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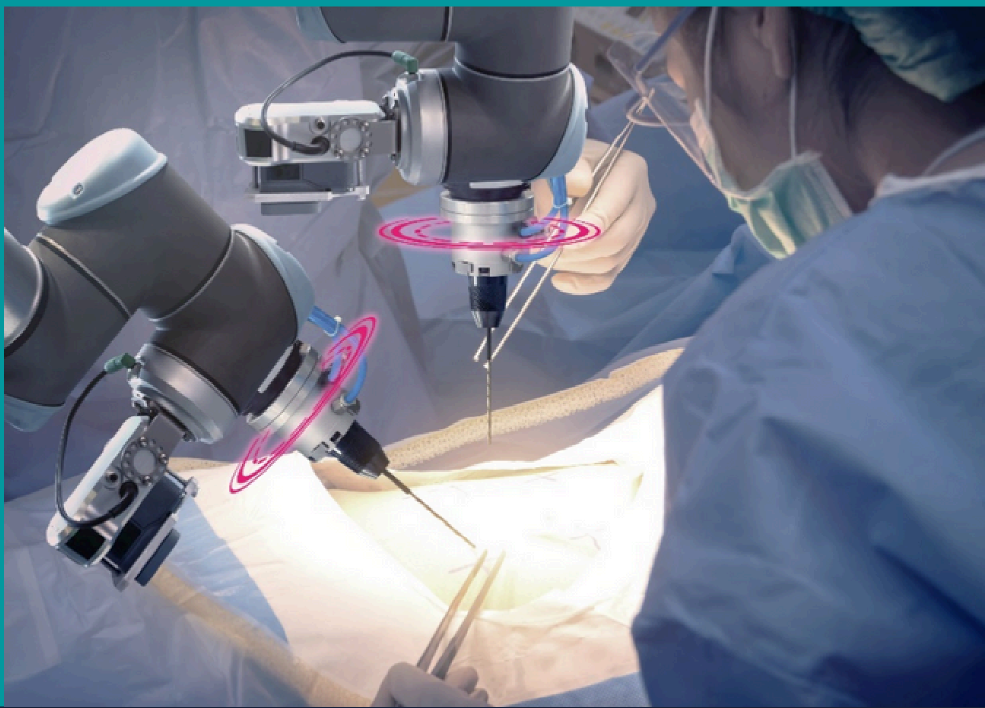

TACKLING REAL-TIME SURGICAL VIDEO ANALYTICS IN NEARDATA

By Raúl Gracia (Dell Technologies)

The National Center for Tumor Diseases (NCT) in Germany is one of the key clinical partners in the NEARDATA project, contributing a use case focused on computer-assisted surgery. In laparoscopic and robotic procedures, NCT collects high-resolution video streams from endoscopic cameras to support AI-assisted decision-making. These streams are used to detect surgical tools, segment anatomical structures, and classify procedural phases — all in real time. However, the volume, sensitivity, and latency requirements of this data make it a textbook example of an “extreme data” use case, and a strong candidate for near-data processing solutions.

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Part I: Real-Time Surgical Video Processing and Storage

Surgical video data is continuous, high-bandwidth, and latency-sensitive. During procedures, AI models must process frames in real time to provide guidance — for example, identifying liver tissue or detecting the presence of surgical instruments. Traditional storage systems often introduce delays that compromise responsiveness, and scaling to multiple concurrent video streams further strains infrastructure.

In NEARDATA, we leveraged **Pravega**, a tiered streaming storage system developed by Dell Technologies, with GStreamer to build a real-time analytics pipeline. AI models were containerized and deployed as GStreamer plugins, enabling frame-by-frame inference and fast IO. Benchmarks showed that Pravega sustained multiple parallel writers and readers with end-to-end latency below 15 milliseconds, even at bitrates of 5–20 Mbps — suitable for intraoperative use.

Part II: Semantic Search in Stream Video Data

Once video data is stored as a data stream, another problem arises: how to find specific moments or scenes without relying on manual annotations or metadata. Surgeons and researchers often need to locate clips showing particular tools, anatomical structures, or procedural phases — but traditional search methods fall short.

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In NEARDATA developed StreamSense, a semantic video search system that uses AI models to generate vector embeddings from video frames. These embeddings are indexed in a vector database, enabling image-based queries across the archive. StreamSense supports both intra-video and inter-video search, and its two-level indexing strategy ensures scalability. In tests, it delivered results with latency under 30 milliseconds and reduced data ingestion for AI training by over 80%, allowing models to be trained on just the relevant fragments.

Part III: Scaling Embeddings Indexing on Object Storage

As the volume of video data and vector embeddings grew, scalability became a bottleneck. Traditional vector databases may struggle in terms of elasticity, scalability and cost, especially for sparse and/or bursty workloads. Maintaining performance while controlling infrastructure costs became a key concern.

The team designed a serverless vector DB built on top of Function-as-a-Service (FaaS) and using a block-based partitioning for storing and indexing groups of vector embeddings as data objects. This architecture distributes data and compute load across stateless FaaS functions, supporting automatic and fast autoscaling. Compared to clustering-based methods, it achieved up to 65× faster indexing and reduced costs by up to 99% for sparse workloads.

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A Clear Example of Applied Research Impact

The collaboration between NCT and research partners (e.g., Dell Technologies, URV) within NEARDATA exemplifies how advanced research can directly address real-world problems. By combining streaming storage, AI inference, semantic search, and serverless architectures, the team built a system that not only meets the technical demands of surgical video analytics but also improves productivity and usability. This use case stands as a strong example of how targeted research and engineering can translate into tangible improvements in healthcare technology.

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