IMAGE COMPLETION

Deceivingly simple, impressive results

WHAT IS IT?

- fill in a missing part of an image

not an actual result

MANY NAMES

- image completion
- in-painting
- object removal
- image restoration
- filling-in
- error concealment
- image extrapolation

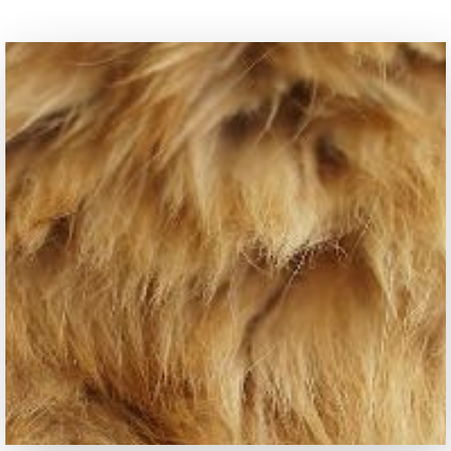
- we'll see why in later examples

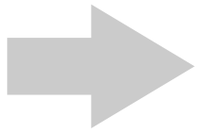
TEXTURE SYNTHESIS

a detour?

WHAT IS IT?

- produce a similar texture starting from a sample





not an actual result

IEEE International Conference on Computer Vision, Corfu, Greece, September 1999

Texture Synthesis by Non-parametric Sampling

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Abstract

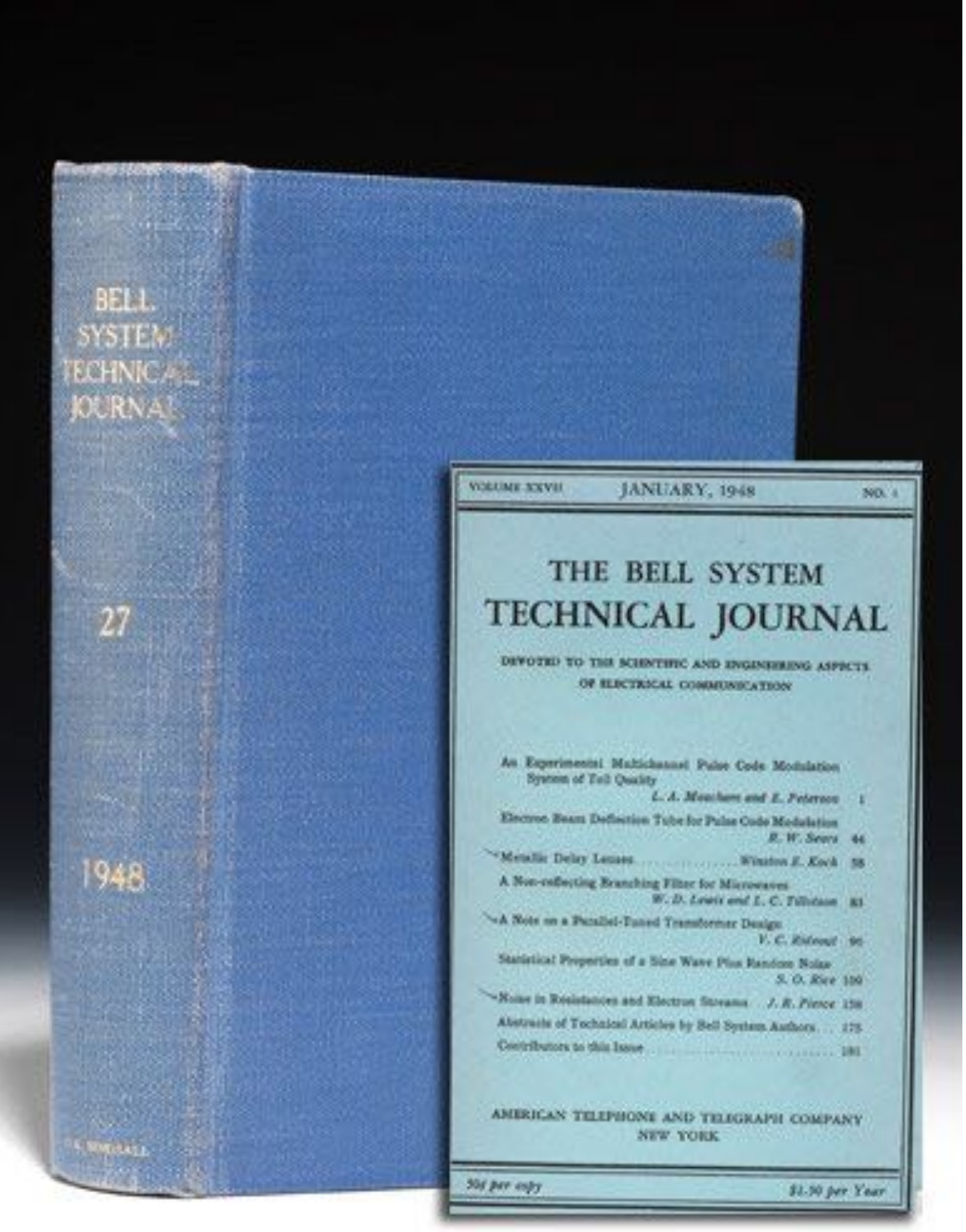
A non-parametric method for texture synthesis is proposed. The texture synthesis process grows a new image outward from an initial seed, one pixel at a time. A Markov random field model is assumed, and the conditional distribution of a pixel given all its neighbors synthesized so far is estimated by querying the sample image and finding all similar neighborhoods. The degree of randomness is controlled by a single perceptually intuitive parameter. The method aims at preserving as much local structure as possible and produces good results for a wide variety of synthetic and real-world textures.

1. Introduction

Texture synthesis has been an active research topic in computer vision both as a way to verify texture analysis methods, as well as in its own right. Potential applications of spatial locality. The result is a very simple texture synthesis algorithm that works well on a wide range of textures and is especially well-suited for constrained synthesis problems (hole-filling).

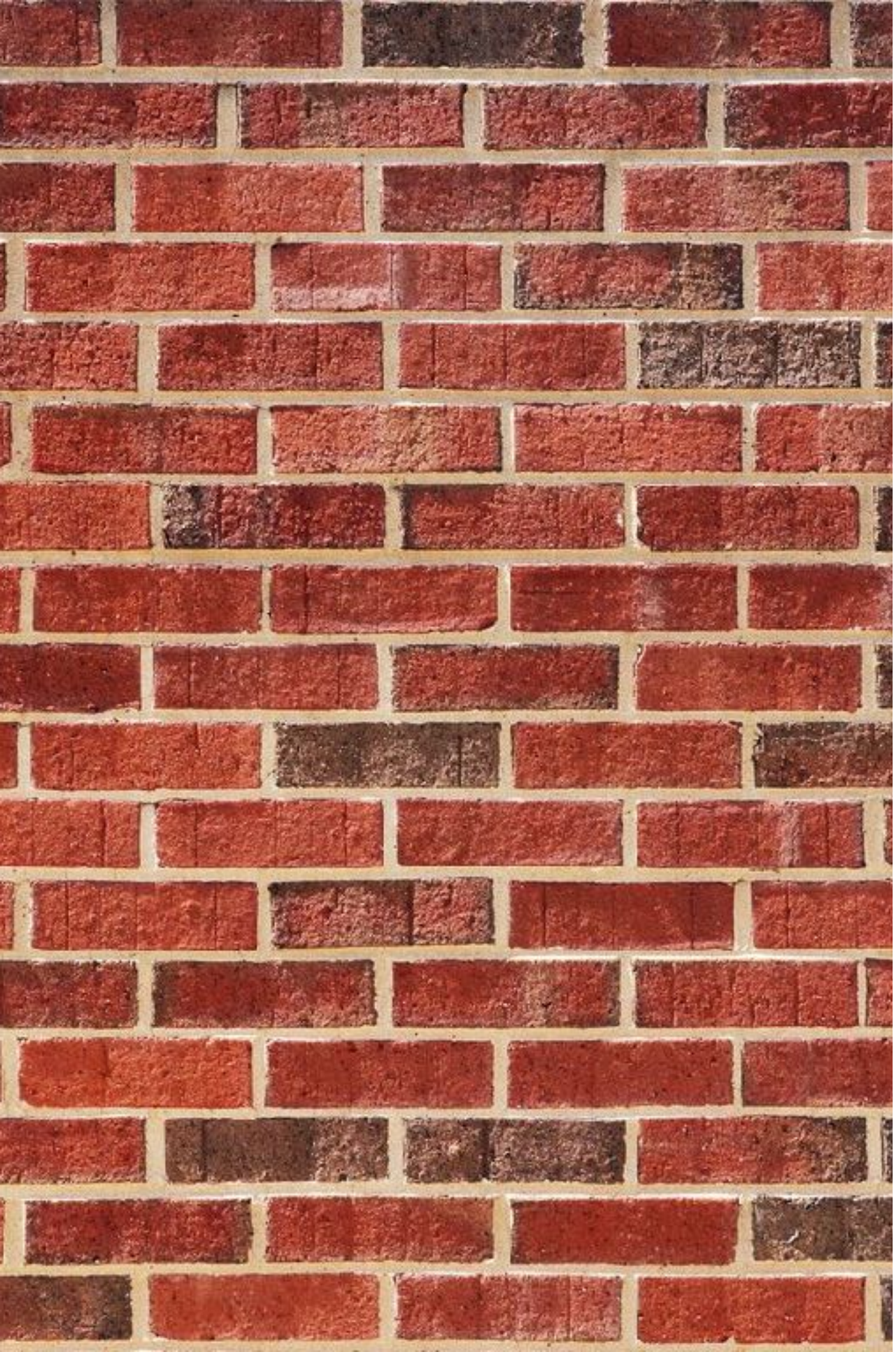
1.1. Previous work

Most recent approaches have posed texture synthesis in a statistical setting as a problem of sampling from a probability distribution. Zhu et. al. [12] model texture as a Markov Random Field and use Gibbs sampling for synthesis. Unfortunately, Gibbs sampling is notoriously slow and in fact it is not possible to assess when it has converged. Heeger and Bergen [6] try to coerce a random noise image into a texture sample by matching the filter response histograms at different spatial scales. While this technique works well on highly stochastic textures, the histograms are not pow-



INSPIRATION

- *A Mathematical Theory of Communication – Shannon 1948*
- build n-grams probabilities from a book, eg:
  - ***home** often comes after **go***
  - ***how**, **are**, **you** are frequently seen together*
- sample repeatedly to create sentences



CORE IDEA

- generalize to 2D
  - unit: letter ~ pixel
  - context: n-gram ~ texel
- eg:
  - **red** *often follows* **red**
  - **white** *seldom after* **red**
- find pixel value in probability table, looking at neighbors

BUT THERE'S A PROBLEM

- words are categorical, pixel values are continuous
  - finite sample so an exact match might not be present
  - info about **red** should also (partially) apply to **dark red**
- building a probability table is unfeasible
  - too large
  - one image does not provide exhaustive info
- **solution:** mimic table by looking up in the image every time

OTHER CONSIDERATIONS

- fill out hole inwards

- texture types:
  - regular (repeating)
  - stochastic
  - combination
- add stochasticity by not always picking the closest match

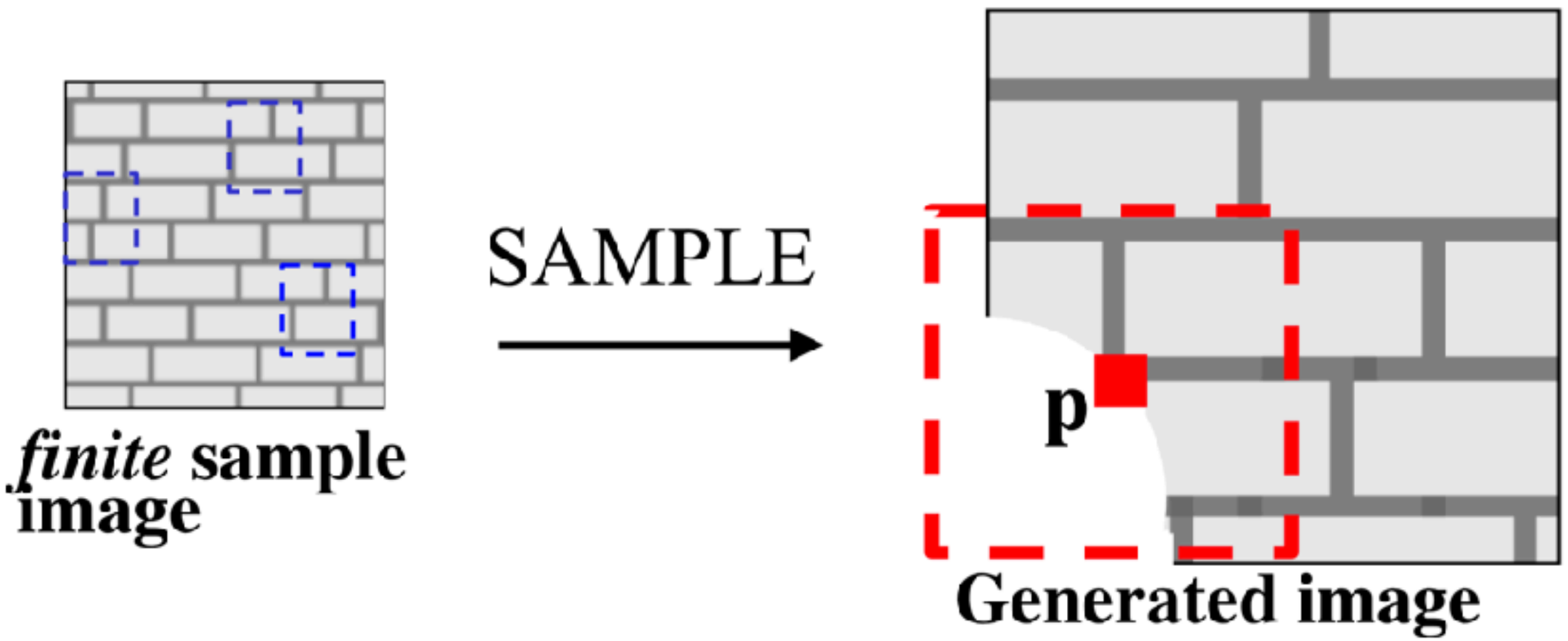
ALGORITHM

- input: image and hole position

1. select a pixel on the hole's edge
   empty pixels having at least one filled neighbor
2. fill it with the one having the most similar neighbors
   sum of square distances for a small square around it
   sometimes pick the second / third most similar
3. repeat until the hole is filled

- output: filled image

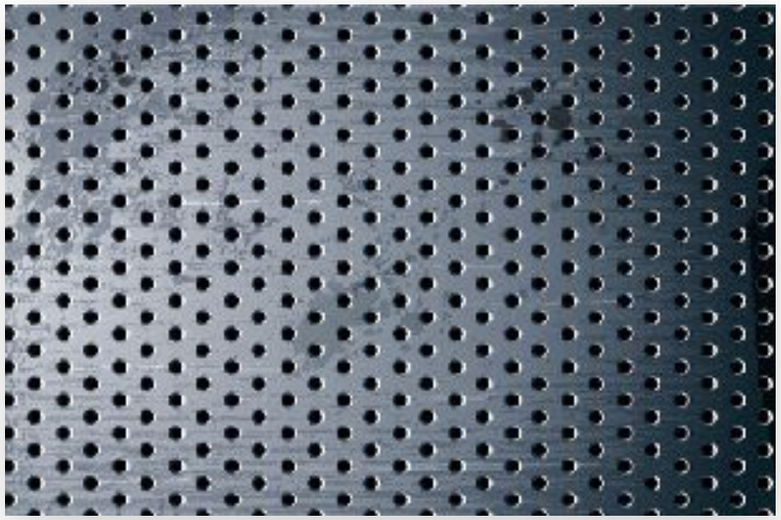
ALGORITHM



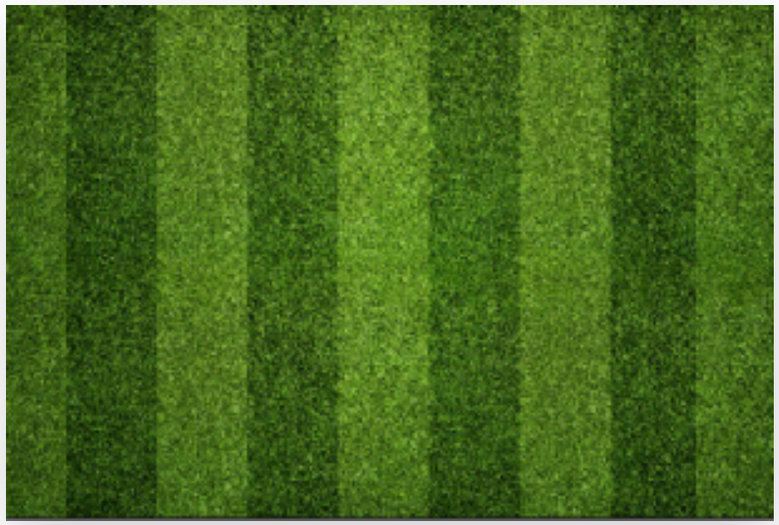
source: Texture Synthesis Paper presentation

PARAMETERS

- *patch size*: texel size (how often texture repeats)

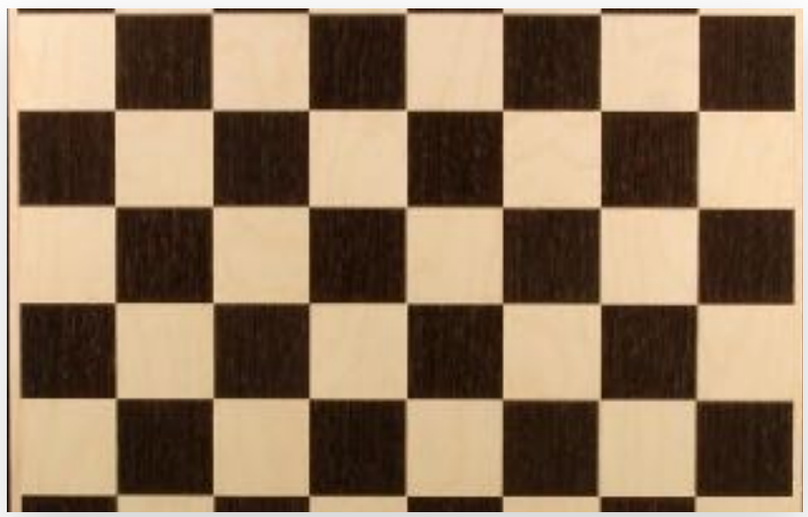


small



large

- *selection std*: texture randomness (when picking similar)

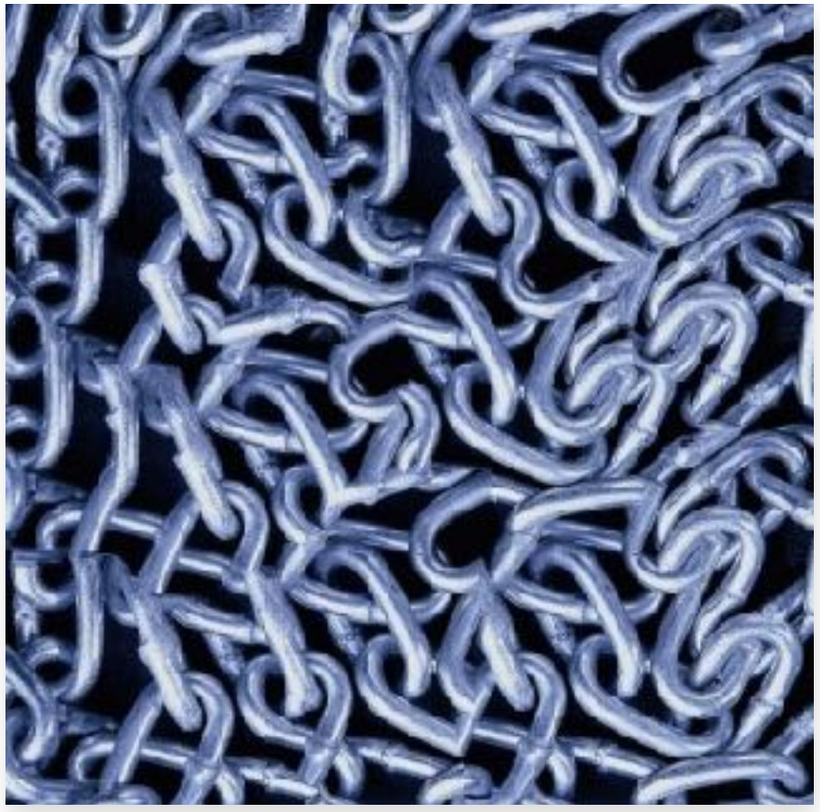


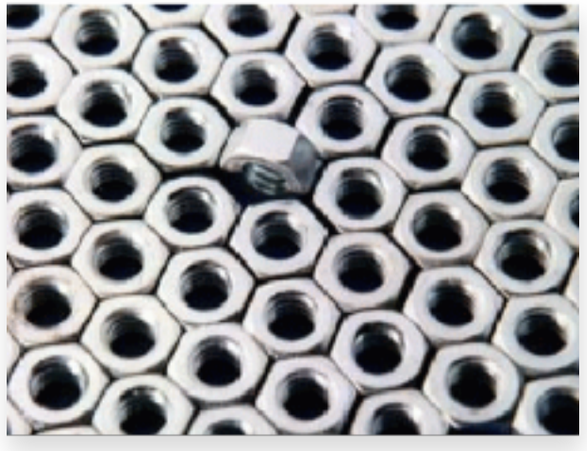
little

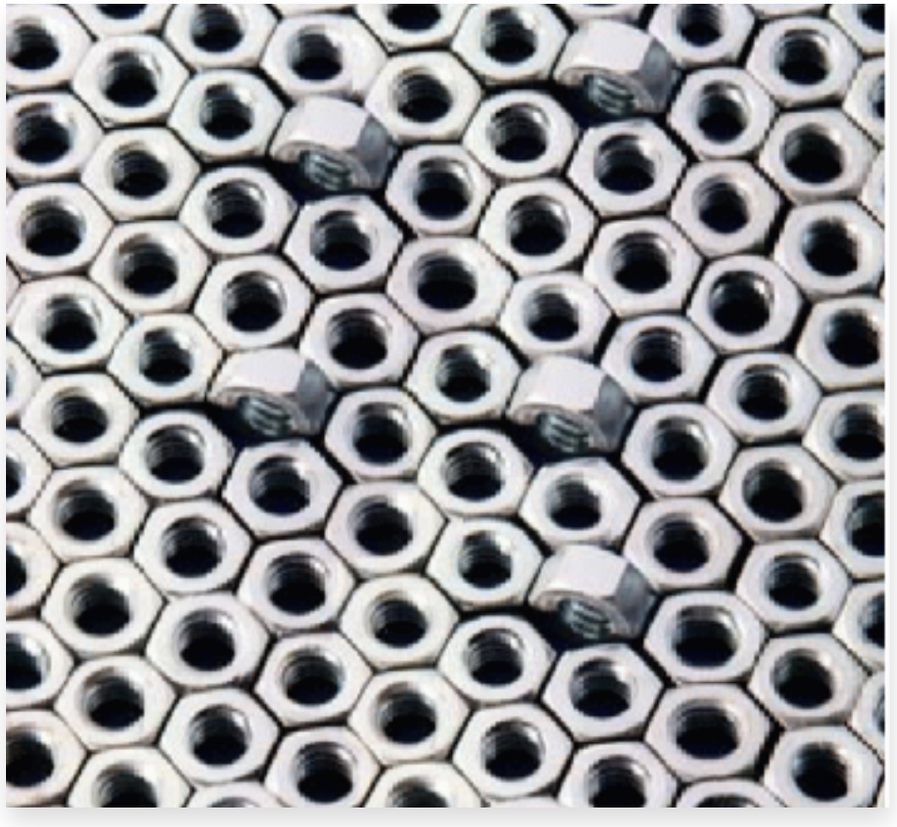
a lot

EXAMPLES

not run by me







DEMO

PRACTICAL CONSIDERATIONS

- to speed up computation:
  - restrict searching from whole image to a smaller area
  - replace a whole patch at a time instead of single pixels

ORIGINAL

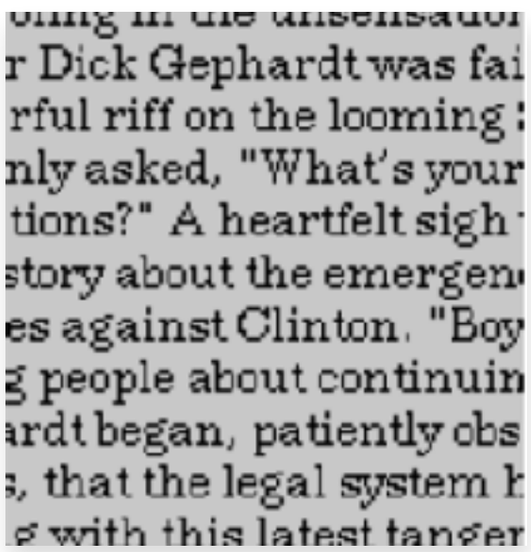
REMOVED

THAT WAS NOT JUST A TEXTURE!

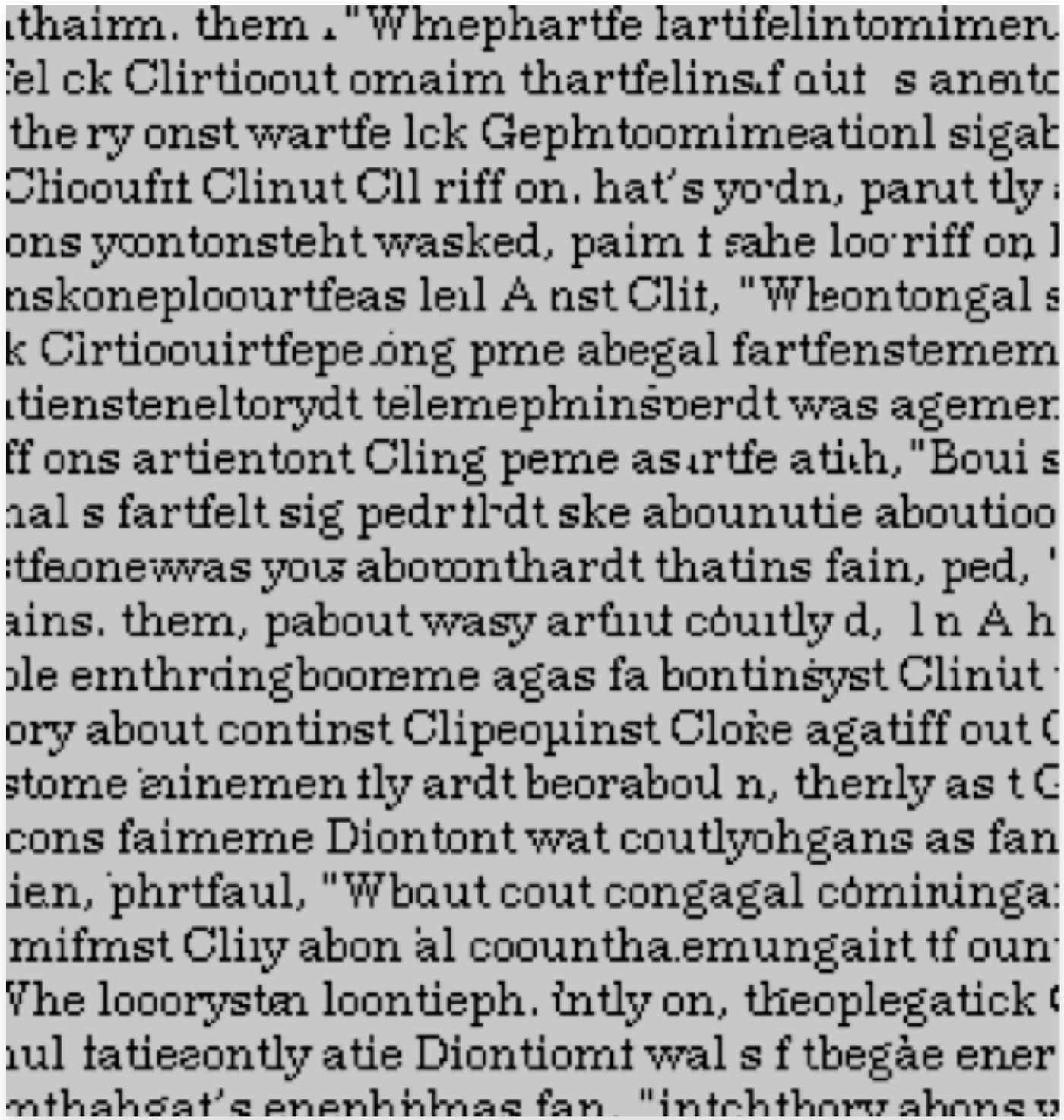
- turns out texture synthesis was not a detour
- photos are made up of many "textures"
- the method can be used for many tasks

MORE EXAMPLES

not run by me, various methods



WORDS



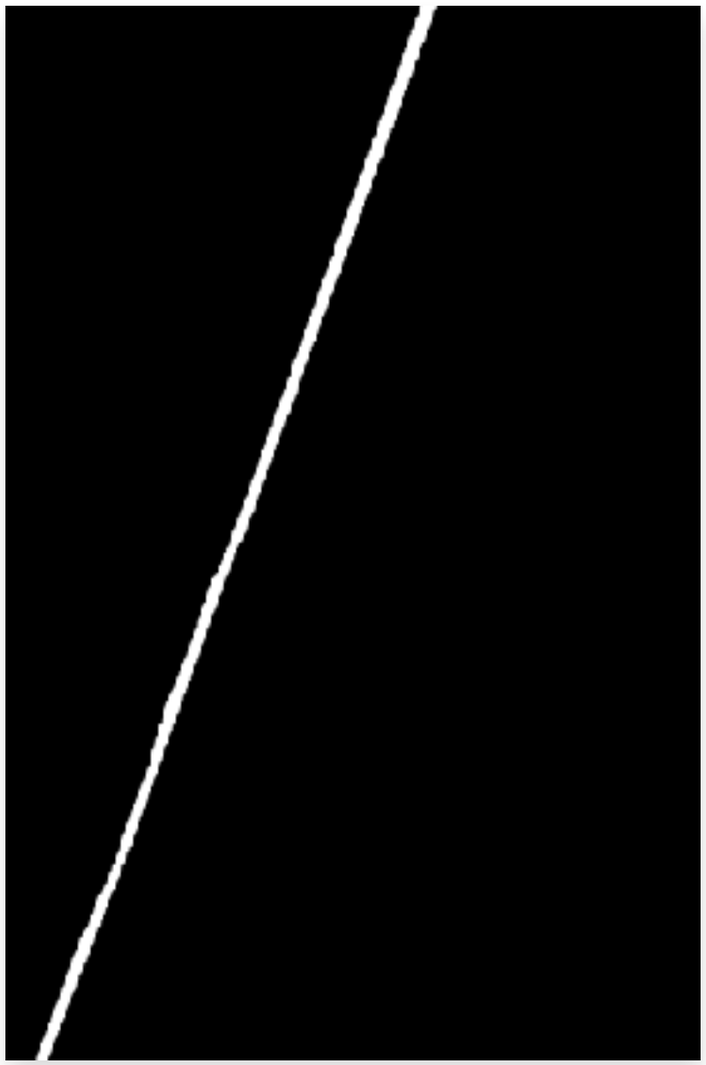
NOT ACTUAL WORDS!

ORIGINAL

EXPANDED

IMAGE RESTORATION

DAMAGED



MASK

RESTORED

WRINKLE REMOVAL

ORIGINAL

MASK

REMOVED

OBJECT REMOVAL

ORIGINAL

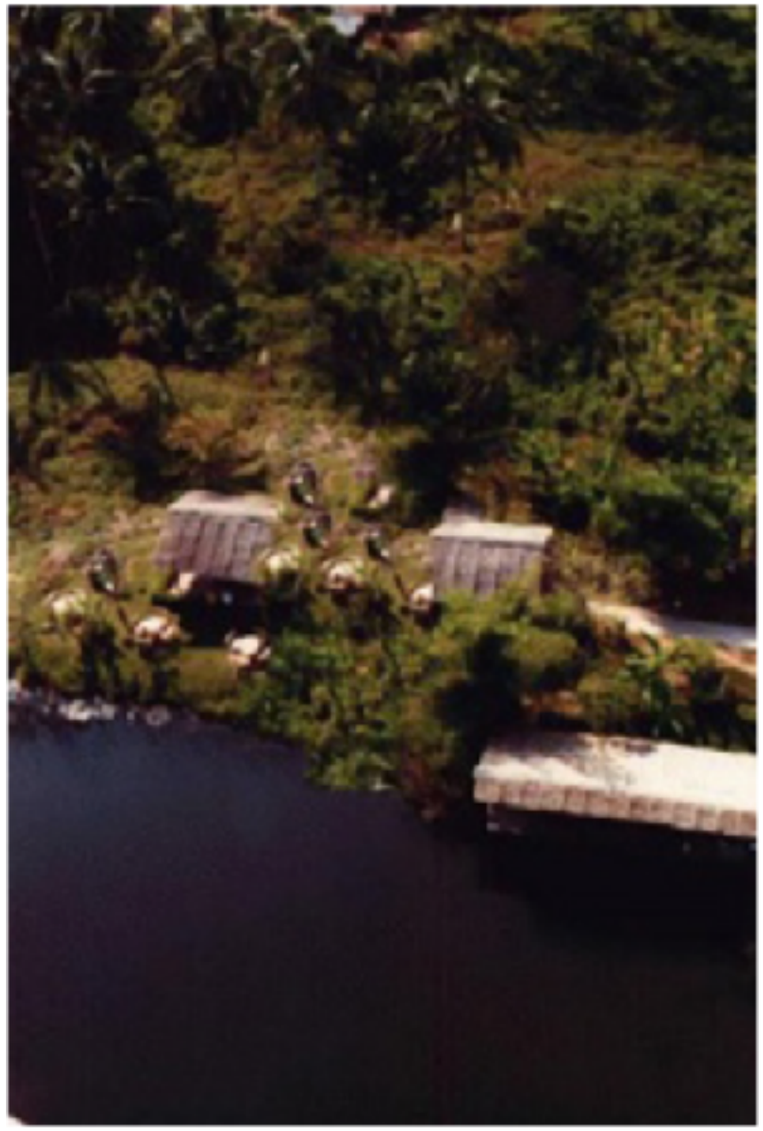
MASK

REMOVED

OBJECT REMOVAL

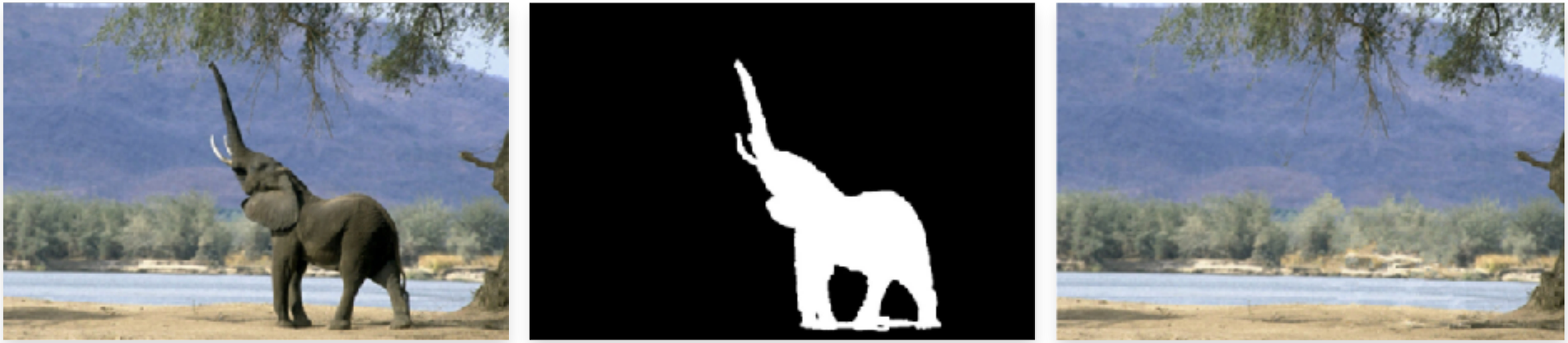
ORIGINAL

MASK

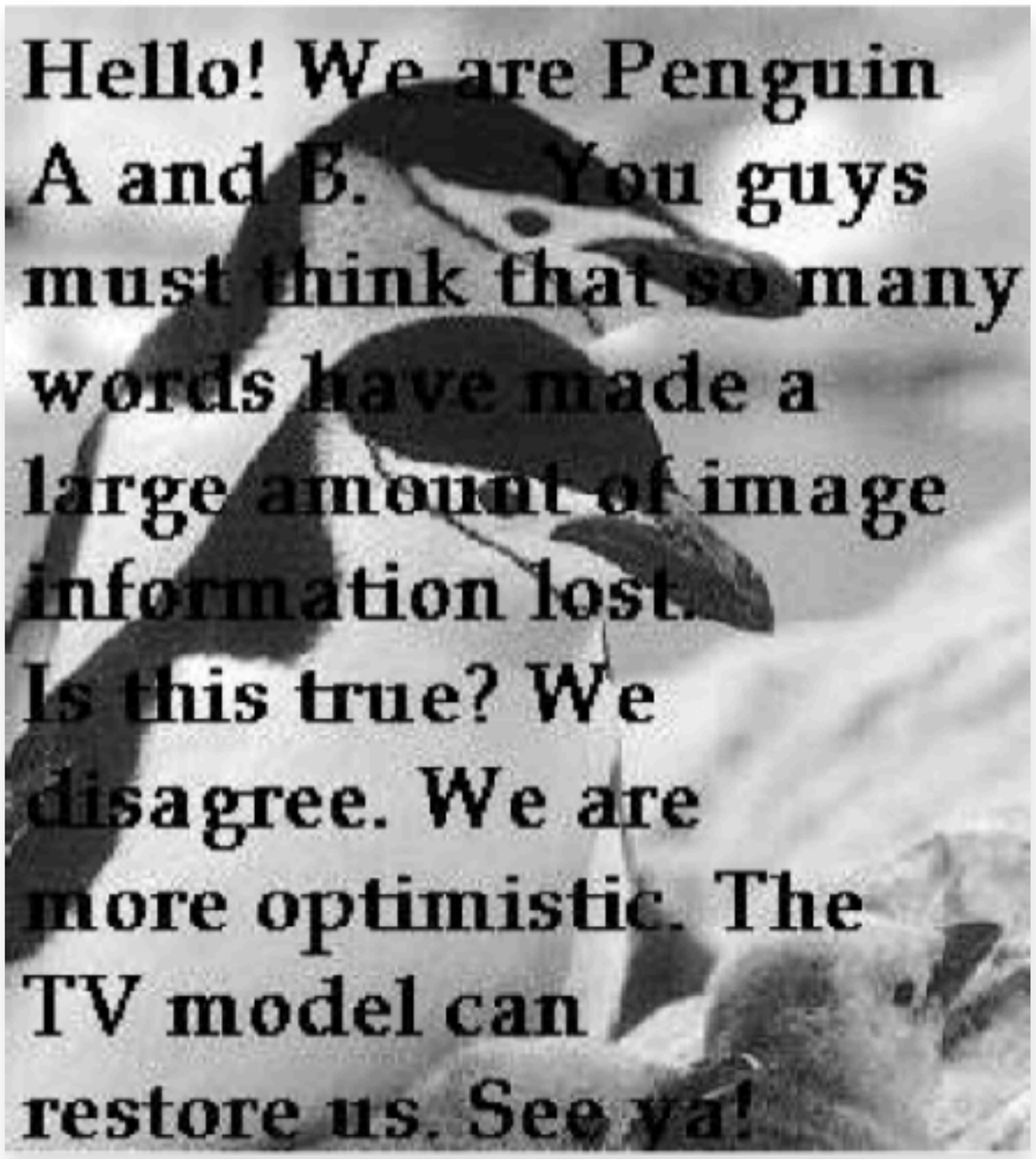


REMOVED

OBJECT REMOVAL



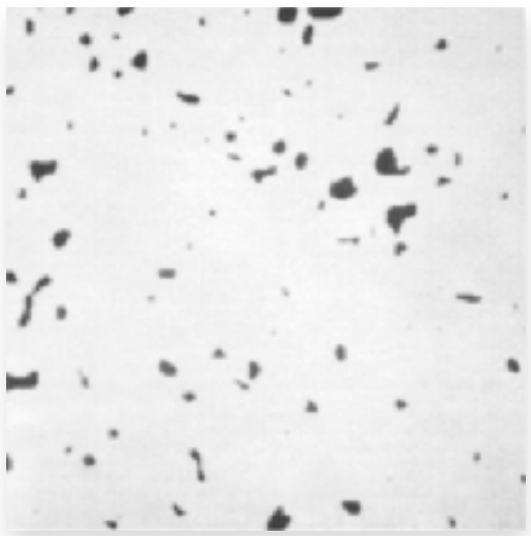
TEXT REMOVAL




有木明功
館幸雄
庄司重太郎
細田


有木明功
庄司重太郎
細田


有木明功
庄司重太郎
細田



LIMITATIONS

ORIGINAL

FAILURE

METHOD COMPARISON

ORIGINAL

REMOVED

CONTENT-AWARE RESIZE

source: FMI UB CV lecture 4

IN-PAINTING

RESIZING

SUMMARY

TEXTURE SYNTHESIS

- fundamentally sound
- conceptually simple
- widely applicable
- not perfect

REFERENCES

- *Texture Synthesis by Non-Parametric Sampling*, A. Efros & T. Leung
- *Inpainting Methods Survey*, M. Bertalmio et al
- *Assignment 4 – CPSC 425: Computer Vision*, University of British Colombia

- many runs on various inputs

THANK YOU!