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Brenden Lake: Concepts and Questions as Programs

<https://youtu.be/wkWNfyocwQ8> & <http://web.stanford.edu/class/ee380/Abstracts/161012.html>

This talk is about machine learning dealing with higher concepts and questions as program. The discussion begins with the idea to extend algorithms to think more like humans do, and produce more human like answers to specific questions. When people are leaning concepts, they are often broken down into two major differences than what a computer would do. The first is the speed of learning and the second is the richness of representation. Throughout this seminar, Lake discusses various case studies and methods of machine learning to act similarly to human identification and learning. He discusses methods using Bayesian programming learning (BPL), one contains both learning to learn and compositionality, one without learning to learn, and one without compositionality.

To combat problems of simplistic thinking, and direct a machine towards new methodologies of learning, Lake created the concept of Bayesian programming learning containing 3 components: compositionality, causality, and learning to learn. Compositionality is the representation that are constructed through the combination of parts/primitives. Causality is the generative model that captures, at the abstract level, aspects of the real casual process. Learning to learn is the experience with previous concepts helps for learning new concepts.

The BPL itself is a layered program that is pre-trained on a certain alphabet, then tested on new ones. Generative model is used to generate new letters by the following steps: 1) is to sample how many parts you want 2) each stroke sample how many sup-strokes you want (primitive motor actions that make up a stroke) 3) sample relations of how the parts attach to each other, and 4) return an object, which is another piece of code that generates types of letters. This program then generates different instances of that letter, adds motor noises, differences in how strokes are laid out, and contains transformations of those letters, thus producing different variations of that letter. The program itself uses Bayes rule to identify the probability of the programs data given the program’s eye, by telling us how likely a letter is to be generated.

In the first case study, Lake compared the difference between human and machine learning to draw differentiations of symbols. In the study, he took human subjects, and asked them to draw variations of a certain symbol, then coded a machine to learn and recreate that symbol using compositionality, learning to learn, and the full BPL model. From the case, they were able to identify that the full BPL model created the most similar drawings of symbols to the humans. However, as you began to eliminate these human-like qualities, of learning to learn and compositionality, they became less legible, and more easily identified as machine generated letters. They then use the same BPL models to test the error rate of the program to identify a similar symbol to one provided. In this problem, the error rate of the BPL model was a little less than human error rate, and had significant improvement over the lesser BPL models as well as deep learning models.

The part of the seminar was discussing the questions asked by humans, and how models can ask rich types of questions like humans. When learning about something new, for instance instruments, a human may as rich questions like “how does it make sound?” or “which features are especially important”, whereas a machine is built to only ask simple questions like “what is the category label of this object.” Lake discusses a model that creates a task that frees people to ask rich questions, yet is still amendable to formal (ideal observer) modeling. Thus, creating a program able to identify how rich or beneficial a question is in the context of the game battleship. This uses algorithmic analysis to see how much benefit each of the asked questions provide, through their information gain the game. This task is difficult as it has to create a learning tree to identify language within a question, and correctly generate a response. This lead to questions generated by the machine that created too complex of question that would not be likely asked by a human.

Overall, this discussion goes over the importance of active learning and synthesizing programs in order to create more human like quality in games and other activities. BPL answers the question for a range of simple visual, yet natural concepts, and embodies three principles of compositionality, causality, and learning to learn, which are likely to be important for the rapid learning of rich concepts. Also, Lake raises the discussion that questions can be represented as programs, and synthesized utilizing compositionality and learning to learn to teach machines to ask rich questions just as humans would. This discussion pushes the forward thinking and abstract context of how to take machine learning to the next level, and create a more human-like machine program.