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The Imitation Game

Shaping AI through history

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In the year of 1964, during the USSR Chess Championship, a gripping game ensured between Mikhail Tal, often regarded as a creative genius and one of the best attacking players of all time and grandmaster Evgeni Vasiukov. Mikhail Tal is known for his unpredictability and improvisation, often sacrificing pieces for a better position in the game. After losing 2 pawns each, at the 19th move Tal sacrificed his knight for a pawn to weaken his opponents king. He almost took 40 mins to sacrifice the knight. The next day, every newspaper emphasized about this move, mentioning how he analyzed all possible variations and made the best possible move. Later, he laughingly puts away all these speculations that in reality, he started thinking of all variations but possibilities seemed endless and somehow got deviated to thinking about ways to get hippo out of a swamp, a reference from Russian couplet he remembers. When he gave up on his engineering skills to save the animal, he played the knight sacrifice step with pure intuition. He is immortalized in the world of chess for his great initiatives, often challenging his opponents against his threats and intuitive sacrifices.

Are these intuitions always rational? Or are they based on logic? According to Herbert Simon, a cognitive psychologist and a nobel laureate, more expertise means better intuition. Expertise gives the ability to recognize a large number of relevant cues and retrieve from memory how to respond in a particular situation.

Chess grandmasters, during the game, generally form a hypothesis about the best move within just five seconds. In most cases, the final decision move is usually from initial intuition . Moreover, it is this ability that accounts for a very large proportion of their chess skill. In blitz or speed chess, even the grandmaster may just prefer these first cues. Considering very few choices consciously, they often discard several others at a subconscious level. It is this work of Herbert Simon, that paved the way for Neural networks in AI.

Neural Networks work similarly with hidden layers that recognize the unexplainable patterns through learning and the final layers then process recognized information of heuristic patterns. Therefore, Herbert Simon is rightly considered the founding father of Artificial Intelligence. Thus the foundations for AI were laid on the theories of human intelligence

Study of Human Intelligence

Objective Approach

From the viewpoint of "Information process theory", intelligence is a by-product of one's learning ability. For understanding the concept of learning, it would be necessary to look at the evolution of its concepts in psychology i.e., learning described by behavioral school of thought. "Behaviorism" which was founded by John B Watson, approached psychology as an experimental and objective science that emphasizes concepts that can be observed. Hence learning behaviors through stimuli and response was at its focus.

The association of stimuli and response through "reinforcements" in Operant conditioning by B.F Skinner is parallel to the machine learning concept of association between explanatory and response variables. Reinforcement Learning draws inspiration from the operant conditioning. In classical conditioning the association between conditioned and unconditioned stimuli is parallel to finding correlations in ML. In fact, the Spearman correlation coefficient which is widely used in statistics and machine learning was developed by Charles Spearman. He was an English psychologist and pioneer in psychometrics who developed approaches for measurement of intelligence.

Cognitive Approach

This approach succeeded the behavioral approach, basing its focus on understanding the internal process that went between stimuli and response, largely considered a black box by behaviorism. Cognitive psychology measures behavior to infer mechanisms of cognition. It details such mechanisms along with experiments to verify them. This approach attempts to apply scientific understanding to human behavior. The development of computers made it possible to measure the response times for specific stimuli with great precision, helping the study of underlying cognitive processes.

Event-Related Potential (ERP's) technology enabled us to study the brain's electrical activity . But how did we apply this in AI? Deconstruction of mental process through scientific means gave us objective insights. These insights can be used in reconstructing similar neural network models. Information process theory, parallel neural networks, etc., stand testimony to this.

One of the important contributions of cognitive psychology to machine learning comes from the area of problem solving. The four major stages of problem solving recognized by cognitive psychology are: 1) problem identification and understanding, 2) potential solution generation, 3) solution examination and 4) result evaluation. At the evaluation stage, the outcome is evaluated on how close it is to the goal and this cycle repeats. This process is directly applied in machine learning where the goal is to reduce the errors (or loss function) in final output. The amount of error in each iteration is used as feedback for re-adjusting the weights.

Some strategies of problem solving recognized by cognitive psychology like trial and error, heuristic analysis, algorithm approach and insights (sub-conscious mental memory) have found relevance in the field of Deep Neural Networks.

Intelligence : A broader perspective

How intelligent can computers be? Actually, modern-day computers perform complex calculations at blinding speeds. They carry out millions of computations per second, far beyond us mortals. This is only true for repetitive tasks. However, intelligence is not just about computation speed and accuracy, it also involves learning by interacting with environment in meaningful ways.

Intelligence can be broadly classified into two categories: General intelligence and Social / Flexible intelligence. One of the modern branches of computer science that deals with social intelligence is "Affective Computing". It is the study and development of systems and devices that can recognize, interpret, process, and simulate human affects. It is an interdisciplinary field spanning computer science, psychology, and cognitive science.

In the long run, social skills and an understanding of human emotion along with game theory would be valuable for a social agent. The understandig of emotions and motivation would give better insights for an agent in decision-making. Some computer systems mimic human emotion and expressions to appear more sensitive in their human interactions. This has great applications when used with "Decision-Making theory" and bounded rationality in administrative behavior.

One of the early products of this research in affective computing is Kismet, an autonomous robot designed to engage in social interactions with human, termed the "Cog Project" at MIT. Kismet was given auditory, visual, and proprioception abilities to interact with humans. Kismet emotes through various facial expressions, vocalizations and some posture movements. One of the key area of expression for kismet are facial expressions that included movements of eyebrows, eyelids lips, jaws, ears, and head. Kismet uses variety of phonemes to express in language and resembles a baby's babbling. Sentiment analysis and chatbots have far greater implications when advanced in affective computing.

The AI Revolution in Chess Engines

The game of chess represented the pinnacle of AI research over several decades. Today machines can easily outplay the best players in the world at GO, Chess, Shogi etc. In Chess, there were very early attempts, right from the 1950s to design computer chess engines to defeat human grand masters. However, it wasn't until 1991, when "Deep Thought" (renamed DeepBlue) announced to take up the challenge, did these attempts come to the spotlight.

In 1997, "DeepBlue", the Chess engine by IBM, for the first time comprehensively defeated the then world reigning champion Garry Kasparov, who is considered by many as the greatest chess player to have ever lived. DeepBlue cannot be termed as AI since it uses Alpha-Beta pruning algorithm, and no neural networks were involved. It explores a vast search tree by using a large number of clever heuristics and domain-specific adaptations that were programmed into it. Grand masters in chess generally evaluate 5 to 7 steps ahead. Computer chess engines need to explore tree variations much more than those steps. This brute force algorithm of exploring possibilities minimizing the value of opponent's pieces. Since 1997, Chess Engines ruled the Chess board and have greatly contributed to the game of chess and the process of chess education.

> "An engine's solution may look ugly to human eyes, even if it is unquestionably a winning move"

It was only after a decade, "DeepMind Technologies", a UK based company which was later acquired by Google started deploying chess engines based on Reinforcement Learning. In 2017, "AlphaZero" by DeepMind, a chess engine with just basic knowledge of chess rules, taught itself chess within 4 hours by playing zillions of games with itself based on trial and error through reinforcement learning. It was able to defeat Stockfish8, the top chess engine champion 2016 in a 100 games match with 28 wins and 72 draws. It can be noted that "AlphaGo" and "Elmo" developed by DeepMind, the best computer chess engines at Go and Shogi (Japanese chess) respectively in 2016, were defeated by AlphaZero in 2017.

Also, the recently released "Agent57" can outperform the human benchmark in Atari57 suite of computer games.

But what has changed in 22 years reign of computer chess engines? Earlier chess engines easily surpassed 3000 FIDE rating, a feat yet to be achieved by humans (highest ever FIDE rating 2882 by Magnus Carlsen in 2014). However, the earlier models like DeepBlue, failed to give insights into the way humans played chess. Hence, initial enthusiasm of chess engines in giving insights to the way chess is played, had quickly evaporated.

In earlier models like DeepBlue, despite the hand-crafted heuristics, the fundamentals of an engine's superiority lies in the calculation and execution of a true brute force algorithm exploring vast number of moves to solve a position. A chess program or an "engine" like Stockfish examines about 60 million positions a second.

An engine's solution may look ugly to human eyes, even if it is unquestionably a winning move. It may suggest a queen sacrifice to save a pawn to exploit some other positional advantage. Hence these engines didn't add too much value to the way humans play chess. There's a clear distinction in the way computer engines and humans play chess. Hence, a move is categorized as an "engine move" if it, though for a winning cause, doesn't make sense to humans. Today, most Grand Masters base their preparation for tournaments by playing against other strong players than with a machine. They sometimes use chess engines to understand certain complex positions. After his defeat with DeepBlue, Garry Kasparov recognized this distinct style of play. He pioneered a game called Advanced Chess, that involved humans and computers collaborating which never took off.

AlphaZero by DeepMind, used Deep Reinforcement Learning that has given it a distinctive and instantly recognizable style. Its ideas are efficient, more visible, in more strategic way towards the final goal of a checkmate than for a material balance. Interestingly, many of AlphaZero's ideas match accepted human rules derived from years of playing chess. However it would effectively combine small heuristics that are considered minor like the activating all pieces, dominating center in to a whole game strategy . Its style of play is described as "alien" unlike other computer chess engines. A fit description of its play would be that of a human chess player with unusually high FIDE rating.

"To err is human", because AlphaZero has learned chess like a human does and reinforcement learning that's etched in the annals of human evolution, its play may be more insightful to chess education. Although it is still early to judge its impact on chess education, the response from the upper echelons of the chess community has been largely positive. In future, it is necessary to assimilate AI technologies with the understanding of human limitations, knowledge of human psychology for more effective collaborations as against a mindless AI. The fields of administration, economics and psychology have greatly advanced with adoption from classical to neo classical theories by adopting more humanistic approaches based on bounded rationality. Hence, the future of AI appears & requires to be a more interdisciplinary study and cross domain collaborations.