VRIJE UNIVERSITEIT BRUSSEL

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DOCTOR OF ENGINEERING SCIENCES

of **Evgenia Papavasileiou**

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# TOWARDS MORE EFFICIENT NEUROEVOLUTION: APPLICATION ON FEATURE SELECTION AND CLASSIFICATION PROBLEMS

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# Abstract of the PhD research

NeuroEvolution (NE) is a sub-field of Artificial Intelligence whose purpose is to optimize Artificial Neural Networks (ANNs) by modeling the biological evolutionary process. NeuroEvolution of Augmenting Topologies (NEAT) that evolves the topology and the connectivity weights of the ANNs, is one of the most influential algorithms in the field. This PhD performs different studies on NEAT extensions, namely FD-NEAT, FS-NEAT and HA-NEAT and proposes new extensions so that the resulting methods could require fewer generations, evolve smaller and less complex networks and scale on complex problems. After the publication of NEAT in 2002 many methods have appeared that extend its functionality in various ways. In this PhD, a systematic review is performed to identify and categorize the NEAT's successors. The proposed clustering scheme can support researchers 1) understanding the current state of the art that will enable them 2) exploring new research directions or 3) benchmarking their proposed method to the state of the art, if they are interested in comparing, and 4) positioning themselves in the domain or 5) selecting a method that is most appropriate for their problem. In addition, different studies are conducted to achieve important intermediate stepping stones. The first set of investigations concern design choices in the initial topologies of two NEAT extensions, namely FD-NEAT and FS-NEAT. These include the introduction of a hidden layer in the initial topologies, the initialization of the topologies with a different connectivity setting and the employment of different activation functions in the output layer. Additionally, BS-HA-NEAT and BS-NEAT are proposed as new extensions of HA-NEAT and NEAT, that perform speciation in the behavioral rather than in the genotypic space. It is found that BS-HA-NEAT and BS-NEAT outperform HA-NEAT and NEAT solving previously unsolvable problems or improving the accuracy and reducing the complexity of the evolved networks. Furthermore, HA-FD-NEAT, extending both HA-NEAT and FD-NEAT is proposed. This is able to evolve the topology, the connectivity weights and the activation functions of ANNs while identifying the relevant features. HA-FD-NEAT outperforms HA-NEAT and performs as good as FD-NEAT. Also, BS-HA-FD-NEAT is proposed as an extension to HA-FD-NEAT by performing speciation in the behavioral space. BS-HA-FD-NEAT outperforms its ancestor by evolving significantly smaller networks. In overall, the resulting algorithm outperforms its ancestors, NEAT, FD-NEAT, and HA-NEAT achieving better accuracy, in fewer generations and evolving smaller and less complex networks. Finally, BS-HA-FD-NEAT is tested on a complex, real world application of reducing the false positives outputed from a detector of abnormal COVID-19 related findings from lung Computer Tomography (CT) images.