Determining time delay in gravitational lensing: How significant are the results.

Juan C. Cuevas-Tello[1]

Peter Tiňo[1]

Somak Raychaudhury[2]

[1]School of Computer Science

{J.C.Cuevas, P.Tino}@cs.bham.ac.uk

[2]School of Physics and Astronomy

somak@star.sr.bham.ac.uk

THE UNIVERSITY OF BIRMINGHAM

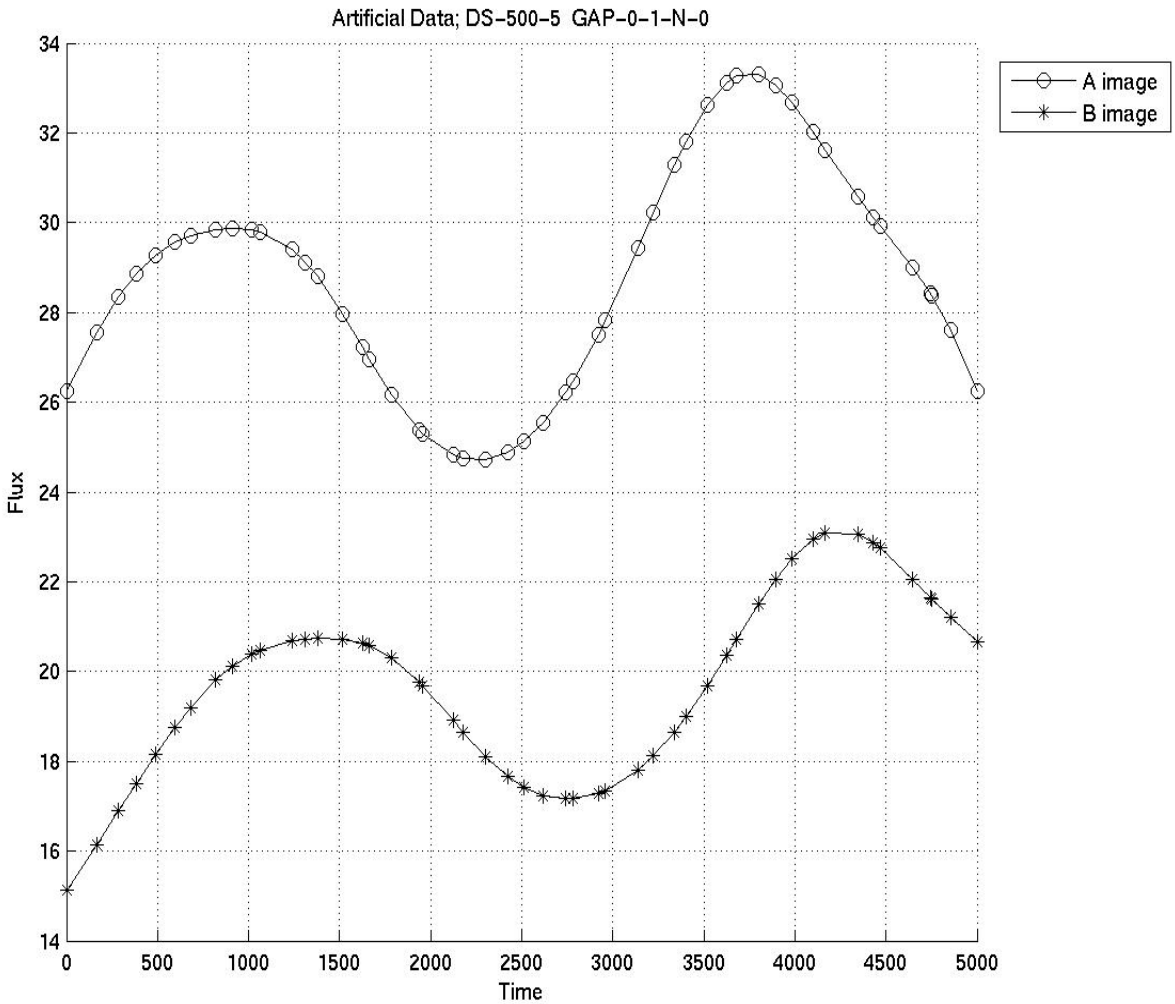
Abstract

We use artificial data sets to perform large-scale experiments in order to validate the accuracy of the time delay estimation in gravitational lens systems. We generate simulated data sets with different levels of noise, varying the size and location of observational gaps. We present a new approach to estimating the time delay, which is based on generalised linear Kernel Regression. We compare results with the most popular methods.

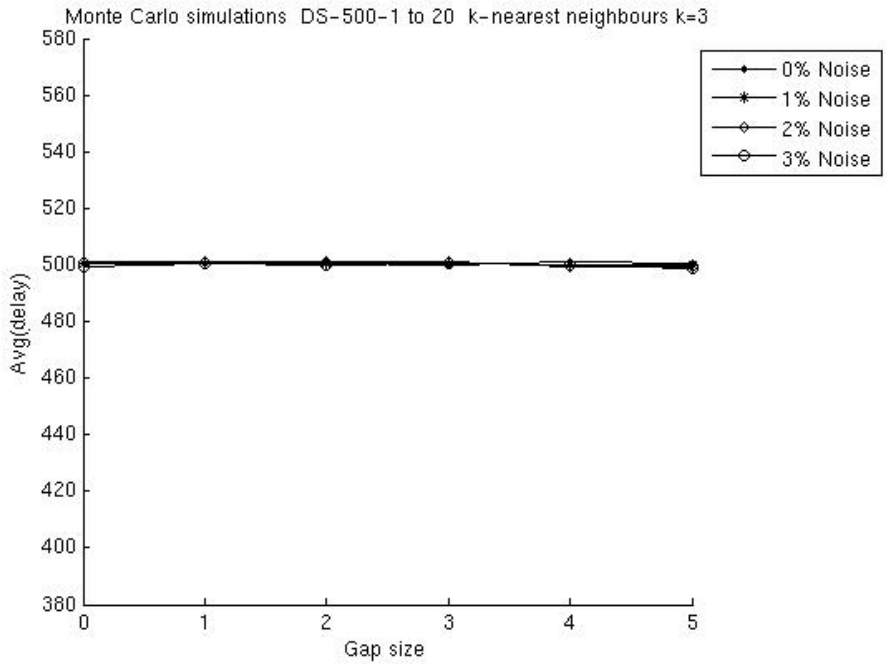
Artificial data

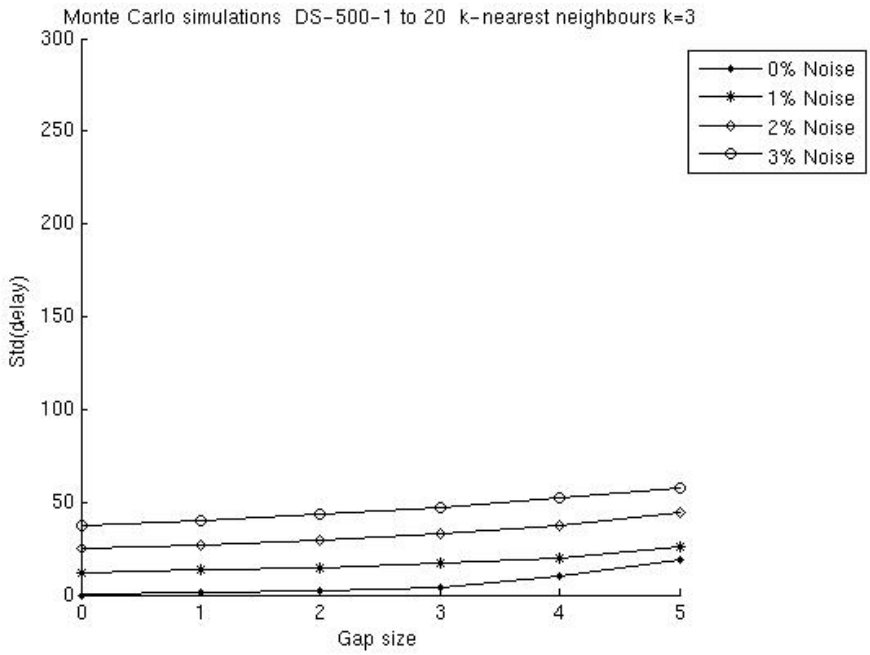
- 20 Gaussian functions with centers and widths generated randomly.
- Amplitude as radio data, 4cm. [1]
- Fixed magnification ratio: 1.44. Between A and B.
- Fixed delay: 500 days
- Irregularly sampled.
- 50 samples.
- 3 levels of noise: 1%, 2% and 3%.
- 5 gaps of size 0 to 5 (missing samples). The gaps are located randomly with at least one sample in between.
- 20 different underlying functions.
- 10 realisations for gap size (1 to 5).
- 100 realisations for noise.

Example of underlying function

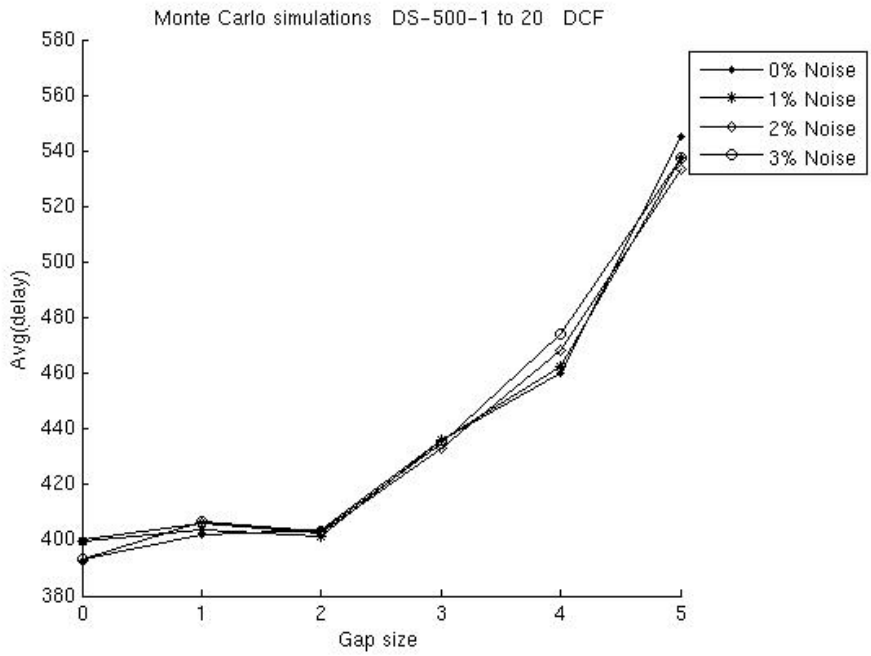


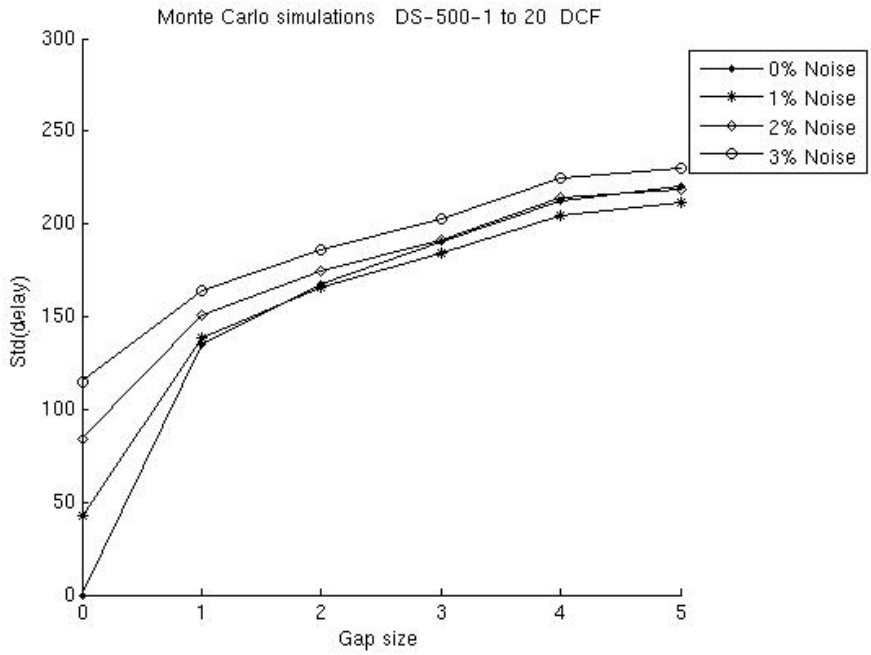
k-nearest neighbours + Kernel Regression (*k*=3) [2]



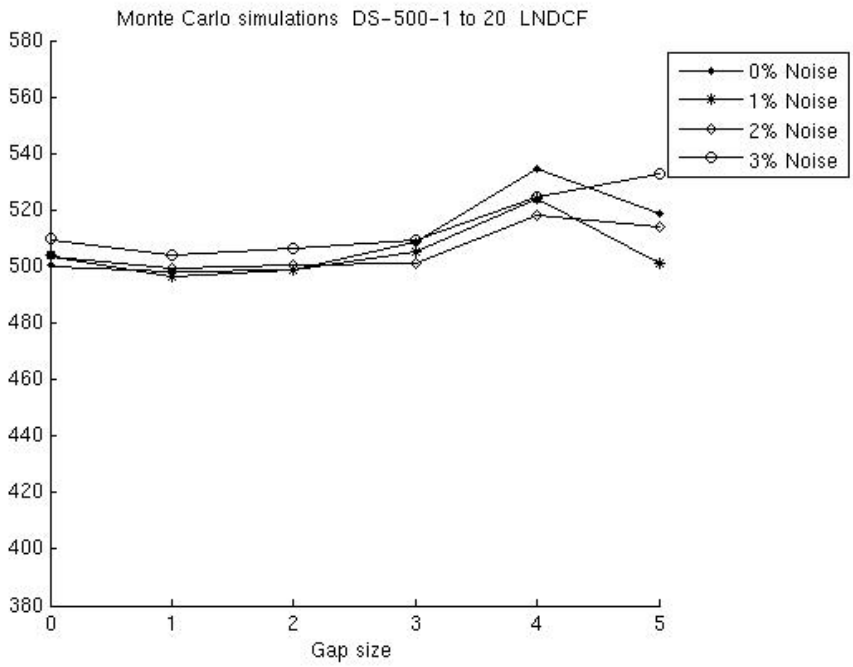


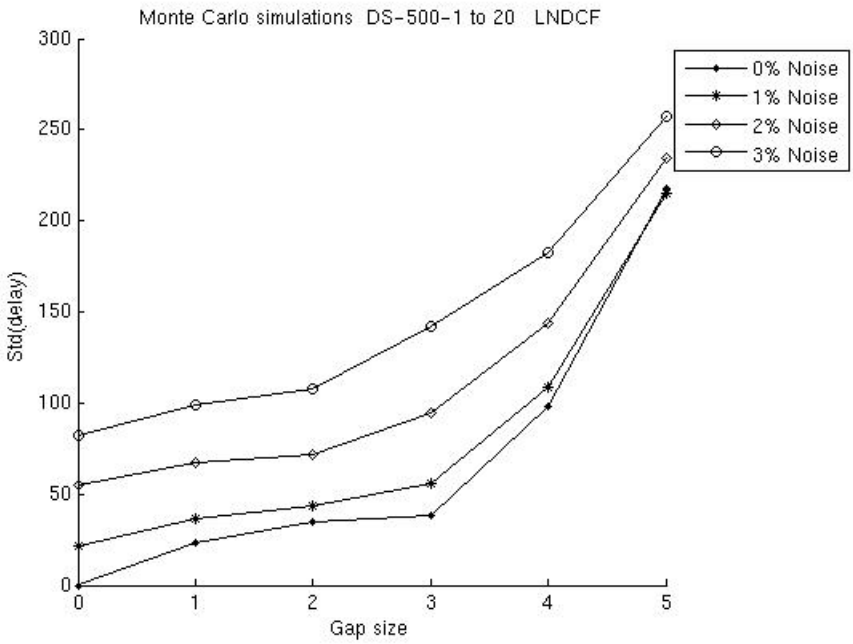
Discrete Correlation Function (DCF) [3]





Locally Normalised Discrete Correlation Function (LNDCF) [4]





Future work

Evaluation of the previous data sets by using other methods such as:

- PRH method (Press et al 1992).

- Dispersion Spectra (Pelt et al. 1996).

Application of this methodology to optical data, real and simulated.

References

[1] Haarsma D.B., Hewitt J.N., Lehár J., and Burke B.F. (1999). The Radio Wavelength Time Delay of Gravitational Lens 0957+561, *Astrophysical Journal*, 510(1), 64–70.

[2] Hastie, T., Tibshirani, R. and Friedman J. (2001). *The elements of statistical learning: data mining, inference and prediction*. Springer Series in Statistics.

[3] Edelson, R.A. and Krolik, J.H. (1988). The discrete correlation-function - a new method for analyzing unevenly sampled variability data. *Astrophysical Journal*, 333(2), 646-659.

[4] Lehár, J., Hewitt, J.N., Roberts, D.H. and Burke, B.F. (1992). The radio time delay in the double quasar 0957+561, *Astrophysical Journal*, 384, 453–466.