Artificial Life in Haptic Virtual Environment

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abstract: This paper describes about a method for interaction with emergent objects in virtual environment. We have developed a software tool for programmers of virtual environment called VECS (Virtual Environment Construction System). VECS manages attributes of virtual objects and physical law. Artificial life is implemented as a user application of VECS. A tree-like virtual object is selected as artificial life. Growth of the object is determined by randomly selected ramification. The system enables the user to direct manipulation of artificial life. Time, congenital characteristics, and acquired characteristics are interactively controlled by the user. These operation is done through an 8 degree-of-freedom force display.

1. Introduction

Design of 3D shapes is a major application area of virtual reality. Direct manipulation of 3D shapes has been realized in virtual environment. In this case, shape of the object is originally determined by a human designer. This paper proposes autonomously growing objects in virtual environment. Designers are often inspired by shapes of living creature.

Creation of living systems by computer software is called artificial life. The major objective of research on artificial life is duplicating the emergent mechanics of biology[1]. We tried to introduce the emergent mechanics in virtual environment. The user of our system can interact with artificial life in its morphological process. Parameters of congenital characteristics can be interactively changed. Shape of artificial life can be directly manipulated by the user during its growing process. In this way, autonomous shape and intentional shape are mixed.

Manipulation of virtual objects essentially requires force feedback. We have developed a software tool for programmers of haptic virtual environment called VECS (Virtual Environment Construction System). In this system, controller of force display, description of virtual space, and user application are divided into modules. Artificial life is implemented as a user application of VECS.

2. Virtual Environment Construction System

Virtual world technology usually employs various types of input/output devices. In case of haptic virtual environment, methods for force feedback are at a fumbling stage. We have developed several kinds of force displays. Software of virtual environment has been tightly connected to control program of force displays. This problem is a hazard for development of further application of haptic virtual environment. Therefore, we developed a software tool for programmers of haptic virtual environment, in which control program of force display, description of virtual space, and user application are divided into modules. The system is called VECS (Virtual Environment Construction System). Basic structure of VECS is illustrated in Figure 1. Various types of force displays can be plugged into VECS. The system supports two force displays. Two users can simultaneously interact in the same virtual environment. This function enables easy construction of groupware program[2].

Physical laws for the virtual world are contained in VECS. Gravity, elasticity, and viscosity are currently implemented. Collision between virtual objects are detected in real time. Shapes and attributes of virtual objects are defined in the user application module. Users of VECS programs the methods for interaction between virtual objects and operators.

Software configuration of VECS is illustrated in Figure 2. VECS is composed of following three programs:

(1)program for object data
  supervising behavior of virtual objects
(2)program for device data
  communication with force display
(3)program for application data
  detection of user intention and updating virtual environment

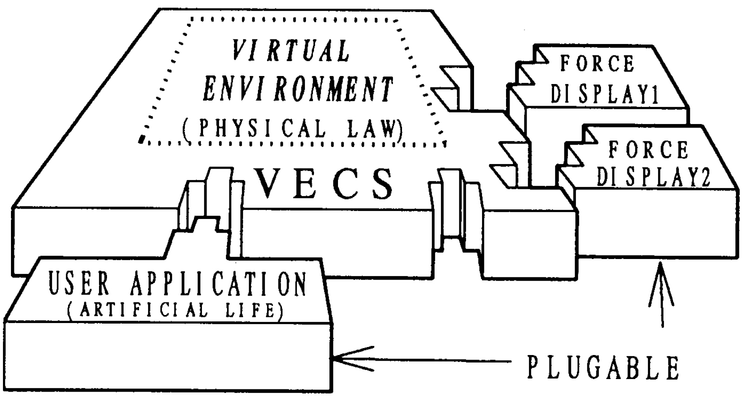

Figure 1. Basic structure of VECS

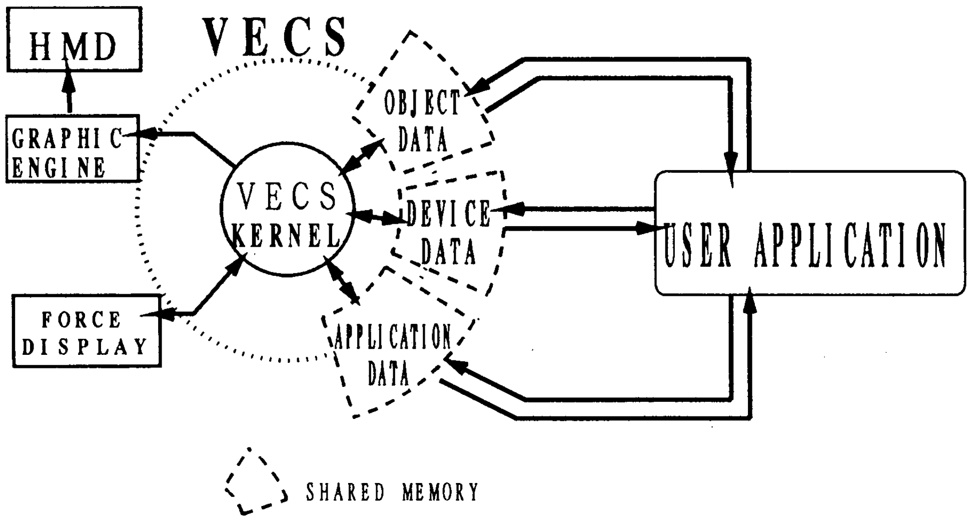

Figure 2. Software configuration of VECS

Dividing into these programs, force displays and physical laws in virtual environment are easily reconfigured. Moreover, this system defines "time" of virtual environment. Time of virtual environment increases independently from the user. This function enables autonomous growth of virtual objects.

VECS is composed of two processes: kernel and user application. Kernel of VECS determines behavior of virtual objects and generates graphic image of virtual environment. This process runs autonomously. User application determines the methods for interaction between virtual objects and operators. Shared memory is used for communication between these processes.

VECS is currently implemented in HP9000/425t with personal VRX graphics engine. Exchanging graphics library, the system can be ported to other graphics work station.

3. Force Display

An 8 degree-of-freedom force display is connected to VECS. The force display is composed of three parts: 3 degree-of-freedom pantograph link, three-axis gimbal, and 2 string tensioners for thumb and index finger[3]. Overall view of the device is shown in Figure 3. The pantograph link has approximately same working area as a human arm. The three-axis gimbal enables the operator to easy rotation of the hand. Each joint is equipped with a DC motor. The maximum generated force is 400gf, and the maximum generated torque is 200gfcm. The string tensioner presents rigidity of virtual objects.

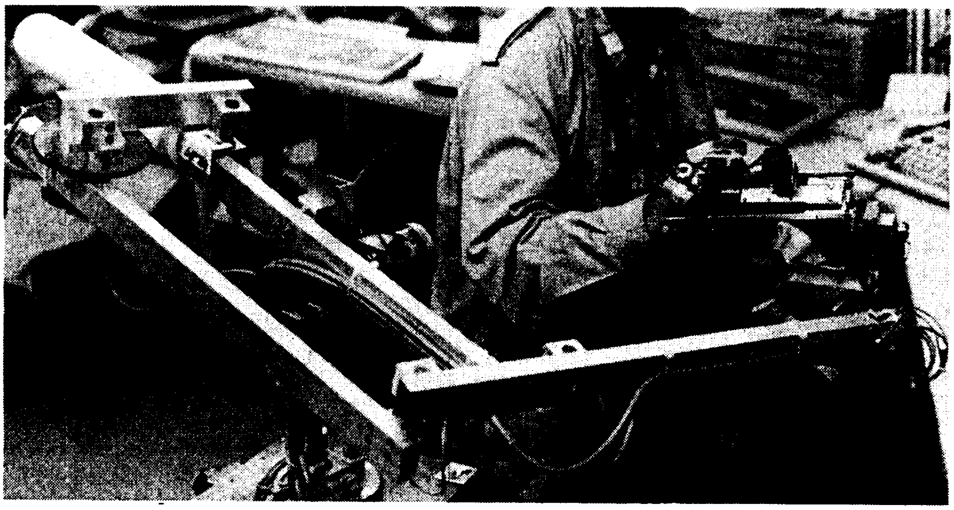

Figure 3. Force display

4. User Interface of VECS

Visual image of user interface of VECS is shown in Figure 4. The user of the system sees his/her virtual hand, virtual objects, and virtual control panels. Virtual control panels include buttons or slide bars. Command input and parameter setting are done through these devices. If the virtual hand comes close to these buttons, the hand is pulled toward the center of the buttons by force display. This applied force assists the user to operation of control panels. If the user grasp the button, the color of the button changes and command is input. VECS supports two force displays, and two users can simultaneously interact in the same work space as shown in Figure 4.

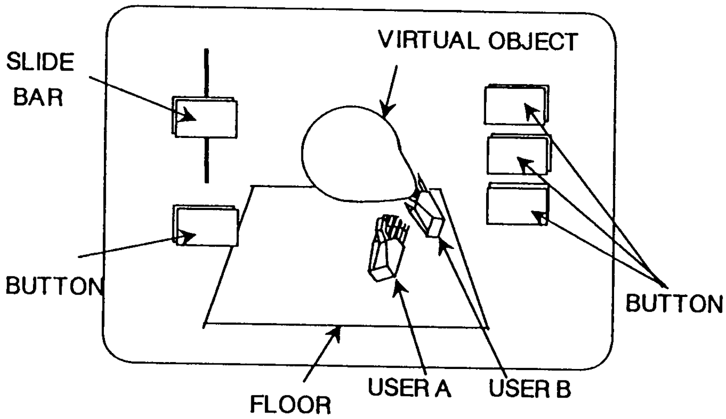

Figure 4. User interface of VECS

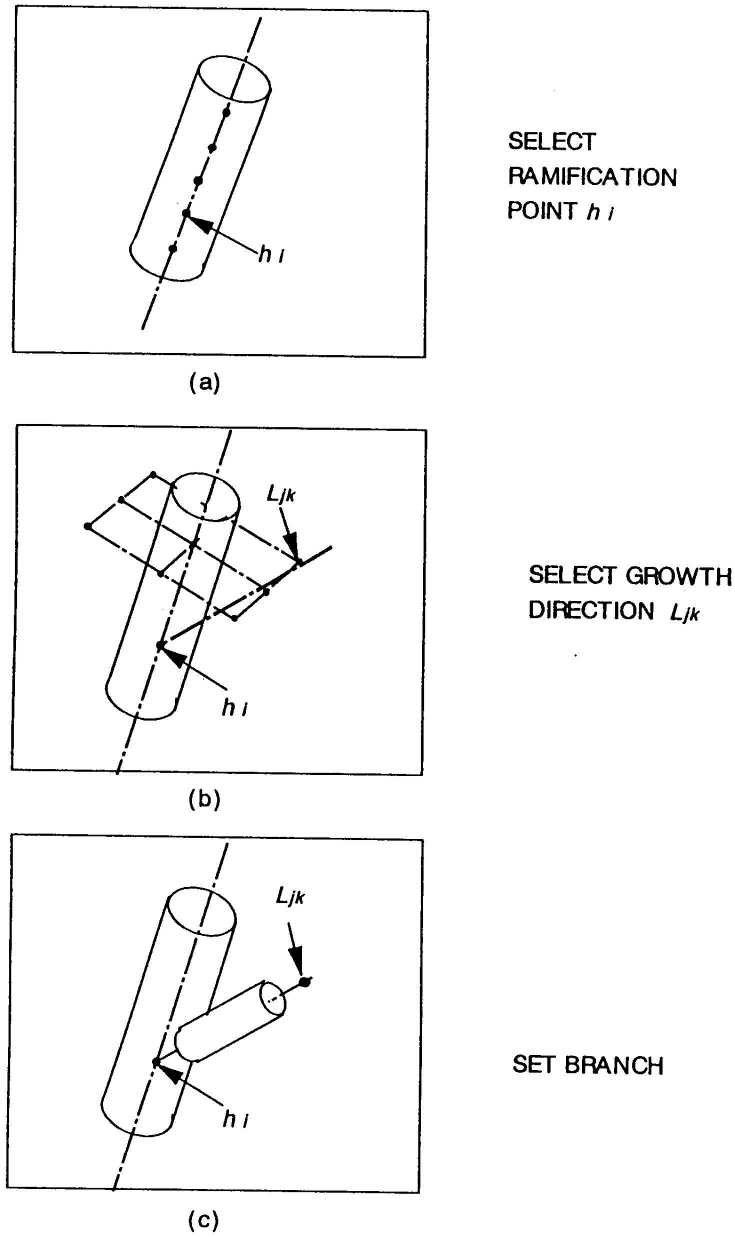

Figure 5. Principle of growth

5. Direct Manipulation of Tree-like Artificial Life

A tree-like virtual object is selected as artificial life. Principle of growth of the tree is illustrated in Figure 5. A cylinder in the figure indicates the trunk of the tree. The length and diameter of the cylinder increases according to the time clock of VECS. Ramification occurs in preset frequency. At first, ramification point h_i is randomly selected from five points as shown in Figure 5(a). Then growth direction L_{jk} is randomly selected from eight point as shown in Figure 5(b). After these selection, new cylinder appears(Figure 5(c)). This principle is applied to the new cylinder. Figure 6 shows an example of growing process.

The user can directly manipulate the tree-like artificial life by three parameters: time, congenital characteristics, and acquired characteristics. The time of the virtual environment is controlled by four buttons: start, stop, fast forward, and reverse. These buttons are set at the left hand of the virtual environment(Figure 6). Operation of the buttons is similar to that of VCR. Congenital characteristics is determined by frequency of ramification. The frequency is controlled by a slide bar which is located at the right side of the virtual environment. Figure 7(a) shows an example of growth with large frequency of ramification. Figure 7(b) shows an example of growth with small frequency of ramification. Acquired characteristics is determined by chopping off the branches by the user's virtual hand. Branches can be chopped off at any ramification point while the tree is growing. The user can intentionally form the final shape of the tree. This procedure is similar to "*bonsai*" or dwarf-tree culture.

6. Conclusions

We have developed VECS and tree-like artificial life. The tree-like artificial life grows and directly manipulated in real time. Principle of our current artificial life is fairly simple. However, Principles of living systems are very intricate. Implementation of complex mechanics of lives such as mutation or adaptation may leads to more interesting results.

References

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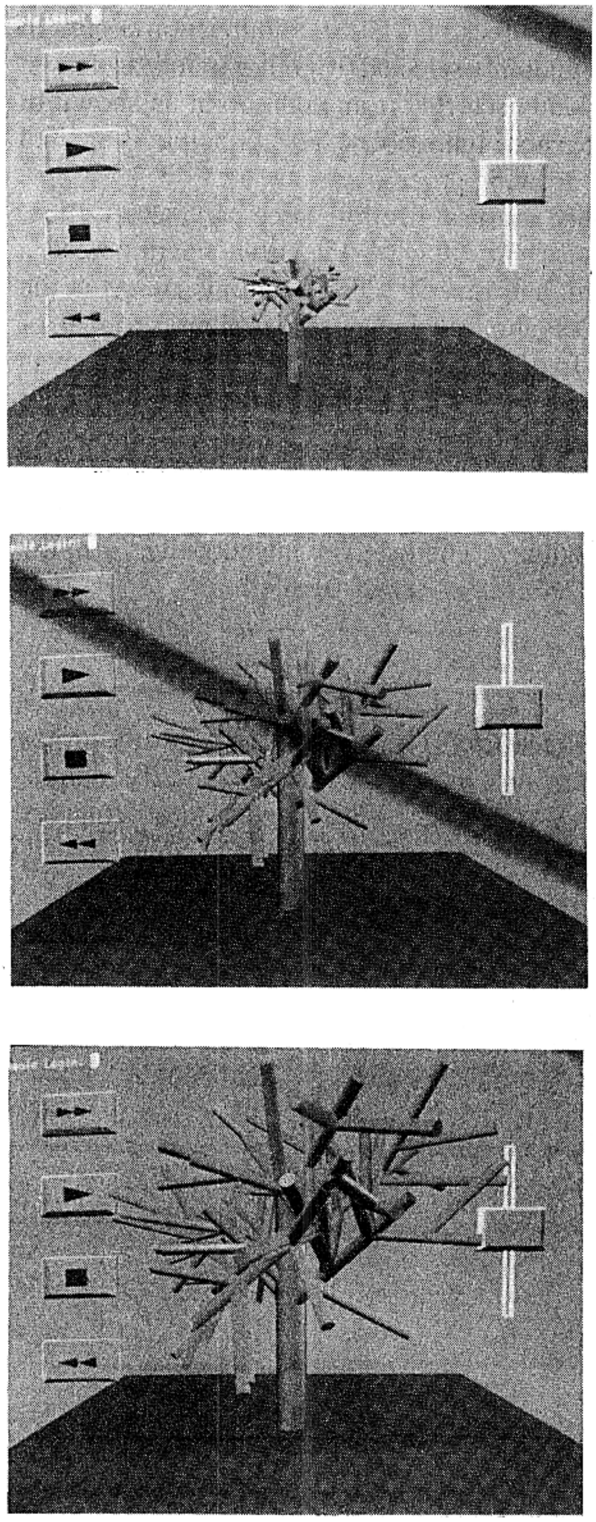
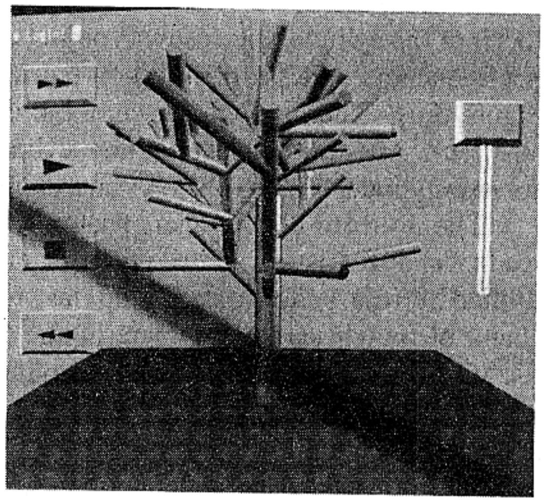
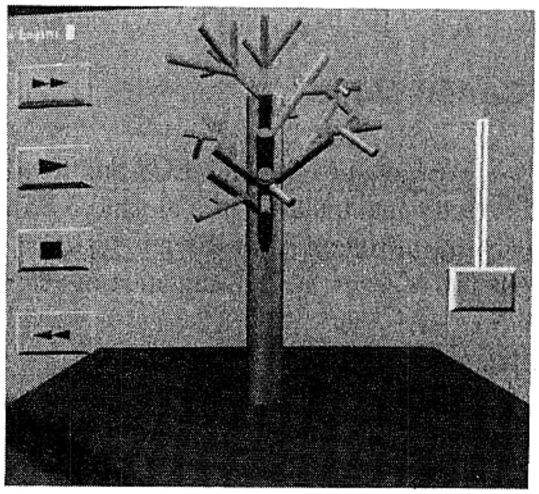


Figure 6. An example of growing process



(a)



(b)

Figure 7. Examples of modified ramification frequency