap plug-in, dynamic elements can be added to the robot's representation of



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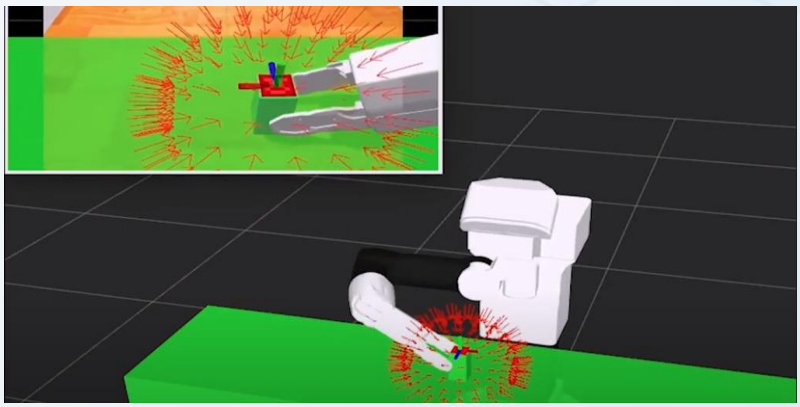
the environment ensuring that it will avoid unwanted collisions with its changing environment.

- MoveIt can quickly evaluate grasping poses and excels at pick-and-place applications with random objects of varying size and orientation. It's possible to interface with several machine learning grasp libraries, including GPD and DexNet.

- MoveIt servo can be used for real-time teleoperation or tracking moving objects such as conveyor belt applications. It uses the inverse jacobian method to provide collision-free paths for the robot at cycle times nearing 1 kHz.

- MoveIt provides several tools for benchmarking and optimizing motion planning algorithms. This makes it possible to find the optimal algorithm for your application, which can result in faster and more efficient automation solutions.



Standard robotic automation systems, on the other hand, are often proprietary and bound to specific robot vendors. This can result in significant costs and limitations when trying to implement automation solutions across multiple robots or environments. It gets even worse when a robotic arm has to be replaced with one from a different vendor as all the now-incompatible logic, state machine, and configurations go down the drain and a new project might need to be started from scratch.

Additionally, standard robotic automation systems often lack the advanced capabilities provided by MoveIt and ROS, such as sampling-based motion planning, task planning, dynamic collision avoidance, and manipulation.

Another disadvantage of standard robotic automation systems is the lack of community support, documentation and general hardware compatibility. This can make it difficult to learn and use the software, find solutions to common problems, and combine peripherals like end-effectors and cameras.

MoveIt versus standard robotic automation

The following table provides an overview of the pros and cons of using the MoveIt and ROS system versus standard robotic automation.

Advantages	Disadvantages
Motion planning – the ability to reason about its environment	Requires ROS expertise (C++ / Python) – a steep learning curve
Flexibility of planning – no teaching required, just specify the start and end poses ➢ Task planning in advance (MTC) – It's possible to plan for the whole trajectory and optimize the grasp and the subsequent movements accordingly. Therefore, avoiding greedy single-step solutions that might get the robot stuck in a position	➢ In most cases, the vendor-specific language would have to be learned ➢ When building a complex application, it's necessary to learn the specific language required anyway. ➢ MoveIt uses C++ / Python which are used for many more situations in technology development than the more specific languages.
Manipulation (grasp generation)	May require more development time for simple automation
Given the object, a gripper, and a few parameters, it is possible to plan collision-free paths to a grasp pose. ➢ Using MoveIt and AI, one can plan multiple grasps in all the various grasp positions that aren't in any collision path for the robot.	This could be done via the teach pendant, and it's easier and quicker for standard robotic automation. ➢ However, MoveIt is much more flexible and the setup effort is not lost if more customization is required down the line.
Easy integration with all ROS-compatible sensors and actuators	Planned trajectories are not deterministic
MoveIt uses ROS which is an open-source hub where the community makes sensors, controllers, planners, and actuators compatible with the hub and, therefore, with everything in it. ➢ In *standard* robotic arms, it's only possible to use sensors and actuators that are specifically integrated into the vendor software.	Most motions from sampling-based planners are not cartesian and, due to the randomness in the planning process, the generated path might be different and unpredictable ➢ Addressed by MTC with joint interpolation: a different way of planning a path that is not random, and resembles more what is done in a standard robotic automation. Using a joint interpretation path planner, and when and only if the perfect path fails use the original methods for the path determination, that may be less beautiful in execution.
Collision checking – avoiding obstacles	
As part of the path planning process, voxels or more complex 3D shapes can be used to represent obstacles to be avoided in the robot's operation space.	
Robot agnostic	
It doesn't depend on a vendor-specific programming language as does standard robotic automation ➢ Can simply swap the robot model with minor changes making it faster and more effective to adapt to needs.	

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➢ No reliance on a specific vendor, allowing for flexibility.	
Control – Not only of a path but also a trajectory	
MoveIt adapts easily to planning a path through the environment, as well as adding timings to each path step. This creates a trajectory, which includes velocity and acceleration.	
Inverse kinematics – figuring out which joint angles are required to achieve a pose	
It's more sophisticated and easily adaptable in MoveIt any changes that are made to the robot can be easy adapted and not limited by using MoveIt	

MoveIt and ROS provide several advantages over standard robotic automation systems. They are open-source, robot agnostic, and provide advanced motion planning and manipulation capabilities while simultaneously being more scalable and flexible.

"MoveIt is a flexible and comprehensive framework, easily adaptable to the user's needs, that can address anything from single motion to complex multi-step tasks in an efficient and modular way" Robert Haschke

Robert Haschke, a smartR AI advisor and consultant, has contributed to multiple ROS packages over the last decade. He's a distinguished member of the ROS community and actively maintains the following (key) packages:

- MoveIt and MoveIt Task Constructor
- Rviz
- Xacro

Why work with smartR AI? - Benefits and expertise

The smartR AI team provides several benefits to clients based upon our expertise in MoveIt and ROS applications:

- smartR AI has delivered several successful proofs of concept using MoveIt and ROS, integrating 6DOF Industrial Robotic Arms with AI to accomplish flexible tasks using Computer Vision and Path Planning in unpredictable environments outside the industrial context.
- Our team can easily integrate any of the 80+ supported robot models from ABB, Fanuc, Kuka, Motoman, Staubli and Universal in your completely custom work cell in a single day, or add ROS support to your unique hardware.

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- The intelligent automation team demonstrated the ability of using AI applications to pick and place vegetables of varying sizes, as well as pick ice blocks, from a cluttered bin, thus showing our vision system's ability to adapt to any shape and size.
- Providing time and money savings by connecting a ROS-compatible system to our pre-trained vision models and pick-and-place state machine templates. Allowing our clients to reap the benefits of interoperability and modularity by having easy-to-maintain and reusable software.
- Final results delivered to the client exceed their expectations regarding precision, successful execution, and picking speed, while keeping development time at a minimum compared to their previous experiences.
- The intelligent automation team at smartR AI gain advice from and work with MoveIt and ROS industry experts, thus certain that the solutions developed use the best approaches available today.

At smartR AI, we invent tomorrow's products today by breaking free from pre-programmed rules.

About smartR AI

smartR AI™ is committed to developing life-changing artificial intelligence applications based on the evolution of interactions, behavior changes, and emotion detection.

Focusing on behavioral intelligence and interconnections with IoT, we use AI applications to understand, interpret, predict, and respond to complex scenarios. As intelligence moves to the edge of the network smartR AI is all about doing things the smartest way.

To solve complex real-world problems and optimize decision-making, smartR AI uses its intelligence-based proprietary engines. These engines ensure optimal efficiency and performance, improve quality, and reduce human error. They learn faster, leverage existing and historical knowledge, provide data efficiency, and allow for connectivity, to name just a few of their attributes.

The team builds products with the latest AI techniques, knows how to help integrate AI into your product, and our expertise and diversity of knowledge ensure clients benefit from high levels of adaptability. We listen to your ideas and turn them into reality.

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