

# ATTENUATION-BASED LIGHT FIELD DISPLAYS

Bachelor Thesis

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Institut für Informatik und angewandte Mathematik

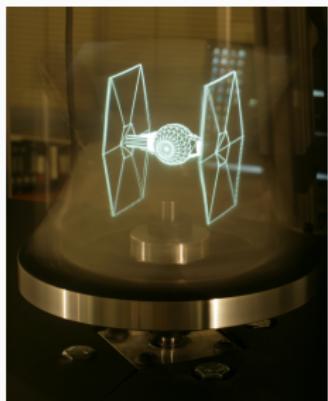
# OUTLINE

1. Motivation
2. Introduction to Light Fields
3. Problem Statement
4. Results
5. Assessment
6. Conclusion

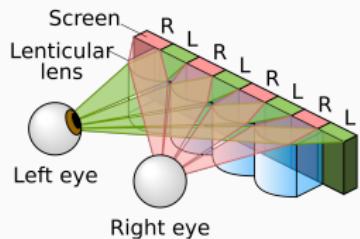
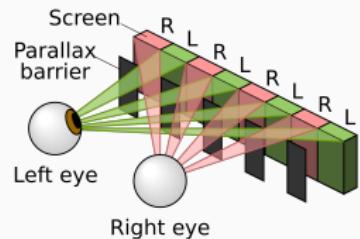
# MOTIVATION

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# EXISTING 3D DISPLAYS



Add more images

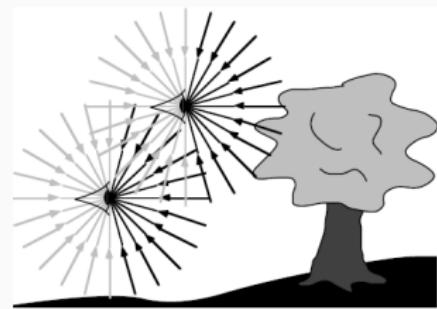


# INTRODUCTION TO LIGHT FIELDS

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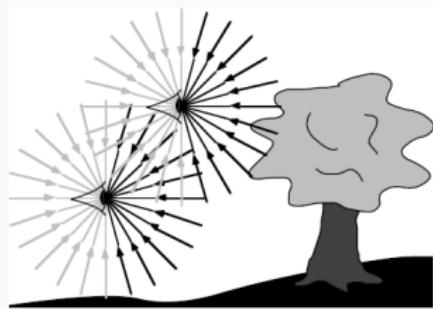
# THE PLENOPTIC FUNCTION

- Measures light in the world



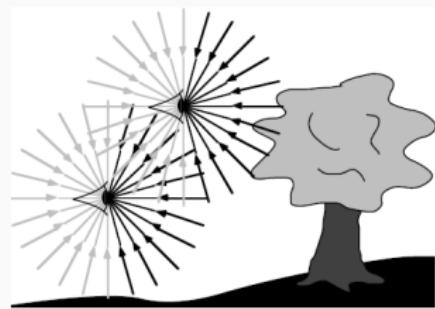
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- Measures light in the world
- $P(x, y, z, \theta, \phi, t, \lambda)$



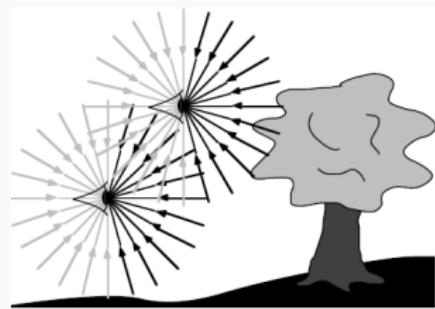
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- Measures light in the world
- $P(x, y, z, \theta, \phi, t, \lambda)$
- Position and viewing direction
- Time, Wavelength



# THE 4D LIGHT FIELD

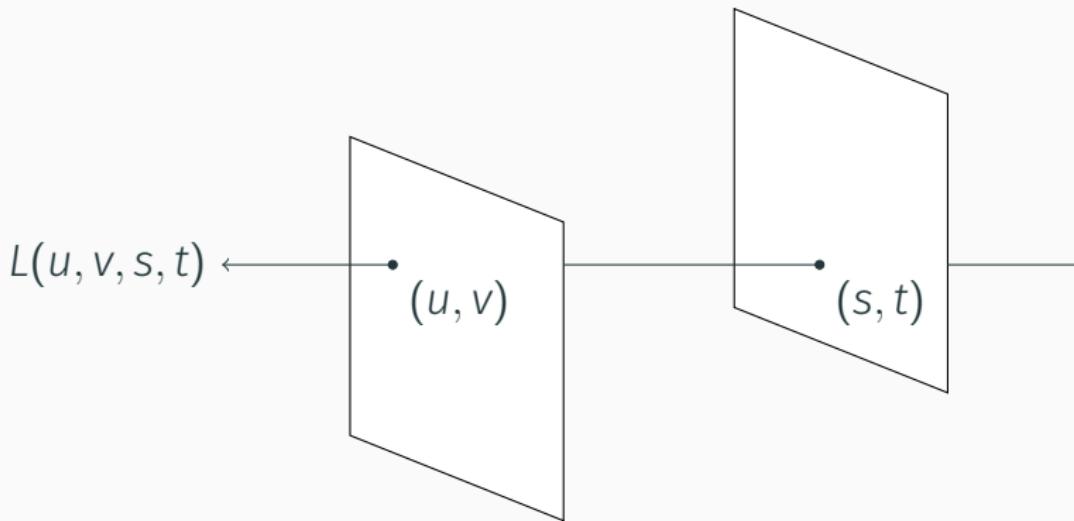
- Reduce dimensions of  $P$

# THE 4D LIGHT FIELD

- Reduce dimensions of  $P$
- $L(u, v, s, t)$

# THE 4D LIGHT FIELD

- Reduce dimensions of  $P$
- $L(u, v, s, t)$
- Defined by two planes



# LIGHT FIELD ACQUISITION

- Camera array



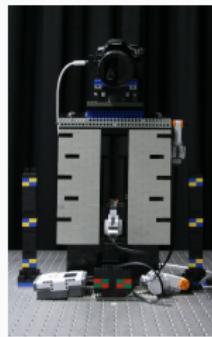
# LIGHT FIELD ACQUISITION

- Camera array
- Gantry

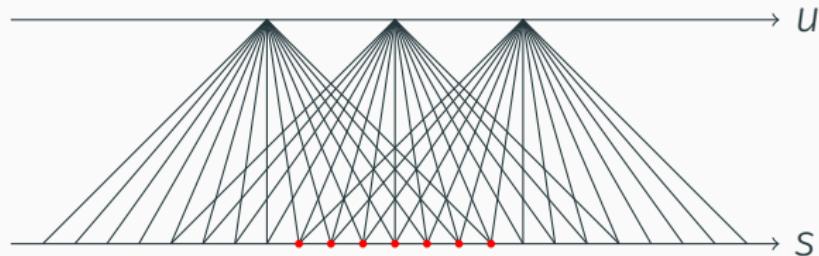


# LIGHT FIELD ACQUISITION

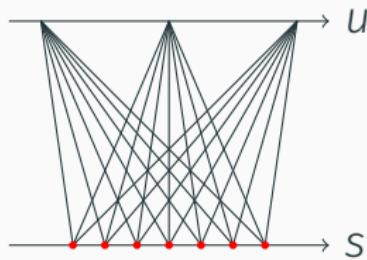
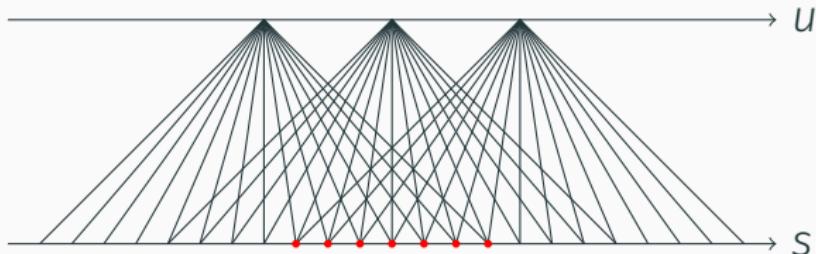
- Camera array
- Gantry
- Plenoptic camera



# PARAMETERIZATION



# PARAMETERIZATION



# PARAMETERIZATION

Raw



Rectified



# PARAMETERIZATION

Raw



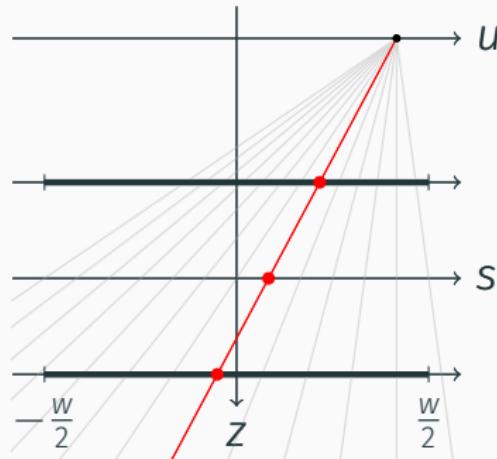
Rectified



# PROBLEM STATEMENT

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# LIGHT TRANSMISSION



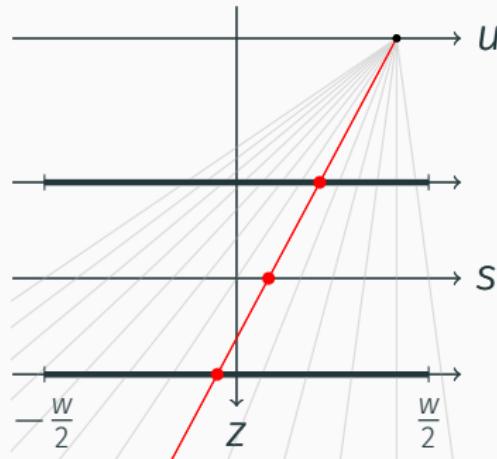
$$L_m = L_0 \prod_{n=1}^N t^{(n)}(h(m, n))$$

$L_m$  Color of ray  $m$

$t$  Transmission

$h$  Intersection

# LIGHT TRANSMISSION



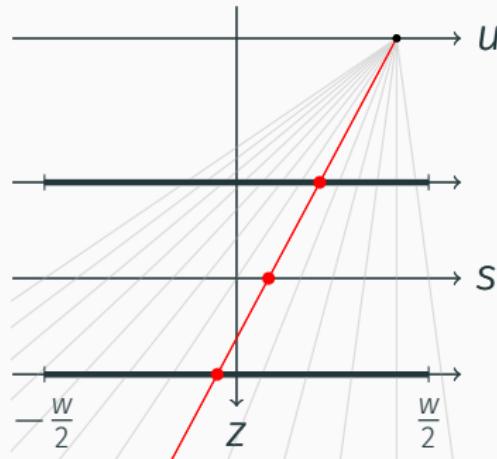
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- Hard to solve directly

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- Transform to log-domain

$$L_m = L_0 \prod_{n=1}^N t^{(n)}(h(m, n))$$

  $t = e^{-a}$

$$\bar{L}_m = \bar{L}_0 - \sum_{n=1}^N a^{(n)}(h(m, n))$$

## LIGHT TRANSMISSION

- Hard to solve directly
- Transform to log-domain
- Solve for absorbance

$$L_m = L_0 \prod_{n=1}^N t^{(n)}(h(m, n))$$

  $t = e^{-a}$

$$\bar{L}_m = \bar{L}_0 - \sum_{n=1}^N a^{(n)}(h(m, n))$$

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$$\bar{L}_m = \bar{L}_0 - \sum_{n=1}^N a^{(n)}(h(m, n))$$

  $L_0 = 1$

$$\bar{L}_m = - \sum_{n=1}^N a^{(n)}(h(m, n))$$

# RAY CASTING

- One linear constraint per ray
- Create a big matrix  $P$
- Matrix encodes intersections

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# RAY CASTING

$$P = \begin{pmatrix} & \alpha_1 & \alpha_2 & \alpha_3 & \alpha_4 & \alpha_5 & \alpha_6 & \alpha_7 & \alpha_8 & \alpha_9 & \alpha_{10} \\ \bar{L}_1 & & & 1 & & & & 1 & & & \\ \bar{L}_2 & & & & 1 & & & & 1 & & \\ \bar{L}_3 & 1 & & & & & & & 1 & & \\ \bar{L}_4 & & 1 & & & & & & & 1 & \\ \hline \bar{L}_5 & & & & 1 & & & & & 1 & \\ \bar{L}_6 & & & 1 & & & & 1 & & & \\ \bar{L}_7 & 1 & & & & & & & & 1 & \\ \hline \bar{L}_8 & & & & 1 & & & 1 & & & \\ \hline \bar{L}_9 & & 1 & & & & & & 1 & & \\ \bar{L}_{10} & & & 1 & & & & & & 1 & \\ \hline \bar{L}_{11} & & & 1 & & & & & & 1 & \\ \bar{L}_{12} & & & 1 & & & & & & & 1 \end{pmatrix}$$

# THE EQUATION

$$\bar{L} = -P\alpha$$

- $\bar{L}$  Vectorized log light field
- $\alpha$  Vector holding unkowns

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# OPTIMIZATION PROBLEM

$$\operatorname{argmin}_{\alpha} \|P\alpha + \bar{L}\|^2$$

subject to  $\alpha \geq 0.$

- System is overdetermined
- Need iterative solver

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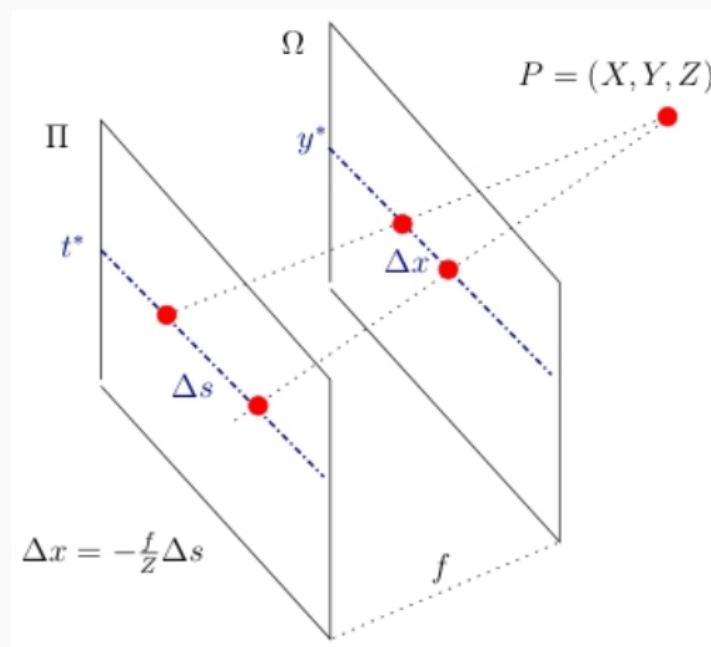
# RESULTS

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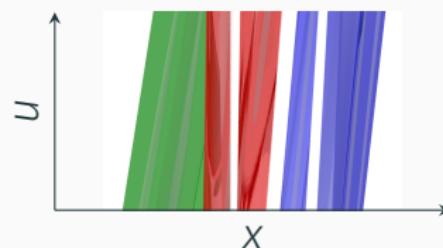
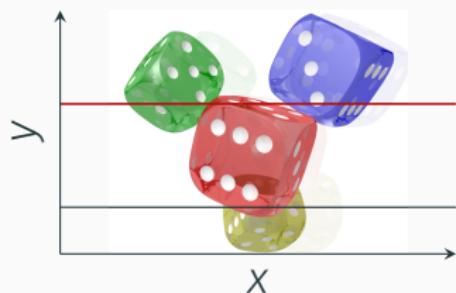
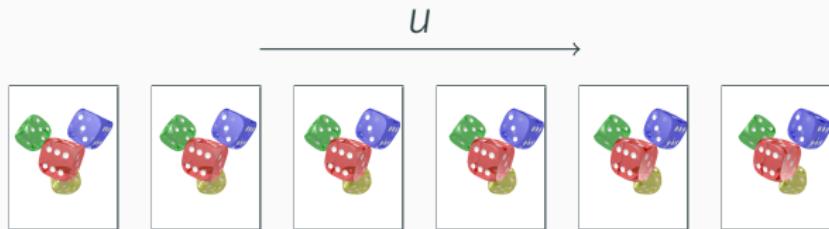
# ASSESSMENT

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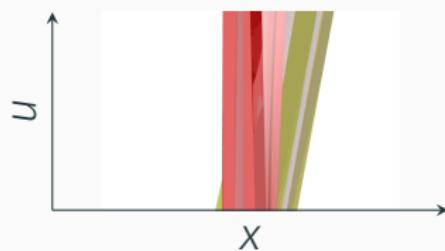
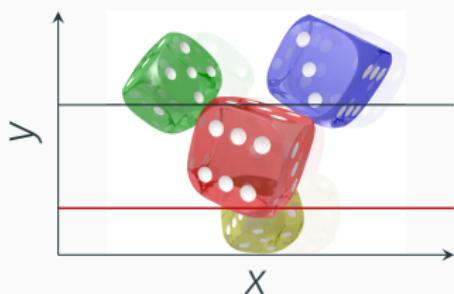
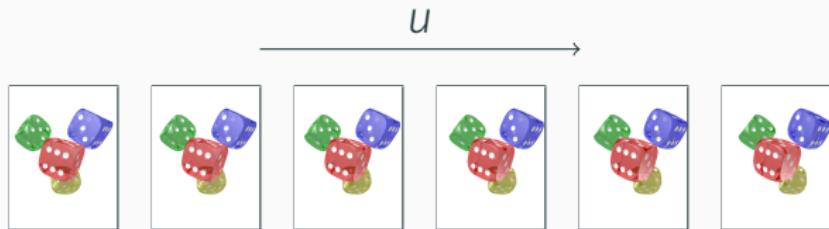
# EPIPOLAR PLANE GEOMETRY



# EPIPOLAR PLANE IMAGE



# EPIPOLAR PLANE IMAGE



# CONCLUSION

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The *mtheme* is a Beamer theme with minimal visual noise inspired by the HSRM Beamer Theme by Benjamin Weiss.

Enable the theme by loading

```
\documentclass{beamer}  
\usepackage{m}
```

Note, that you have to have Mozilla's *Fira Sans* font and XeTeX installed to enjoy this wonderful typography.

# SECTIONS

Sections group slides of the same topic

```
\section{Elements}
```

for which the *mtheme* provides a nice progress indicator

...

# TYPOGRAPHY

The theme provides sensible defaults to `\emph{emphasis}` text, `\alert{accent}` parts or show `\textbf{bold}` re-

becomes

The theme provides sensible defaults to *emphasis* text,  
**accent** parts or show **bold** results.

# LISTS

Items	Enumerations
· Milk	1. First,
· Eggs	2. Second and
· Potatos	3. Last.

# DESCRIPTIONS

PowerPoint Meeh.

Beamer Yeeeha.

# ANIMATION

- This is important

# ANIMATION

- This is important
- Now this

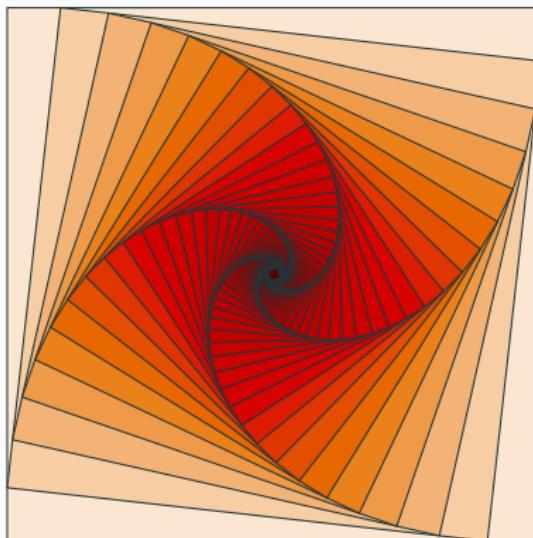
# ANIMATION

- This is important
- Now this
- And now this

# ANIMATION

- This is really important
- Now this
- And now this

# FIGURES



**Figure:** Rotated square from [texample.net](http://texample.net).

# TABLES

**Table:** Largest cities in the world (source: Wikipedia)

City	Population
Mexico City	20,116,842
Shanghai	19,210,000
Peking	15,796,450
Istanbul	14,160,467

# BLOCKS

This is a block title

This is soothing.

$$e = \lim_{n \rightarrow \infty} \left(1 + \frac{1}{n}\right)^n$$

# QUOTES

*Veni, Vidi, Vici*

plainDark background



## SUMMARY

Get the source of this theme and the demo presentation from

[github.com/matze/mtheme](https://github.com/matze/mtheme)

The theme *itself* is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.



plainQuestions?