VRIJE UNIVERSITEIT BRUSSEL

The faculty of Engineering of the Vrije Universiteit Brussel invites you to attend the public defense leading to the degree of

DOCTOR OF ENGINEERING SCIENCES

of **Krishan Harkhoe**

The public defense will take place on **Friday, 7th October 2022 at 4:00pm** in room **Q.D** (Building Q, Brussels Humanities, Sciences & Engineering Campus)

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NEURO-INSPIRED PHOTONIC COMPUTING: STRATEGIES TOWARDS ALL-OPTICAL INTEGRATED DELAY-BASED RESERVOIR COMPUTING

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Abstract of the PhD research

Reservoir computing (RC) is a neuro-inspired computing technique that shares commonalities with artificial neural networks (ANNs). The training of an RC is a simpler and faster procedure than for ANNs, which saves time and energy. In RC the neural network can be replaced by a physical system, eliminating the need of digital processing units to emulate artificial neurons. Photonic systems are especially well-suited to this end, as they are in general high-bandwidth components supporting ultra-high processing speeds with low power consumption.

In this thesis we study delay-based RC (DB-RC) using semiconductor lasers, with the aim to achieve an all-optical integrated implementation. We start off with a proof-of-concept experiment to benchmark a partially integrated DB-RC for a timeseries predictions task. This is followed by a numerical investigation of the task-independent memory capacities of our system, to gain further insight in the results from the experiment. The second part of the dissertation, focuses on how to decrease the footprint of the integrated device while increasing its processing speed. One approach focuses on the use of dual-mode lasers, where the artificial neurons are distributed over two modes. The number of artificial neurons is thus effectively doubled as compared to a DB-RC based on a single-mode laser, which allows for a smaller footprint in the integrated design. Similarly, we propose to utilize the two polarization modes in a spin-VCSEL in our DB-RC scheme, with the added benefit that the polarization dynamics of spin-VCSELs happen on a shorter timescale and thus the processing speed of the scheme is increased. The last part of our investigation focuses on the combination of existing RC architectures. We demonstrate that such compound RC architectures have much better processing speeds and eliminate the need for complex preprocessing of data before it is injected in the RC.