

THE PROBLEM

Visualizing True Color Images

(24 bit = over 16 million possible colors)



Lenna (512 x 512)
148279 colors
(USC Image Data Base ©)

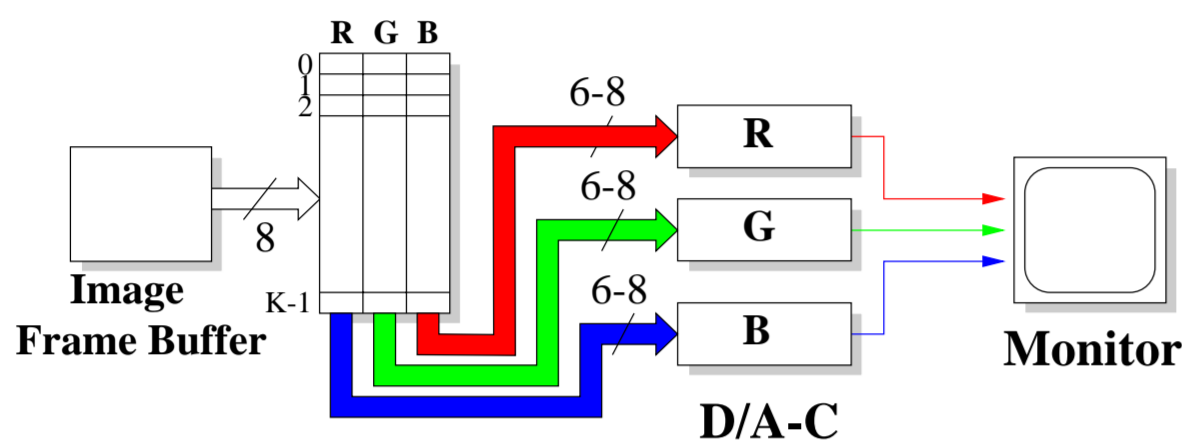


Poolballs (383 x 510)
13583 colors
(Anthony Dekker ©)



Tube (768 x 1024)
27326 colors
(Steven Anger ©)

on a CLUT-oriented graphical device:



- limited number of colors
- data compression ratio 1:3
- less hardware effort
- realtime animation effects

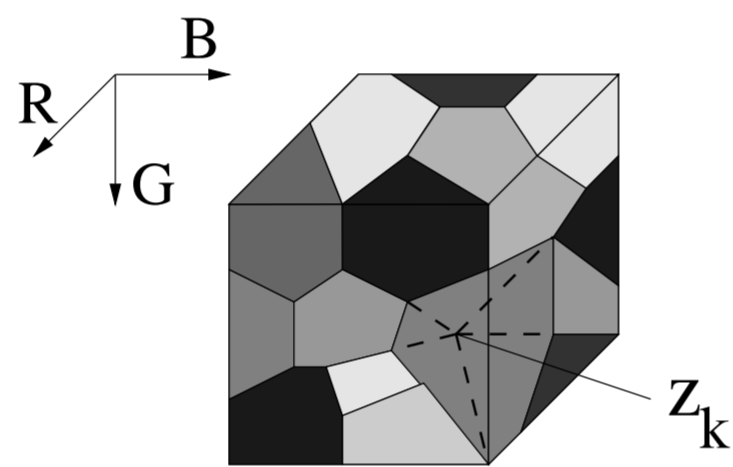
⇒ **Color Quantization** (np-complete)
 Subdividing color space into K disjoint cluster:

$$S := \bigcup_{1 < k < K} S_k \quad \text{with representatives } z_k = (z_R, z_G, z_B)$$



Colors of Poolballs in RGB color space

Goal:
Minimize Error



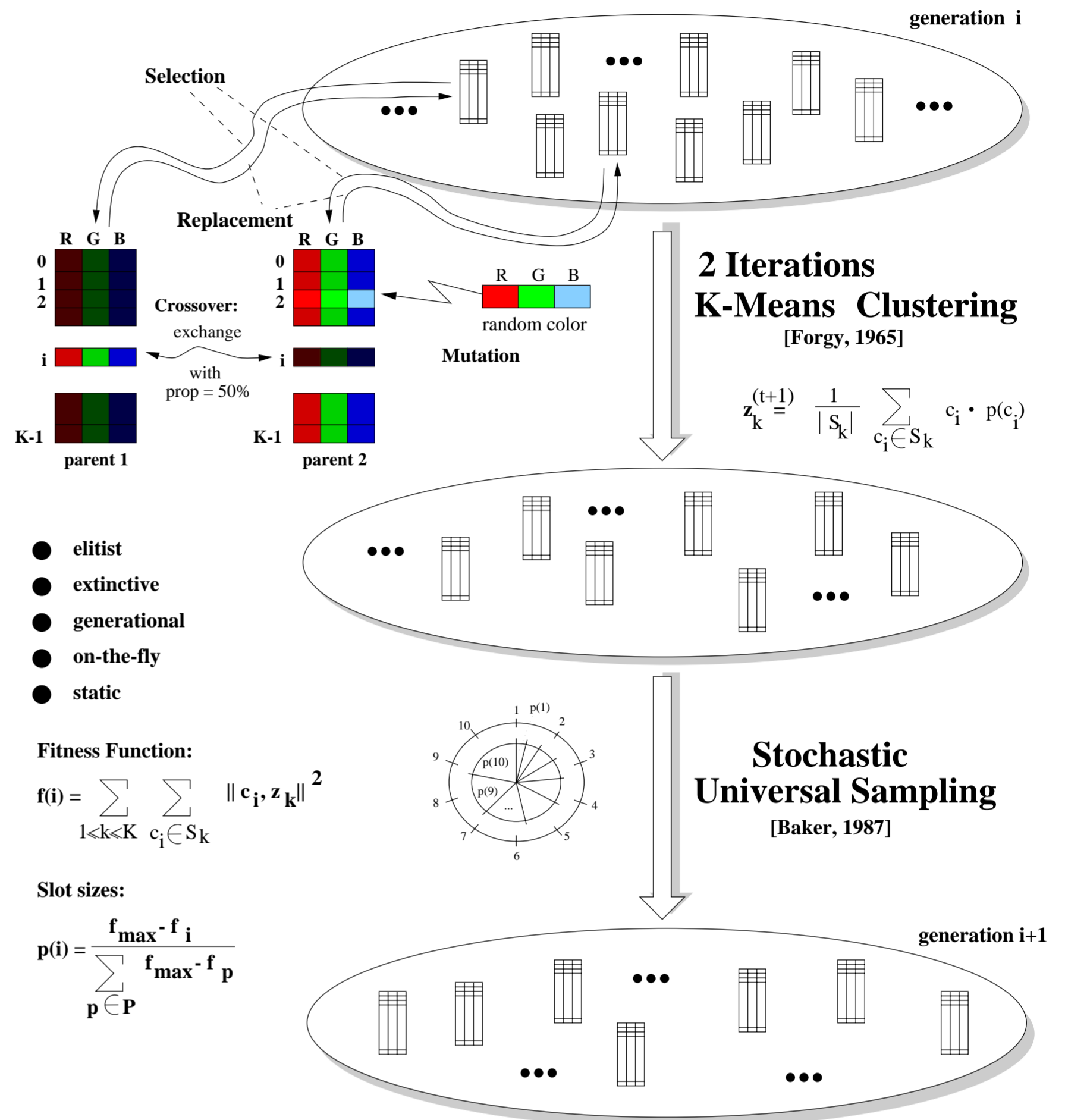
Voronoi Tessellation

THE SOLUTION

HYBRID GENETIC ALGORITHM

Combination of probabilistic genetic algorithm for exploration and local optimizing K-Means clustering algorithm for exploitation

- Initialization: Random image colors
- Individuals: 5-20 CLUT's
- Crossover: Uniform Crossover (p_cross = 20%)
- Mutation: Random Color Change in convex hull of image colors (p_mut = 0.5%)



SPEEDING UP

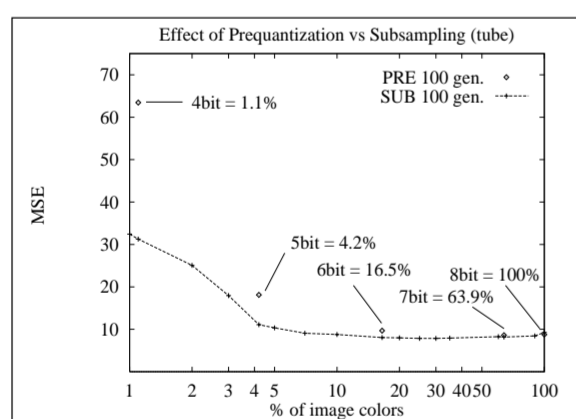
Runtime improvement with

PREQUANTIZATION

Using only k most significant bits

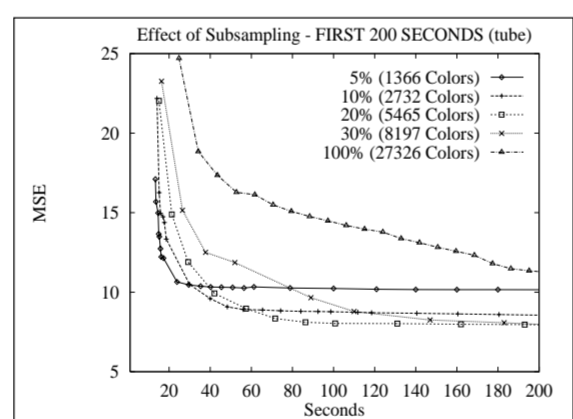
SUBSAMPLING:

Using only a (randomly chosen) part of the image colors



Prequantization vs. Subsampling (Image: Tube)

⇒ Subsampling is much more flexible and effective



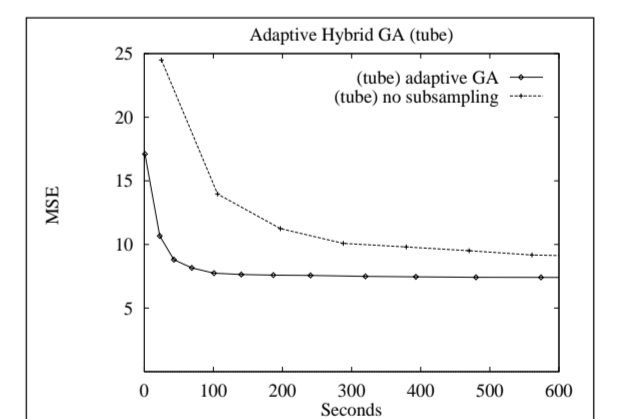
First 200 seconds with various sampling rates (Image: Tube)

⇒ Optimal sampling rate is time dependent

```
SAMPLE_ADJUST
begin
sample_step = 0.05 x (#image_colors - CLUTsize)
if gen <= 380 then
begin
if gen MOD 20 == 0 then
begin
sample_image(sample_step x (1+gen/20));
end
end
end
end
```

Resampling procedure

⇒ Resampling every 20 generations



Convergence behaviour adaptive/non-adaptive HGA (Image: Tube)

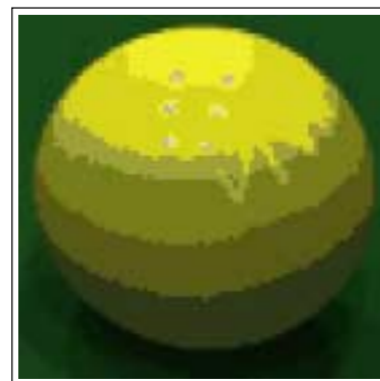
⇒ 10 times faster for images with moderate number of colors

RESULTS

K = 256
CLUT colors of Poolballs
ADAPTIVE HYBRID GA



Image Poolballs



MEDIAN CUT
(ppmquant, xv)
Heckbert, 1982



OCTREE
(ImageMagick)
Gervautz/Purgathofer, 1988



KOHONEN SOM
(xfig)
Dekker, 1994



LOCAL K-MEANS
Verevka/Buchanan, 1995



ADAPTIVE HYBRID GA

MSE	Poolballs	Tube	Lenna	
MEDIAN CUT	50.994	34.405	50.060	
OCTREE	9.004	11.105	42.605	
KOHONEN SOM	11.121	9.217	31.958	
LOCAL K-MEANS	10.770	13.251	35.271	
ADAPTIVE HYBRID GA	20 gen	7.805	9.208	31.915
	400 gen	4.859	7.342	29.747