OpenCL implementation of ’Volterra’ system models for GPU-accelerated computation

Ausschreibung Master Thesis
Timo Oster
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Open-Source Volterra Toolbox

If you are interested in contributing to this project (which is eventually supposed to become open-source) in a master thesis, just let me know at timo.oster@ies.tu-darmstadt.de

TECHNISCHE UNIVERSITÄT DARMSTADT

Scope of this project

For many engineering problems, nonlinear system behaviour can pose quite a few problems: Control circuits might unexpectedly become unstable, measured waveforms are degraded, and distortion products might interfere in RF communication. Volterra series, even though limited in their accuracy, offer a favourable way of describing these systems: They allow for a wide range of formalized mathematical operations, like nonlinear system inversion or concatenation. They can be thought of as the concept of taylor series interwoven with the concept of impulse responses.

This makes it possible to use Volterra series over a wide range of real-world applications, which share the same underlying mathematics. They are ideal for ’black box’-type system characterization, and further processing of the obtained models.

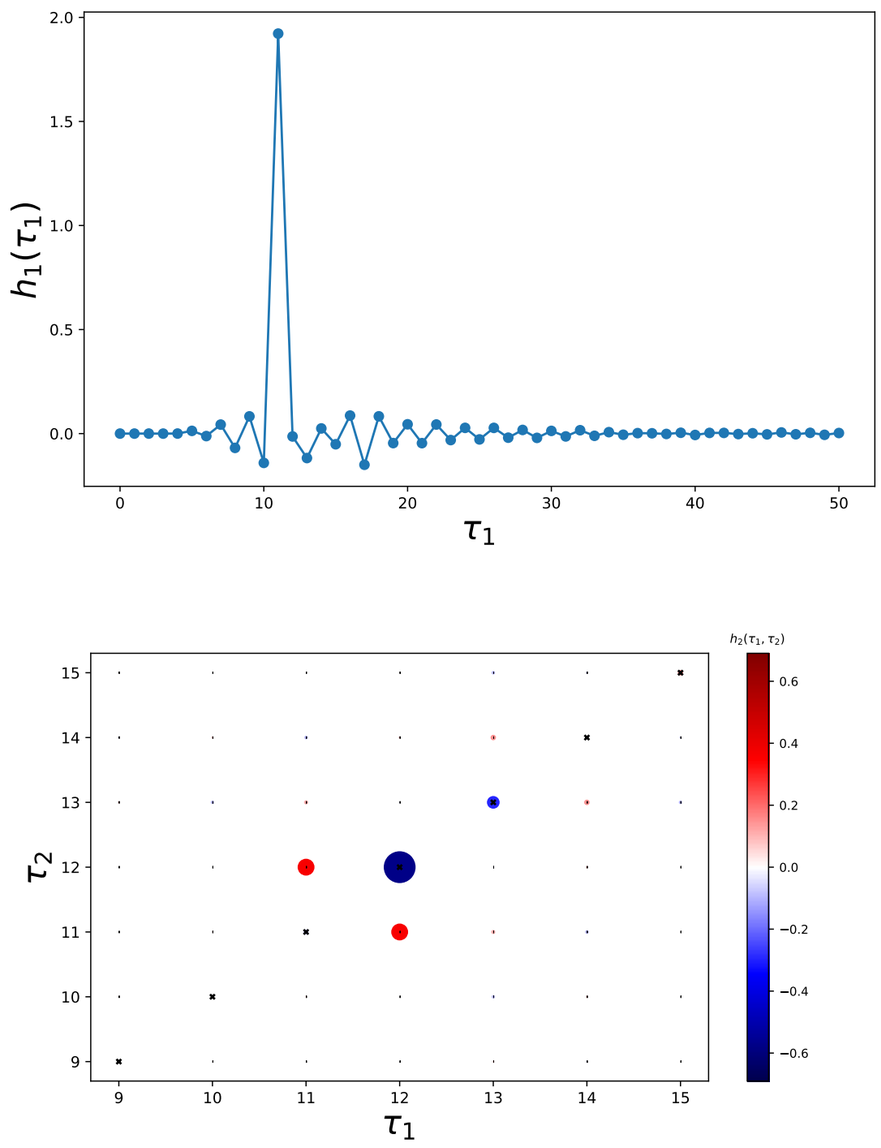
But Volterra series come with a price: Their computational complexity makes higher-order calculations on standard CPUs prohibitively long. This can be resolved by making use of parallel processing on GPUs. In this project, a python-based, OpenCL-accelerated toolbox for Volterra- based nonlinear system model calculations will therefore be developed. The results could eventually be published as an open source library.

Your Task

In preliminary work, some python code has been developed, which is capable of performing calculations for third order Volterra systems. Some of its functions have already been translated to OpenCL code. However, for efficiently calculating higher-order systems (the goal being 5th order), a thoroughly optimized version of the code is needed, as well as an implementation of the 5th order calculations themselves.
Your task will be to do a review the literature on nonlinear Volterra systems, and the corresponding system-level mathematical operations. Then, in a first step, you will extend the already existing third-order python implementation towards 5th order; after that, the code can be optimized to use OpenCL and make use of underlying symmetries, speeding up the calculations.

Useful Skills or Interests:

- Python programming
- C programming
- GPU-accelerated computing (OpenCL, Cuda, Vulkan...)
- RF electronics
- Nonlinear dynamics, preferably Volterra series
- Digital signal processing



First-, second-, and third-order Volterra kernels of an RF amplifier