Holographic Angular Slice 3D Display

Third Dimension Technologies

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Third Dimension Technologies

- **Located** in Knoxville, Tennessee
- **Products**
  - Digital Holography (measurement with holograms)
  - Holographic Angular Slice 3D Display (HAS3D)
  - Deployable Flight Training Simulators
- **Team**
  - **C. E. (Tommy) Thomas, PhD** (MIT) – CTO
  - **Steve Kelley -** Software Engineering
  - **Paul Jones -** Business Development
  - **Andrew Smith -** Physics Technical Support

Dr. Thomas

Mr. Jones

Mr. Smith

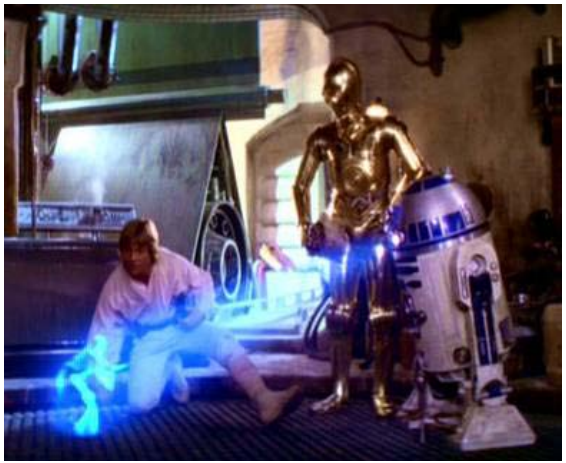
Mr. Kelley

Presentation Outline

- Electronic Holographic Stereography
  - Holographic Angular Slice 3D Display (HAS3D)
- Problems of 3D Frames Rendered for 2D Displayed on a True 3D Display
- Thoughts on an SMFoLD Standard

Forms of Holography

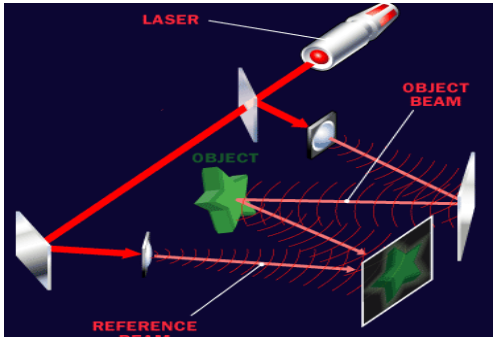
Very Difficult
Ionizing Air



Display Requires: R2D2
When: Long, Long Time…

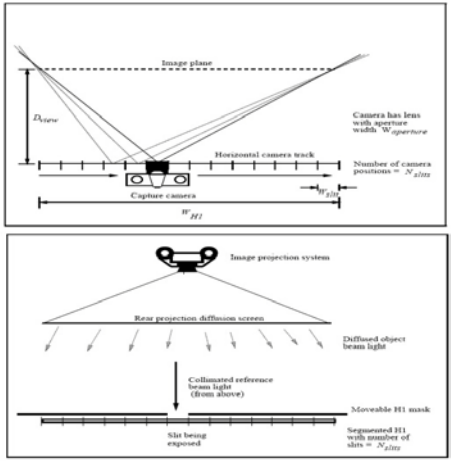
Difficult
Diffractive Holography

$$\lambda = 2d \sin\left(\frac{\theta}{2}\right)$$



10 to 500 TeraPixels
20 years or more

Much Simpler
Holographic Stereogram



-Halle, SPIE 1994.

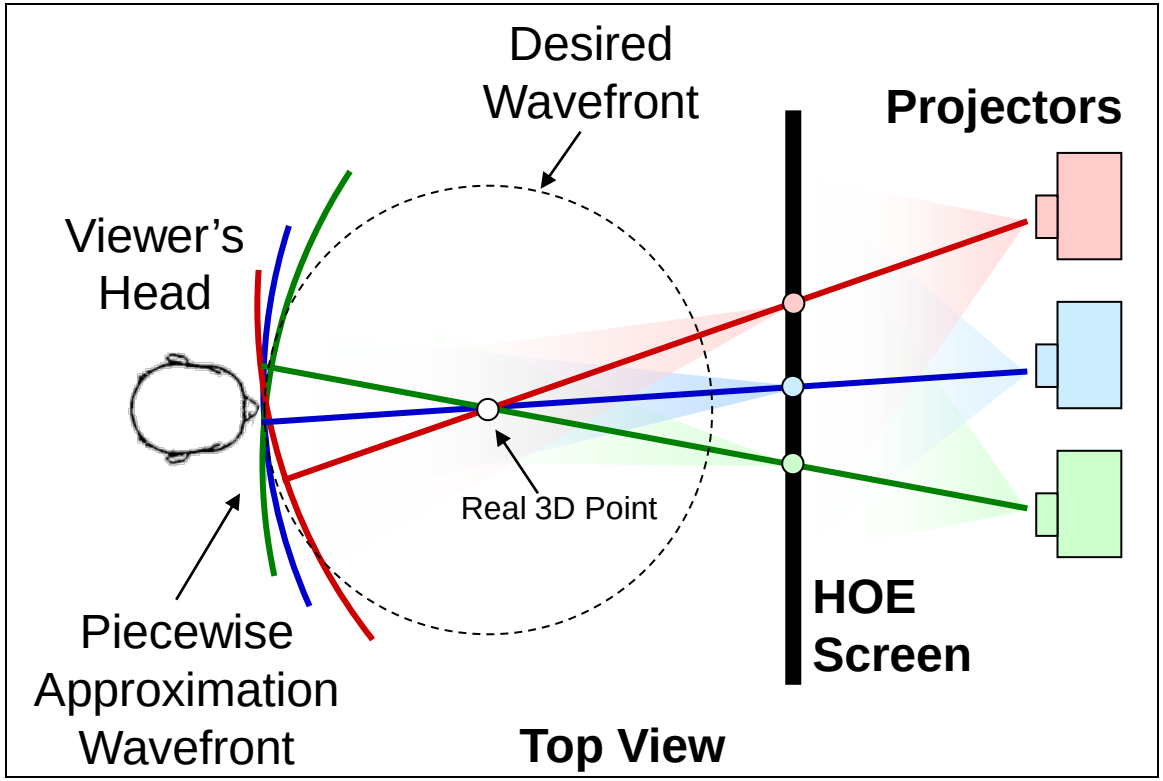
20 to 100 MegaPixels
TDT Today!

Holographic Angular Slice 3D Display (HAS3D)

- Array of Projectors
- Holographic Optical Element (HOE) Screen

Twenty-Three Projector Array

Electronic Holographic Stereogram



Holographic Optical Element (HOE)

1° horizontal diffusion
90° vertical diffusion

Projector Spacing

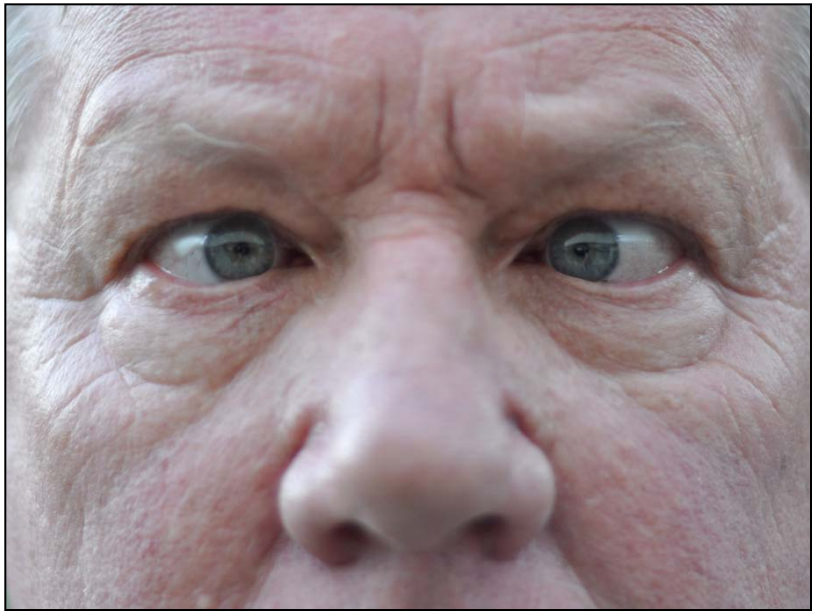
~1° horizontally

ALL Human Visual Cues

Accurately reproducing all human visual cues eliminates problems caused by vergence-accommodation conflicts.

Eyes point (vergence) and focus (accommodation) at the actual 3D spatial point.

No headaches, sickness or visual fatigue (asthenopia)!



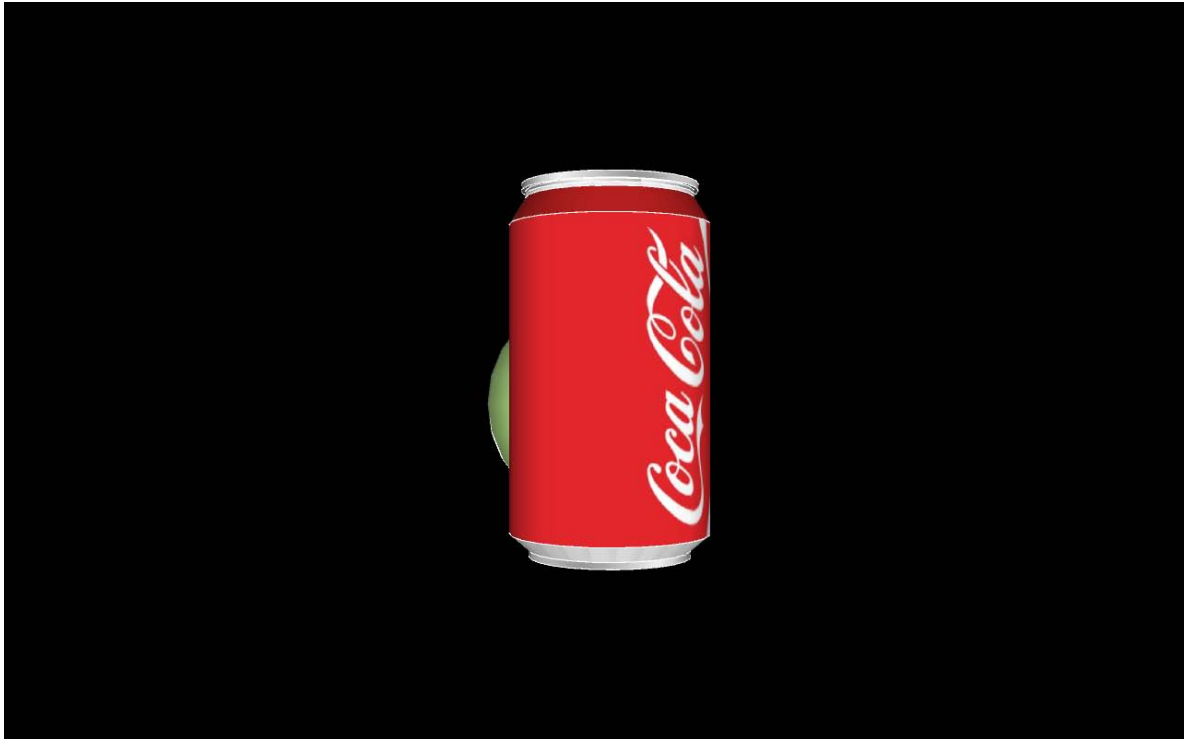
HAS3D Horizontal Parallax

Move Left

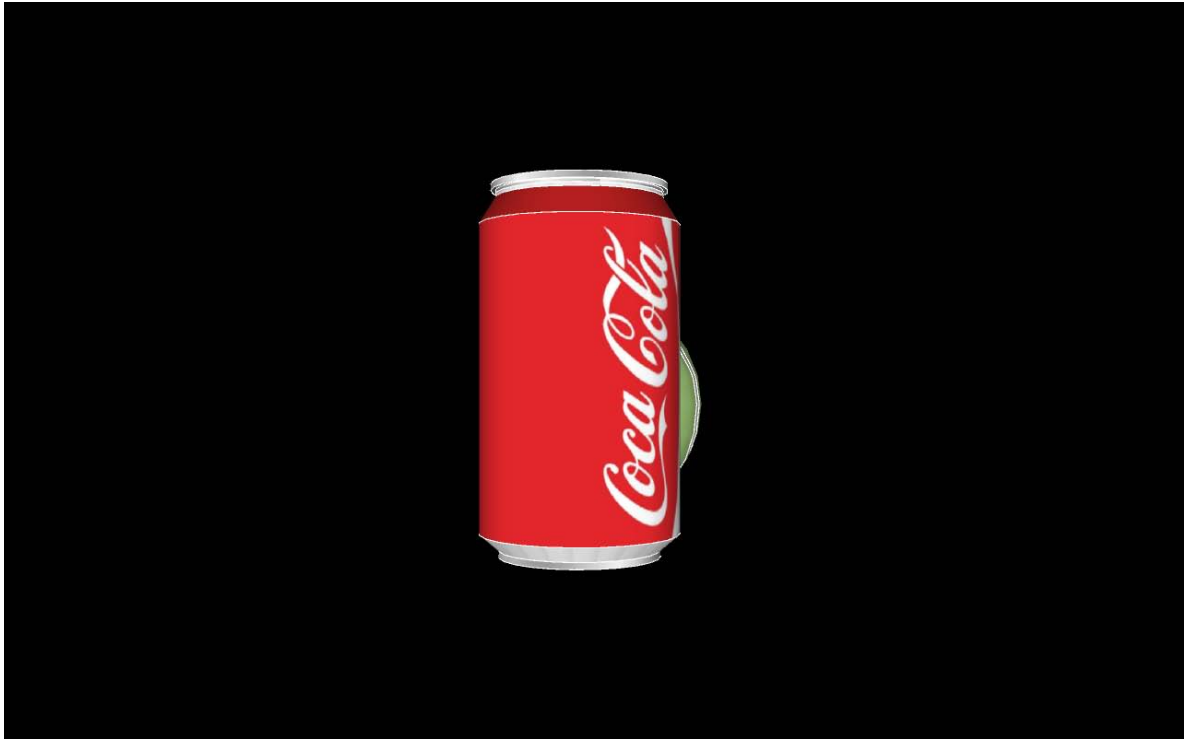
Move Right

Change position to view objects from different perspective.

Left View Look-Around

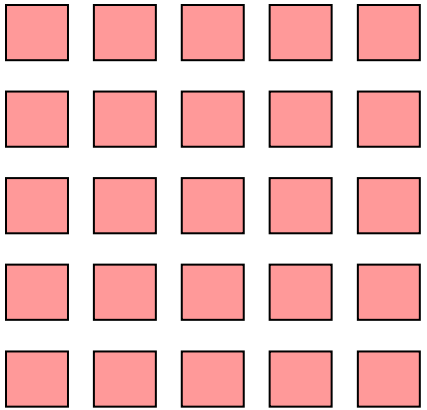


Right View Look-Around



Full Parallax vs Horizontal Parallax

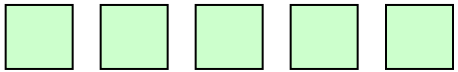
Full (Horizontal & Vertical) Parallax



N^2

Cost and complexity increase exponentially with angular field of view!

Horizontal Parallax



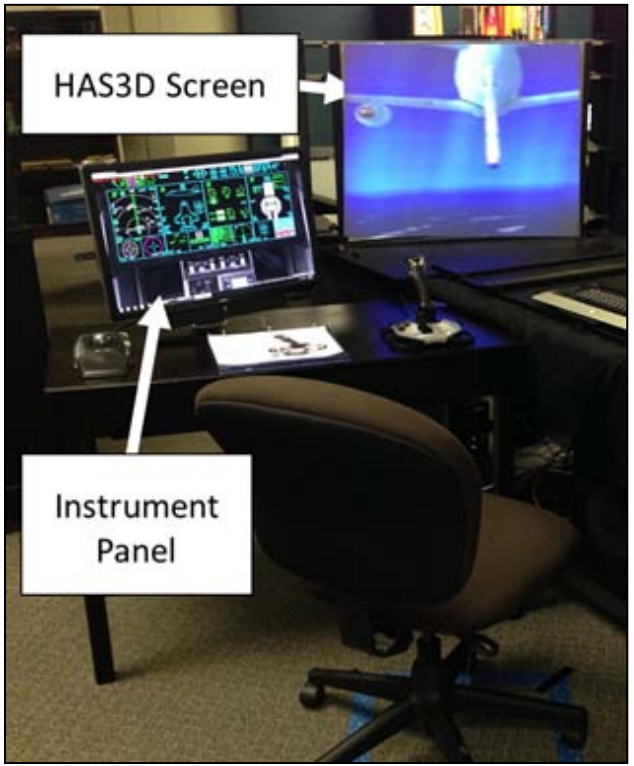
N

Cost and complexity is linear!
Reduces cost and complexity significantly.

Human Eyes are Separated Horizontally!

12 Channel 3D Display

- 12 Inexpensive Pico-Projectors
- Single Gaming Computer
  - Three Graphics Cards
- 12 Inch Horizontal Viewing Box
  (horizontal parallax only, 90-deg vertical)
- Full Screen View in Viewing Box



HAS3D Flight Simulator

Lockheed Martin Game-Based Software

PREPAR3D®

High Fidelity Controls & PCD

Pico-Projector Array

70” Curved 3D Light Field Display

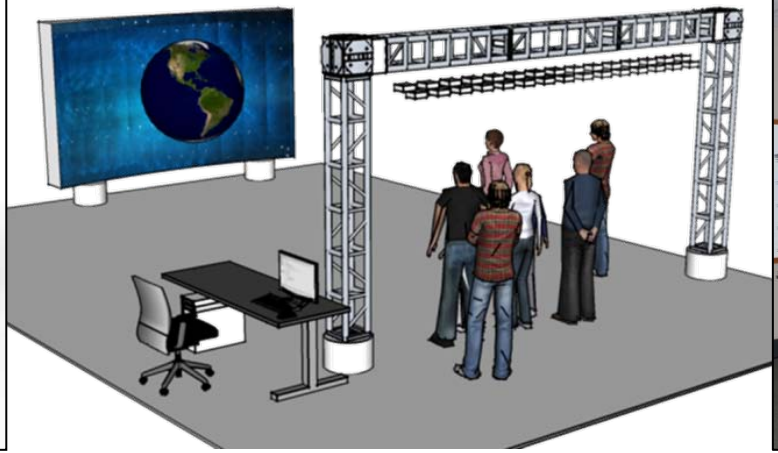
Image Generator & Electronics

Flight Sim Video

- Third Dimension Technologies Shows Improved Light Field Display at IITSEC 2015

Current Projects

Anatomy Table
National Institutes of Health



Virtual Trainer
Major Defense Contractor

Flight Simulator
Air Force

HAS3D True 3D Display

- No Glasses or Eye-Tracking Required
- Stereopsis and Motion Parallax
  - *Multiple perspective views*
  - *Move head to see around objects*
- Continuously Blended 3D Views
  - *No dead zones or image flipping*
- No Vergence-Accommodation Conflicts
  - *No discomfort with prolonged use*
- Resolution (1.5Mp/eye) Brightness (5100 lm)
- Scalable to Theater Sized Screens
- HPO Faster & Less Costly than Full-Parallax

BioDigital Human and
30”x24” Curved HAS3D Display

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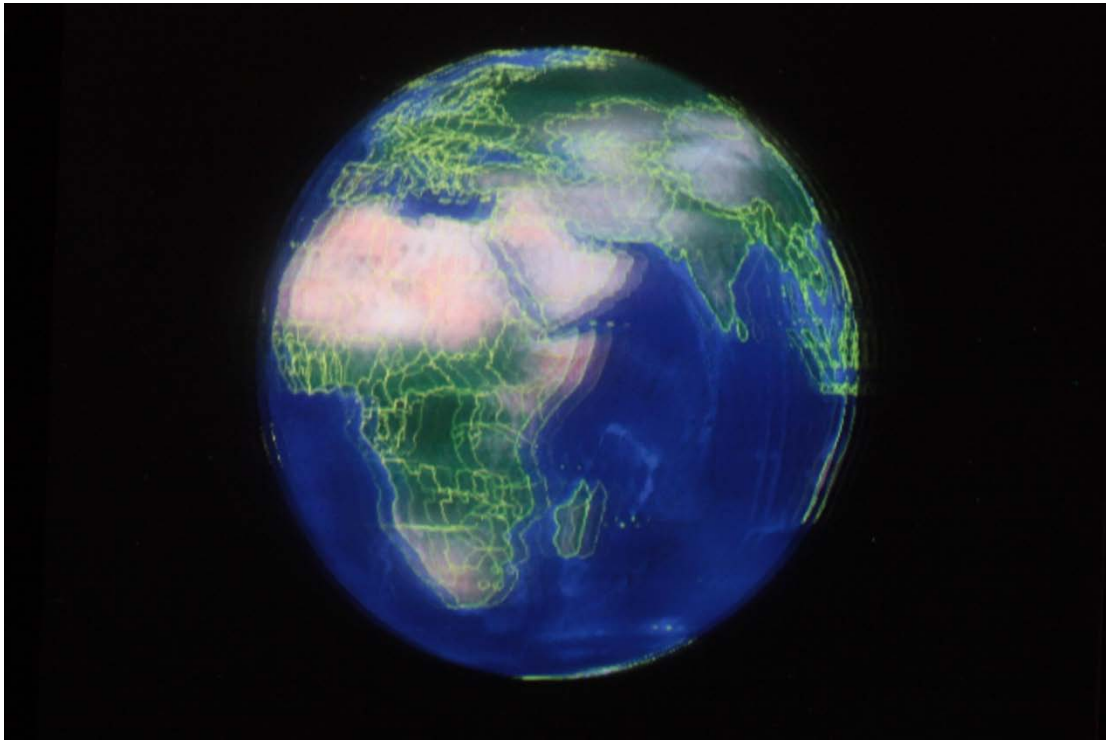
- **Problems of 3D Frames Rendered for 2D Displayed on a True 3D Display**
- Thoughts on an SMFoLD Standard

A 3D Display Challenge

- 3D Frames Rendered for 2D Screens Generally Look Awful on 3D Displays

3D Rendered for 2D



Google Earth data: Google, SIO, NOAA, US Navy, NGA, GEBCO

Modified for True 3D Display

Google Earth data: Google, SIO, NOAA, US Navy, NGA, GEBCO

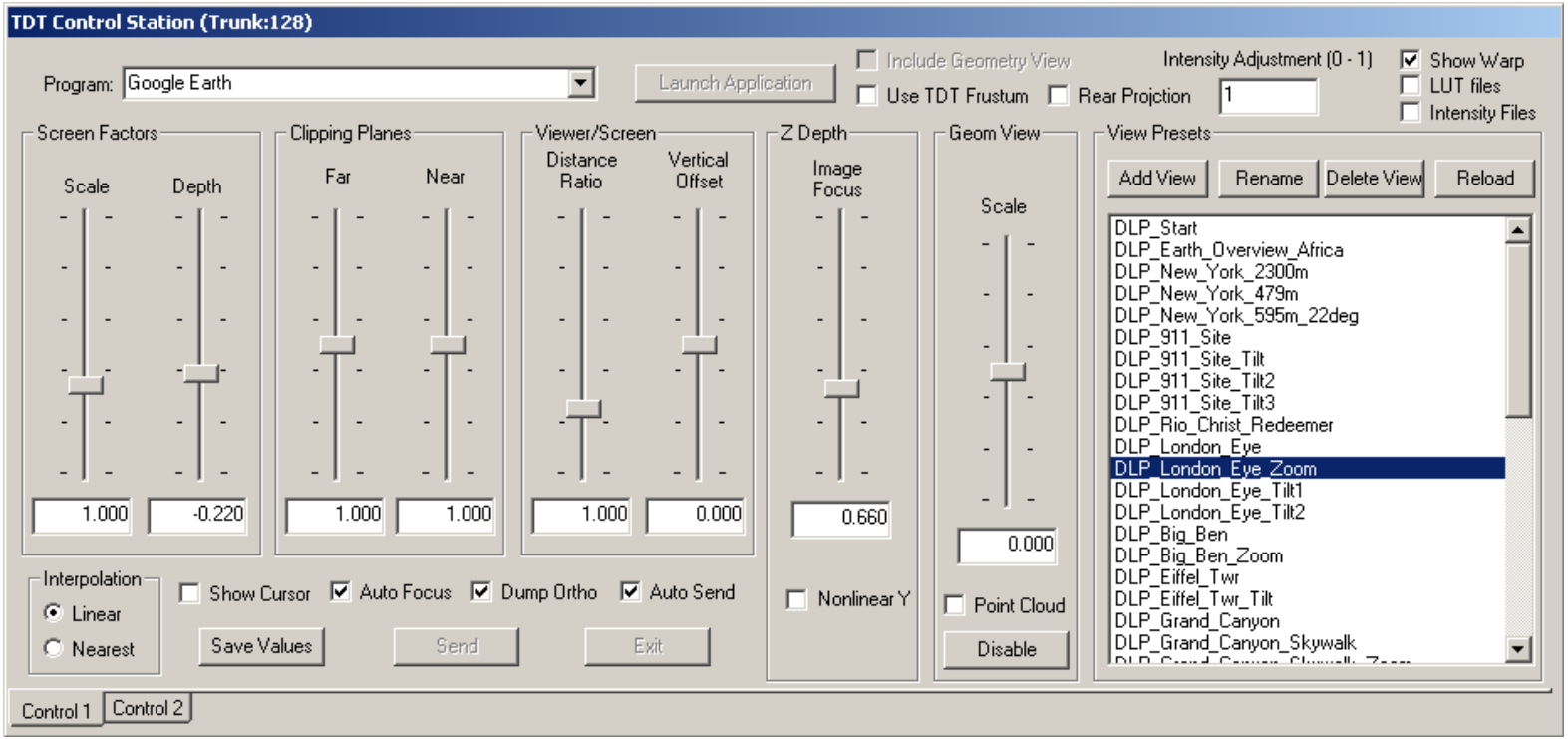
3D Rendered for 2D

Google Earth data: Google

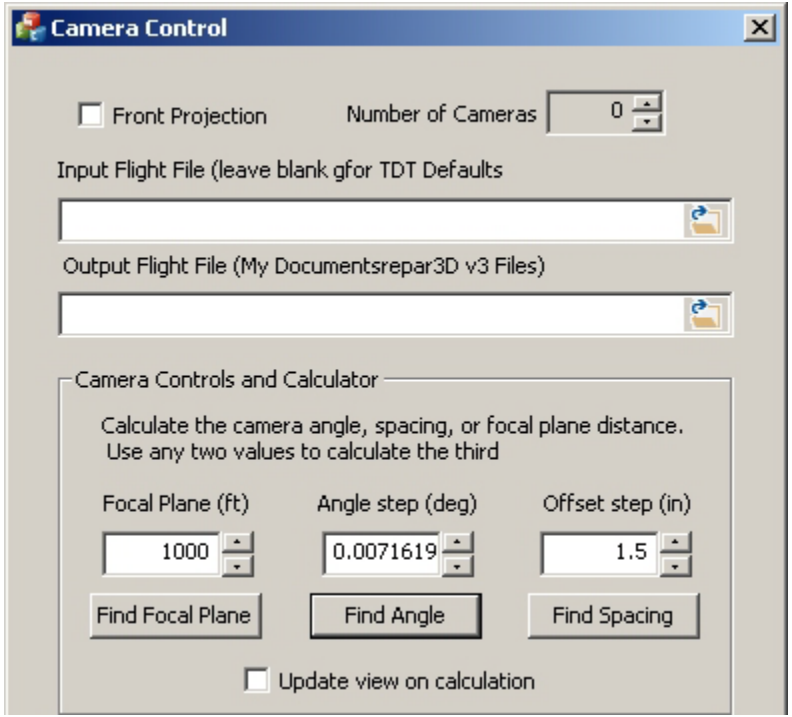
Modified for True 3D Display

Google Earth data: Google

TitaniumGL (TiGL) Control Station



Prepar3D Flight Sim 3D Camera Control



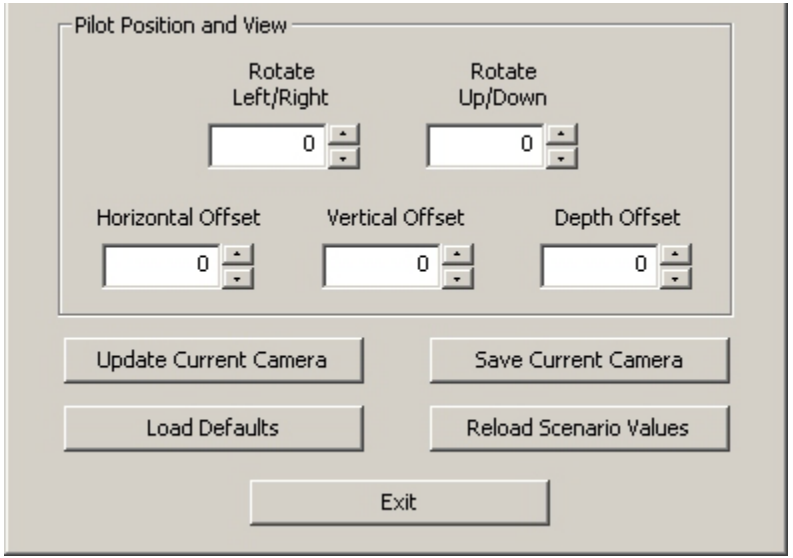


Photo of Flight Simulator Image

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HAS3D Current Data Model

- Frame Information Needed to Create View Geometry
  - Relationship between data, focal plane, and viewer
    - To create focused view with correct parallax and depth of field
- Geometry Parameters
  - Set focal plane, depth of field, and parallax
  - Majority of data must fall within focal range of display
  - Geometry calculated from average depth and range
- 3D Source Applications Don’t Provide Adequate Data
- TiGL™ Adjusts for Missing 3D Metadata

HAS3D SMFoLD Focus MetaData Model

- Metadata needed to produce in-focus HAS3D view (provide units, or all units the same!)
  - The average depth of the data in the region of interest
  - Desired focal plane distance
  - Data range
    - Nearest point that should be included in the focal range
    - Farthest point that should be included in the focal range.

Example 3D Frame Sizes and HAS3D Frame Rates

Program	Description	Single 3D Frame Size (bytes)	HAS3D FPS
Google Earth, TiGL, 22 ch	Grand Canyon (static terrain scenery)	658,726	N/A
Google Earth, TiGL, 22 ch	New York City from 490 meters (static)	5,774,446	N/A
Google Earth, TiGL 22 ch	Spinning Globe	2,049,837	92
Poles, TiGL 22 ch	20 generated spinning cylinders	1,248,427	185
3D Fish, TiGL 22 ch	3D Aquarium with animated fish	4,279,805	54
Prepar3D, TiDX 12 ch	Scenery settings at highest levels	29,157,256	22
Prepar3D, TiDX 12 ch	Scenery settings at lowest levels	27,827,878	28
Prepar3D, TiDX 12 ch	Scenery settings at intermediate levels	28,492,567	25

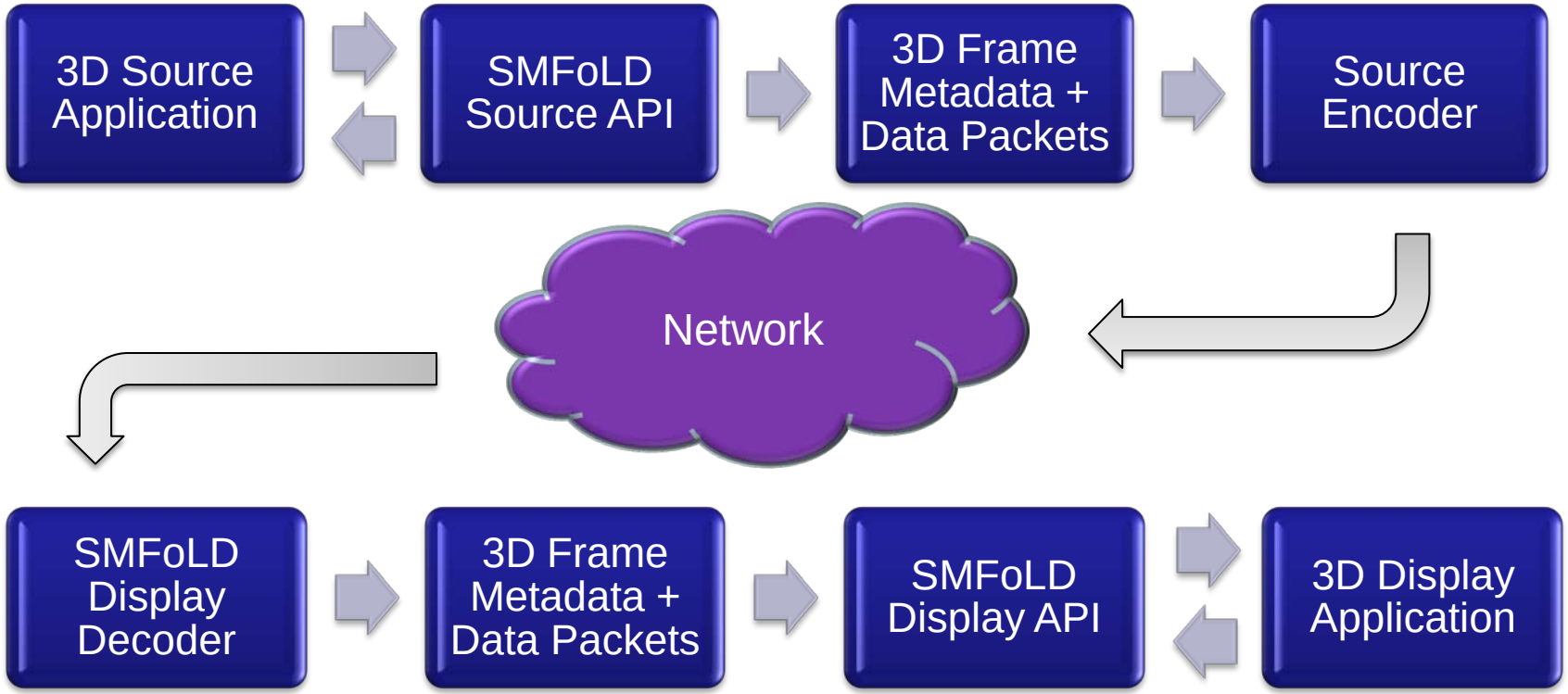
Source Data Challenge

- Many Forms of Source Data
  - Mesh data with textures
  - Point clouds
  - Light field (plenoptic)
  - Etc.
- Depth is Explicit or Derived from Data
  - Explicit with mesh (easy for HAS3D)
  - Calculated for plenoptic light-field data (difficult for HAS3D!)

HAS3D Display Desired Frame Format

- Stream of Complete 3D Data Frames of Graphics Primitives
  - API extensions for metadata
  - API extensions for plenoptic data type
    - Must be converted to volumetric data for HAS3D!
  - Video data converted to
    - RGB + depth (multiple streams) or
    - Converted to object descriptions or
    - Sparse array of video streams (HAS3D interpolated)

Possible SMFoLD Flow Model



Source End Questions

- Should source application be forced to create a common 3D frame format?
  - Or does SMFoLD API provide converters?
  - Or does SMFoLD transmit different 3D frame types?

Display End Questions

- If a common format is transmitted, do we force the display application to accept it?
  - Or provide converters?
- If multiple formats are transmitted, should we assume that the display can accept the transmitted format (handshaking?)?

3D Frame Types Question

- If different 3D frame types, then what data types should be included?
  - Plenoptic light field, point cloud, CAD, medical, etc?
  - What is the minimum number needed?

End

- Questions or Comments?

Potential Solution

- Define APIs that application calls to create graphics primitives.
- Converter takes in various data formats and uses API to standardize output.
- Stream contains graphics primitive types followed by associated data.
- Primitives contain items such as color, 3D points, arrays of vertices, etc.

Potential Solution (2)

- Bitmap data supported.
- Metadata to set up scene, i.e. focal plane distance, angular field of view etc.
- Metadata used by display to set focus.
- All information to create 3D scene handled in this way.