Bansilal Ramnath Agarwal Charitable Trust's
Vishwakarma Institute of Technology
(An Autonomous Institute affiliated to
Savitribai Phule University)
Department of Information Technology

IT Bulletin December 2024

Powering the Future of AI-Enabled Medical Devices with NVIDIA Holoscan and RTI Connext

Vishwakarma Institute of Technology, Pune – Welcome to the December 2024 edition of the IT Bulletin on AI-Enabled Medical Devices! In this monthly publication, we're excited to bring you the latest advancements and insights into the world of artificial intelligence and medical technology.

Today's featured topic explores "Powering the Future of AI-Enabled Medical Devices with NVIDIA Holoscan and RTI Connext."

Introduction

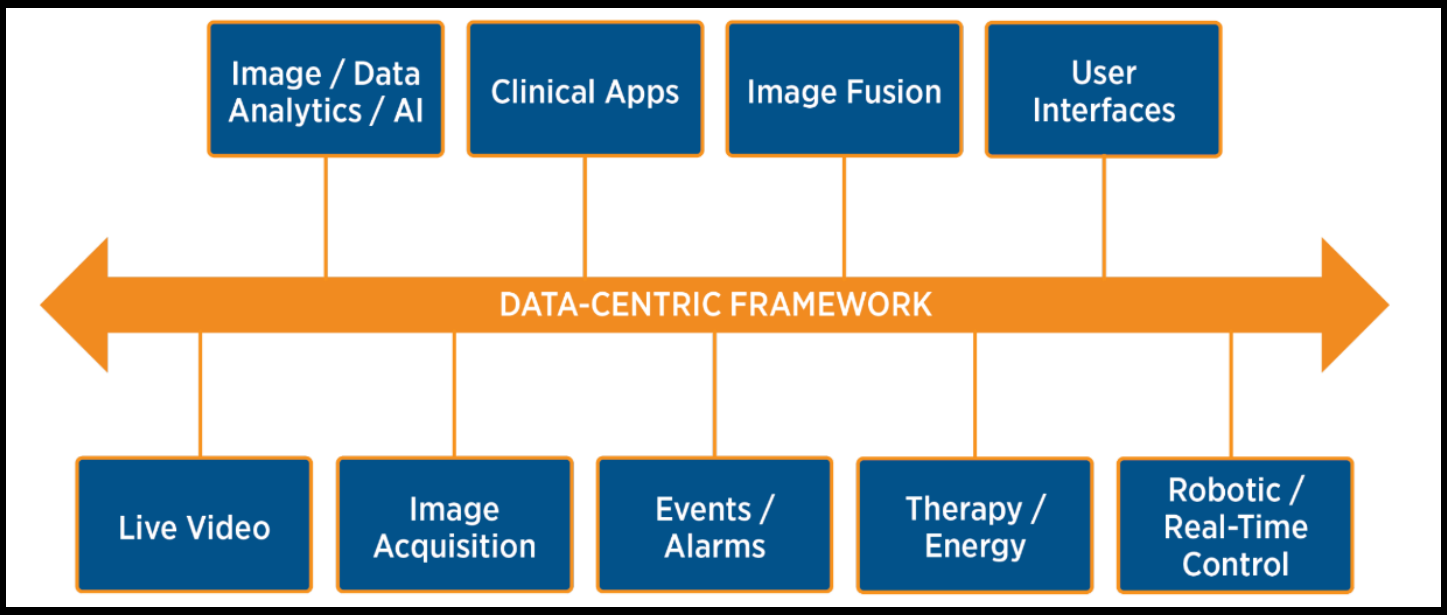
In today's rapidly evolving healthcare landscape, the demand for real-time insights and autonomous decision-making is reshaping medical practices. Leveraging advancements in edge AI technology, healthcare systems are poised to deliver more precise treatments, enhance patient outcomes, and optimize operational efficiency. This transformation extends to the operating rooms of the future, where AI-enabled devices are seamlessly interconnected, enabling immediate access to comprehensive patient data, surgical insights, and real-time decision-making capabilities.

Central to this evolution is the integration of software as a medical device (SaMD), which must adhere to stringent performance and latency requirements while operating within complex, distributed healthcare environments. Achieving efficient data connectivity and exchange across diverse sensors, displays, and applications is critical for maintaining reliability and security without compromising speed or performance. This post explores how the combination of NVIDIA Holoscan and RTI Connext addresses these challenges, offering developers a robust framework for creating AI-powered medical applications.

RTI Connext for real-time, data-driven connectivity

RTI Connext, built on the Data Distribution Service (DDS) standard, facilitates seamless connectivity in complex, scalable systems by providing a distributed, real-time communication framework. When integrated with Holoscan applications, Connext enables easy connection to distributed data sources and applications, reducing both overhead and the complexity of achieving necessary performance, security, and reliability in healthcare environments.

Connext enables real-time data exchange across intricate system components while meeting high standards for reliability, cybersecurity, and performance. It supports low-latency processing, analysis, and action on large volumes of real-time data in a resilient, fault-tolerant setup with no single points of failure. This framework allows medical systems to self-form, self-heal, and meet the demands of distributed, intelligent surgical systems through customizable quality of service options. Additionally, Connext incorporates features like automatic discovery and robust security measures based on the DDS Security standard, ensuring authentication, encryption, security logging, and fine-grained access control. These capabilities safeguard critical systems from breaches and meet the cybersecurity regulations imposed by agencies like the FDA.



Integrating NVIDIA Holoscan and RTI Connext

Today's healthcare systems are built on legacy infrastructure that wasn't originally designed for AI capabilities, and many medical devices don't natively support platforms like NVIDIA Holoscan. These systems still rely on complex networks of sensors, actuators, and control systems, which can make modernization a challenge. By integrating RTI Connext with Holoscan, developers can breathe new life into these legacy systems, turning them into AI-enabled, software-defined devices. Holoscan can act as a companion module, or "sidecar," adding advanced AI functionality even to devices without built-in support. For example, Holoscan can enhance existing Windows-based medical imaging equipment or

bring AI into robotic surgery systems that run on real-time operating systems (RTOS). Even simpler devices, like patient monitors, can benefit from Holoscan's AI capabilities without being held back by older hardware or software.

Through its interoperability with RTI Connext, Holoscan allows for real-time communication and data exchange with these legacy systems in a seamless and scalable way. It also provides a robust, GPU-accelerated framework that enables AI-powered workflows to run smoothly in modern healthcare environments, where fast data processing and low latency are critical. With RTI Connext, Holoscan applications can integrate easily into distributed healthcare systems, minimizing the complexity of development while ensuring high standards of performance, reliability, and security. In fact, in many cases where Connext is already in use, developers can introduce AI workflows powered by Holoscan without making any major changes to the existing infrastructure.

Example Holoscan application with RTI Connext integration

- **Overview**:

The example demonstrates a Holoscan application functioning as a sidecar system, where video frames are read from a DDS databus

using RTI Connext, processed through a Holoscan workflow, and then published back to the databus for display on another device.

- Common Healthcare Scenario:

The use case addresses a typical setup in healthcare, where multiple sensors capture data, and the aggregated information is displayed on a monitoring system. AI-powered Holoscan workflows can be integrated into this data pipeline with minimal modifications to existing systems, even when Holoscan isn't natively supported. RTI Connext ensures seamless communication between components.

- Core Components:

The Holoscan DDS video streaming operators, available via GitHub in nvidia-holoscan/holohub, enable real-time reading and writing of video frames on a DDS databus, allowing efficient integration.

- Applications Demonstrating the Use Case:

- **dds_video**: Captures frames from video devices (e.g., USB cameras) and publishes them to the DDS databus or renders frames from DDS to a display through Holoviz.
- **body_pose_estimation**: Modified to receive video frames from DDS, apply body pose estimation, and publish processed frames (with overlays) back to DDS.

- Process Flow:

1. The dds_video application captures video from a camera and publishes it to the DDS databus.
2. The body_pose_estimation application processes the video, adding a body pose estimation overlay, and sends the results back to DDS.
3. A second dds_video application reads the processed frames and renders them for display.

- Advantages:

- **Seamless AI Integration**: Allows AI workflows to be added to legacy healthcare systems with minimal changes.
- **Scalability**: Can be implemented across distributed systems, as each process can run on any discoverable system within the same DDS domain.
- **Real-Time Processing**: Enables real-time video processing and data exchange between devices.
- **Flexibility**: Works even on non-NVIDIA platforms where Holoscan isn't natively supported, such as Windows-based systems or real-time operating systems (RTOS).
- **Minimal Overhead**: The integration of AI capabilities through a sidecar reduces the complexity of upgrading legacy systems.

- Disadvantages:

- **Network Dependency**: Requires a multicast-capable network and proper system discovery, which could be a limitation in certain network environments.

- **Potential Latency**: While optimized for real-time processing, system performance could be affected by network speed or data handling capabilities, introducing latency in some cases.
- **Compatibility**: The need for RTI Connext DDS setup and specific hardware configurations may limit implementation in highly heterogeneous environments.
- **Resource Intensive**: GPU-accelerated processing requires significant computational resources, which may not be available on lower-end or outdated devices.
- **Setup Requirements**: Users should consult the HoloHub DDS Operators documentation for details on RTI Connext setup, and refer to the Body Pose Estimation documentation for application building and running instructions under the DDS Support section.

References

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