EPFL-TTO

EPFL Innovation Park J
CH-1015 Lausanne
Switzerland
+41 21 693 70 23
http://tto.epfl.ch/

Research Contact

Dr Sanket Diwale
+41 21 693 29 23
sanket.diwale@epfl.ch

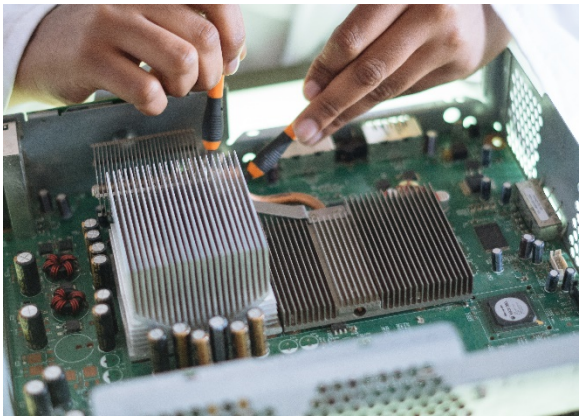
TTO Contact

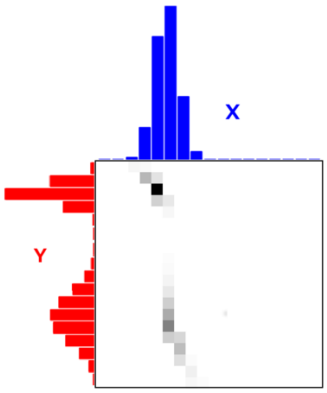
Dr Frédéric Pont
+41 21 693 13 09
frederic.pont@epfl.ch

Licensing Opportunity

TTO – Technology Transfer Office

Gradient Flow Emulation Using Drift Diffusion Processes





Ref. Nr

6.2054

Keywords

Optimal transport, Bayesian inference, PDEs, gradient flow equations, circuit design, semi-conductors, hardware acceleration

Intellectual Property

Swiss Patent Application:
PCT/IB2019/060782
Application date: 13/12/2019

Publications

Date

09/11/2020

Description

Many real-world problems, such as in image registration and seismic tomography, have been formulated to have solutions based on optimal transport theory. In brief, this theory aims to find a transformation of data from one space to another whilst minimizing some cost function associated with moving this data. A special case of this theory is Bayesian inference and solutions to these problems traditionally involved intractable integrals.

Most practical applications avoid these integrals and either rely on sampling schemes such as Monte Carlo, which is computationally expensive, or reformulate the problem into 'differential form', where the goal is to then solve a partial differential equation (PDE), or 'gradient flow equation'.

This invention provides a completely novel way of solving such gradient flow problems by using a physical emulation device which relies on inherent physical processes within a semiconductor or charge carrying material to emulate the solution to a PDE.

The technology is principally a hardware accelerator and consists of both first and second type charge carrier regions and the associated charge-flow barrier, as well as separating regions for the first type charge carrier regions. It also includes input terminals to configure the problem and output terminals to measure the output signals.

Advantages

This novel method presents several advantages to both traditional and more recent approaches in terms of speed and energy consumption. Moreover, it is more cost effective and can be made smaller than other hardware accelerators.

Since the device relies on semiconductor physics, the emulation of the gradient flow equation occurs in the order of microseconds, whilst numerical solutions to the same problem can take tens of minutes or even hours even with a multicore processor or other hardware acceleration like graphics processing units (GPUs).

The device emulation consumes zero current and does not bear resistive loss. Energy consumption occurs only in configuring the input voltage and during output current measurement. GPUs, for example, consume considerable energy resources in order to achieve reasonable acceleration rates.

The size of the devices ensures modularity and allows N-dimensional gradient flow problems to be solved by arranging N such devices. Traditional approaches using integrals become unfeasible due to the so-called curse of dimensionality.

Applications

- Optimal transport problems
- Bayesian inference problems