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A new maximum-likelihood phase estimation method for X-ray pulsar signals

Key words: X-ray pulsar, Poisson model, Phase estimation, Maximum likelihood

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Introduction

- Techniques for estimating the phase of X-ray pulsar radiation involve the maximization of the general non-convex object functions based on the average profile from the epoch folding method.
- A new maximum likelihood (ML) phase estimation method is presented that directly uses the measured time of arrivals (TOAs).
- A parallel ML estimation method is put forward to improve the ML solution.

Design method (I)

The probability density function of the TOA sequence is given by

$$p(\{t_i\}_{i=1}^{m};\varphi_0)=\prod_{i=1}^{m}h_{\mathrm{g}}(\tau_i;\varphi_0).$$

An ML estimation problem can be formulated to estimate φ_0:

$$\mathrm{LLF}(\varphi_0)=\sum_{i=1}^{m}\ln h_{\mathrm{g}}(\tau_i;\varphi_0).$$

The initial phase can be estimated by solving the following optimization problem:

$$\hat{\varphi}_0=\underset{\varphi_0\in[0,1)}{\operatorname{argmax}}\,\mathrm{LLF}(\varphi_0).$$

Design method (II)

A parallel ML estimation method is used,

namely, parallel computation of pLLF($\boldsymbol{\theta}$):

$$\mathrm{pLLF}(\boldsymbol{\theta}) = \sum_{l=1}^{L} \sum_{i=la+1}^{la+a} \frac{\partial \ln h_{\mathrm{g}}(\tau_n;\boldsymbol{\theta})}{\partial \boldsymbol{\theta}}$$

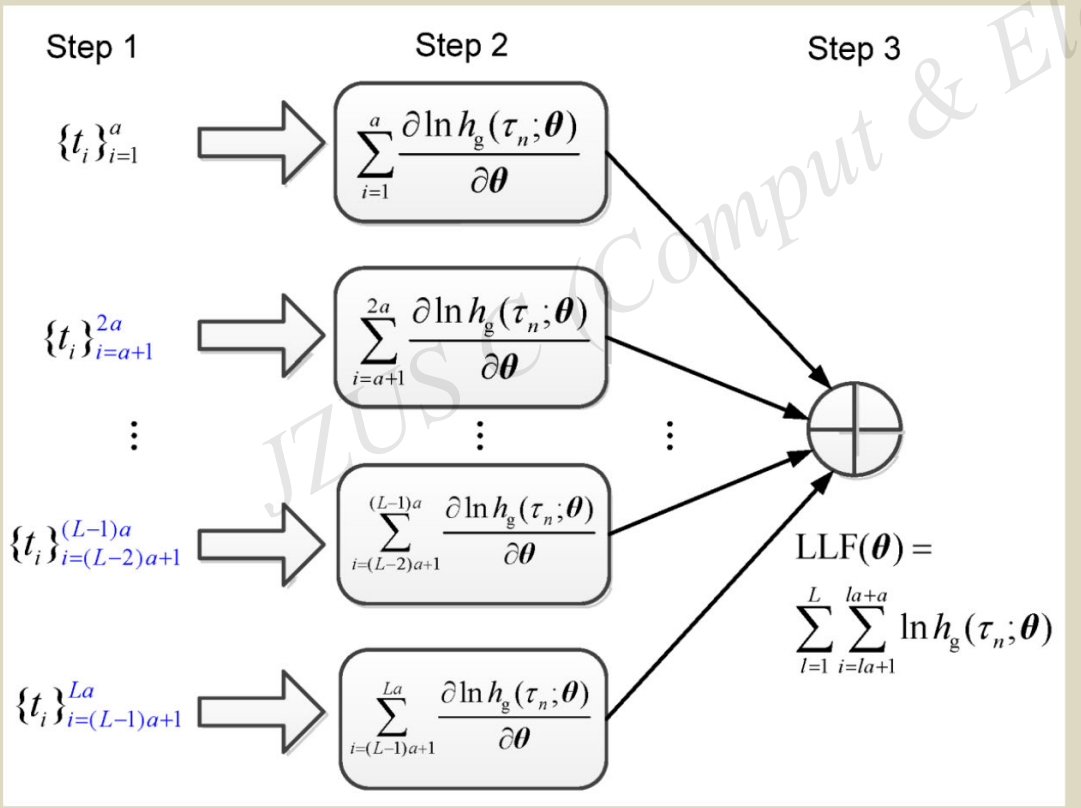
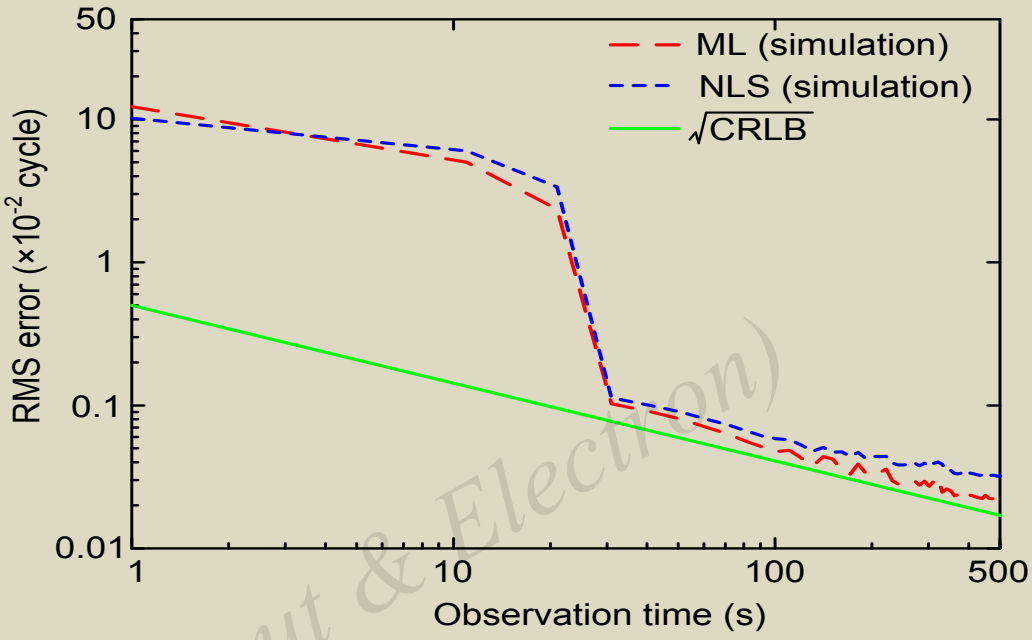
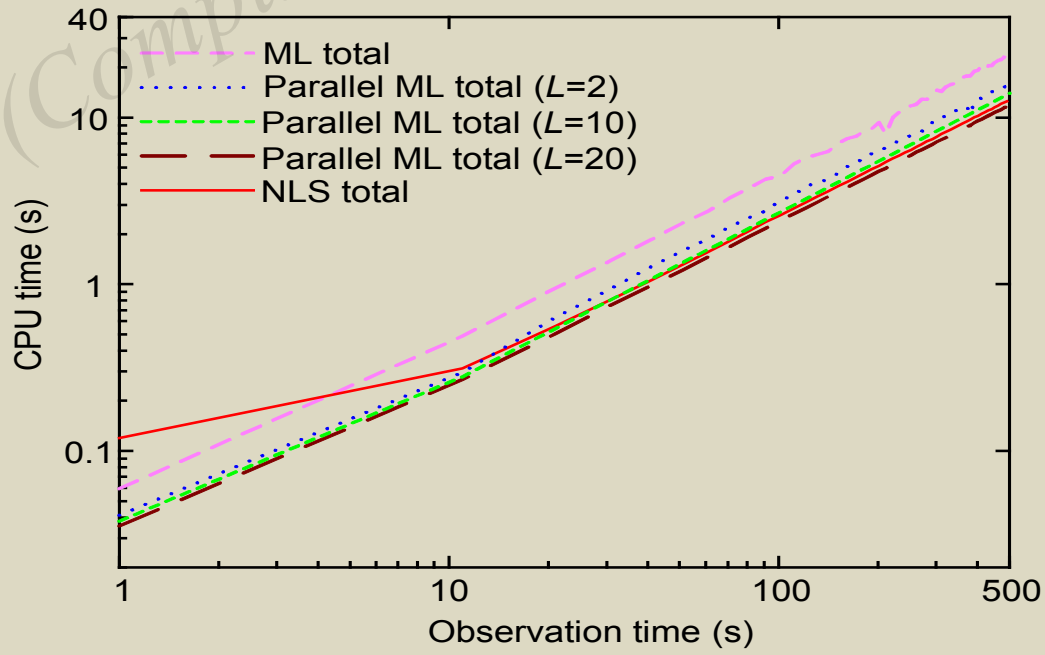


Fig. 1 Schematic of the parallel strategy

Simulation results





RMS errors (top) and CPU time (bottom) of different simulation methods

Conclusions

- A new maximum likelihood (ML) phase estimation method is presented.
- A parallel ML estimation method is developed and compared with the current ML estimator and the NLS estimator.
- Numerical simulation results show that the estimator described here presents higher precision and reduces computational complexity compared with currently used estimators.