ASTEROIDS@HOME

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Abstract

Asteroids@home (http://asteroidsathome.net) is a volunteer-computing project that uses an open-source BOINC (Berkeley Open Infrastructure for Network Computing) software to distribute tasks to volunteers, who provide their computing resources. The project was created at the Astronomical Institute, Charles University in Prague, in cooperation with the Czech National Team. The scientific aim of the project is to solve a time-consuming inverse problem of shape reconstruction of asteroids from sparse-in-time photometry. The time-demanding nature of the problem comes from the fact that with sparse-in-time photometry the rotation period of an asteroid is not apriori known and a huge parameter space must be densely scanned for the best solution. The nature of the problem makes it an ideal task to be solved by distributed computing – the period parameter space can be divided into small bins that can be scanned separately and then joined together to give the globally best solution. In the framework of the the project, we process asteroid photometric data from surveys together with asteroid lightcurves and we derive asteroid shapes and spin states. The algorithm is based on the lightcurve inversion method developed by Kaasalainen et al. (2001, Icarus 153, 37). The enormous potential of distributed computing will enable us to effectively process also the data from future surveys (Large Synoptic Survey Telescope, Gaia mission). We also plan to process data of a synthetic asteroid population to reveal biases of the method.

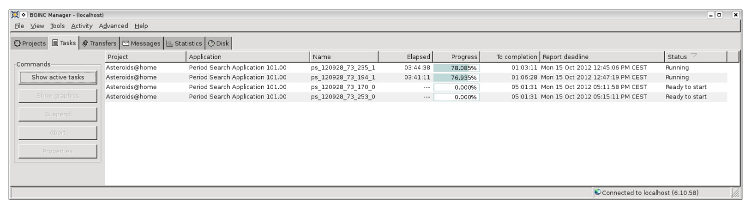
Why distributed computing?

With huge amount of photometric data coming from big all-sky surveys as well as from backyard astronomers, the lightcurve inversion becomes a computationaly demanding process. In the future, we can expect even more data from surveys that are either already operating (Pan-STARRS) or under construction (Gaia, LSST). Moreover, data from surveys are often sparse in time, which means that the rotation period – the basic physical parameter – cannot be estimated from the data easily. Contrary to classical lightcurves where the period is "visible" in the data, a wide interval of all possible periods has to be scanned densely when analysing sparse data. This fact enormously enlarges the computational time and the only practical way to efficiently handle photometry of hundreds of thousands of asteroids is to use distributed computing. Moreover, the problem is ideal for parallelization – the period interval can be divided into smaller parts that are searched separately and then the results are joined together.

Users

Users install the BOINC client and set up the preferences. The tasks are then automatically downloaded, computed, and the results are uploaded to the server. Each user scans a small part of the parameter space. The whole period interval 2–100 hours is divided into typically several hundreds of workunits that are distributed to users. The typical time needed for computing one workunit is of order of hours.

BOINC Manager



Server

The results sent by users are validated by comparing the same tasks computed by two different users. If the results are different, the workunit is sent to other users until an agreement is reached. The results are stored in the database and are accesible via a web interface.

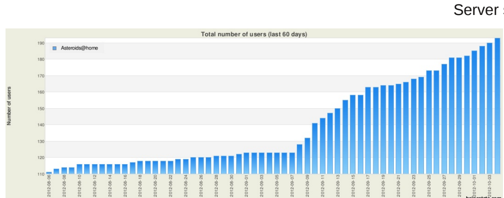
Computing status (Oct 4, 2012)

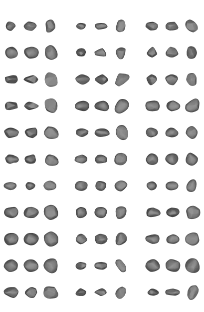
Work	#
Tasks ready to send	16,483
Tasks in progress	3,205
Workunits waiting for validation	0
Workunits waiting for assimilation	0
Workunits waiting for file deletion	0
Tasks waiting for file deletion	0
Transitioner backlog (hours)	0

Users	#
with recent credit	169
with credit	194
registered in past 24 hours	4
Computers	**#**
with recent credit	386
with credit	477
registered in past 24 hours	11
current GigaFLOPs	543

Tasks by application				
application	unsent	in progress	avg runtime of last 100 results in h (min-max)	users in last 24h
Period Search Application	16,476	3,202	4.43 (1.64 - 13.38)	70

Server statistics





Results

The aim of the project is to derive shapes and spins for a significant part of the asteroid population. As input data, we use any photometry that is available. The results are asteroid convex shape models with the direction of the spin axis and the rotation period. New models will be published in peer-reviewed journals and then made public in the Database of Asteroid Models form Inversion Techniques (DAMIT). http://astro.troja.mff.cuni.cz/projects/asteroids3D

First asteroid models based on Asteroids@home results

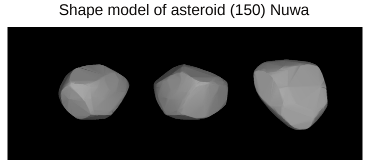
Scientific results

Asteroid models derived so far:

Asteroid	λ[deg]	β[deg]	P[h]	shape	computed by
150 Nuwa	0	20	8.13456	fig	BobCat13,koll
	175	19		fig	
272 Antonia	359	-90	3.85479	fig	Qubity,zombie67 [MM]

Here λ and β are ecliptic longitude and latitude of the spin axis direction and P is the rotation period. Usually, there are two possible pole directions and corresponding shape models for one asteroid - the lightcurve inversion cannot solve this ambiguity for asteroids orbiting close to the ecliptic plane. Each figure shows the corresponding shape model from its equator (the first two views, 90 degrees apart) and pole-on (the third view). The 'computed by' column lists all users that provided valid results that contained the solution listed in the table.

Shape model of asteroid (150) Nuwa



Shape model of asteroid (272) Antonia