# The Terrain Surface Simulator ALF (ALive! Floor)

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## Introduction

In recent years, we have been developing several virtual reality (VR) devices and systems aimed at creating more sophisticated virtual environments. In this paper, we describe a terrain surface simulator system called the ALF (ALive! Floor). Designed for somatic interaction in a virtual environment, the ALF system is a mechanical device for simulating a natural terrain surface. The ALF system can simulate terrain surfaces ranging from flat and smooth to rough and bumpy, similar to a natural field. Users can walk on the simulated terrain.

This paper describes the objective and background of this ALF development program, the basic idea of the ALF system, the technical basis of its implementation and an overview of the first prototype system development.

## 1. Objective and Background

In current VR technology, there are many research and development programs that are attempting to create high-fidelity simulated real worlds or enhance the reality of the real world in a virtual world. Most of these programs focus on the visual reality of a simulated world, because visual information is the most effective media for the human cognition process and is easy to generate using computing technologies such as three-dimensional computer graphics (3-D CG). However, humans also have auditory, tactile and somatic sensations. These sensations are a very important part of the whole human sensory mechanism, but current VR technology does not have the ability to stimulate them. This is a big problem in creating high-fidelity simulated worlds. To cope with this problem, we focus on the somatic sensation and somatic interaction. The somatic sensation includes the generic feeling of motion and posture, and is effective for giving non-verbal or non-symbolic information to human. We assume that the somatic sensation is an important factor in interaction and that it is also a missing part of existing virtual environments. We intend to create an effective somatic interaction device and system. This ALF development program is one part of this aim.

The ALF system can simulate a terrain surface as a natural replacement for a real surface in a simulated world. This is also a novel device in VR technology. Here, we assume that the footing surface is a key point in somatic sensation, because the shape of the surface strongly influences or restricts human posture and motion.

## 2. Basic Idea of the ALF system

The basic idea of the ALF system is very simple. As shown in Fig. 1, the ALF system basically consists of a movable floor, actuator units and an actuator controller. The movable floor consists of many pieces of small tiling panels in a matrix, and these tiling panels can elevate to a

3.2 Methodology of Surface Patching

As we mentioned previously, the movable floor consists of many tiling panels. Here, the methodology for the surface patching of the movable floor is a very important point in implementation, because it is closely related to the complexity and difficulty of system configuration. The most simple methodology is a one-to-one combination of each tiling panel and actuator unit (Fig. 3).

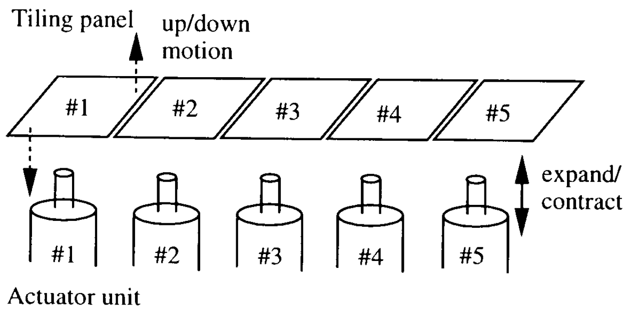
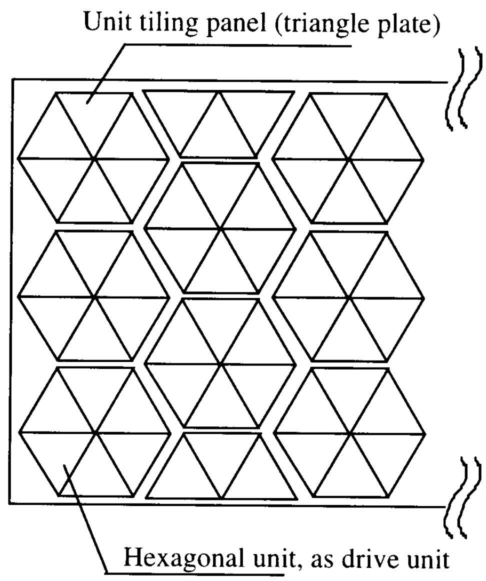


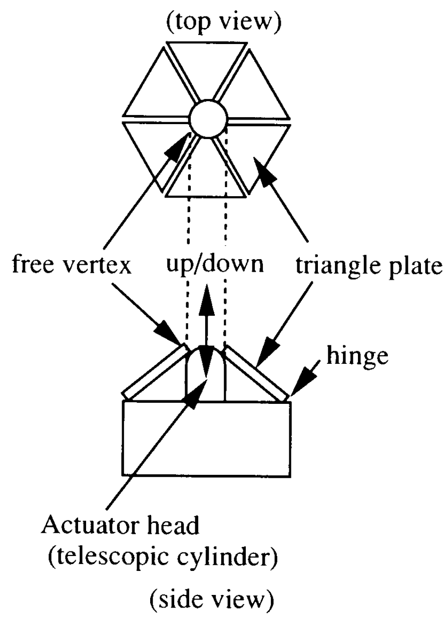

Figure 3 : Simple combination of tiling panels and actuator units

In a such configuration, the total number of actuator units is equal to the number of tiling panels. However, as we mentioned in the previous section, we intend to make a high-resolution device. To achieve this, it is better to use smaller tiling panels, and these require a large number to fill the surface. Thus, it also requires a large number of actuator units. This is a typical trade-off problem in system development. So, we had to consider a surface patching methodology that could manage both a smaller panel size and fewer actuators. To cope with this, we propose the surface patching methodology that follows. In this proposed methodology, each tiling panel is an equilateral triangle plate, and six of these plates are gathered into a hexagon as a drive unit. This hexagonal unit is arranged in a matrix to fill the movable floor surface (Fig. 4 & Fig. 5). Each hexagonal unit is driven by an actuator unit. The actuator unit can push up and pull down the center of the hexagonal unit.

This methodology can manage the above requirements. Figure 6 shows the triangle plate and actuator head in the first prototype system. Here, the base of the triangle plate is fixed to a hinge, one vertex is free and the elevation can be by the actuator. It also has another advantage. This mechanical configuration can represent a smooth contour.




(1)Surface view of proposed patching




(2)Relationship between the hexagonal unit and the actuator

Figure 4 : Proposed methodology

### 3.4 Projection System

In this first prototype system, to make a more realistic simulated environment, there is a projection system (Fig. 2). It consists of two LCD projector units (EPSON ELP-5500) mounted on the overhead frame of the system. These projector units receive texture graphics of the simulated terrain from the host CPU and directly project onto the tiling floor panels.

## 4. Conclusion

The first prototype ALF system has the technical specifications shown in Table 1. We have already confirmed that it functions appropriately. The system can simulate various shapes of terrain surface under the control of the host CPU.

Currently, the first prototype system is used in two applications. One is a static simulation of a natural outdoor field, i.e., a virtual trekking system. In this application, the ALF system can simulate a trekking course or a golf green. We assume that this application is primarily for indoor amusement or rehabilitation use. The other applicatione is a dynamic one. In this application, the ALF system creates a continuously changing surface shape that gives an unnatural feeling to the user. In other words, the system continuously stimulates the somatic sensation of the user. This is aimed to give curious or unnatural feelings to the user, like walking on a cloud or an water. As we mentioned previously, the ALF system is a VR device, and a VR device can give an unreal feeling or exprerience to users. This is a real advantage of the VR device in interaction or amusement. We focus on this feature, and aim to achieve a live and emotional virtual environment using the ALF system.

We have also interviewed users about their impression of the system. Many users reported curious, unnatural and previoualy inexperienced feelings with the motion floor. They also felt a tilted feeling with less floor motion, that is, when the floor was elevated only a few centimeters, but they felt that their bodies lifted up at ten centimeters or more. This shows that the ALF system can effectively stimulate and fake a somatic sensation.

Table 1: Technical specifications of the first prototype ALF

| | |
|---|---|
| Surface patching | Equilateral triangle plate/Hexagonal unit |
| Number of tiling panel | 168 pieces |
| Number of actuator unit | 28 units |
| Elevating stoke | 100mm(Max.) 0.1mm(Unit) |
| Host I/F | Serial (RS-232C) |
| PLC/Motor unit | OMRON SYSMAC (PLC)/Hermonic DRIVE |
| Projection unit | EPSON ELP-5500 x 2 (VGA-SVGA/NTSC) |
| Surface size | 1100mm x 1900mm |

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