Image transparency, composition by α-blending

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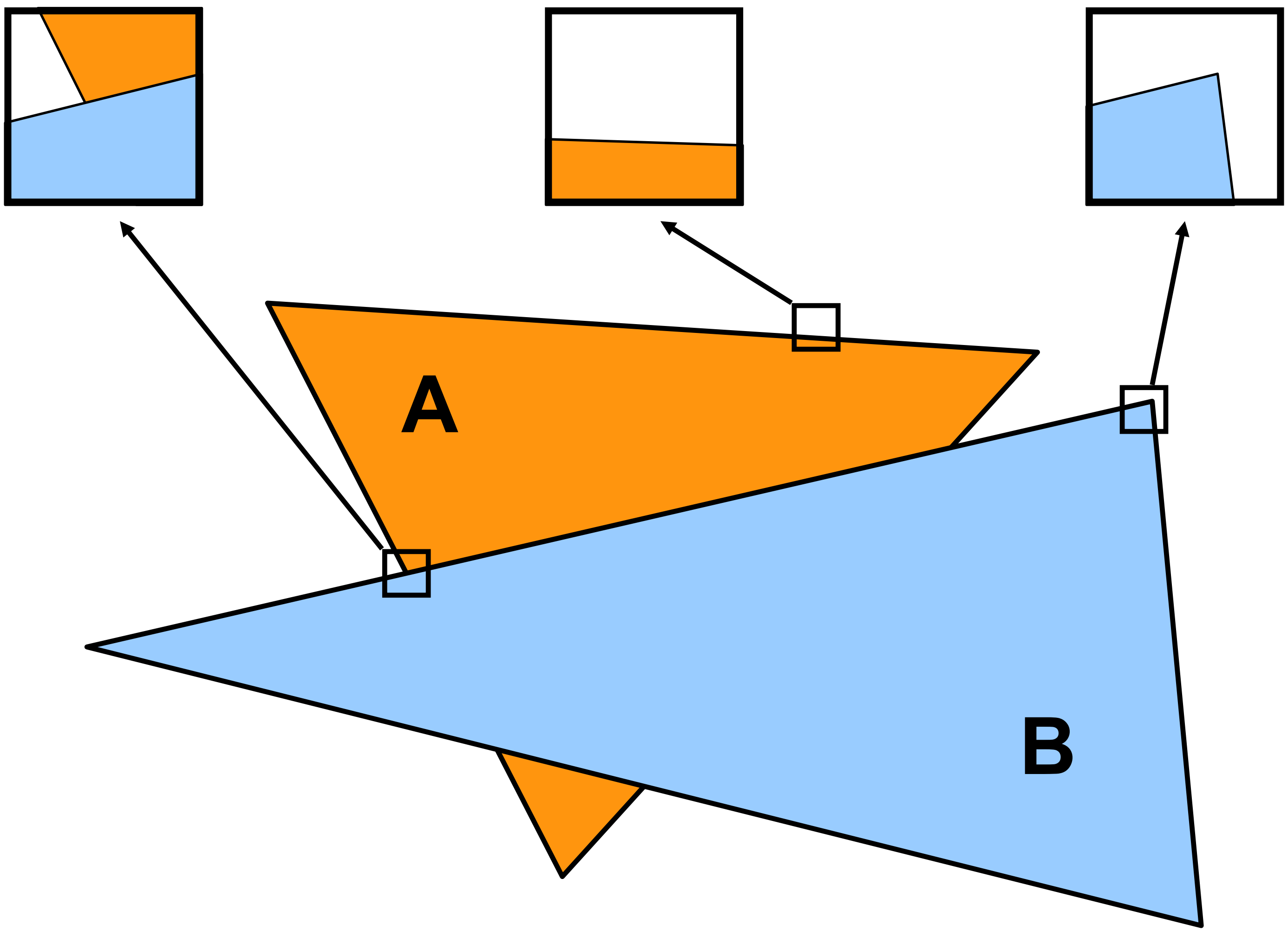
Image composition

- composition using **real images**
  – changing (tampering with) image background, ..
- **image fading** („fade-in”, „fade-out”)
  – animation, video cutting
- **image synthesis**
  – picture can be assembled from several independent parts (e.g. background, foreground, flames, mist, clouds, ..)

Pixel-area coverage

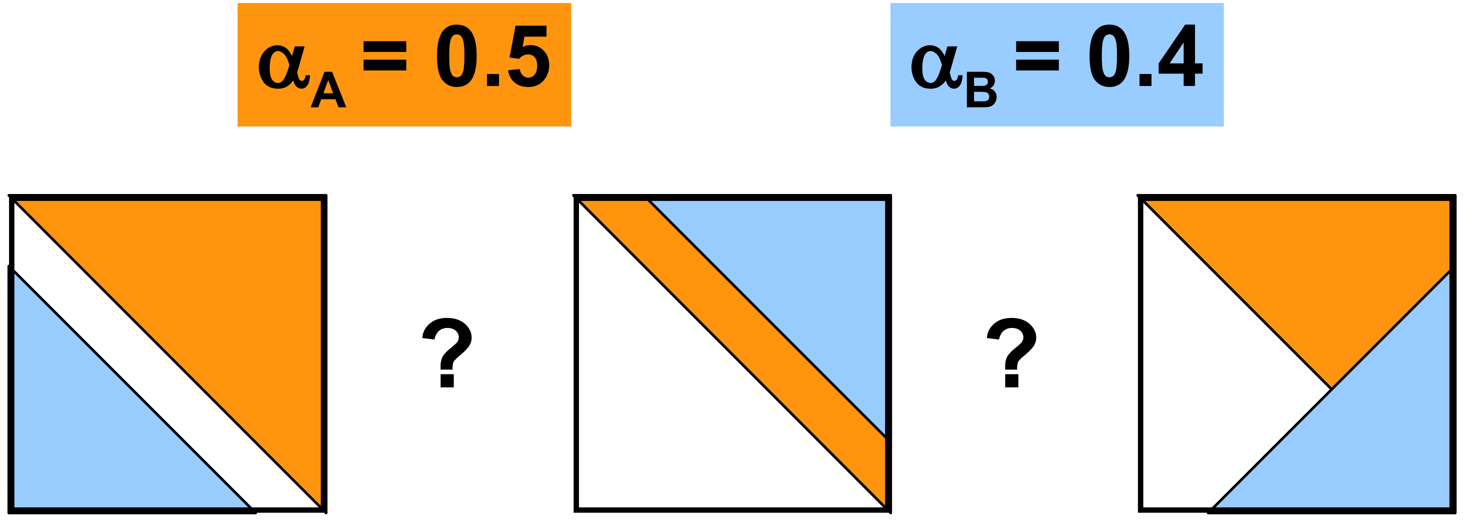


α channel

- percentual **pixel-area coverage** („opaque paint“)
  - complementary to **„transparency”**
  - **α = 0** … absolutely transparent (no effect on result)
  - **α = 1** … completely opaque („nothing shows through”)
- **α value** stored in every pixel
  - integer representation (0 ÷ 255)
  - quadruple **[R, G, B, α]**
  - more practical format **[Rα, Gα, Bα, α]**

Composition of two images

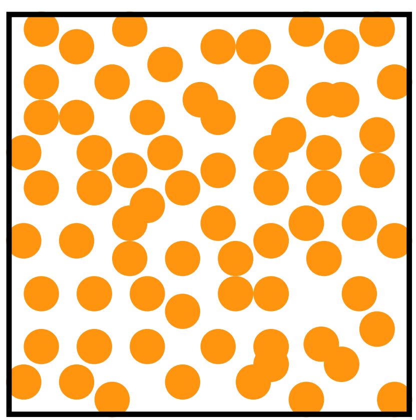
- two source pixels: **[A, α_A]** and **[B, α_B]**
  - need to define result **[C, α_C]**
- ? **composition model** ?



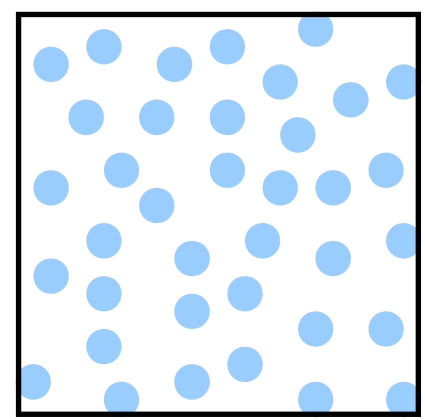
Pixel-area coverage model

- pixel **[A, α_A]** is **randomly covered** by an opaque paint **A** (with **uniform probability** α_A)
  - composition of arbitrary geometric. independent shapes
  - sufficient in most cases

α = 0.5

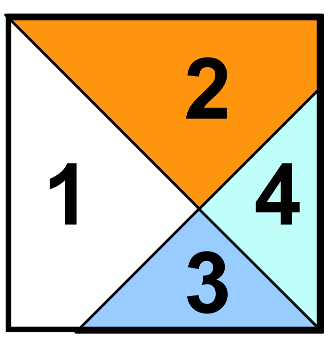


α = 0.2



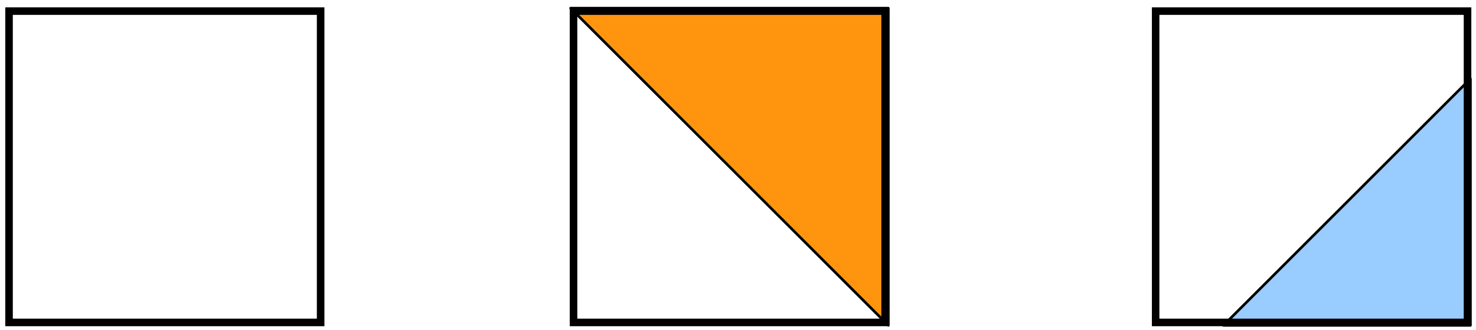
Superimposition of two pixels

	segment	area	color
1	void	$(1 - \alpha_A)(1 - \alpha_B)$	0
2	A	$\alpha_A(1 - \alpha_B)$	0, A
3	B	$\alpha_B(1 - \alpha_A)$	0, B
4	A i B	$\alpha_A\alpha_B$	0, A, B



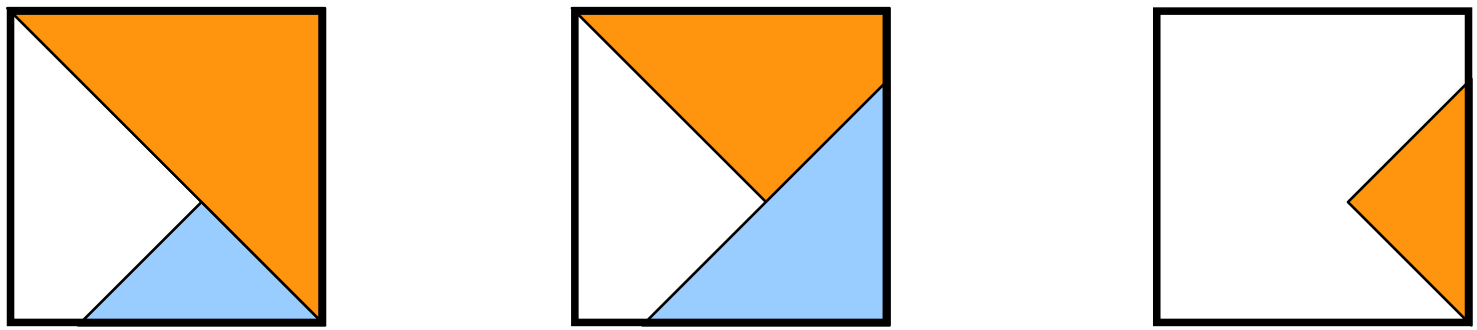
total **12 combinations**

Superimposition of two pixels



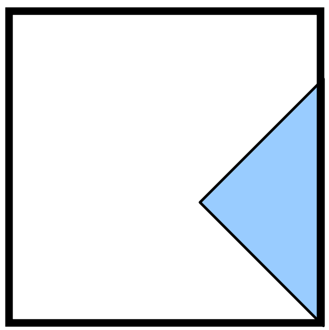
op.	clear	A	B
colors	(0,0,0,0)	(0,A,0,A)	(0,0,B,B)
F_A	0	1	0
F_B	0	0	1

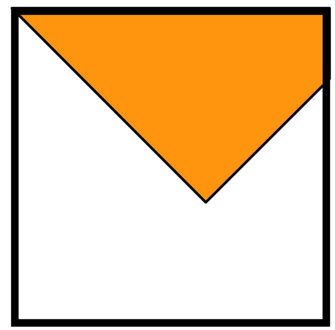
Superimposition of two pixels

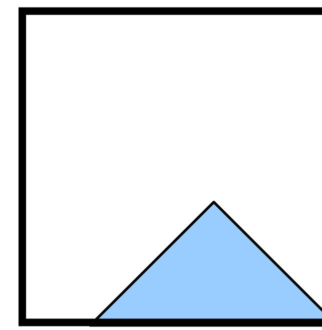


op.	A over B	B over A	A in B
colors	(0,A,B,A)	(0,A,B,B)	(0,0,0,A)
F_A	1	$(1 - \alpha_B)$	α_B
F_B	$(1 - \alpha_A)$	1	0

Superimposition of two pixels

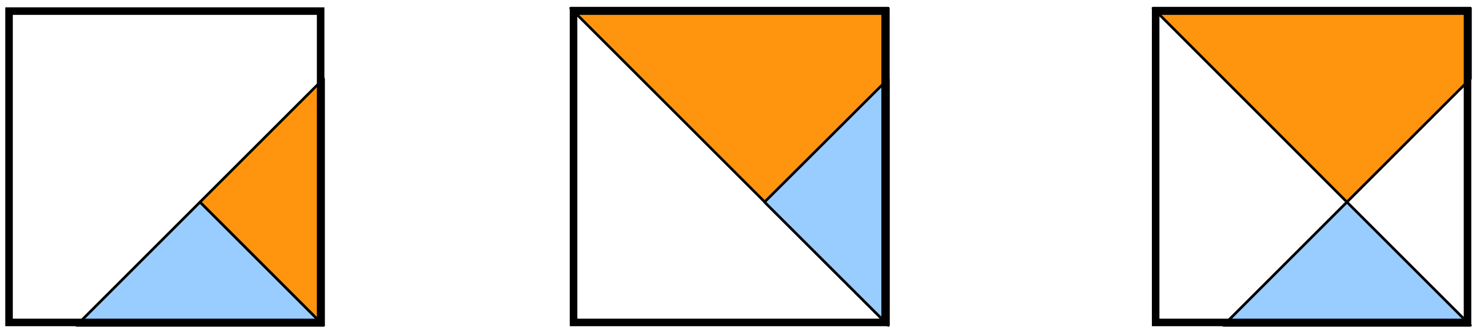






op.	B in A	A out B	B out A
colors	(0,0,0,B)	(0,A,0,0)	(0,0,B,0)
F_A	0	$(1 - \alpha_B)$	0
F_B	α_A	0	$(1 - \alpha_A)$

Superimposition of two pixels



op.	A atop B	B atop A	A xor B
colors	(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	$(1 - \alpha_A)$

Implementation

- quadruples **RGBα** are **stored** as **[Rα, Gα, Bα, α]**
  – α-channel will be multiplied in any case
- conversion back to RGB .. **dividing by α**
  – rare operation
  – just throwing away the 4th component looks much better
- **superimposition of two pixels**
  – all four components are multiplied by the factor $\mathbf{F_X}$
  – linear blending operation on quadruples (fast SSE, GPU instructions..)

Operator summary

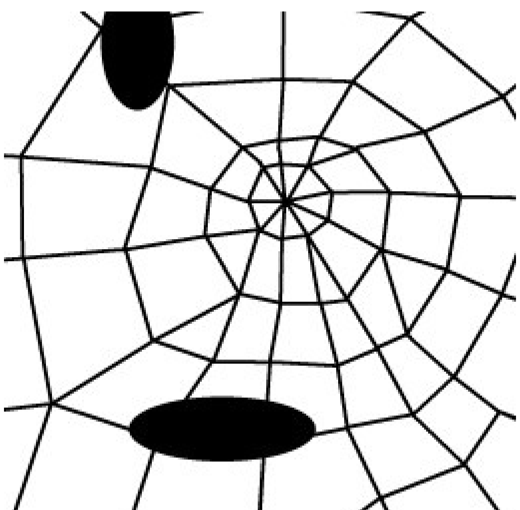
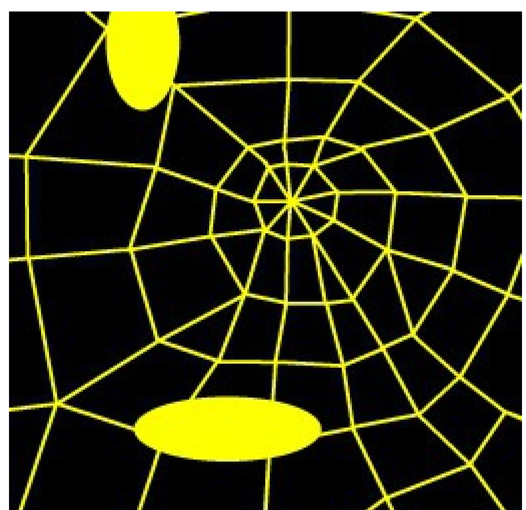
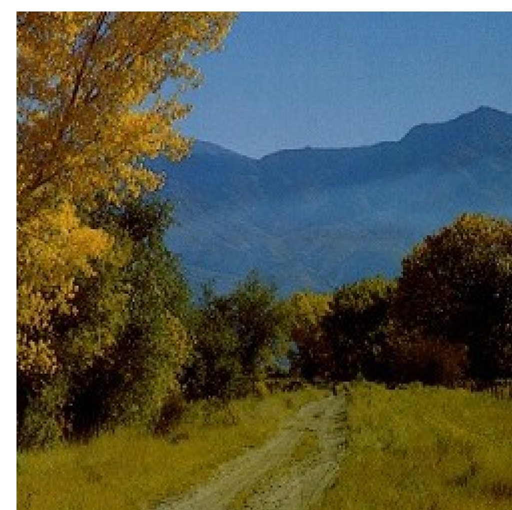
- general binary superimposition A **op** B:

  $$[\, F_A R_A + F_B R_B,\ F_A G_A + F_B G_B,\ F_A B_A + F_B B_B,\ F_A \alpha_A + F_B \alpha_B \,]$$

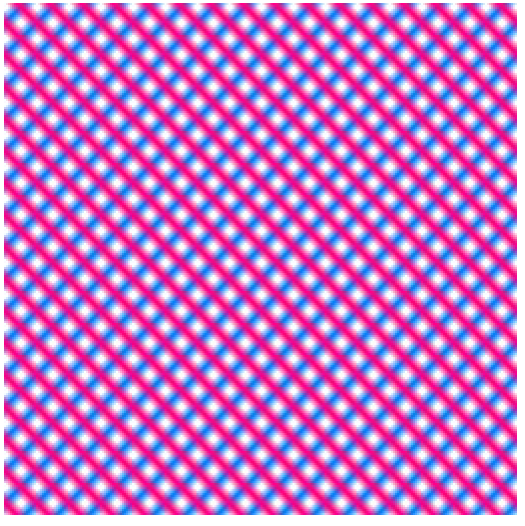
- **darken** $(A, \rho) = [\, \rho R_A,\ \rho G_A,\ \rho B_A,\ \alpha_A \,]$
- **fade** $(A, \delta) = [\, \delta R_A,\ \delta G_A,\ \delta B_A,\ \delta \alpha_A \,]$
- **opaque** $(A, \omega) = [\, R_A,\ G_A,\ B_A,\ \omega \alpha_A \,]$

Examples – inputs



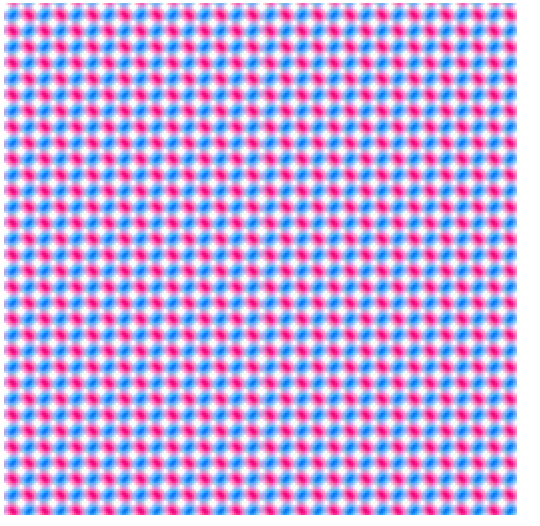





Examples – binary op. I



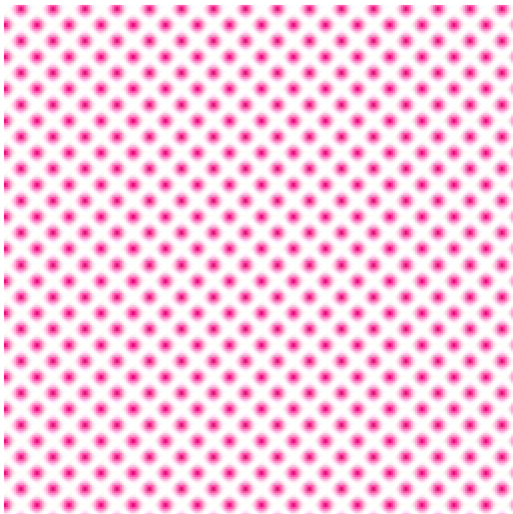
1 over 2

1 atop 2

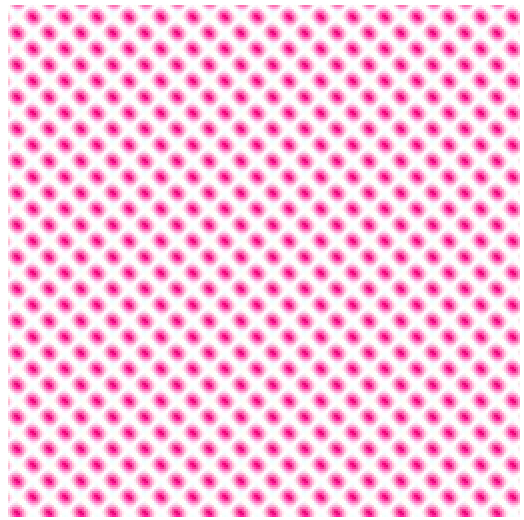


1 xor 2

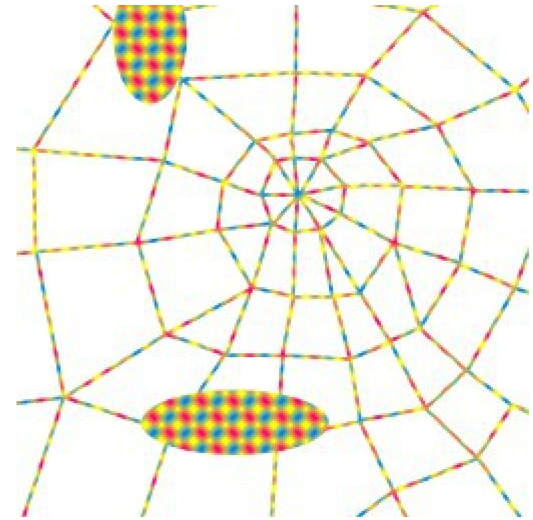
Examples – binary op. II



1 in 2

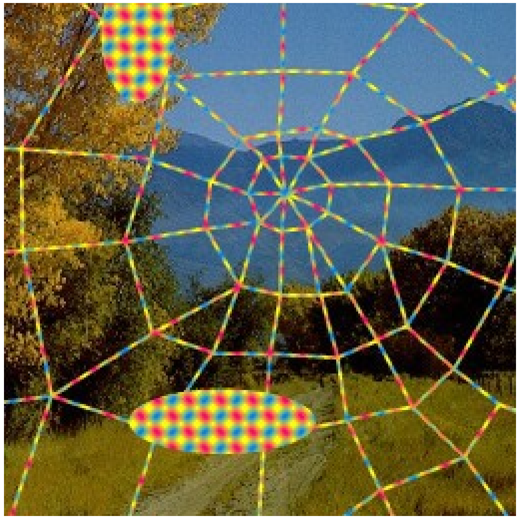


1 out 2



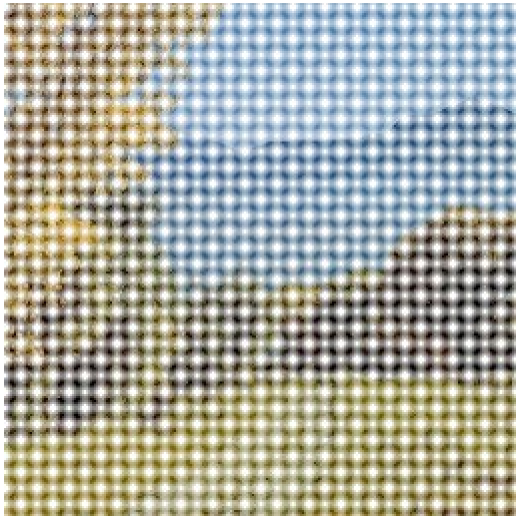
(1 xor 2) atop W

Examples – binary op. III



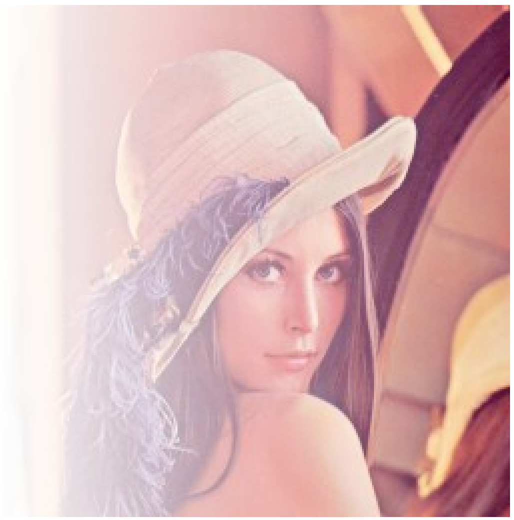
((1 xor 2) atop W) over V

(V atop (1 xor 2)) over L



V atop (1 xor 2)

Examples – image fading



fade(L, horiz)

fade(L, horiz) over V

Operator „plus”

- additive operator A **plus** B:
  [R_A+R_B, G_A+G_B, B_A+B_B, $\alpha_A+\alpha_B$]
  - carefully! (can cause overflow)

- example 1: **fading** of two images
  fade(A,**t**) **plus fade**(B,**1 - t**)

- example 2: **tree on fire**
  (FFire **plus** (BFire **out** Tree)) **over darken**(Tree,**0.8**) **over** Background

Originally from the movie „Star Trek II“ (1982) – „Genesis Effect“:
https://www.youtube.com/watch?v=Qe9qSLYK5q4

The End

More info:

- **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

  https://keithp.com/~keithp/porterduff/p253-porter.pdf