ATTENUATION-BASED LIGHT FIELD DISPLAYS

Bachelor Thesis

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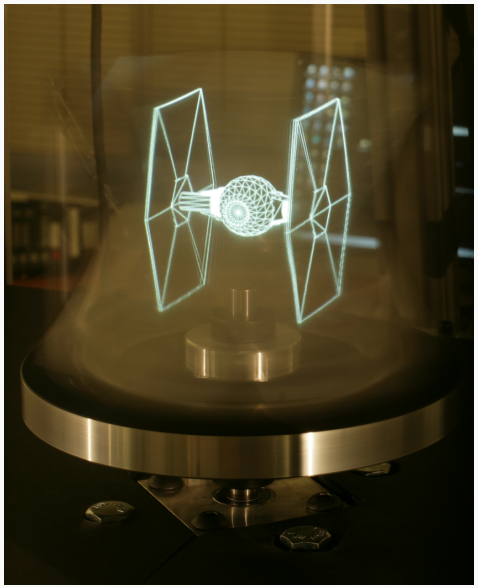
Institut für Informatik und angewandte Mathematik

OUTLINE

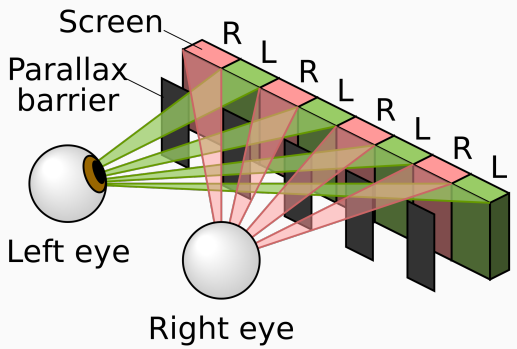
1. Motivation
2. Introduction to Light Fields
3. Attenuation Display
4. Results
5. Assessment
6. Conclusion

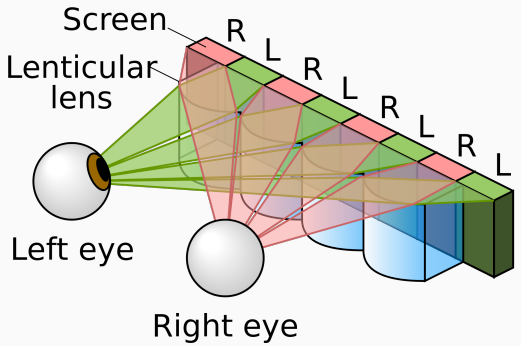
MOTIVATION

EXISTING 3D DISPLAYS



Add more images

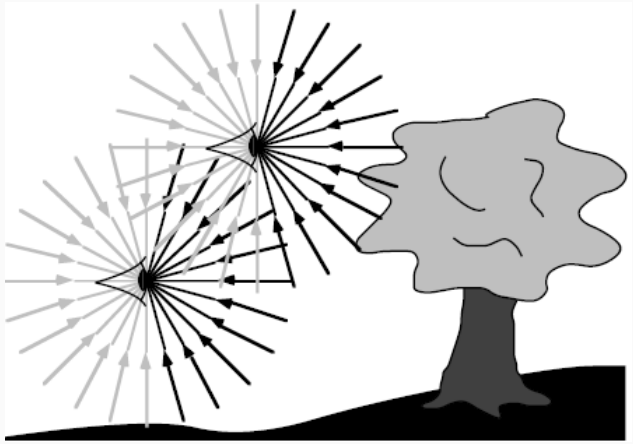




INTRODUCTION TO LIGHT FIELDS

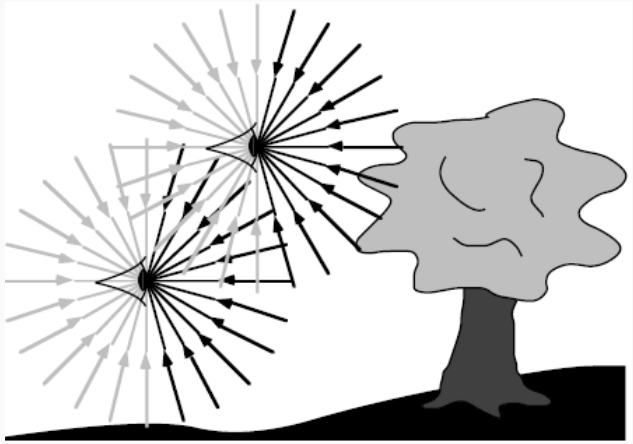
THE PLENOPTIC FUNCTION

- Measures light in the world



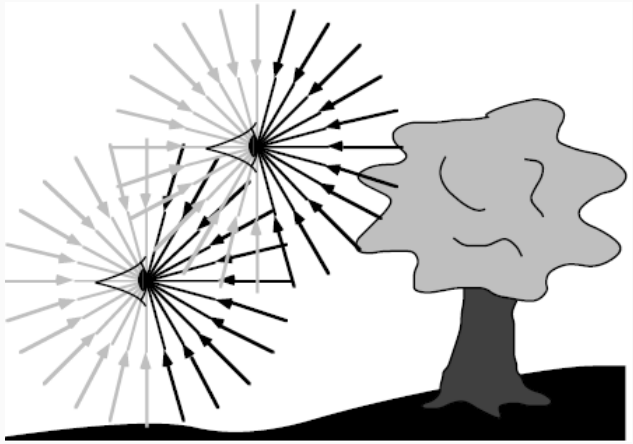
THE PLENOPTIC FUNCTION

- Measures light in the world
- Position, viewing direction



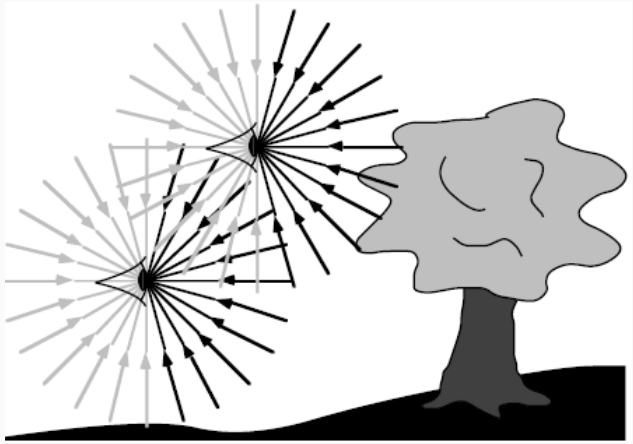
THE PLENOPTIC FUNCTION

- Measures light in the world
- Position, viewing direction
- Time, Wavelength



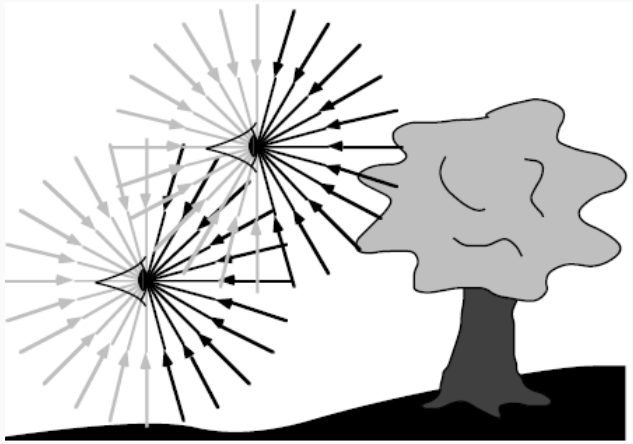
THE PLENOPTIC FUNCTION

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



THE PLENOPTIC FUNCTION

- Measures light in the world
- Position, viewing direction
- Time, Wavelength
- $P(x, y, z, \theta, \phi, t, \lambda)$
- 7D



The 4D light field

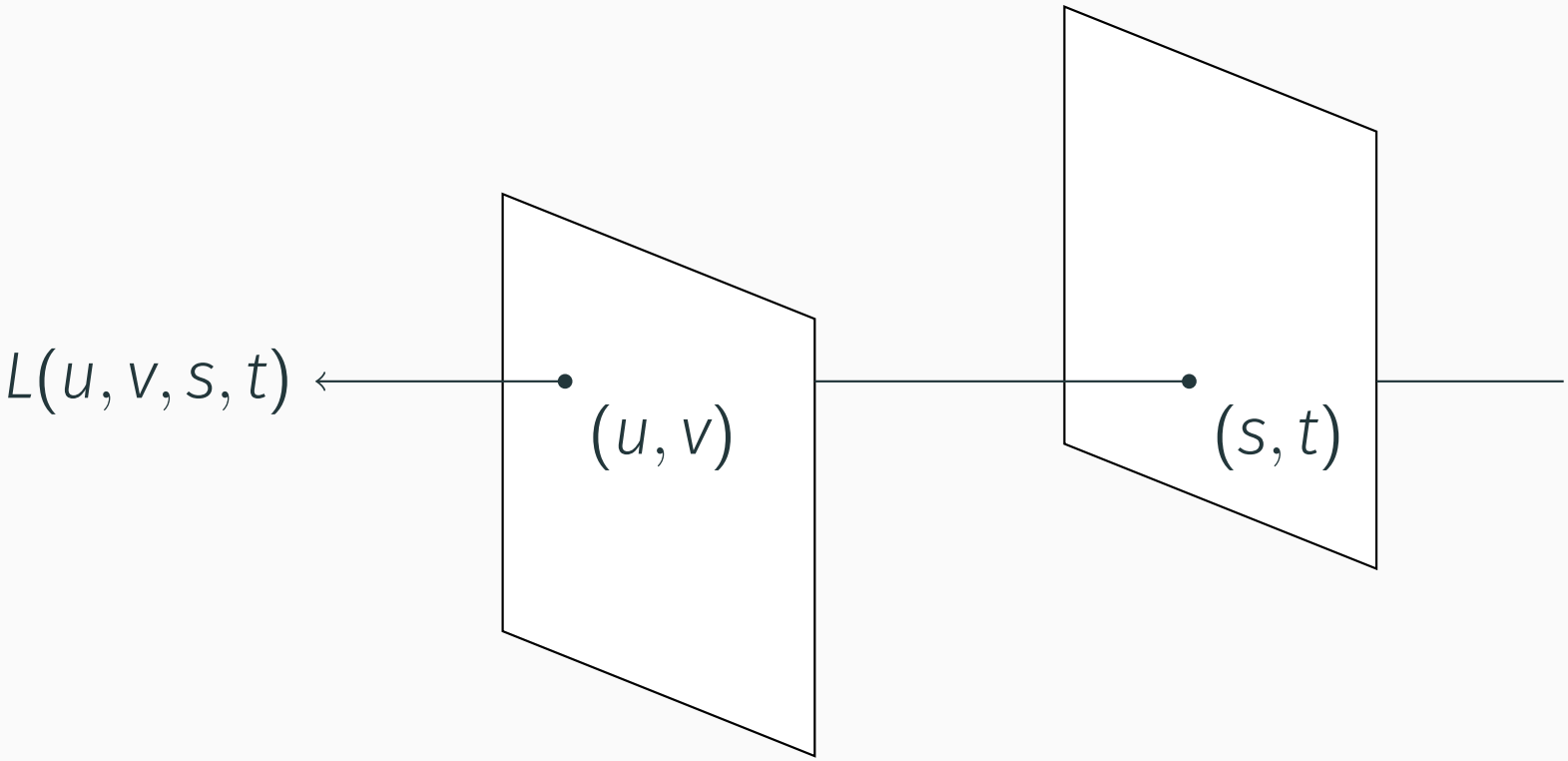
- Reduce dimensions of P

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

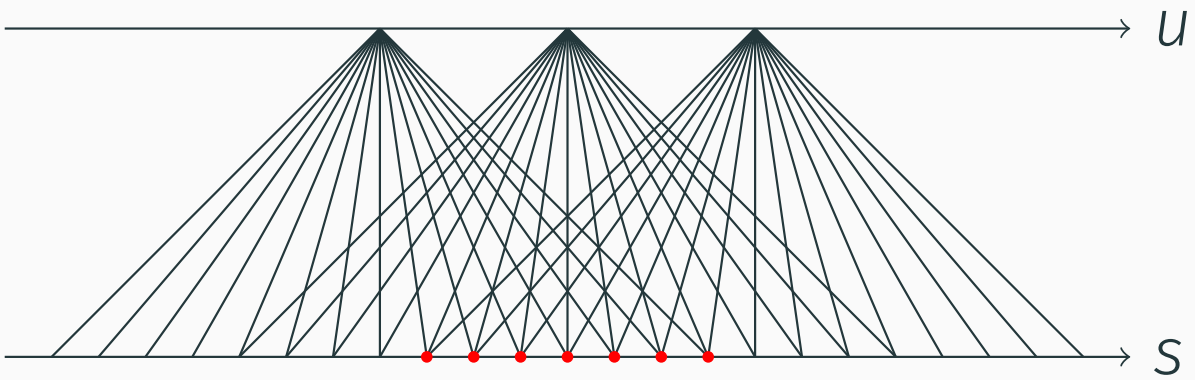
LIGHT FIELD ACQUISITION

- Camera array
- Gantry

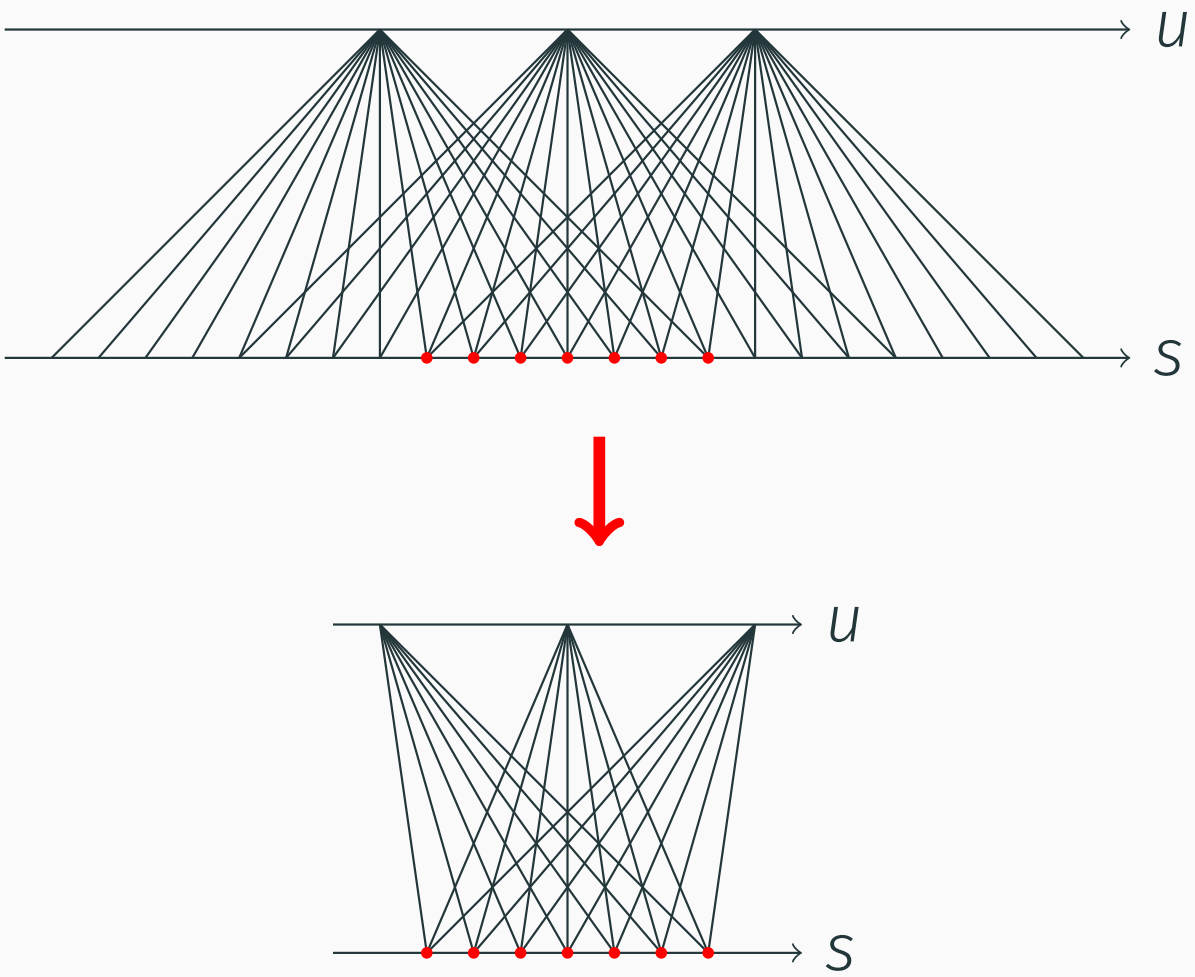
LIGHT FIELD ACQUISITION

- Camera array
- Gantry
- Plenoptic camera

RE-PARAMETERIZATION TO GLOBAL COORDINATES



RE-PARAMETERIZATION TO GLOBAL COORDINATES



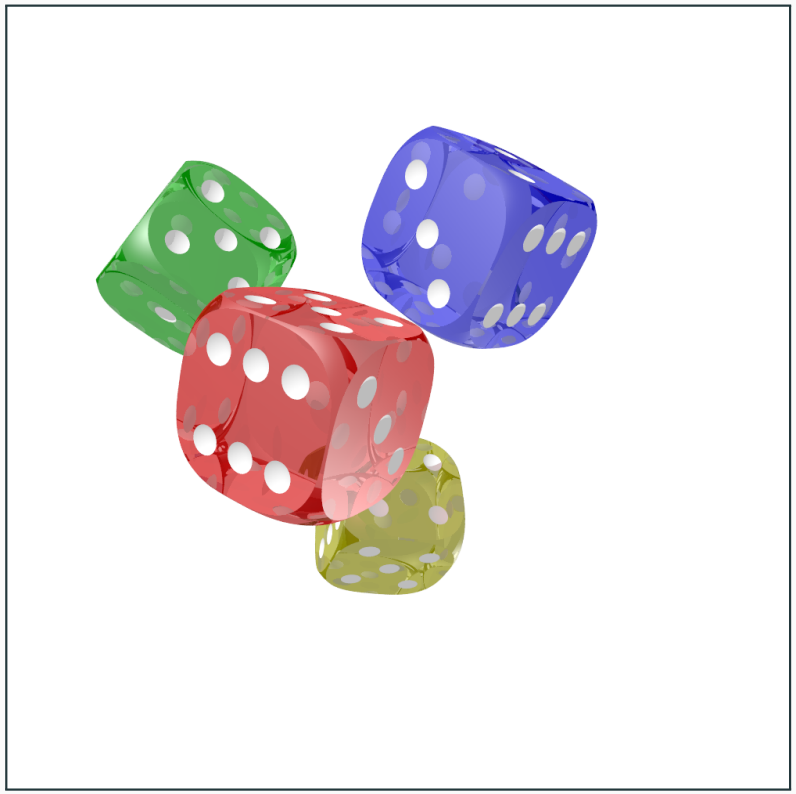
Re-parameterization to global coordinates

Raw

Rectified

Re-parameterization to global coordinates

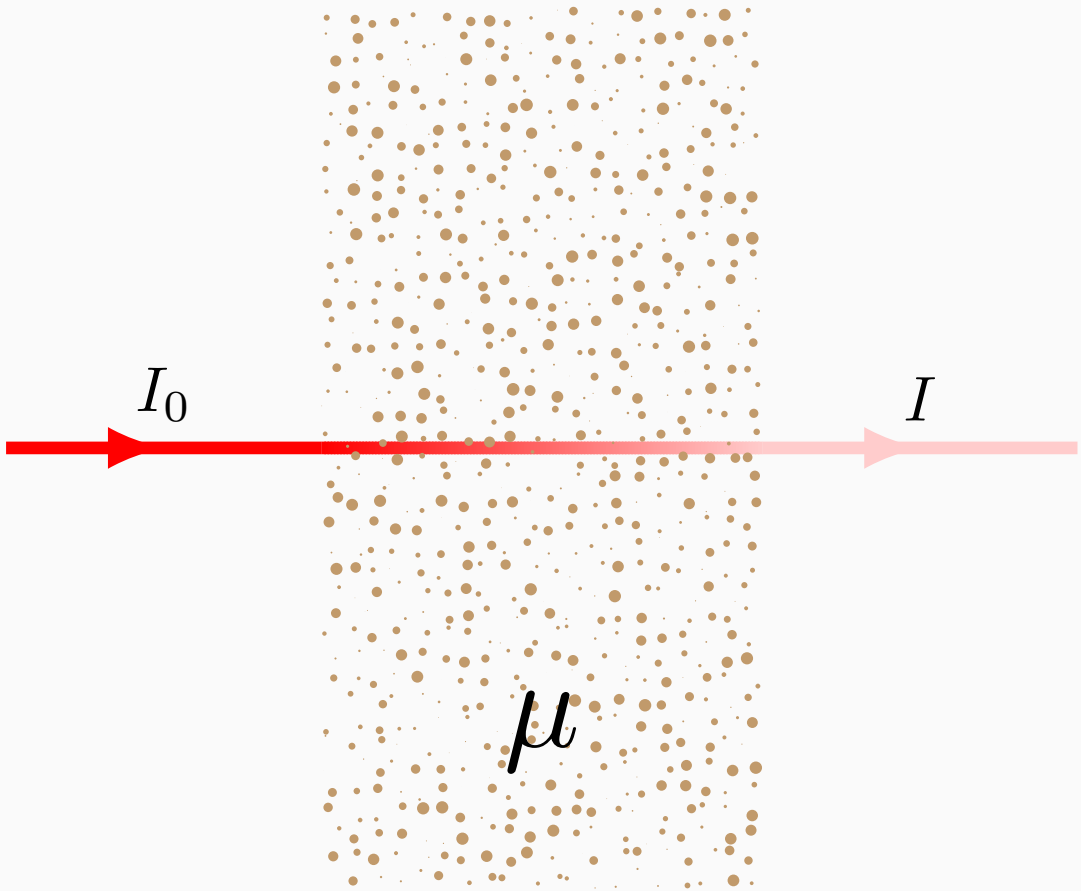
Raw



Rectified

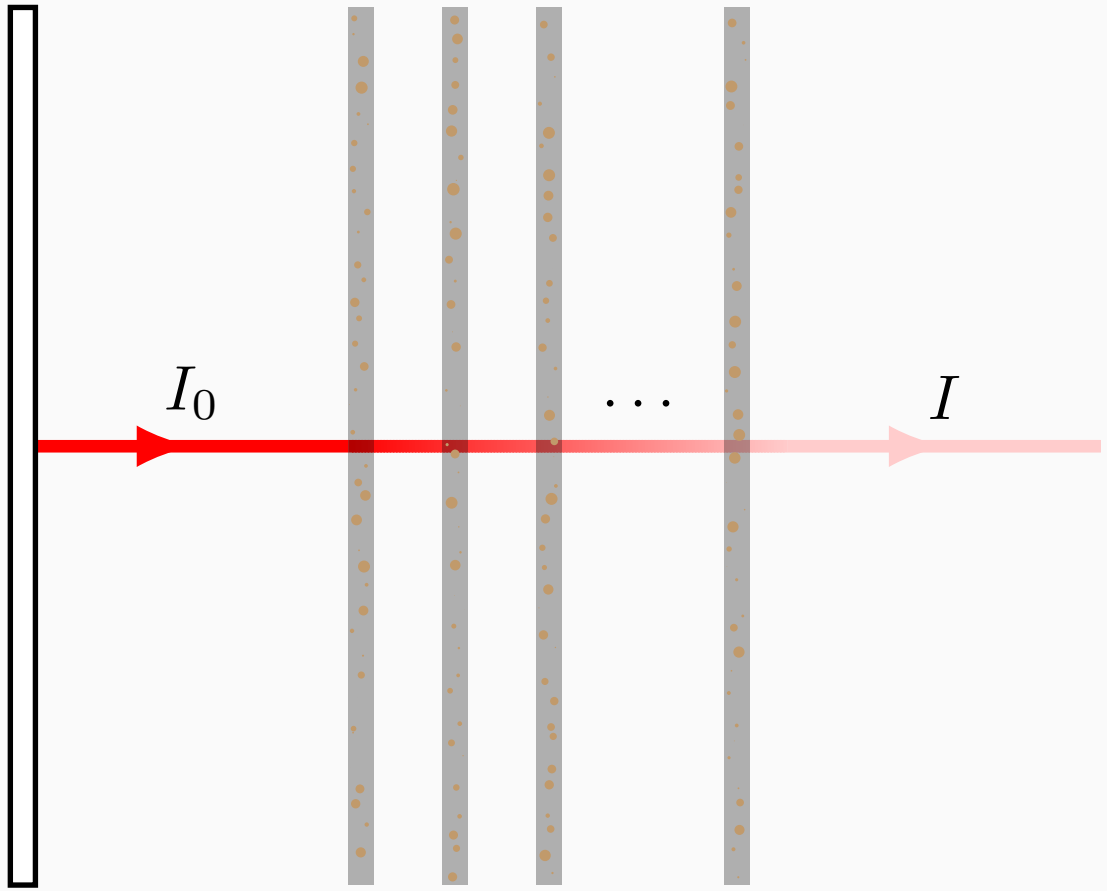
ATTENUATION DISPLAY

THE BEER-LAMBERT LAW



$$\frac{I}{I_0} = \exp\left(-\int_{\mathcal{R}} \mu(r)\mathrm{d}r\right)$$

THE BEER-LAMBERT LAW



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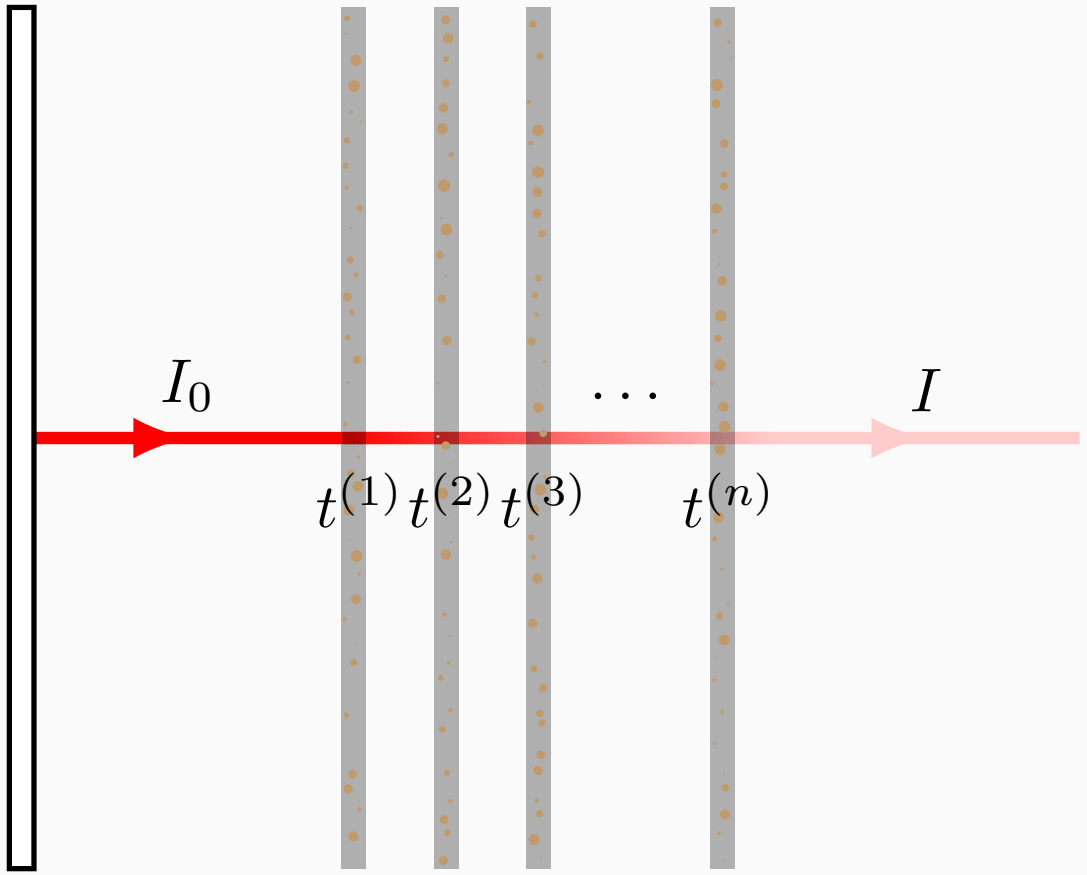
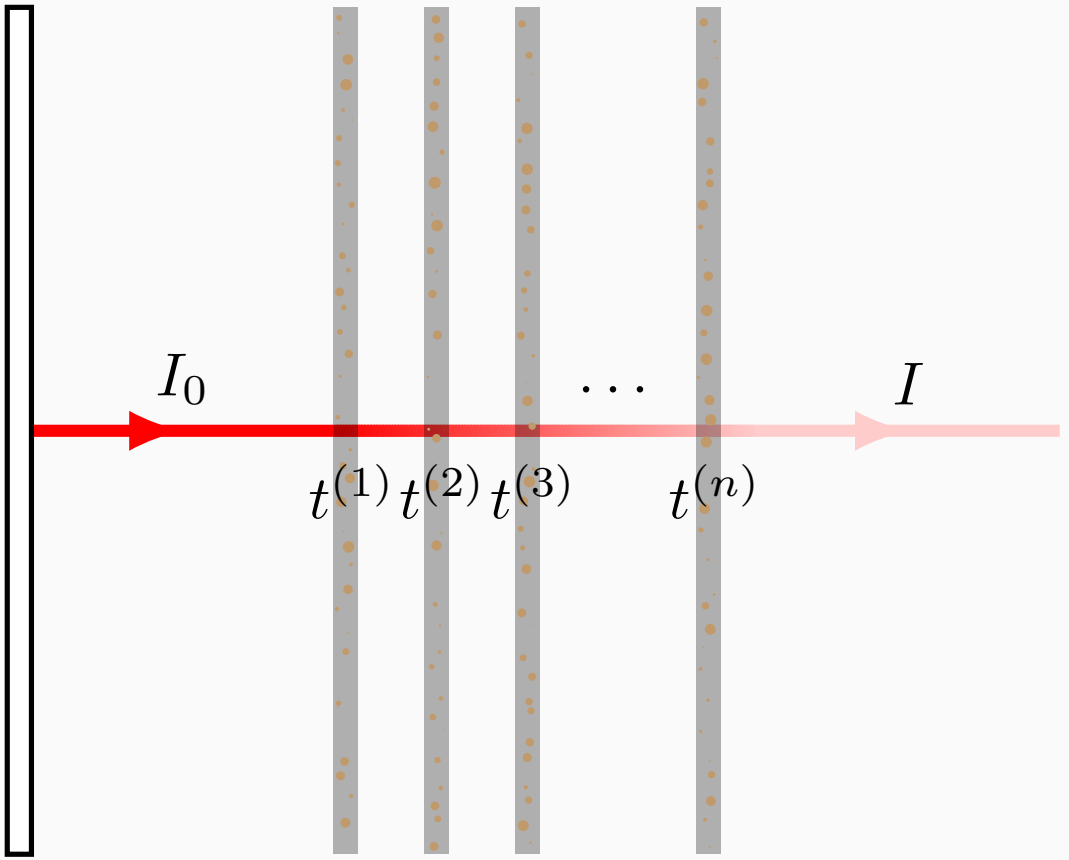
THE BEER-LAMBERT LAW



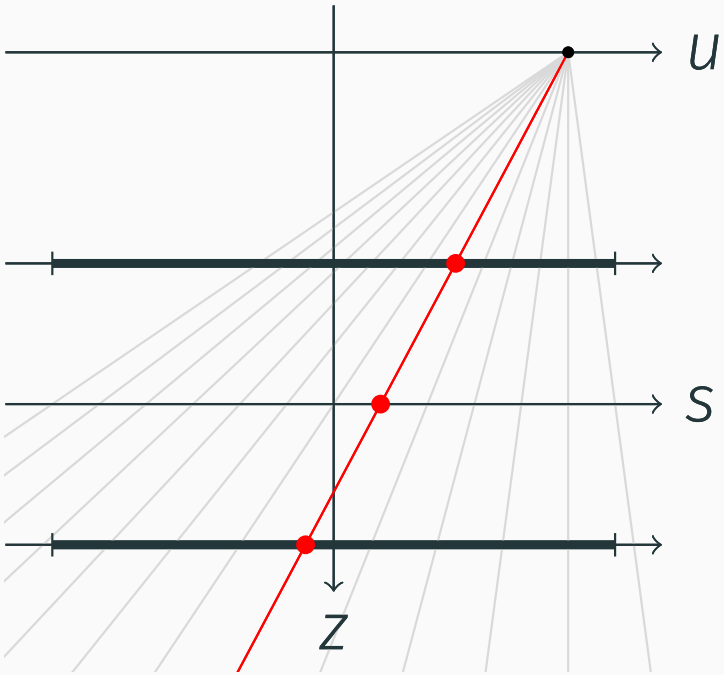
$$\frac{I}{I_0} = \exp\left(-\int_{\mathcal{R}} \mu(r)\mathrm{d}r\right) = \prod_i t^{(i)}$$

THE BEER-LAMBERT LAW



$$\frac{I}{I_0} = \exp\left(-\int_{\mathcal{R}} \mu(r)\mathrm{d}r\right) = \prod_i t^{(i)} = \exp\left(-\sum_i a^{(i)}\right)$$

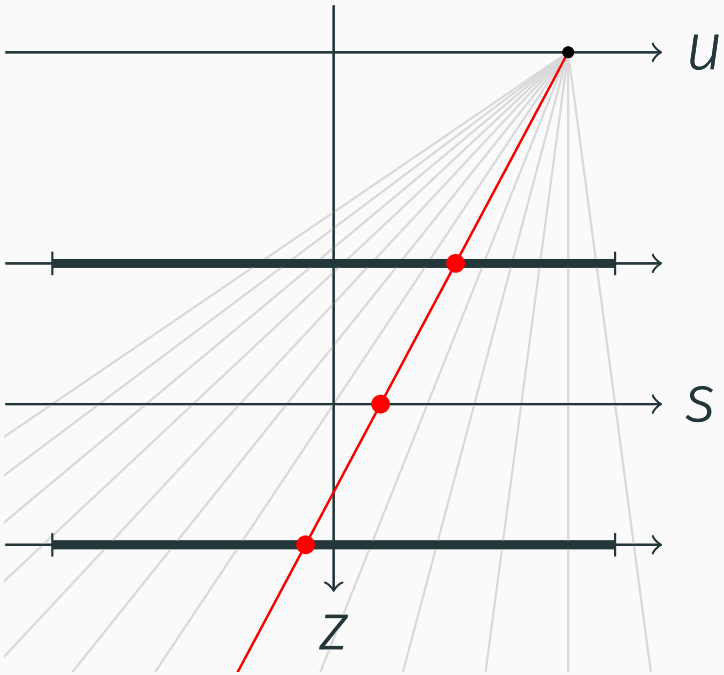
LIGHT TRANSMISSION



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

L_m Color of ray m

LIGHT TRANSMISSION

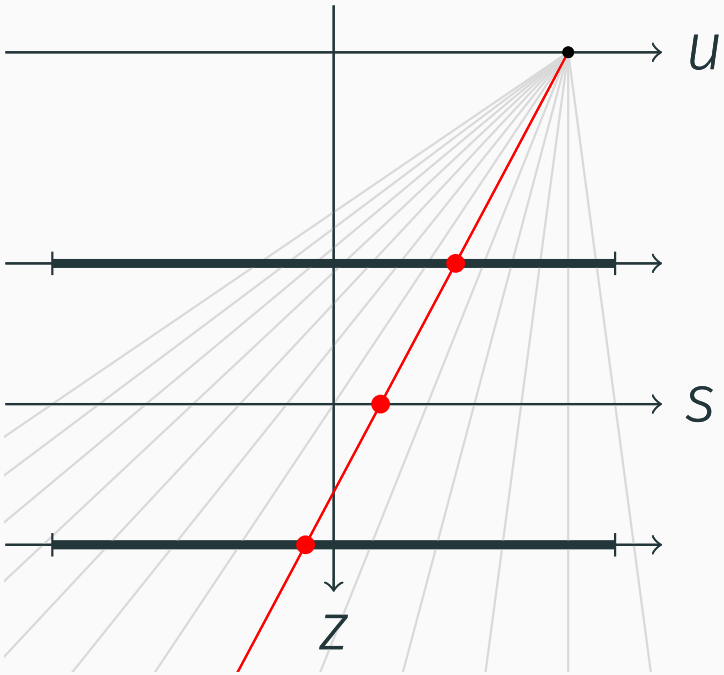


$$L_m = L_0 \prod_{n=1}^{N} t^{(n)}(h(m,n))$$

L_m Color of ray m

t Transmission

LIGHT TRANSMISSION



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

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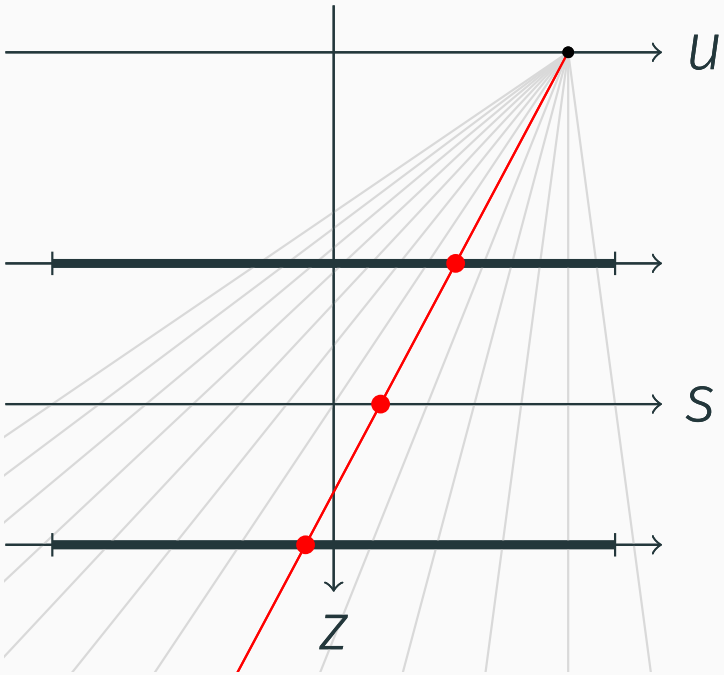
LIGHT TRANSMISSION



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

L_m Color of ray m

t Transmission

h Intersection

From now on: $L_0 = 1$

FROM TRANSMISSION TO ABSORBANCE

- Transmission values unknown

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

FROM TRANSMISSION TO ABSORBANCE

- Transmission values unknown
- Solve equations simultaneously for all rays

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

FROM TRANSMISSION TO ABSORBANCE

- Transmission values unknown
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- This is hard

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

FROM TRANSMISSION TO ABSORBANCE

- Transmission values unknown
- Solve equations simultaneously for all rays
- This is hard
- Transform to log-domain

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

$$\downarrow \quad t = e^{-a}$$

$$\log(L_m) = -\sum_{n=1}^{N} a^{(n)}(h(m,n))$$

FROM TRANSMISSION TO ABSORBANCE

- Transmission values unknown
- Solve equations simultaneously for all rays
- This is hard
- Transform to log-domain
- Solve for absorbance

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

$$\downarrow \quad t = e^{-a}$$

$$\log(L_m) = -\sum_{n=1}^{N} a^{(n)}(h(m,n))$$

RAY CASTING

- One linear constraint per ray

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

RAY CASTING

- One linear constraint per ray
- Create a big matrix P

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

RAY CASTING

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

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

RAY CASTING

$$
P = \begin{array}{c} \\ \bar{L}_1 \\ \bar{L}_2 \\ \bar{L}_3 \\ \bar{L}_4 \\ \bar{L}_5 \\ \bar{L}_6 \\ \bar{L}_7 \\ \bar{L}_8 \\ \bar{L}_9 \\ \bar{L}_{10} \\ \bar{L}_{11} \\ \bar{L}_{12} \end{array}
\begin{array}{c}
\begin{array}{cccccccccc}
\alpha_1 & \alpha_2 & \alpha_3 & \alpha_4 & \alpha_5 & \alpha_6 & \alpha_7 & \alpha_8 & \alpha_9 & \alpha_{10}
\end{array} \\
\left(\begin{array}{cccccc|cccc}
 & & 1 & & & 1 & & & & \\
 & & & 1 & & 1 & & & & \\
1 & & & & & & 1 & & & \\
 & 1 & & & & & & & 1 & \\
\hline
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 & & 1 & & & & & & 1 & \\
 & 1 & & & & & & & 1 &
\end{array}\right)
\end{array}
$$

OPTIMIZATION PROBLEM

$$\begin{aligned} \underset{\alpha}{\text{argmin}} \quad & \left\| P\alpha + \bar{L} \right\|^2 \\ \text{subject to} \quad & \alpha \geq 0. \end{aligned}$$

RESULTS

ASSESSMENT

CONCLUSION

MTHEME

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}
\usetheme{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{empha
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

- Milk
- Eggs
- Potatos

Enumerations

1. First,
2. Second and
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

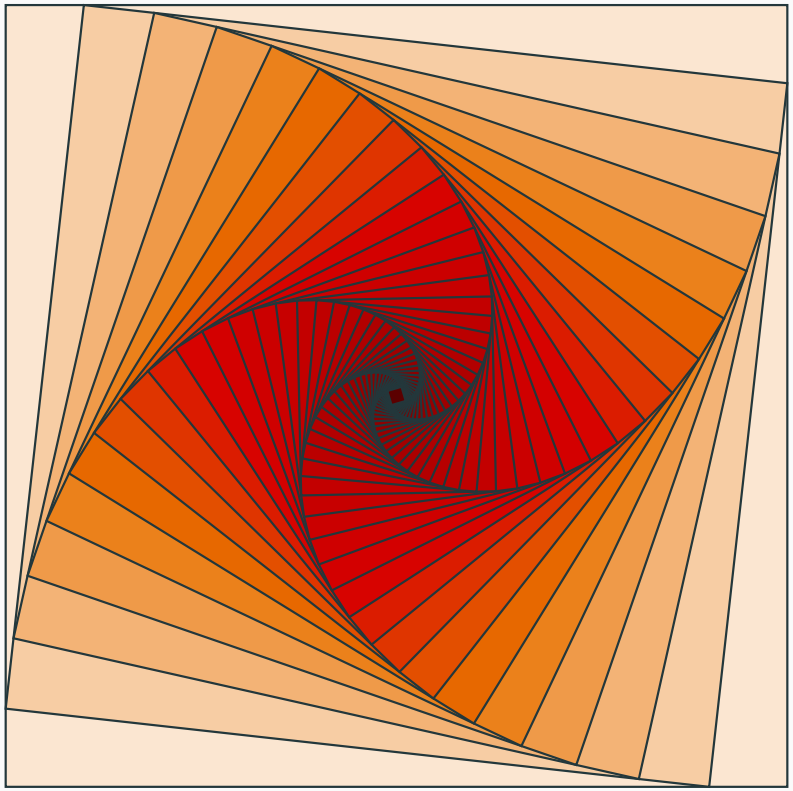

Figure: Rotated square from texample.net.

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.

MATH

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

QUOTES

Veni, Vidi, Vici

plainDark background

SUMMARY

Get the source of this theme and the demo presentation from

`github.com/matze/mtheme`

plainQuestions?