occupied squares "alive" and the unoccupied squares "dead." The rules he developed were applied to each cell on the grid in turn. After the rules had been applied to all of the cells, the grid was updated to reflect the new values of the cells. The rules are then applied to each cell again. Each application of the rules is considered one generation.

In this project, a series of Pascal programs were written that applied a simple rule structure to a simple set of building elements: a column, a beam and a wall. A slightly modified version of the Life rules is used by the program, which displays each generation in a 2-D (plan) view. Interesting configurations can be imported into Alias UpFront and displayed as a 3-D surface model.

Rules for Columns:

Initial Cell Value	Number of Neighboring Columns	Cell Value in Next Generation
Empty	1 or fewer	Empty
Short Column	1 or fewer	Empty
Tall Column	1 or fewer	Short Column
Empty	2	Empty
Short Column	2	Short Column
Tall Column	2	Tall Column
Empty	3	Short Column
Short Column	3	Short Column
Tall Column	3	Tall Column
Empty	4 or more	Empty
Short Column	4 or more	Tall Column
Tall Column	4 or more	Short Column

Rules for horizontal elements (walls and beams):

Target Cell Value	Contents of Cell Right of Target	Contents of Cell Below Target	Inserted
Short Column	Short or Tall Column		Wall
Short Column		Short or Tall Column	Beam
Tall Column	Tall Column		Wall
Tall Column		Tall Column	Beam

RESULTS

By the repeated application of the rules, organized structures emerge. Different morphologies can be created by changing the initial data file (which represents an initial configuration of columns). An unexpected result is that if the original data file is symmetrical, the resulting morphologies will be symmetrical.

A NEW TYPE OF AGENT

Investigative agents are used as part of a dialogue, where the designer must first ask the question, then investigate answers through the use of the agent. With the Artificial Life agent, however, *the agent does not wait for the designer to ask the question*. By using this type of agent, we are using the computer as more than investigative agent as a *generative agent*, which proactively gives information to the designer. A generative agent is a new type of agent, one that has been made possible only by the advent of the computer. We have

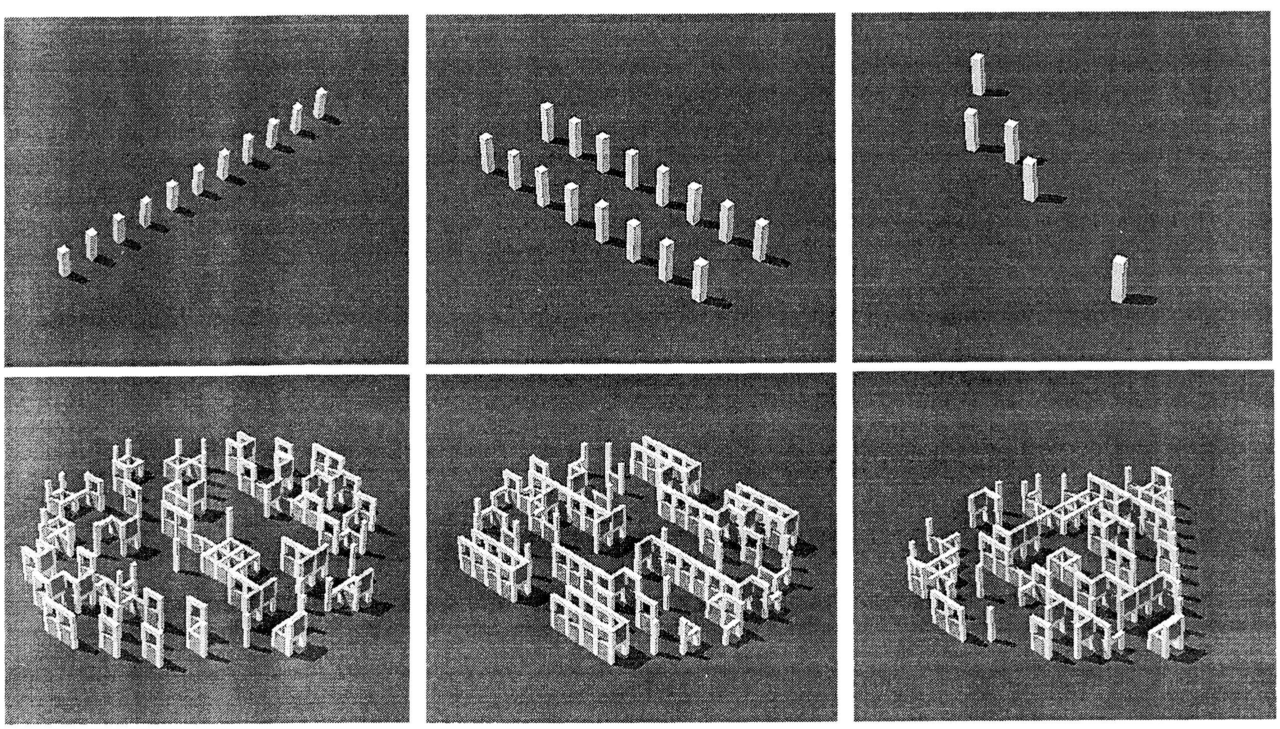

Fig. 1. The top row of pictures displays three different starting configurations. The result of each starting configuration after 12 generations is shown in the second row. When the initial configuration is symmetrical, each subsequent generation is also symmetrical.

no other means of obtaining this type of information.

Using the concepts of Artificial Life in the form of a generative agent has several benefits:

It uses existing hardware and inexpensive software (total development costs for a Pascal compiler and a copy of Alias UpFront: under $200).

What the computer is doing is simple, transparent and understandable by inexperienced computer users, who may be unsure of just how much "thinking" their computer is doing.

The Artificial Life agent does not try to replace the human designer with a computer program. A human designer possesses attributes such as intuition, experience and cultural values that cannot be duplicated by a computer now or in the foreseeable future. The emphasis is not on duplication of human talents, but on the unique attributes inherent in the computer, and how these can be best used to complement the attributes possessed by the human designer.

The computer is uniquely suited to generation, organization and presentation of data, while the human is uniquely suited to understanding relationships and patterns in that data. This is what the Artificial Life agent does, tirelessly generating and presenting data. Once the data has been organized and displayed by the computer, the designer can begin the process of making sense out of what is displayed. However, as with other agents, the designer should not be a passive interpreter. The designer can influence what sorts of morphologies are generated by changing the initial data file, changing the rules, the structural elements or the configuration of the grid.

The results are free from the preconceived ideas of the designer. One cannot tell by looking at a table of the rules what emergent morphologies will be generated by those rules. Each generation brings something new and surprising.

Perhaps most importantly, working with this agent is fun. Watching the computer generate the structures is fascinating, and has the aura of a game. Working with the results in UpFront is easy, fostering an attitude of play.

A generative agent may also suggest changes to the design process. The Artificial Life generative agent is not amenable to top-down, functional decomposition types of design. It suggests a design process that is instead bottom-up, beginning with elementary components, and letting the computer make suggestions about how those components could go together to produce an organized morphology. The design concept does not have to come from elsewhere, but could be suggested by the generative agent. The designer watches and interprets the results, looking for emergent morphologies that suggest an interpretation, or multiple interpretations.

The agent generates suggestions so rapidly that many concepts could be explored. The designer would have the luxury to discard concepts that are not promising, without worrying that another idea may not be forthcoming.

FUTURE PLANS

Future plans call for the development of an interface that would turn this prototype into a full-fledged generative agent. Its uses could then be more fully explored by myself and others. The ultimate goal is to explore evolution of structures by making it possible for users to combine sets of rules. By selective combination of rules that achieve desired morphologies, it should be possible for the designer to practice a sort of genetic engineering, breeding structures with desired characteristics. It may be possible to "evolve" two or more systems to work together i.e., a structural system that evolved in response to the characteristics of a mechanical system or vice versa.

It would also be interesting to explore the effect of using different elementary components. Currently, the computer

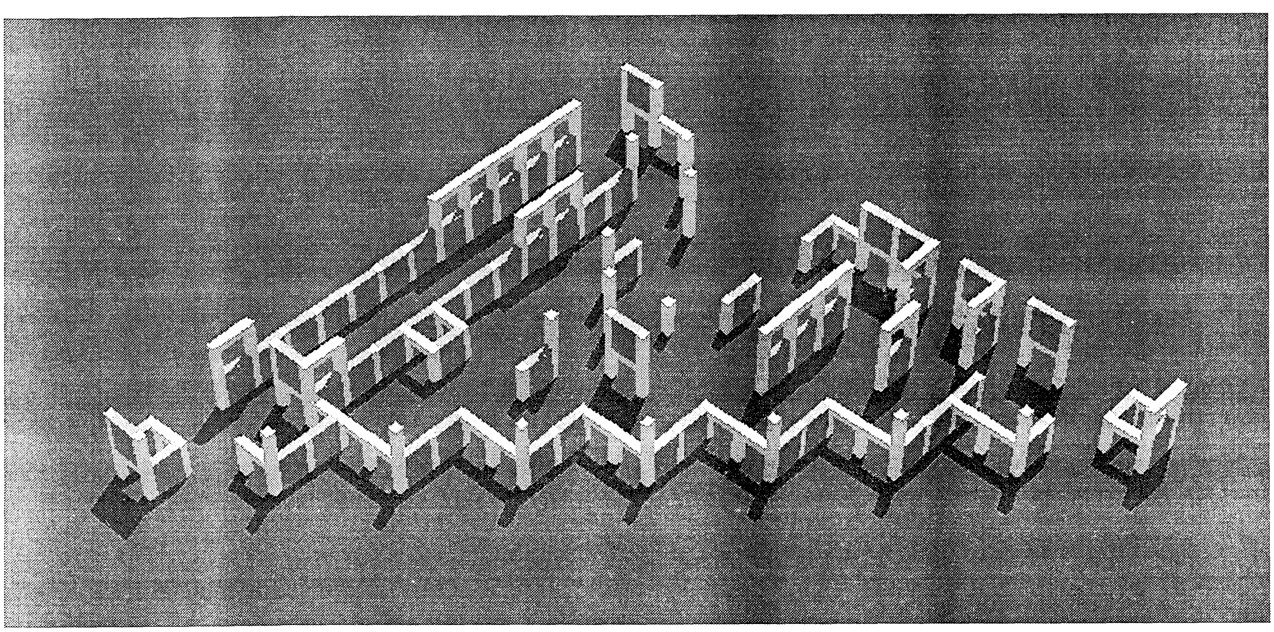

Figure 2. Beginning with three columns in a corner of the 30-by-30 grid, the above morphology emerged after seven generations.

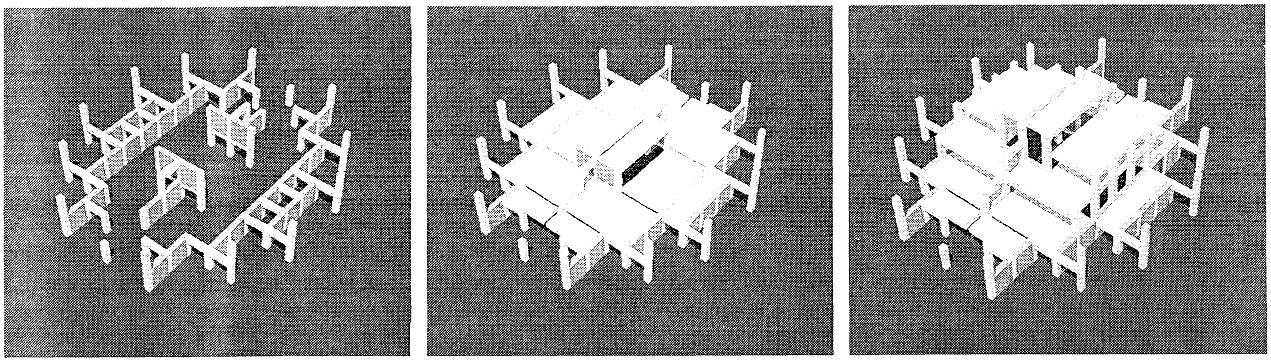

Figure 3. The designer takes an interesting morphology (left), and sees in it an intriguing idea of pieces being "slid out" from the center. The designer next choses to add horizontal planes as "roofs" (center), and from there continues to expand upon the suggestion originally given by the computer (right). The whole series took five minutes to generate.

generates suggestions at a fairly abstract level, due to the abstract nature of the column, beam and wall. This level of abstraction invites quite a bit of interpretation from the human designer. Other levels of abstraction might suggest ways in which this generative agent could be used at different phases of the design process.

We have on our desktops now more computing power than could be imagined a decade ago. I believe that generative agents will be a key to more fully utilizing this power. As we search for and develop such agents, we may begin to see the fullfillment of the dream of a true partnership between humans and computers.

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