Arrayed Air Jet Based Haptic Display: Implementing An Untethered Interface

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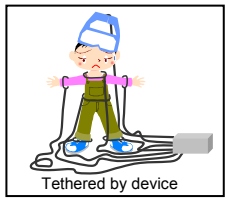
- Summary -

This paper presents the basic idea of an air pressure based force feedback interface and an initial implementation. The goal of this project is to realize an untethered human interface for virtual reality systems that never constrain the user's activity. To achieve this goal, we implement a force feedback system that utilizes air jets. The basic system uses single air jet to provide the sense of hitting a soft object. The latest system uses multiple air jets arranged in a matrix to express the surface of three-dimensional virtual objects. By eliminating tethers, which bother users, VR technologies are expected to become effective tools for everyday life.

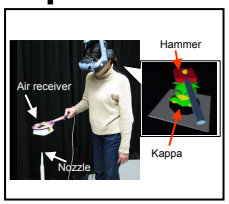
- Motivation -
Untether users from VR devices



Today's Virtual reality devices mostly tether users with wires or heavy body devices. As tools for everyday life, it is critical that the resulting human interface does not constrain the user's activities. The aim of this research is to realize an "untethered" interface.

Force feedback technology is one of the hardest to make untethered. This is because the conventional wisdom is that the users must physically contact the interface device to receive the feedback force. These devices prevent the users from moving freely and so are bothersome. Our research goal is a force feedback interface that eliminates with all tethers.

- Basic idea -
Air-pressure-based Force Feedback



The basic idea of this method is that
- The air impacts the "air receiver", which is held by the user.
- The user feels the air jet not as wind, but as a force.

The key features of this system are;
- Untethered : this system does not constrain users with arm- or wire-based devices.
- Easy to use : it is easy to start using it and easy to stop using it.
- Safe : the air receiver places no undue forces on the user.

The basic system uses single air jet to provide the sense of hitting a soft object.

ARRAYED AIRJET HAPTIC DISPLAY

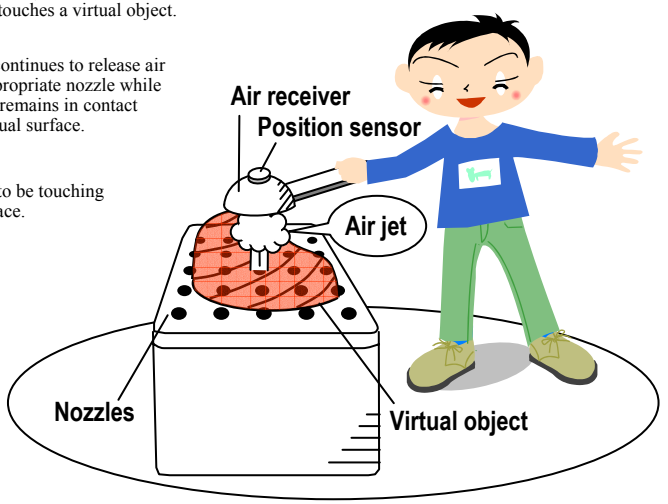
This system expresses the "feel" of touching three dimensional virtual objects by using air jets from multiple nozzles arranged in a matrix. The purpose of this system is to implement an untethered force feedback interface for virtual reality systems.

1.The system detects the position and direction of the air receiver.

2.The system checks if the receiver touches a virtual object.

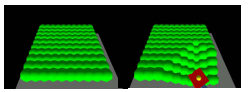
3.The system continues to release air from the appropriate nozzle while the receiver remains in contact with the virtual surface.

4.The user "feels" to be touching the object's surface.

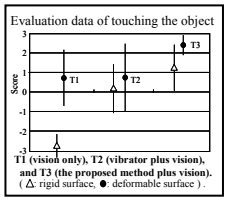


The current system uses a 10 by 10 planar matrix of vertical air jets placed at 4cm intervals. The air flow through each nozzle is controlled independently. For simplicity, the strength of each air-jet is constant.
A wired magnetic sensor and a head mounted display are used.

We designed the virtual objects to make them deformable, so that the receiver is not seen as passing through the virtual object when touched; the deformation matches the soft feel provided by the air jet.

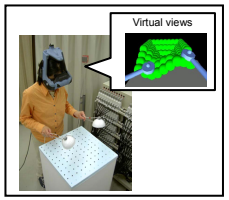


- Preliminal evaluation -



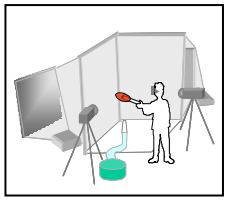
To confirm the effectiveness of this method for presenting virtual objects, we evaluated the "feel" of touching virtual objects. 10 employees in our laboratory compared three interfaces. Our results showed this method provided the subject with a better feel of the virtual object compared to the two other interfaces. Moreover, the use of deformable surfaces enhances the realism provided by the proposed interface. Also, most subjects reported that they enjoyed the using the interface.

- Two hand application -



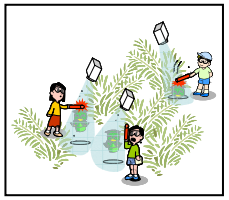
To further broaden the applicability of this method, we are expanding the system to support two-hand operation. The implementation is that two air receivers are checked if they contact virtual objects and air is released from the appropriate nozzles based on the contact positions of each receiver, independently. We found that the two-hand operation made it easier to perceive the distance between two objects or the size of objects.

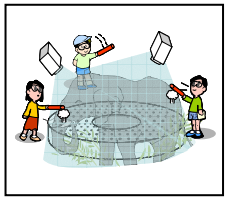
- The completely untethered system -



The ultimate goal of our research is to realize a fully untethered force feedback interface based on the use of air-jets. We are currently building a system that employs a projection display and computer vision based sensing technologies. These strategies remove all wires, and untether the user, so user can move freely in the field and enjoy the interface.

- Multi-user system -





Because of the system's simple construction, it is easy to add more air receivers like two-hand operation, as many as the space permits. Used in the way, the system can be easily expanded to support more than two users.