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RPPR Final Report

as of 20-Dec-2021

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Final Report for Period Beginning 01-Mar-2019 and Ending 31-Aug-2019

Title: AAI Symposium on Causal Models, Counterfactual Inference, and Imagination-based AI

Begin Performance Period: 01-Mar-2019

End Performance Period: 31-Aug-2019

Report Term: 0-Other

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STEM Degrees:

STEM Participants:

Major Goals: The AAI spring symposium is intended to bring together people from many fields inside and outside AI who are interested in studying causality. The current project is to support students and a small number of invited speakers to attend the AAI spring symposium which is focused on causality as the central theme. It is expected that the symposium will inspire the next generation of AI scientists to work on this important problem and make lasting contributions.

Accomplishments: The symposium featured a keynote talk by Judea Pearl, professor of Computer Science and Statistics at the University of California, Los Angeles, and Turing Award winner for his work on probabilistic and causal reasoning.

The symposium was organized into sessions following the format causality plus a select area such as computer vision and imagination, machine learning and artificial intelligence, the social sciences and economics, and the health sciences. The speakers discussed the present and future research in their fields, including the recent advances in causal inference that changed their areas as well as the most pressing issues that causal inference tools may be able to help within the next few years.

Furthermore, the symposium held sessions of short talks and posters for the contributed papers over a broad variety of topics such as bias analysis, causal discovery, missing data, instrumental variables, transportability, counterfactual reasoning, and data fusion.

Training Opportunities: The symposium provided funding for 12 student participants. Many other students participated without funding.

Results Dissemination: The video of the keynote as well as the slides of the presentations and the papers are available online in the symposium's website <https://why19.causalai.net> .

The symposium summary was published as part of an AI magazine paper:

Baldini, I., Barrett, C., Chella, A., Cinelli, C., Gamez, D., Gilpin, L., Hinkelmann, K., Holmes, D., Kido, T., Kocaoglu, M., Lawless, W., Lomuscio, A., Macbeth, J., Martin, A., Mittu, R., Patterson, E., Sofge, D., Tadepalli, P., Takadama, K., & Wilson, S. (2019). Reports of the AAI 2019 Spring Symposium Series. *AI Magazine*, 40(3), 59-66. <https://doi.org/10.1609/aimag.v40i3.5181>

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PARTICIPANTS:

Participant Type: PD/PI

Participant: Prasad Tadepalli

Person Months Worked: 1.00

Project Contribution:

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Funding Support:

Participant Type: Faculty

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Person Months Worked: 1.00

Project Contribution:

National Academy Member: N

Funding Support:

Participant Type: Faculty

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Person Months Worked: 1.00

Project Contribution:

National Academy Member: N

Funding Support:

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Project Contribution:

National Academy Member: N

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Person Months Worked: 1.00

Project Contribution:

National Academy Member: N

Funding Support:

Participant Type: Other (specify)

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Funding Support:

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Project Contribution:
National Academy Member: N

Funding Support:

Partners

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Beyond Curve Fitting: Causation, Counterfactuals, and Imagination-based AI

Carlos Cinelli, Murat Kocaoglu, Prasad Tadepalli

The AAAI symposium, Beyond Curve Fitting: Causation, Counterfactuals, and Imagination-based AI, was held at Stanford University, Stanford, California, from March 25-27, 2019. The goal of this symposium was to bring together researchers in multiple disciplines to discuss the integration of causal and counterfactual reasoning into data-driven sciences, building a richer framework for research and a new horizon of applications in the coming decades.

Artificial Intelligence (AI) and Machine Learning (ML) have received increased attention from the general public, primarily due to the successful application of deep neural networks to many tasks, including computer vision, natural language processing, and game playing. However, despite all this progress, there is a growing segment of the scientific community that questions whether these successes can be extrapolated to create general AI without a major retooling. The goal of this symposium was to bring together researchers across multiple disciplines (computer science, cognitive science, economics, medicine, statistics, etc.) to discuss the capabilities of current AI and ML technologies and the integration of causal and counterfactual reasoning into the data-driven sciences to help alleviate their shortcomings.

The symposium featured a keynote talk by Judea Pearl, professor of Computer Science and Statistics at the University of California, Los Angeles, and Turing Award winner for his work on probabilistic and causal reasoning. Following the discussion in his new book [1], Pearl's talk focused on the foundations and types of causal inference in terms of a three-layer causal hierarchy that sharply distinguishes (1) associations, (2) interventions and (3) counterfactuals. These theoretical foundations unveil how several important problems found throughout society are beyond the reach of the current generation of ML systems, but which can be solved with the tools of causal inference [2-4].

The symposium was organized into sessions following the format "Causality+X," where X is a select area that included (1) Computer Vision & Imagination, (2) Machine Learning & Artificial Intelligence, (3) the Social Sciences & Economics and (4) the Health Sciences. The speakers were asked to discuss the present and future of their fields, including the recent advances in causal inference that changed their areas (both in terms of methodology and practice) as well as the most pressing issues that causal inference tools may be able to help within the next few years.

Specifically, the session on Computer Vision & Imagination included topics ranging from the construction of causal variables using unsupervised learning, to leveraging causal models for enabling unsupervised learning techniques (such as GANs) to sample from interventional distributions. The speakers of the session were Frederick Eberhardt (Caltech), Murat Kocaoglu (MIT-IBM Watson AI Lab), and Mohammed Elhoseiny (KAUST). The Machine Learning & Artificial Intelligence session featured how causal and counterfactual reasoning guides human cognition and decision-making, its relationship with reinforcement learning, and initial explorations on how it can be related to deep learning. The speakers of the session were Tobias Gerstenberg (Stanford

University), Thomas Dietterich (Oregon State University), and Yoshua Bengio (University of Montreal).

The Social Sciences & Economics session focused both on how causal modeling tools can help tackle well-known problems such as confounding bias, selection bias, generalizability of experimental findings and transportability, as well as several methodological issues that still need to be addressed, mainly involving new challenges due to social interactions and the availability of unstructured and high-dimensional data. The speakers were Kosuke Imai (Harvard University) and Paul Hünermund (Maastricht University). Finally, the talks on the Health Sciences revolved around how causal modeling has helped in the clarification of long-standing issues in Epidemiology, and also on the risks of biases and (un)fairness of predictive algorithms. The speakers were Maria Glymour (UCSF) and Mark Cullen (Stanford University).

Furthermore, the symposium held sessions of short talks and posters for the contributed papers over a broad variety of topics such as bias analysis, causal discovery, missing data, instrumental variables, transportability, counterfactual reasoning, and data fusion. Overall, the participants discussed how the recent increase in popularity of ML techniques in their fields has rekindled the interest in understanding their theoretical limitations through the lens of causality, and exchanged ideas with experts from various fields to put this discussion in a broader context. Participants agreed on several challenges that remain to be addressed through the development of new methodological tools, which should be discussed in future symposia.

Elias Bareinboim, Prasad Tadepalli, Sridhar Mahadevan, Csaba Szepesvari, Bernhard Scholkopf, and Judea Pearl served as co-chairs of this symposium. The video of the keynote as well as the slides of the presentations and the papers are available online in the symposium's website [5].

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- [1] J. Pearl, and D. Mackenzie. The book of why: the new science of cause and effect. Basic Books, 2018.
- [2] J. Pearl. "The seven tools of causal inference, with reflections on machine learning." Communications of the ACM, V. 62(3), pp. 54-60, 2019.
- [3] P. Spirtes, C. Glymour, R. Scheines. Causation, prediction, and search. MIT Press, 2001.
- [4] E. Bareinboim and J. Pearl. "Causal inference and the data-fusion problem." Proceedings of the National Academy of Sciences 113.27 (2016): 7345-7352.
- [5] WHY-19 website - <https://why19.causalai.net>

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