Internship (software engineer): "(GPU-CUDA) parallel implementation of a new dose calculation algorithm for cancer radiation therapy treatments"

Host structure

The Institut Curie is a major player in cancer research and treatment. It consists of a hospital and a research center with more than 3,000 employees and a strong international presence. The Orsay Proton therapy Center (CPO) founded in 1991 is part of the radiation oncology department at Institut Curie hospital group, which is one of the European-wide recognition as a Comprehensive Cancer Center of excellence. This internship will be carried out as part of a research project whose goal is to investigate new dose calculation tools for ultra-high dose rate radiotherapy, and is an exciting opportunity to join the radiation therapy research activities in Orsay, within a hospital and a research center.

Subject description

Objectives

Graphic Processing Units (GPUs) are a computing technology that has recently gained prominence in the scientific community, in particular for health applications. While initially developed for graphical applications, its parallelization possibilities find several other uses, such as performing repeated operations on large data sets, running Monte Carlo simulations, and training Artificial Intelligence (AI) models. Nonetheless, a few recent applications extending the GPU use to other scientific computing tasks has an enormous potential, and can allow clinicists to run too-expensive computations (for today's software) in almost real-time tasks. An example of such application are the dose calculation algorithms for particle beam interactions: while hours (if not days) are required to run Monte Carlo simulations using state-of-the-art CPU based codes, a CUDA based tool on a GPU could simulate millions of particles in just a few seconds.

Within the medical physics research team based at the Institut Curie Orsay (91), we are looking for a student, with a strong interest in translational research on cancer therapy and computer science. A 6 months internship position is proposed to work on a (GPU) parallel implementation of a new dose calculation algorithm dedicated to radiation therapy treatments with electrons. The current Matlab and Python implementation we have implemented does not make use of parallelism and can only handle simplified models. The objective of the internship is therefore to implement a parallel and optimized version of the algorithm that will run on GPUs. During his/her stay, the intern will have the opportunity to learn about state of the art methods in radiation therapy, and parallel programming in addition to working in a stimulating research environment (INSERM U1288 & Cancer hospital) and experiencing life.

Context

Radiation therapy is currently one of the main techniques used for cancer treatment. More than 50% of patients treated for cancer - about 180,000 per year in France - benefit from it. Over the last thirty years, numerous technical advances have made it possible to considerably improve the conformation of irradiation to the specific characteristics of each tumour and to reduce their side effects. Nevertheless, the tolerance of healthy tissues remains the main limitation of this type of treatment, particularly in the case of particularly radiosensitive patients, such as children, for whom controlling the side effects of radiotherapy remains a major therapeutic challenge. Recently, pioneering work conducted at Institut Curie has shown that ultra-high dose rate irradiation (known as FLASH) has a major effect in sparing healthy tissue - while preserving anti-tumor efficacy (Favaudon et al 2014). VHEE radiotherapy (very-high energy electrons, in the energy range of 100 to 250 MeV), first proposed in the 2000s, would be particularly accurate and independent of tissue heterogeneities (unlike low energy electrons or protons), and could be applicable in a large number of anatomical localizations (Figure 1). This technique is also potentially less expensive than others, and would allow accelerated treatment, for example through magnetic scanning of particle beams, with high doses per fraction, thereby improving its effectiveness. Dose calculations in radiotherapy are mainly based on fast but accurate dose calculation algorithms, such as superposition/convolutions or Monte Carlo simulations, which do not currently take into account the temporal aspects of the dose delivery. For such algorithms, the dose and the optimisation of the treatment parameters are usually separated, whereas multiple dose delivery parameters are of possible importance for enabling new biological effects. For the moment, calculations are parallelized on large computing clusters, and generally require several hours to obtain sufficient precision.

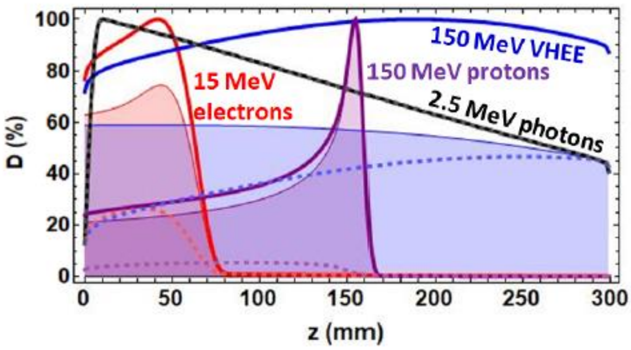

Figure 1: Depth dose distribution in water for several radiation types (photons, electrons, protons, Lagzda 2019).

The aim of this placement is to implement algorithmic processing on the GPU using the CUDA Toolkit (C++) framework. The algorithmic processing will mainly come from our implementations in Python and Matlab.

Your tasks will involve:

- Getting to grips with the in-house code written in Matlab.
- Setting up a C++ / CUDA / GPU development environment.
- First comparisons with algorithms already implemented in our environment (Monte Carlo simulations in particular) will be carried out.

Profile required

A background in parallel programming (CUDA/C++) is preferable. Familiarity with git, C, and Python are necessary. You will also be expected to work as part of a multidisciplinary team.

Informations sur le contrat

Type of contract: Internship
Contract duration/Starting date: *4-6 months*
Working hours: Full time – *39h/week*
Remuneration: standards for students.
Benefits*:* Collective restaurant, 70% reimbursement of the transport ticket, company mutual insurance
Location: Institut Curie, Centre de protonthérapie d'Orsay, France
Reference: CUDA

Contact

Please apply by e-mail (CV + application letter) to ludovic.demarzi@curie.fr

Institut Curie is an inclusive, equal opportunity employer and is dedicated to the highest standards of research integrity. All our opportunities are open to people with disabilities.