

# AN14240

## i.MX 8MP AI Robot的vSLAM自动化导航定位系统

第1.0版—2024年3月11日

应用笔记

### 文档信息

信息	内容
关键词	AN14240、i.MX 8MP AI Robot、vSLAM ROS、i.MX 8MP EVK
摘要	本文介绍了基于i.MX 8MP AI Robot板和i.MX Robot软件平台的自动化导航应用。



## 1 介绍

本文介绍基于i.MX 8MP AI Robot板和i.MX Robot软件平台的自动化导航应用。如果您没有AI Robot板，也可以在i.MX 8MP EVK平台上构建并运行一些vSLAM ROS演示。

## 2 硬件平台

本节介绍硬件平台。

### 2.1 i.MX 8M AI Robot板

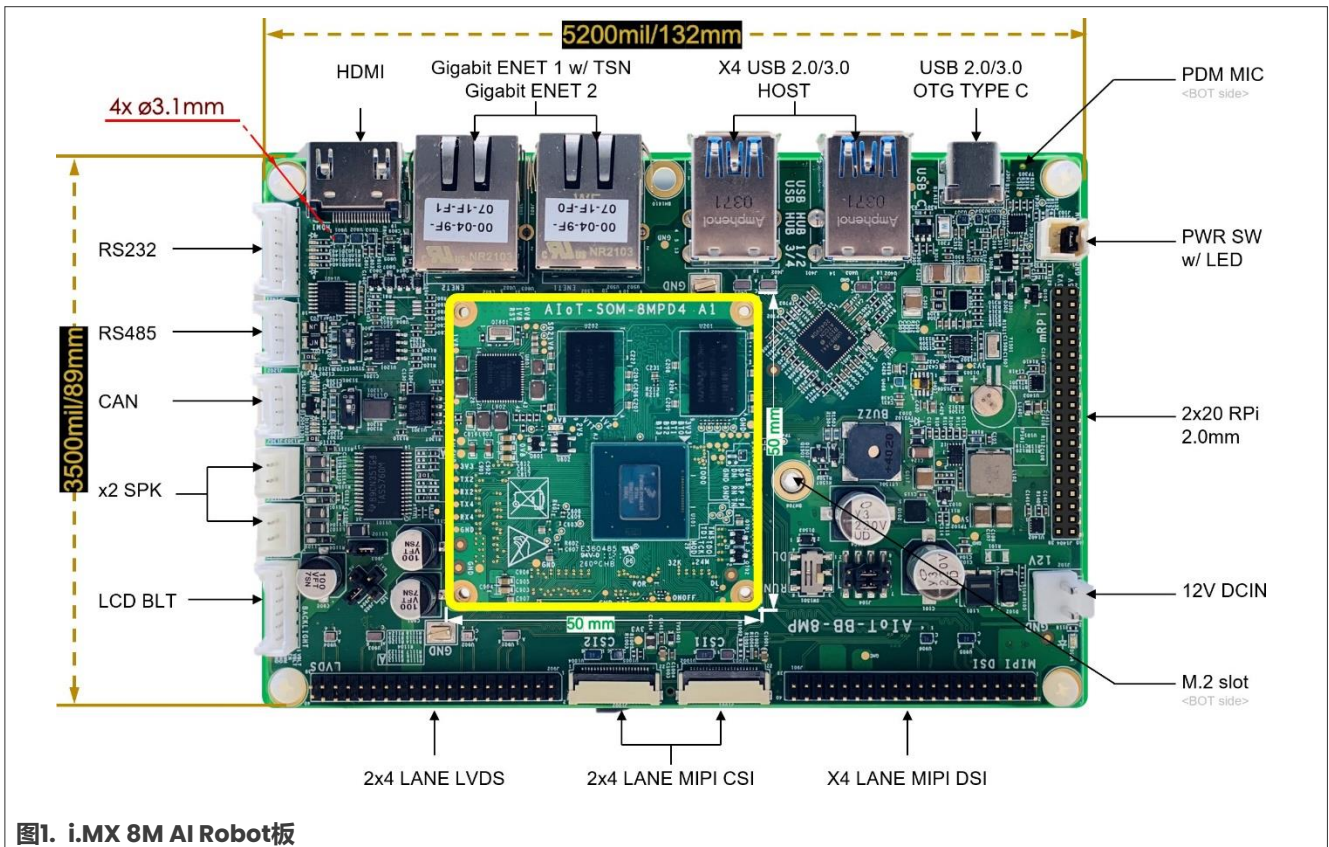


图1. i.MX 8M AI Robot板

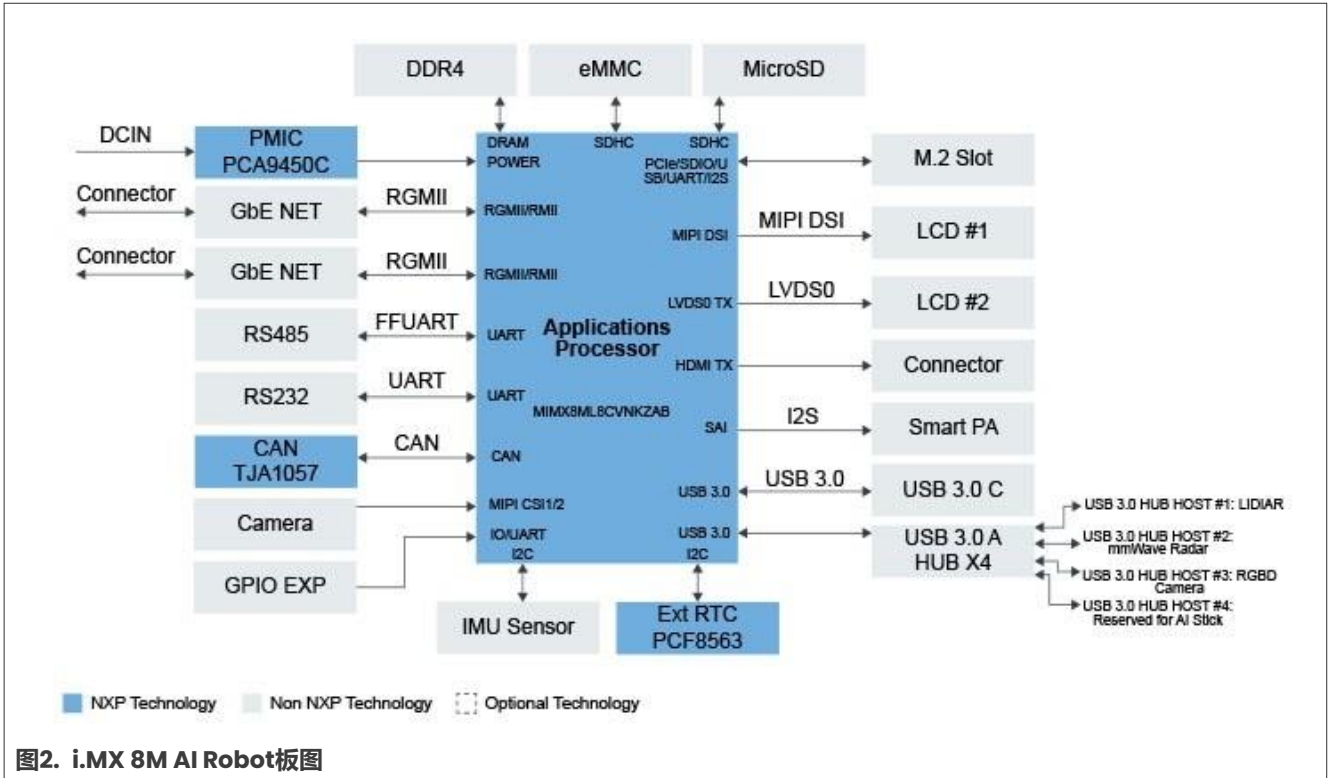


图2. i.MX 8MP AI Robot板图

## 2.2 Intel Realsense D455和智能车模



图3. Intel Realsense D455

如需了解有关Intel Realsense D455的信息，请访问以下网页：<https://www.intelrealsense.com/depth-camera-d455>。



图4. SeekFree智能车模

您可以购买智能车模、i.MX RT1064控制板、电池和其他配件。

### 2.3 硬件组装

您可以组装RGB-D摄像头、AI Robot板和智能车模，如图5所示。您可能需要根据智能车模的外形修改imx-aibot1\_description文件夹中的imxaibot1.urdf.xacro文件或imx-aibot2\_description文件夹中的imxaibot.urdf文件。

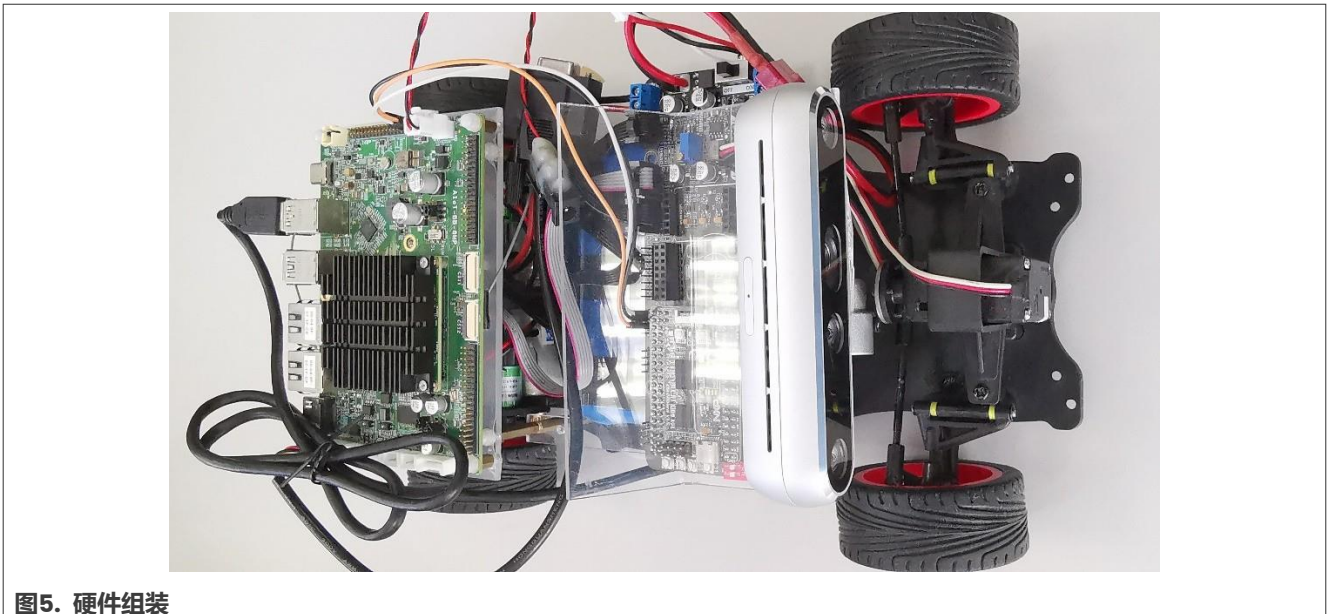


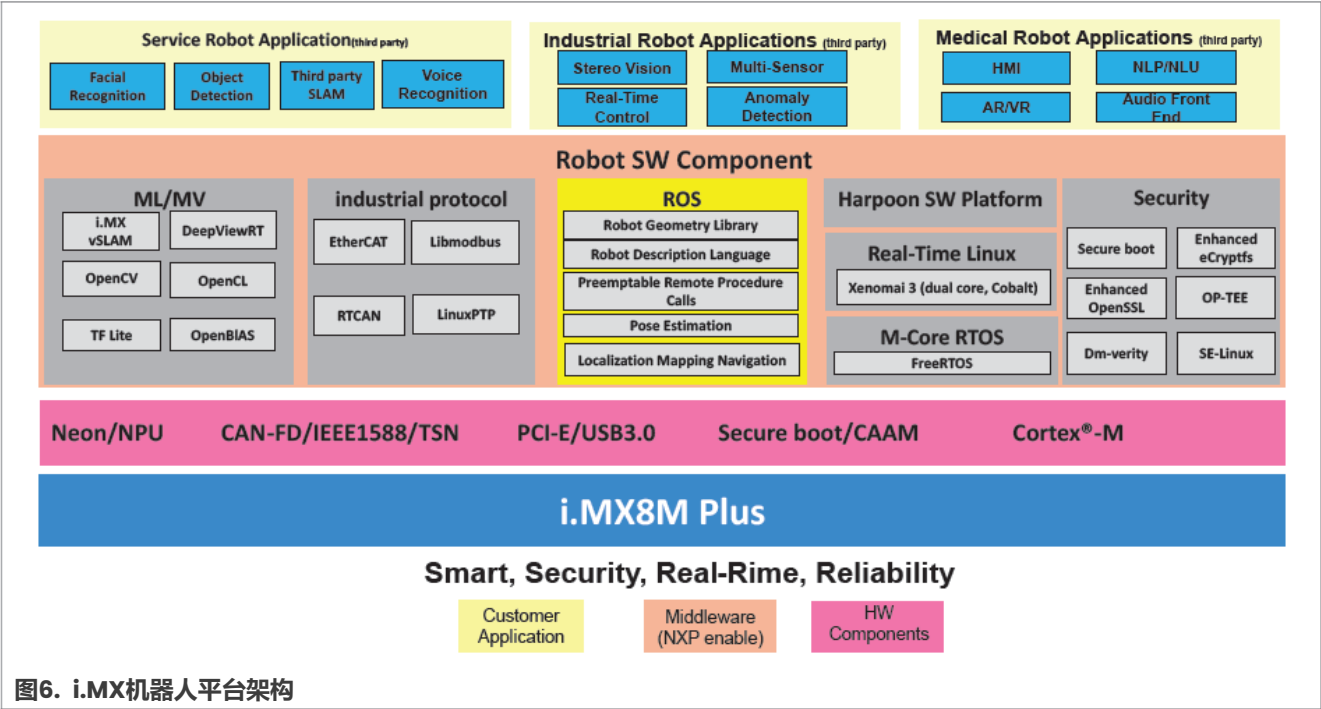
图5. 硬件组装

## 3 软件架构

本节介绍软件架构。

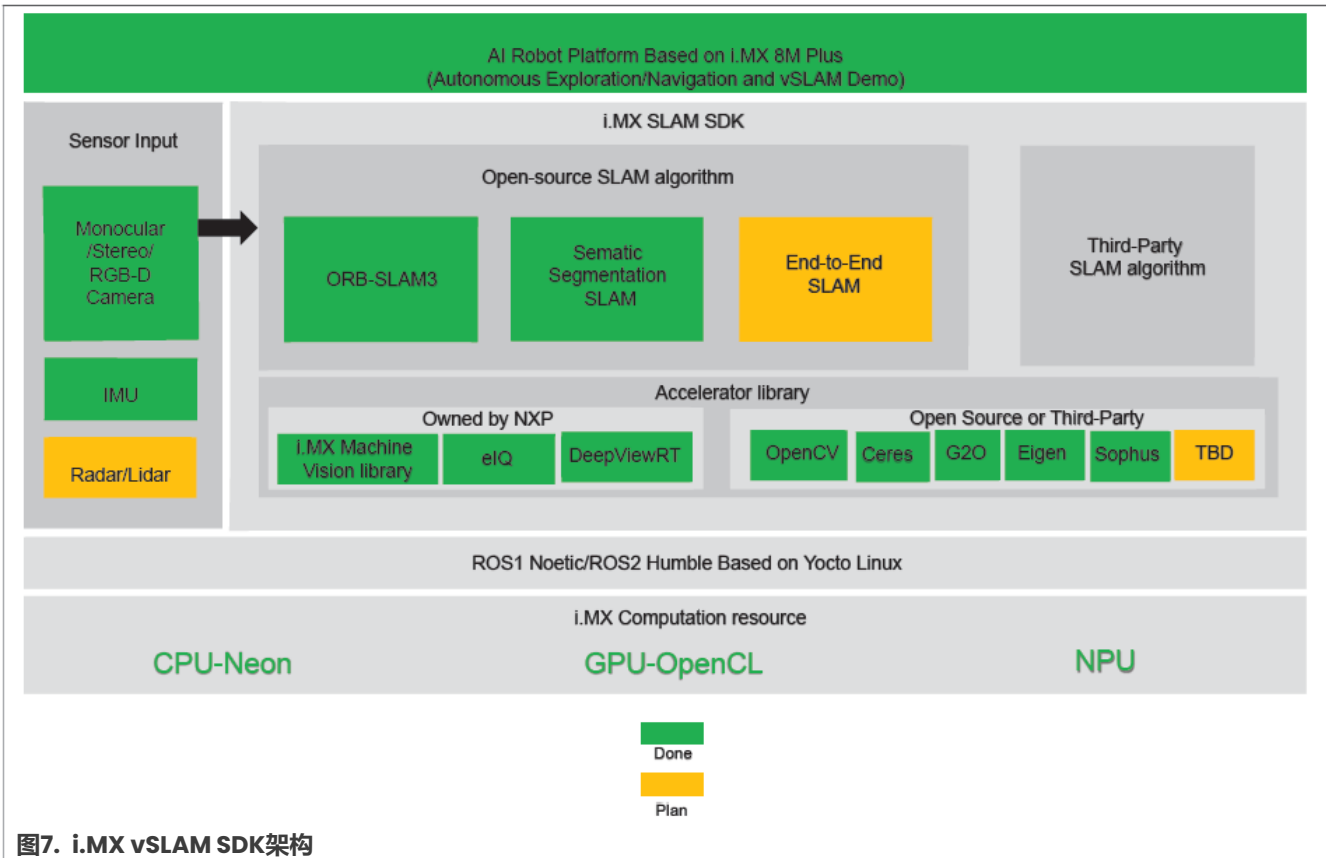
### 3.1 i.MX机器人平台架构

图6显示了i.MX机器人平台架构。



### 3.2 i.MX vSLAM SDK架构

图7展示了i.MX vSLAM SDK架构。



软件目录树如下所示：

```
meta-robot-platform/
|-- imx
|  |-- meta-imx8mp-ai-robot /* BSP patches of i.MX8M Plus AI Robot */
|  |  |-- conf
|  |  |-- EULA.txt
|  |  |-- recipes-bsp
|  |  |-- recipes-kernel
|  |  |-- recipes-security
|  |  |-- SCR.txt
|  |  |-- setup
|  |-- meta-robot /* i.MX Robot Yocto layer */
|  |  |-- conf
|  |  |-- COPYING.MIT
|  |  |-- README
|  |  |-- recipes-core /* Build Image type */
|  |  |-- recipes-demo /* demo folder for ROS1 and ROS2*/
|  |  |-- recipes-devtools
|  |  |-- recipes-industrial-protocol
|  |  |-- recipes-machine-vision /* OpenCV 3.4.15 for ROS1*/
|  |  |-- recipes-nnstreamer
|  |  |-- recipes-real-time /* RT Linux Xenomai */
|  |  |-- recipes-security /* Enhanced OpenSSL and GmSSL */
|  |  |-- recipes-slam-sdk /* i.MX SLAM SDK */
|  |  |-- recipes-support
```

```
| | `-- tools  
| | `-- meta-ros /* ROS's Yocto layer */  
| |-- meta-python2  
| |-- meta-ros1  
| |-- meta-ros1-noetic  
| |-- meta-ros2  
| |-- meta-ros2-foxy  
| |-- meta-ros2-humble  
| |-- meta-ros-common  
| |-- meta-ros-python2  
| `-- scripts  
|-- LICENSE.txt  
`-- SCR.txt
```

## 4 构建和运行演示

本节介绍如何构建和运行演示。

### 4.1 为Yocto项目设置构建环境

本节介绍如何为Yocto项目设置构建环境。

#### 4.1.1 下载库 (如有需要)

下载如下所示的库：

```
$ mkdir ~/bin (this step may not be needed if the bin folder already exists)  
$ curl https://storage.googleapis.com/git-repo-downloads/repo > ~/bin/repo  
$ chmod a+x ~/bin/repo  
$ export PATH=~/bin:$PATH
```

#### 4.1.2 设置Git (如有需要)

设置Git，如下所示：

```
$ git config --global user.name "Your Name"  
$ git config --global user.email "Your Email"  
$ git config --list
```

#### 4.1.3 创建Yocto构建环境

创建如下的Yocto构建环境：

```
$ mkdir imx-yocto-bsp  
$ cd imx-yocto-bsp  
$ repo init -u https://github.com/nxp-imx/imx-manifest -b imx-linux-kirkstone -m  
imx-5.15.71-2.2.0.xml  
$ repo sync
```

## 4.2 构建映像

本节介绍如何构建映像。



### 4.2.1 从GitHub下载meta-robot-platform

从GitHub下载meta-robot-platform, 如下所示:

```
git clone -b imx-aibot-release_v3.3 https://github.com/nxp-imx-support/meta-robot-platform.git
```

### 4.2.2 在构建过程中添加meta-robot-platform层

在构建过程中添加meta-robot-platform层, 如下所示:

1. 将meta-robot-platform复制到<i.MX Yocto folder>/source文件夹。
2. 创建如下的符号链接: `setup-imx-robot.sh -> sources/meta-robot-platform/imx/meta-robot/tools/setup-imx-robot.sh`。

### 4.3 构建机器人映像

按以下步骤构建机器人映像:

```
$ DISTRO=imx-robot-xwayland MACHINE=imx8mp-ai-robot source setup-imx-robot.sh -r noetic -b imx8mp-ai-robot-noetic  
[or DISTRO=imx-robot-xwayland MACHINE=imx8mp-ai-robot source setup-imx-robot.sh -r foxy -b imx8mp-ai-robot-foxy ]  
[or DISTRO=imx-robot-xwayland MACHINE=imx8mp-ai-robot source setup-imx-robot.sh -r humble -b imx8mp-ai-robot-humble ]  
$ bitbake imx-robot-sdk  
[or bitbake imx-robot-core ]  
[or bitbake imx-robot-system ]  
[or bitbake imx-robot-agv ]
```

如果在local.conf文件中添加XENOMAI\_KERNEL\_MODE = "cobalt"或XENOMAI\_KERNEL\_MODE = "mercury" (默认为XENOMAI\_KERNEL\_MODE = "mercury"), 还可以使用以下命令通过Xenomai构建实时映像:

```
bitbake imx-robot-core-rt  
[or bitbake imx-robot-system-rt ]
```

如果没有AI Robot板, 也可以为EVK板构建映像。

```
$ DISTRO=imx-robot-xwayland MACHINE=imx8mpevk source setup-imx-robot.sh -r noetic -b imx8mpevk-robot-noetic  
[or DISTRO=imx-robot-xwayland MACHINE=imx8mpevk source setup-imx-robot.sh -r foxy -b imx8mpevk-robot-foxy ]  
[or DISTRO=imx-robot-xwayland MACHINE=imx8mpevk source setup-imx-robot.sh -r humble -b imx8mpevk-robot-humble ]  
$ bitbake imx-robot-sdk  
[or bitbake imx-robot-core ]  
[or bitbake imx-robot-system ]  
[or bitbake imx-robot-agv ]
```

如果在local.conf文件中添加XENOMAI\_KERNEL\_MODE = "cobalt"或XENOMAI\_KERNEL\_MODE = "mercury" (默认为XENOMAI\_KERNEL\_MODE = "mercury"), 还可以使用以下命令通过Xenomai构建实时映像:

```
bitbake imx-robot-core-rt
```



```
[or bitbake imx-robot-system-rt ]
```

## 4.4 机器人映像健全性测试

在健全性测试之前，请刷写<i.MX Yocto folder>/<build folder>/tmp/deploy/images/imx8mp-ai-robot/文件夹中的映像。

```
//ROS1 Sanity Test
#source /opt/ros/noetic/setup.sh
#echo $LD_LIBRARY_PATH
#roscore &
#rostopic list
#rostopic list
#rostopic info /rostopic
//ROS2 Sanity Test
#source ros_setup.sh
#echo $LD_LIBRARY_PATH
#ros2 topic list
#ros2 interface list
#(sleep 5; ros2 topic pub /chatter std_msgs/String "data: Hello world") &
#ros2 topic echo /chatter
```

## 4.5 运行i.MX AIBot导航演示

首先刷写imx-robot-agv或imx-robot-sdk wic映像。如果您想使用RVIZ观察机器人的状态或设定目标，请在Ubuntu PC和AI Robot板上设置开发环境。

对于ROS1，可为Ubuntu PC和AI Robot板导出ROS\_MASTER\_URI和ROS\_HOSTNAME。

```
//on UART console of AI Robot
#source /opt/ros/noetic/setup.sh
#roslaunch imx_aibot1_navigation imx_aibot1_navigation.launch
//on SSH console of AI Robot after login board by WiFi network
#source /opt/ros/noetic/setup.sh
#roslaunch imx_aibot1_teleop imx_aibot1_teleoperator.launch -screen
```

此时，您可以在AI Robot的SSH控制台中使用键盘控制智能车模，或在RVIZ中设定目标。

如果想尝试自动化探索功能，请参阅[https://github.com/fazildgr8/ros\\_autonomous\\_slam](https://github.com/fazildgr8/ros_autonomous_slam)，在RVIZ窗口中为RRT设置探索区。imx\_aibot1.rviz文件（在imx\_aibot1\_exploration/rviz/文件夹中）可用于配置RVIZ。

在RVIZ中设置之前，必须先启动roslaunch imx\_aibot1\_exploration RRT.launch文件。对于ROS2，请使用以下命令：

```
#source ros_setup.sh
#ros2 launch imx_aibot2_navigation navigation2.launch.py
#python3 /usr/lib/imx_aibot2_teleop/imx_aibot2_teleoperator.py
```

**注：**从<https://github.com/rmsalinas/DBow3/blob/master/orbvoc.dbow3>下载orbvoc.dbow3文件，并将其复制到开发板上的/opt/ros/noetic/share/imx\_aibot1\_vslam/param/(ROS1)或/usr/share/imx\_aibot2\_vslam/param/(ROS2)文件夹。

在开发板上运行以下命令来安装scikit-learn:

```
#pip3 install --trusted-host pypi.org --trusted-host files.pythonhosted.org
scikit-learn
#pip3 install scikit-learn
```

## 4.6 运行vSLAM ROS演示

从imx-vslam-ros1-demo或imx-vslam-ros2-demo订阅主题 (Image、Pointcloud2、Path和TF) 后, 可通过RVIZ或RVIZ 2软件观察特征点的渲染结果。还可以观察到窗口右侧生成的白色地图点云和绿色摄像机轨迹信息。

```
//ROS1
#source /opt/ros/noetic/setup.sh
#roslaunch imx_vslam_ros1_demo imx_rgb_d455.launch --screen
//ROS2
#source ros_setup.sh
#ros2 launch imx_vslam_ros2_demo imx_rgb_d455.py
```

**注:** 从<https://github.com/rmsalinas/DBow3/blob/master/orbvoc.dbow3>下载orbvoc.dbow3文件, 并将其复制到电路板上的/opt/ros/noetic/share/imx-vslam-ros1-demo/param/ (ROS1)或/usr/share/imx-vslam-ros2-demo/param/ (ROS2)文件夹中。

## 5 关于本文中源代码的说明

本文中所示的示例代码具有以下版权和BSD-3-Clause许可:

2024年恩智浦版权所有; 在满足以下条件的情况下, 可以源代码和二进制文件的形式重新分发和使用本源代码 (无论是否经过修改):

1. 重新分发源代码必须保留上述版权声明、这些条件和以下免责声明。
2. 以二进制文件形式重新分发时, 必须在文档和/或随分发提供的其他材料中复制上述版权声明、这些条件和以下免责声明。
3. 未经事先书面许可, 不得使用版权所有者的姓名或参与者的姓名为本软件的衍生产品进行背书或推广。

本软件由版权所有者和参与者“按原样”提供, 不承担任何明示或暗示的担保责任, 包括但不限于对适销性和特定用途适用性的暗示保证。在任何情况下, 无论因何种原因或根据何种法律条例, 版权所有或参与者均不对因使用本软件而导致的任何直接、间接、偶然、特殊、惩戒性或后果性损害 (包括但不限于采购替代商品或服务; 使用损失、数据损失或利润损失或业务中断) 承担责任, 无论是因合同、严格责任还是侵权行为 (包括疏忽或其他原因) 造成的, 即使事先被告知有此类损害的可能性也不例外。

## 6 修订历史

[表1](#)总结了本文档的修订情况。

表1. 修订历史

文档ID	发布日期	说明
AN14240 v.1.0	2024年3月11日	首次公开发布

## Legal information

### Definitions

**Draft** — A draft status on a document indicates that the content is still under internal review and subject to formal approval, which may result in modifications or additions. NXP Semiconductors does not give any representations or warranties as to the accuracy or completeness of information included in a draft version of a document and shall have no liability for the consequences of use of such information.

### Disclaimers

**Limited warranty and liability** — Information in this document is believed to be accurate and reliable. However, NXP Semiconductors does not give any representations or warranties, expressed or implied, as to the accuracy or completeness of such information and shall have no liability for the consequences of use of such information. NXP Semiconductors takes no responsibility for the content in this document if provided by an information source outside of NXP Semiconductors.

In no event shall NXP Semiconductors be liable for any indirect, incidental, punitive, special or consequential damages (including - without limitation - lost profits, lost savings, business interruption, costs related to the removal or replacement of any products or rework charges) whether or not such damages are based on tort (including negligence), warranty, breach of contract or any other legal theory.

Notwithstanding any damages that customer might incur for any reason whatsoever, NXP Semiconductors' aggregate and cumulative liability towards customer for the products described herein shall be limited in accordance with the Terms and conditions of commercial sale of NXP Semiconductors.

**Right to make changes** — NXP Semiconductors reserves the right to make changes to information published in this document, including without limitation specifications and product descriptions, at any time and without notice. This document supersedes and replaces all information supplied prior to the publication hereof.

**Suitability for use** — NXP Semiconductors products are not designed, authorized or warranted to be suitable for use in life support, life-critical or safety-critical systems or equipment, nor in applications where failure or malfunction of an NXP Semiconductors product can reasonably be expected to result in personal injury, death or severe property or environmental damage. NXP Semiconductors and its suppliers accept no liability for inclusion and/or use of NXP Semiconductors products in such equipment or applications and therefore such inclusion and/or use is at the customer's own risk.

**Applications** — Applications that are described herein for any of these products are for illustrative purposes only. NXP Semiconductors makes no representation or warranty that such applications will be suitable for the specified use without further testing or modification.

Customers are responsible for the design and operation of their applications and products using NXP Semiconductors products, and NXP Semiconductors accepts no liability for any assistance with applications or customer product design. It is customer's sole responsibility to determine whether the NXP Semiconductors product is suitable and fit for the customer's applications and products planned, as well as for the planned application and use of customer's third party customer(s). Customers should provide appropriate design and operating safeguards to minimize the risks associated with their applications and products.

NXP Semiconductors does not accept any liability related to any default, damage, costs or problem which is based on any weakness or default in the customer's applications or products, or the application or use by customer's third party customer(s). Customer is responsible for doing all necessary testing for the customer's applications and products using NXP Semiconductors products in order to avoid a default of the applications and the products or of the application or use by customer's third party customer(s). NXP does not accept any liability in this respect.

**Terms and conditions of commercial sale** — NXP Semiconductors products are sold subject to the general terms and conditions of commercial sale, as published at <https://www.nxp.com/profile/terms>, unless otherwise agreed in a valid written individual agreement. In case an individual agreement is concluded only the terms and conditions of the respective agreement shall apply. NXP Semiconductors hereby expressly objects to applying the customer's general terms and conditions with regard to the purchase of NXP Semiconductors products by customer.

**Export control** — This document as well as the item(s) described herein may be subject to export control regulations. Export might require a prior authorization from competent authorities.

**Suitability for use in non-automotive qualified products** — Unless this document expressly states that this specific NXP Semiconductors product is automotive qualified, the product is not suitable for automotive use. It is neither qualified nor tested in accordance with automotive testing or application requirements. NXP Semiconductors accepts no liability for inclusion and/or use of non-automotive qualified products in automotive equipment or applications.

In the event that customer uses the product for design-in and use in automotive applications to automotive specifications and standards, customer (a) shall use the product without NXP Semiconductors' warranty of the product for such automotive applications, use and specifications, and (b) whenever customer uses the product for automotive applications beyond NXP Semiconductors' specifications such use shall be solely at customer's own risk, and (c) customer fully indemnifies NXP Semiconductors for any liability, damages or failed product claims resulting from customer design and use of the product for automotive applications beyond NXP Semiconductors' standard warranty and NXP Semiconductors' product specifications.

**Translations** — A non-English (translated) version of a document, including the legal information in that document, is for reference only. The English version shall prevail in case of any discrepancy between the translated and English versions.

**Security** — Customer understands that all NXP products may be subject to unidentified vulnerabilities or may support established security standards or specifications with known limitations. Customer is responsible for the design and operation of its applications and products throughout their lifecycles to reduce the effect of these vulnerabilities on customer's applications and products. Customer's responsibility also extends to other open and/or proprietary technologies supported by NXP products for use in customer's applications. NXP accepts no liability for any vulnerability. Customer should regularly check security updates from NXP and follow up appropriately. Customer shall select products with security features that best meet rules, regulations, and standards of the intended application and make the ultimate design decisions regarding its products and is solely responsible for compliance with all legal, regulatory, and security related requirements concerning its products, regardless of any information or support that may be provided by NXP.

NXP has a Product Security Incident Response Team (PSIRT) (reachable at [PSIRT@nxp.com](mailto:PSIRT@nxp.com)) that manages the investigation, reporting, and solution release to security vulnerabilities of NXP products.

**NXP B.V.** — NXP B.V. is not an operating company and it does not distribute or sell products.

### Trademarks

Notice: All referenced brands, product names, service names, and trademarks are the property of their respective owners.

**NXP** — wordmark and logo are trademarks of NXP B.V.

**i.MX** — is a trademark of NXP B.V.

**Intel, the Intel logo, Intel Core, OpenVINO, and the OpenVINO logo** — are trademarks of Intel Corporation or its subsidiaries.

**Microsoft, Azure, and ThreadX** — are trademarks of the Microsoft group of companies.

## 目录

<b>1</b>	<b>介绍</b> .....	<b>2</b>
<b>2</b>	<b>硬件平台</b> .....	<b>2</b>
2.1	i.MX 8M AI Robot板.....	2
2.2	Intel Realsense D455和智能车模 .....	3
2.3	硬件组装.....	4
<b>3</b>	<b>软件架构</b> .....	<b>4</b>
3.1	i.MX机器人平台架构 .....	5
3.2	i.MX vSLAM SDK架构 .....	5
3.3	软件目录树 .....	6
<b>4</b>	<b>构建和运行演示</b> .....	<b>7</b>
4.1	为Yocto项目设置构建环境 .....	7
4.1.1	下载库 (如有需要) .....	7
4.1.2	设置Git (如有需要) .....	7
4.1.3	创建Yocto构建环境.....	7
4.2	构建映像.....	7
4.2.1	从GitHub下载meta-robot-platform.....	8
4.2.2	在构建过程中添加meta-robot-platform层 .....	8
4.3	构建机器人映像 .....	8
4.4	机器人映像健全性测试 .....	9
4.5	运行i.MX AIBot导航演示.....	9
4.6	运行vSLAM ROS演示.....	10
<b>5</b>	<b>关于本文中源代码的说明</b> .....	<b>10</b>
<b>6</b>	<b>修订历史</b> .....	<b>10</b>
	<b>法律声明</b> .....	<b>12</b>

Please be aware that important notices concerning this document and the product(s) described herein, have been included in section 'Legal information'.

© 2024 NXP B.V.

All rights reserved.

For more information, please visit: <https://www.nxp.com.cn>

Date of release: 11 March 2024  
Document identifier: AN14240