Deus Ex Machina—A Higher Creative Species in the Game of Chess

Shay Bushinsky

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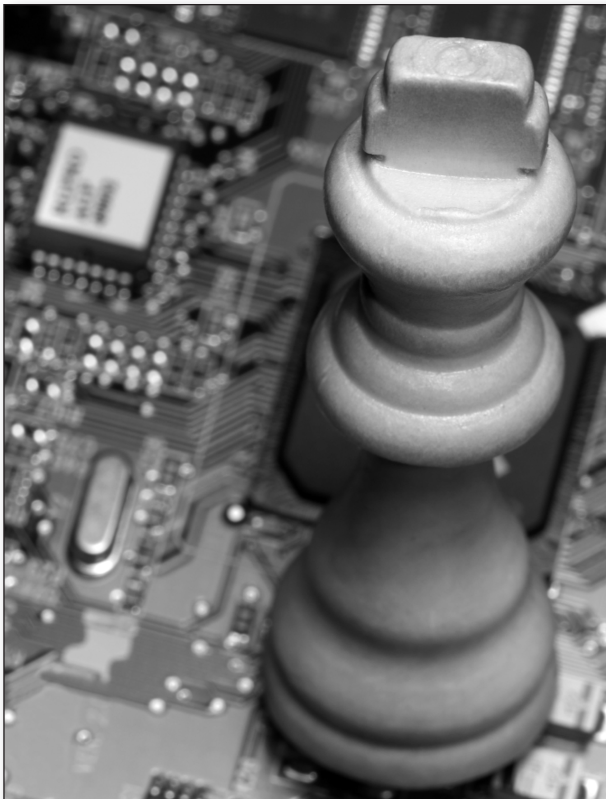
Not surprisingly, the superiority of computers over humans in chess provokes antagonism. The frustrated critics often revert to the analogy of a competition between a racing car and a human being, which by now has become a cliché.

In 2007, Amir Ban (my partner) and I flew to Elista, capital of Kalmkya, to take part in a chess match dubbed "The Ultimate Computer Chess Challenge." Our program, Deep Junior, then the world computer chess champion, was to play a match against Deep Fritz, which a few months earlier had defeated Vladimir Kramnik, the world's human chess champion.

Parallel to the computers' match, at the same venue, some of the best human chess players assembled to play in the semifinal tournament for the world title. FIDE, the international organizing body, had asked top commentators to annotate the games in both competitions. Among the commentators was Boris Spasky, the famous former world champion.

Some of the games between Deep Junior and Deep Fritz were exciting: in one of them, Deep Junior was able to discover an important theoretical novelty in the Sicilian defense. After sacrificing no fewer than four pawns, it managed to find a winning

 ISSN 0738-4602



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maneuver that was not known beforehand. Disappointingly, the commentators shied away from the computer games, refraining to analyze them.

Mig Greengard, an influential chess commentator, tried to explain why humans avoid computer games. According to him, spectators prefer to watch how chess icons lose by committing terrible blunders of the kind that do not occur any more in computer chess. Perhaps this provides them with consolation for their own imperfections.

Perhaps Greengard's comment agrees with Grandmaster Robert Huebner's view that "we play chess because we do not know how to play it"; in other words, mistakes are just part of the fun of playing. However by ignoring computer games, humans miss the great progress that has been made and the beauty of their play—just as if one chose to ignore a beautiful picture merely because it was painted by a computer.

Some of the people who take an interest in computer chess admit computer superiority but cast doubt over the methods employed to achieve it. They revive the term *brute force* in reference to the overwhelming computer search mechanism, pointing out that mortal players reach comparable results looking at many fewer positions. While indeed human abilities really are amazing, beneath their hood hide millions of neurons probably performing primitive calculations as well. To quote Marvin Minsky, "We are not just simple machines, we are wonderful ones."

This article is about how roles have changed: humans play chess like machines, and machines play chess the way humans used to play.

Computer Intuition and Concrete Play

It is conceivable that the computer's "chess neuron" (a role attributed to its static evaluation function) is superior to the human one because it is designed to perform a limited yet special task. Either way, the net result in both cases is the emergence of a creative thinking process. The spectator witnesses the beautiful expression of the machine's inner self and should not be bothered by all those neurons. In this sense, computer chess programs pass the Turing test big time.

Another interesting analogy exists in a comparison between the intelligent search process that occurs in clever computer chess machines and *swarm intelligence* (SI). SI imitates animals that collaboratively perform smart tasks and are very robust even though each individual is stupid and weak (for example, ant colonies and bees). Some consider the hive itself as the actual organism and not each component individual (Kelly 1995).

The fundamental differences between the ways both species play the game are reflected in their style. The human style can be characterized as logical. Human players tend to develop their game according to a *plan*. When humans are taught chess, they are often warned to stick to a plan at all costs. "A bad plan is better than none" goes the saying. Accordingly, when reasoning why players lose, a popular explanation is the choice of the wrong plan.

Computer programs do not play according to plans. In fact, attempts to design effective chess programs to this end failed a long time ago. They rather "play the position." This is why until the late 1980s; programs were ridiculed for not knowing what they were doing. However, in our era, the human experts characterize the computers' way of playing as of "concrete style." Grandmaster Ram Soffer believes that Garry Kasparov may be considered the father of the computer style since he pioneered the age of concreteness. His successors, which are computers, have dramatically influenced the way chess is being played today. Kasparov was not involved in designing computer software. The linkage is probably due to the right way chess should be played.

"Playing the position" means that computers are often much more objective in their assessment than humans. It also makes computers more flexible and thus more creative across the board. The computers' big leap during the past decade was in understanding the concept of positional compensation. By the end of the 1980s, the common feeling among experts was that computers would sacrifice material only for very concrete reasons. When humans sacrificed for a long-run positional advantage without an obvious gain, they were believed to be highly inspired, with stroke-of-genius category intuition. The concept of a "positional sacrifice," for which there is no immediate gain within the searchable horizon, seemed unattainable by AI and solely God's gift to man. Computer programs' weakness was ridiculed because of their innate greed.

When Deep Blue sacrificed its white knight in the French opening against Garry Kasparov during their final decisive game (New York, 1997), Kasparov felt cheated. Deep Blue did not make the sacrifice on its own. Rather it followed a human move played before. Perhaps Garry forgot about that move himself, or was preconditioned to the idea that computers cannot make positional sacrifices. The move was actually entered into the program's opening book by Grandmaster Joel Benjamin. Therefore, Deep Blue played it automatically without wasting a single CPU cycle over it. In retrospect, without the book, it is unlikely that Deep Blue was capable of playing that move on its own.

Six years later, when Deep Junior sacrificed its black bishop in the Nimzo-Indian defense of its fifth game against Garry Kasparov (New York, 2003), it made our human opening expert think it had gone berserk. This time, the sacrifice was made purely out of Deep Junior's "imagination" and was not motivated by a concrete materialistic gain. In the postmortem, Kasparov remarked that progress in AI has been achieved.

The move depicted in figure 1 is an imaginative sacrifice, surprising, to say the least. Such early-stage sacrifices were popular during the romantic period of chess (1850–1920). This move is not a concrete combination aimed at gaining some material later for the bishop. It is more like Deep Junior saying, "Let's throw away this piece and flush out Kasparov's king—perhaps this will work out OK…."

Kasparov raised his eyebrows at this move, but took the bishop without much thought. He played Kg3 derisively, looking left and right, as if asking, "Is this serious—are you trying to tease the world champion with stupid moves?" The pattern of this sacrifice and what happens next is well known. With black's pieces undeveloped and no other supporting feature in black's position, what is there to consider? Moreover, how can it succeed? These are good questions, but not the kind that Deep Junior asks itself: from here on all evaluations were 0.00.

The two senior grandmaster commentators—famous grandmasters Yasser Seirawan and Maurice Ashley—remarked instantly that Deep Junior was about to lose quickly here. The general comment

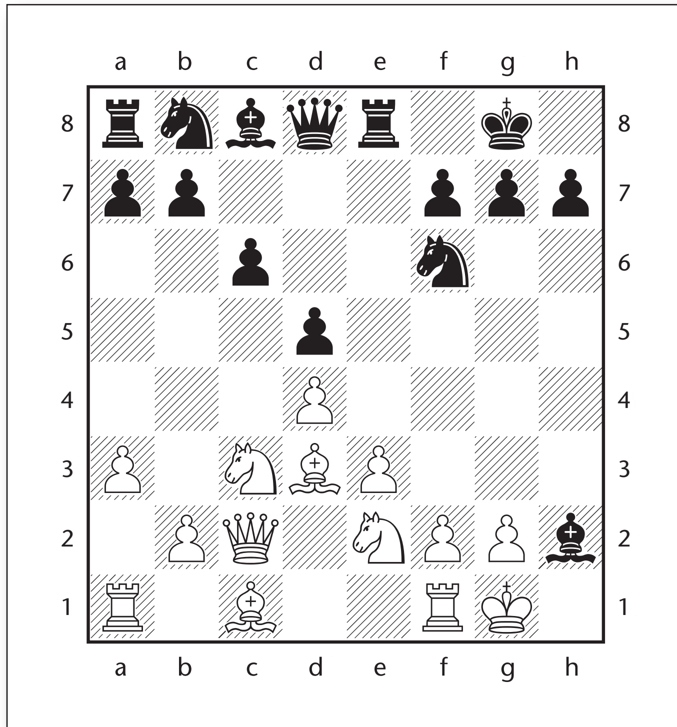

Figure 1. Garry Kasparov Versus Deep Junior 8X3D Man-Machine Match, New York, 2 May 2003.

Notes by Amir Ban: 1.d4 Nf6 2.c4 e6 3.Nc3 Bb4 4.e3 0-0 5.Bd3 d5 6.cxd5 exd5 7.Nge2 Re8 8.0-0 Bd6 9.a3 We are out of book here 9 ... c6 10.Qc2 Bxh2+

was "hmmm … interesting—but Deep Junior is going to lose in a few moves here."

It turned out that Deep Junior understood more about the position, and after a long think by Kasparov, the game ended in a draw. A few days later, in his concluding remarks about the match with Deep Junior, Kasparov admitted that the sacrifice was sound.

Tracing the Sources of Human Creativity in Chess

The game of chess has exact rules but inexact principles for playing it. Many of these principles were discovered over centuries through insight and experience and are documented in chess literature. Careful authors mention the fact that for almost any given principle there is an exception that may occur in certain positions. Some of these principles even conflict with each other. Knowing how to play chess well is largely about applying good judgment as to when a particular principle should be applied and when it should be broken.

Famous past world champions such as Mikhail Tal and Garry Kasparov are often singled out as exceptionally creative. So are Alexei Shirov and

Alexander Morozevich, who are active top grandmasters. Grandmasters examining their games correlate their creativity with a high flexibility in breaking the principles.

The elements that spark creativity in chess are no different than in other domains.

Creativity in chess could be explained using the Eduard De Bono theory of *lateral thinking*. According to De Bono (1970), the creative process is highly motivated by techniques such as (1) nonconformism; (2) provocation (in the positive sense); (3) flexibility; (4) casting doubt; (5) "thinking out of the box"; and (6) transfer.

The following example, given by Grandmaster Boris Alterman, might provide a clue: Suppose the white queen is attacked by a black piece. Ninety percent of the players will instinctively move the queen to evade the threat. Nine percent would consider an option to counter-threaten the black queen. Only 1 percent would seek another option—perhaps an effective intermediate move that could be made.

It is perhaps paradoxical that there is a strong consensus amongst chess experts that human creativity in chess stems from a traceable orderly process. Amazia Avni, a psychologist and a chess master, analyzed the roots of creativity in human play in his book *Creative Chess* (Avni 1998). He describes an intelligent process composed of four distinct steps: (1) gathering—collecting the raw materials during position evaluation; (2) synthesis—opinion forming and plan shaping; (3) enlightenment—a sudden observation of an idea; (4) realization—translating the idea into practical lines of play. Again, not unexpectedly, this might be a good recipe for a creative process that could possibly work in other domains.

Avni goes further to outline particular creative elements in the game of chess that stem creativity, among which he mentions nonstandard positioning or functions of chess pieces, the removal of one's own piece, the breaching of theoretical principles, observation of small nuances occurring in a position, and many more.

Grandmaster Alon Greenfeld, Deep Junior's openings consultant, is a strong believer of methodical creativity. He explains that often he instructs his students not to despair upon finding a hole in a good idea. "For example if there is a tactic that doesn't work on the f7 square, try the move combination in a different order. Surprisingly you may discover a different way to implement the idea," Greenfeld explains.

In parallel to his early stages in chess, Grandmaster Greenfeld took an interest in military history. He recalled having borrowed the idea of avoiding piece exchanges when holding a space advantage directly from military strategy.

World champion Tal once told how his chess game was inspired from watching ice hockey! He noticed that many of the hockey players had the habit of hanging around the goal even when the puck was far away from it. He realized that this habit helped them score when an opportunity came. Following the hockey game, he decided to try transferring the idea to his chess game by positioning his pieces around the enemy king, still posing no concrete threats. Indeed, in a later stage, an opportunity arrived to use them to checkmate his opponent's king.

It turns out that many of the creative processes take place off the board during players' preparation and analysis. During the game, subjective circumstances such as psychological blocks impair the creative process. Stress and external factors such as the current standing in the tournament and a desired result restrict a player's tendency to take "unnecessary risks." What might be considered rational behavior constrains creativity.

As a direct result, counter-creative chess is often demonstrated. Take the recent "grand slam" Wijk aan Zee tournament as an example. While I was writing this article, more than two-thirds of the games ended in a draw. The chess played in many tournaments is often very conservative—experts following the games mark over 90 percent of the moves played as highly predictable.

A common speculation attributes the "drawing phenomenon" to very high-quality chess. However, in the 2008 world computer chess championships held in Beijing, only 19 percent of the games ended in a draw, most of which were of absolute high quality. The same trend continued for the 2009 world computer chess championships held in Pamplona where 27 percent of the games resulted in a draw while in parallel; a Super GM tournament was held in Sofia with 63 percent of the games resulting in a draw.

Computer Resources of Creativity

It might cause some despair among human players to realize that some of the most ingenious chess maneuvers are discovered by programs like Deep Junior in less than a second. Equally annoying perhaps is Deep Junior's ability to discover "holes" in some of the most brilliant pieces of chess games played, ruining pieces of art.

It is important to note that strong chess programs are not developed for this purpose. Nor does the solving of a particular chess problem serve as a guideline for progress. In fact, stronger program versions are often less successful in solving such problems. Their mere capability is another indication of the "emerging intelligence phenomenon." The good news is that neither Deep Junior nor its siblings can find all the creative moves ever played by human players; however the bad news is that the number of positions beyond computer reach is diminishing rapidly.

The human expert's observation that creativity in chess is a methodical process strengthens the opinion that machines can indeed be creative. Therefore, it is an interesting exercise to identify analogies between human creational devices and computer chess ones. Grandmasters emphasize that the inventive processes must be efficient. Making chess programs efficient is always a good investment. It is common knowledge that chess programs rely heavily on *heuristics*. Inherently, heuristics are methods that help programs in problem solving, in turn leading to learning and discovery.

Artificial Intelligence theory encourages the discovery of effective heuristics by neglecting logical constraints in the problem. This process is completely analogous to Genrich Althuller's TRIZ method for sparking creativity (Altshuller 1973, 1984). TRIZ is based on the following principle: "Inventing is the removal of technical contradiction with the help of certain principles."

Deep Junior's evaluation function implements such heuristics in many different ways. One example is a code allowing it to evaluate hypothetical positions for pieces by moving them to squares even beyond pieces blocking them. This heuristic, which simulates illegal moves, is completely analogous to "contradiction removal." As a matter of fact, instances of this heuristic are heavily employed in single-agent search as well.

The null move heuristic for pruning the search, which is extremely popular among many top programs, is another example of the TRIZ inventive principle. Its premise is allowing one side to move twice, which is again illegal in chess. Moving consecutively without improving one's position is often a good enough reason to prune the first move. When the null move heuristic is explained to grandmasters, they recognize it in the way they formulate plans.

Chess programs make use of *killer move heuristics*, which allow them to try "good moves" in different positions. This heuristic parallels Grandmaster Greenfeld's proposal to try the same idea in different variations over and over again.

Tal's "ice hockey concept" is implemented as a heuristic in Deep Junior's evaluation function. Proximity to the opponent king is highly encouraged. Some might recognize it in the effective technique of *influence maps*.

Brainstorming is a common human technique designed to generate a large number of ideas for solving a problem. The idea of tossing out different hypotheses sometimes at random is based upon the hope that quantity might eventually lead to quality.

Evolutionary paradigms, such as *genetic algorithms* and *genetic programming*, follow the "quantity leads to quality" idea. They have been a successful technique in many different fields. In chess they are used to yield improved evaluation functions. The advantage of these "electronic brainstorming" methods is in the ability to obtain several good evaluation functions. The functions obtained may be very different, allowing chess programs to switch personalities.

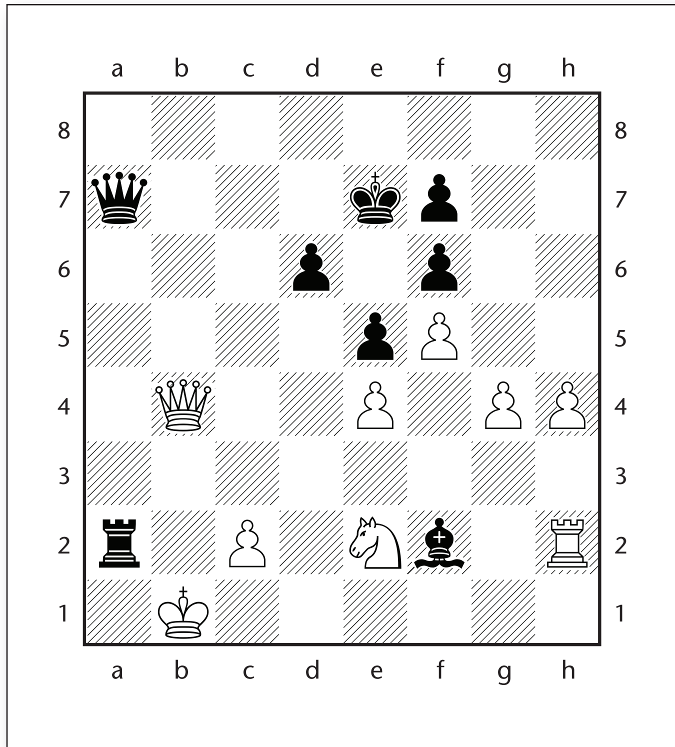

Figure 2. Deep Fritz Versus Deep Junior [B67]. BGN World Qualifiers, Cadaques (3), 25 April 2001. Position After 46 … Rxa2.

Kasparov singled out this position where Deep Junior began a beautiful combination. Deep Junior deliberately left its bishop en-pris. Deep Fritz took it and held a decisive material advantage of a full piece and a pawn. Deep Junior had to come up with a hat trick. Otherwise, it would lose. Interestingly enough, Deep Junior evaluated the position as being about a pawn up for itself! The reason was that it saw sufficient compensation in the white king's poor safety.

47.Rxf2 Ra4 634kN/s -0.92/18 3 **48.Qb3 Ra1+** 1335kN/s -0.93/18 25 **49.Kb2 Rh1** 1558kN/s -1.05/19 9:37 **50.Qg3** (Qa3) **50…Qa1+** 1477kN/s -1.23/18 2:34 **51.Kb3 Rb1+** 1493kN/s -1.53/19 6:29 **52.Kc4 d5+** 286kN/s -1.83/19 11:37

Flexibility is innate in strong chess programs that employ an *adaptive evaluation model*. Their evaluation modifies scales and values according to different types of positions or to different phases in the game—just like a chess player would know that in some positions pawns are worthless, while in others a particular pawn may make a world of difference.

Attempts to address the difficult issue of "positional sacrifice" were made throughout the history of computer chess. Programs have been created

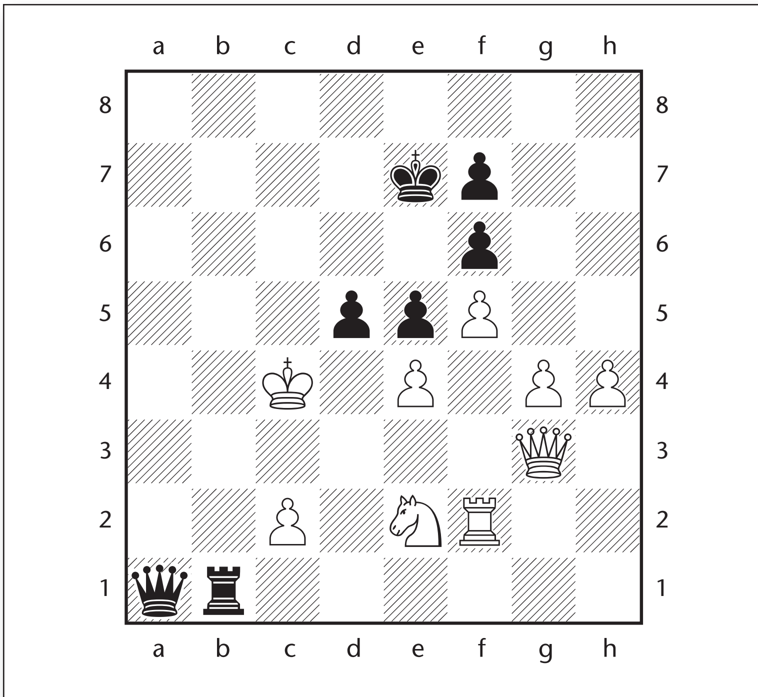

Figure 3. Deep Fritz Versus Deep Junior. Position After 52 … Qxd5+.

Here came another pawn sacrifice. By the mere looks of the position, it seemed that black was running out of resources, desperately trying to create something. Paradoxically, by the increase in its evaluation of its position, Deep Junior was becoming more and more confident in its position.

53.exd5 Qa6+ 946kN/s -1.83/17 54 **54.Kc3 Qa5+** 419kN/s -2.56/19 3 **55.Kd3 Rd1+** 808kN/s -2.78/19 3 **56.Ke4** (Ke3) **56...Qxd5+** 934kN/s -3.67/17 31

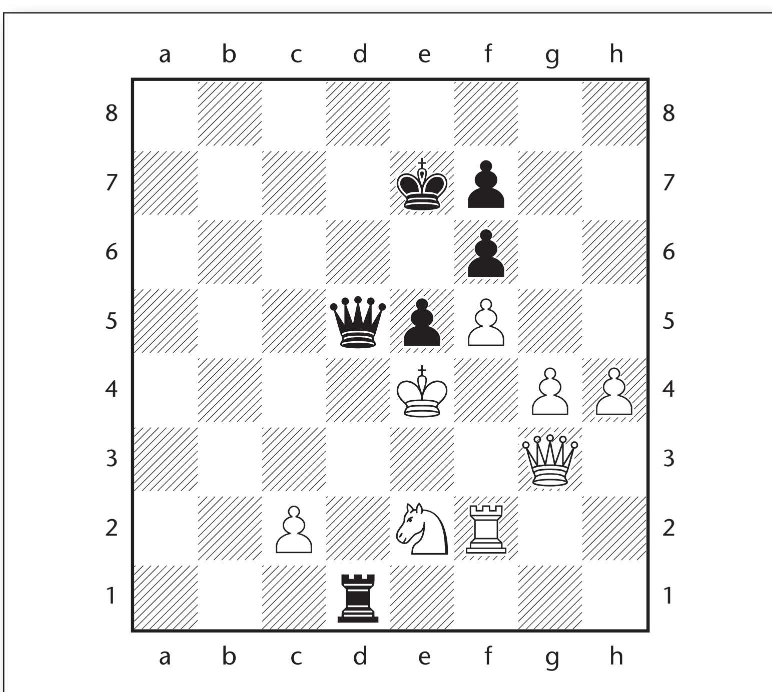

Figure 4. Deep Fritz Versus Deep Junior. Position After 56 … Qxd5+.

with an element of speculation built into them. For example, in some positions, such programs would search for patterns that seemingly allow a thematic maneuver. An example of such a position is one that allows the "Greek gift" romantic pattern.

Upon *pattern recognition,* the program would sacrifice a piece hoping that the outcome would work out for it just as it worked in past similar situations. This ad hoc method was certainly entertaining, but it failed miserably against strong computer opponents who would not fall for the resulting complications.

Vishy Anand, the reigning world chess champion, characterized Deep Junior as the program that takes compensation to the limit. He referred to Deep Junior's recognizable style as willing to take chances by sacrificing material without apparent gains. If humans played this way, they would be considered somewhere between unsound and cheeky.

Chess is an infinite game from the practical sense. This means that every chess move carries a certain amount of risk. Accurately estimating the risk involved in a move is critical.

Deep Junior's evaluation function is the product of a mathematical model for risk assessment and machine learning. The program is trained using this model off the board by learning selected positions from a game corpus. Initially, Deep Junior's training set was compiled from games played by world-class human players. Today, the training set consists of positions played by computers only.

The example illustrated in figures 2–5 was pointed out to me by Garry Kasparov. He received a database of Deep Junior games prior to our match and studied them. The game that attracted his attention was held at the BGN World Qualifiers, in Cadaques, Spain, on 25 April 2001, between Deep Fritz and Deep Junior 6.0. Kasparov remarked that the only way such a maneuver could be demonstrated by a human is if the human player had conceived of such a theme beforehand. He contended that this position only could occur artificially, by playing it backwards. This is the work of chess problemists who create chess compositions and not a possible product of practical chess players.

Humans still prove to be superior over programs in some positions, in particular, a class of positions labeled "fortresses," recognizable by the long blocked pawn chains in them. Limited to the employment of the search and evaluate paradigm, it would require an "infinite search horizon" to play such positions. On the other hand, even low-skilled players can understand them quickly relying on geometric vision. Sadly for humans, such positions are so rare that they are of little practical importance to the programmers. A notable exception is the work on blockage detection in pawn

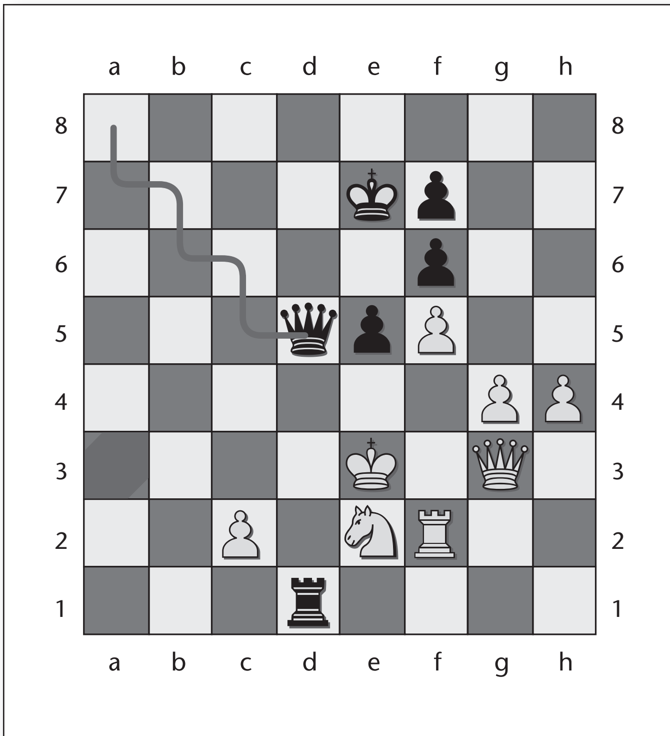

Figure 5. Deep Fritz Versus Deep Junior. Winning Queen Maneuver.

At this point, Deep Junior had a winning score. Its slick winning queen maneuver captured Kasparov's eye: The black queen took advantage of the trapped king position (having only two free squares e4 and e3) to execute a *stairways queen maneuver.* The queen's objective was to reach the a3 square, the only square allowing her a deadly horizontal check.

57.Ke3 Qc5+ 1167kN/s -3.67/17 29 **58.Kf3 Qc6+** 1361kN/s -3.67/19 3:29 **59.Ke3 Qb6+** 1261kN/s -3.67/16 35 **60.Ke4 Qb7+** 1215kN/s -3.67/19 3 **61.Ke3 Qa7+** 1174kN/s -3.67/17 24 **62.Kf3 Qa8+** 641kN/s -3.82/19 3 **63.Ke3 Qa3+** 1224kN/s -3.82/17 34 **64.Ke4**

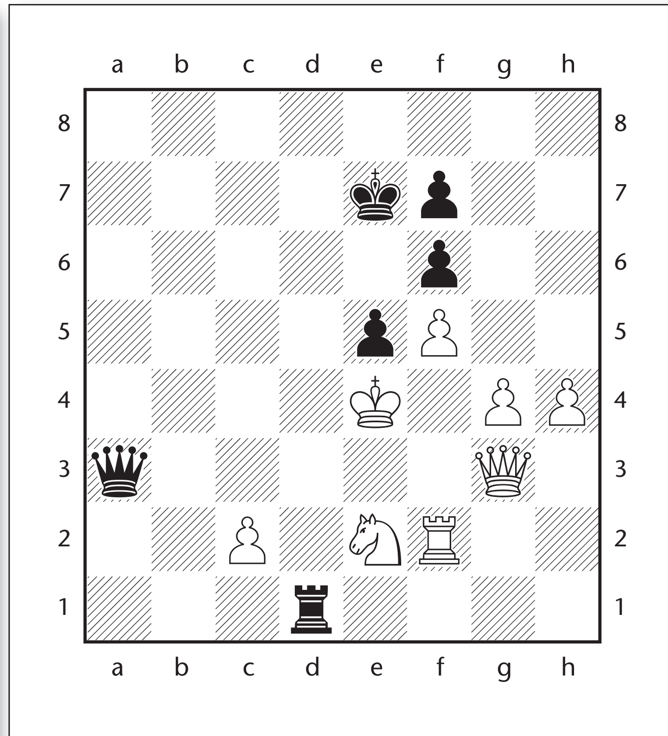

Figure 6. Deep Fritz Versus Deep Junior. Position After 64. Ke4.

Now came the point of the combination, which was the rook's check on d4. It forced Deep Fritz's knight to abandon its protection of the queen. Deep Junior managed to turn the tables, obtaining a decisive material advantage.

Rd4+ 929kN/s -3.97/19 3 **65.Nxd4 Qxg3** 1243kN/s -4.15/19 1:24 **66.Nc6+ Kd6** 605kN/s -4.75/20 3 **67.Nxe5** (Rf1) **67...fxe5** 1300kN/s -5.35/19 5:32 **68.Rd2+** (Rf3) **68...Kc6** 1252kN/s -5.35/18 1:17 **69.Rd8** (c3) **69...Qf4+** 1432kN/s -5.35/15 1:01 **0-1**

endgames (Tabibi, Felner, and Netanyahu 2004), which copes with such positions and was integrated into the Israeli Falcon program.

Creative Synergy

At the start of this new millennium extremely strong chess programs were made available to anyone. As a result chess is undergoing a small revolution. True, there are no new openings being invented, but this was also true for more than 50 years BC (before computers).

Modern chess has become more concrete and accurate. Chess programs allowed the revival of old openings that were deserted because they were believed to be inferior. Openings, such as the Janish gambit in the Ruy Lopez, that were "lying dead" for decades are now extremely popular thanks to computer analysis.

Computers have inspired "concrete chess," allowing players to desert "old Russian school principles," a discipline popular during Karpov's era. Chess then was a dogmatic game, where one expected to be punished for not following the principles.

In some openings, for example, computers now allow one to develop the queen early. Computers proved that she could grab a few pawns and bail out alive. Such a maneuver is marked as a big "no-no" even in recent chess literature just because it is true most of the time.

Computers managed to cast doubt on the way humans used to play chess. In this sense, they have encouraged creativity among humans.

To quote world champion Vishy Anand, "I would say nowadays it is impossible to work without computers. And you don't become mechanical at all. It allows you to do incredibly creative things. I mean there are positions I can work on where it was not feasible to work on alone.… I would also say we have developed a certain tolerance for unusual moves. I mean, humans themselves play unusual moves nowadays. When I see some move my first reaction is no longer 'Oh, this is ghastly.' My first reaction is 'aha, the tactics are working' or something. So I would say it is an evolutionary thing. We have slowly learned that our understanding of chess was not complete and computers have got better."[1]

As a by-product of the computer revolution, many young chess players, who grew up in the age of personal computer chess, infiltrated the top 20. Notable examples are grandmasters Magnus Carlsen and Sergei Karjakin, who are still under 20 but are singled out as candidates for becoming the next world chess champion.

There are also very good young poker players. The Internet made the opportunity to study the game available to all. Before computers, one had a hard time finding high-quality competition, which is essential to improve. Imagine what would happen to basketball if everyone had a chance to play with NBA quality players. This may be possible in the future, when robots might play basketball. In that case, perhaps the game of basketball will undergo a revolution as well.

Prior to the computer age, players had to move with seconds (assistants). Now all top players move around with their laptops. They use them to find innovative moves that will surprise their opponents mostly based on computer evaluation. The older generation of chess players finds it hard to compete against the computer-age players—"for them it is like confronting tennis players with a huge serve," explains Grandmaster Alterman .

During the late 1990s, a group of strong Dutch players did develop an effective method to confront AI. Paradoxically, their method, dubbed "anticomputer chess," was to dilute as much creativity as possible out of the position. "Anticomputer chess" is about simplifying the position by limiting the search branching factor from the AI perspective. Kasparov, aware of the method, refrained from using it against Deep Junior—it was against his character to become anticreative.

Conclusions

Computers today are more creative than humans in the game of chess. This article outlined four main reasons supporting the above claim.

Creative chess play is mainly about willingness to take risks by deviating from the conventional moves. It is evident that there is correlation between strength of play and creativity (Garry Kasparov). In this sense, computers know how to calculate risks in chess better than humans. In addition, they simply are more objective when analyzing a position. As a result of Deep Junior's experience in playing humans, we have often found that human opponents bring a certain amount of prejudice when assessing their position.

Humans are more predictable than computers in their game (a fact reflected by their higher draw rate). This is mainly because humans tend to disqualify moves that seem to be against the principles of playing the game. However computers prove that such moves can work for concrete reasons. For the past decade, the only successful way for humans to confront computers was to limit their creativity by "drying up the position" and simplifying it. Our machine-learning mechanisms that benefited in the past by analyzing human games now only can benefit by analyzing computer games.

Computer chess programs have changed the way people play chess. They rely more and more on creative ideas that are cooked using their computers. Perhaps they tell us something more about the nature of the game. If concrete play works well, it is because chess is more a tactical game than a strategic one. Sadly enough, it looks as if the human race has given up too early. Ever since Garry Kasparov's courageous effort to confront computers, which lasted over a decade, there is no successor who has attempted confronting AI in a serious manner.

My hope is that, among those young emerging chess giants, there will be found one who is creative enough and familiar with the best chess programs and who will dare to challenge AI dominance over the game of chess.

Note

1. See the interview with Anand by Sriram Srinivasan and Jaideep Unudurti on intuition, creativity, and blitz chess made 26 December 2008 at www.chessbase.com/newsdetail.asp?newsid=5282.

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