RIVERBED IMAGE SIMULATION FOR A BETTER EXPLORATION OF COARSE-GRAINED SEDIMENT SIZING IMAGE ANALYSIS METHODS

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GRAIN-SIZE MAPPING OF RIVER BED

Grain size, a key information in:

- Hydro-ecology (Wood et al., 2007)
- Fluvial hydraulics (Sneldner et al., 2011)
  - Flow rugosity
  - Solide transport

Useful variable:

- Median diameter $\varnothing_{50}$
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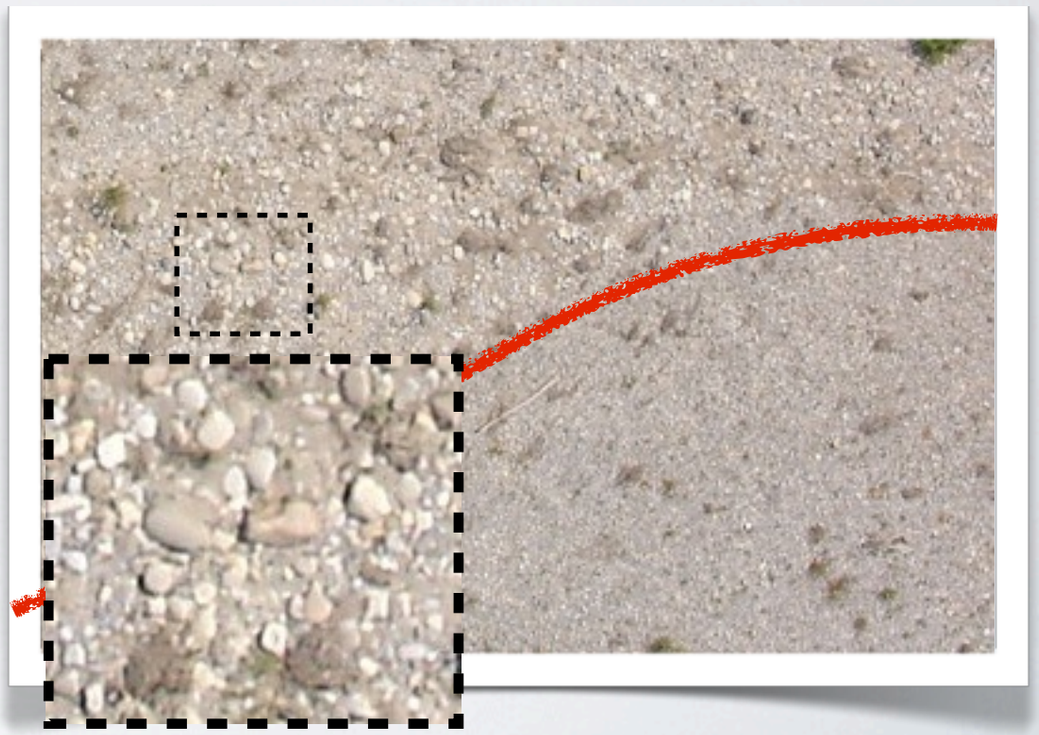

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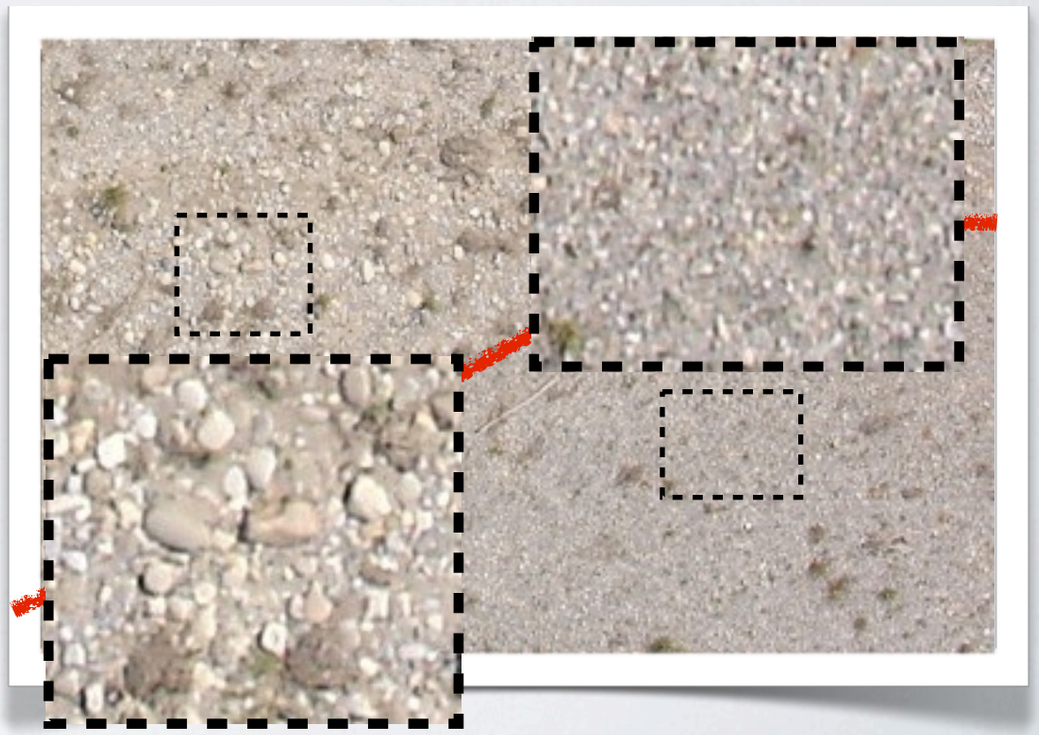


GRAIN-SIZE MAPPING FROM FIELD SURVEY

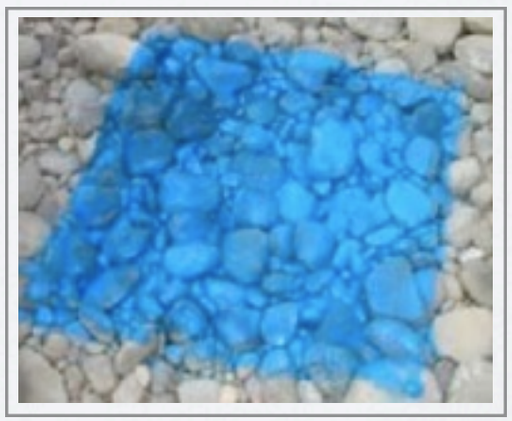
Usual protocol:

- Several zones
- Random location of 1 pebble
- Chose n<10 nearest pebbles
- Median statistic from neighbor

→ time consuming

→ uncertainty

Other protocols, such as «paint & pick» (Rollet, 2007)



=> Remote sensing from images

ALTERNATIVE: GRAIN-SIZE MAPPING FROM IMAGES

Proxy-detection:

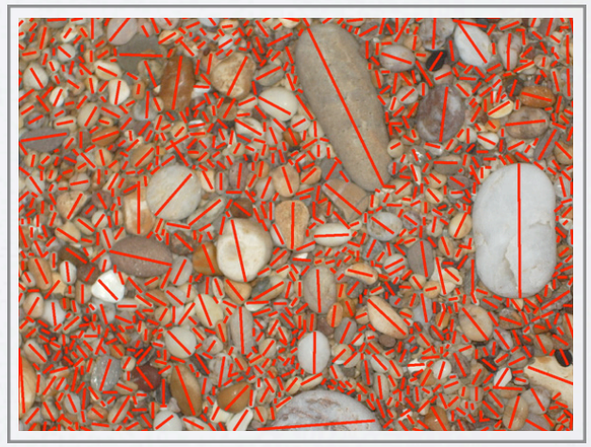
- Rubin, 2004
- Rollet et al., 2002

Feurer, 2008

Airborne detection:

- Carbonneau et al., 2005

Manual measurements on images or image processing

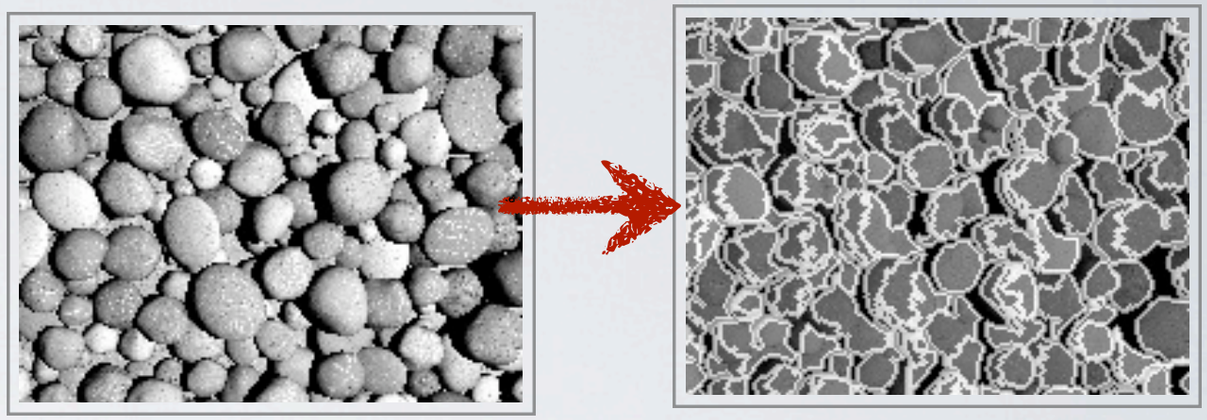


Buscombes, 2008

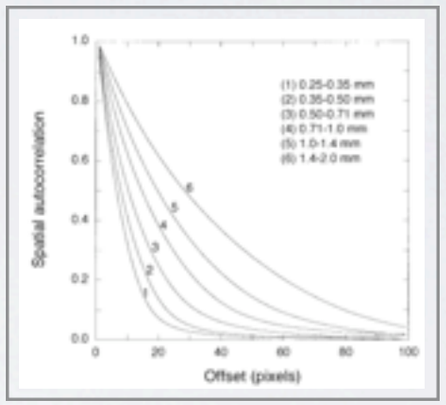
Rollet et al., 2002

IMAGE PROCESSING METHODS

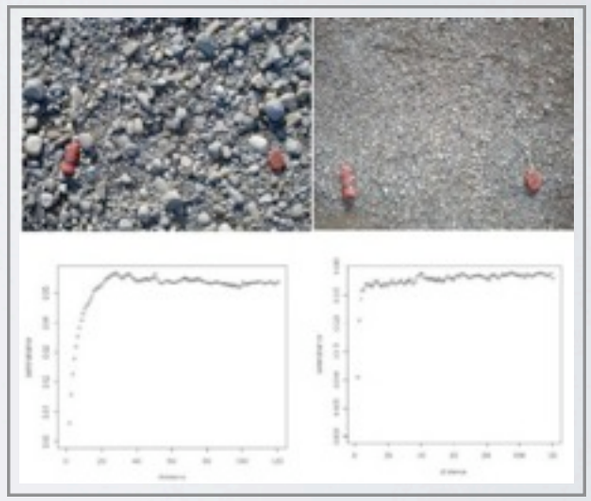
- Segmentation
  - Rollet et al., 2002; Graham et al., 2005



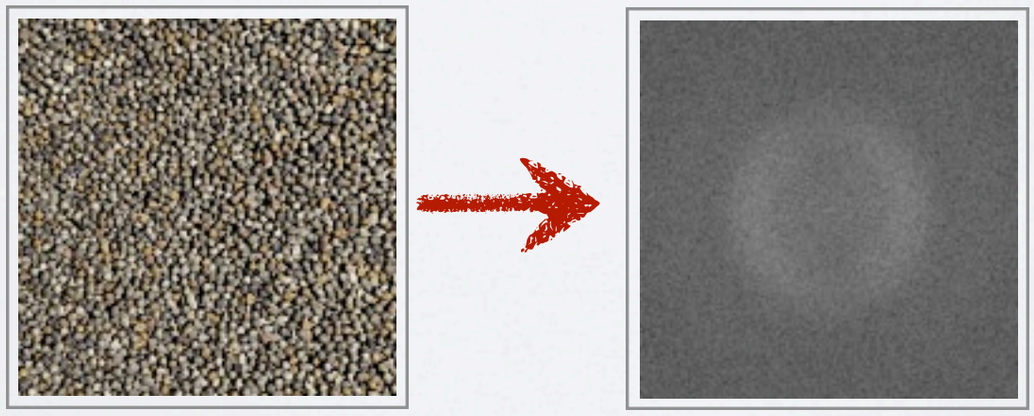
- Textural indices
  - Autocorrelation
    Rubin, 2004; Carbonneau et al., 2005
  - Fourier spectrum
    Buscombes et al., 2010



Rubin, 2004



Ducroix, 2008



VALIDATION ISSUE

- Which method is the most efficient/accurate ?
- Sensitivity with respect to parameters such as:
  - external conditions (brightness, solar incidence...)
  - presence of water (water depth, turbidity, flow velocity...)

- Difficulties with ground truth measurements:
  - Time consuming => costly
  - Low accuracy
  - Scene variability

=> Use of computer generated images

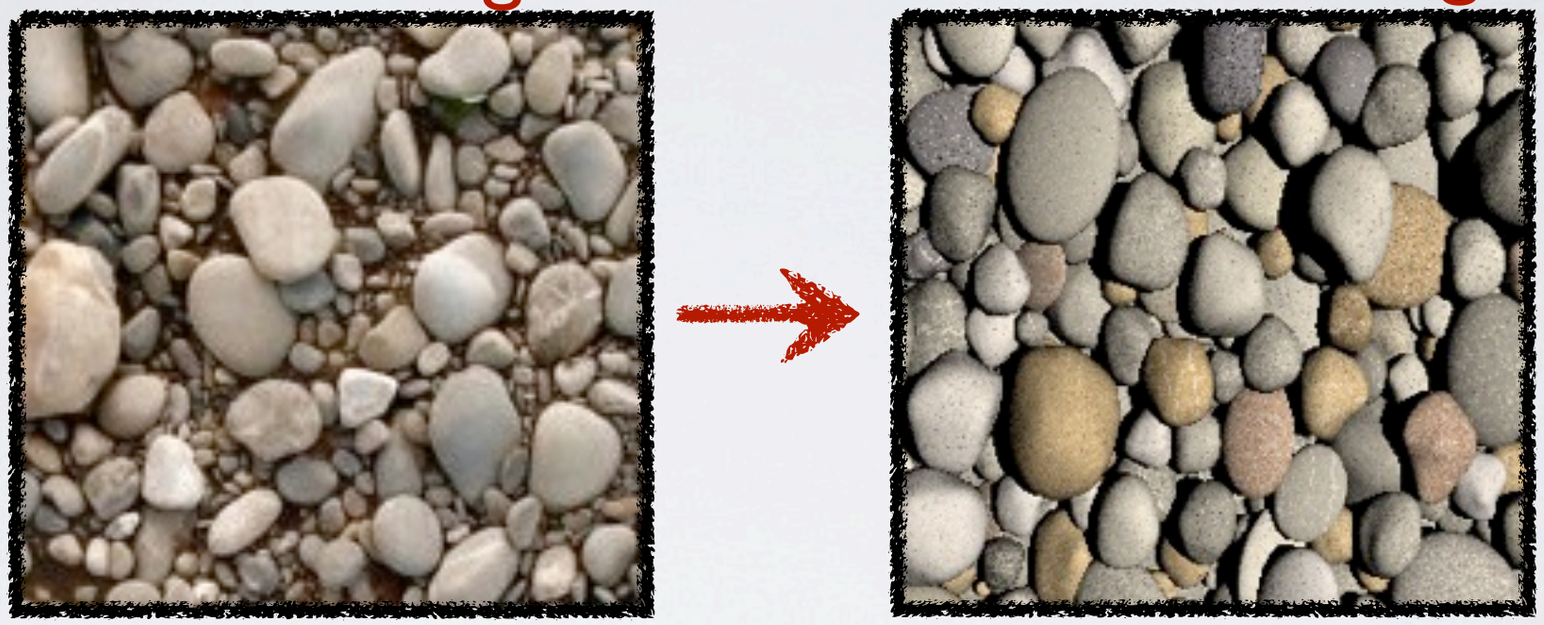
OBJECTIVE

Method performance assessment from computer generated images database

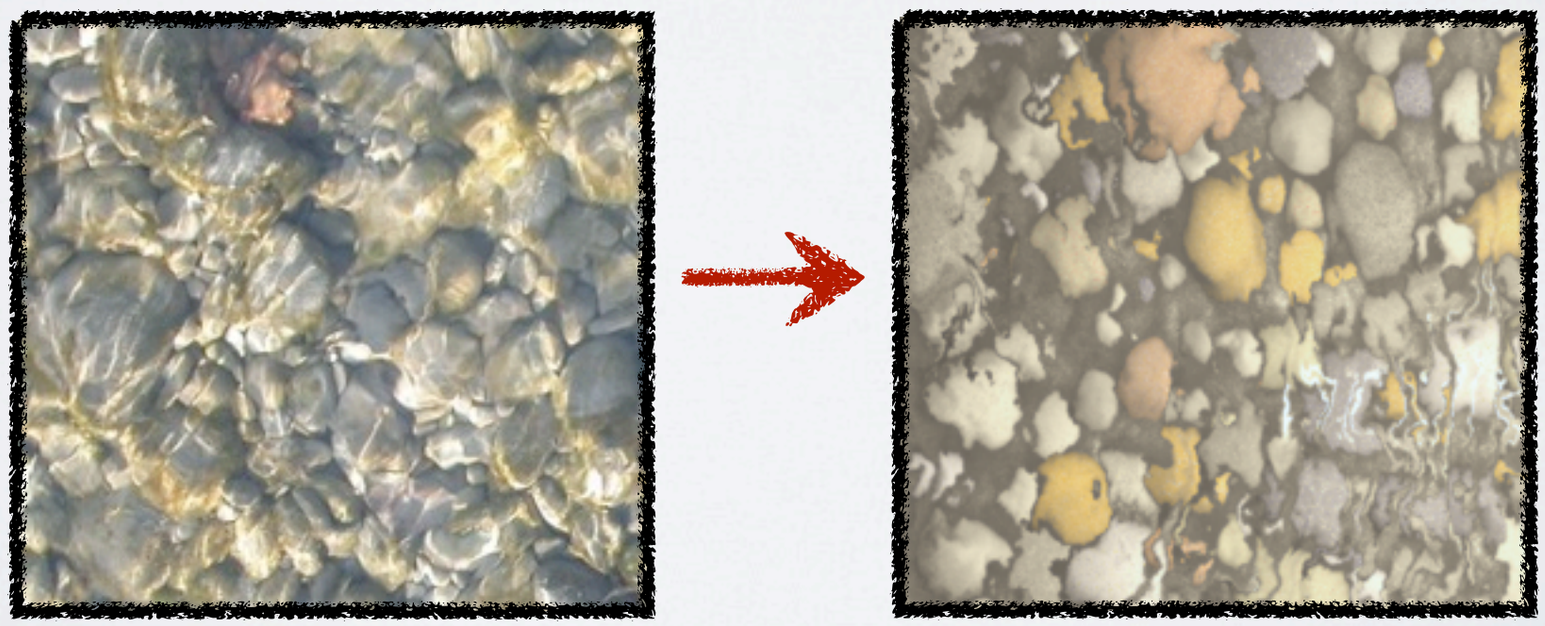
Actual image

Generated image

Overwater



Underwater



COMPUTER GENERATED IMAGES

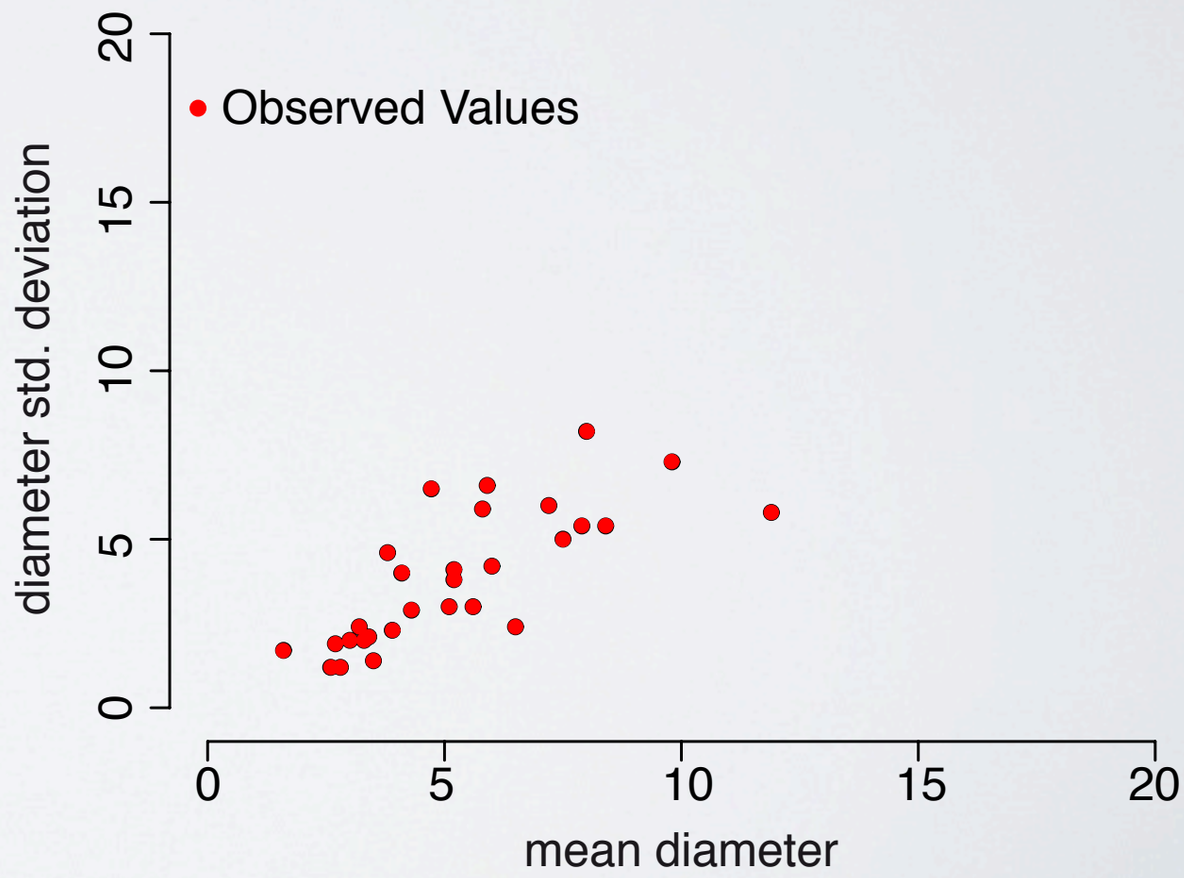
- Use of the ray-tracing software POV-Ray
  (Persistence of Vision Pty. Ltd., 2004)
- *Pebbles* routine developed by J. Hunt

«Pebbles» by J. Hunt

- Controlled «image acquisition»:
  - solar incidence, camera position...
- Controlled pebble population:
  - defined diameter distribution
  - random position
  - random aspect using predefined patterns, colors and shapes

IMAGE GENERATION FROM OBSERVED GRAIN SIZE DISTRIBUTIONS

- Assume gaussian distribution $N(\mu, \sigma)$ of pebbles diameter $\varnothing$ in each image with μ in [2,20]cm
- Empirical relationship between μ, σ from observed values:



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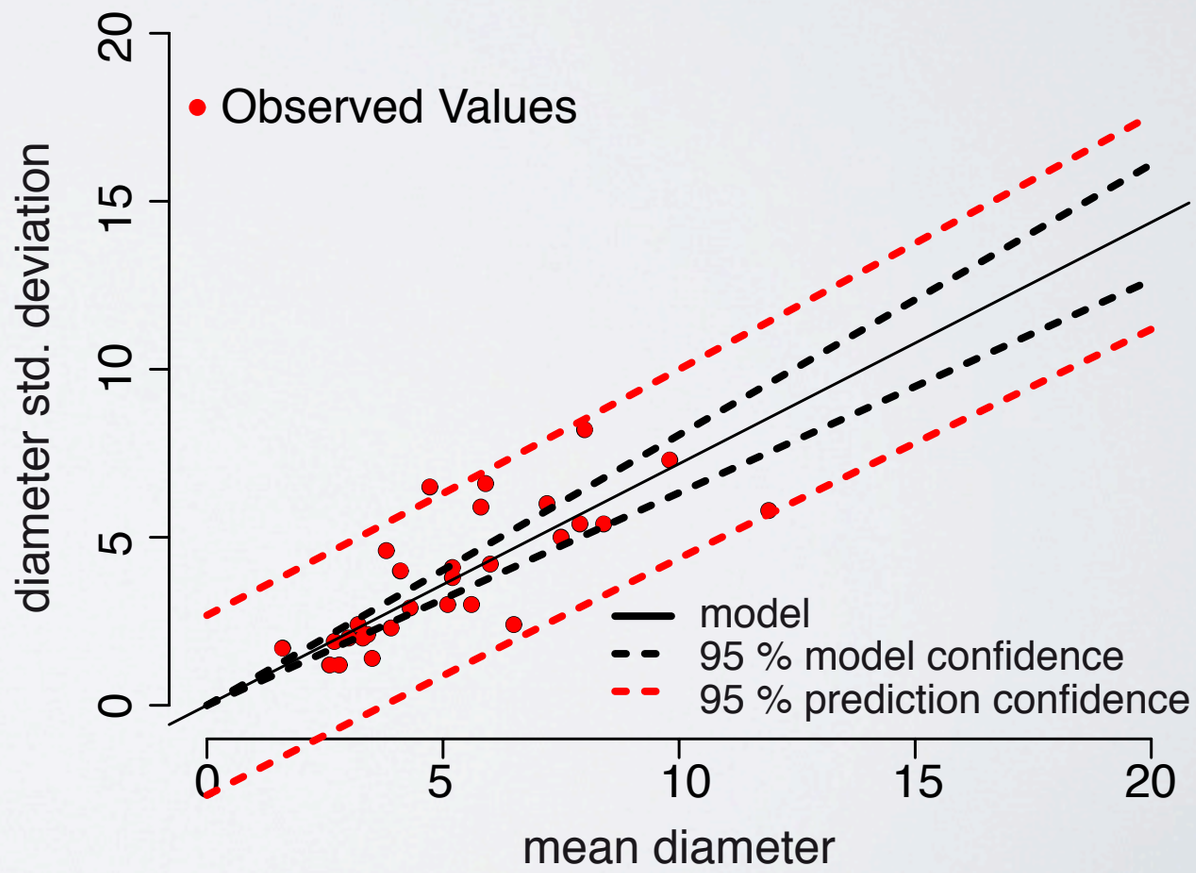

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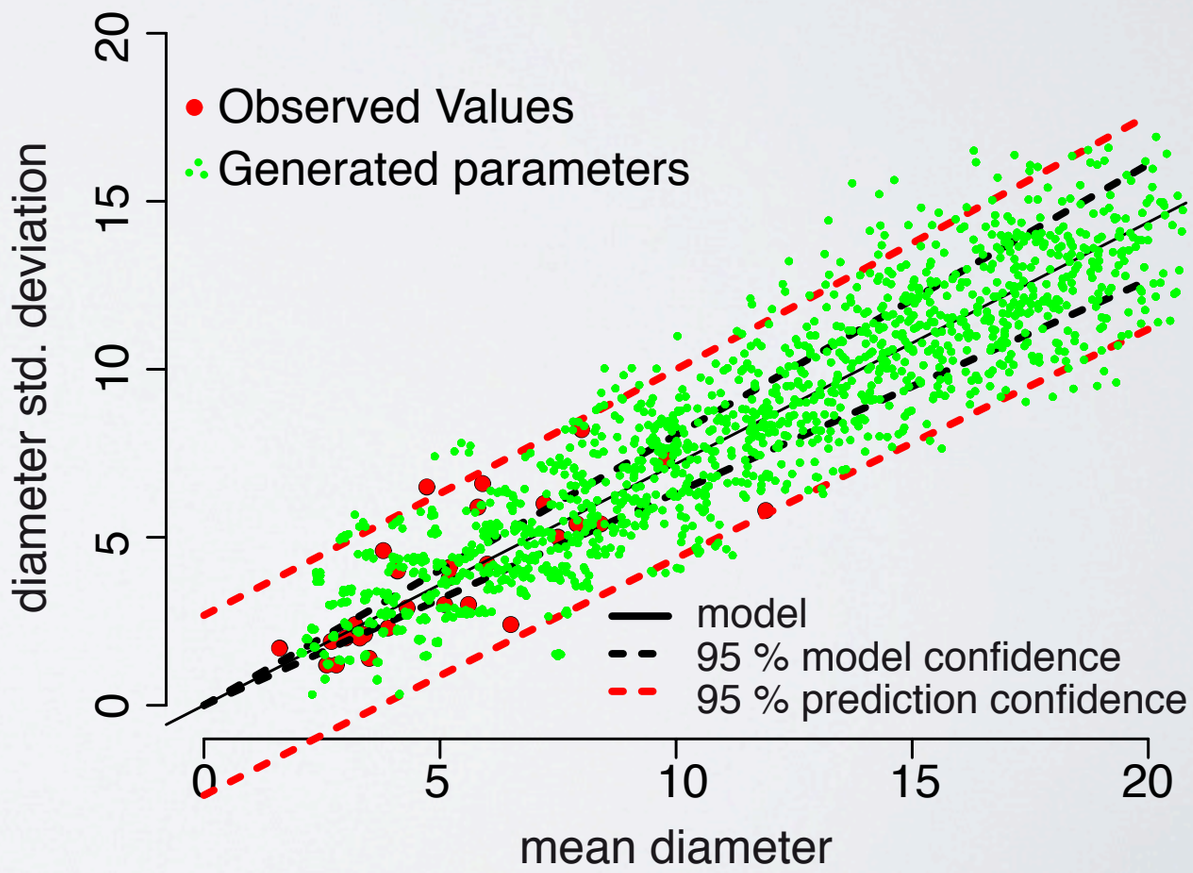
- Experimental design in μ, σ domains
  - using stratified Monte-Carlo
  - with random repetitions

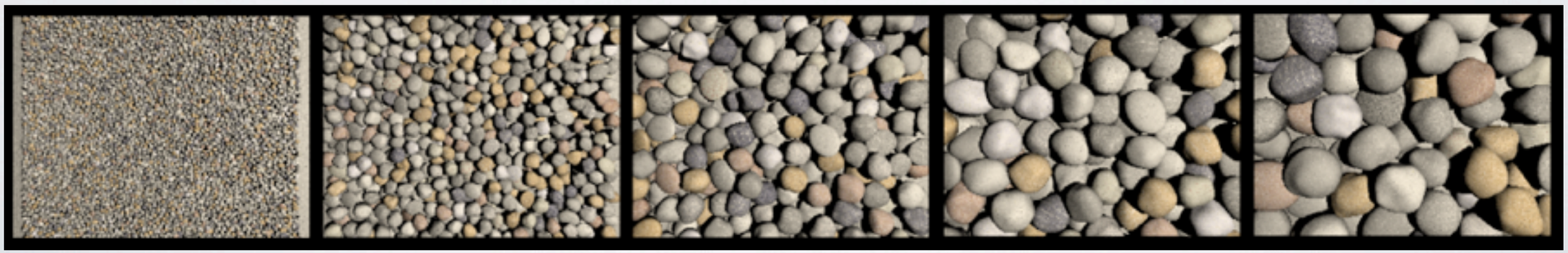


COMPUTER GENERATED IMAGES DATABASE

- 7500 images with ∅ in $N(\mu,\sigma)$

$\mu \in U[2, 20]\mathrm{cm}$
σ depending on μ

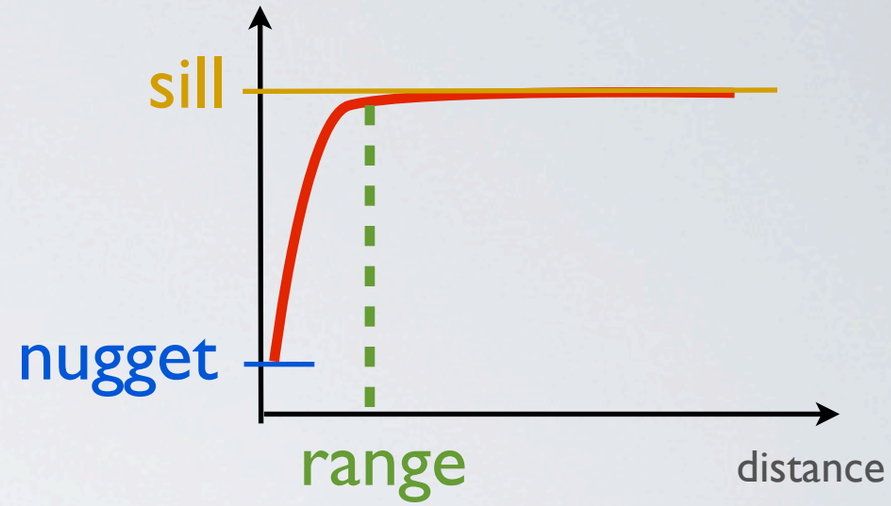
- 1500 images with ∅ constant in [2,20] cm



METHODOLOGY: AUTOCORRELATION

- Image variogram
- Automatic adjustment of an exponential model

using R software



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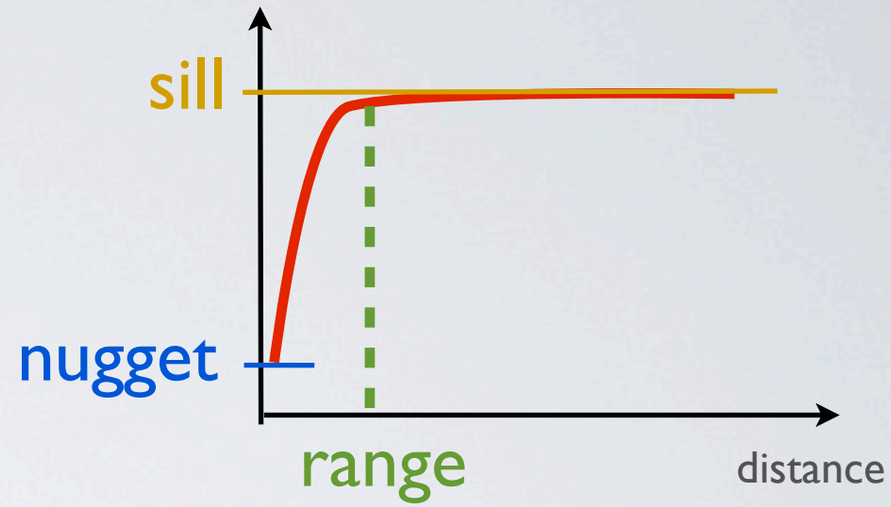

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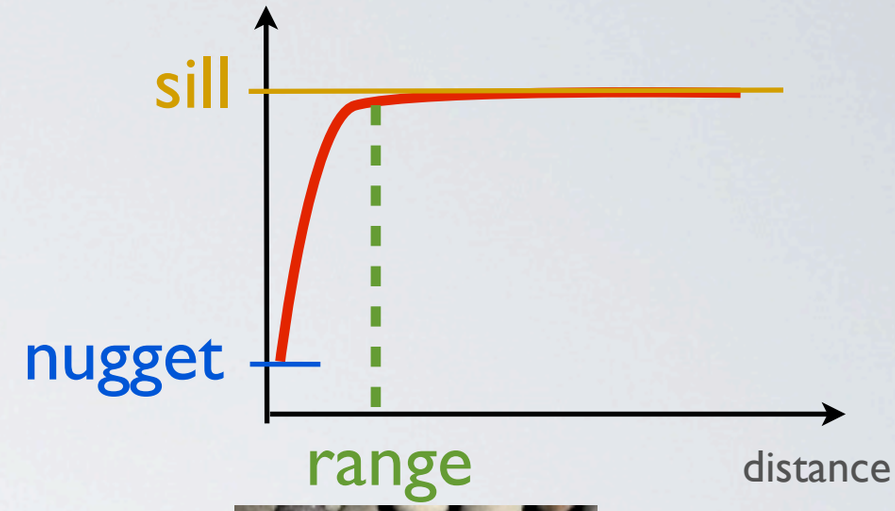
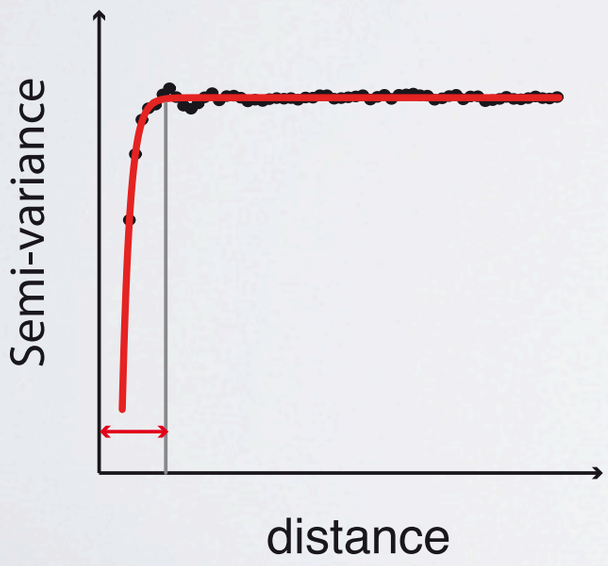
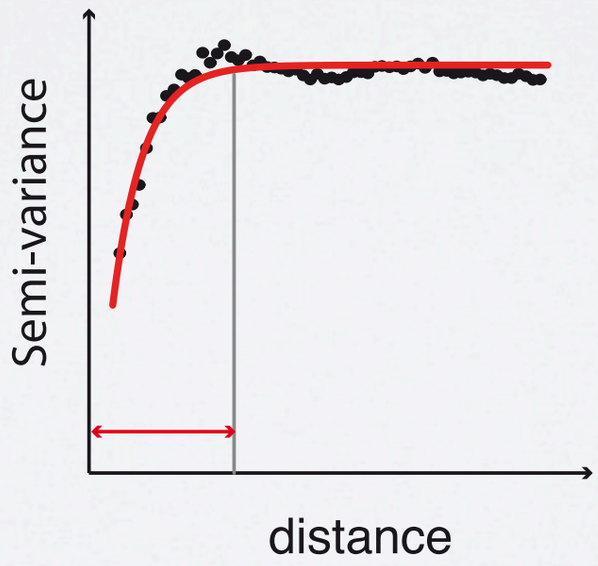
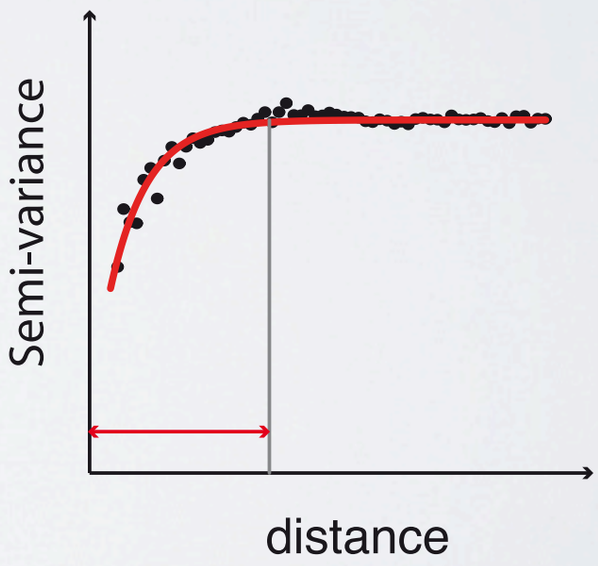


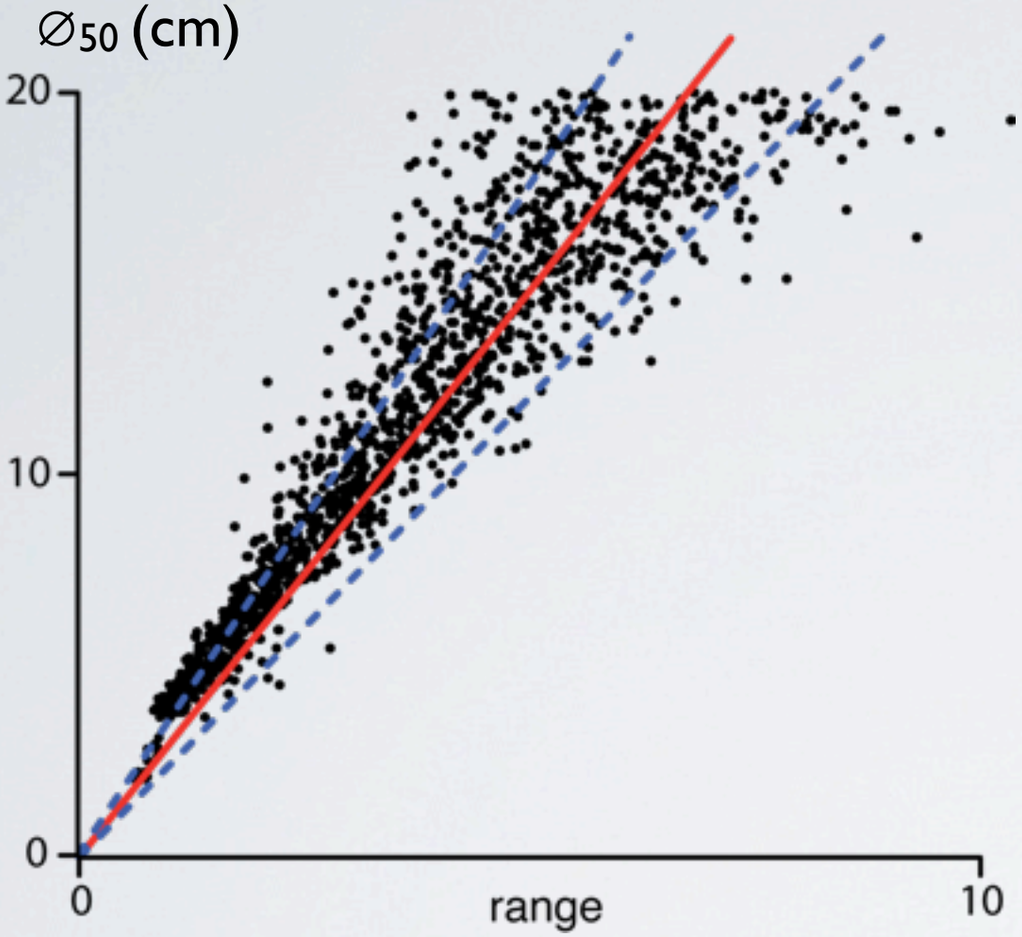






Variogram range correlated to median diameter

FIRST RESULTS
USING AUTOCORRELATION METHOD



1500 images with ∅ constant in (2,20)cm

- good linear relationship range/$\varnothing_{50}$ (R^2=0.8)
- unbiased estimates of $\varnothing_{50}$ (except small $\varnothing_{50}$)
- but heteroscedasticity: relative estimation error: 14% of $\varnothing_{50}$

⇒ Distance effect

⇒ Model adjustment ...

7500 images with ∅ in $N(\mu,\sigma)$

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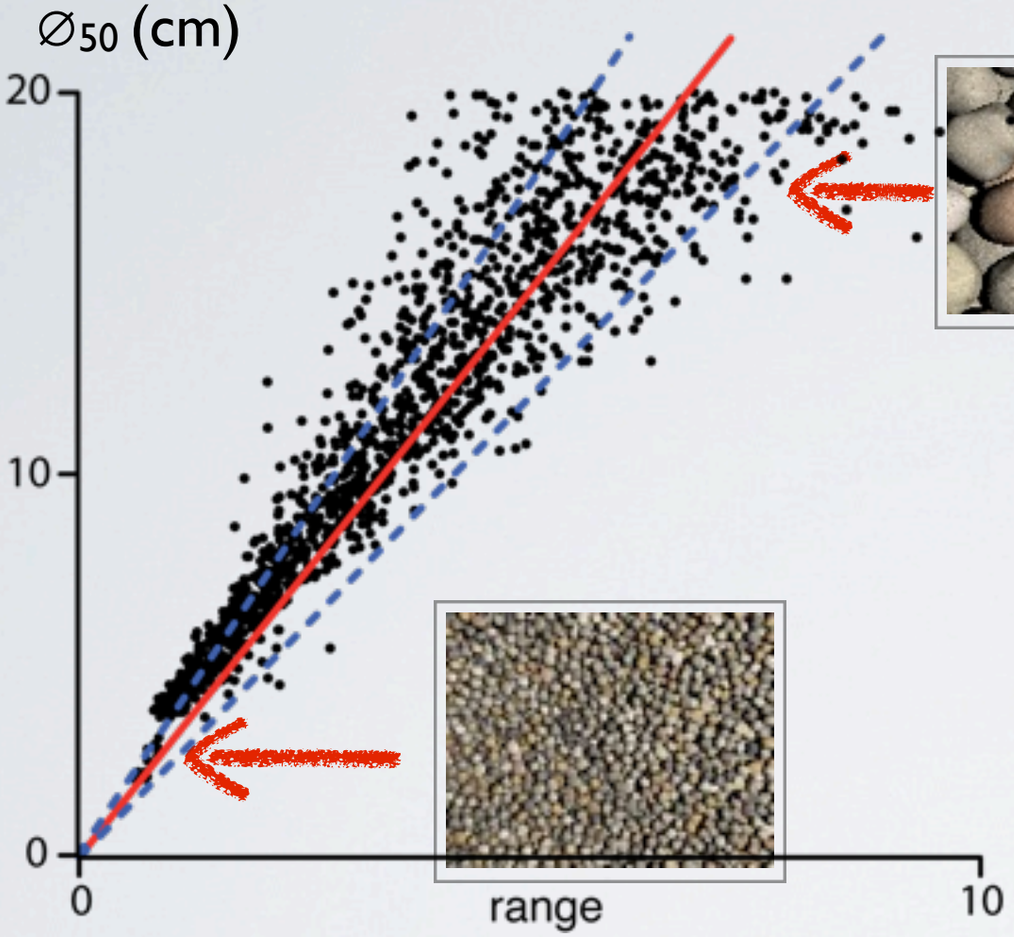

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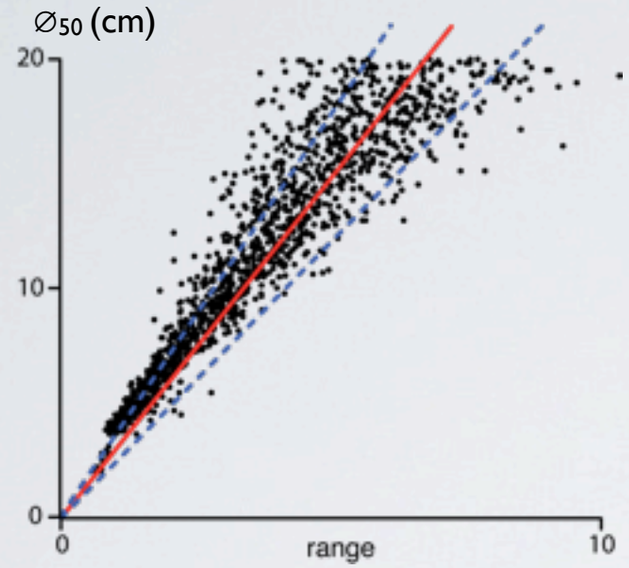

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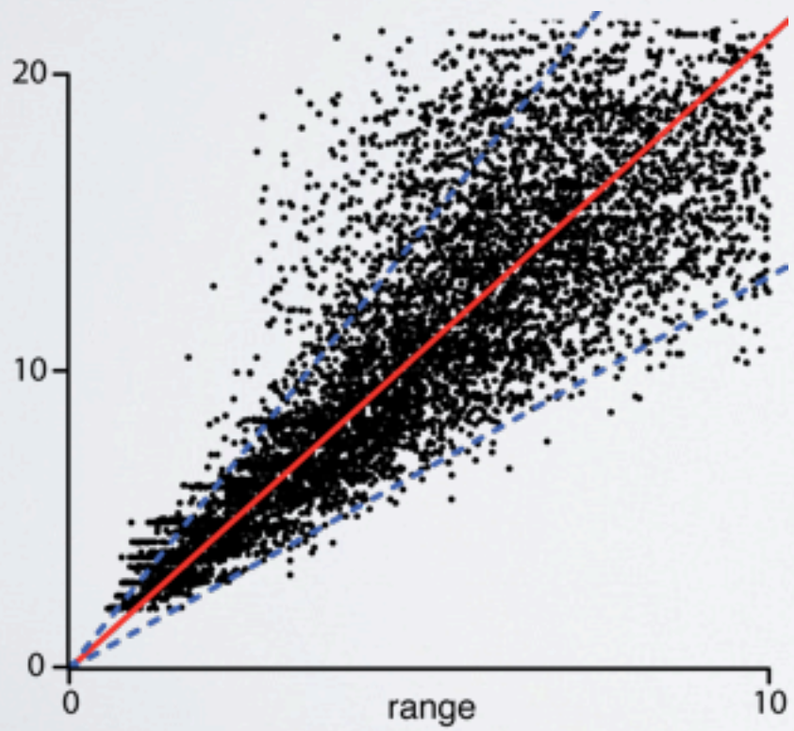

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- but heteroscedasticity: relative estimation error: 14% of $\varnothing_{50}$
  - ⇒ Distance effect
  - ⇒ Model adjustment ...
- R^2 = 0.69
- relative estimation error: 19% of $\varnothing_{50}$
  - ⇒ 5pt coming from diameter variability inside image

CONCLUSION

Computer generated images enable method validation

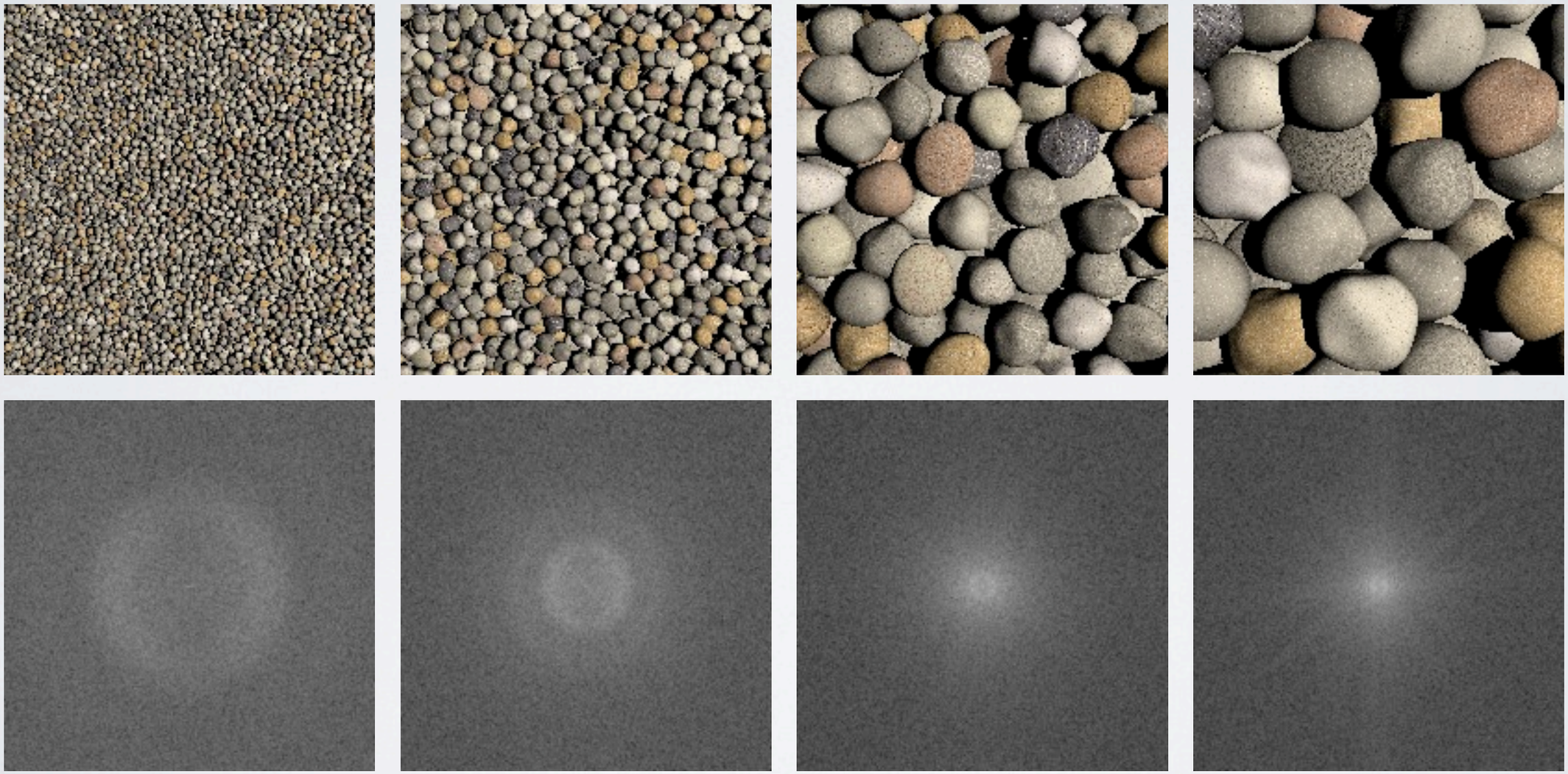
- Case of autocorrelation method:
  - robust but not really accurate
  - Useful to discriminate grain size classes (relevant in most applications)
  - Can accelerate data collecting using proxy detection

Some perspectives

- Assess the precision of other approaches
  - → ongoing works on Fourier analysis
- Generate other image series with controlled conditions:
  - → underwater, sun incidence, image resolution, other distributions...
  - → assess parameters influence on results

FOURIER ANALYSIS

- Link between amplitude of Fourier transform and diameter distribution



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