WHIRL RESEARCH STATEMENT

January 2020   AMR KAYID
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I am a senior final year undergraduate student at the German University in Cairo, working on affective computing, reinforcement learning, and machine intelligence. Multi-agent deep reinforcement learning, speech emotion recognition, federated learning, and multi-modal deep learning are areas that fascinate me the most and I am very interested in exploring and investigating these fields. Moreover, I am currently working as a *machine learning researcher* with **FOR.ai** team, where my work involved around researching curriculum learning, hierarchical reinforcement learning, and neural network optimization. I recently joined **OpenMined** Organization to work on advancements for Federated Learning. I was a visiting student at the **Technical University of Munich** where I have worked on my bachelor project in the area of distributed deep reinforcement learning. I am writing this document to apply for **WhiRL/DeepMind** Doctoral Studentship and briefly express my research experience and interests in machine learning and reinforcement learning.

My research goals are oriented towards the intersection between deep reinforcement learning, affective computing, emotional and explainable AI that can be extended for rational sequential decision making and in creating human-centered AI. I am highly interested to explore the potentials of multi-agent reinforcement learning [Wit+18; Car+19; Bar+20] and the communication [Foe+16] that happens between the agents, how to effectively optimize, secure and distribute the learning to efficiently emerge to extremely complex and human-relevant behavior which can be deployed to *social robots [Qur+16] and autonomous systems [Pal19; Che+19]*. Moreover, I want to investigate in the area of emotional artificial intelligence aiming toward human-centered AI that should be collaborative, augmentative, and enhancing human productivity and quality of life. This further depends on understanding the fundamental questions of how we as humans *feel, behave, make decisions based on our observations and learn from our experiences*. I believe my research objectives and interests can flourish intellectually through pursuing doctoral studies at **WhiRL** where I will be exposed to learn and work with Professor Shimon and the current DPhil students and Postdoc researchers.

I am drawn towards understanding how the recent advancements in multi-agent reinforcement learning [ZYB19a; ZYB19b; Mah+19], and federated learning [Kai+19] can be combined and applied towards achieving the goal of building secure and distributed reinforcement learning agents. Furthermore, recent work on meta reinforcement learning [Che+18; Gup+18; FTH19; Zin+19] can be extended to advance the area of multimodal recognition and social robot interactions by investigating the combination of the fields and applying them for *nlp [Luk+19] and vision [FIY19; Kul+19]* tasks. Recent work towards a better understanding of language models, realistic simulation of human behavior in reinforcement learning can further have applications in complex robotic tasks and explainable AI. Moreover, using reinforcement learning can help to improve the performance of detecting emotions [Nov+17] and giving computers the ability to express different emotions and learn more from interacting with humans in the loop and the surrounding environments. This would mean AI agents being able to communicate in human languages to learn to improve their behavior policy based on social interactions, towards the goal of learning multiple complex high dimensional policies at the same time resulting in *expert-level* performance.

My interest in machine learning started to grow in my second year at the German University in Cairo when I joined the affective computing and machine intelligence research cluster under the supervision of Professor Slim Abdennadher. The overall goal of the research project was towards building an intelligent system that can recognize emotions from facial expressions and/or voices. My project focused on implementing a facial recognition system for the lab which can recognize the team members, unlock the door and provide access to enter the lab. I worked on implementing the TensorFlow model that extracts the features from the given images in the dataset and augment the custom data towards improving the model performance. This was followed by converting the model to work in *real-time* and integrating the system with Arduino and proper hardware for door unlocking and scanning cameras. During my summer research, I also participated in Amazon Innovation Hackathon at the American University in Cairo with the idea of building an *emotional recommendation system* that can provide suggestions and recommendations based on the user's mood.

Following my summer experience, I got interested in reinforcement learning and autonomous systems and I took more courses related to these fields from prestigious universities such as MIT, Oxford, Stanford, UCL and Harvard and from Google, fast.ai and Udacity. I got motivated to further broaden my interests towards recent research advances and wanted to do my bachelor thesis in reinforcement learning where I have contacted one of the lab members *Wendelin Boehmer* at WhiRL. Unfortunately, due to time constraints, I was not able to proceed with the lab application process. Despite that, I insist on pursuing my thesis in the reinforcement learning field. My thesis on improving and optimizing the training time and benchmarking the efficiency of distributed reinforcement learning algorithms was supervised by Professor Alois Knoll at the Technical University of Munich in affiliation with the Human Brain Project Organization. I worked towards developing and implementing modularized distributed deep reinforcement learning algorithms that were tested and benchmarked on different RL environments including OpenAI Gym and Unity ML-Agents. I optimize the learning process and apply automatic hyper-parameter tuning, using *ray-tune & rllib*. During my work, I studied, used and compared between the state of the art distributed deep reinforcement learning algorithms including IMPALA and Ape-X algorithms. Results from my work showed that distributed reinforcement learning can ensure faster training and learning processes for the agent and the distributed algorithms can scale up to hundreds supporting multiple workers.

During my bachelor thesis and my stay in Munich, I seek for collaboration, participating in new challenges and exploring new fields. Hence, I continue working on speech emotion recognition with navel robotics company advised by Professor Marc Toussaint and Professor Martina Mara, I also explored the field of robotics with the brilliant team of Roboy at TUM and lastly investigated new challenging and quite a unique field of quantum machine learning at the Max Planck Institute of Quantum Optics.

Currently, I am in my last pre-master year at my university and I am taking courses focused on advanced deep learning and reinforcement learning. I keep my eyes on the current state of the art publications in the field and keep contributing to open-source projects and working on my research projects. I recently joined a multi-disciplinary team of scientists and engineers from different research institutions such as Google Brain, University of Oxford, and Vector Institute for Artificial Intelligence. Our objective is to publish good machine learning research and we have publications at top ML conferences like ICML, ICLR, NIPS. I am participating with the team in the area of reinforcement learning where we are currently building modularized reinforcement learning library [1] for generic and public usage and we are investigating the state of the art advancement in reinforcement learning and tackling the most challenging and interesting problems in the field. We are also exploring many fields including curriculum learning, hierarchical reinforcement learning, and neural network optimization. Since I've joined the team, I worked on upgrading some algorithms of the reinforcement learning library from Tensorflow 1 to Tensorflow 2 version and implementing a PyTorch codebase with the same goal. I also worked on automatic synchronizing for the public reinforcement learning library with our codebase and I am currently working conditional imitation learning and autonomous driving.

Combining my research experiences, technical skills, and all the support, guidance, resources that will be provided through **Whiteson Research Lab (WhiRL) doctoral studentship** will support me and provide me a suitable environment, brilliant team-workers and computational resources that will assist me to pursue and investigate these fields. I am hoping with being enrolled in this program specifically, that I will gain more research experience that would help me achieve my goals, publish good research papers at top conferences and build applications that will affect our society.

My career goal is to continue to explore the edges of human knowledge as a research scientist. My real-world experience and the advice of friends and colleagues have shown me that I will need to continue pursuing postgraduate studies to work on the types of problems that interest me. I also believe that building on my undergraduate class and research experience will allow me to get the most out of a graduate career. The resources and breadth of computer science research will provide me with the experience that I need to pursue my passion for artificial intelligence.

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[1] https://github.com/for-ai/rl

References

[Foe+16] Jakob N. Foerster et al. *Learning to Communicate with Deep Multi-Agent Reinforcement Learning*. 2016. arXiv: 1605.06676 [cs.AI].

[Qur+16] Ahmed Hussain Qureshi et al. "Robot gains social intelligence through multimodal deep reinforcement learning". In: *2016 IEEE-RAS 16th International Conference on Humanoid Robots (Humanoids)* (Nov. 2016). DOI: 10.1109/humanoids.2016.7803357. URL: http://dx.doi.org/10.1109/HUMANOIDS.2016.7803357.

[Nov+17] Jekaterina Novikova et al. "Sympathy Begins with a Smile, Intelligence Begins with a Word: Use of Multimodal Features in Spoken Human-Robot Interaction". In: *Proceedings of the First Workshop on Language Grounding for Robotics* (2017). DOI: 10.18653/v1/w17-2811. URL: http://dx.doi.org/10.18653/v1/W17-2811.

[Che+18] Fei Chen et al. *Federated Meta-Learning with Fast Convergence and Efficient Communication*. 2018. arXiv: 1802.07876 [cs.LG].

[Gup+18] Abhishek Gupta et al. *Unsupervised Meta-Learning for Reinforcement Learning*. 2018. arXiv: 1806.04640 [cs.LG].

[Wit+18] Christian A. Schroeder de Witt et al. *Multi-Agent Common Knowledge Reinforcement Learning*. 2018. arXiv: 1810.11702 [cs.MA].

[Car+19] Micah Carroll et al. *On the Utility of Learning about Humans for Human-AI Coordination*. 2019. arXiv: 1910.05789 [cs.LG].

[Che+19] Dong Chen et al. *Autonomous Driving using Safe Reinforcement Learning by Incorporating a Regret-based Human Lane-Changing Decision Model*. 2019. arXiv: 1910.04803 [cs.RO].

[FTH19] Haotian Fu, Hongyao Tang, and Jianye Hao. *Efficient meta reinforcement learning via meta goal generation*. 2019. arXiv: 1909.13607 [cs.LG].

[FIY19] Ryosuke Furuta, Naoto Inoue, and Toshihiko Yamasaki. "PixelRL: Fully Convolutional Network With Reinforcement Learning for Image Processing". In: *IEEE Transactions on Multimedia* (2019), pp. 1–1. ISSN: 1941-0077. DOI: 10.1109/tmm.2019.2960636. URL: http://dx.doi.org/10.1109/tmm.2019.2960636.

[Kai+19] Peter Kairouz et al. *Advances and Open Problems in Federated Learning*. 2019. arXiv: 1912.04977 [cs.LG].

[Kul+19] Jonas Kulhanek et al. "Vision-based Navigation Using Deep Reinforcement Learning". In: *2019 European Conference on Mobile Robots (ECMR)* (Sept. 2019). DOI: 10.1109/ecmr.2019.8870964. URL: http://dx.doi.org/10.1109/ECMR.2019.8870964.

[Luk+19] Jelena Luketina et al. "A Survey of Reinforcement Learning Informed by Natural Language". In: *Proceedings of the Twenty-Eighth International Joint Conference on Artificial Intelligence* (Aug. 2019). DOI: 10.24963/ijcai.2019/880. URL: http://dx.doi.org/10.24963/ijcai.2019/880.

[Mah+19] Anuj Mahajan et al. *MAVEN: Multi-Agent Variational Exploration*. 2019. arXiv: 1910.07483 [cs.LG].

[Pal19] Praveen Palanisamy. *Multi-Agent Connected Autonomous Driving using Deep Reinforcement Learning*. 2019. arXiv: 1911.04175 [cs.LG].

[ZYB19a] Kaiqing Zhang, Zhuoran Yang, and Tamer Başar. *Decentralized Multi-Agent Reinforcement Learning with Networked Agents: Recent Advances*. 2019. arXiv: 1912.03821 [cs.LG].

[ZYB19b] Kaiqing Zhang, Zhuoran Yang, and Tamer Başar. *Multi-Agent Reinforcement Learning: A Selective Overview of Theories and Algorithms*. 2019. arXiv: 1911.10635 [cs.LG].

[Zin+19] Luisa Zintgraf et al. *VariBAD: A Very Good Method for Bayes-Adaptive Deep RL via Meta-Learning*. 2019. arXiv: 1910.08348 [cs.LG].

[Bar+20] Nolan Bard et al. "The Hanabi challenge: A new frontier for AI research". In: *Artificial Intelligence* 280 (Mar. 2020), p. 103216. ISSN: 0004-3702. DOI: 10.1016/j.artint.2019.103216. URL: http://dx.doi.org/10.1016/j.artint.2019.103216.