The Geometrician: a Computer Prototype of Problem Solving in Geometry Construction

Edgar R. Acosta Villaseñor (avillase@connect.carleton.ca)
Institute of Cognitive Science; 1125 Colonel By Drive
Ottawa, ON K1S 5B6 Canada

Rafael Pérez y Pérez (rpyp@servidor.unam.mx)
Instituto de Investigación en Matemáticas Aplicadas y en Sistemas
UNAM, Mexico, DF 04510 Mexico

Keywords: creativity; problem solving; geometry.

Introduction

Most theories of creativity assume the interaction of two kinds of cognitive processes: the generation and evaluation of possible ideas (Sternberg & Lubart, 1999). Pérez y Pérez and Sharples (2001) described in great detail both processes in their Engagement-Reflection computer model of creativity (E&R model). Originally the model was developed with the aim of describing in detail a cognitive account of creative writing. As a way to improve the model, and to evaluate its potential for problem solving, a computer program based on the E&R model known as the Geometrician was implemented.

The Geometrician

The Geometrician solves geometry construction problems in which, given some initial geometric objects (e. g. points, lines), new geometric objects are constructed employing only a straightedge and a compass. The E&R model, and its implementation in the Geometrician are outlined in this document.

Engagement & Reflection

The E&R model establishes that all knowledge structures in the system are created from a set of previous solved problems provided by the user. Once these structures are created the system starts to solve the problem through a cycle between two processes: engagement and reflection. Engagement is the generative process in the E&R model. During engagement, the system employs the problem's context as a cue to probe memory and retrieve a set of possible actions to perform in order to solve the problem. After a number of actions are produced, or if the system is unable to retrieve more actions from memory (i. e. if an impasse is declared), the reflection process takes control.

During reflection, the system evaluates the actions generated so far and eliminates those that are not useful to solve the problem, checks the coherence of the sequence of actions generated during engagement, tries to break impasses, determines whether the problem has been solved, and generates a set of guidelines that drive the production of material during engagement. Then the system switches back to engagement. In this way, the outputs of the system are the result of the interaction between engagement and reflection.

The cycle ends when the problem is solved or when it is impossible to break an impasse. Each time a problem is solved, the solution is added to the system's knowledge base.

Implementation

The actual implementation of the Geometrician does not embody the whole E&R model (e. g. the function to eliminate useless actions has not been finished yet). However, the Geometrician contributes with some characteristics not present in the original E&R model, as for example the capacity to execute the E&R cycle recursively to solve sub-problems of the current problem. A sub-problem is created each time the sequence of produced actions lacks coherence.

Discussion

The prototype provides some insights on how useful the E&R model is for problem solving in geometry. In an experiment the Geometrician was provided with an initial knowledge base consisting of 3 solved problems. With this information the system was able to solve four new and more complex problems.

Another interesting feature of the model is that different solutions were produced on different runs. This occurred because the search on memory could retrieve more than one candidate action, and the engagement procedure selected only one. Thus, the decisions made by the system influenced the way in which the problem was solved.

Conclusion

Although the Geometrician is just a prototype subject to further development, the interaction between the engagement and reflection procedures proved to be useful on problem solving.

References

Pérez y Pérez, R., & Sharples, M. (2001). Mexica: A computer model of a cognitive account of creative writing. *J. Expt. Theor. Artif. Intell.*, *13*, 119–139.

Sternberg, R. J., & Lubart, T. I. (1999). The concept of creativity: Prospects and paradigms. In R. J. Sternberg (Ed.), *Handbook of creativity.* Cambridge University Press.