Jhonatan S. Oliveira

Ph.D.

Regina, SK, S4V2M9

13065524930

jhonatanoliveira@gmail.com

Dear members of the hiring committee,

I am a Brazilian who, in December 2019, completed all degree requirements for my Ph.D. in Artificial Intelligence (AI) at the University of Regina in Canada. Now, I am eager to start working in industry, hopefully in a position involving some aspects of research. My graduate research focused on probabilistic graphical models such as Bayesian networks (BNs) and deep learning models, including sum-product networks (SPNs). I have been active in research since 2013. I have published 25 peer-reviewed papers, including one paper at AAAI-2019. The interest in this paper led to a formal invitation to visit the University of Cambridge for three months, yielding a joint research paper posted on arxiv (https://arxiv.org/abs/1912.10092), which is to be submitted to ICML-2020. I have been asked to be a program committee member at ICML-2020. I completed my undergrad in Electrical Engineering at the Universidade Federal de Viçosa in Brazil, one of the best universities in the country. I have been awarded numerous scholarships worth over $100K CDN in total.

The main contribution of my Ph.D. thesis is the introduction of Deep Convolutional Sum-Product Networks (DCSPNs). A DCSPN is a deep learning model that leverages the probabilistic semantic rigour of an SPN, while being implemented as a convolutional neural network (CNN). I gave conditions to when subclasses of CNNs define valid SPNs, including convolutional layer filters of certain sizes and non-overlapping windows in sum-pooling layers. Representing an SPN as a CNN allows for a vectorized implementation of SPNs using tensor libraries such as Tensorflow. One salient feature of DCSPNs is that they are a rigorous probabilistic model. As such, they can exploit multiple kinds of probabilistic reasoning, including marginal inference and most probable explanation (MPE) inference. In fact, I show how to vectorize MPE inference using a mask algorithm and how it plays a role similar to the generative adversarial networks (GANs) generator. I also showed encouraging preliminary results on the generation of human face images by suggesting a sampling algorithm for DCSPNs. Moreover, I ran experiments on left- and bottom-completion of faces, which produced results competitive to the state-of-the-art. Lastly, I had a pleasant surprise when DCSPNs could perform well on the task of image completion in a small dataset (around 65 images), while GANs, a popular model, struggled with this task. The DCSPN paper was published in AAAI-2019, which is ranked A* by the Australian CORE conference ranking. The

category A* comprises only the top 4% of all computer science conferences and is reserved for extremely selective venues.

Our DCSPN paper at AAAI-2019 was well-received by the research community. This led to a formal invitation to visit the University of Cambridge in England. I received partial funding from the University of Cambridge to spend three months collaborating with Dr. Robert Peharz, a leading expert in SPNs. I worked in the Computational and Biological Learning Lab (CBL) under the supervision of Dr. Carl Edward Rasmussen, a leading expert in Gaussian processes. The main idea of this work is to bring more interpretability to deep learning models. There is a trade-off between the high-level interpretability of classical probabilistic graphical models and the inference performance of recent tractable probabilistic models. One way of improving the performance of BNs is to compile them into SPNs, a well-understood technique due to Darwiche's seminal work on arithmetic circuits (ACs) compilation. The converse direction of SPN decompilation into BNs has received somewhat limited attention. In my research conducted at the University of Cambridge, I formalize SPN decompilation and discuss the implications of having a better understanding of the latent space in a deep learning model. Our collaboration led to a joint paper on SPN decompilation. A preprint to the SPN decompilation paper is available on arxiv (https://arxiv.org/abs/1912.10092), which will be submitted to ICML-2020 (submission deadline is February 7th, 2020).

Another exciting research contribution of mine is simple propagation (SP), a state-of-the-art inference algorithm for BNs. Lazy propagation (LP), the previous state-of-the-art algorithm, optimizes inference in a join tree by constructing and analyzing secondary graphical structures. For instance, LP builds a secondary structure, called a domain graph, and then graphically tests independencies to determine which potentials are relevant to message construction. In contrast, SP uses one simple rule for message construction. SP never explicitly tests independencies, nor does it determine elimination orderings. Thus, SP saves the overhead of having to build and examine graphs. In optimally built join trees, 28 real-world BNs, SP is faster than LP in 18 cases, ties LP in 5 cases, and is slower than LP in 5 cases. The SP paper was a collaboration with Anders Madsen, a co-founder of LP and CEO of Hugin Expert. After implementing and running the experiments himself, Dr. Madsen expressed his enthusiastic surprise in private communication with how SP could beat his sophisticated LP algorithm.

A third main contribution of my Ph.D. thesis worth mentioning is the founding of Darwinian networks (DNs). DNs are a new graphical representation of BNs, as well as of BN inference. I started by graphically depicting a BN conditional probability table (CPT) $P(X|Y)$. The difference with respect to the literature, which always uses black nodes and edges, is that, in DNs, variables on the left-hand side X are represented with white nodes, while variables on the right-hand side Y are represented with black nodes. Furthermore, I graphically represented the operations over the CPTs. Multiplying or dividing CPTs involves merging their graphical representations. Similarly, I depict the marginalization of a variable out of a CPT through a duplication process. In this way, DNs graphical representations have a one-to-one correspondence with BN inference equations. Upon reflection, the DN graphs have a biological look, hence the name. DNs simplify BNs to the point of expressing challenging concepts as a graphical puzzle.

Using DNs, one can teach different types of BN inference algorithms without writing a single equation. Besides being a powerful teaching tool, DNs have practical value by showing flaws in well-established BN algorithms. For instance, I developed a new test of independence method for BNs, which tends to be 15% faster than the d-separation implementation suggested in Adnan Darwiche's 2009 textbook on page 66.

I am looking for a position in industry that involves some aspect of research. I am passionate about theoretically developing the field of AI. This has been driving my interest in the area since high school. Back then, I studied programming by myself (Python and PHP) and developed a rudimentary but functional chatbot. What started as a fun personal project caught the attention of local business, and that is how I ended up receiving funding for my education. During my undergrad, I furthered my knowledge in AI by being the lead developer of an autonomous robot soccer team. I always found excitement in seeing some of my ideas being useful to people. I believe that being part of a research team in industry is a unique opportunity for fulfilling this dream. During my graduate studies, I had the chance to be involved with different research teams, which was a valuable learning experience. I collaborated with Dr. John Stavrinides, from the Biology Department at the University of Regina, in applying machine learning techniques for understanding bacteria interactions. Furthermore, I worked with Dr. Pascal Poupart, from the Computer Science Department at the University of Waterloo, in an empirical evaluation of SPN learning and inference. Dr. Poupart is internationally known in AI.

On the practical side, I enjoy implementing experiments and developing projects, especially if that meant learning new languages, libraries, or techniques. Therefore, I have a broad experience with a variety of programming languages, including Python, C++, Java, Javascript (Typescript), Matlab, and OCaml. More specifically, Python is my go-to language for personal projects or research implementations. I have academic experience with C++ since I taught it in an introductory programming class. On the other hand, I had professional experience with Java for web development during a one-year internship as a software engineer. Similarly, I currently use Typescript daily as a lead developer of a mobile app startup. During my undergrad, I made extensive use of numerical programming languages, such as Matlab, Scilab and Octave. When implementing experiments for my papers, I acquired experience with commonly used machine learning frameworks such as scikit-learn and Tensorflow. Also, I contributed to an open-source project on BNs implementation, called PgmPy, which lead to an invite to be a mentor in the Google Summer of Code program. More details can be found in my CV.

On the personal side, I consider myself an outgoing person who enjoys arts, as well as physical activities. I always thought of creativity as a key strength of mine, so I try cultivating it by being involved in diverse activities. I have been awarded multiple writing prizes in Brazil, at local and national levels. During my undergrad, I was also a professional theatre actor/director for four years with a handful of awards in regional festivals. I have volunteered in a variety of social events, including using my computer science skills for helping to improve the conditions of a non-profit school for underprivileged kids. At the same time, I try to maintain a healthy lifestyle by being

active and exercising often. For instance, I am currently a light-blue belt in jiu-jitsu martial arts.

I feel ready for the next professional phase in my life. I am grateful for all the opportunities I have had so far; they allow me to offer a distinctive and innovative point of view to face the challenges in industry. Having had myself a humble childhood, I deeply value all of my accomplishments. Most importantly, I am extremely excited about my future.

I look forward to speaking with you regarding my application.

Sincerely,
Jhonatan S. Oliveira