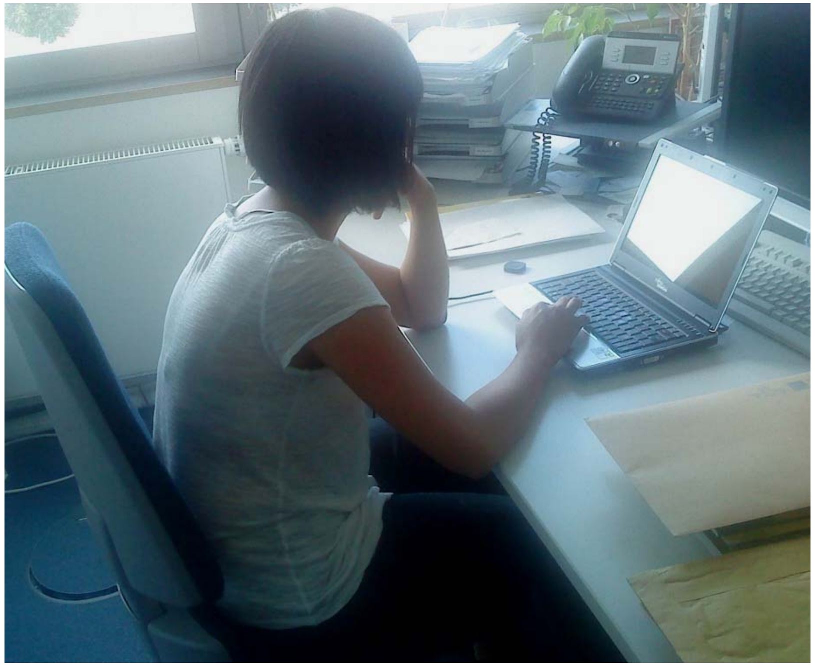
Qualitative VDT Screen Simulation



Radiance workshop 2010

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Problem

Different types of glare
Discomfort glare
Disability glare
Veiling glare

Reflections from

- surround light sources
- objects

⇒

Contrast between foreground and background less than **Minimum Required Contrast**

Minimum Required Contrast (MRC)

Latest standard model for minimum required contrast for working on computer screen
ISO 9241-303 (Annex D)

$$CRmin = K_{age} * (2.2 + 4.84 * LL^{-0.65})$$

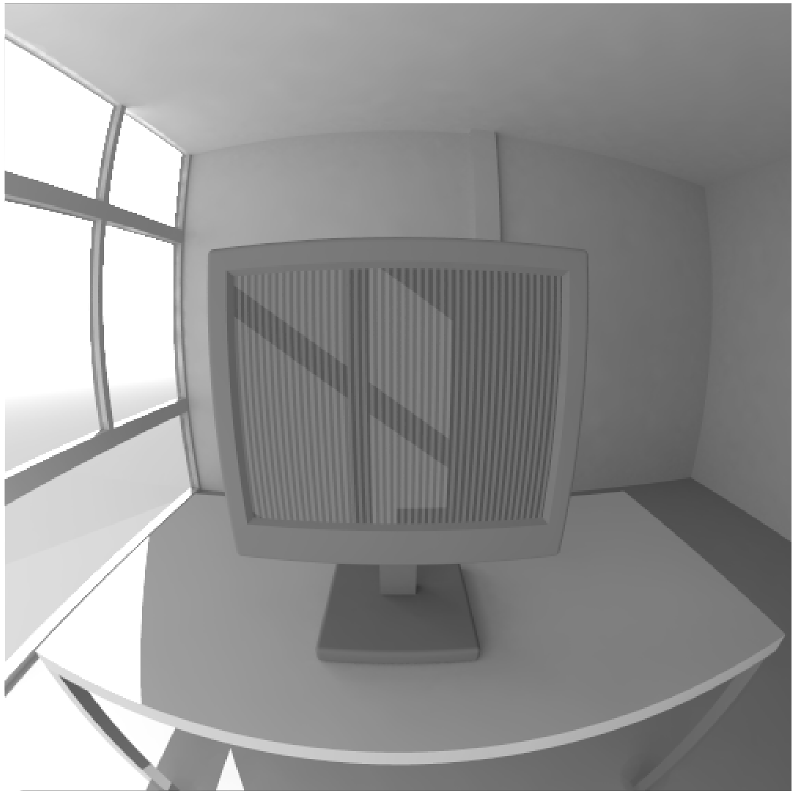
LL: low state luminance
K_{age}: age factor
There is no validation study to show the reliability of this model

Example

Veiling reflection due to contrast reduction

A flat screen monitor located in a room

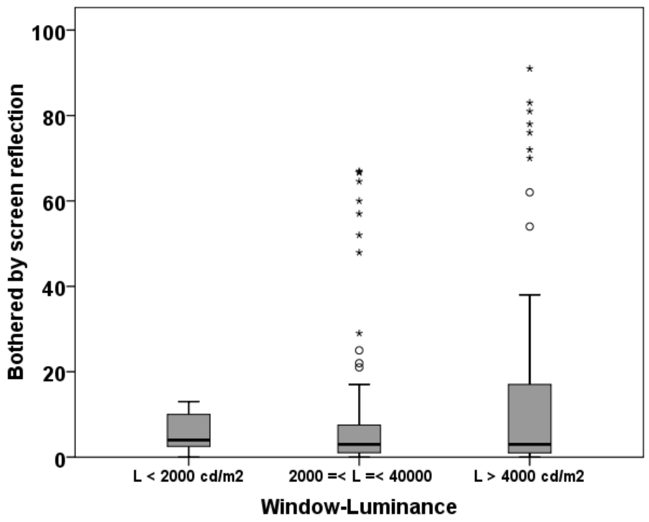
Modelled and simulated under different daylight conditions by RADIANCE



Is it necessary to evaluate veiling glare???
Is standard MRC reliable for this reason???

Results of two experimental studies accomplished to answer these questions are illustrated in the following

Experiment 1: Evaluation of **Subjective Survey**, **Luminance of Façades** and **Contrast** on VDT screens in an experimental study



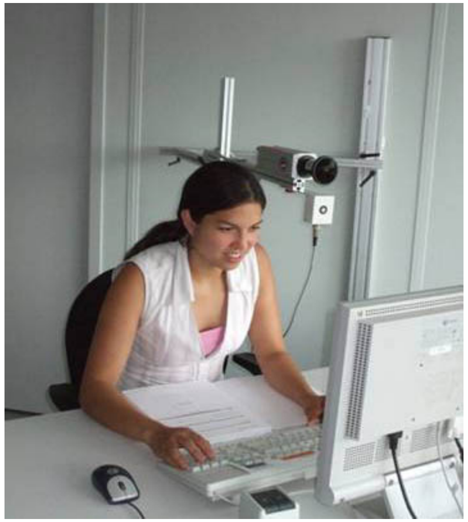
Despite the standards, **Window Luminance** is not a good indicator for screen quality in office buildings

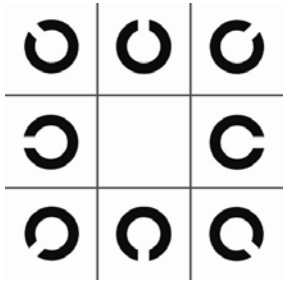
Necessitty of a new factor to evaluate the visual displays at work places

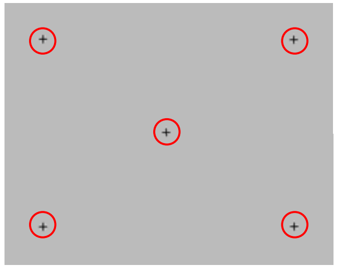
Experiment 2: Evaluation of a user assessment study included the task: **Detection of landolt rings on monitor with a contrast close to threshold**

Existing contrast threshold Model **doesn't fit**
Subjective detection profile especially for older age group

Therefore
Standard MRC for VDTs which is based on "Contrast Threshold" need more evaluations







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So…, a reliable method to evaluate screen quality at work places is missing which is the reason to develop

An accurate simulation based veiling glare evaluation model

For that reason it is necessary to have:

1- A material model with correct reflection characteristic for visual display

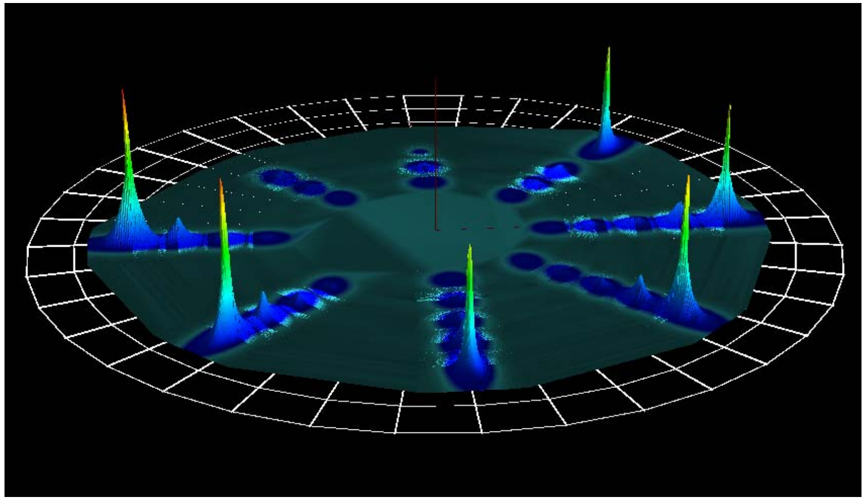
2- An accurate model for minimum required contrast, MRC

3- A Radiance tool which make the whole process possible for users

Step 1- Material Model → Presented in Radiance workshop 2008

Screen Measurement by Goniophotometer to derive:

Reflection distribution curves of monitor



Modeling Procedure

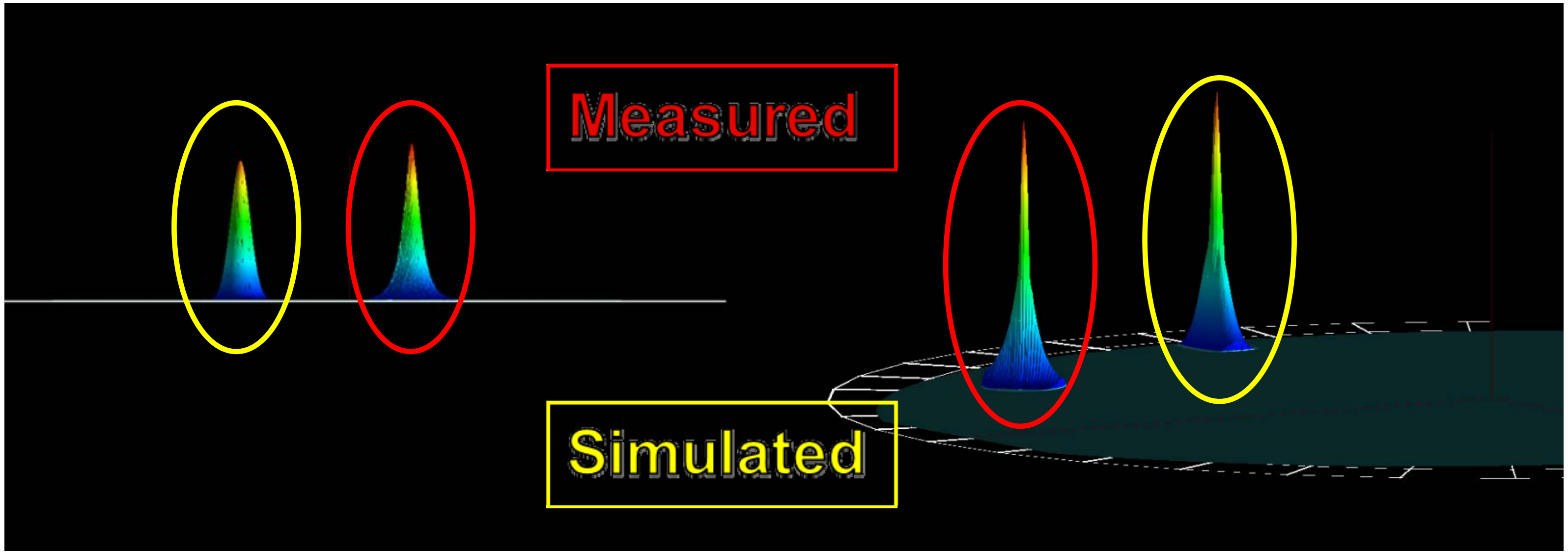
Finding a compatible mixture of the standard radiance materials that fits the measured BRDF data

Virtual Goniophotometer tool

Searching for compatible materials at two extreme incident angle

Left Image: measured and simulated BRDF, at **incident angle 30**

Right Image: measured and simulated BRDF, at **incident angle 70**



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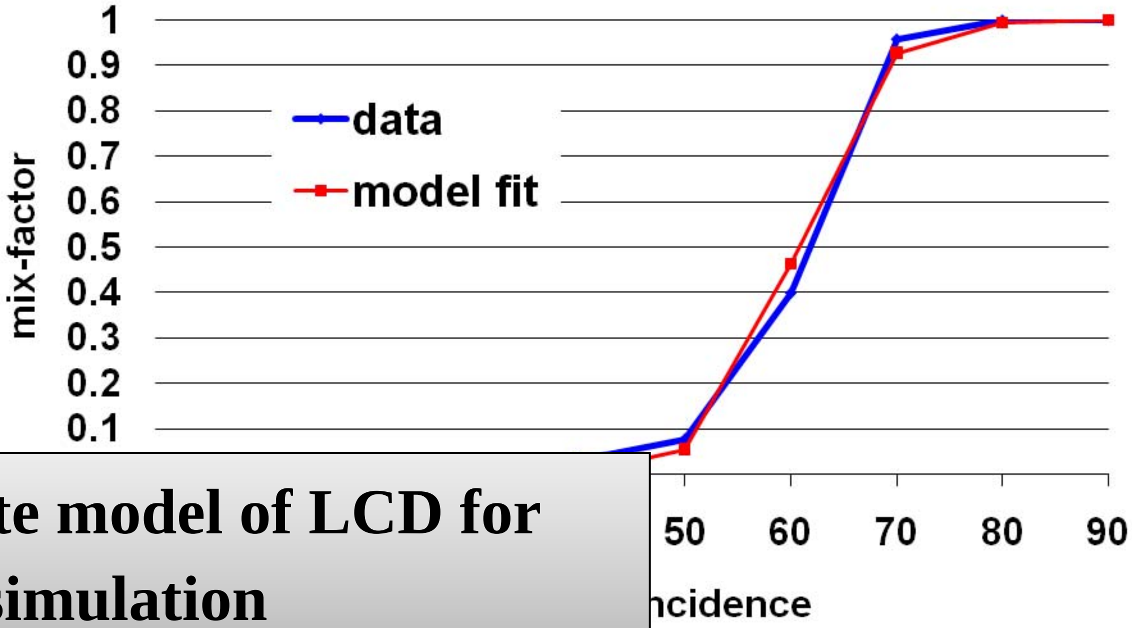
Function file for mixing two materials

$$P = \frac{e^{a+bX}}{1+e^{a+bX}}$$



An accurate model of LCD for Radinace simulation

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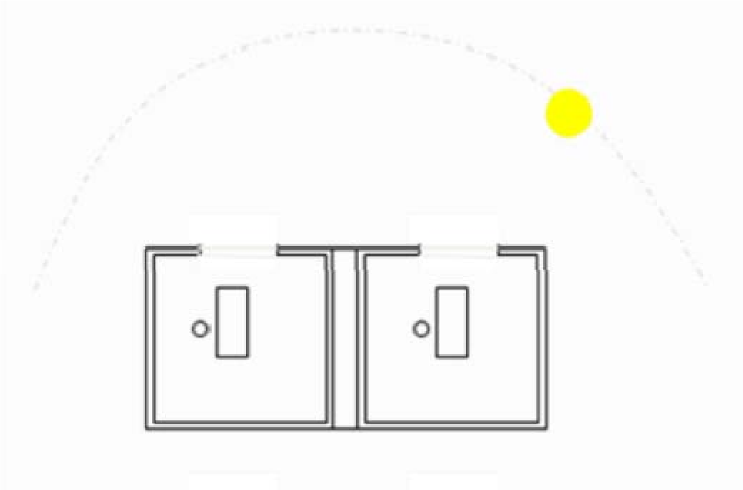
Step 2: A new experimental test was desigend to improve standard MRC or develope a new one

Three Age Groups :20-30; 40-50; 60-70
Each age group → 15 subjects

Test set up: two rotatable test rooms on the roof of ISE



Main Concept

Reading Test → Subjects read from flash images of unrelated words that appear on middle part of monitor with different exposure time and/or different contrast, with both **negative and positive polarity**

Reading Rate in words per minute is computed as number of words correctly read, divided by the exposure time

Contrast perception of subjects while they have their **maximum readability** and when they state **comfort reading** was tested

dritte Tod zehn
Sonntag nie Juli
sechs Mai Zählen
mir einmal lila
Strahl Kuh Steht

Million man rosa
Mai Uhr Tod sehr
einmal ihr Abend
nie Sommer träge
Winter nur schön

Readable

Readable but not comfortable

Unreadable

New form of the model was assumed to be:

$\mathbf{CR_{new}=K_{age}*[A+B*(LE^{C}/LL^{D})]}$, in which:

LE : Environtmental luminance

New factor

LL: Low stae luminance

K_{age}: Age factor

So far the best correlation has been derived with values of:

A=1 B=80 C=0.136 D=1.238

But other statistical analysis are in process which could change above parameters

Pearson correlation between MRC and subjective results for both standard and new developed MRC

		Min contrast for max subjective readability	Min contrast stated as comfortable to read
Standard MRC	Negative polarity	0.48	0.008
	Positive polarity	0.069	0.41
New MRC	Negative polarity	0.9132	0.956
	Positive polarity	0.965	0.92

Implementing the new model into Radiance
Developing a new tool

Input

Geometry → VDT and Room

VDT-Material → Default: material of measured LCD
Optional: by user

View point → Default : Standard work station view point
Optional: by user

Resolution → Default : Defined by program due to VDT size
Optional: by user

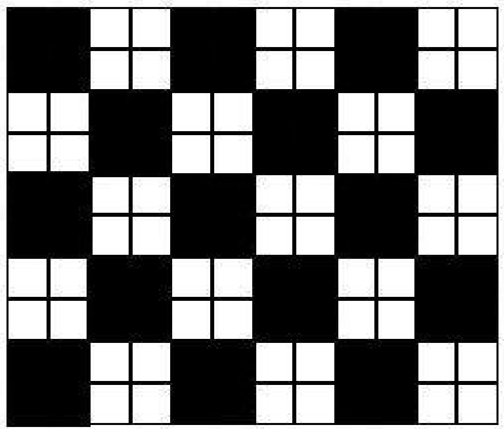
No change in Radiance codes, just making a package of necessary Radiance commands, plus calculation procedure

Process

Tracing rays to each screen pixel and calculating luminace of any pixel in both on and off state after reflection

Considering a view angle of about 2-3 min of arc

Deviding the screen pixels according to this angle to alternative white and black



Calculating contrast between any two adjacent area:
CR= Lum of white area / Lum of black area

Comparing the contrast betwenn all neighbouring areas with new developed MRC model and determining the areas with contrast defficiency and classify them into different classes.

If **Contrat < MRC → Veiling glare**

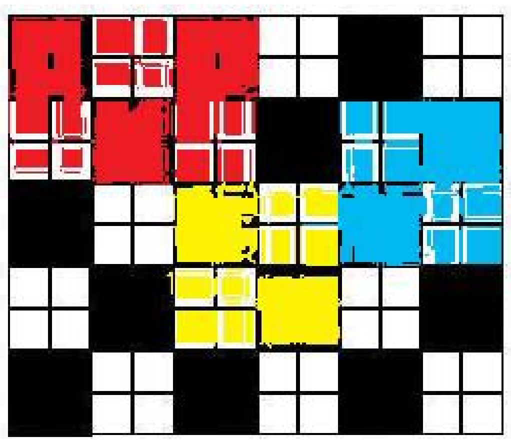
Veiling index

1. Contrast deficiency is **Low**
2. Contrast deficiency is **Middle**
3. Contrast deficiency is **High**

Output

Fractions of the screen area with different classes of veiling glare
and
Visualaizing them by means of color

- Class 1-Low 20%
- Class 2-Medium 13.3%
- Class 3- High 13.3%



Dynamic model

Next step after implementing the model into Radiance is conducting an annual calculation of veiling glare

Which is possible by integrating the method into Daysim

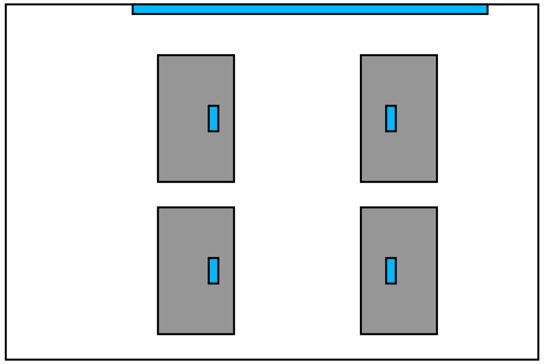
Table of output

- Annual hourly veiling index in different classes
- Average annual veiling index at each class
- Histogram evaluation of the Maximum veiling glare value throughout the year
- Periods with high, medium, low and without glare

Application

1- office and Work places,

- designing office layout
  - best location/orientation of desk
  - best location/orientation of VDT on desk
- designing facades
  - shape and dimension
  - transmittance
- designing daylighting-shading systems
  - Design in advance
  - Integrating in automatically control system



Application

2- Public Places

- Deciding about the best location, Orientation and angle of screen

- Optimizing daylighting or artificial lighting to minimize veiling glare

- Designing automatically control systems to change the angle of screen to minimize veiling glare under different daylight conditions

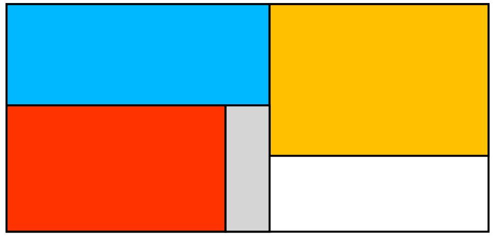
Outlook

The tool could be expanded later in the form of the following tools

An aiding tool for office layout design

input: Different potential VDT location

output: Categorization of these locations according to possibility of veiling glare



A specified tool for public-use screens

Evaluating screen quality for several view point simultaneously and averaging the results → suggesting the best choice for all view points

Thank you very much for your attention