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HPC course 2021
Assignment 1.1.
Q1: Will you and why will you need HPC in your research?

My area of research is monitoring supercomputer Zhores itself. There are lots of metrics which have to be collected and there is a huge amount of data which analysis and storage require the same level of computational resources, therefore analysis of work of Zhores is made on the Zhores.

From my point of view, even if there is no need in your current research of direct usage of HPC, it is still relevant to learn, since we have a big trend of Big Data Analysis, which appears in many spheres, from economics to the Disney movies, where you modulate the movement of the villi of the shirt when the character moves around the room.

Q2: Find an interesting/fun application of HPC and supercomputers and briefly describe it

High performance computing and supercomputers have a broad area of application. American company, one of the five world leaders in the market of disk storage systems and solutions for storing and managing information, NetApp[1] provided a list of HPC use cases, which has been shown below[2]:

- **Research labs** . HPC is used to help scientists find sources of renewable energy, understand the evolution of our universe, predict and track storms, and create new materials.
- **Media and entertainment** . HPC is used to edit feature films, render mind-blowing special effects, and stream live events around the world.
- **Oil and gas** . HPC is used to more accurately identify where to drill for new wells and to help boost production from existing wells.
- **Artificial intelligence and machine learning.** HPC is used to detect credit card fraud, provide self-guided technical support, teach self-driving vehicles, and improve cancer screening techniques.
- **Financial services.** HPC is used to track real-time stock trends and automate trading.
- HPC is used **to design** new products, **simulate** test scenarios, and make sure that parts are kept in stock so that production lines aren't held up.
- HPC is used to **help develop cures for diseases** like diabetes and cancer and to enable faster, more accurate patient diagnosis.

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[1] "NetApp — Википедия." , , https://ru.wikipedia.org/wiki/NetApp. Доступ получен 10 апр.. 2021.
[2] "What Is High-Performance Computing (HPC)? How It Works | NetApp." , , https://www.netapp.com/data-storage/high-performance-computing/what-is-hpc/. Доступ получен 10 апр.. 2021.

In this assignment, I want to represent 3 recent works from different research areas which were done with usage of high performance computing.
As the newest research, which was done by usage of HPC and supercomputers, in 15 February 2021 there was a collaboration of JINR (Joint Institute of Nuclear Reactions) Laboratories in **search of the root causes of Alzheimer's Disease**[3].
It is believed that an important role at the initial stage of Alzheimer's disease is played by the interactions of the beta-amyloid peptide and the cell membrane, regulated by its composition, which correlates with the structural-dynamic and elastic-mechanical properties of the membrane. Since 2019, three laboratories which are the FLNP (Frank Laboratory of Neutron Physics), LIT (Laboratory of Information Technology) and LRB(Laboratory of Radiation Biology) has been working to study the properties of cell membranes and cell interactions in order to understand and study the mechanisms of Alzheimer's disease. At present, model systems of various biological membranes in the presence of ions and with the addition of cholesterol, melatonin, and beta-amyloid peptide have been investigated by the methods of small-angle neutron scattering and molecular dynamics.

In the physics of elementary particles and the atomic nucleus, usage of HPC is an actual tool for modeling nuclear reactions and processes as well as for analysis of data collected by detectors. The process works in the following way. Charged particles leave signals ("hits") in the detector, along which their trajectories ("tracks") are reconstructed. So in one of the fresh researches, which was released in 2021 in the scientific journal “Письма в ЭЧАЯ”, **a track recovery method** based on a limited combinatorial search for track candidates, i.e., combinations of hits in detectors, possibly belonging to a track, is presented[4].
Both previous works used the heterogeneous platform "HybriLIT"[5].

As the last interesting, I want to represent a research “**Fast Nonlinear Least Squares Optimization of Large-Scale Semi-Sparse Problems**” which is applied to the problem of model-based facial capture, made by Disney Research Studios[6].
In the paper they use the nonlinear Levenberg-Marquardt method to locally linearize the problem in parallel, based on its first-order approximation. and

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[3] "Коллаборация лабораторий ОИЯИ в поиске первопричин ...." , 15 февр.. 2021, , http://www.jinr.ru/posts/kollaboratsiya-laboratorij-oiyai-v-poiske-pervoprichin-bolezni-altsgejmera/. Доступ получен 10 апр.. 2021.
[4] "Vector Finder—A Toolkit for Track Finding in the MPD Experiment ...." , 19 февр.. 2021, , https://link.springer.com/article/10.1134/S1547477121010131. Доступ получен 10 апр.. 2021.
[5] "Суперкомпьютер "Говорун" — Гетерогенный кластер | ЛИТ/ОИЯИ." , , http://hlit.jinr.ru/. Доступ получен 10 апр.. 2021.
[6] "Fast Nonlinear Least Squares Optimization on the GPU - Disney ...." , , https://studios.disneyresearch.com/wp-content/uploads/2020/04/Fast-Nonlinear-Least-Squares-Optimization-of-Large-Scale-Semi-Sparse-Problems.pdf. Доступ получен 10 апр.. 2021.

decompose the linear problem in small blocks, using the local Schur complement, leading to amore compact linear system without loss of information. Such an approach made the optimization process entirely parallel and scalable and made it suitable to be mapped onto graphics hardware (GPU).
They implemented the solver on the GPU using Cuda, and performed the comparisons by running Ceres solver[7] on an Intel i7-7700KCPU, quad-core processor with 8 hyperthreads, and their solver on the Nvidia GeForce GTX 1080 Ti with 28 Multi-Processors.

[7] "Ceres Solver." , , http://ceres-solver.org/. Доступ получен 10 апр.. 2021.