

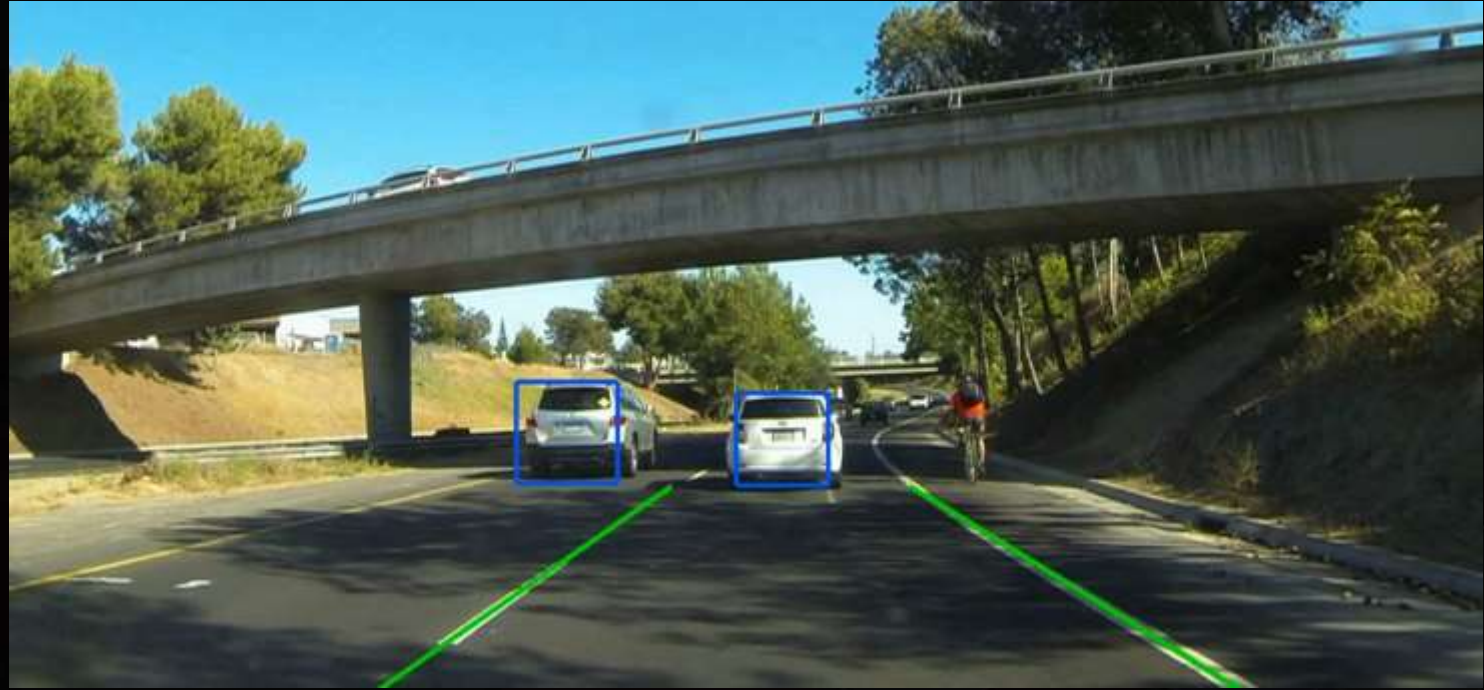
Visualizing a Car's Camera System

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Computer Vision for Automotive

Previously, NVIDIA GPUs:
All things graphics
in the car





Goal:
Driver Assistance

and, ultimately:
autonomous driving!

INTRODUCING NVIDIA DRIVE™ PX

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Dual Tegra X1 ● 12 camera inputs ● 1000 GPix/sec

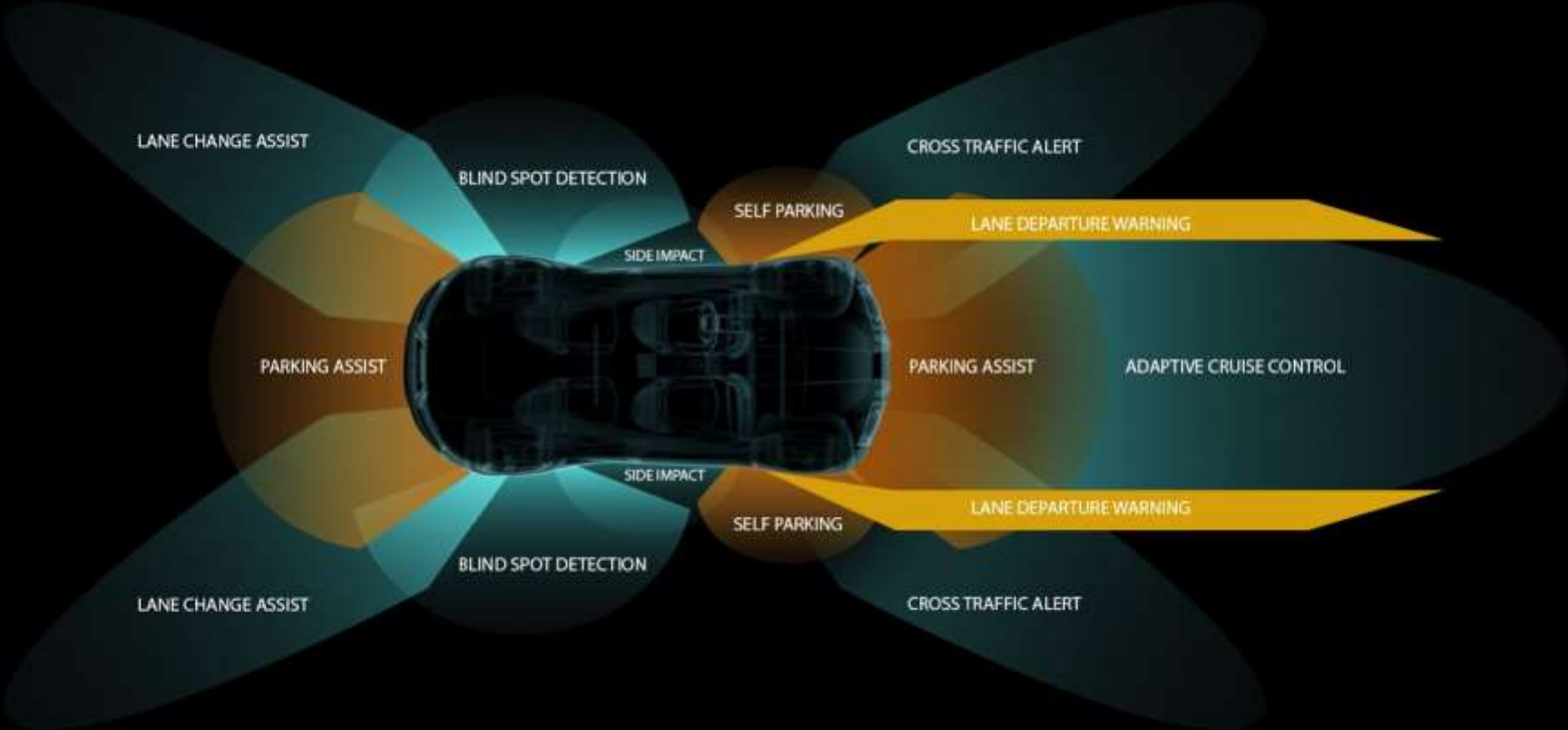
- ▶ 2.3 Teraflops mobile supercomputer
- ▶ Surround Vision
- ▶ Deep Neural Network Computer Vision



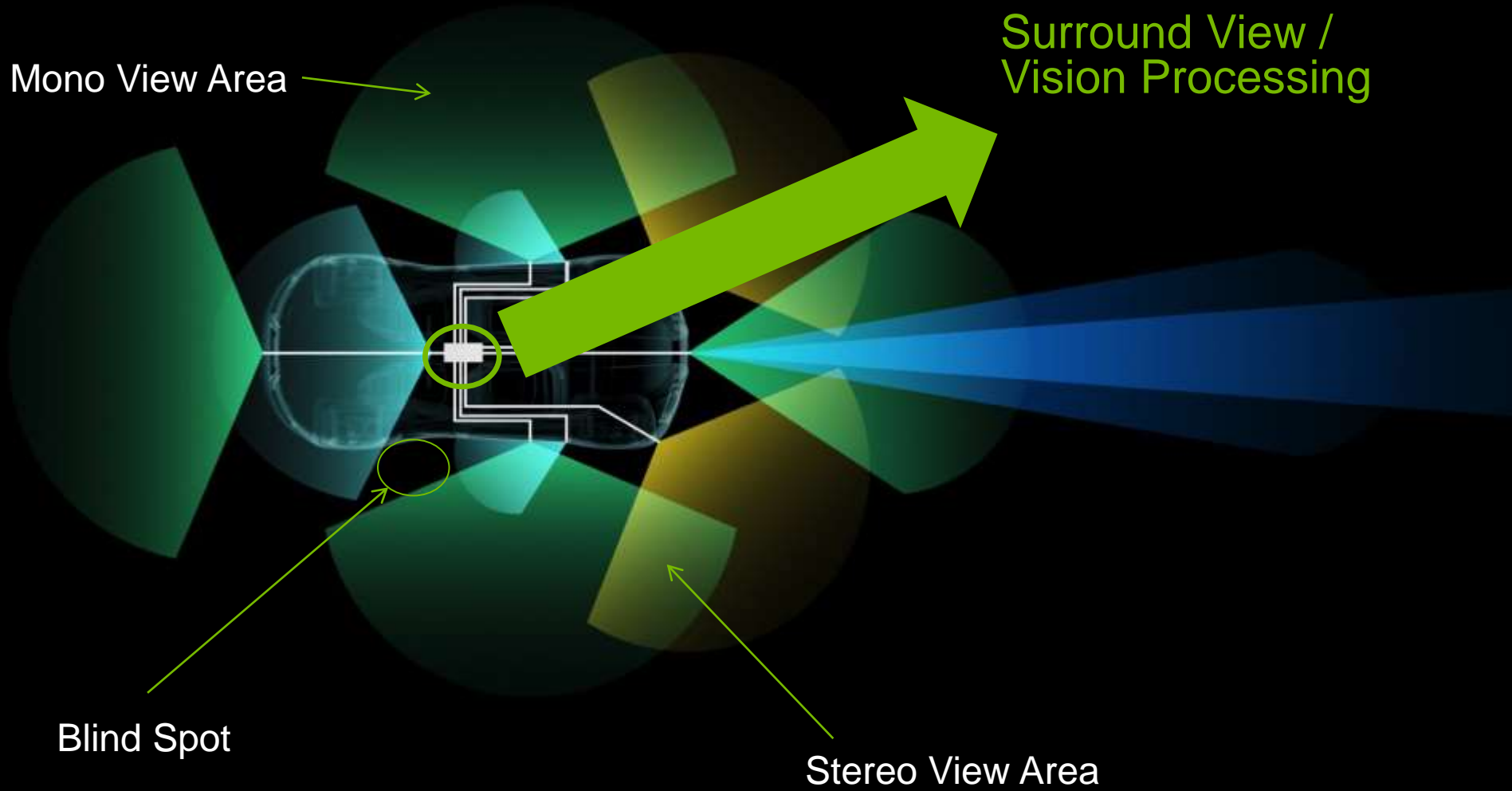
NVIDIA DRIVE™ PX SURROUND VISION



Sensor system tasks



“View Space”



Topview Reconstruction

We have camera images (and camera positions) -
How does one obtain a top view image?



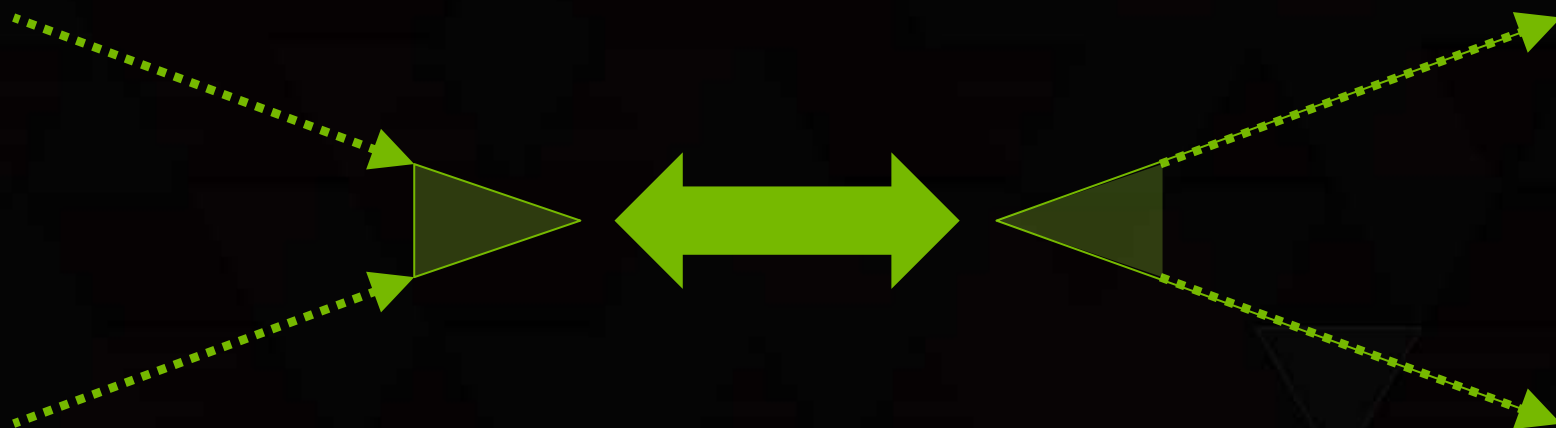
Camera images



Reconstructed top view

Camera/Projector dualism

A camera image is a recording of light – simulate light projection from camera position!

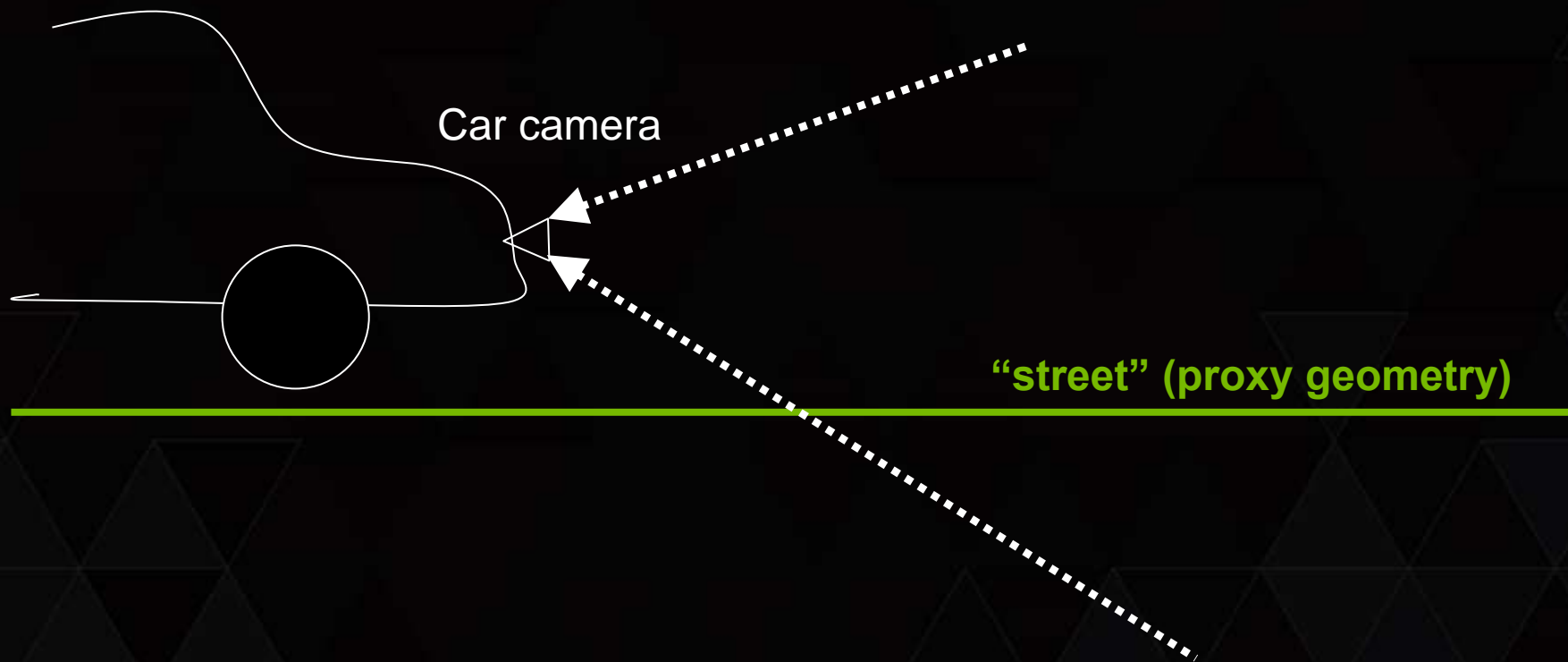


Camera images
“record”
incoming light
in real world

Project “recorded” light
into virtual world!

Geometry Proxy

Place “projection canvas” in virtual world (proxy geometry) at position where recorded object was relative to camera.



Example : Soccer Field

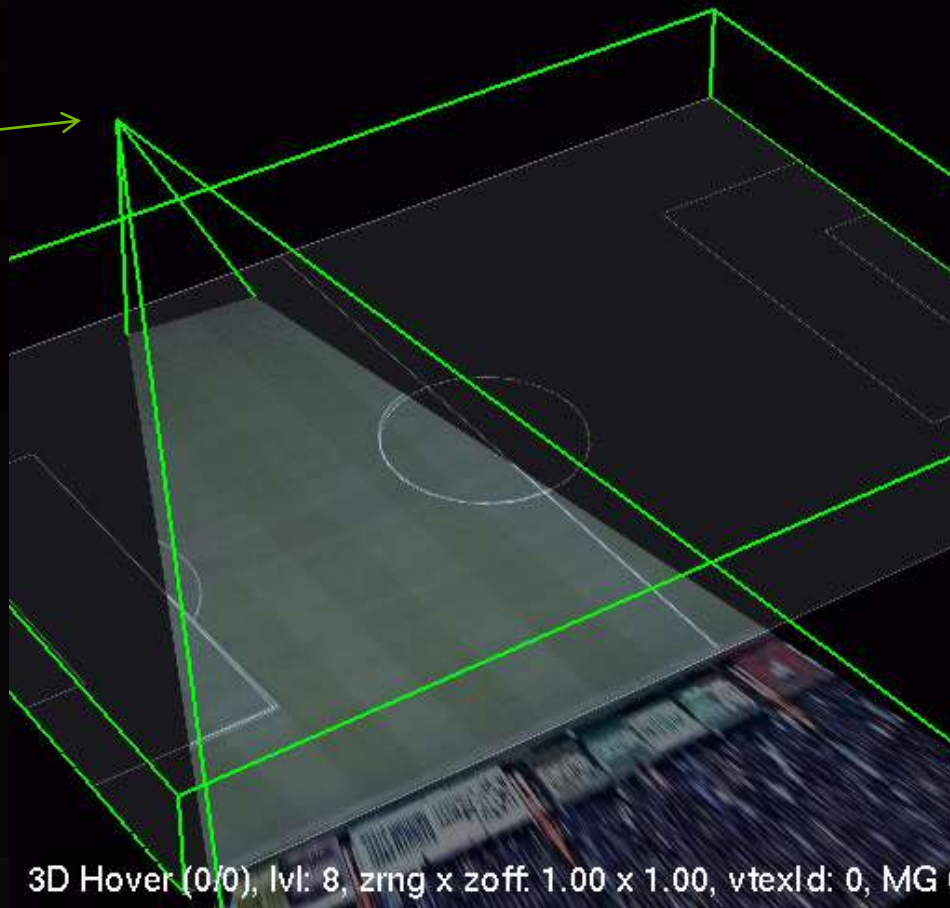
In: Camera images from soccer field, camera positions known from calibration.



Camera image

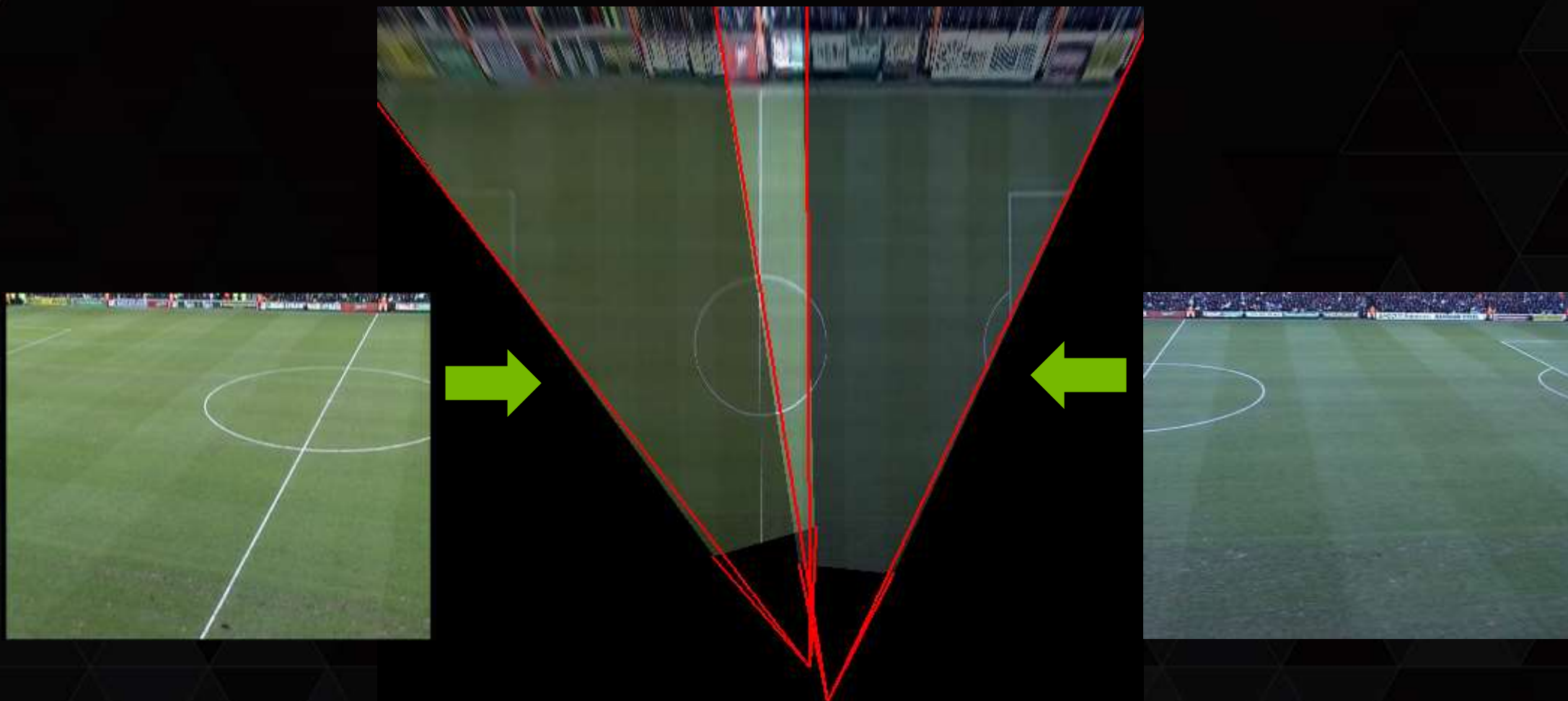


Proxy geometry



Camera/Projector Overlay

Now render geometry with a blend of multiple camera images. Voila! TopView. 😊



[Video Topview, 5:49]

Car View Calibration and beyond

Approach and goals

Traditionally, camera calibration is achieved using image homographies achieved by camera vs. camera calibration.

However, the GPU can easily visualize taken camera images in a 3D world, and complement with objects.

This leads to a merger of car camera visualization and car view reconstruction – already in the design process.

Camera calibration by proxy

We have a way to reconstruct a top view. But what happens if the camera positions are not well calibrated?

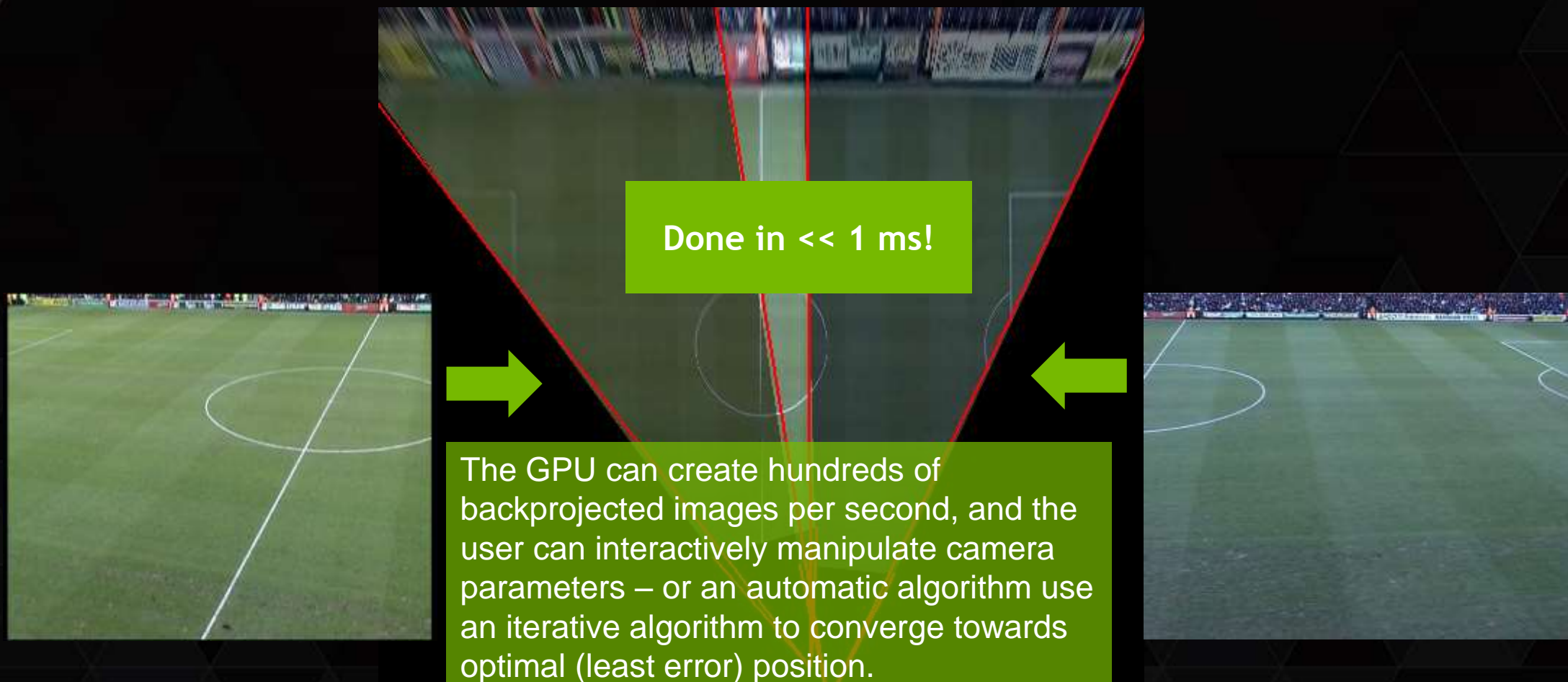
-> We can use a known proxy for camera alignment!

Isn't that expensive?

No.

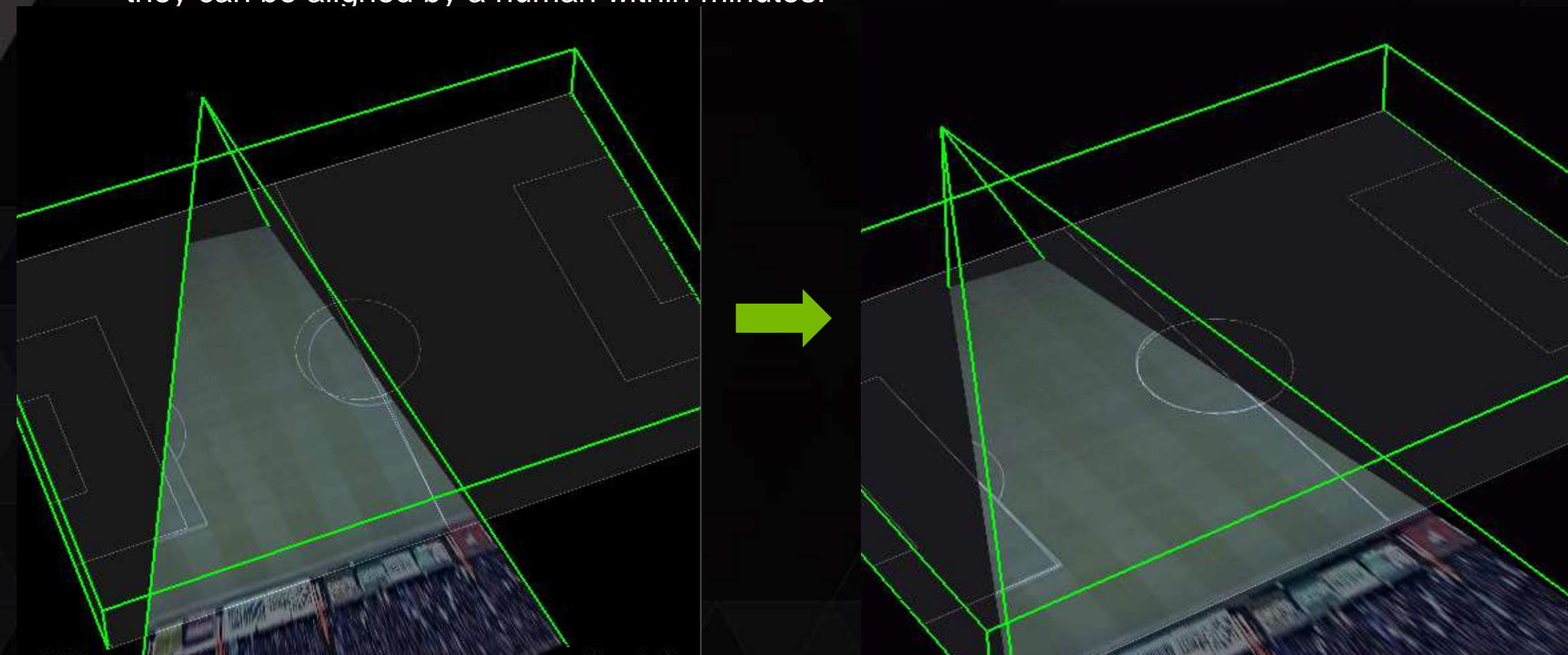
Camera/Projector Overlay

Now render geometry with a blend of multiple camera images. Voila! TopView. 😊



Manual Camera Calibration

Camera images given, but not the exact camera positions. Soccer field geometry was known. With real-time projections onto the soccer field and changing the camera positions, they can be aligned by a human within minutes.



Camera calibration by proxy

Why ? Example: During checkup, drive the car into a calibration room.

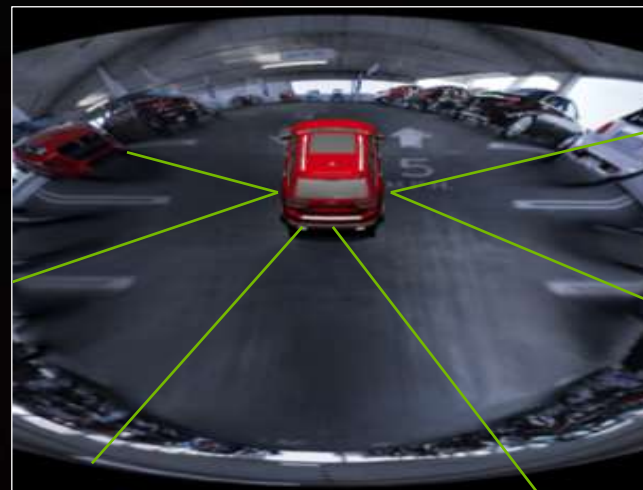


Camera calibration by proxy

It is now easy to see where the cameras are misaligned, and even possible to re-adjust the camera positioning interactively.



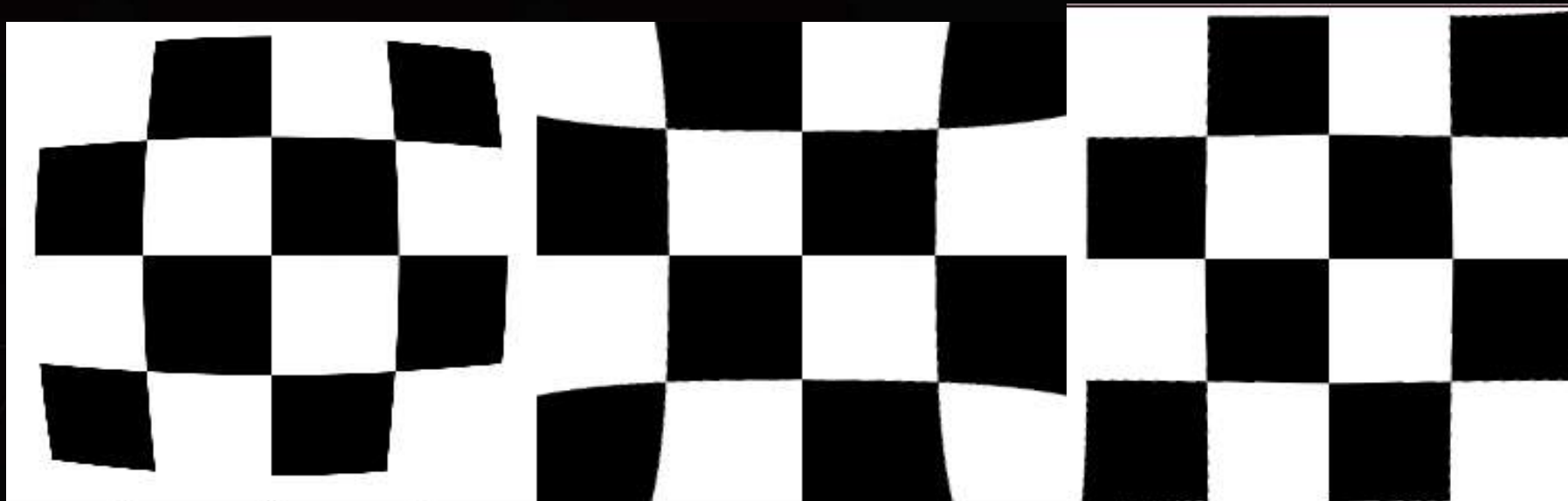
https://ec.europa.eu/jrc/sites/default/files/7200_hi-res.jpg



**Human insight into the
car's vision system!**

Intrinsic Camera Calibration

Given a proper proxy, even lens parameters and camera FOV can be calibrated interactively.



Camera output

Overcompensated

Best result with k^2

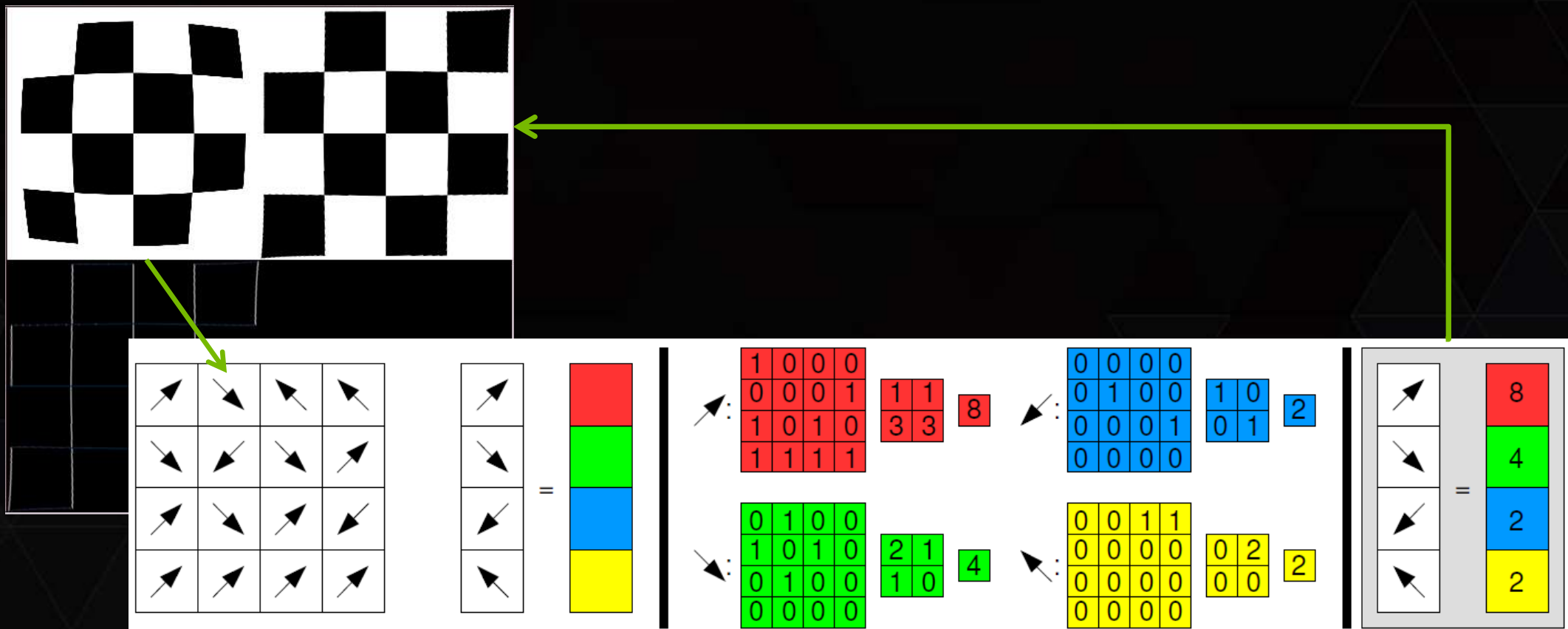
Further development

Approach is user-controlled and manual.
But nothing keeps it from being automatized

Can step by step introduce “assistants”,
and verify their performance against
hand-optimized calibration result.

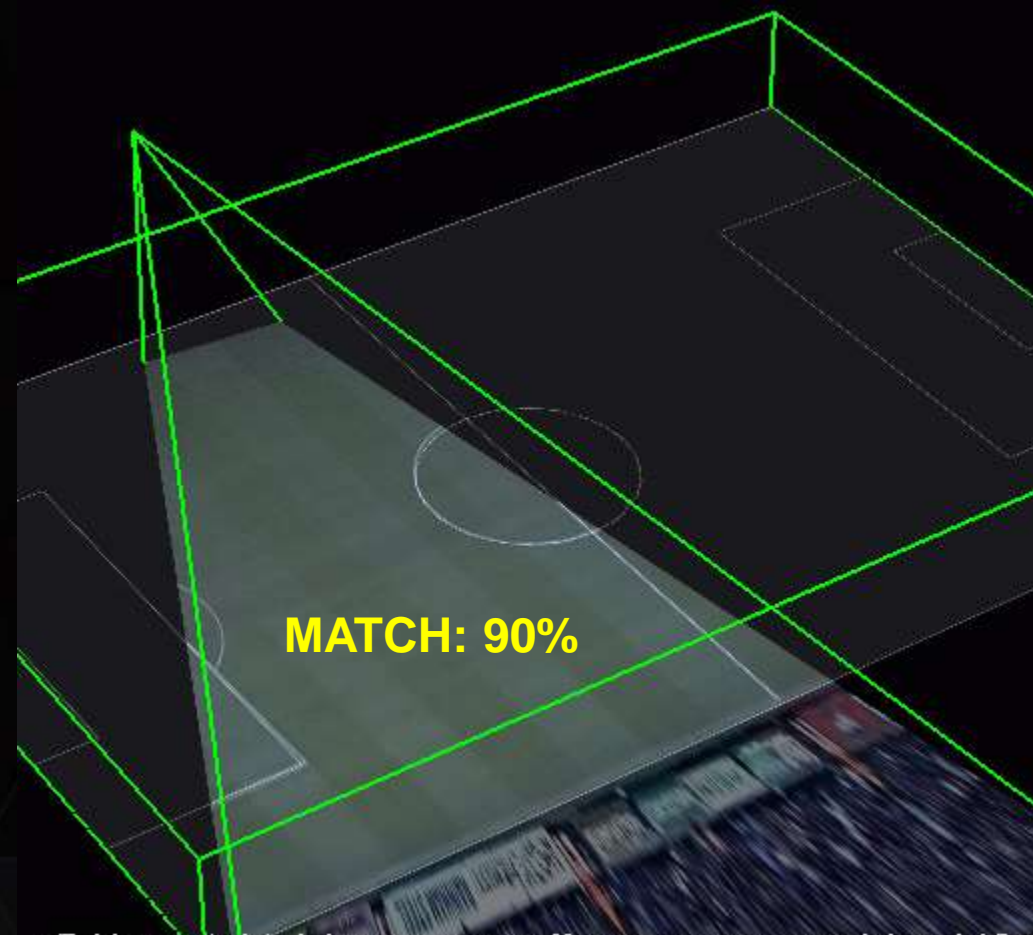
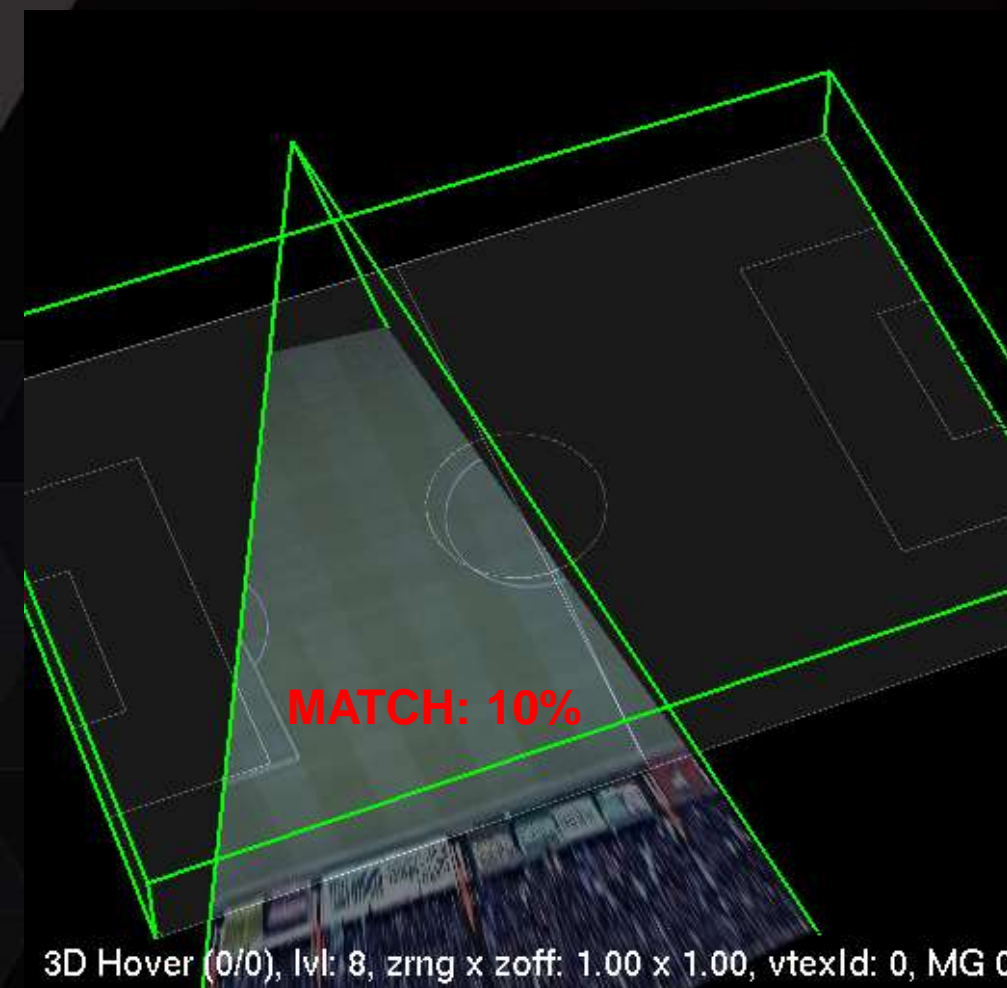
Intrinsic CamParam Assistant

Variance from edge direction histograms guide assistant towards best compensation.



Extrinsic CamParam Assistant

Uses pixel agreement (SAD) between geometry proxy model and camera view (or inbetween several blended camera views) to guide parameter choice.



Depth Reconstruction Usage

Depth reconstruction

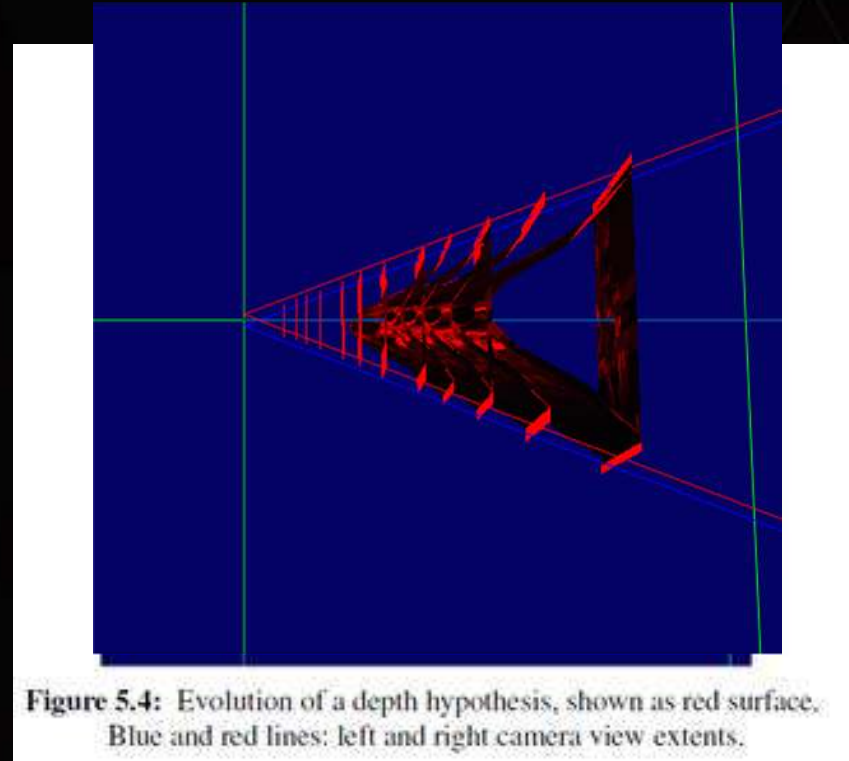
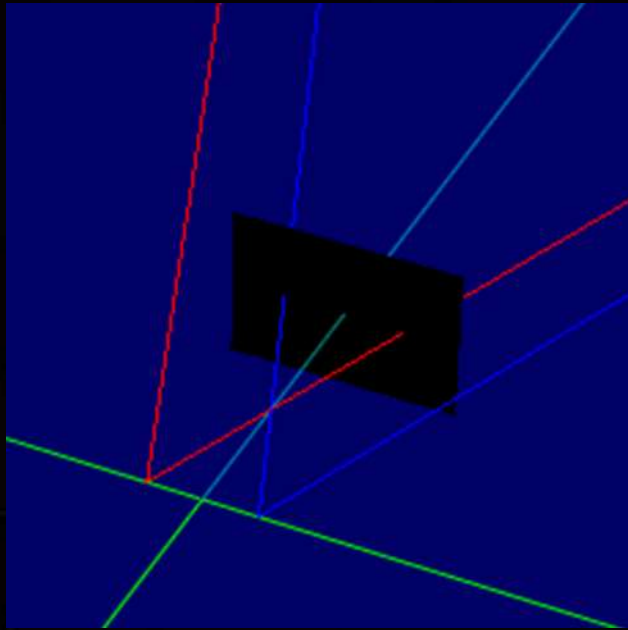
Now that camera positions are known, reconstruction of perceived world can commence.

We place out surfaces in the virtual world, and see if the incoming projections match/co-incide -> indicator that surfaces are at right position.

Again, manual at first (depth surface editor), then automatized (“magic wand for right depth”).

Depth reconstruction from projection

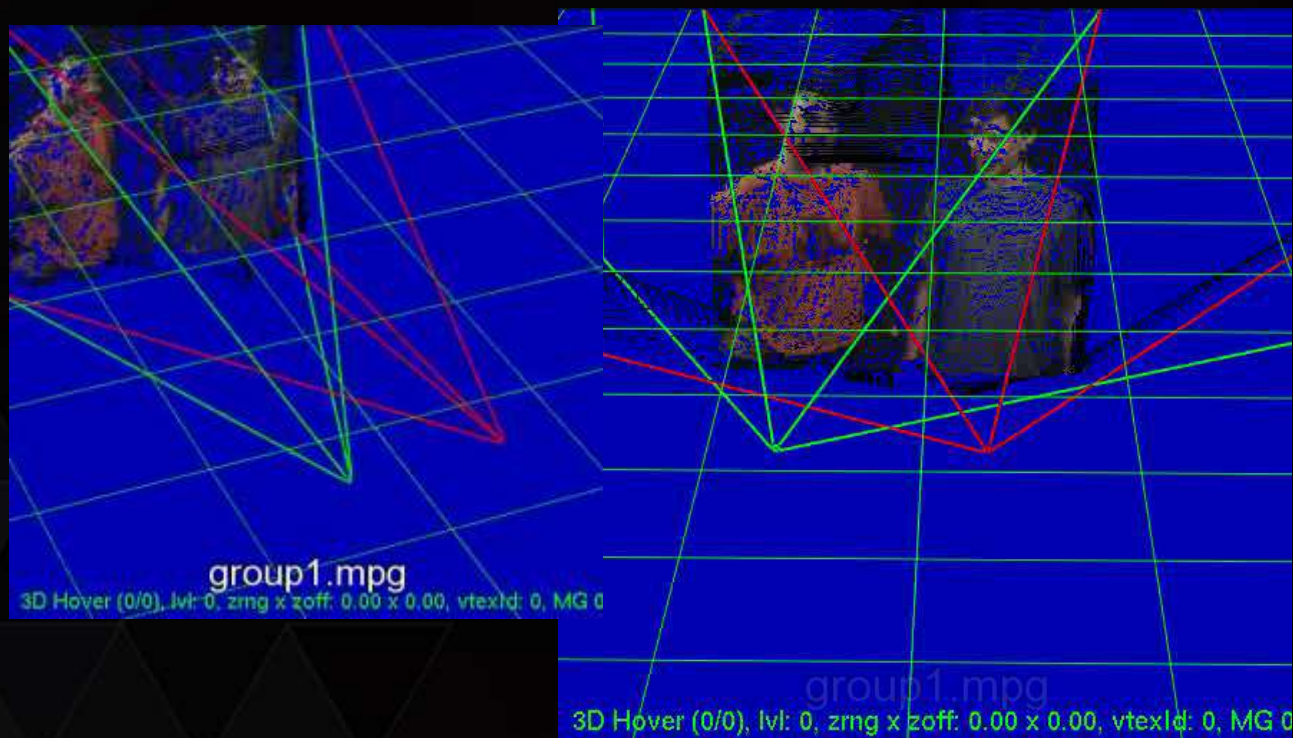
Iterate through depth planes, check camera view agreement for right depth hypothesis:



More at <http://www.geofront.eu/thesis.pdf>

Depth reconstruction from projection

Iterate through depth planes, check camera view agreement for right depth hypothesis.



Advantage: Visualizes all depth hypothesis in world coordinates, can render geometry proxy to verify algorithm.

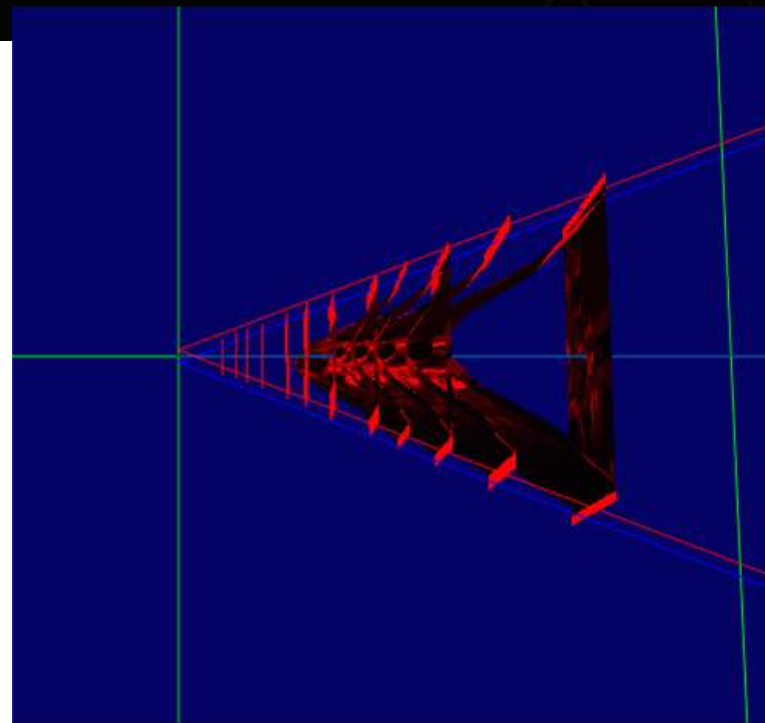


Figure 5.4: Evolution of a depth hypothesis, shown as red surface. Blue and red lines: left and right camera view extents.

Conclusion

The GPU can assist in detection and remedy of camera decalibration, using real-time *projected camera data*.

By designing and calibrating in a virtual world scene, much of the forthcoming car visualization is implemented.

The GPU framework uses OpenGL concepts, and can be used on both developer systems (desktop PCs) and in the car's embedded system (code re-usage).

Gernot Ziegler <gziegler@nvidia.com> says

THANK YOU

For your kind attention.

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#GTC15



(More camera vs. projector ideas at
<http://www.geofront.eu/thesis.pdf>)

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