Composition of Raster Images

CGG MFF UK Praha

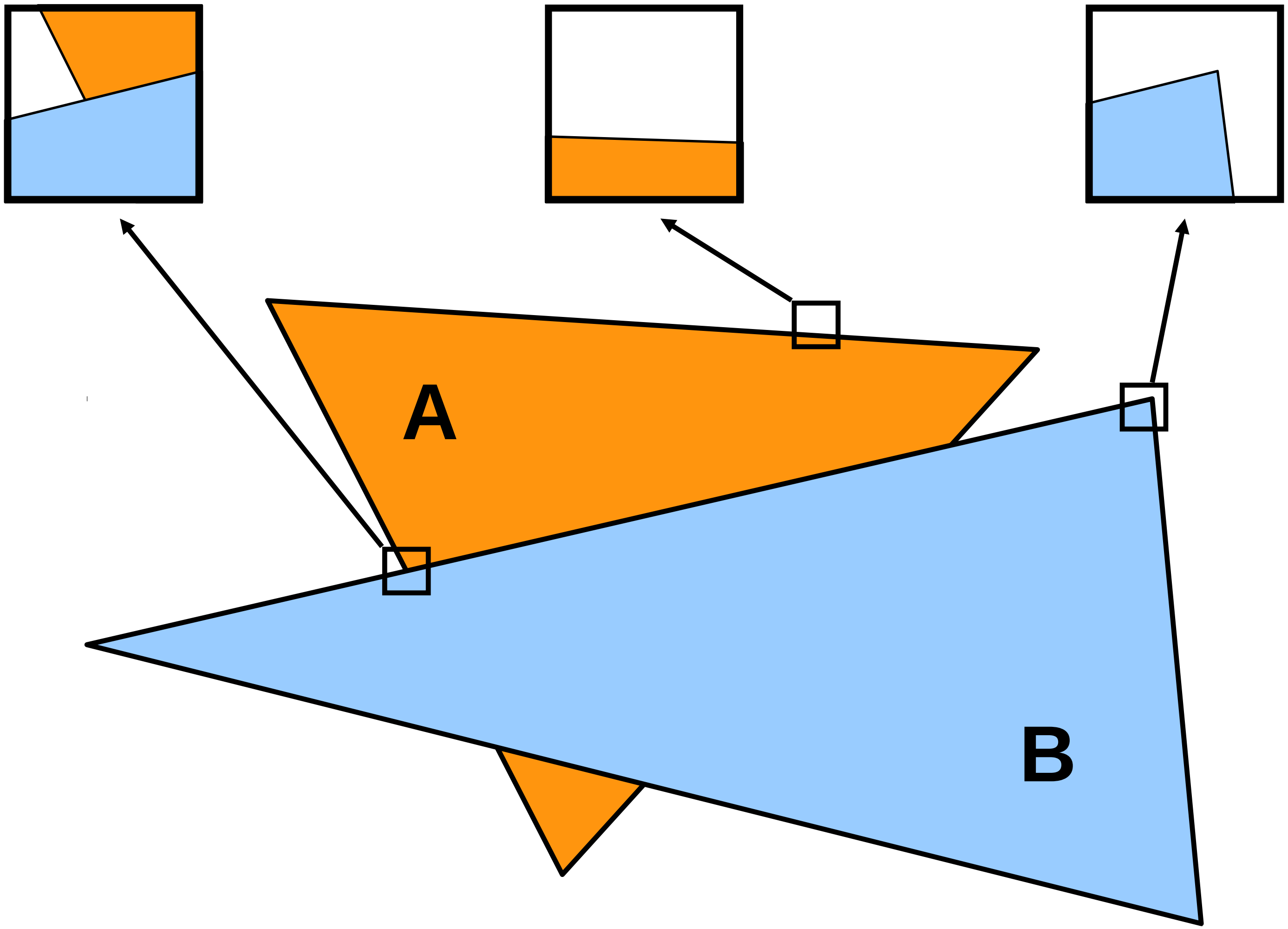
pepca@cgg.mff.cuni.cz

http://cgg.mff.cuni.cz/~pepca/

Image Composition

- **Superposition** of several real images
  - Inserting of objects into a different background, ...
- **Blending** of images, „**fade-in**", „**fade-out**"
  - Animations, editing
- **Synthesis** of images
  - Composing an artificial images from several independently produced parts (e.g. background, foreground, hero character, fog, ...)

Coverage of the Pixel Area

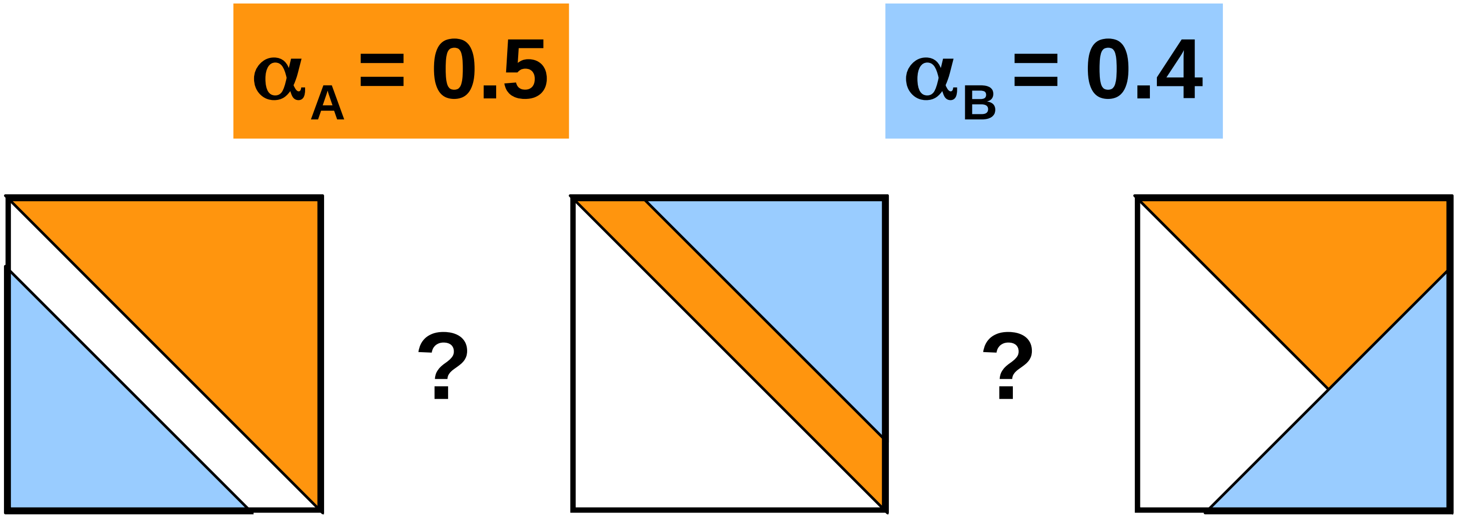


Alpha Channel

- Measure of **pixel coverage** in percent
  – Stored as **transparency**:
  – **α = 0** … totally transparent pixel (no effect on result)
  – **α = 1** … opaque pixel („shows nothing beyond”)
- Values for **α** are stored in each pixel
  – Frequently integer representation (0 ÷ 255)
  – Quadruplet **[R, G, B, α]**
  – More frequent representation: **[Rα, Gα, Bα, α]**

Compositing Two Images

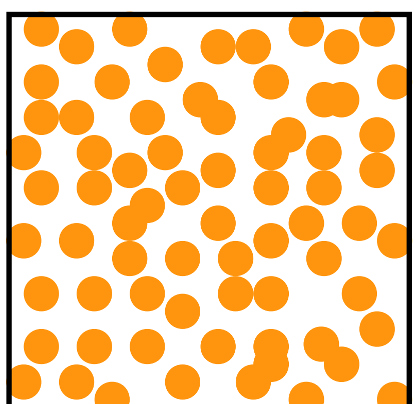
- Two input pixels **[A, α_A]** resp. **[B, α_B]**
  - Result value: **[C, α_C]**
- ? **how are these pixels composited** ?



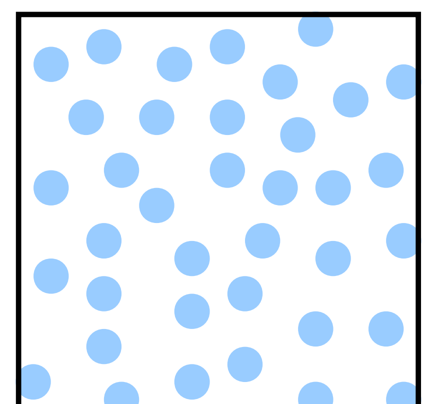
Pixel Coverage Model

- The pixel **[A, α_A]** is assumed to be **randomly covered** with colour **A** with equal probability α_A
  – Independent of underlying shapes
  – Suitable in most cases

α = 0.5

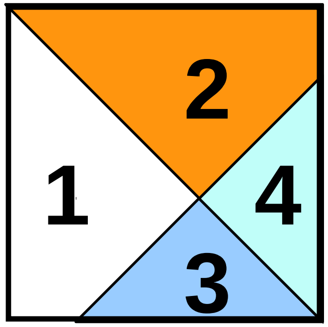


α = 0.2



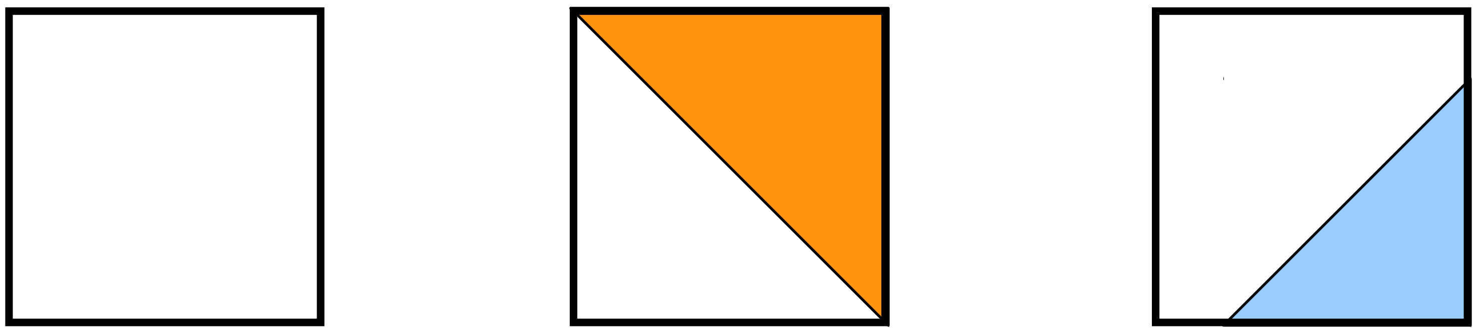
Overlap of Two Pixels

	Content	Area	Colour
1	*(empty)*	$(1 - \alpha_A)(1 - \alpha_B)$	0
2	A	$\alpha_A(1 - \alpha_B)$	0, A
3	B	$\alpha_B(1 - \alpha_A)$	0, B
4	A & B	$\alpha_A\alpha_B$	0, A, B



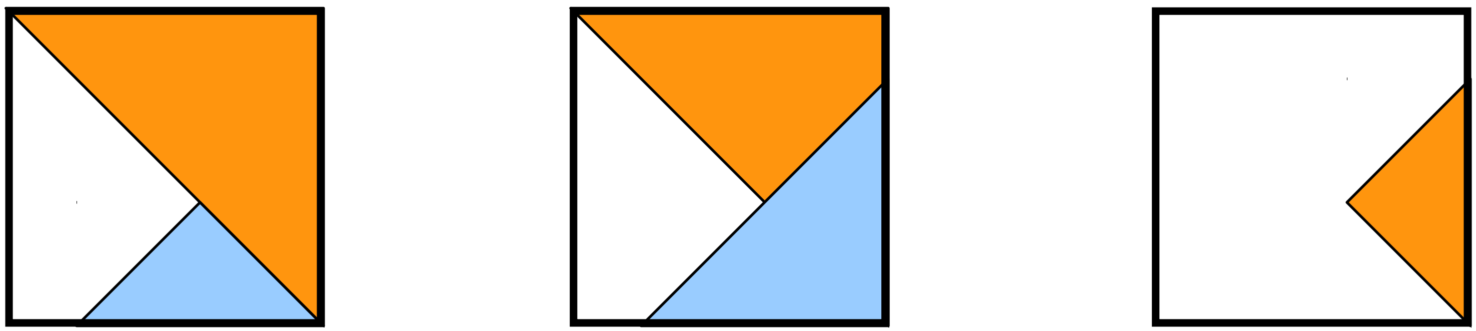
overall **12 possibilities**

Combining Two Pixels



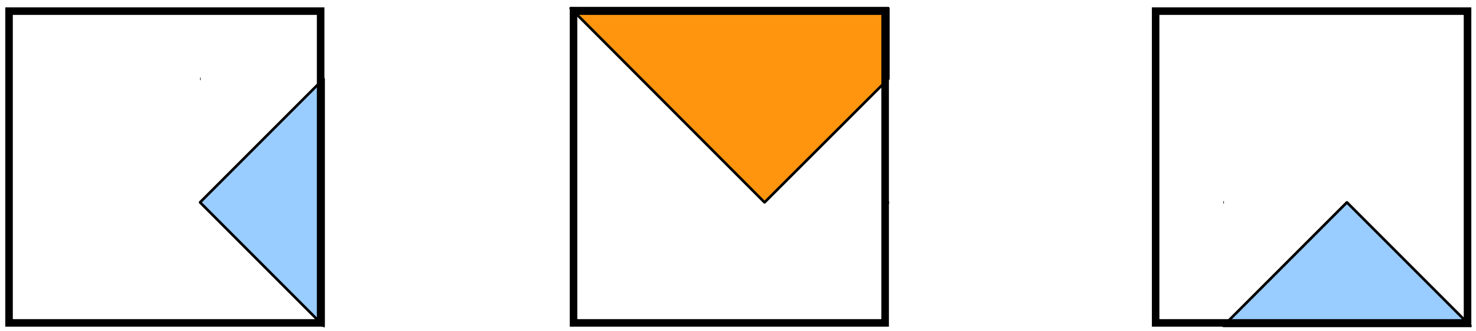
	clear	A	B
Colours	**(0,0,0,0)**	**(0,A,0,A)**	**(0,0,B,B)**
F_A	**0**	**1**	**0**
F_B	**0**	**0**	**1**

Combining Two Pixels



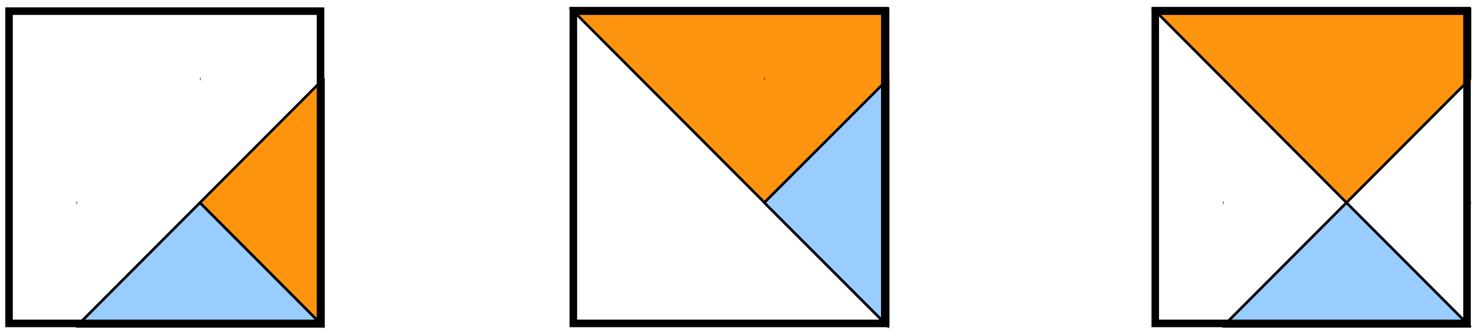
	A over B	B over A	A in B
Colours	**(0,A,B,A)**	**(0,A,B,B)**	**(0,0,0,A)**
F_A	1	$(1 - \alpha_B)$	α_B
F_B	$(1 - \alpha_A)$	1	0

Combining Two Pixels

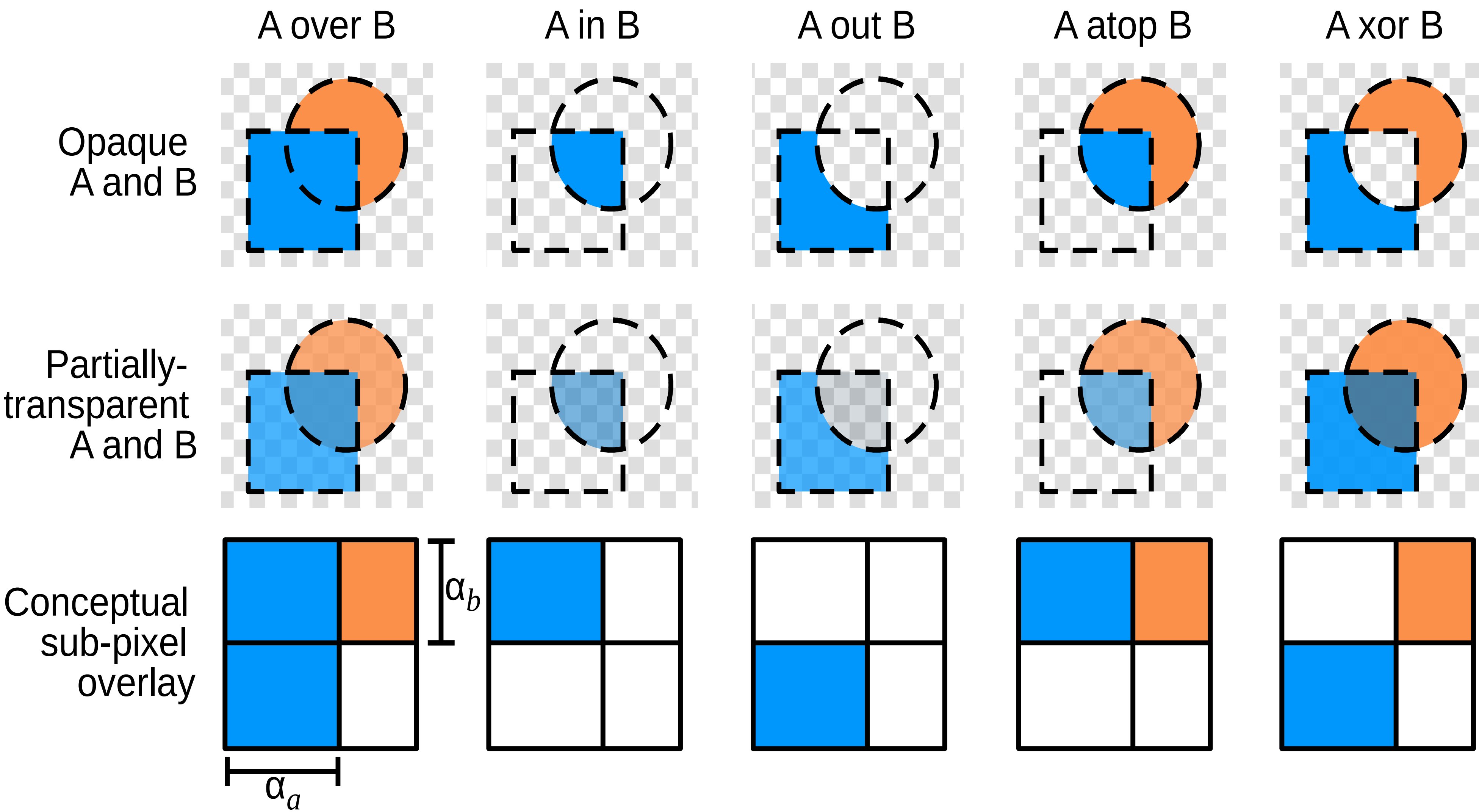


	B in A	A held out by B	B held out by A
Colours	**(0,0,0,B)**	**(0,A,0,0)**	**(0,0,B,0)**
F_A	0	$(1 - \alpha_B)$	0
F_B	α_A	0	$(1 - \alpha_A)$

Combining Two Pixels



	A atop B	B atop A	A xor B
Colours	(0,0,B,A)	(0,A,0,B)	(0,A,B,0)
F_A	α_B	$(1 - \alpha_B)$	$(1 - \alpha_B)$
F_B	$(1 - \alpha_A)$	α_A	$(1 - \alpha_A)$


A over B
A in B
A out B
A atop B
A xor B
Opaque
A and B
Partially-
transparent
A and B
Conceptual
sub-pixel
overlay
α_b
α_a

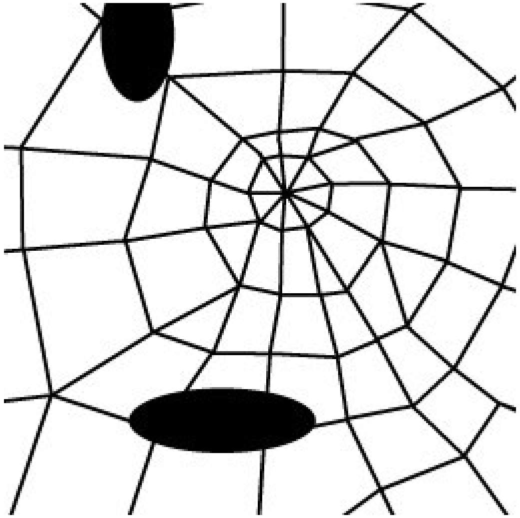
Implementation

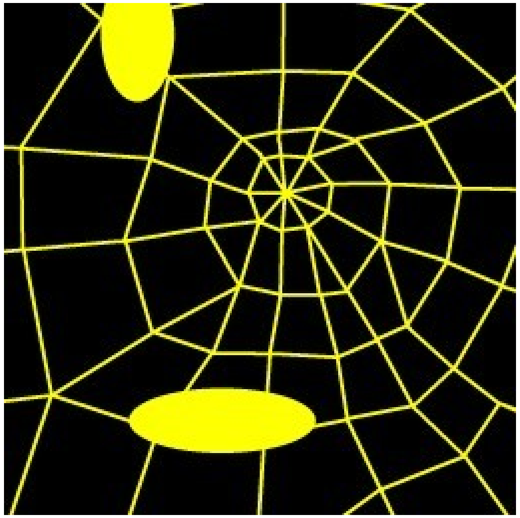
- The four-tuple **RGBα** is **stored** in the form
  [Rα, Gα, Bα, α]
  - This is referred to as **pre-multiplied alpha**
- When using the values, alpha has to be **divided out**
  - E.g. when displaying the RGB values
- During pre mul alpha operations that involve **two pixels**, all four factors $\mathbf{F_X}$ are used
  - Advantage of pre-mul alpha: arithmetic ops work exactly like in the non-alpha case

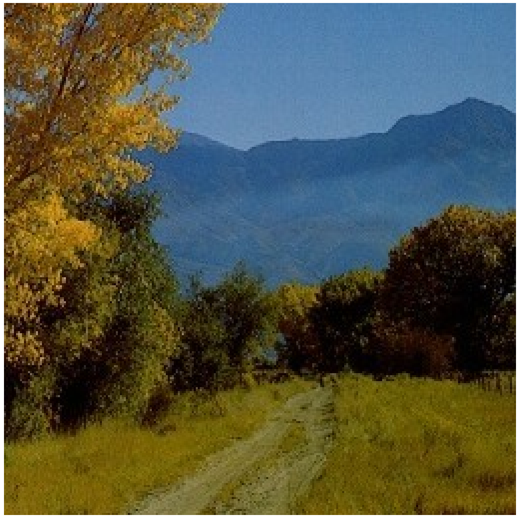
Operations

- **Two pixel operation** A **op** B:
  $[F_A R_A + F_B R_B, F_A G_A + F_B G_B, F_A B_A + F_B B_B, F_A \alpha_A + F_B \alpha_B]$
- Operator **darken** (A, ρ):
  $[\rho R_A, \rho G_A, \rho B_A, \alpha_A]$
- Operator **fade** (A, δ):
  $[\delta R_A, \delta G_A, \delta B_A, \delta \alpha_A]$
- Operator **opaque** (A, ω):
  $[R_A, G_A, B_A, \omega \alpha_A]$

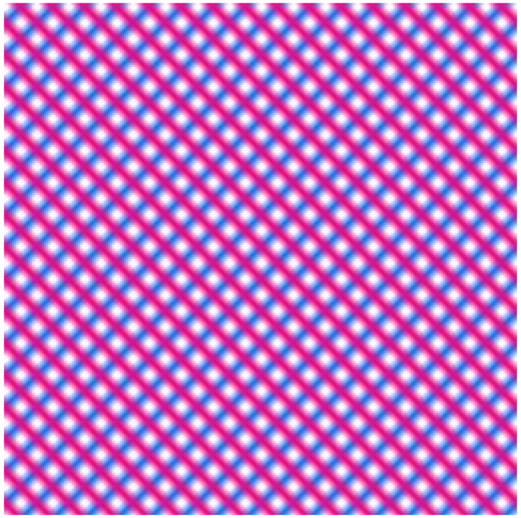
Example - Inputs



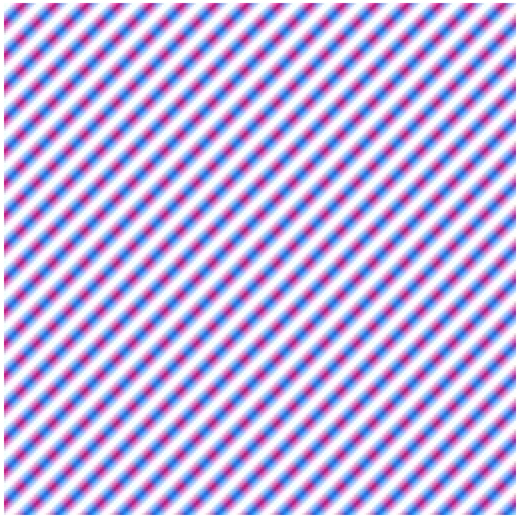




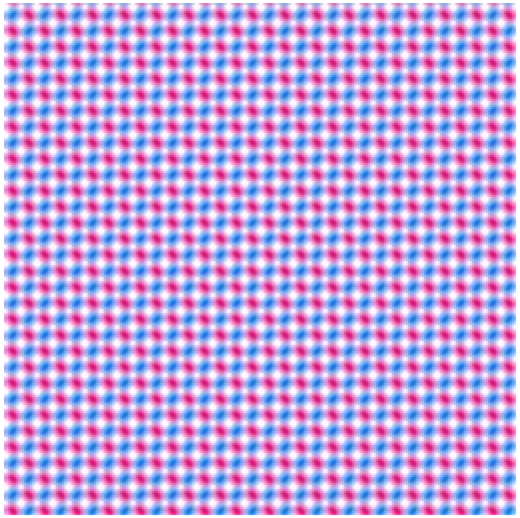
Example – binary operations I



1 over 2



1 atop 2

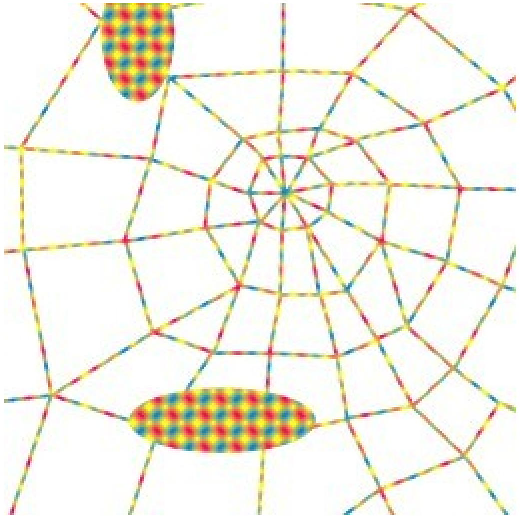


1 xor 2

Example – binary operations II

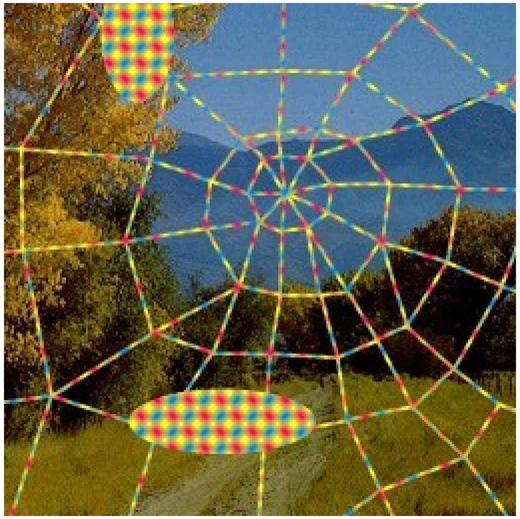
1 in 2

1 held out by 2

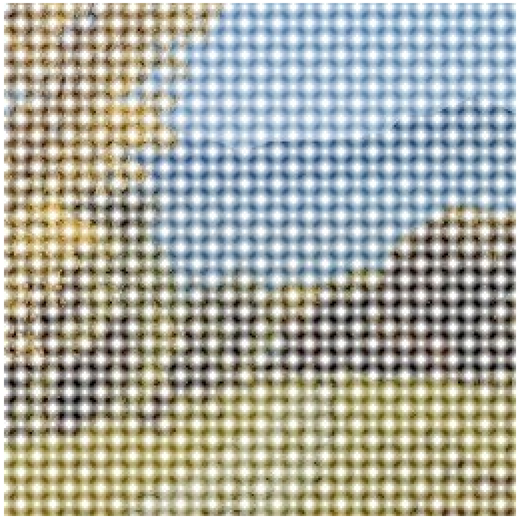


(1 xor 2) atop W

Example – binary operations III



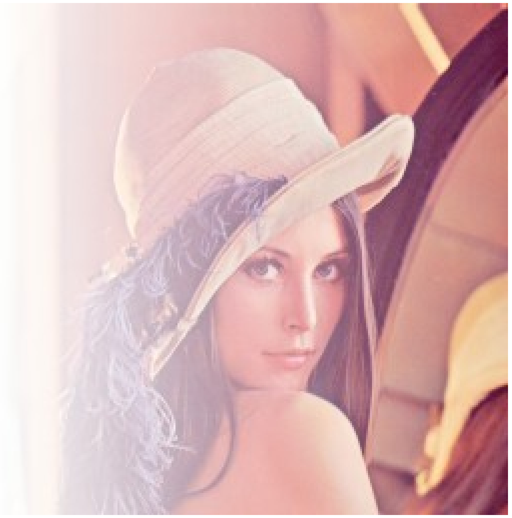
((1 xor 2) atop W) over V



V atop (1 xor 2)

(V atop (1 xor 2)) over L

Example – Combinations



fade(L, horiz)

fade(L, horiz) over V

Operation „plus”

- **Addition:** operator A **plus** B:
  [R_A+R_B, G_A+G_B, B_A+B_B, $\alpha_A+\alpha_B$]

- Example 1: **combination of two images**
  fade(A,**t**) **plus fade**(B,**1 - t**)

- Example 2: **burning tree**
  (FFire **plus** (BFire **held out by** Tree)) **over**
  darken(Tree,**0.8**) **over** Background

First use in the film Star Trek II (1982) – „Genesis Effect“:
https://www.youtube.com/watch?v=Qe9qSLYK5q4

End

Further information:

- **J. Foley, A. van Dam, S. Feiner, J. Hughes**: ***Computer Graphics, Principles and Practice***, 835-843
- **T. Porter, T. Duff** (Lucasfilm): ***Compositing Digital Images***, Computer Graphics 18(3), 1984