

Ti5用户手册 EBLM/ARM系列机器人

Ti5 User Manual EBLM/ARM Series Robot



使用产品前请仔细阅读本手册
Please read this manual carefully before using the product

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前言 Preface

感谢您购买和使用本公司研发的轻型Eblm/Arm系列6自由度协作机器人。

Thank you for buying & using our company's light series Eblm/Arm of 6-DOF collaborative robot.



Eblm/Arm本体外形结构示意图
Schematic diagram of EBLM/ARM ontology configuration

Eblm/Arm系列机器人采用关节模块化设计，使用面向开发者层面的机器人系统。用户可根据 Eblm/Arm平台提供的应用程序接口，开发属于自己的机器人控制系统；此外，Eblm/Arm 机器人配有专用的可编程操作界面，用户可通过此界面实时观察机器人的运行状态，对机器人进行诸多控制设置，也可脱机进行离线仿真，极大地提升了实际应用的工作效率。

Eblm/Arm系列为钛虎机器人科技（上海）有限公司推出的第一代智能轻型6自由度模块化协作机器人。

The Eblm/Arm family of robots uses Modular design, developer-oriented robotic systems. Users can develop their own robot control system based on the application programming interface provided by the Eblm/Arm platform, in addition, Eblm/Arm robots are equipped with a dedicated programmable operating interface, through this interface, the user can observe the running state of the robot in real time, make many control settings for the robot, and also do off-line simulation, which greatly improves the work efficiency of the practical application.

Eblm/Arm series is the first generation of intelligent light-duty 6-Dof modular cooperative robot, which is introduced by Ti5robot Technology Shanghai Co.,Ltd. .

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2. 使用时范围超出用户手册所示规格或标准；
The specifications or standards shown in the user manual are exceeded during use;
3. 将本产品用于指定以外用途；
Use this product for purposes other than specified;
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产品质量保证书 Product Quality Guarantee

Eblm/Arm 机器人具有 12 个月有限保修期。

若新设备及其组件在投入使用后 12 个月内（如包括运输时间则最长不超过 15 个月），出现因制造或材料不良所致的缺陷，钛虎机器人科技（上海）有限公司应提供必要的备用部件予以更换或维修相关部件。

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在保修期外，如果设备出现缺陷，钛虎机器人科技（上海）有限公司不承担由此引起的任何损害或损失，例如生产损失或对其他生产设备造成的损坏。

Eblm/Arm robots have a 12-month limited warranty.

In the event that defects arising from poor manufacturing or materials occur within 12 months of the commissioning of the new equipment and its components, including a maximum of 15 months for transportation, Ti5robot Technology Shanghai Co.,Ltd.shall provide the necessary spare parts to replace or repair the relevant parts.

The ownership of the equipment or components that have been replaced or returned to Ti5robot Technology Shanghai Co.,Ltd.. is owned by Ti5robot Technology Shanghai Co.,Ltd. .

If the product is no longer under warranty, Ti5robot Technology Shanghai Co.,Ltd. reserves the right to charge the customer for replacement or maintenance.

Outside the warranty period, if the equipment is defective, Ti5robot Technology Shanghai Co.,Ltd. will not assume any damage or loss caused by this, such as production loss or damage to other production equipment.

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一、安全 Security

1.1 简介 Introduction

本章介绍了操作机器人或机器人系统时应该遵守的安全原则和规范。集成商及用户必须认真阅读本手册，带有警示标识的内容需要重点掌握并严格遵守。由于机器人系统复杂且危险性较大，使用人员需要充分认识操作的风险性，严格遵守并执行本手册中的规范及要求。用户及集成商需要具备充分的安全意识并且遵守工业机器人安全规范 ISO 10218。

This chapter describes the safety principles and specifications that should be followed when operating a robot or robotic system. Users and integrators must read this manual carefully, with the content of the warning logo needs to be focused and strictly observed. Because of the complexity and danger of the robot system, the user needs to fully understand the risk of operation, strictly comply with and implement the specifications and requirements in this manual. Users and integrators should be fully aware of safety and comply with the Industrial Robot Safety Specification ISO 10218.

1.2 安全警示标志 Safety Warning Sign

本手册中有关安全的内容，使用如下警示标志进行说明，手册中有关警示标志的说明，表示重要内容，请务必遵守。

The safety-related content in this manual shall be explained by the following warning signs. The instructions on the warning signs in this manual indicate the important content, which must be observed.

表格 1 警示标示说明 Form 1 Warning Label Description

标志 Sign	说明 Introduction
 有电危险! Caution: Electricity!	即将引发危险的用电情况，如果不避免，可导致人员伤亡或设备严重伤害。 Can cause dangerous electricity use, if not avoided, can lead to personal injury or serious damage to equipment.

 危险! DANGER!	可能引发危险的热表面，如果接触了，可造成人员伤害。 May cause dangerous thermal surfaces that, if touched, may cause human injury.
 高温危险! High TEMPERATURE -E DANGER!	即将引发危险的情况，如果不避免，可导致人员死亡或严重伤害。 An imminent dangerous situation, if not avoided, may result in death or serious injury
 警告! WARNING!	可能引发危险的用电情况，如果不避免，可导致人员伤害或设备严重损坏。 Can cause dangerous electricity use, if not avoided, can lead to personal injury or serious damage to equipment.
 注意! CAUTION!	可能引发危险的情况，如果不避免，可导致人员伤害或设备严重损坏。 标记有此种符号的事项，根据具体情况，有会有发生重大后果的可能性。 A potentially dangerous situation, if not avoided, may result in injury to personnel or serious damage to equipment. Matters marked with such symbols sometimes have the possibility of significant consequences, depending on the circumstances.
 小心! CAREFUL!	标记有此种符号的事项，根据具体情况，有时会有发生重大后果的可能性，如果不避免，可导致人员伤害或设备损坏。 Matters marked with such symbols sometimes have the possibility of significant consequences, depending on the circumstances. If not avoided, may result in injury to persons or damage to equipment.

1.3 安全注意事项 Safety Precautions

1.3.1 概述 Overview

手册包含保护使用人员及预防机器损坏的安全措施。用户需要阅读说明书里的 所有相关描述并且完全熟知安全事项。本手册中，我们尽量描述各种情况，但是由于有太多的可能性，所有不能做或者不可以做的情况不可能都被记录下来。

This manual contains safety measures to protect users and prevent damage to machines. The user needs to read all the relevant descriptions in the manual and be fully familiar with the security issues. In this manual, we try to describe various situations, but because there are so many possibilities, it is impossible to keep track of all the things that can not be done or can not be done.

1.3.2 使用须知 Instructions for Use

在首次启动机器人或机器人系统时需要理解并遵循以下基本信息，其他安全相关信息在手册的其他部分予以介绍。不过，也不可能面面俱到，在实际应用中，需要具体问题具体分析。

The following basic information needs to be understood and followed when starting a robot or robotic system for the first time, and other safety-related information is described elsewhere in the manual. However, it is not possible to cover all aspects, in practical application, the need for specific analysis of specific issues.

 危险! DANGER!	请务必按照本说明书中的要求和规范安装机器人及所有电气设备。 Please be sure to install the robot and all electrical equipment in accordance with the requirements and specifications in this manual. 在第一次使用机器人及投入生产前需要对机器人及其防护系统进行初步测试和检查。 It is necessary to carry out preliminary test and inspection of the robot and its protective system before the first use of the robot and its production.
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	首次启动系统和设备前，必须检查设备和系统是否完整、操作是否安全、是否检测到任何损坏。本次检测中需观察到是否符合国家或地区有效的安全生产规章制度，必须测试所有的安全功能。 Before starting the system and equipment for the first time, you must check that the equipment and system are complete, that the operation is safe, and that any damage has been detected. This test should observe whether to comply with the national or regional effective safety production regulations and regulations, must test all safety functions. 用户必须检查并确保所有的安全参数和用户程序是正确的，并且所有的功能工作正常。需要具有操作机器人资格的人员来检查每个安全功能。只有通过全面且仔细的安全测试且到达安全级别后才能启动机器人。 The user must check and ensure that all security parameters and user programs are correct and that all security functions are working correctly. Personnel qualified to operate robots are required to check each security function. The robot can not be started until it has passed a comprehensive and careful security test and has reached a security level. 当机器人安装完成和构建完成后，需再次进行全面的风险评估并保留文件记录。 Once the robot has been installed and built, a comprehensive risk assessment should be conducted and documented. 由具有授权许可的人员来设置和更改安全参数，使用密码或者隔离措施来防止未被授权的人员更改或设置安全参数。安全系数修改后，相关的安全功能需要被分析。 Security parameters are set and changed by authorized personnel, using passwords or isolation measures to prevent unauthorized personnel from changing or setting security parameters. Once the factors of safety are modified, the relevant security functions need to be analyzed.
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	机器人在发生意外或者运行不正常等情况下，可以按下电源开关，停止机器人动作。 In case of an accident or abnormal operation of the robot, the robot can press the emergency stop switch to stop the robot action. Eblm/Arm 系列机器人二关节和三关节内安装有刹车，断电时保持机器人姿态，切勿人为频繁开断供电系统，建议每次开关机时间间隔应大于 10s。 Eblm/Arm series robot is equipped with brake in the joint module, keep the robot posture when the power is cut off, do not interrupt the power supply system frequently, it is recommended that each switch-on time interval should be more than 10s.
 高温危险! High TEMPERATURE DANGER!	1. 机器人本体和控制盒在运作的过程中会产生热量。机器人正在工作时或刚停止工作时，请不要操作或触摸机器人。 1. The robot body and the control box generate heat during operation. Please do not operate or touch the robot while it is working or when it has just stopped working. 2. 切断电源并等待一小时，机器人才可冷却下来。 2. Turn off the power and wait an hour before the robot cools down. 3. 切勿将手指伸到控制盒发热处。 3. Do not put your fingers in the heat of the control box.
 警告! WARNING!	1. 确保机器人的手臂和工具都正确并安全地安装到位。 1. Make sure the robot's arms and tools are properly and safely in place. 2. 确保机器人的手臂有足够的空间来自由活动。 2. Make sure the robot's arm has enough space to move freely. 3. 如果机器人已损坏，请勿使用。 3. If the robot is damaged, do not use it.

	4.不要将安全设备连接到正常的 I/O 接口上，只能使用安全型接口。 4.Do not connect a secure device to a normal I/O ports; use only secure ports. 5.确保进行正确的安装设置（例如机器人本体的安装角度，安全配置） 5.Make sure the correct setup settings are in place (for example, robot body mounting angle, security configuration) . 6.工具及障碍物不得有尖角或扭点。确保所有人的头和脸在机器人可触及的范围之外。 6.Tools and obstructions shall not have sharp corners or kinks. Make sure everyone's head and face are out of reach of the robot. 7.任何撞击将释放大量的动能，这些动能比高速和高有效负载的情况下的要高得多。 7. Any impact will release a large amount of kinetic energy, which is much higher than at high speeds and high payloads. 8.将不同的机械连接起来可能加重危险或引发新的危险。始终对整个安装进行全面的风险评估。始终都要阅读和理解安装中使用到的所有设备的手册。 8.Connecting different machines may aggravate the danger or create new dangers. Always conduct a comprehensive risk assessment of the entire installation. Always read and understand the manual for all devices used in the installation. 9.切勿改动机器人。对机器人的改动有可能造成集成商无法预测的危险。机器人授权重组需依照最新版的所有相关服务手册。如果机器人以任何方式被改变或改动，钛虎机器人科技（上海）有限公司拒绝承担一切责任。 9.Do not modify the robot. Changes to the robot may pose a risk that the integrator can not predict. Robot reconfiguration is authorized in accordance with the latest version of all relevant service manuals. Ti5robot Technology ShangHai Co.,Ltd. refuses
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	to accept any responsibility if the robot is altered or altered in any way. 10.在运输机器人之前，用户需要检查绝缘情况及保护措施。 10.Before transporting the robot, the user needs to check the insulation and protective measures. 11.搬运机器人时要遵守运输要求，小心搬运，避免磕碰 11.When carrying the robot to comply with the transport requirements, careful handling, to avoid collision
 CAUTION!	1. 当机器人与能够造成机器人损坏的机械连接在一起或在一起工作时，强烈推荐单独对机器人的所有功能以及机器人程序进行检查。 1. When a robot is connected to or working with a machine that can cause damage to the robot, it is highly recommended that all functions of the robot and the robot program be checked separately. 2. 钛虎机器人科技（上海）有限公司对由于程序出错或机器人的不当操作而对机器人造成的损坏或人员伤害概不承担责任。 2. Ti5robot Technology Shanghai Co.,Ltd.shall not be liable for any damage or personal injury caused to the robot due to a programming error or improper operation of the robot. 3. 不要将机器人一直暴露在永久性磁场。强磁场可损坏机器人。 3. Don't expose the robot to a permanent magnetic field. A strong magnetic field can damage a robot.

1.3.3 人员安全 Personnel Safety

在运行机器人系统时，首先必须要确保作业人员的安全，下面列出一般性的注意事项，请妥善采取确保作业人员安全的相应措施。

When running the robot system, you must first ensure the safety of operators. The general precautions are listed below. Please take appropriate measures to ensure the safety of operators.



1. 使用机器人系统的各作业人员请不要穿宽松的衣服，不要佩戴首饰。
。操作机器人时请确保长头发束在脑后。

1. All operators using the robot system shall not wear loose clothes or jewelry. When operating the robot, make sure long hair is tied behind your head.

2. 在设备运转之中，即使机器人看上去已经停止，也有可能是因为机器人在等待启动信号而处在即将动作的状态。即使在这样的状态下，也应该将机器人视为正在动作中。

2. In the process of equipment operation, even if the robot seems to have stopped, it may be that the robot is waiting for the start signal and is in a state of imminent action. Even in such a state, the robot should also be considered to be in motion.

3. 应在地板上画上线条来标清机器人的动作范围，使操作者了解机器人包含握持工具（机械手、工具等）的动作范围。

3. Draw lines on the floor to mark the motion range of the robot, so that the operator can understand the motion range of the robot including tools (robot hands, tools, etc.).

4. 确保在机器人操作区域附近建立安全措施（例如，护栏、绳索、或防护屏幕），保护操作者及周边人群。应根据需要设置锁具，使得负责操作的作业人员以外者不能接触机器人电源。

4. Ensure that safety measures (such as guardrails, ropes, or protective screens) are established near the robot operation area to protect the operator and the surrounding people. Locks shall be set as required to prevent anyone other than the operator in charge of the operation from contacting the power supply of the robot.

5. 在人被机器人夹住或围在里面等紧急和异常情况下，通过用力推动或拉动机器人手臂，迫使关节移动。无电力驱动情况下手动移动机器人手臂仅限于紧急情况，并且可能会损坏关节。

5. In emergency and abnormal situations such as people being trapped or surrounded by robots, push or pull the robot arm with force to force the joints to move. Moving the robot arm manually

	without electric drive is limited to emergency situations and may damage joints.
--	--

1.4 责任及规范 Responsibilities and Specifications

Eblm/Arm 系列机器人可以与其他设备组成完整的机器，其本身并不完整。因此本手册信息中并不包含如何全面的设计、安装和操作一个完整的机器人，也不包含所有对这一完整的系统的周边设备的安全造成影响的可能性。完整机器人安装的安全性取决于该机器人是如何集成的。集成商需要遵循所在国的法律法规及安全规范和标准对该完整系统的设计和安装进行风险评估。风险评估是集成商务必完成的最重要任务之一，集成商可参考以下标准执行风险评估流程。

Eblm/Arm series of robots with other devices can form a complete machine, itself is not complete. Therefore, the information in this manual does not cover how to fully design, Install, and operate a complete robot, nor does it cover all possibilities that may have an impact on the security of the peripheral equipment of such a complete system. The safety of a complete robot installation depends on how the robot is integrated. The integrator is required to conduct a risk assessment for the design and installation of the complete system in accordance with the laws, regulations and safety norms and standards of the host country. Risk assessment is one of the most important tasks that the integrator must perform. The Integrator can refer to the following criteria to perform the risk assessment process.

- ◆ ISO 12100:2010 机械安全-设计通则-风险评估与风险降低。
ISO 12100:2010 Safety of Machinery - General Principles for Design - Risk Assessment and Risk Reduction.
- ◆ ISO 10218-2:2011 机器人与机器人设备-安全要求-第2部分：工业机器人系统与集成。
ISO 10218-2:2011 Robots and robotic equipment - Safety requirements - Part 2: Industrial robot systems and integration.
- ◆ RIA TR R15.306-2014 工业机器人与机器人系统的技术报告-安全要求、任务型风险评估方法。
RIA TR R15.306-2014 Technical Report on Industrial Robots and Robotic Systems - Safety Requirements, Task based Risk Assessment Methods.
- ◆ ANSI B11.0-2010 机械安全；一般要求与风险评估。
ANSI B11.0-2010 Mechanical Safety; General requirements and risk assessment.
- ◆ Eblm/Arm 机器人的集成商需要履行但不限于以下责任：

The integrator of Eblm/Arm robot shall perform but not limited to the following responsibilities:

- ◆ 对完整的机器人系统做全面的风险评估；
Conduct a comprehensive risk assessment of the complete robot system;
- ◆ 确认整个系统的设计安装准确无误；
Confirm that the design and installation of the whole system are correct;
- ◆ 向用户及工作人员提供培训；
Provide training to users and staff;
- ◆ 创建完整系统的操作规范，明确使用流程说明；
Create a complete system operation specification and specify the use process description;
- ◆ 建立适当的安全措施；
Establish appropriate security measures;
- ◆ 将剩余风险传达给最终用户；
Communicate the residual risk to the end user;
- ◆ 在机器人上标示集成商的标志和联系信息；
Mark the logo and contact information of the integrator on the robot;
- ◆ 存档相关技术文件。
Archive relevant technical documents.

该手册所包含的所有安全方面的信息均不得视为钛虎机器人科技（上海）有限公司的保证，即使遵守所有的安全指示，操作人员造成的人员伤害或设备损坏依然有可能发生。

钛虎机器人科技（上海）有限公司致力于不断提高产品的可靠性和性能，并因此保留升级产品的权利，恕不另行通知。钛虎机器人科技（上海）有限公司力求确保本手册内容的准确性和可靠性，但不对其中的任何错误或遗漏信息负责。

All the safety information contained in this manual shall not be regarded as the guarantee of Ti5robot Technology ShangHai Co.,Ltd. Even if all safety instructions are followed, personal injury or equipment damage caused by operators may still occur.

Ti5robot Technology (Shanghai) Co., Ltd. is committed to continuously improving the reliability and performance of products, and therefore reserves the right to upgrade products without notice. Ti5robot Technology ShangHai Co.,Ltd. strives to ensure the accuracy and reliability of the contents of this manual, but is not responsible for any errors

or omissions.

1.5 危险识别 Hazard Identification

风险评估应考虑正常使用期间操作人员与机器人之间所有潜在的接触以及可预见的误操作。操作人员的颈部、脸部和头部不应暴露，以免发生碰触。在不使用外围安全防护装置的情况下使用机器人需要首先进行风险评估，以判断相关危险是否会构成不可接受的风险。

The risk assessment should take into account all potential contacts between the operator and the robot during normal use, as well as foreseeable misoperation. The neck, face and head of the operator should not be exposed to avoid contact. The use of a robot without the use of an external security device requires a risk assessment to determine whether the associated hazard poses an unacceptable risk.

例如：

For example:

- ◆ 使用尖锐的末端执行器或工具连接器可能存在危险；
Possible hazards of using sharp end actuators or tool connectors;
- ◆ 处理毒性或其他有害物质可能存在危险；
Possible hazards of handling toxic or other hazardous substances;
- ◆ 操作人员手指有被机器人底座或关节夹住的危险；
Risk of operator fingers being caught in robot bases or joints;
- ◆ 被机器人碰撞发生的危险；
The risk of collision by a robot;
- ◆ 机器人或连接到末端的工具固定不到位存在的危险；
The risk of a robot or a tool attached to the end not being in place;
- ◆ 机器人有效负载与坚固表面之间的冲击造成的危险。
The risk of an impact between a robot's payload and a solid surface.

集成商必须通过风险评估来衡量此类危险及其相关的风险等级，并且确定和实施相应的措施，以将风险降低至可接受的水平。请注意，特定机器人设备可能还存在其他重大危险。

通过将 Eblm/Arm 机器人所应用的固有安全设计措施与集成商和最终用户所实施的安全规范或风险评估相结合，将与 Eblm/Arm系列机器人协作性操作相关的风险尽可能降低至合理可行的水平。通过此文档可将机器人在安装前存在的任何剩余风险传达给集成商和最终用户。如果集成商的风险评估测定其特定应用中存在可能对用户构成不可接受风险的危险，集成商必须采取适当的风险降低措施，以消除或最大限度降低这些危险，直至将风险降低至可接受的水平为止。在采取适当的风险降低措施（如有需要）之前使用是不安全的。

如果对机器人进行非协同性安装（例如，当使用危险工具时），风险评估可能推断集成商需要在其编程时连接额外的安全设备（例如，安全启动设备）确保人员及设备安全。

The integrator must measure such hazards and their related risk levels through risk assessment, and determine and implement corresponding measures to reduce risks to an acceptable level. Please note that there may be other significant hazards associated with specific robotic equipment.

By combining the inherent safety design measures applied by the Eblm/Arm robot with the safety specifications or risk assessments implemented by the integrators and end users, the risks associated with the cooperative operation of the Eblm/Arm series robots are reduced to a reasonable and feasible level as far as possible. This document can be used to communicate any remaining risks of the robot before installation to the integrators and end users. If the risk assessment of the integrator determines that there are risks in its specific application that may pose unacceptable risks to users, the integrator must take appropriate risk reduction measures to eliminate or minimize these risks until the risk is reduced to an acceptable level. It is not safe to use it before taking appropriate risk reduction measures (if necessary).

If the robot is installed non cooperatively (for example, when using dangerous tools), the risk assessment may infer that the integrator needs to connect additional safety equipment (for example, safe starting equipment) to ensure the safety of personnel and equipment when programming.

1.6 预定用途 Intended Use

Eblm/Arm 机器人只限于一般工业设备使用，如用作操作或固定工具、设备，加工或传递零件、产品。Eblm/Arm 机器人仅允许在规定的条件下使用。

Eblm/Arm 机器人具有特殊的安全等级特性，可进行协作性操作，即在不设置外围安全防护装

置的情况使用，但仅限于经过风险评估无危险的情况，即在不使用任何安全防护装置和现场感应装置的前提下，工作人员与 Eblm/Arm 机器人或其末端执行器或部件之间的预期或意外接触不会构成不可接受的风险，与工作区内其他物体（工具、设备、表面等）的预期或意外接触也不会构成不可接受的风险。

机器人控制器以及机器人只限于一般工业设备使用，不可用于与预定用途违背的应用，禁止用途包括但不限于以下情况：

Eblm/Arm robot is only used for general industrial equipment, such as operating or fixing tools, equipment, processing or transferring parts and products. The Eblm/Arm robot is only allowed to be used under the specified environmental conditions.

Eblm/Arm robot has special safety level characteristics and can be operated cooperatively, that is, it can be used without peripheral safety protection devices, but only when there is no danger after risk assessment, that is, on the premise of not using any safety protection devices and on-site induction devices, expected or accidental contact between workers and Eblm/Arm robot or its end effectors or components will not constitute an unacceptable risk, Anticipated or accidental contact with other objects (tools, equipment, surfaces, etc.) in the work area will not constitute an unacceptable risk.

The robot controller and robot are only used for general industrial equipment and shall not be used for applications contrary to the intended purpose. The prohibited purposes include but are not limited to the following:

◆ 用于易燃易爆等危险环境中；

It is used in flammable, explosive and other dangerous environments;

◆ 用于移动或搬运人或其他动物的装置；

Devices for moving or carrying people or other animals;

◆ 用于涉及人命的医疗设备等装置；

Devices used for medical equipment involving human life;

◆ 用于对社会性及公共性有重大影响的装置；

Devices that have a significant impact on the social and public;

- ◆ 用于车载、船舶等受到振动环境；

It is used in vibration environment such as vehicle and ship;

- ◆ 用于攀爬工具使用。

Used for climbing tools.

二、产品介绍 Product Introduction

2.1 产品概述 Product Overview

机器人本体是用于完成机器人系统各种作业任务的机械主体，主要包括机器人外壳、驱动装置、传动单元以及内部传感器等部分。

The robot body is a mechanical body used to complete various tasks of the robot system, mainly including the robot shell, driving device, transmission unit and internal sensors.

同传统工业机器人粗重且多芯的线缆相比，由于Eblm/Arm系列的驱动装置、制动器等都集成到本体中，大大减少了从本体连接到控制器的线缆芯数，也提高了线缆传递数据的稳定性和抗干扰能力，同时降低了该项成本。

Compared with the heavy and multi-core cables of traditional industrial robots, the drive device and brake of Eblm/Arm series are integrated into the body, which greatly reduces the number of cable cores connected from the body to the controller, improves the stability and anti-interference ability of cable data transmission, and reduces the cost of this item.

本体外壳的主要材料为铝合金。机器人的运动原理是六个关节的旋转运动组合，利用运动学和动力学分析，求解算法，完成机器人末端的期望运动。

The main material of the body shell is aluminum alloy. The motion principle of the robot is the rotary motion combination of six joints. Kinematics and dynamics analysis are used to solve the algorithm to complete the desired motion of the robot end.

Eblm/Arm系列具有部署时间短、易于操作，使用安全以及方便扩展周边设备等优势，可以极大的缩短工厂对于自动化项目改造的部署时间，降低部署的总成本。具体优点如下：

Eblm/Arm series has the advantages of short deployment time, easy operation, safe use and convenient expansion of peripheral equipment, which can greatly shorten the deployment time of the factory for automation project transformation and reduce the total cost of deployment. Specific advantages are as follows:

◆ 快速部署

为了缩短自动化产线改造成本与部署时间，不同于传统的机器人对整条自动化产线改造的部署方式，钛虎机器人的产品主要面向独立工位的升级与改造。客户或系统集成商可以自主选择已适配好的末端执行器、雷达或摄像头，与机器人配合使用。

◆ Rapid Deployment

In order to shorten the transformation cost and deployment time of the automatic production line, unlike the traditional robot deployment mode for the transformation of the entire automatic production line, the products of the Ti5 robot are mainly oriented to the upgrading and transformation of independent stations. Customers or system integrators can independently select the adapted end actuators, radars or cameras for use with robots.

◆ 简单操作

Eblm/Arm机器人以及解决方案可以帮助客户尽快尽早设计一个独立的工作站，安装末端执行系统、机座、摄像头以及其他配套设备。并且，拖动示教功能可以帮助用户缩短示教时间，简化调试步骤。

◆ Simple Operation

Eblm/Arm robots and solutions can help customers to design an independent workstation as soon as possible, and install the terminal execution system, stand, camera and other supporting equipment. In addition, dragging the teaching function can help users shorten the teaching time and simplify the debugging steps.

2.2 产品组成 Product Composition

如图 2-1 所示，Eblm/Arm系列中，每一个机器人系统包括两个主要 组成部分:机器人本体，控制盒。

As shown in Figure 2-1, each robot system in Eblm/Arm series includes two main components: robot body and control box.



1-机器人本体

1 - Robot body



2-控制盒

2 - Control box

图 2- 1 机器人系统

Figure 2-1 Robot System

一套完整的Eblm/Arm机器人系统产品组成如下表所示。

A complete set of Eblm/Arm robot system product components are shown in the table below.

表2-1 产品组成 Product composition

名 称 Name	数 量quantity
机器人本体 Robot body	1
控制器 controller	1
控制器连接线 Controller connecting line	1
控制盒 Control box	1
机器人本体连接电线 Connecting cable of robot body	1
电源连接线 Power connection cable	1
底座（选配） Base (optional)	1

Ti5 Robot Eblm-1是一款负载为1kg,活动范围380mm的机器人。

Ti5 Robot Eblm-1 is a robot with a load of 1kg and a range of motion of 380mm.

Ti5 Robot Eblm-2是一款负载为2kg,活动范围520mm的机器人。

Ti5 Robot Eblm-2 is a robot with a load of 2kg and a range of motion of 520mm.

Ti5 Robot Arm-3是一款负载为3kg,活动范围600mm的机器人。

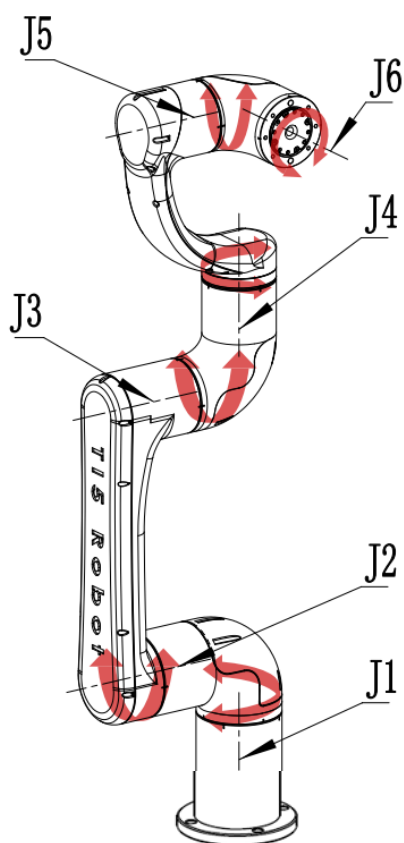
Ti5 Robot Arm-3 is a robot with a load of 3kg and a range of motion of 600mm.

Ti5 Robot Arm-5是一款负载为5kg,活动范围900mm的机器人。

Ti5 Robot Arm-5 is a robot with a load of 5kg and a range of motion of 900mm.

机器人本体示意图如图 2-2所示。

The schematic diagram of the robot body is shown in Figure 2-2.



Arm系列的机械本体可看作是一个开链式多连杆机构，始端连杆就是机器人的基座，末端连杆与末端执行器相连，相邻连杆之间用一个关节连接在一起。Arm系列机器人是一个6自由度工业机器人，它由6个杆和6个关节组成。编号时，基座称为杆0，不包含在这6个杆内，杆1与基座由关节1相连，杆2通过关节2与杆1相连，依此类推。

The mechanical body of Arm series can be seen as an open chain multi link mechanism. The starting link is the base of the robot, the end link is connected with the end actuator, and adjacent links are connected with a joint. Arm series robot is a 6-DOF industrial robot, which is composed of 6 rods and 6 joints. When numbering, the base is called rod 0, which is not included in the six rods. Rod 1 is connected to the base by joint 1, rod 2 is connected to rod 1 by joint 2, and so on.

图 2- 2 机器人本体示意图 Schematic diagram of robot body

末端法兰盘可用于连接末端执行器，例如电动夹爪或气动吸盘等末端执行器。

The end flange can be used to connect end actuators, such as electric grippers or pneumatic suction cups.

2.3 型号 Model

Eblm/Arm系列中共有四款机器人，分别是Ti5 Robot Eblm-1和Ti5 Robot Eblm-2和Ti5 Robot Arm-3和Ti5 Robot Arm-5，其型号名称解析如表 2-2 所示。

There are four type robots in the Eblm/Arm series, namely Ti5 Robot Eblm-1, Ti5 Robot Eblm-2, Ti5 Robot Arm-3 and Ti5 Robot Arm-5. The model name resolution is shown in Table 2-2.

表 2- 2 型号说明表 Model Description Table

Eblm/Arm	1/2/3/5
系列名称 Series Name	负载能力 Load capacity 1kg/2kg/3kg/5kg

2.4 工作范围 Operating Range

Ti5 Robot Eblm-1、Eblm-2、Arm-3和Arm-5 机器人的工作空间如图 2-3~6所示。机器人有效工作范围分别为 380mm、520mm、600mm和900mm。请在使用机器人前根据机器人的运动范围限制测量实际的范围，以免造成臂长不够或碰撞的后果。选择机器人安装位置时，务必考虑机器人正上方和正下方的圆柱体空间。尽可能避免将工具移向圆柱体空间，因为这样会造成工具慢速运动时关节却运动过快，从而导致机器人工作效率低下，风险评估难以进行。

The workspaces of the Ti5 Robot Eblm-1, Eblm-2, Arm-3 and Arm-5 robots are shown in figure 2-3~6. The effective working range of the robot is 380mm, 600mm and 900mm respectively. Please limit the actual range of measurement according to the range of motion of the robot before using the robot, so as to avoid the consequences of insufficient arm length or collision. When choosing the position of robot installation, it is important to consider the space of cylinder directly above and directly below the robot. Avoid moving the tool into cylindrical space as much as possible, as this can cause the joint to move too fast when the tool is moving slowly, making the robot inefficient and difficult to assess risk.

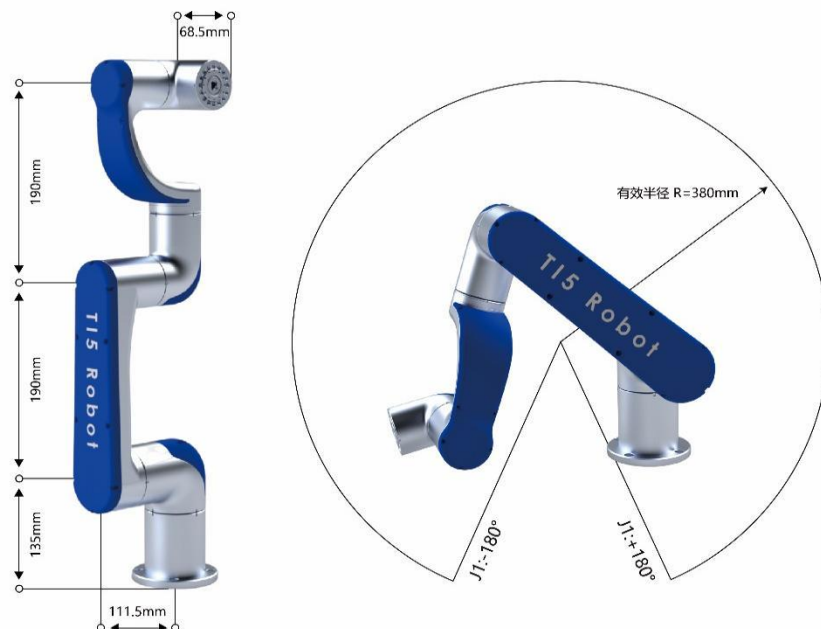
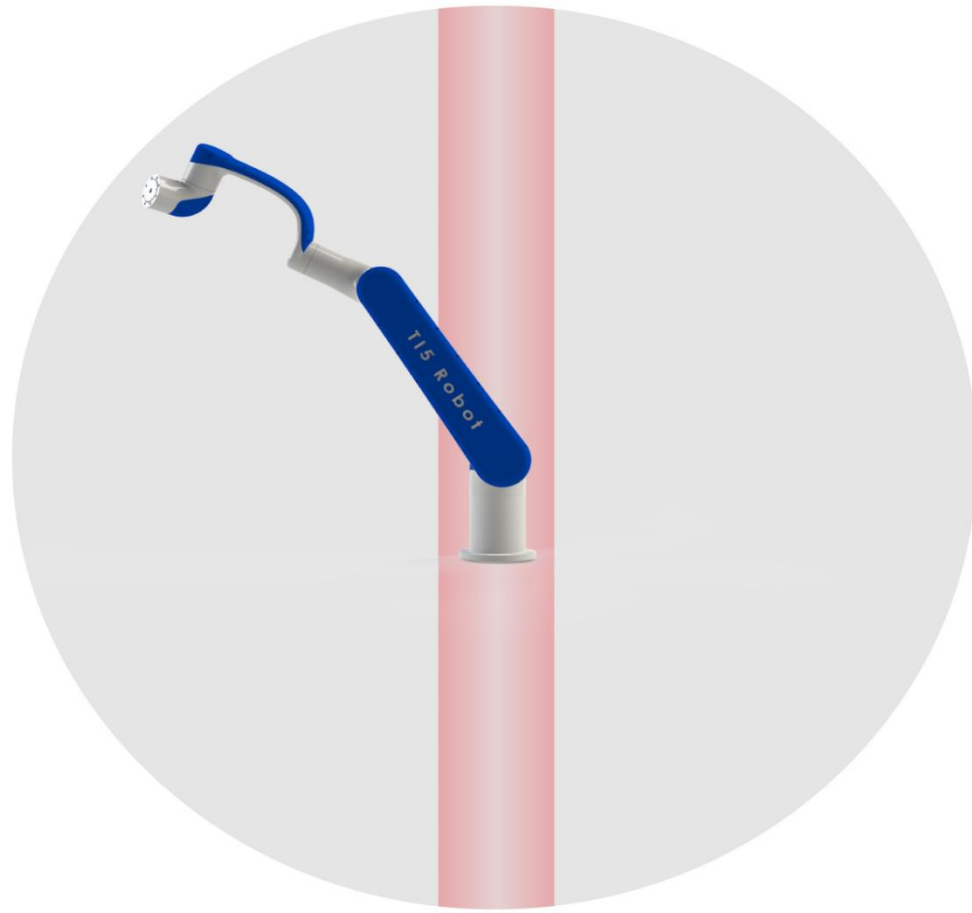


图 2- 3 Ti5 Robot Eblm-1工作空间示意图

Schematic Diagram of Ti5 Robot Eblm-1 Workspace

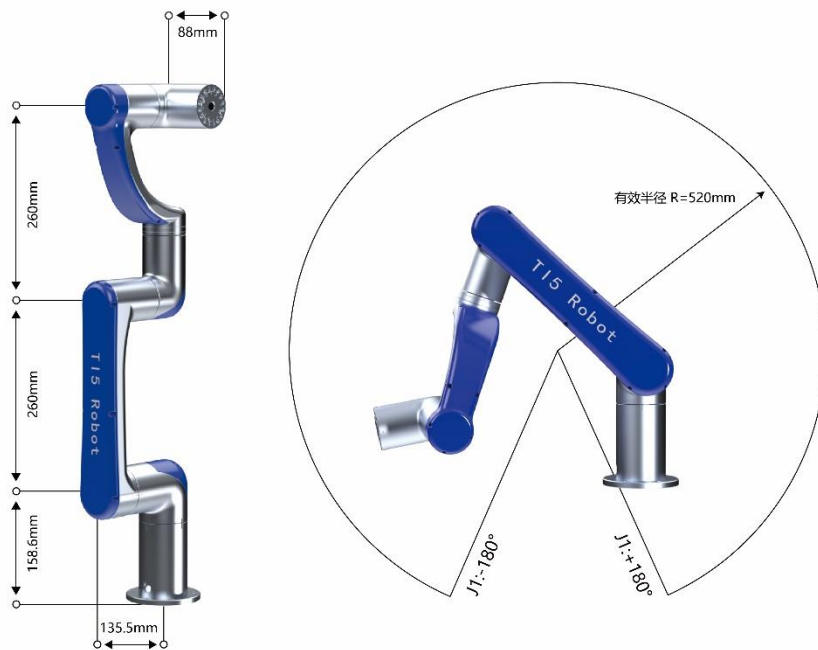


图 2- 4 Eblm-2工作空间示意图

Schematic Diagram of Eblm-2 Workspace

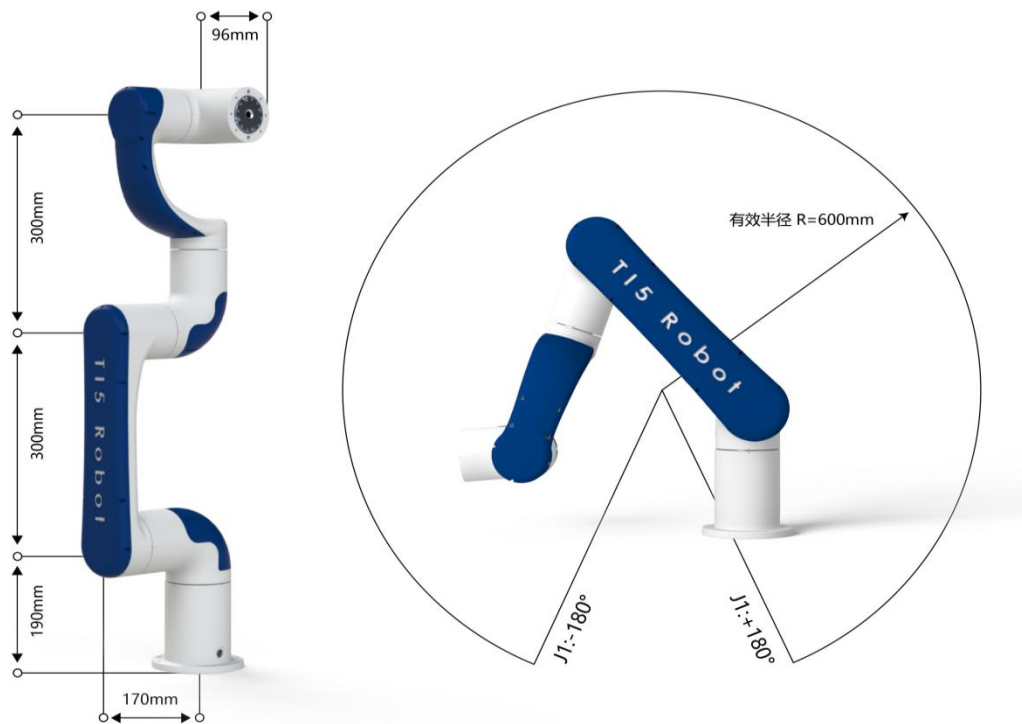


图 2- 5 Arm-3工作空间示意图

Schematic Diagram of Arm-3 Workspace

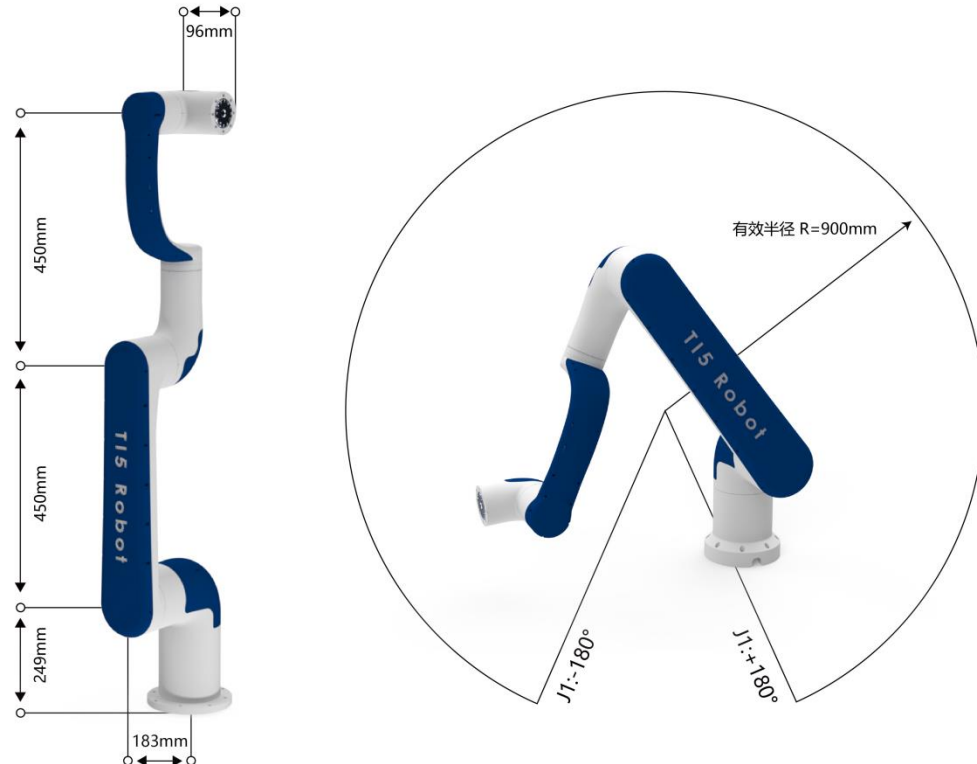


图 2- 6 Arm-5工作空间示意图

Schematic Diagram of Arm-5 Workspace

2.5 有效负载 Payload

Ti5 Robot Eblm-1机器人的额定负载为1kg ,可以在1kg及以下负载情况下正常工作。

The rated load of Ti5 Robot Eblm-1 robot is 1kg, and it can work normally under the load of 1kg or less.

Eblm-2机器人的额定负载为2kg ,可以在2kg及以下负载情况下正常工作。

The rated load of Eblm-2 robot is 2kg, and it can work normally under the load of 2kg or less.

Arm-3机器人的额定负载为3kg ,可以在3kg及以下负载情况下正常工作。

The rated load of the Arm-3 robot is 3kg, and it can work normally with a load of 3kg or less.

Arm-5机器人的额定负载为5kg ,可以在5kg及以下负载情况下正常工作。

The rated load of Arm-5 robot is 5kg, and it can work normally under the load of 5kg or less.

随着负载与J6法兰盘位置的距离越来越远，其有效负载也会越来越小。

As the distance between the load and J6 flange position gets farther and farther, its payload will become smaller and smaller.

2.6 技术参数表 Technical Parameters

Eblm/Arm系列的各项规格参数如表2-3所示。

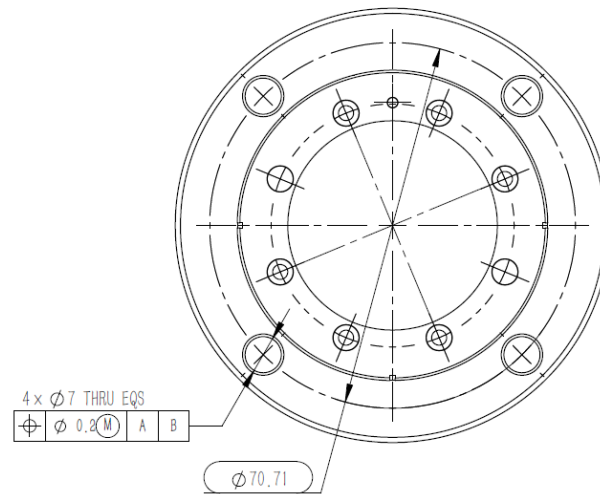
The specifications and parameters of Eblm/Arm series are shown in Table 2-3.

名称 Name	Ti5 Robot Eblm-1	Ti5 Robot Eblm-2	Ti5 Robot Arm-3	Ti5 Robot Arm-5
重量 Weight	2.6kg	4.5kg	9.7kg	18kg
有效负载 Payload	1kg	2kg	3kg	5kg
工作半径 Working Radius	380mm	520mm	600mm	900mm
自由度 Freedom	6			
重复定位精度 Repetitive Positioning Accuracy	±0.05mm	±0.05mm	±0.05mm	±0.05mm
功耗 Power Waste	50W	100W	200W	500W
推荐电源盒子 Supply Power Box	150W	300W	750W	1500W
接口与开放性 Interface and Openness	ROS、PYTHON、C++			
电机参数 Motor Parameters	中空谐波机器人一体化关节 Hollow harmonic robot integrated joint			
电源 Power Supply	28V-48V			
关节范围 Joint Range	J1 ±180° J2 ±90° J3 ±135° J4 ±180° J5 ±150° J6 ±180°			
材料 Material	铝合金、树脂 Aluminum alloy, resin			
工作环境	0-50℃			

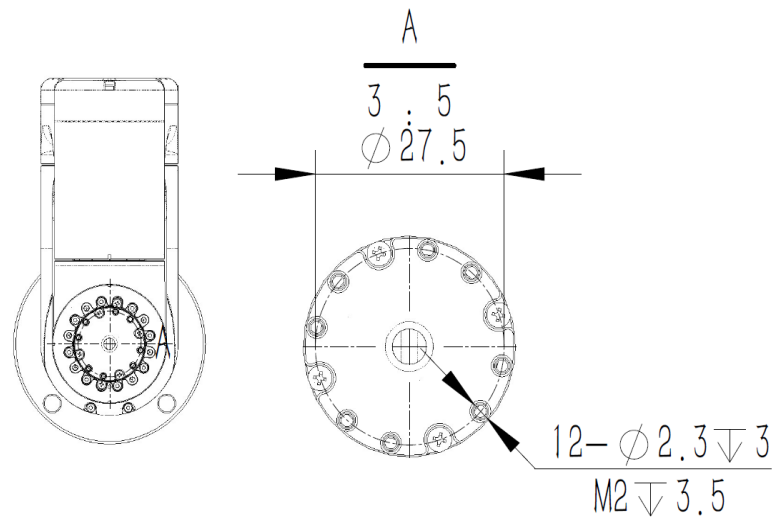
Work Environment	
供电 Power Supply	DC 48V, 5A; DC 28V 5A
USB	USB3.0*4
HDMI	HDMI2.0*1
IO接口 IO Interface	SPI/I2C/GPIO/UART
关节最大速度 Maximum Joint Speed	J1/J2/J3 : 35.6°/sec J4/J5/J6 : 35.6°/sec
底座安装面积 Base Installation Area	150mm×150mm
IP 等级 IP Rating	IP50
噪声 Noise	<70dB
机器人安装方式 Robot Installation Mode	任意角度 Any angle
工作环境湿度 Working Environment Humidity	5%-95%

2.7 末端关节和底座安装孔位图 End Joint & Base Installation Hole Diagram

Ti5 Robot Eblm-1:

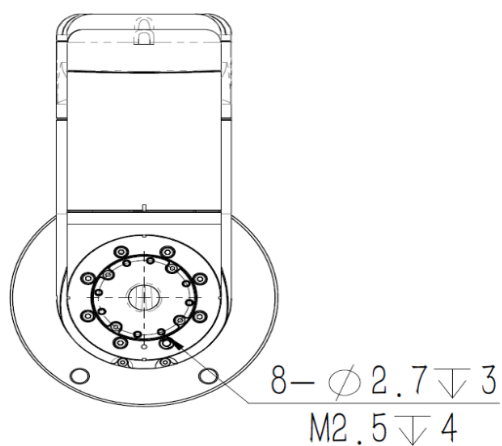


底座 Base J1

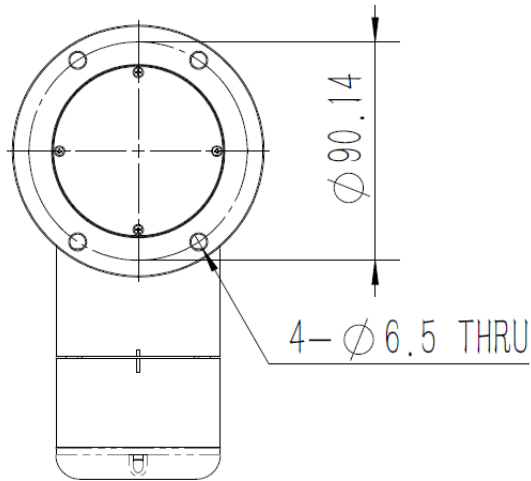


末端关节 End Joint J6

Ti5 Robot Eblm-2:

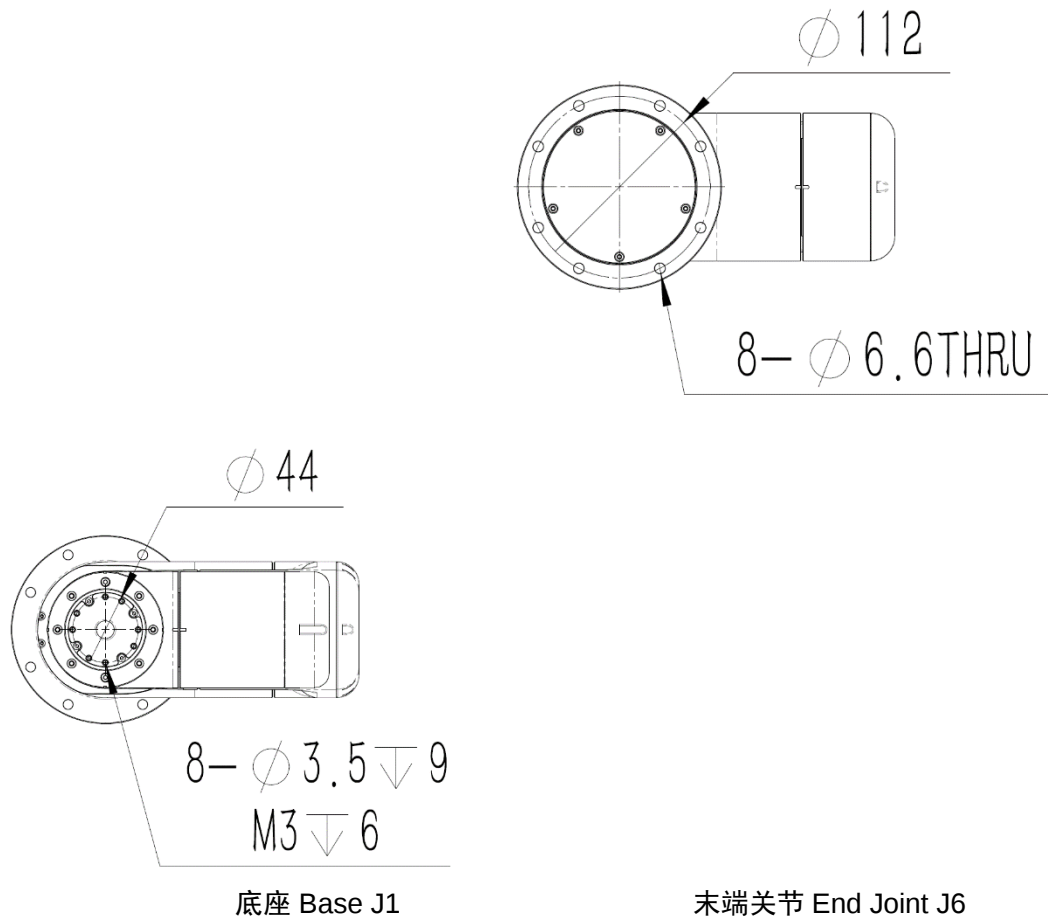


底座 Base J1

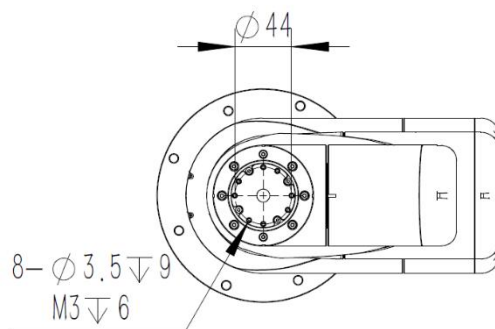


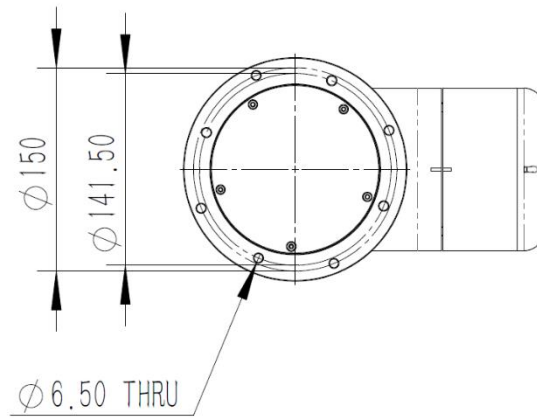
末端关节 End Joint J6

Ti5 Robot Arm-3:



Ti5 Robot Arm-5:



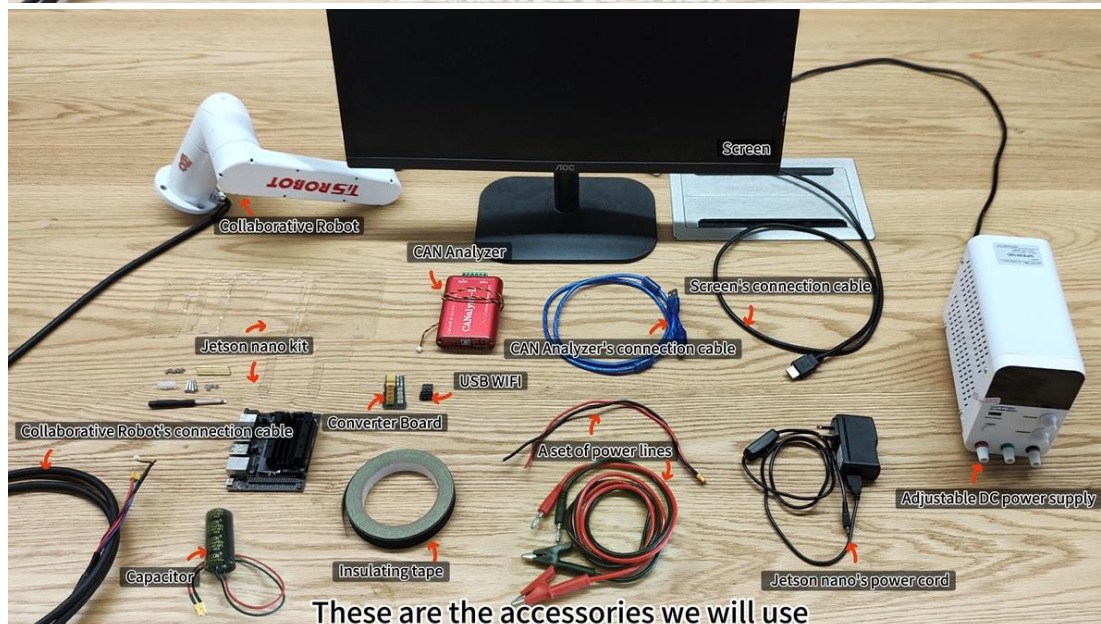


2.8 开机指南 Boot Guide

2.8.1 连线操作 connect operation

具体操作可见连线视频，连线时请不要带电插拔，请先将所有连线工作完成后再插电源。
下面简要介绍如何快速连线。

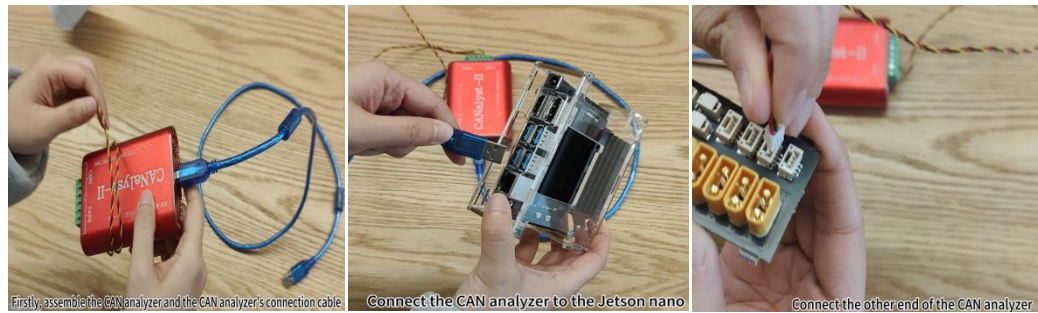
The specific operations can be seen in the connecting video. When connecting, please refrain from plugging or unplugging while the power is on. Please complete all connection work first before plugging in the power supply. Here's a brief introduction on how to quickly make connections.



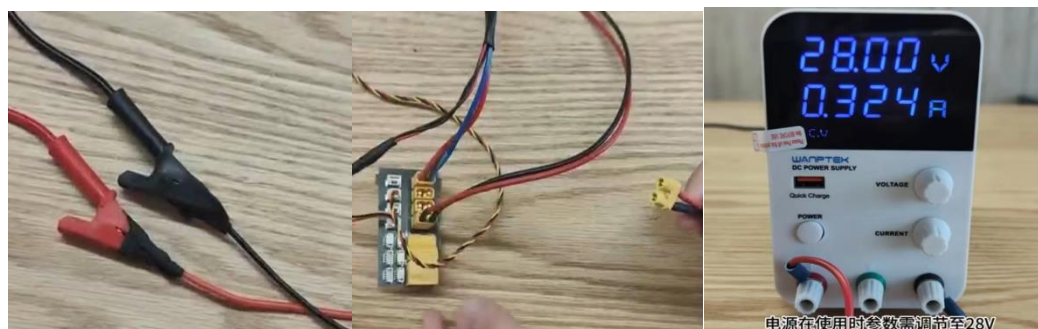
CAN分析仪



CAN analyzer



可调电源



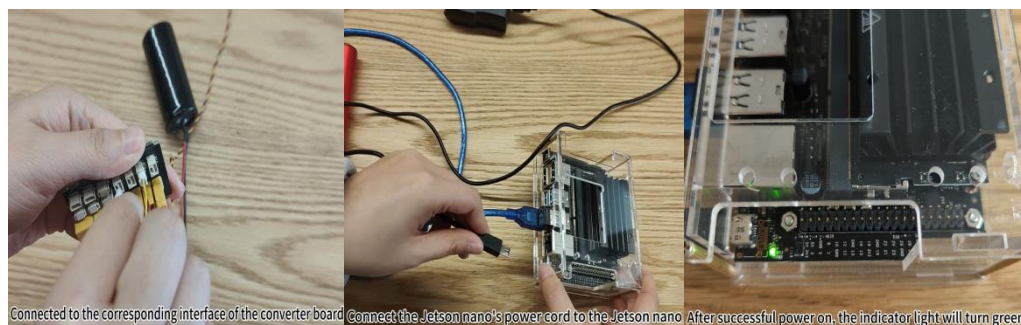
Adjustable power supply



机械臂和Jetson Nano



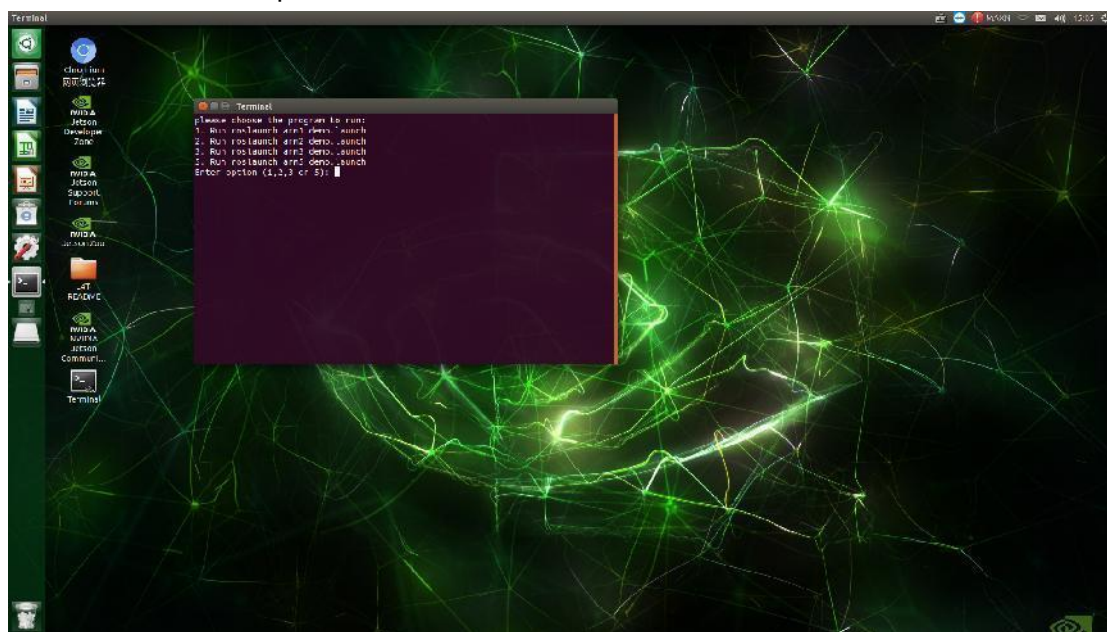
Robotic Eblm/Arm and Jetson Nano



连线工作完成后，将微型电脑插电，启动可调电源，电源在使用时参数调节到28-48V。连接显示器输入密码（dongguan）。

After completing the connections, plug in the microcomputer and start the adjustable power supply, setting the power parameters to 28-48V during use. Upon connecting the display and entering the password (dongguan).

2.8.2 开机自启 boot-up auto-start



当 jetson nano 开机后便会出现此页面，该页面为钛虎方提供的开机自启功能，用户第一次使用机械臂时可通过该功能来快速让机械臂动起来并且运动时可观察机械臂状态。

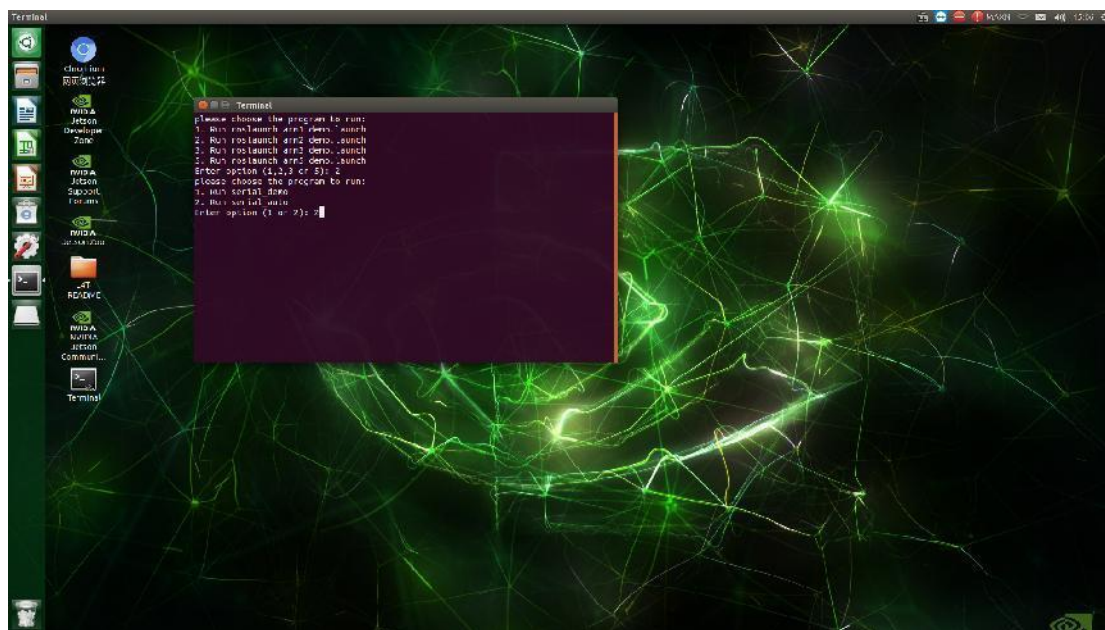
After the Jetson Nano boots up, you will encounter this page, which is the boot self-start function provided by Ti5robot. Users can quickly get the robotic arm moving and observe its status during operation for the first time using this feature.

第一次使用的用户推荐体验该功能。

For first-time users, we recommend experiencing this feature to quickly initiate the robotic arm's motion and observe its status during operation.

终端中会出现如图所示的提示信息，若用户使用的机械臂是负载为 1KG 的，则输入 1，若为 2KG 的，则输入 2，若为 3KG 的，则输入 3，若为 5KG 的，则输入 5。该选项是为了确定机械臂的具体模型，然后在 RVIZ 中显示出来，输入完成后，会出现如下界面

The terminal will display a prompt message as shown in the figure. If the user's robotic arm has a payload of 1KG, they should input 1; for a 2KG payload, input 2; for a 3KG payload, input 3; and for a 5KG payload, input 5. This option is to determine the specific model of the robotic arm and display it in RVIZ. After inputting the value, the following interface will appear.



初次使用推荐输入 2

For first-time usage, we recommend inputting '2'.

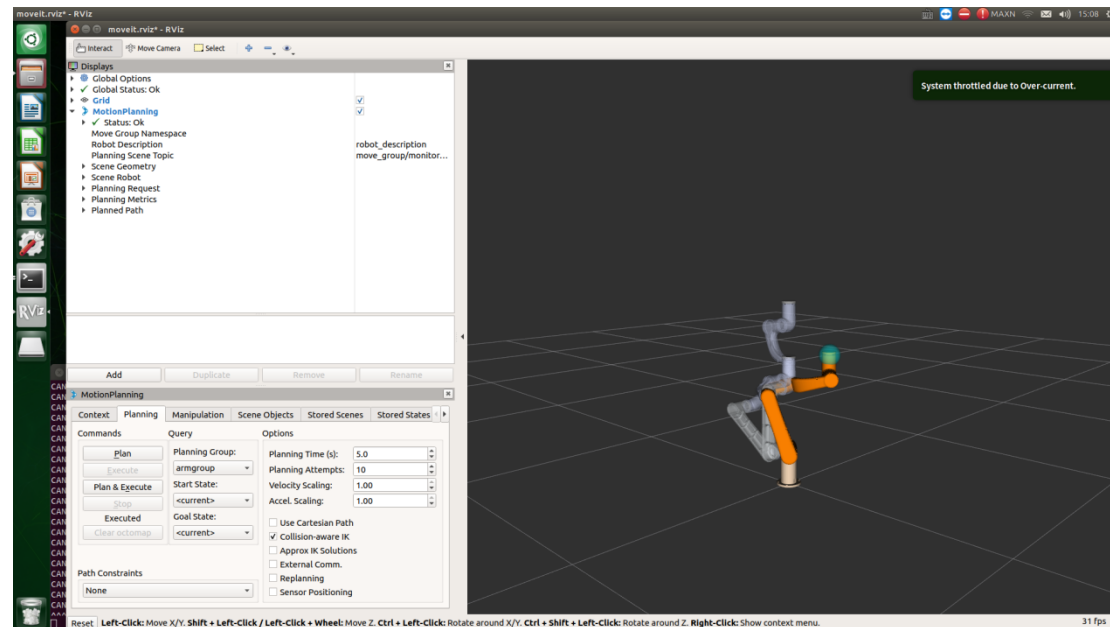
此选项若输入 1，则会先打开 Rviz，然后执行 serial_demo 程序，该程序实现的功能是与机械臂进行通信，可以在打开的 Rviz 中拖动末端的球和箭头来拖拽到其他地方，并点击左下角的 plan&Execute 来让实际的机械臂移动到指定位置。

If '1' is input for this option, Rviz will first open, followed by the execution of the 'serial_demo' program. This program facilitates communication with the robotic arm. Users can manipulate the end-effector's ball and arrow in the opened Rviz to drag them to other locations. Then, they can click on the 'Plan & Execute' button located in the bottom left corner to command the actual robotic arm to move to the specified position.

此选项若输入 2，同样会打开 Rviz，不过会执行 serial_auto 程序，在该程序中，机械臂会自动运行一段已经写好的轨迹，运动时用户可以观察机械臂运行状态，机械臂运动时需要确保底座已经固定并且周围没有障碍物，以免造成人员或财产损失。当机械臂运动停止以后，可以在打开的 Rviz 中拖动末端的球和箭头来拖拽到其他位置，并点击左下角的 plan&Execute 来让实际的机械臂移动到所指定的位置。

If '2' is input for this option, Rviz will also open, but the 'serial_auto' program will be executed. In this program, the robotic arm will automatically run a pre-defined trajectory. While the arm is in motion, users can observe its operational status. It is essential to ensure that the base of the robotic arm is securely fixed and there are no obstacles in the vicinity to prevent any potential harm to individuals or property. After the robotic arm stops moving,

users can drag the end-effector's ball and arrow to other positions in the opened Rviz and then click on the 'Plan & Execute' button in the bottom left corner to command the actual robotic arm to move to the specified location."



2.8.3 手动启动 manual start

打开第一个终端，输入：

```
roslaunch arm1 demo.launch
```

（以下仅以 1 公斤机械臂 Eblm-1 为例，如果是 Arm-3，则输入：roslaunch arm3 demo.launch）

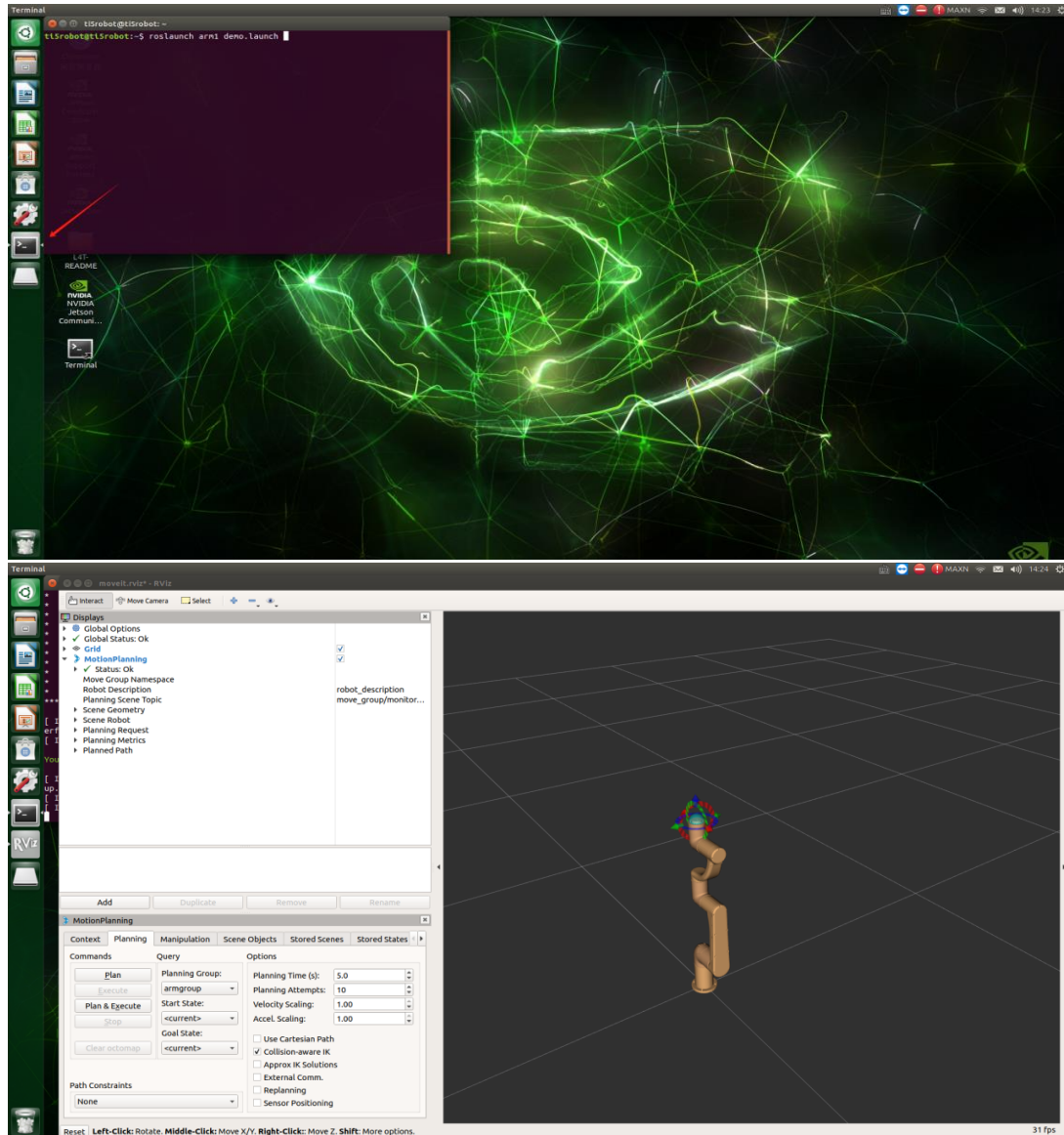
Open the first terminal and enter:

```
roslaunch arm1 demo.launch
```

(Using only Eblm-1 as an example, if it is Arm-3, enter: roslaunch arm3 demo. launch)

该命令是用于启动 arm1 软件包中的 demo.launch。运行该命令之后会启动一个 RViz 窗口，其中显示了机械臂模型和控制界面。

This command is used to start demo. launch in the arm1 software package. After running this command, an RViz window will be launched, displaying the robotic arm model and control interface.



再打开第二个终端，输入：
`sudo chmod -R 777 /dev/`

若输入：`roslaunch serial_demo serial_demo`

该命令实现启动机械臂并将机械臂回到零位，零位即机械臂相邻关节之间的矩形缺口位置对齐,同时与机械臂进行通信以便传输数据。

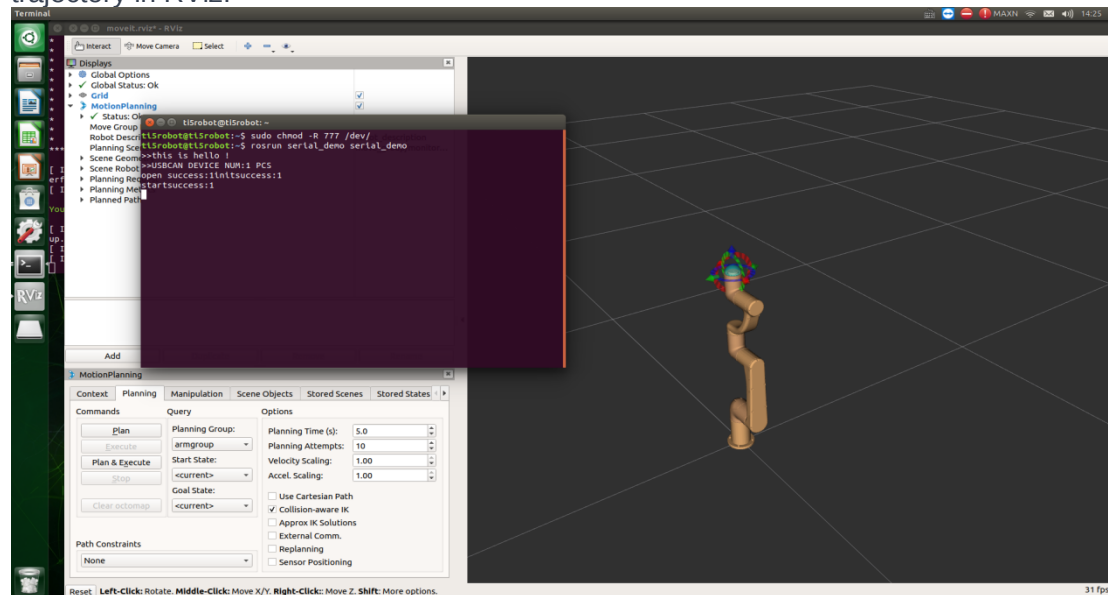
在 RViz 中可以通过拖动机械臂末端的球上的箭头来选择一个合适的位置，然后点击左下方的 plan&execute 来让机械臂到达 RViz 中的位置，同时可以在 RViz 中观察到机械臂的移动轨迹。

Open a second terminal and enter the command:
`sudo chmod -R 777 /dev/`

If, input: `roslaunch serial_demo serial_demo`

The command initiates the startup of the robotic arm, brings it back to the zero position, which is where the rectangular notches between adjacent joints of the robotic arm align. Simultaneously, it establishes communication with the robotic arm for data transmission.

In RViz, you can select an appropriate position by dragging the arrow on the sphere at the end of the robotic arm. Then, click on 'plan&execute' at the bottom left to make the robotic arm reach the selected position in RViz. Additionally, you can observe the arm's movement trajectory in RViz.



若输入:

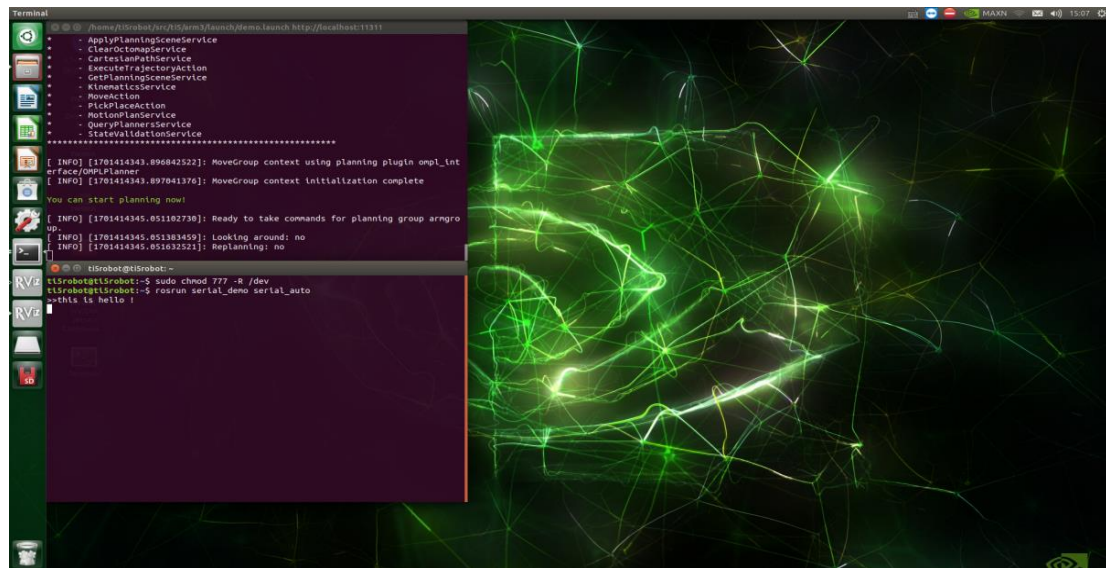
```
roslaunch serial_demo serial_demo
```

该命令为自动运行一个机械臂运动的实例程序，可以通过该程序观察机械臂运动时的各个关节状况。该命令和上面命令的区别为上条命令没有示例程序，该命令可运行示例程序来让机械臂运动。两种方式根据需求进行二选一即可。请确保已固定好机械臂底座并保持机械臂周围没有障碍物，以免造成人员或者财产损失。

If input:

```
roslaunch serial_demo serial_demo
```

The command runs an instance program that automates the movement of the robotic arm. Users can observe the condition of each joint of the robotic arm while it is in motion through this program. The difference between this command and the previous one is that the previous command does not include a sample program, while this command can run a sample program to make the robotic arm move. You can choose either method based on your requirements. Please ensure that the robotic arm's base is securely fixed and there are no obstacles around it to prevent any potential harm to individuals or property.



打开第三个终端，输入：

```
python ~/move_a_b_round.py
```

该命令为运行~目录下的 move_a_b_round.py 的 python 程序。该程序可以实现机械臂从一个位置移动到另一个位置。

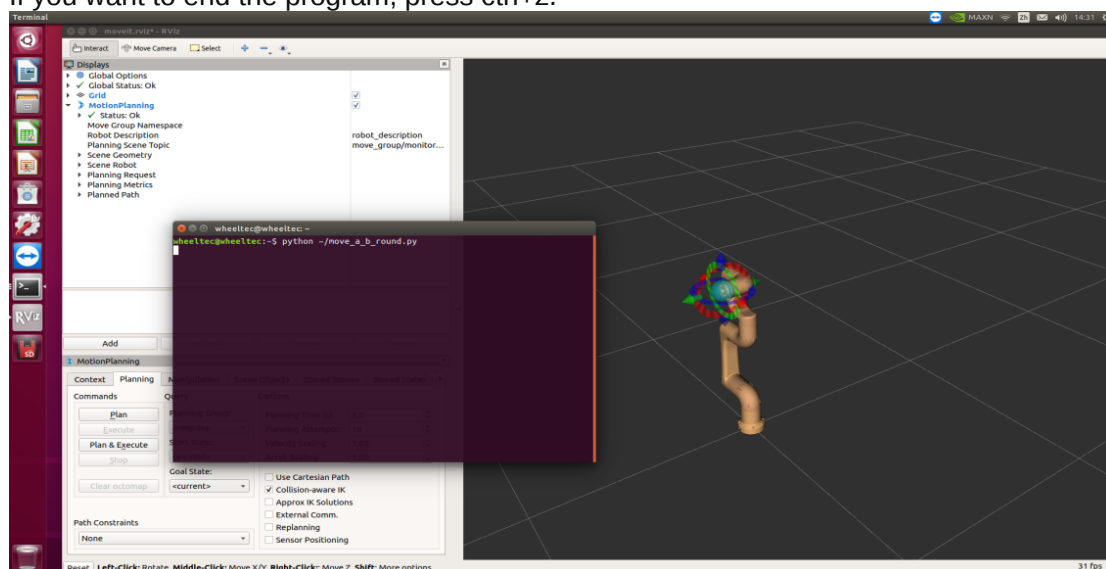
如果想要结束程序，按 ctrl+z 即可。

Open a third terminal and enter:

```
python ~/move_a_b_round.py
```

This command is to run the python program move_a_b_round.py in the ~ directory. This program allows the robot arm to move from one position to another.

If you want to end the program, press ctrl+z.



打开第四个终端，依次输入：

```
roslaunch moveit_commander moveit_commander_cmdline.py  
use armgroup  
ground
```

该组命令是为机械臂增加一个 ground，来保证运动轨迹保持在水平线以上。在有些时候机械臂可能会移动到水平线以下，这种情况在 RViz 中表现为机械臂的某些部分出现在了黑色方格水平线的下方。在实际应用中，这种情况可能会损坏机械臂或者造成其他意外事件，所以通过该组命令来保证机械臂运动轨迹保持在水平线以上。如果在使用过程中发生了机械臂运动到了水平线下方，请及时关闭机械臂。

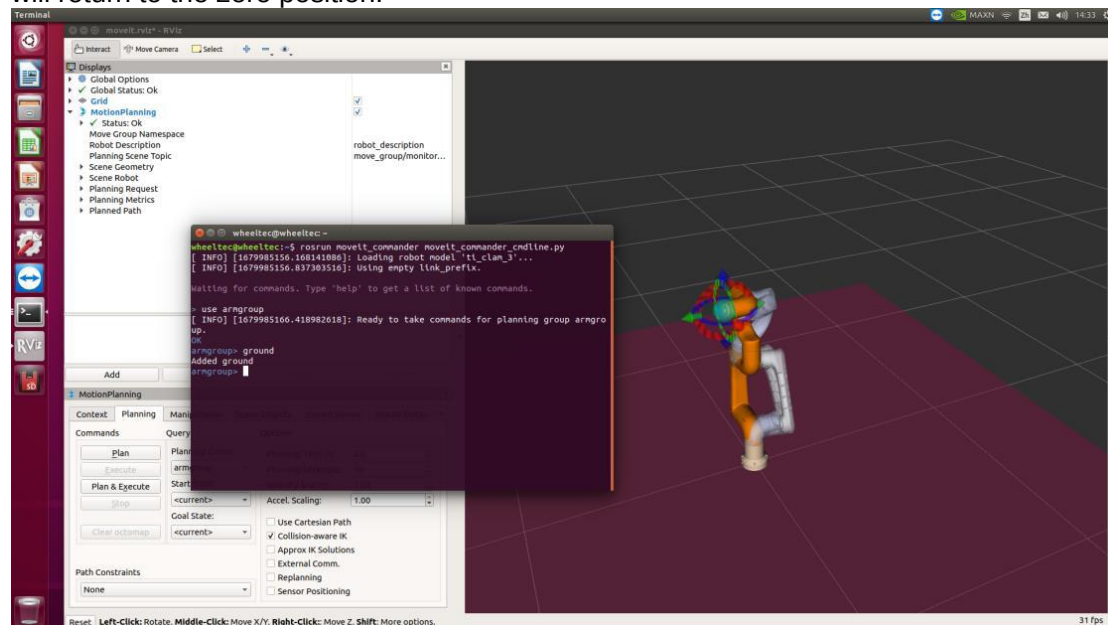
关闭之后如果发现机械臂不在零位，如果想要让机械臂回到初始位置可以拖拽上方的小球直到机械臂回到零位，也可以进行重启，按照前面所写的打开第一个第二个终端，运行第二个终端的命令，机械臂就会恢复到零位。

Open the fourth terminal and input in sequence:

```
roslaunch moveit_commander moveit_commander_cmdline.py
use armgroup
ground
```

This group of commands is to add a ground to the robotic arm to ensure that the motion trajectory remains above the horizontal line. At some times, the robotic arm may move below the horizontal line, which is manifested in RViz as some parts of the robotic arm appearing below the black grid horizontal line. In practical applications, this situation may damage the robotic arm or cause other unexpected events, so this group of commands is used to ensure that the trajectory of the robotic arm remains above the horizontal line. If the robotic arm moves below the horizontal line during use, please close the robotic arm in a timely manner.

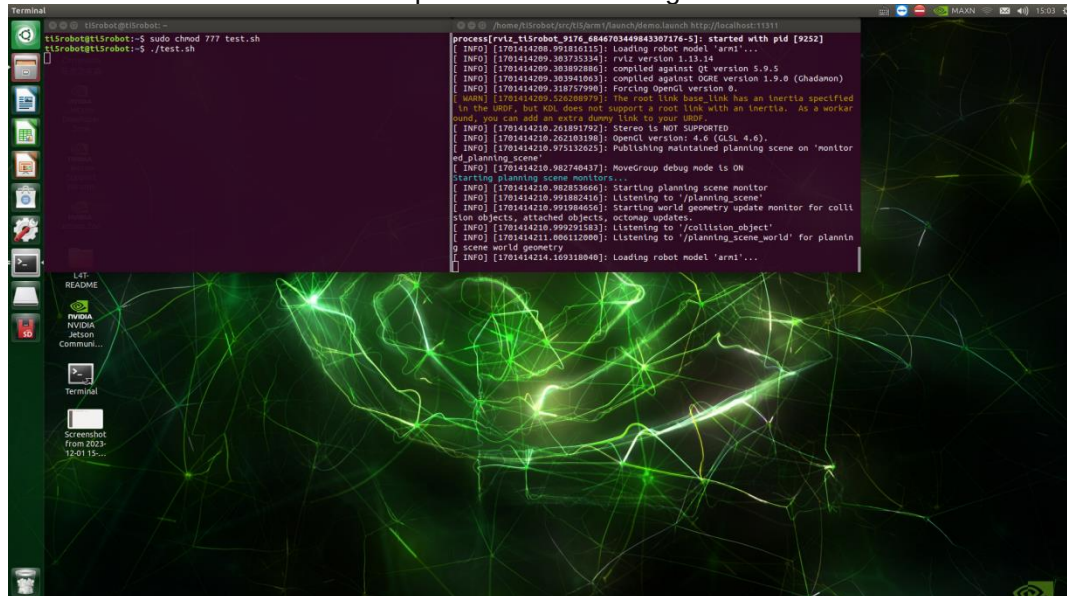
After closing, if it is found that the robotic arm is not in the zero position, if you want to return the robotic arm to the initial position, you can drag the ball above until the robotic arm returns to the zero position, or you can restart it. Open the first and second terminals according to the command written earlier, run the second terminal, and the robotic arm will return to the zero position.



上述为依次打开每一个终端来实现机械臂的运动，也可以通过运行 run.sh 脚本文件来实现自动运行机械臂的运动 demo。打开一个新的终端，输入 `sudo chmod 777 run.sh`

然后输入 `./run.sh` 该组命令可以让机械臂实现几个位置的自动运行，不需要像前面介绍的
那样手动一个一个的打开多个终端。同样的，在运行该程序时请固定好机械臂底座同时不
要有障碍物。

The provided sequence allows for the sequential opening of each terminal to execute the
robotic arm's movement. Alternatively, you can achieve the same by running the "run.sh"
script file. Open a new terminal, input "sudo chmod 777 run.sh" to grant executable
permissions to the script, then input "run.sh". This set of commands enables the robotic
arm to automatically move to several positions without the need to manually open multiple
terminals as described earlier. Similarly, ensure that the base of the robotic arm is securely
fixed and there are no obstacles present while running this



2.8.4 A-B点移动SDK A-B point mobile SDK

文件位置

file location:

`~/move_a_b_round.py`

初始化 MoveGroupPythonInterfaceTutorial 节点

Initialize MoveGroupPythonInterfaceTutorial node

初始化 moveit_commander 和 rospy:

Initialize moveit_commander and rospy:

```
moveit_commander.roscpp_initialize(sys.argv)
moveit_commander.roscpp_initialize(sys.argv)
rospy.init_node("listenerjoy",anonymous=True)
```

实例化 RobotCommander 对象，这个接口是机器人总入口：

Instantiate the RobotCommander object, which is the main entrance of the robot

```
robot = moveit_commander.RobotCommander()
```

实例化 PlanningSceneInterface 对象:

Instantiating the PlanningSceneInterface object

```
scene = moveit_commander.PlanningSceneInterface()
```

实例化 MoveGroupCommander 对象，这个接口应用与一组关节。这里使用左臂，使用左臂来规划和执行动作。

Instantiate the MoveGroupCommander object, which applies to a set of joints. Here, use the left arm to plan and execute actions:

```
group = moveit_commander.MoveGroupCommander("armgroup")
```

创建 DisplayTrajectory 发布者，可以得到轨迹在 Rviz 中实现可视化：

Create a DisplayTrajectory publisher to visualize trajectories in Rviz.

```
display_trajectory_publisher = rospy.Publisher(  
    '/move_group/display_planned_path',  
    moveit_msgs.msg.DisplayTrajectory)
```

获得基本信息

Obtain basic information.

打印这个组的末端执行器的连接名称：

Print the connection name of the end effector for this group:

```
print "===== Reference frame: %s" % group.get_planning_frame()
```

获得机器人的所有组

Obtain all groups of robots:

```
print "===== Reference frame: %s" % group.get_end_effector_link()
```

用于调试，打印机器人的状态：

Used for debugging and printing the status of the robot:

```
print "===== Robot Groups:"  
print robot.get_group_names()
```

规划姿态目标

Planning attitude goals:

```
print "===== Printing robot state"  
print robot.get_current_state()  
print "=====
```

为这个组规划动作，实现末端执行器到达期望的姿态目标：

Plan actions for this group to achieve the desired attitude target of the end effector:

```
pose_target = geometry_msgs.msg.Pose()
```

```
pose_target.orientation.w = 1.0
pose_target.position.x = 0.7
pose_target.position.y = -0.05
pose_target.position.z = 1.1
group.set_pose_target(pose_target)
```

调用规划器：

invoke planner

```
plan1 = group.plan()
```

附言：调用规划器计算规划并在 Rviz 里显示，注意：这里只是规划，不是实际执行。

PS: Call the planner to calculate the plan and display it in Rviz. Note: this is only a plan, not an actual execution.

移动到姿态目标：

移动到一个姿势的目标是类似于上述步骤除了我们现在使用的 go() 功能。

请注意，我们已经设置了前面的姿势目标仍然是有效的，所以机器人将尝试移动到那个目标。我们不会在本教程中使用该函数，因为它是一个阻塞函数，需要一个控制器是激活，执行后报告成功的轨迹。

Move to pose target:

The goal of moving to a pose is similar to the above steps, except for the go() function we are currently using.

Please note that we have set the previous pose target and it is still valid, so the robot will attempt to

Move to that target. We will not use this function in this tutorial because it is a blocking function,

A controller is required to activate and report successful trajectories after execution.

```
# Uncomment below line when working with a real robot
```

```
# group.go(wait=True)
```

笛卡尔路径：

你可以计划一个笛卡尔路径通过直接为末端执行器指定航点列表。

Cartesian path:

You can plan a Cartesian path by directly specifying a waypoint list for the end effector.

```
waypoints = []
# start with the current pose waypoints.append(group.get_current_pose().pose)
# first orient gripper and move forward(+x)wpose=geometry_msgs.msg.Pose()
wpose.orientation.w = 1.0
wpose.position.x=waypoints[0].position.x+ 0.1
wpose.position.y = waypoints[0].position.y
wpose.position.z = waypoints[0].position.z
waypoints.append(copy.deepcopy(wpose))
# second move down wpose.position.z -= 0.10
waypoints.append(copy.deepcopy(wpose))
# third move to the side
wpose.position.y += 0.05 waypoints.append(copy.deepcopy(wpose))
```

我们希望笛卡尔路径被内插在一个分辨率为 1 厘米，这就是为何在笛卡尔转换指定 0.01 作为最大值。我们指定阈值为 0，实际上是禁用它。

We want the cartesian path to be interpolated at a resolution of 1 cm which is why we will specify 0.01 as the max step in cartesian translation. We will specify the jump threshold as 0.0, effectively disabling it.

```
(plan3, fraction) = group.compute_cartesian_path(
    waypoints, # waypoints to follow
    0.01, # eef_step
    0.0) # jump_threshold
```

2.8.5 A-B点移动实例 A-B point moving instance

打开新终端：

```
roslaunch moveit_commander moveit_commander_cmdline.py
```

连接机器人：

use armgroup

查看各关节当前位置及俯仰角：

current

Open the new terminal:

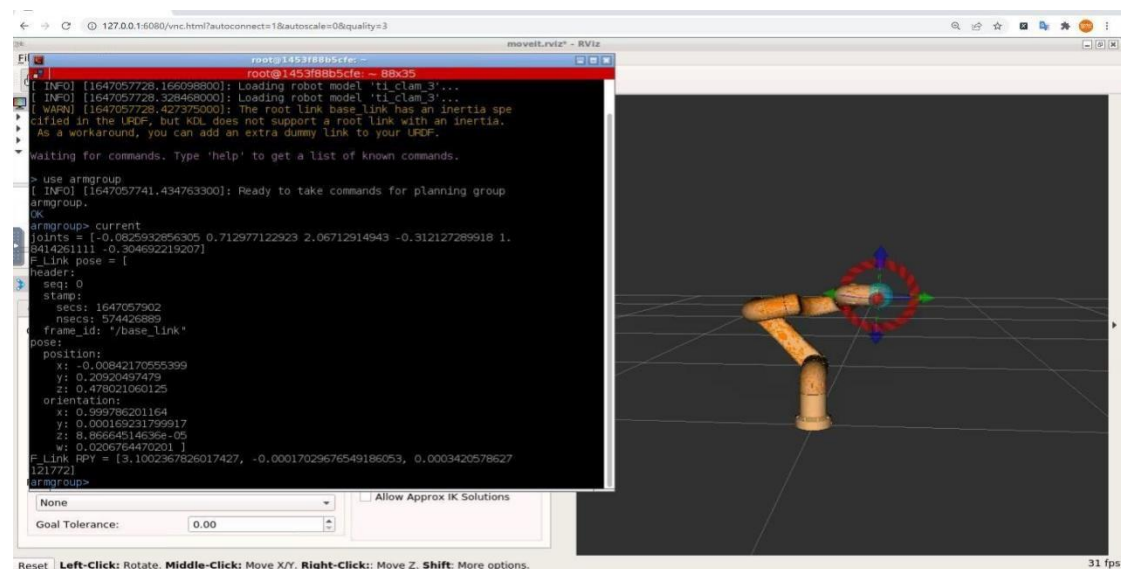
```
roslaunch moveit_commander moveit_commander_cmdline.py
```

To connect robots:

use armgroup

View the current position and pitch angle of each joint:

current



各关节当前位置：

joints

打开一个新的终端：

```
vim ~/move_a_b_round.py
```

move_a_b_round.py 中 go_to_pose_goal2 函数如下：

Current positions:
joints

Open terminal

vim ~/move_a_b_round.py

The go_to_pose_goals function in move_a_b_round.py is as follows:

```
#!/usr/bin/env python
import rospy
from geometry_msgs.msg import Pose
from tf.transformations import quaternion_from_euler

rpylist=[-5.420797797694599e-05, 0.00020787699155017496, 3.823067437933508e-05]
pose_goal = geometry_msgs.msg.Pose()

quaternion = quaternion_from_euler(rpylist[0], rpylist[1], rpylist[2])
#quaternion = quaternion_from_euler(self.roll, self.pitch, self.yaw)
pose_goal.orientation.x = 0.0
pose_goal.orientation.y = 0.0001
pose_goal.orientation.z = -0.0
pose_goal.orientation.w = 0.9999

pose_goal.position.x = -0.0
pose_goal.position.y = -0.144
pose_goal.position.z = 0.5763
```

把第二个终端中的信息输入到 pose_goal

current 中的 pose.position 对应 move_a_b_round.py 中的 pose_goal.position

current 中的 pose.orientation 对应 move_a_b_round.py 中的 pose_goal.orientation

机械臂末端的移动的的第一个点设置完毕

按照以上再次设定第二个第三个目标点

各个目标点设置完成后, 执行 python move_a_b_round.py 机械臂会按照之

前设定的点, 依次移动到位

Input the information from the second terminal into pose_goal

current's pose.position corresponds to move_a_b_round.py's pose_goal.position.

current's pose.orientation corresponds to move_a_b_round.py's pose_goal.orientation.

The first point for the movement of the robotic arm's end-effector has been configured.

Follow the same steps to set the second and third target points.

2.8.6 ROS接口SDK ROS Interface SDK

用户在编写程序实现需要的功能时, 可以直接使用 ROS 提供的库函数来实现, 也可以使用钛虎方提供的基于 ROS 的二次开发的函数来实现。

When users are programming to implement the desired functionalities, they can either directly utilize the library functions provided by ROS or leverage the secondary development functions based on ROS provided by Titanium Tiger.

代码地址为: <https://github.com/ti5robot/zx.git>

The code repository can be accessed at: <https://github.com/ti5robot/zx.git>

执行命令以下命令进行下载:

git clone <https://github.com/ti5robot/zx.git>

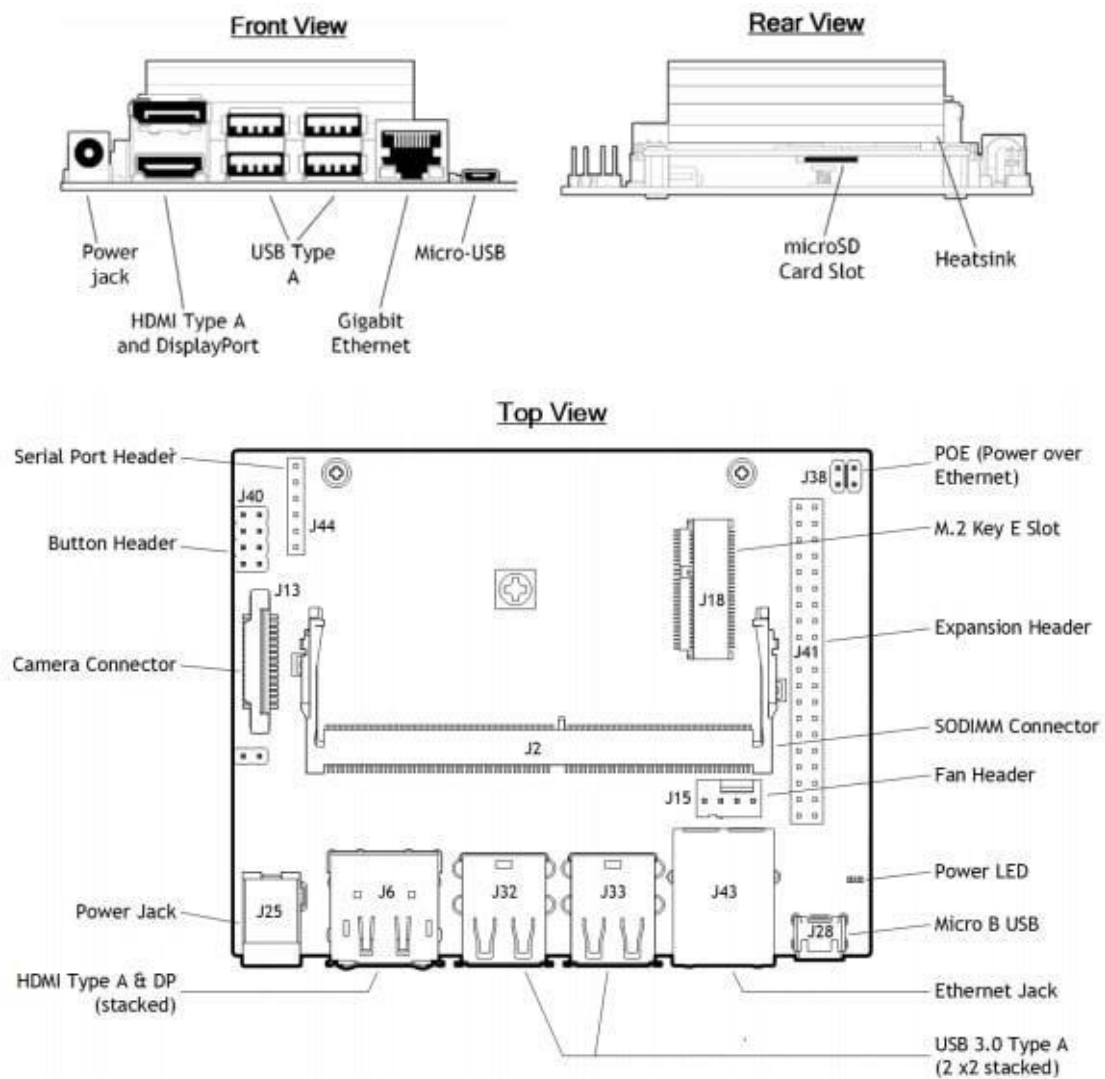
To download the repository, you can execute the following command in your terminal:

具体使用说明可查看 ROS 接口文档说明。

For specific usage instructions, please refer to the ROS Interface documentation.

2.8.7 电气接口 electrical interface

Jetson NANO 开发板接口 Development Board Interface



Jetson Nano J41 Header					
Sysfs GPIO	Name	Pin	Pin	Name	Sysfs GPIO
	3.3 VDC Power	1	2	5.0 VDC Power	
	I2C_2_SDA I2C Bus 1	3	4	5.0 VDC Power	
	I2C_2_SCL I2C Bus 1	5	6	GND	
gpio216	AUDIO_MCLK	7	8	UART_2_TX /dev/ttyTHS1	
	GND	9	10	UART_2_RX /dev/ttyTHS1	
gpio50	UART_2_RTS	11	12	I2S_4_SCLK	gpio79
gpio14	SPI_2_SCK	13	14	GND	
gpio194	LCD_TE	15	16	SPI_2_CS1	gpio232
	3.3 VDC Power	17	18	SPI_2_CS0	gpio15
gpio16	SPI_1_MOSI	19	20	GND	
gpio17	SPI_1_MISO	21	22	SPI_2_MISO	gpio13
gpio18	SPI_1_SCK	23	24	SPI_1_CS0	gpio19
	GND	25	26	SPI_1_CS1	gpio20
	I2C_1_SDA I2C Bus 0	27	28	I2C_1_SCL I2C Bus 0	
gpio149	CAM_AF_EN	29	30	GND	
gpio200	GPIO_PZ0	31	32	LCD_BL_PWM	gpio168
gpio38	GPIO_PE6	33	34	GND	
gpio76	I2S_4_LRCK	35	36	UART_2_CTS	gpio51
gpio12	SPI_2_MOSI	37	38	I2S_4_SDIN	gpio77
	GND	39	40	I2S_4_SDOUT	gpio78

Jetson Nano 的 40 个 GPIO 引脚可用于数字和模拟输入/输出，支持 3.3V 和 5V 电平。以下是这些引脚的详细说明：

1. GPIO 0-27 这些引脚用于数字输入和输出，可用于控制 LED、电机、传感器等外部设备。其中，GPIO2、3、4、5、6、7、8、9、10、11、12、13、14、15、16、17、18、19、20、21、22、23、24、25、26、27 引脚支持 PWM 输出。
2. GPIO 28-31 这些引脚用于 I2C 总线通信。GPIO28 和 GPIO29 是 I2C 总线的数据线，GPIO30 是 I2C 总线的时钟线。GPIO31 是可编程 GPIO，可以配置为 I2C 总线的中断输出或 电平检测输入。
3. GPIO 32-33 这些引脚用于 SPI 总线通信。GPIO32 是 SPI 总线的片选引脚，GPIO33 是 SPI 总线的数据输入引脚。
4. GPIO 34-35 这些引脚用于 UART 通信。GPIO34 是 UART 的 RX 引脚，GPIO35 是 UART 的 TX 引脚。
5. GPIO 36-37 这些引脚用于 PWM 输出。GPIO36 和 GPIO37 支持 4 路 PWM 输出。
6. GPIO 38-40 这些引脚用于电源管理。GPIO38 是重启引脚，GPIO39 是关机引脚，GPIO40 是电源按钮引脚。

Jetson Nano's 40 GPIO pins can be used for digital and analog input/output, supporting 3.3V and 5V level. The following are detailed descriptions of these pins:

1. GPIO pins 0-27 are used for digital input and output, and can be used to control external devices such as LEDs, motors, sensors, etc. Among them, GPIO2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18. Pins 19, 20, 21, 22, 23, 24, 25, 26, and 27 support PWM output.
2. GPIO 28-31 pins are used for I2C bus communication. GPIO28 and GPIO29 are on the I2C bus
3. The data line, GPIO30, is the clock line of the I2C bus. GPIO31 is a programmable GPIO that can be configured as
4. Interrupt output or level detection input of I2C bus.
5. GPIO 32-33 pins are used for SPI bus communication. GPIO32 is the chip selection pin of the SPI bus, and GPIO33 is the data input pin of the SPI bus.
6. GPIO 34-35 pins are used for UART communication. GPIO34 is the RX pin of UART, and GPIO35 is the TX pin of UART.
7. GPIO 36-37 pins are used for PWM output. GPIO36 and GPIO37 support four PWM outputs.
8. GPIO 38-40 pins are used for power management. GPIO38 is the restart pin, GPIO39 is the shutdown pin, GPIO40 is the power button pin.

SPI 的使用：

1. Jetson Nano SPI 硬件接口 Jetson Nano SPI 总线使用 GPIO32 作为片选引脚，GPIO33 作为数据输入引脚。Jetson Nano 的 SPI 总线支持标准 SPI 和高速 SPI，数据传输速率可达到 10MHz 或 40MHz。
2. Jetson Nano SPI 软件接口 Jetson Nano 的 Linux 内核已经内置了 SPI 设备驱动程序和相关的工具。您可以使用 spidev 驱动程序来控制 SPI 总线，并使用 spi_transfer 函数来读写 SPI 设备的寄存器。
3. Jetson Nano SPI 应用 Jetson Nano 的 SPI 总线可用于连接各种 SPI 设备，如显示器、传感器、存储器等。例如，您可以使用 Jetson Nano 连接一个 SPI 显示屏，显示当前环境的温度值。

Use of SPI:

1. The Jetson Nano SPI hardware interface uses GPIO32 as the chip selection pin and GPIO33 as the data input pin for the Jetson Nano SPI bus. Jetson Nano's SPI bus

supports both standard SPI and high-speed SPI, with data transfer rates up to 10MHz or 40MHz.

2. The Linux kernel of the Jetson Nano SPI software interface has built-in SPI device drivers and related tools. You can use the spider driver to control the SPI bus and use SPI_ The transfer function is used to read and write registers of SPI devices.
3. Jetson Nano SPI Application Jetson Nano's SPI bus can be used to connect various SPI devices, such as displays, sensors, memory, etc. For example, you can use Jetson Nano to connect an SPI display screen that displays the current ambient temperature value.

I2c的使用：

1. Jetson Nano I2C 硬件接口 Jetson Nano I2C 总线使用 GPIO28 和 GPIO29 作为数据线，GPIO30 作为时钟线。Jetson Nano 的 I2C 总线支持标准 I2C 和快速 I2C，数据传输速率可达到 100kHz 或 400kHz。
2. Jetson Nano I2C 软件接口 Jetson Nano 的 Linux 内核已经内置了 I2C 设备驱动程序和相关 的工具。您可以使用 i2cdetect 命令来检测 I2C 设备是否连接到总线上，并使用 i2cget 和 i2cset 命令来读写 I2C 设备的寄存器。
3. Jetson Nano I2C 应用 Jetson Nano 的 I2C 总线可用于连接各种 I2C 设备，如传感器、显示器、扩展模块等。例如，您可以使用 Jetson Nano 连接一个 I2C 温度传感器，读取当前环境的温度值。

Use of I2c:

1. The Jetson Nano I2C hardware interface uses GPIO28 and GPIO29 as data lines and GPIO30 as clock lines on the Jetson Nano I2C bus. Jetson Nano's I2C bus supports standard I2C and fast I2C, with data transfer rates up to 100kHz or 400kHz.
2. The Linux kernel of the Jetson Nano I2C software interface has built-in I2C device drivers and related tools. You can use the i2cdetect command to detect whether the I2C device is connected to the bus, and use the i2cget and i2cset commands to read and write the registers of the I2C device.
3. Jetson Nano I2C Application Jetson Nano's I2C bus can be used to connect various I2C devices, such as sensors, displays, expansion modules, etc. For example, you can use Jetson Nano to connect an I2C temperature sensor and read the current ambient temperature value.

RS485 的使用：

1. Jetson Nano RS485 硬件接口 Jetson Nano 的 RS485 通信需要使用一个外部 RS485 转换芯片，例如 MAX485。您需要将 Jetson Nano 的 TXD 和 RXD 信号连接到 MAX485 的 DI 和 RO 信号，将 DE 和 RE 信号连接到 GPIO 引脚上。
2. Jetson Nano RS485 软件接口 Jetson Nano 的 Linux 内核已经内置了 RS485 设备驱动程序和相关 的工具。您可以使用 rs485-ctl 命令来控制 RS485 总线，并使用 rs485_read 和 rs485_write 函数来读写 RS485 设备的寄存器。
3. Jetson Nano RS485 应用 Jetson Nano 的 RS485 总线可用于连接各种 RS485 设备，如 PLC、传感器、控制器等。例如，您可以使用 Jetson Nano 连接一个 RS485 温度传感器，读取当前环境的温度值。

Use of RS485:

1. The Jetson Nano RS485 hardware interface requires the use of a External RS485 conversion chip, such as MAX485. You need to connect the TXD and RXD signals of Jetson Nano to the DI and RO signals of MAX485, and connect the DE and RE signals to the GPIO pins.

2. The Linux kernel of the Jetson Nano RS485 software interface has built-in RS485 device drivers and related tools. You can use the rs485 ctl command to control the RS485 bus and use rs485_Read and rs485_ The write function is used to read and write registers of RS485 devices.
3. Jetson Nano RS485 Application Jetson Nano's RS485 bus can be used to connect various RS485 devices, such as PLCs, sensors, controllers, etc. For example, you can use Jetson Nano to connect an RS485 temperature sensor and read the current ambient temperature value.

RS232 的使用：

1. Jetson Nano RS232 硬件接口 Jetson Nano 的 RS232 通信需要使用一个外部 RS232 转换芯片，例如 MAX232。您需要将 Jetson Nano 的 TXD 和 RXD 信号连接到 MAX232 的 T1 和 R1 信号，将 VCC 和 GND 信号连接到相应的引脚上。
2. Jetson Nano RS232 软件接口 Jetson Nano 的 Linux 内核已经内置了 RS232 设备驱动程序 和相关的工具。您可以使用 stty 命令来配置串口参数，例如波特率、数据位、停止位和校验位，并使用 echo 和 cat 命令来读写串口数据。
3. Jetson Nano RS232 应用 Jetson Nano 的 RS232 串口可用于连接各种 RS232 设备，如调试器、数据采集器、串口转网口等。例如，您可以使用 Jetson Nano 连接一个 RS232 数据采集器，读取当前环境的湿度值。
4. 网络接口 Jetson Nano 具有 10/100/1000Mbps 以太网接口和支持 802.11ac Wi-Fi 和蓝牙的 M.2 E-key 插槽，以提供快速的网络连接和通信功能。
5. USB 接口 Jetson Nano 具有多个 USB 接口，包括 USB 3.0 和 USB 2.0 接口，可用与连接外部设备，如鼠标、键盘、摄像头、传感器等。

Use of RS232:

1. The RS232 communication of the Jetson Nano hardware interface requires the use of an external RS232 conversion chip, such as MAX232. You need to connect the TXD and RXD signals of Jetson Nano to the T1 and R1 signals of MAX232, and connect the VCC and GND signals to the corresponding pins.
2. The Linux kernel of the Jetson Nano RS232 software interface has built-in RS232 device drivers and related tools. You can use the stty command to configure serial port parameters, such as baud rate, data bits, stop bits, and parity bits, and use the echo and cat commands to read and write serial port data.
3. Jetson Nano RS232 Application Jetson Nano's RS232 serial port can be used to connect various RS232 devices, such as debuggers, data collectors, serial port to network ports, etc. For example, you can use Jetson Nano to connect an RS232 data collector and read the humidity value of the current environment.
4. The Jetson Nano has a 10/100/1000Mbps Ethernet interface and an M.2 E-key slot that supports 802.11ac Wi Fi and Bluetooth, providing fast network connectivity and communication capabilities.
5. The Jetson Nano has multiple USB interfaces, including USB 3.0 and USB 2.0 interfaces, which can be used to connect external devices such as mice, keyboards, cameras, sensors, etc.

三、维护维修 Maintenance and repair

3.1 关于维护时的安全 Safety during maintenance

当机器人运行了一段时间后，需要进行必要的维护，以确保机器人的 功能正常发挥，请联系专业人员：

请务必由经过安全方面培训的人员进行机器人的维护。

经过安全培训的人员是指接受过由各国法规与法令规定的。

旨在对从事工业机器人相关业务的劳动者进行的安全方面的培训（有关工业机器人的知识、操作、示教等知识、检查等业务作业相关知识、相关法令等的培训）的人员。

本公司进行培训的对象为已完成安装培训与维护培训的人员。

维护之前，请仔细阅读“关于维护时的安全”、本手册及相关手册，在充分理解安全维护方法的基础上进行维护。

After the robot has been running for a period of time, necessary maintenance is required to ensure the normal functioning of the robot. Please contact professionals:

Please ensure that the robot is maintained by personnel trained in safety.

Personnel who have received safety training refer to those who have received regulations and decrees of various countries.

Personnel who are intended to provide safety training for workers engaged in industrial robot related businesses (training on knowledge, operation, teaching, inspection and other business operations related to industrial robots, relevant laws, etc.).

The training objects of the company are the personnel who have completed the installation training and maintenance training.

Before maintenance, please carefully read "Safety during maintenance", this manual and relevant manuals, and conduct maintenance based on full understanding of safety maintenance methods.

	不要随意改变软件安全配置中的任何信息（比如力限制）。如果安全参数变更，整个机器人系统应被视为新系统，这就意味着所有安全审核过程，比如风险评估，都必须更新。 Do not arbitrarily change any information (such as force limit) in the
--	--

 警告! WARNING!	software security configuration. If the safety parameters change, the entire robot system should be considered as a new system, which means that all safety audit processes, such as risk assessment, must be updated.
	除非本手册另有说明，否则请勿拆下任何部件。根据所述内容严格遵守维护步骤。如果进行错误的拆卸或维护，不仅机器人系统会出现故障，还可能会造成严重的安全问题。另外，保修期内自行拆卸将失去保修资格。 Do not remove any components unless otherwise stated in this manual. Strictly follow the maintenance procedures according to the contents described. If wrong disassembly or maintenance is carried out, not only the robot system will fail, but also serious safety problems may be caused. In addition, self disassembly during the warranty period will lose the warranty qualification.
	请务必在机器人动作区域之外确认更换部件后的机器人动作。否则，动作确认之前的机器人可能会进行意想不到的动作，并可能造成严重的安全问题。 Be sure to confirm the robot action after replacing parts outside the robot action area. Otherwise, the robot before action confirmation may perform unexpected actions, which may cause serious safety problems.
	所有拆卸后的机器人需要重新进行校准。 All disassembled robots need to be recalibrated.
	如果未接受过培训，请在电源接通时远离机器人。另外，请勿进入到动作区域内。即使看到机器人似乎停止了动作，但处于通电状态的机器人可能还会意外进行动作，并可能造成严重的安全问题。 If not trained, stay away from the robot when the power is turned on. In addition, do not enter the action area. Even if the robot seems to have stopped moving, the robot in the energized state may still act unexpectedly, which may cause serious safety problems. 进入正规运转之前，请确认紧急停止开关与安全护板开关动作状态正常。如果在开关不能正常动作的状态下进行运转，发生紧急状况时则无法发挥安全功能，可能会导致重伤或重大损害，非常危险。 Before entering the normal operation, please confirm that the emergency stop switch and the safety guard switch operate normally. If the switch can not operate normally, it will fail to play

	the safety function in case of emergency, which may lead to serious injury or major damage, which is very dangerous.
	请务必在关闭控制器与相关装置电源并拔出电源插头之后进行维护、更换及配线作业，否则可能会导致触电或故障。 Be sure to perform maintenance, replacement and wiring operations after turning off the power supply of the controller and related devices and unplugging the power plug, otherwise electric shock or failure may result.

3.2 可以联系的人 Persons who can be contacted

1、系统集成商 System Integrator

你可以直接联系负责安装和调试Eblm/Arm系列的系统集成商。

You can directly contact the system integrator responsible for installing and debugging the Eblm/Arm series.

2、供应商 Supplier

你可以联系钛虎机器人在你所在地区的供应商。具体供应商信息请查看官网：

<https://www.ti5robot.com/>。

You can contact the suppliers of Ti5robot in your area. See the official website for specific supplier information: <https://www.ti5robot.com>

3、官方网站 Official Website

你可以查看钛虎机器人的官网（<https://www.ti5robot.com/>）以找寻更多的信息。

You can check the official website of the Ti5robot（<https://www.ti5robot.com/>）To find more information.

3.3 维护计划 Maintenance Plan

为了使机器人能够长期保持高效的性能，必须定期进行维护。

In order for the robot to maintain efficient performance over the long term, it must be maintained regularly.



CAUTION!

- 保持产品清洁。
- Keep the product clean.
- 每三个月检查一次紧固件是否松动。
- Check for loose fasteners every three months.

维修必须由授权服务商或本公司指定的专业技术人员进行。必须确保维护维修工作规定的安全级别，遵守有效的国家或地区的工作安全条例，同时应检测所有的安全功能是否正常。维护维修工作的目的是为了确保系统正常运行，或在系统故障时帮助其恢复正常状态。维修包括故障诊断和实际的维修。

Maintenance must be carried out by authorized service providers or professional technicians designated by the company. The specified safety level for maintenance and repair work must be ensured, the valid national or regional work safety regulations must be observed, and all safety functions must be checked for proper functioning. The purpose of maintenance and repair work is to ensure the normal operation of the system, or to help it restore the normal state in the event of a system failure. Maintenance includes fault diagnosis and actual repair.

操作机器人或控制箱时必须遵循以下安全程序和警告事项：

The following safety procedures and warnings must be followed when operating the robot or control box:

- 维修时需要采取必要的预防措施以避免其他人在维修期间重新接通系统电源。断电之后仍要重新检查系统，确保其确已断电。
- Servicing requires taking the necessary precautions to prevent others from reconnecting power to the system during servicing. After a power outage, the system should still be rechecked to make sure it is indeed powered off.
- 重新开启系统前请检查电源插头接地连接。

- Check the power plug ground connection before turning the system back on.
- 严禁用户自行拆卸机器人或控制箱。
- It is strictly forbidden for users to disassemble the robot or control box by themselves.
- 指定服务商或专业技术人员维修时请遵守ESD（静电释放）法规。
- Please comply with the ESD (Electrostatic Discharge) regulations when repairing by designated service providers or professional technicians.
- 避免水或粉尘进入机器人或控制箱。
- Prevent water or dust from entering the robot or control box.
- 使用部件号相同的新部件或本公司批准的相当部件替换故障部件。
- Replace defective parts with new parts of the same part number or equivalent parts approved by our company.
- 将所有维修操作记录下来，并保存在整个机器人系统相关的技术文档中。
- Record all maintenance operations and keep them in the technical documentation related to the entire robot system.
- 控制箱没有最终用户可自行维修的零件。如果需要维护或维修服务，请联系您的经销商或本公司。
- The control box has no end user serviceable parts. If maintenance or repair service is required, please contact your dealer or our company.

3.4 维修 Maintenance

当机器人发生故障时，请勿继续运转，应立即联系接受过规定培训的作业人员，进行实施故障分析，明确掌握现象，并判断什么部件出现异常。

有关机器人的修理、检查、调整等事项，必须由授权的系统集成商或代理商进行，请联系专业人员进行处理，切勿随意拆卸机器人。

When the robot failure, please do not continue to operate, should immediately contact trained operators, carry out fault analysis, clearly grasp the phenomenon, and judge what parts abnormal.

Robot Repair, inspection, adjustment, and other matters must be carried out by authorized system integrators or agents, please contact professionals to deal with, do not disassemble the robot at will.