Real-time Teleoperation

Product Introduction

Product Documentation

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Product Introduction
Overview

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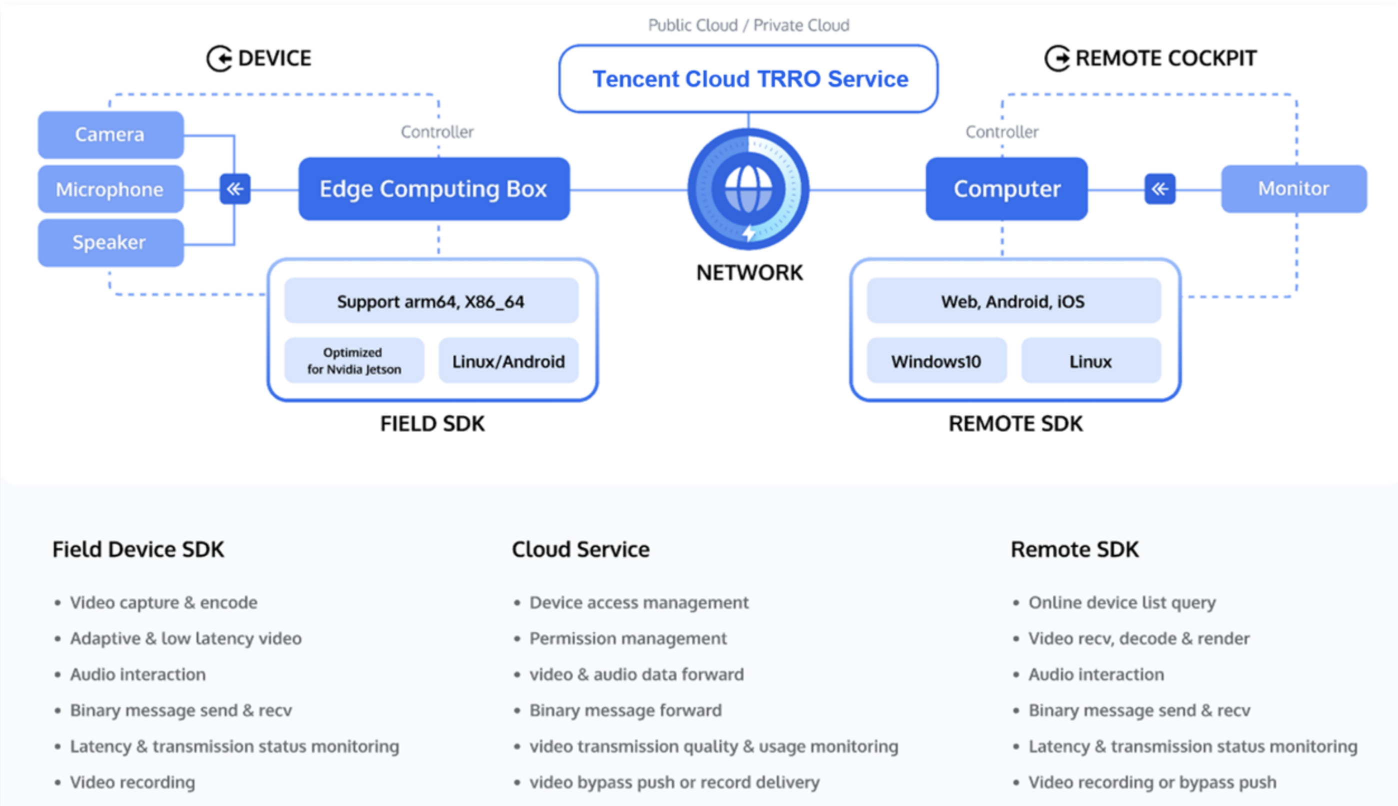
Our real-time teleoperation product (also named TRRO) is well designed for the teleoperation scenarios, e.g. autonomous driving remote takeover, remote operation in hazardous environments and online remote services. It provides video/audio transmission and status/control data interaction capabilities, and helps developers quickly build their teleoperation applications.

Architecture

TRRO provides SDKs for field devices and remote devices in teleoperation scenarios, making it easy for developers to quickly integrate SDK and connect to TRRO cloud service. Currently, SDK is available for Linux / Windows C/C++, Web, Android, and iOS platforms, and supports both aarch64 and x86_64 architecture chips. The product architecture is shown in the figure below:



Strengths

Low latency

Provides ultra-low latency audio and video transmission, greatly enhancing the remote operating experience. The video transmission and processing latency can be less than 30ms.

- Local Network Scenario:
  - Vehicle Camera: 30fps GMSL camera glass-to-glass latency can be less than 100ms.
  - Industrial Camera: 60fps USB3.0 camera glass-to-glass latency can be less than 50ms.
- Public Network Scenario(< 50ms rtt):
  - Vehicle Camera: 30fps GMSL camera glass-to-glass latency can be less than 150ms.
  - Industrial Camera: 60fps USB3.0 camera glass-to-glass latency can be less than 100ms.

The above data is tested using the stopwatch capture method in a good network environment.

Weak Network Resistance

Able to resist weak network conditions such as network latency jitter and packet loss, reduce the impact of network fluctuations, and enhance the experience and sustainability of remote control under weak network conditions.

- Packet Loss Resistance (30ms RTT)
  - 10% Packet loss, 150ms Lagging rate < 0.1%.
  - 30% Packet loss, 150ms Lagging rate < 1%.
- Bandwidth limited (30ms RTT)
  - 1Mbps Bandwidth, 1080p Video, 150ms Lagging rate < 0.1%.

The above data is tested by a weak network simulation tool in a 30ms RTT network environment. For higher packet loss rates scenarios (40%-80%), you can proactively set the FEC feature to achieve a lagging rate of 1% or lower. The lagging rate is calculated as the total lagging duration / total session duration * 100%.

Security

- Identity Security: Supports two-way authentication between devices and the cloud, device keys are managed by the customer, supports one device one key, no storage in the cloud.
- Transmission Security: End-to-end encryption of session content, one session one key with real-time DTLS negotiation.
- Permission Security: device level session permission and operation permission management, provides black and allowlist configurations and dynamic permission switching.

Multi-Path Network Transmission

Supports multi-path transmission for audio and video streams and control data streams. It can adaptively select the optimal network path and transmission mode or use multiple paths simultaneously according to various network scenarios, to ensure fluent and continuously teleoperation for the device moving under different network conditions like 4G/5G.

- Network Switching Performance
  - under 50ms RTT, network switching delay < 50ms.
  - under 50ms RTT, no visible video lagging during network switching.

The above data is tested in a multi-network environment by plugging and unplugging network cables.

Features

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Feature Overview

Features	Modules	Feature Description
Control Sessions	Field and Remote Device SDK	Establish a safe and reliable, low-latency real-time session between remote devices and field devices for real-time interaction of audio and video, status, control, and other data.
Device management	Console, TencentCloud API	Provide remote and field device creation, modification, deletion, and other actions to facilitate user device management, set authentication information, and configure device control permissions.
Session Data Viewing	Console, TencentCloud API	Provide status data statistics and detailed views of session links to help users quickly understand session quality and analyze potential link issues.

Basic Features

Features	Modules	Feature Description
Video Capture	Field Device SDK	Capture camera video via RTSP, V4L2 protocols, supports formats like mjpeg, yuyv, and h264.
Video Input	Field Device SDK	External input video image or compressed video data can be used as the transmitted video stream.
Video Session	Field and Remote Device SDK	Field device transmits video to remote equipment, supporting up to 8 simultaneous video paths per single on-site equipment.
Audio Session	Field and Remote Device SDK	Send and receive audio data, used for audio calls between field and remote equipment.
Control Transmission	Field and Remote Device SDK	Send and receive binary data, can be used for real-time interaction and sensor data control between field devices and remote devices, providing different QoS levels transmission guarantee.
Video Link Monitoring	Field and Remote Device SDK	Real-time monitoring of video link network latency, packet loss rate, frame rate, transmission bit rate, etc.

Latency Monitoring	Field and Remote Device SDK	Real-time monitoring of video transmission delay, control transmission delay, and video control closed-loop delay.
Video rendering	Remote Device SDK	Render and display video images in the specified window, providing various rendering configurations such as image, scalability method, etc.
Session Management	Field Device SDK	Automatically manage the audio and video stream transmission status based on control requirements to avoid invalid stream transmission, save bandwidth, and automatically handle network disconnection exception recovery issues.
Control Right Management	Field and Remote Device SDK	Set the control rights for field devices, providing explicit management for control right switching to avoid control risks caused by misoperations.
Audio/video storage	Field and Remote Device SDK	Local storage for control session audio/video files.
Audio/video push	Remote Device SDK	supports RTMP bypass push, which can be used for live streaming or cloud storage.

Advanced features

Features	Modules	Feature Description
High Compression Encoding	Field Device SDK	Supports AV1 high compression ratio encoding: • NVIDIA Orion Platform 1080P video can be compressed to 1 Mbps. • Built-in Tencent Self-developed Encoder (X86 Platform) 1080P video can be compressed to 500 Kbps.
Dynamic Encoding	Field Device SDK	Based on the real-time network status, the frame rate, resolution, and encoding method of the encoding can be flexibly changed to save network bandwidth, improve network packet loss resistance capability, and can be used in scenarios with extremely weak network coverage.
Error correction encoding	Field Device SDK	Supports variable-length error correction encoding, allowing flexible adjustment of encoding redundancy. The SDK provides two modes: adaptive change of error correction encoding redundancy based on real-time network status and specified redundancy.

Text overlay	Field Device SDK	Each frame can have custom text overlay for annotation or watermark, supporting Chinese and English fonts.
Local stitching	Field Device SDK	Supports local stream mixing of multiple video streams with customizable mixing layout.
Multi-network transmis sion	Field Device SDK	Supports session transmission using multiple network paths to improve transmission reliability in weak outdoor network environments, such as scenarios where a single ISP network cannot guarantee coverage. It supports control flow and video stream transmission in different modes, allowing specific multi-network transmission strategies for different weak network scenarios.
Night vision enhance ment	Remote Device SDK	Supports enhanced processing of nighttime video, with adjustable enhancement levels. Processing delay <2ms.
Super resolutio n	Remote Device SDK	Supports automatic super resolution processing for low resolution screens to match display resolution with a processing delay <2ms. In case of 2x scaling, PSNR is about 32dB compared to the original image.

Use Cases

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The Real-Time Teleoperation service helps applications establish secure, low-latency and reliable teleoperation sessions. Application developers can develop related applications based on the client SDK provided by our service. The following are some examples of teleoperation application scenarios.

Online Remote Service

With the help of teleoperation session, service staff can remotely control the offline devices, e.g. delivery robots, and provide service for their customers. Since cross-region service is supported, it may reduce the labor cost and improve the efficiency.

Delivery robot

Remotely Take Over

The AI of autonomous driving vehicle may meet some unprocessable scenarios or happen to be abnormal. In that case, the backend staff can take over the vehicle with teleoperation and handle the problem.

Driverless park minibus

Driverless mining truck

Driverless port truck

Tough Environment Operate

Machinery operators can be far from the tough work site, and operate the machinery equipement with teleoperation applications in the remote comfortable office. In this manner, the work experience and safety can be significantly improved.

Excavator