VRIJE UNIVERSITEIT BRUSSEL

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The faculty of Engineering of the Vrije Universiteit Brussel and the Faculty of Engineering of the Universiteit Gent invite you to attend the public defense leading to the degree of

DOCTOR OF ENGINEERING SCIENCES (VUB)

DOCTOR OF PHOTONICS ENGINEERING (UGENT)

of **Ian Bauwens**

The public defense will take place on **Tuesday 3rd September 2024 at 4:00 pm** in room **D.2.01** (Building D, VUB Main Campus)

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OPTIMIZING PHOTONIC RESERVOIR COMPUTERS FROM INPUT TO OUTPUT LAYER

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Abstract of the PhD research

Reservoir computing (RC) is a computing technique inspired by the way the human brain processes information. While the brain relies on transient neuronal activity excited by input sensory signals, RC rather exploits the transient behavior of an analog nonlinear dynamical system. Using photonic components to physically implement RC has several benefits over the conventional digital von Neumann approach, including a low-energy consumption, high bandwidth and the possibility of high inherent parallelism of photonics. Over the years, a large variety of photonic RC systems have been proposed and developed, all with closely related architectures and design principles. In this thesis, we want to revisit the structure and workings of several of these photonic reservoir computers. Putting aside any preconceptions or biases, we adapt each layer of these RC systems with the goal to obtain considerable performance gains. The first system under study is delay-based RC using a single-mode semiconductor laser. We revisit the type of information encoding used in the optical injection signal at the input layer. By relying on a phase modulation based data injection scheme we can greatly improve the performance. At the output layer where the training is performed, we show that we can use the concept of transfer learning to re-use information between different learning tasks, thereby reducing the cost of retraining. Additionally, we demonstrate that we can replace the traditional linear perceptron by a relatively small deep neural network, which improves the performance of the RC system. As a second RC system, we have focused on a passive spatially distributed RC system consisting of a network of waveguides connected via optical splitters and combiners. We have investigated the incorporation of an additional active nonlinear component into this system. Our approach involves the integration of a single semiconductor laser in an external electro-optical delay line within the network. Besides compensating for losses, this new RC system has a significantly increased nonlinear computational capacity. Additionally, this network can also be used as a delay-based RC approach but with the complex preprocessing procedure removed.