What Computers Might Be Able to Do

By William M. Bulleit, Ph.D., P.E.

In the November 2009 issue of STRUCTURE, Jon Schmidt's InFocus column discussed "What Computers Can't Do". In principle, I agree with his major conclusion: "…engineering is – and probably always will be – something that computers can't do." However, just because computers appear unlikely to emulate *all* human abilities does not mean that they cannot do much more to enhance engineering design, and possibly even appear 'intelligent' as they do so.

Garry Kasparov reportedly said, after losing to Deep Blue in chess, that he felt at times that he was playing against an "alien intelligence." This is probably because even though Deep Blue had a significant amount of chess knowledge programmed into it, it also had the ability to search deeper into the space of possible moves than any human ever could. This ability, due to its high computational speed, allowed it to make moves that appeared "alien" to Kasparov, because *no* human would know to make them. Raw computational speed is one area where computers can do things that will never be possible for humans to do.

When it comes to structural engineering, the first thing that computers might be able to do is to search the "design space," the range of possible solutions, in a much more complete manner than we humans can. A computational method called a genetic algorithm (GA) uses evolutionary computing techniques to do this. The potential options are placed into a mathematical chromosome, and then pairs of chromosomes make new ones by combining parts of themselves in a process called crossover. Although other evolutionary mechanisms are used, the primary one other than crossover is mutation.

A cost function is used to tell the GA which regions of the design space are most promising. The cost function can include any information that can be obtained from whatever type of analysis is being performed. For instance, using BIM, the GA could consider a wide range of factors, including building topology. The only real limitation is computational speed. The GA could find a set of promising designs and send them out to the engineer, who could then do the human part. A GA, as described, might send out possible designs that no one had ever considered, and some of them might prove to be excellent. The GA might even appear to be an "alien intelligence."

The next thing that computers might be able to do is to learn from past decisions and designs, and store that learning using an artificial neural network (ANN), rather than something like a database. Your brain resembles a giant neural network with billions of tiny computational elements (neurons) communicating with each other through trillions of connections (synapses). ANNs simulate brain behavior, using hardware or software.

Someday, for structural engineering, a massive ANN may store a vast quantity of past designs, in a way more like how we remember things, and be more adept at bringing those memories out for use by the engineer. The difference from a human is that the ANN will be dedicated to remembering designs and will have significantly greater computational speed. The combination of GAs with ANNs could lead to long-term probing of design spaces, and take structural engineering far beyond what we can now do.

As a third example, in Jon Schmidt's InFocus column in the March 2007 issue of STRUCTURE, he wrote about "Risk-Based Design". He divided hazards into three types, where the third included malevolent hazards such as crime, sabotage, and terrorism. These hazards are hard to incorporate into design because development of appropriate design criteria is difficult. A possible solution is to use agent-based modeling (ABM), a computational technique presently beginning to show promise in social science simulations. In ABM, living entities are modeled as computational agents who interact with an environment and with each other. In the case of humans, the agents would have to be complicated enough to model the behaviors that are necessary to cause them to produce the effects that are being examined; e.g., terrorist attacks.

ABM has been used with fairly simple agents to model civil violence and has been used to examine human egress from buildings in emergencies. The ability to model and predict terrorist attacks or sabotage, at least for development of design criteria, is not yet possible; but it likely will be in the not-too-distant future. Then we, as structural engineers presumably in concert with social scientists, may be able to develop design criteria for malevolent hazards using a combination of agent-based simulation and appropriate data. Agent models may also be used in scenario analysis where the simulation can help decision-makers open their minds to possible types of situations that they may not have considered otherwise.

So, yes, there may be a number of human behaviors that computers are unlikely to be able to perform; but, there are a number of situations where computers almost certainly can perform better than humans. I think that it would be advisable for us to consider how computers can help us perform more effectively as humans, rather than worry that computers will outperform us.▪

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