Cartesian path

Preface: ROS on Raspberry Pi 5 and Jetson-nano runs in Docker, so the performance of running MoveIt2 is average. It is recommended that users of Raspberry Pi 5 and Jetson-nano motherboards run MoveIt2 related cases in a virtual machine. ROS on Orin motherboard runs directly on the motherboard, so users of Orin motherboard can run MoveIt2 related cases directly on the motherboard. The instructions are the same as running in a virtual machine.

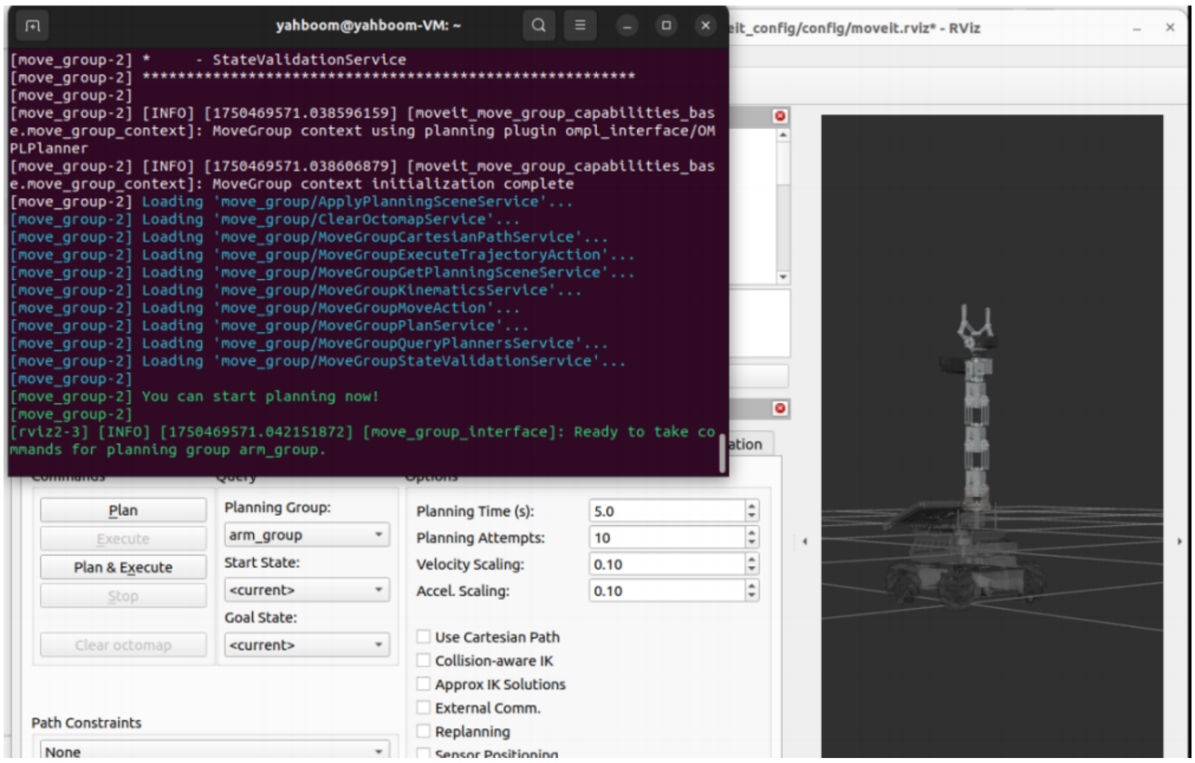
The following content uses running on a virtual machine as an example.

1. Content Description

This section explains how to use functions in MoveIt2 to implement Cartesian paths. Cartesian path planning is an important feature in robotic arm control. It allows users to specify the trajectory of the end effector in Cartesian space (i.e., three-dimensional space) rather than directly specifying the motion in joint space. MoveIt provides powerful Cartesian path planning capabilities.

2. Program startup

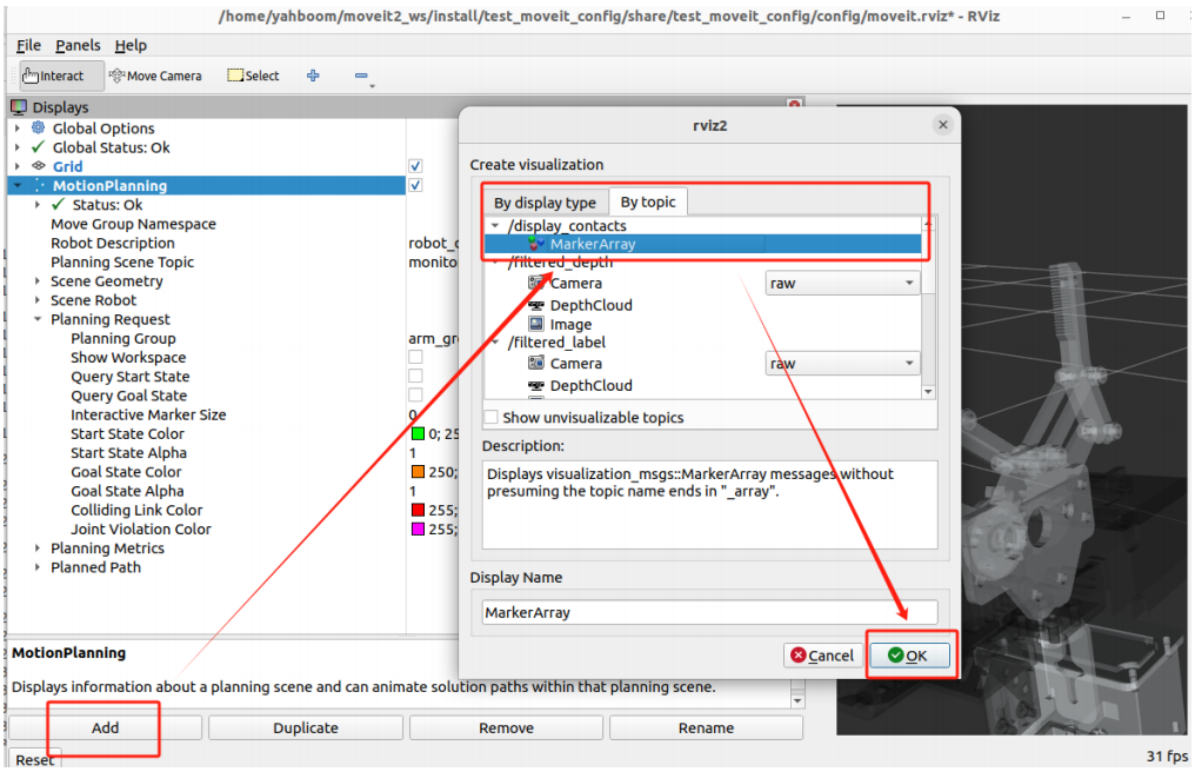
After the program is started, when the terminal displays **"You can start planning now!"** , it indicates that the program has been successfully started, as shown in the figure below.



```
[move_group-2] *     - StateValidationService
[move_group-2] ********************************************************
[move_group-2]
[move_group-2] [INFO] [1750469571.038596159] [moveit_move_group_capabilities_bas
e.move_group_context]: MoveGroup context using planning plugin ompl_interface/OM
PLPlanner
[move_group-2] [INFO] [1750469571.038606879] [moveit_move_group_capabilities_bas
e.move_group_context]: MoveGroup context initialization complete
[move_group-2] Loading 'move_group/ApplyPlanningSceneService'...
[move_group-2] Loading 'move_group/ClearOctomapService'...
[move_group-2] Loading 'move_group/MoveGroupCartesianPathService'...
[move_group-2] Loading 'move_group/MoveGroupExecuteTrajectoryAction'...
[move_group-2] Loading 'move_group/MoveGroupGetPlanningSceneService'...
[move_group-2] Loading 'move_group/MoveGroupKinematicsService'...
[move_group-2] Loading 'move_group/MoveGroupMoveAction'...
[move_group-2] Loading 'move_group/MoveGroupPlanService'...
[move_group-2] Loading 'move_group/MoveGroupQueryPlannersService'...
[move_group-2] Loading 'move_group/MoveGroupStateValidationService'...
[move_group-2]
[move_group-2] You can start planning now!
[move_group-2]
[rviz2-3] [INFO] [1750469571.042151872] [move_group_interface]: Ready to take co
mmands for planning group arm_group.
```

Planning Group: arm_group
Start State: <current>
Goal State: <current>
Planning Time (s): 5.0
Planning Attempts: 10
Velocity Scaling: 0.10
Accel. Scaling: 0.10
☐ Use Cartesian Path
☐ Collision-aware IK
☐ Approx IK Solutions
☐ External Comm.
☐ Replanning
☐ Sensor Positioning
Path Constraints: None

Then, we need to add a plug-in to display the planned trajectory, and set it up as shown in the figure below.



MotionPlanning

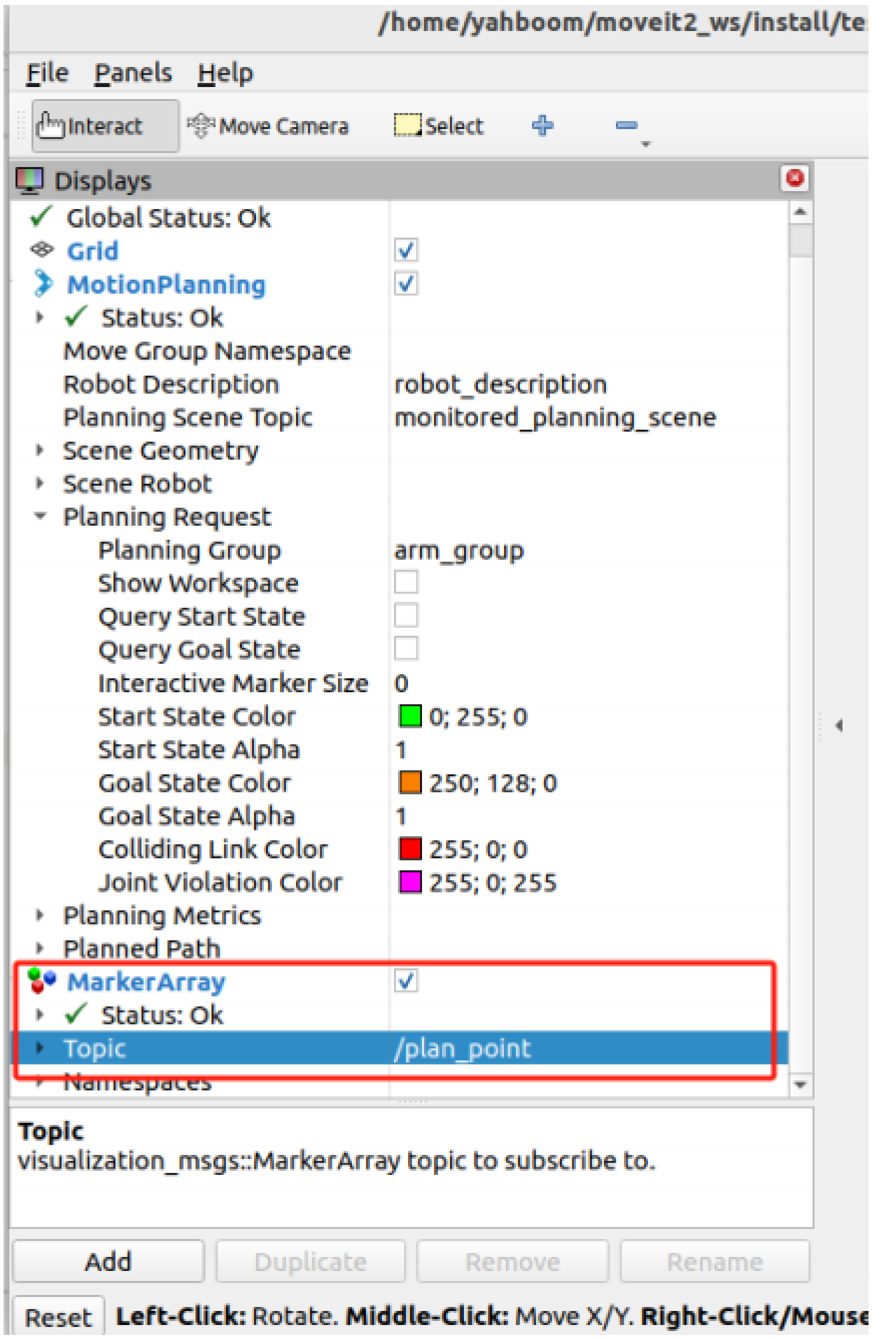
Displays information about a planning scene and can animate solution paths within that planning scene.

Description:

Displays visualization_msgs::MarkerArray messages without presuming the topic name ends in "_array".

Display Name: MarkerArray

Next, we modify the topics that need to be displayed, as shown below.


/home/yahboom/moveit2_ws/install/te

Displays	
Global Status: Ok	
Grid	✓
MotionPlanning	✓
Status: Ok	
Move Group Namespace	
Robot Description	robot_description
Planning Scene Topic	monitored_planning_scene
Scene Geometry	
Scene Robot	
Planning Request	
Planning Group	arm_group
Show Workspace	☐
Query Start State	☐
Query Goal State	☐
Interactive Marker Size	0
Start State Color	🟩 0; 255; 0
Start State Alpha	1
Goal State Color	🟧 250; 128; 0
Goal State Alpha	1
Colliding Link Color	🟥 255; 0; 0
Joint Violation Color	🟪 255; 0; 255
Planning Metrics	
Planned Path	
MarkerArray	✓
Status: Ok	
Topic	/plan_point
Namespaces	

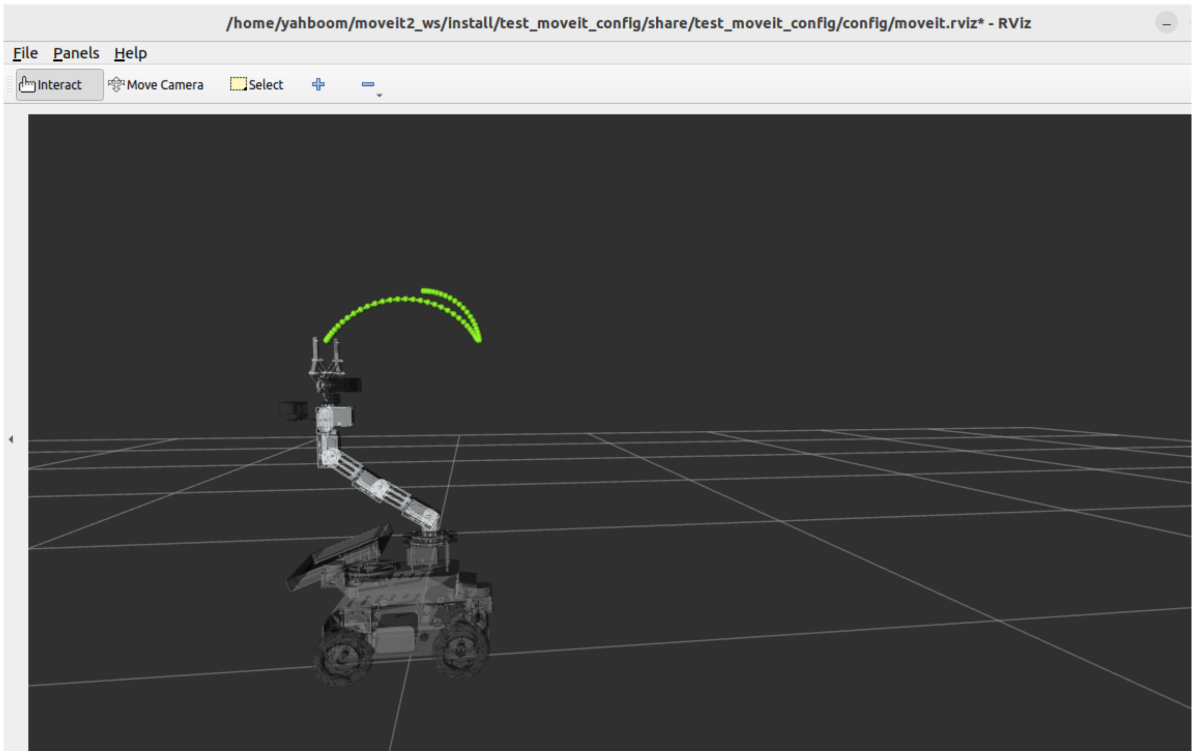
Topic
visualization_msgs::MarkerArray topic to subscribe to.

File
Panels
Help
Interact
Move Camera
Select
Add
Duplicate
Remove
Rename
Reset
Left-Click: Rotate. **Middle-Click:** Move X/Y. **Right-Click/Mouse

Then, enter the following command in the virtual machine terminal to start the Cartesian path program,

```
ros2 run MoveIt_demo cartesian_path
```

After running, the robot arm will move to the set posture and a green Cartesian path point will be displayed, as shown in the figure below.


/home/yahboom/moveit2_ws/install/test_moveit_config/share/test_moveit_config/config/moveit.rviz* - RViz
File
Panels
Help
Interact
Move Camera
Select

3. Core code analysis

Virtual machine code path: `/home/yahboom/moveit2_ws/src/MoveIt_demo/src/cartesian_path.cpp`

```
#include <rclcpp/rclcpp.hpp>
#include <moveit/move_group_interface/move_group_interface.h>
#include <moveit/planning_scene_interface/planning_scene_interface.h>
#include <moveit_msgs/msg/display_trajectory.hpp>
#include <moveit_visual_tools/moveit_visual_tools.h>
#include <geometry_msgs/msg/pose.hpp>
#include <vector>
#include <moveit/robot_trajectory/robot_trajectory.h>
#include <moveit/robot_state/robot_state.h>
#include <moveit/robot_model/robot_model.h>
#include <moveit/robot_model_loader/robot_model_loader.h>

class  CartesianPathPlanning : public  rclcpp::Node
{
public :
  CartesianPathPlanning ()
    : Node ( "cartesian_path_planning" )
    {
        RCLCPP_INFO ( this -> get_logger (), "Initializing
CartesianPathPlanning." );
    }
  void  initialize ()
  {
    int  max_attempts  =  5 ;   // Maximum number of planning attempts
    int  attempt_count  =  0 ;   // Current number of attempts
    // Use RobotModelLoader to load the robot model
    robot_model_loader::RobotModelLoader  robot_model_loader ( shared_from_this
(), "robot_description" );
    const  moveit::core::RobotModelPtr &  robot_model  =  robot_model_loader .
getModel ();
```

```
    //Initialize move_group_interface_ in this function and create a planning
group named arm_group
    move_group_interface_  =  std::make_shared <
moveit::planning_interface::MoveGroupInterface > (
      shared_from_this (), "arm_group" );
    planning_scene_interface_  =  std::make_shared <
moveit::planning_interface::PlanningSceneInterface > ();
    move_group_interface _-> setNumPlanningAttempts ( 10 );   // Set the maximum
number of planning attempts to 10
    move_group_interface _-> setPlanningTime ( 5.0 );          // Set the maximum
time for each planning to 5 seconds
    const  moveit::core::JointModelGroup *  joint_model_group  =  robot_model ->
getJointModelGroup ( "arm_group" );

    // Initialize the coordinate system of the trajectory display to base_link,
the trajectory topic to plan_point, and the robot model to the planning group
model
    moveit_visual_tools::MoveItVisualTools  visual_tools_ ( shared_from_this (),
"base_link" , "plan_point" ,
                                                    move_group_interface_ ->
getRobotModel ());



    moveit::planning_interface::MoveGroupInterface::Plan  up_plan ;
    // Set the predefined target position
    move_group_interface_ -> setNamedTarget ( "up" );
    //Start planning the robot arm to the up position
    bool  success  = ( move_group_interface_ -> plan ( up_plan ) ==
moveit::core::MoveItErrorCode::SUCCESS );
    //If the plan is successful, execute the plan
    if ( success )
    {
        RCLCPP_INFO ( this -> get_logger (), "Init arm successful." );
        move_group_interface_ -> execute ( up_plan );
    }
    else
    {
        RCLCPP_ERROR ( this -> get_logger (), "Init arm failed!" );
    }




    // Define a series of target poses
    std::vector < geometry_msgs::msg::Pose >  waypoints ;

    geometry_msgs::msg::Pose  target_pose ;
    target_pose . position . x  =  0.111475 ;
    target_pose . position . y  =  - 0.00398619 ;
    target_pose . position . z  =  0.381269 ;
    target_pose . orientation . x  =  2.14803e - 05 ;
    target_pose . orientation . y  =  - 0.000202467 ;
    target_pose . orientation . z  =  - 6.38068e - 05 ;
    target_pose . orientation . w  =  1 ;
    waypoints . push_back ( target_pose );
    geometry_msgs::msg::Pose  target_pose_2 ;
    target_pose_2 . position . x  =  - 0.10527 ;
    target_pose_2 . position . y  =  0.00216908 ;
    target_pose_2 . position . z  =  0.385409 ;
    target_pose_2 . orientation . x  =  2.5884e - 05 ;
    target_pose_2 . orientation . y  =  4.08345e - 05 ;
    target_pose_2 . orientation . z  =  - 0.161976 ;
    target_pose_2 . orientation . w  =  0.986795 ;
    waypoints . push_back ( target_pose_2 );




    //Define some necessary parameters for the Cartesian path
    moveit_msgs::msg::RobotTrajectory  trajectory_msg ;
    double  jump_threshold  =  0.0 ;
    double  eef_step  =  0.25 ;
    int  maxtries  =  1000 ;    //maximum number of attempts to plan
    int  attempts  =  0 ;      //Number of attempts already made
    double  fraction  =  0.0 ;

 while ( attempts  <  maxtries )
    {
        //Call computeCartesianPath to calculate the Cartesian path. waypoints
represents the target pose, eef_step represents the maximum step size between
waypoints, jump_threshold represents the allowed joint space jump threshold (in
radians), trajectory_msg represents the output trajectory, and the fraction
returned is the path fraction. A fraction of 1.0 indicates that the path planning
was successful and can be executed safely. A fraction of 0.0 indicates a complete
failure and requires checking for collisions, workspace restrictions, etc. A
fraction between 0.0 and 1.0 indicates partial success and may require adjustment
of the path or optimization parameters.
        fraction  =  move_group_interface_ -> computeCartesianPath ( waypoints ,
eef_step , jump_threshold , trajectory_msg );
        if ( fraction  >  0.0 )
        {
                RCLCPP_INFO ( this -> get_logger (), "Cartesian path planned
successfully (%.2f%% achieved)" , fraction  *  100.0 );

              robot_trajectory::RobotTrajectory  trajectory (
move_group_interface_ -> getRobotModel (), move_group_interface_ -> getName ());

              // Visualize the trajectory in RViz. The trajectory parameters are
the planned path. Set the end execution link to Gripping. The point color of the
robot trajectory is green.
              visual_tools_ . publishTrajectoryLine ( trajectory_msg ,
move_group_interface_ -> getRobotModel () -> getLinkModel ( "Gripping" ),
joint_model_group , rviz_visual_tools::LIME_GREEN );
              visual_tools_ . trigger ();


              moveit::planning_interface::MoveGroupInterface::Plan  plan ;
              plan . trajectory_  =  trajectory_msg ;
              move_group_interface_ -> execute ( plan );
              break ;
        }
        else
        {
             RCLCPP_ERROR ( this -> get_logger (), "Failed to compute Cartesian
path" );
             attempts ++ ;
        }
  }
}
private :
  std::shared_ptr < moveit::planning_interface::MoveGroupInterface >
move_group_interface_ ;
  std::shared_ptr < moveit::planning_interface::PlanningSceneInterface >
planning_scene_interface_ ;
  std::shared_ptr < moveit_visual_tools::MoveItVisualTools >  visual_tools_ ;
};

int  main ( int  argc , char  ** argv )
{
  rclcpp::init ( argc , argv );
  auto  node  =  std::make_shared < CartesianPathPlanning > ();

  rclcpp::executors::SingleThreadedExecutor  executor ;
  executor . add_node ( node );
  // Start asynchronous Spinner
  node- > initialize ();
  executor.spin ( ) ;

  //rclcpp::spin(node);
  rclcpp::shutdown ();
  return  0 ;
}
```