Bias-Free Gravitational Shear Estimates with Neural Networks

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Structure

Who am I and what am I doing here?

Weak Lensing

Definition

Weak Lensing: slight gravitational distortion of background objects perceptible only to statistical analysis

Limitations due to:

Scatter

- obviously present
- less a problem as sample size increases

Bias

- depends on various factors
- directly influences results

The KSB Approach

KSB Shear Measurement

Kaiser, Squires, Broadhurst (1995):
shapes measured with weight function
using linear corrections

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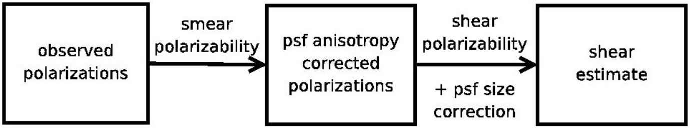

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$$\boldsymbol{e}^{\mathrm{obs}} = \boldsymbol{e}^{\mathrm{true}} + P^{\mathrm{sm}}\boldsymbol{p} + P^{\gamma}\boldsymbol{g}$$

$$\langle \boldsymbol{g} \rangle = \langle {P^{\gamma}}^{-1} (\boldsymbol{e}^{\mathrm{obs}} - P^{\mathrm{sm}}\boldsymbol{p}) \rangle$$

KSB - Choices

Decisions

- source extraction
- psf anisotropy correction
- weight function radius
- selection criteria
- tensors
- tensor inversion
- correction factor

Problem

It's not at all clear which one is the *right* choice!

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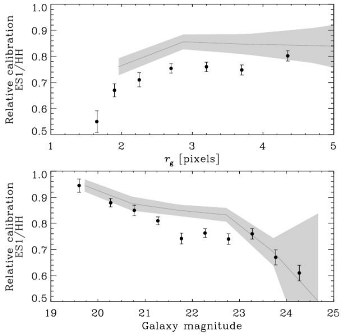

Samboloni / Hoekstra KSB ratio, source: STEP2

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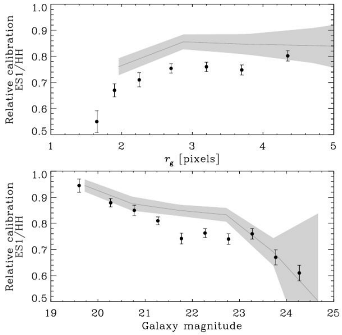

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Idea

Problem

- bias is present
- simulations necessary
  - calibration of methods
  - training!

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Use neural networks for best possible bias reduction!

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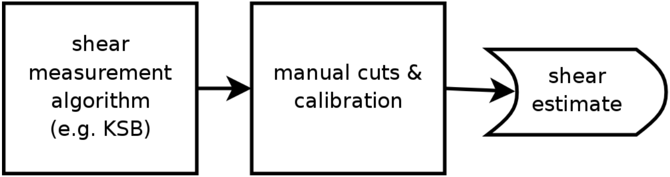
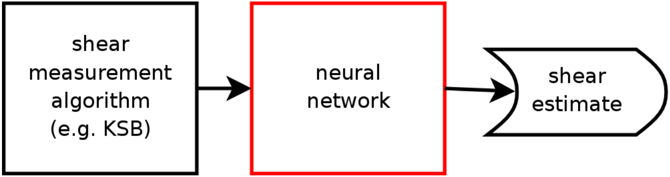
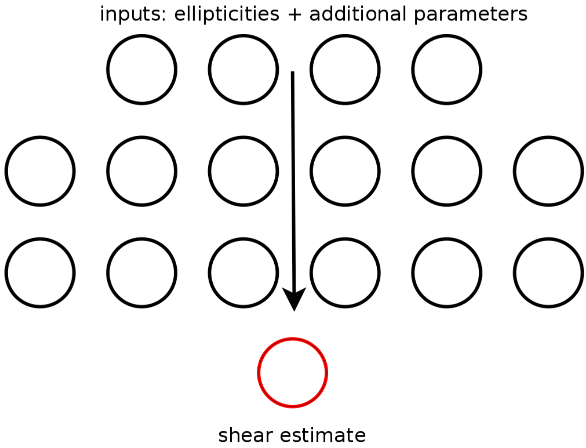


shear measurement algorithm (e.g. KSB)
manual cuts & calibration
shear estimate

Pipeline


shear measurement algorithm (e.g. KSB)
neural network
shear estimate

Perceptron Architecture



Averaging Networks

Network training

- need true results
- only known *on average*

$$E = \sum_{i,j} (x_{i,j} - \hat{x}_{i,j})^2$$

Solution

$\rightarrow$ train networks to find shear as *average* output!

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panna

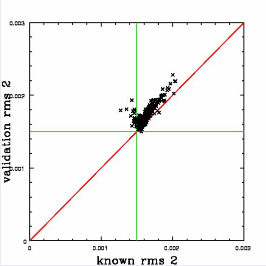
Perceptron **A**rtificial **N**eural **N**etworks for **A**veraging

panna with KSB inputs

Data

- 1500 sets, same psf
- different s/n, sizes, galaxy models
- KSB output, $q = 10^{-4}/\langle(\Delta g)^2\rangle \approx 13$
- P^γ, $\Delta\vec{e}$, $\mathtt{FLUX}$, r_h

Results

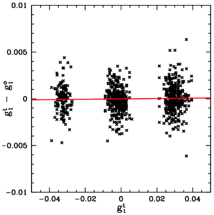


$q \approx 40 - 50$

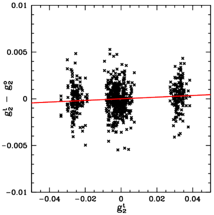
Linear Bias

$$g_i^o - g_i^t = m_i \cdot g_i^t + c_i$$

$m_i \leq 10^{-3}$, $\quad c_i \leq 3 \times 10^{-4}$ [Amara & Réfrégier (2008)]



$$m_1 = 2 \times 10^{-3}$$
$$c_1 = -1 \times 10^{-5}$$



$$m_2 = 9 \times 10^{-3}$$
$$c_2 = -2 \times 10^{-6}$$

Sixpack Effect

Definition

$q_1 \propto$(squared error)$^{-1}$ of individual set shear estimate
$q_6 \propto$same after averaging residuals over 6 similar sets

Interpretation

- $\frac{q_6}{q_1} = 1$: no scatter, bias only
- $\frac{q_6}{q_1} = 6$: no bias, scatter only

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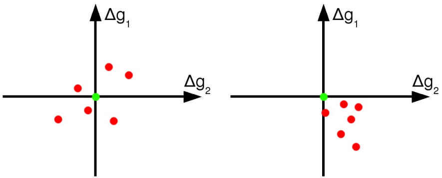

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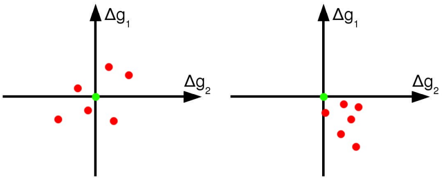

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Results (GREAT08)

Method	q
KSB_H	52.3
lensfit	118.8
KK99 (stacked fitting)	131.4
Fourier	210.9
KSB+NN	200-350 (?)

Problems

- similar data with known shear has to be simulated
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