Oral History of Monty Newborn

Interviewed by:
Dag Spicer

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Dag Spicer: --February 28, 2005 in Mountain View, California. Monty is a huge figure, a seminal figure, in computer chess and has been organizing tournaments for 30 plus years. We're really happy to have you here.

Monty Newborn: It's my pleasure to be here.

Q: I wanted to start with a really general question for you. Why is computer chess an interesting problem for you, and for AI as well?

Monty: That's two separate questions. For AI, I think that you have to go back and look at the first people interested in computer chess, and their motivation. They were of course interested in the question of how intelligent could computers be. They were looking for a problem on which one could study how intelligent computers could be and somehow, they backed into chess. They, and of course Turing and Shannon, and Norbert Weiner, and of course Babbage even further back, was interested in this. Herb Simon, who won a Nobel Prize, became interested in it in the '50s. John McCarthy, now of Stanford, became interested in the '50s and '60s. Some of the leading names in the history of computers backed into looking at chess as the environment in which to study how smart computers could be at solving a difficult problem. I think that's the original motivation.

Q: It's amazing, the names that you mentioned. Every major figure in computer science, as you said, has had some contact with this particular problem.

Monty: Even Von Neumann. If you look at Von Neumann, he of course got into the theory of games. Von Neumann was fiddling around with the minimax algorithm. That's a lot of impressive names that all focused on chess and computers.

Q: When you say they "backed into" this problem, what do you mean by that?

Monty: Well I guess, probably, maybe they all played chess a little bit, so maybe that was a common aspect of it. They didn't have to be real good chess players to do it, but chess was always sort of the game where one thought man's intellect was put to the real test. When you had a computer that could follow directions and do calculations relatively quickly, it seemed like chess was a good one to have these computations carried out on, so these early guys were trying to figure out how to program the computers to play chess. Of course, they thought it would unlock some of the secrets of the mind's way of computing. The bigger question, of course, is what does a human mind do that a computer can't do? Where is the distinction? What tells us, for example, that we're alive? A computer doesn't know it's alive.

Is the idea of being alive a computation, or is it something more than a computation? We haven't been able to figure out what it is that tells us that we're alive, as far as I know, to this date. That's still an open question. Where in the brain do we figure out that we're alive? These are the big questions.

Q: They are. I'm sorry, I cut you off.

Monty: Going back to my own interest, it combined two of my lifelong interests, which were chess - which I was never a great player, but I was a reasonable player - and computers and programming. I enjoyed both of them. I guess my interest aroused in the '70s. As a scientist, the thing that I enjoyed about working in the environment of computer chess was just that you could put your ideas to a test, and that there's a lot of science in universities that probably should be put more to a test. The exciting thing in this long-term experiment we did was that we sort of weeded out the talk from the action. In the world of science there's often a lot of talk, and we filtered that out quite well by the time the programs got to be at the level of the world's best chess players. The people involved were a real tough bunch of scientists, and a talented bunch of guys.

Q: We had Ken Thompson in a week or so ago. We did an oral history with him. One thing that really surprised me was his comment that he stopped playing chess in 6th grade. He doesn't play chess very much, and yet he was a major contributor to the field. That was very surprising.

Monty: Well, Hsu himself, the head of the Deep Blue program, was just a fair chess player. He probably learned by training his computer. When you train the computer, you in turn learn yourself.

Q: Right. Take us back to what got you and David Levy to organize this -- back in 1970 was the first tournament, I think.

Monty: In 1970, the ACM had a conference in New York City. They wanted me to be a part of the conference committee, and to organize the special events at this conference. We decided to organize several special events. I had a number of interests at that time. We organized the first tournament for computers. In addition to that, we organized a computer art contest, and we organized a computer music contest. And so our first activity was a combination of a national competition for computer music, and a national competition for computer art, and the chess tournament. We did all three; it was quite exciting. All three were exciting but the chess, of course, maybe captured the imagination of the scientists. All three were exciting, but somehow we wound up sticking with computer chess. I organized the first tournament in New York with Ken King, who was the head of Columbia University's computer center at the time. The second tournament was organized by Ben Mittman from Northwestern.

Q: So not David Levy?

Monty: Well, maybe David helped Ben on the second one. The second one was held in Chicago, where the Northwestern team lived. Ben had it in his own backyard, so to speak. The second tournament then was a big success, and the third tournament I was back involved in organizing as well. For a number of years, Mittman and I organized these tournaments together. I started competing myself in the Boston tournament -- the third tournament.

Q: With Ostrich?

Monty: With Ostrich. Ostrich was not a bad program. It never quite reached the top, but it was not bad. Ben and I organized tournaments year after year. David Levy got involved with some. We organized the ACM tournaments yearly, and in addition we organized world championships every third year. This went on pretty consistently right up until the time that Kasparov played the computer. They're still having these tournaments, but my interest as a scientist sort of was fulfilled when Kasparov lost to the computer. As a scientist, I would say that that was the end of the experiment.

Q: How early on was defeating the world chess champion a goal of the computer chess people?

Monty: If you go back to Norbert Weiner, who was one of the first ones that wrote on the subject, the question was whether you could have a program, I think the word he used was play "reasonable" chess. You've got me on the spot on a perfect quote. I think that the real issue at first was whether they could play "reasonable". Little by little, they kept upping the ante from reasonable to like the level of a good player, a master player, a grand master, and then could they actually beat the world champion. At every stage, there were those that said, "It'll never get any better. This is as good as they're going to get." Of course, these were, to some extent, grand masters holding their turf, or defending their turf, in some crazy way, in denial more than anything. The computers continually got better and better and better. They'll get better and better from here on out. The computer technology is marching along.

Q: These people that are still in the field, what's their goal now that they've dethroned the best human player in the world?

Monty: Well, those that are interested in artificial intelligence, from the standpoint of game theory, are looking at the game of Go. Those that are interested in the deeper question of artificial intelligence are back to this issue, as I said before, as to what distinguishes human intelligence from computer intelligence. I think that's the exciting question. The real exciting question is: What does the human mind do that the computer can't do?

Q: Is it fair to say that chess is solved as a problem?

Monty: As a problem, we found that to play chess better than man is a problem of computation. The computers can out-compute the human mind.

Q: This brings us to the big divide between the two approaches as I see them, which is brute force versus heuristics, or the encoding of game play and bringing in Grand Masters and so on. Kasparov talked about a harmony of the board that great chess players have. I think we understand what he means by that. Can you comment a bit on that, and the fusion of those two approaches? I don't think it's all brute computation. There may be some symbolic reasoning that's going on as well.

Monty: Well, the bottom line, in general, is that, the faster the computer, the more possibilities it will look at. This increase in the number of possibilities eventually overweighs… Well, the idea of heuristics is to narrow your search. It's to not look at as many possibilities, but to look at the more relevant ones. If you can look at enough possibilities, whether they're relevant or not doesn't matter. A faster computer will eventually catch up with the smarter, slower computer that uses heuristics. The problem with most heuristics as it moves to brute force is that the exciting moves are missed by the heuristics, because they go against the rules. It's like if you train somebody to do something using very simple rules -- It's like school children -- if you force them not to be creative, they'll solve most of the problems but they won't solve the difficult ones. What you want is some crazy guy whose mind is uncontrolled, that goes out and thinks of something that nobody else has been thinking about. That's the magic solution, so to speak. To some degree, the heuristics only go so far. They miss out the crazy scenarios that they're programmed to filter out. For example, one classic, very simple rule in chess is one of the heuristics in the early programs. It was don't move your knights to the side of the board because you don't want them getting stuck on the side of the board. Well, that rule works 98% of the time, but it's those 2% that it doesn't work that allows the program to do something exciting.

Q: Is that likely to arise only from a human player, or can a computer still come up with that 2%, really innovative move?

Monty: Well, if you don't force it to follow this heuristic, it will then play those moves but it will possibly not be able to look at other moves more deeply. You have your choice of looking more deeply along highly "interesting" lines, or deeper along all kinds of lines which may look totally stupid, but may pan out later. The more you force the computer to use strong heuristics, unless these heuristics are guaranteed to be successful-- I mean, each heuristic has a certain probability of being correct. When you're looking at millions and millions of positions, the odds are that one of those heuristics is not going to really be that relevant. Little by little the programs have grown more and more towards…. The distinction between brute force and heuristics is not a real hard distinction. The question is: What moves are you giving up shallow in the search to look at others deep in the search? The odds of giving up a move shallow in the search to look at one deeper in the search, you have to be very careful about giving up something shallow in the search in the expectation of being able to search deeper along some line.

Q: How much were the algorithms shared through the 27 years from ’70 to ’97? Was there any published literature in computer chess that sort of created a discipline and a field?

Monty: There was a lot of sharing of ideas. There were several key ideas, of course. As the great experiment went along, of course the minimax was shared by thousands. That’s the first perhaps big idea. The alpha beta algorithm became quickly spread around the community. The idea of using large hash tables, or transposition tables, got spread around in the late ‘60s and early ‘70s. The Greenblatt program, perhaps, was one of the early ones. The key ideas - minimax, alpha beta, the use of large hash tables – and that was then followed by perhaps the key idea, which was Peter Fry’s idea of using iterative deepening search rather than straight depth-first search. The introduction of iterative deepening depth-first search moved the programs up from playing about a weak class A to almost master level in about a one or two year period. So, the iterative deepening was a key. Of course, following the iterative deepening, Ken Thompson’s Belle came in with the special purpose hardware. As soon as Thompson came in with special purpose hardware, others followed right along. Following the special purpose hardware, one looked into a parallel search using many computers in parallel. All of these ideas were shared by others as one marched along. Furthermore, at our ACM conferences every year, we held panel discussions in which the ideas were pretty well shared, so we had our pretty much yearly panel discussions. There was a certain amount of material published in the major publications. In general, the community was a very close community. We had lots of fun together. Following the games, we generally went out to dinner and had a good time and talked. Early on, of course, there were the Russians involved. It was always exciting, getting together with the Russians and talking chess and politics. It was quite an exciting period.

Q: I was just going to ask you about the Russians. What were their contributions, and what was their environment like for developing chess? Obviously, it was the height of the cold war and 1972 was a big year.

Monty: Of course, chess in Russia is a much bigger thing than it is in North America. In Russia, there were basically two groups that got involved in developing chess programs. There was, of course, Botvinnik. Botvinnik was the first. Following Botvinnik, there was the group at ITEP, the Institute of Theoretical and Experimental Physics. That group was a talented bunch of guys. Botvinnik’s group and the ITEP group were in competition with each other. The ITEP group eventually wound up playing McCarthy’s program in a two game match in 1966, 1967, I think the years were. The Russian program dominated very strongly. This was really the first test. The Russian program was more of a brute force program, and the McCarthy-Kotok program was really sort of a selective search program. One of Botvinnik‘s observations when he looked over the games was that the McCarthy-Kotok program threw away the baby with the bathwater, in the sense that it filtered out the good moves that the computer should be playing. That was the first test of brute force versus selective search, and the brute force really dominated. That may not be the only reason, but it was one of the reasons. So the two Russian groups, the Botvinnik and the ITEP group, competed, but the ITEP group were really strong programmers. Botvinnik, as a chess player, was sort of a theoretician who, I think he expected too much out of his ideas, and they were a bit complicated to program. His program never competed again to the level that the ITEP program did. Of course, ITEP was joined by Misha Donskoi at some point. When Donskoi joined the ITEP group, Donskoi came up with his own variation of the program, called Kaissa. Kaissa wound up winning the first world championship. They beat the Northwestern program. It wasn't clear that they were actually better, but sometimes the best team doesn't always win. They were good enough that, following the tournament, there was such interest. The two never played during the tournament. Following the tournament, the organizers decided just to have a one game match to see who would win between the Northwestern program and Kaissa, and Kaissa won. I hope I'm right on that! You'd better edit that carefully.

Q: Ok, we'll check it.

Monty: Anyway, three years later, the Northwestern program was clearly better than Kaissa. Kaissa finished in the next world championship in the middle of the pack. Basically, after that it was never among the top bunch.

Q: When you look at the rankings of the winners in the ACM and the world championships, you see that the various programs seemed to dominate for two to four years, then they start to come down. Belle was one. CHESS 4.0 was another. Hitech won it once, and Deep Thought dominated a little bit. Is there any explanation for why the dominance comes from one team for a little while? Is it just better algorithms or better hardware?

Monty: It's energy. I think the design of a chess program takes a tremendous amount of energy. Also, you get tied into your data structures in your program. Once you've got a program up, running, and playing at a certain level, if you want to improve it, if you're going to make a major change, it takes a lot of work. To some degree, that was one issue. Also, for example -- you have to look at the cases. Each case was a little different. Thompson's Belle was tied into hardware, so if he wanted to improve it, he needed to come up with better hardware, or... You have to come up with better hardware, pretty much. Better hardware could involve, for example, parallel. If you could multiply Belle, get 50 or 100 or 500 version of Belle tied together, then have them play as a team. I'm sure that's what was his next step if he had continued but somehow or other, let's say the Hsu beat him to it. Of course, Hitech was looking at the same idea of parallelism, or hardware parallelism. Berliner's approach didn't have the potential of Hsu's. Hsu's was a simpler approach, I guess, and perhaps its simplicity allowed it to materialize. If you had too complicated of an idea, then you might not get it to work because it takes too much work. It was very interesting that there was this succession of people that moved to the top of the pack. You had to keep running at top speed or you wouldn't keep up. The ideas of one team were available to the next bunch. The sharing of ideas and the racing of technology, and the using of -- for example, Cray Blitz got onto the Cray computers. When the Cray moved up to the top of the pack, Cray Blitz moved up to the top of the pack. Each group found it hard to stay on top because of this big race. The available information was there for everybody to share. Grabbing new technology was important.

Q: Seymour Cray used to say, "Try not to be first. Try to be second," because the first guy is the one who's taking all the risk and, as you say, is locked into his data structures, and his psychic and intellectual investment. That makes it harder to change gears. That second team that comes in can sort of cherry-pick what they like, and come up with a real powerful program. I found it was interesting that Belle could actually beat Cray Blitz. Belle was built for $5,000 or something, and it beat a $10 million supercomputer. That was amazing, I think -- a very impressive feat.

Monty: The PCs of today are probably as good as Deep Blue was. Well, past Deep Blue there's been these two matches, one with Kramnik and one with Kasparov with much weaker computing facilities than Deep Blue. Yet, they were able to tie the matches with these top world players.

Q: This brings up an interesting question. Now that players are training on computers using programs that you can run on a PC, programs that all but 100 people in the world can defeat, the style of play of people, especially kids that are learning chess, has changed. At least this is what I've read in the New York Times – I'm not an expert on this topic. Could you tell us a bit about that?

Monty: Well, I think that the tactics side gets tested much more when you play a computer than some of the positional aspects of the game. The one thing that the computer does is it leads the position into scenarios that the human is less likely to have seen when playing. When two people play each other, their minds are much the same. One of my classic observations is that, if I make a mistake, often my opponent won't see that I made a mistake because his mind is thinking like my mind. When I make a mistake when I'm playing chess, I'm saying to myself, "God, I hope my opponent doesn't see my mistake," and quite often he doesn't because his mind is thinking like mine. But the computer's mind, he's looking around mainly for tactical little things to grab, but he's also very clever positionally. Perhaps the balance between tactics and positional play has shifted more towards the tactical side, but the computers will just always outplay the human tactically.

Q: I forget which game it was, but there was one game in one of the two Kasparov Deep Blue matches where the computer actually made a mistake – probably the first one. It was a programming error. Kasparov thought that it was part of a larger strategy, that there was no way the computer would make such an elementary mistake. He said later that it affected his game play. I wish I had more details. There's an interesting example of the psychology occurring between the two players. I guess to play against a computer that ominous, you're already kind of freaked out about what it's really doing and how it's going to attack you.

Monty: Well, you know when you play a computer that you have to be very, very careful. Of course, the computers are way better than I am at this point. You know that you're in trouble when you play. Basically, it's like an octopus. It's got these tentacles all over the board, ready to grab things when you're not looking, because it reaches its arm back and grabs your piece that you're not imagining. You've got to focus on everything. Its mind is focused on everything. The human mind isn't as flexible in certain respects. We're trained to look for certain things. We're trained to look, for example, at structures where the king is castled. If the king doesn't get castled, we get to structures on the board that are less familiar. People study pattern recognition. There are certain patterns in chess that we're programmed to watch for. The computer doesn't have these patterns, and it could care less about these patterns. If you want to worry about these patterns, then you're missing out on worrying about other things that perhaps you should be worrying about.

Q: That brings me to the question of endgame databases, for example, or databases of game play generally. How are those are integrated into game play?

Monty: The Deep Blue program had a certain number of endgame databases built into it. These endgames that are usually for four, five, and six pieces on the board. Whenever the game only has four, five, or six pieces on the board, the computer knows just what to play. It will play perfect chess. The problem is that often you get a position of maybe eight pieces on the board. But the computer, during its search, will find that if it trades off a few pieces, it winds up with only six pieces on the board after three or four levels of search. It knows, from that point on, the perfect play. Even if it's not in a position with six pieces on the board, it can often play essentially perfect chess with seven or eight pieces on the board because, by the time trades get resolved, you'll be down into its databases.

Q: Does that mean that it's deliberately giving up pieces in order to get to that point?

Monty: No, but it's very happy…. If the position looks pretty equal and it's complicated, it doesn't mind getting into these endgames at all.

Q: What impact did Ken Thompson's Belle endgame databases have on computer chess?

Monty: Well, his endgame databases of course fit into Deep Blue. One of the questions was whether they helped Deep Blue. There was one game where they were a small factor. Of course, from the standpoint of the rules of chess, they shook them up. Chess has a rule that says that, after 50 moves, if nobody can take a piece off the board, the game's considered a draw because pieces are just dancing around the board. But Ken's database showed that, in many endgames, you could still win the game but you had to dance around the board for more than 50 moves. The chess community, which had sort of said, "Well, if you can't win a game in 50 moves, it's a draw," then had to come back and argue that you can win a lot of games when you have to dance around for 50 moves. I've lost track of how they've resolved that, but that was a problem in the rules of chess created by Ken.

Q: Is it fair to guess that they raised the number?

Monty: No, I don't think they raised the number. I've lost track of what they've done.

Q: Monty, I wanted to ask you about some stories you were going to tell us, about chess and the people involved.

Monty: Chess and the people involved. Well, there's all kinds of stories. One certainly that you can put on tape [laughs] is my own observations of people, new entries into the tournaments; two cases in particular. One is Bob Hyatt. Hyatt is an awful nice guy. He started coming to the tournaments -- I've lost track exactly, but probably the late '70s. Hyatt came to the tournaments extremely cocky, was sure that his programs would do well.

Q: This was Cray Blitz?

Monty: Cray Blitz. Well, it was called Blitz at first, I believe. Hyatt was extremely disappointed that his program didn't do better. Of course, the interesting thing about the chess programmers is that, while the computer is playing, all the emotions are in the human operator. Every one of these guys -- it was like their child playing. It was like taking your child to the football game and not quite letting him…. It wasn't quite like your child being out on the field playing, but it was like you're holding your child's hand while he's playing. There's tremendous emotion by the programmers while their programs are playing. If the program was doing well, they'd be sitting there smiling. When it wouldn't be doing well, they'd be sitting there frowning. Their emotions were laid out on the table like you can't imagine. Of course, Hyatt was a very emotional guy. When his program wasn't doing well, he was low. He also was very sure that he was going to do well the first few championships, and didn't. The nice thing about Bob, and I like him an awful lot, is that he really learned from this experience. He really became transformed. He was a real scientist. His program got better and better, and eventually wound up at the top of the bunch for a while. He was a totally converted species by that time. Perhaps the other overly enthusiastic guy was Tony Shurzer, who came in with a program called Divi. Tony was always sure that his program was going to do fantastically well, and it always did actually quite well. But he was humbled by his early beatings. I would say that the common experience of all the programmers was a certain humbling when they became involved. They became very realistic as to the reality that there were others possibly better than them, with better ideas, and that they had a lot of work to do. By the time we were finished, those that were in the game were a real tough bunch of guys. The guys that rose to the top had all suffered some tough times at one time or another, and they persevered. Maybe that's a general observation. That's not a story, but that's the flavor of the tournaments. It was this optimism when they joined, a period of time where they were beaten down to become sort of realists, and then a period in which they continued to fight through and make progress and rise. That surely was the common theme.

Q: Tell us a bit about your own program, Ostrich. How did that get started?

Monty: I was at Columbia University at the time. I had a student named George Arnold. I had had his brother, Tom Arnold, as a doctoral student. George was an undergraduate. He turned out to be the valedictorian of his class at Columbia. George wanted a summer job and I hired him to work on a chess program. He did a good part of the early work and developed the program to the point where it was able to play a legal game of chess, and somewhat of a respectable game. By 1972, Ostrich had developed its feathers sufficiently to compete. It played in the Boston tournament, did reasonably well. It went to the first world championship in 1974. It went into the final round with a 2-1 score. It was a four round tournament. It went into the final round with a 2-1 score and played Kaissa in the final round. This was Ostrich's high point, I think. Ostrich got into a position where it had a forced mate against Kaissa. To find the forced mate, it needed one more level of search, and it missed the forced mate. Then, it backed into another position where there was basically a forced mate, or at least a forced win. I've lost track whether it was forced mates or forced wins, but one or the other. It missed each one by just not having quite enough time to compute the correct move. Anyways, Kaissa went on to win the world championship and Ostrich finished 2-2 in that tournament. That was Ostrich's high spot. The program continued. It played in five world championships after that, generally finishing in the middle of the pack. It does have a couple of distinctions. It drew one game with Belle at one point. It actually is one of the few programs that beat Deep Blue, or a version of Deep Blue. It was called Chip Test at that point. It was Chip Test's first tournament that it played in, and Chip Test had a bug in its hash tables.

Q: Was that in San Diego?

Monty: I've lost track. No, it wasn't San Diego. It was 1987. It may have been Dallas. Anyways, so Ostrich had to its credit five world championships, a draw with Belle, and a victory over an early version of Chip Test.

Q: And it was beaten by some of the best players.

Monty: It had sort of a reasonable career.

Q: After the student, Arnold, did the initial programming, did you take over?

Monty: Yes, I took over after that. He graduated and sort of left. He worked on it for about the first year. Ostrich was the first program to run in the competition on more than one computer. The first year, it competed on five Data General Novas tied together. The next year, it competed on eight Data General Novas tied together. That, I think, was in ’82.

Q: How did that work?

Monty: Well, we had the eight computers in a cabinet. They had a high speed communication capacity. We divided up the search of the chess tree among the eight computers. They used what’s known as a principal variation splitting algorithm, in which the tree gets divided up in some optimal fashion. Subsequently, other programs have basically used variations of the principal variation splitting algorithm, including Cray Blitz and Deep Blue.

Q: Cray Blitz, I think, was running a four-way processor.

Monty: Cray Blitz often ran on a four processor Cray, and maybe on an eight processor Cray at some points.

Q: In the early days, was the first Ostrich run on a single Nova?

Monty: In the early days, it ran on a single -- I think the first one was a Super Nova.

Q: Did you carry that with you?

Monty: Well, Data General was quite good and loaned us Super Novas at the various locations where we went to play. I worked with the Data General sales offices, typically. In Sweden, we did that for the world championship. Of course, these tournaments reflect the evolving computer technology from the standpoint that, at the first tournaments, we were sitting there on telephones, talking got each other on telephones. Donskoi was connected to Moscow at the time. I had a local computer, but we had communication all around the world at different times, usually voice. You were sitting there on a telephone for four or five hours. Of course, that changed eventually to nobody speaking on telephones and just connected to remote computers. Nobody was speaking on telephones.

Q: It's interesting to see the photos of those early tournaments, with people on the phone like they're stock brokers or something.

Monty: Right. You were tied to the telephone. And we had to have rules. We assumed that there was a certain overhead in the communication and we built that into the rules. The objective wasn't to force you to respond instantly. I mean, there was a ten second lag or something between what you hear and what you type into the computer. That disappeared at some point.

Q: Which do you think contributed more in the software/hardware divide?

Monty: Well, they were both important. Of course, by the time Deep Blue came along, it was 480 processors. There were definite jumps along the line. Of course, the big jump was when iterative deepening search came in. and then when Thompson's Belle came in with special purpose hardware, there was another leap. The iterative deepening search moved the programs up to, let's say strong expert/weak master level. When Belle came in, it moved the programs up to -- by the end -- strong master level. When Cray Blitz and Hitech came in, they were moving up to the weak grand master level, pretty much.

Q: I know this is speculative. Could you have held the algorithms constant, because the ultimate solution does appear to be strictly computational?

Monty: No, but the algorithms were continually improved. The iterative deepening was an algorithm. The use of hash tables involved complex algorithms as to what information to store in these hash tables and how best to use it. The alpha beta search got modified using a number of heuristics, including what they call a "null move" heuristic, where you assume your opponent won't move and you see what is your next best move. That turns out to be a very powerful heuristic. Thompson used the idea of a narrow window search, in which you assume that you're going to find a move within a certain window. Let's just say you assume that you're not going to win or lose material more than a pawn. You assume that anything that leads to more than a win or a loss of a pawn is outside your window of search, and you restrict your search to not losing more than -- I think, usually, they made it two pawns. You would narrow your window. There were a lot of algorithms added to improve the search along with the hardware.

Q: Can you tell us a bit about evaluation functions? They seem to be a very closely guarded secret. I imagine those were not shared as much as the larger algorithms.

Monty: The general ideas of the evaluation functions were pretty much shared.

Q: <inaudible>

Monty: Well, perhaps the key part of the evaluation functions might have been how you handle pawns, to some degree. Pawns and king safety are tricky. Every program probably had different algorithms for how much credit to give the pawn structures from the standpoint of connectivity, advancement. I guess maybe those two factors are the two general terms, connectivity and their advancement. You wanted to keep your pawns connected. You wanted to advance them. You wanted to have them not in the same files; that's a simple one. Pawn structure was probably the most important and worked on aspect of the scoring functions, I think. Of course, the king safety was important. Then a whole slew of other heuristics - using your rooks effectively, getting control of the right files with your rooks, heuristics for your bishops to keep them on open diagonals. The scoring functions were very important. Every program was slightly different, but they all had generally much the same factors involved.

Q: When IBM brought in some grand masters at the time of the '97 rematch, how much do you think that shaped the power of Deep Blue?

Monty: Well, it definitely helped. They probably added some important lines to Deep Blue's opening book. It's not clear how effective that was, because Kasparov was always trying to find lines that were a bit obscure in that sense. They probably added anywhere from 25 to 50 rating points to the program. That'd be my guess. I think that's a tough one to put a number on.

Q: Can you speculate on the nature of the interaction that a person like the grand master has with computer?

Monty: Well, things like when to move rooks to open files, when to open a file up, when to trade off pawns, when's best to push a pawn, when do you give up on a pawn, when is a sacrifice worth it. When does it make sense to trade off? Do you want to trade off in a situation to get to a simpler situation, or do you want to keep the game complex because the complications are going to work to your favor? I guess that's a number. I think you might have to talk to a grand master to see what he says on that, but that's my answer.

Q: Is there some way in which Deep Blue is embedded in human knowledge? People who don't know say that it's just a machine, but the people who can make the most realistic claims are usually the scientists who build these machines. It's the media, and to some extent Kasparov, who framed the whole contest as man versus machine. It does seem that there's a lot of embedded human knowledge in Deep Blue. In a way, it's like Kasparov was playing against hundreds of masters and grand masters, because all of these games are either in an opening book or endgame database that he doesn't have access too – well maybe a small fraction of them.

Monty: Well, he was not beat by the endgame databases, and he wasn't beat by the opening books. We have to look and see why he was beat. That's a complicated question, but he wasn't beat by the endgame databases. I think Deep Blue could've played without an endgame database and the score would've been the same. The opening books – the opening books were not a deciding factor, either. But it was Deep Blue's ability to look at millions and millions of possibilities in each position, I think. Between the 20^{th} and 30^{th} moves, when a certain amount of material had been traded off, and often the positions were very complicated, Deep Blue did very well in the game.

Q: The Deep Blue story is very interesting. You've written quite a lot about that – a couple of books, which qualifies you. What are some unique things about that effort? Especially the kind of fresh grad student who came in, not even a chess player, to CMU's department where they had some existing chess efforts. I don't mean to stir things up here, but just in general how outsiders – and Ken Thompson's Belle may be another one – has this way of looking at the problem in a fresh way.

Monty: I'm not sure. CB ["Crazy Bird" Hsu] was a special guy. CB and Murray [Campbell] were, in some sense, two contrasting guys from the standpoint of their existence beyond chess. Of course, CB's whole life was chess. Murray was a guy who was a family guy. He had a wife and somewhat of a normal existence. To put things in perspective, when CB was hired by IBM, he moved to New York and was so busy with his work on Deep Blue, according to Murray, that he didn't have time to get himself a bed at home. As I understand it, he slept on the floor for some period of time, until Murray Campbell's wife decided that he needed a bed. So Campbell's wife went and helped CB get a bed, I think. I'm not sure of the exact story, but it puts CB's mentality in perspective. He was a workaholic on Deep Blue. Murray was, I wouldn't say "9 to 5," but he was more a professional at it as opposed to an addict. I mean, CB was an addict. Perhaps the people that were at the top of the pack of the chess programs were addicts by the time they were done.

Q: Do you think they needed to be?

Monty: Well, they enjoyed it so much. It's very addictive. Everybody was addicted to a certain point. I mean, Berliner was a total addict. Hyatt was an addict. The Northwestern bunch were an addict during the time. Ken is an addict. I mean, it's a reasonably healthy addiction, but it's an addiction nevertheless. CB was perhaps the ultimate addict. I don't know if I answered your question exactly there.

Q: I wanted to talk about computer chess as it is today. I was on the web this morning and noticed that Novag, which I believe is Lang's company, has little machine that plays chess at the level of 2500 for $30.

Monty: That's incredible.

Q: How does that feel to you, to have been there at the beginning and now have something that fits in your hand?

Monty: Well, it's fantastic because, of course, when I was a kid, the idea of playing with a master was beyond imagination, and the idea of grand master was out of the question. We all wanted to play against masters or grand masters. I guess my own personal first experience with playing a master was my freshman year in university. That was a very exciting experience! It was a simultaneous exhibition. It wasn't even one to one. To imagine now that the average kid who's eight years old can go down to the store and buy a grand master to go home and play with for $30 is an amazing change.

Q: You know Marshall McLuhan, of course. He had a great line. He said, "We shape our tools and they, in turn, shape us." As you just said, these kids can go down and get this. Do you think this might create human players of incredible skill?

Monty: Well, I think so. I think the human was getting better anyways, probably. I think there's some hereditary selection going on, just like sports. The human race is cracking records in the 100 meters. Every Olympics has new records set. The human, physically, is getting stronger, and I think that the human mind is probably being tuned in some way. It's a much more difficult way to measure, but the human mind is being improved. Tennis rackets get better, and the tennis players are getting better because their tools are better. The tools that our minds are working with are getting better as well, so our mind is probably getting better as well.

Q: That's a good way to look at it. Is there anything else you wanted to say? At the beginning, you started with the nature of consciousness and how a machine doesn't know it's alive. Is there anything you want to say about this grand journey that you went that solved this problem of computer chess?

Monty: Well, what else would I say? Well, we have a number of frontiers in science these days and, of course, the mind is one of them. At a religious level, you wonder to what extent does the mind live on. You get into the world of religion if you go too far in that direction. Of course, if you go in another direction, you ask whether there's other intelligent life in the universe, or was there intelligent life on Mars. Chess is one little spot in this exciting question of where we are in this universe intellectually. I don't know how much of it I'm going to figure out in my lifetime, but the more the better.

Q: One thing that Murray Campbell said in an article in Scientific American was, "With the Deep Blue project, we were going to find out whether the computer needed to be really intelligent to play chess, or whether chess did not require intelligence." That's a really interesting question. Do you have any comments on that?

Monty: Well, chess is a computation. The bottom line is it's a computation. The real question is what isn't a computation? Of course, when we started with chess and computers, people were arguing that you couldn't program intuition into the computer, that the human, when he played chess, had a certain intuition that we'd never be able to copy. Of course, that didn't pan out. The real question is where does computation end? What makes us know that we are who we are? I think that's the big question.

Q: That's great. Thank you.

END OF INTERVIEW

