CoCo Seminar Series
Fall 2024

On the Preservation of Input/Output Directed Graph Informativeness under Crossover

Dr. Andreas Duus Pape, Associate Professor, Department of Economics; Associate Dean of the Graduate School, Binghamton University

Wednesday October 16, 2024 12:00-1:00pm EDT
Hybrid (EB-T1 & Zoom; meeting link available on http://coco.binghamton.edu/)

There is a broad class of networks which connect inputs to outputs. These networks include chemical transformation networks, electrical circuits, municipal water systems, and neural networks. Evolutionary operations like crossover have been used in all these domains. The goal of this paper is to provide a strong theoretical foundation for crossover across this class of networks and connect crossover to informativeness, a measure of the connectedness of inputs to outputs. We define an *Input/Output Directed Graph* (or *IOD Graph*) as a graph with a set of nodes N and directed edges E, where N contains (a) a set of "input nodes" $I \subset N$, where each $i \in I$ has no incoming edges and any number of outgoing edges, and (b) a set of "output nodes" $O \subset N$, where each $o \in O$ has no outgoing edges and any number of incoming edges, and $I \cap O = \emptyset$. We define informativeness, which involves the connections via directed paths from the input nodes to the output nodes: A *partially informative IOD Graph* has at least one path from an input to an output, a *very informative IOD Graph* has a path from every input to some output, and a *fully informative IOD Graph* has a path from every input to every output. A perceptron is an example of an IOD Graph. If it has non-zero weights and any number of layers, it is fully informative. As links are removed (assigned zero weight), the perceptron might become very, partially, or not informative. We define a crossover operation on IOD Graphs in which we find subgraphs with matching sets of forward and backward directed links to "swap." With this operation, IOD Graphs can be subject to evolutionary computation methods. We show that fully informative parents may yield a non-informative child. We also show that under conditions of *contiguousness* and the *no dangling nodes* condition, crossover compatible, partially informative parents yield partially informative children, and very informative input parents with partially informative output parents yield very informative children. However, even under these conditions, full informativeness may not be retained.

Andreas Duus Pape is an Associate Professor of Economics, Associate Dean of the Graduate School at Binghamton University (SUNY), the Associate Director of the Binghamton Center of Complex Systems (CoCo), and the director of Binghamton 2 Degrees, a FEMA-funded, local climate change resilience initiative. He studies learning and individual choice from the perspective of decision theory, game theory, psychology, and agent-based modeling, and also seeks to use agent-based modeling to probe questions of the provision common resources.

For more information, contact Hiroki Sayama (sayama@binghamton.edu). http://coco.binghamton.edu/