An Interactive Consultant

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"Augmented Intelligence" describes systems where human and machine work together and learn how to solve a problem by taking advantage of their respective strengths.

In a joint man-machine cognitive system[5], the human and the machine play specific roles. The human collects relevant information about his environment and goals, and translates them into a language understandable by the machine. The machine then makes a recommendation. Finally, the human evaluates the recommendation. If the recommendation is appropriate, he applies it to the environment; otherwise, the human changes his translation for the machine with the hope of getting a better recommendation.

We propose a machine to whom the user describes his knowledge about a class of problems in a very expressive language: first order logic with arithmetic[4], as taught to many students in secondary schools. We call it an interactive consultant. The originality of the approach comes from the use of the universal mathematical language to embody knowledge. Behind the screen, we use advanced reasoners capable of solving complex problems.

Indeed, we humans have the peculiar ability to recognize the similarity between different situations. Within a particular class of situations, we characterize each situation by a set of characteristics; we describe each specific situation in that class by giving different values to these characteristics, by observation or by imagination. Finally, using some rules or laws combining these characteristics, we make the judgment that a particular decision is possible, acceptable or desirable in a given situation.

This set of characteristics and their domain is the vocabulary with which we construct mathematical formulas that embody the laws that must be respected when searching for a recommendation. We propose to feed these vocabulary and laws to our interactive consultant, so that he can help us reason with them rigorously, and reach correct decisions in particular situations.

The resulting interactive consultant is general purpose, and can be reconfigured without programming to answer questions in engineering (e.g., configuration management), law (e.g., tax adviser) or commerce (e.g., loan decision). It is available online,[1] and is presented in a video.[2]

In engineering, the physical laws and rules of thumb used in the design of industrial seals have been codified and fed to the interactive consultant, so that,

given some customer requirements, he can make design recommendations, e.g. for the choice of material and lubricant. The knowledge base is enriched as the engineering team gains more experience.

In a notary application, the interactive consultant has been told the rules that determine the duties to be paid following the purchase of a house. The purchase is described by up to 27 variables. After the notary enters specific values for some of these variables, the machine makes a concrete recommendation.

Our implementation of the interactive consultant is based on Microsoft Z3[3], a solver that can find solutions to complex problems expressed in first order logic and arithmetic formulas. While typically used for software verification, our research showed that Z3 can be used in knowledge base systems too.

Our interactive consultant has two modes of operation. The first mode is used to enter general knowledge over a class of problems, while the second mode is used to enter knowledge specific to a problem at hand and to obtain recommendations. From the mathematical description of the problem entered in the first mode, our tool automatically generates an interactive website to elicit information about the specific situation, and to show the recommendation. When the user enters information in the second mode, the user interface is updated to reflect its logical consequences, given the general knowledge of the problem entered in the first mode.

The user can ask the interactive consultant to explain how it derives these consequences. It lists the relevant information given by the user concerning the particular situation, as well as the laws in the knowledge base that lead to the derivation. The system can find a solution that maximizes a utility function, given the constraints. In simpler problems, the user may ask instead for any concrete solution compatible with the general knowledge and the particular situation. When enough information is entered, the values of all symbols become fixed: the user can then see the recommendation for his decision. He can also obtain explanations on how the recommendation was reached.

As the world around us becomes more complex every day, we seek to make expertise more accessible. In future work, funded by the Flemish Impulsprogram on AI, we plan to investigate how to guide the conversation with the user to solve a specific (sub-)goal, how to compute a recommendation based on uncertain information or laws, and potential applications in the belgian judicial system (e.g. alimony calculation).

References

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