LightDB
A Database System for Virtual, Augmented, & Mixed Reality Video Applications
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Spherical Panoramic Images

Spherical Panoramic (360°) Videos

Light Fields
What happens here?

Key Features:
• Data management system for VR/AR/MR video applications
• Unified data model for panoramic (360°) and light field video
• Declarative queries with automatic optimization
• Full stack: data ingest, processing, and real-time streaming

Key Results:
• Decreased development complexity (~ 1/10 LOC)
• Increased performance (up to 4x for real-world workloads)
• Reduced client bandwidth & power requirements

Today:
1. LightDB Data Model
2. Physical & Logical Algebra
3. Architecture & Optimizer
4. Application: Predictive 360° Streaming
The Light Field Data Model

Light field data model
\[ F(x, y, z, t, \theta, \phi) \]

Panoramic Image

\[ F(0, 0, 0, 0, \theta', \phi') = \text{green} \]

360° Videos

\[ F(0, 0, 0, t, \theta', \phi') = \text{orange} \]

Light Field Data Model
\[ F(x, y, z, t, \theta, \phi) \]

\[ F(0, 0, 0, 0, \theta, \phi) = \text{red} \]

Spherical Images

\[ \text{Angle (\theta, \phi)} \]

360° Videos

\[ \text{Angle (\theta, \phi), Time (t)} \]

Light Fields

\[ \text{Angle (\theta, \phi), Time (t), Position (x, y, z)} \]
Light field data model

\[ F(x, y, z, t, \theta, \phi) \]

Light Fields

\[ F(0, 0, 0, t, \theta, \phi) = \text{red} \]
\[ F(0, 0, 0, t, \theta, \phi) = \text{green} \]
\[ F(0, 0, 0, t, \theta, \phi) = \text{orange} \]

LightDB Model

User \rightarrow \text{Query} \rightarrow \text{Query}

Light Fields

\[ F(x, y, z, t, \theta, \phi) \]

2D Videos, Geometric Models, ...

LightDB Algebra

\text{PARTITION}(\Delta y)

\text{SELECT}\left[\left\{ x_1, y_1, z_1, t_1, \theta_1, \phi_1 \right\}, \left\{ x_2, y_2, z_2, t_2, \theta_2, \phi_2 \right\}\right]

\text{MAP}\left(\theta, \phi \rightarrow \left(\frac{\theta}{2}, \frac{\phi}{2}\right)\right)

LightDB Query Language

\text{Decode}(\text{INPUT}.\text{MP}4) \gg \text{Union}(\text{Scan}(\text{watermark})) \gg \text{Map}(\text{GRAYSCALE}) \gg \text{Encode}(\text{HEVC}) ;

的实际C++语句！

Logical Plan

Copyright

Actual C++ statement!
Watermark Query Performance

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<th>FPS</th>
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LightDB Architecture

Gaussian Blur FPS

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GPU-Based Map Operator @ 4K

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Homomorphic Tile Union Operator @ 4K

Preconditions:
- HEVC Codec with Tiles
- Non-Overlapping Union
- Temporal Alignment

LightDB Application: Predictive Panoramic Tiling

Adaptive Streaming (HLS, DASH, ...)

Predicted Orientation Bitrate = 2000 kbps
Predicted Orientation Bitrate = 2000 kbps
Adjacent Tile Bitrate = 500 kbps

No one looks at the ground!
Bitrate = 50 kbps
Adjacent Tile Bitrate = 500 kbps

Current VR Video Applications

LightDB Queries

Decode(rtp://…)
>> Partition(Time, 1)
>> Partition(Theta, 90°)
>> Partition(Phi, 45°)
>> Transcode(𝑓)
>> Store(output);

Logical Plan

Physical Plan
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