Tangible Space Initiative

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ABSTRACT

Research in Human Computer Interface (HCI) is towards development of an application environment able to deal with interactions of both human and computers that can be more intuitive and efficient. This can be achieved by bridging the gap between the synthetic virtual environment and the natural physical environment. Thus a project called Tangible Space Initiative (TSI) has been launched by KIST. TSI is subdivided into Tangible Interface (TI) which controls 3D cyber space with user's perspective, Responsive Cyber Space (RCS) which creates and controls the virtual environment and Tangible Agent (TA) which senses and acts upon the physical interface environment on behalf of any components of TSI or the user. This paper is a brief introduction to a new generation of Human Computer Interface that bring user to a new era of interaction with computers in the future.

Key Words : Human Computer Interface, tangible media, virtual reality, intelligent control, human robotics, image processing, multimedia database, haptic, artificial intelligence

1. Introduction

The key purpose of the TSI project is developing a natural and more intuitive Human Computer Interface taking the five sensory organs of human: eyes, nose, tongue, ear and skin into account. Today, the common user interface is the graphical user interface (GUI) without sensing the user intention or giving the user a perceptible response. Thus, the interaction is neither intuitive or natural and this can be cumbersome to interactively manipulate information. The word 'tangible' comes from latin 'tangibilis' meaning 'to touch'. In dictionary it says 'perceptible by the senses especially the sense of touch' [1]. Sense of touch describes mechanical percept that human perceives through its skin. The tactile sense permits to localise and appraise touch, vibration, pain, pressure and temperature from the brain. The acceptance capacity amounts ca. one million bit per second. It is the most highly sensitive organ of the human being. This tactile sense is very important for humans because it enables them to react to danger. Therefore it enables the initiation of quick reflexes.

Taking all the sensory organs into account to develop new interface, user can interact with computers easily. For instance, taking the sense of touch into consideration for developing new interface between human and computer, one can develop the interface more intuitive and natural for user. To make it possible a haptic device must be designed. Haptic devices enable users to have a sense of touch with computer created environment. Haptic which is the key technology to this project is a term referring to the technology of touch. Or the eyes for instance, tracking the user sight can give conclusion about its interests, making computer more responsive to user's action and intention.

TSI researches to reduce the hindrances between human and computer generated virtual environment. Numerous VR interfaces have been developed but with modest success. These interfaces are still being considered as artificial and not natural to users to interact in the virtual environment.

TSI treats the barrier between the physical interface environment and the virtual environment as a malleable structure. This structure can be reshaped, coloured and manipulated according to the user's requirements. To realise it, TSI is subdivided into three components: Tangible Interface (TI), Responsive Cyber Space (RCS) and Tangible Agent (TA). TI enables the user to manipulate virtual objects and synchronises the real and the virtual environment. RCS comprises all the

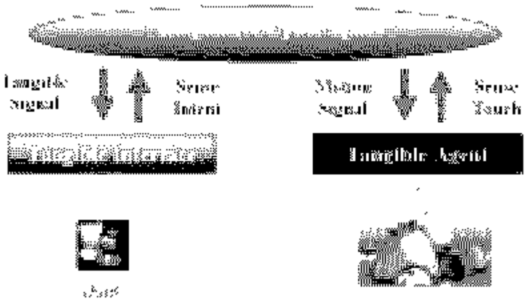

Fig. 1 Three components to realise Tangible Space

virtual objects included in the virtual environment and its behaviours. And TA senses the real environment, user's view and his intention to response to his expectation and to provide desired information. Fig. 1 depicts the components of TSI and their relations. Each component and its tasks are explained in details in the following chapters.

2. Responsive Cyber Space

A responsive cyber space is a modified and refined virtual reality. Up to the present technological development in virtual reality has been focused mainly on 3-dimensional visual images. Hence, the interaction between user and computer generated virtual environment was monotonous and wasn't likely to approach the real world. Like all objects in the real world contain information about their properties, conditions and qualities, the refined virtual reality should also include all information about condition, property and quality of every object which builds the virtual environment. All these information are provided to Tangible Interface from where user can interact to the responsive cyber space. Tangible Interface provides an interface between the user and the virtual reality.

Problem in most cases refers to an issue requiring or asking for a solution [3]. In order to solve a problem, human need the exact state of the problem and all information surrounded the problem. To sense his needs within his environment and to provide him a possible solution is also key feature of the Responsive Cyber Space. Of course, this should be done in non-intrusive way not to deter the user from his activity. Tangible Agent which includes elements of Artificial Intelligence takes over the sensing task. Fig. 2(a) illustrates information flow of an Agent.

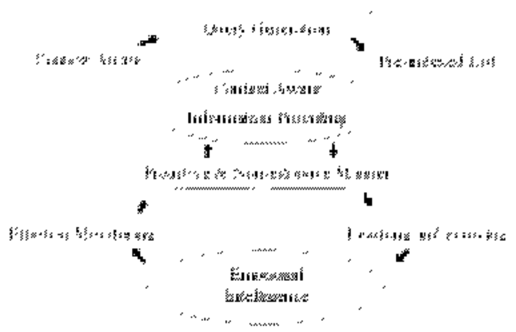

Fig. 2(a) Scheme of an Agent

The Responsive Cyber Space is dependent on Tangible Interface and Tangible Agent. To enable the communication between those three components, a system based on middleware called NAVER (Networked Augmented Virtual Environment aRchitecture) is introduced.

2.1. NAVER

The NAVER kernel is being developed to provide a base platform for prototyping TSI applications easily. The structure of NAVER is briefly explained, here.

Summarising a process flow, Scenario Manager validates user supplied script files in XML format and transmits verified command lists to Command Manager. Then the Command Manager executes appropriate operations such as building a scene graph, setting environmental conditions and preparing network connexions according to these action lists. Also various types of operations which should be done during run-time are executed via Event Manager and Interaction Manager. There can be two types of connexion between NAVER kernel and external modules such as Control Server and Device Server. The first type is a connection between Event Manager and Control Server. We call it loosely coupled connexion because their communication occurs only when required such as when spotlights are disabled promptly. The second type is a connexion between Interaction Manager and Device Server. We call it tightly coupled connexion because Device Server answers queries from NAVER every frame. Fig. 2(b) shows the whole structure of NAVER kernel and a connexion to the external modules.

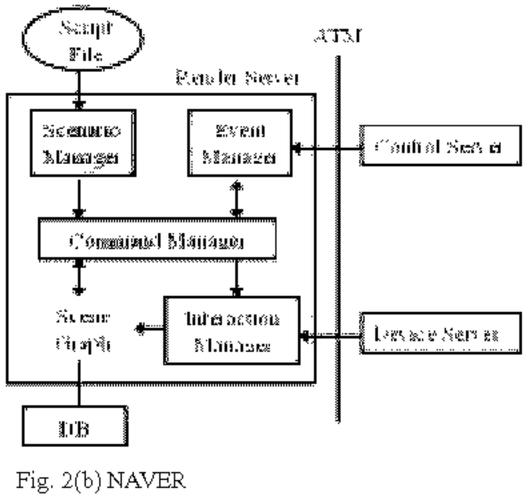

Fig. 2(b) NAVER

3. Tangible Interface

Research in haptic device provides a possibility to bridge the gaps between human and cyber space. It not only gives users force feedback but it also can give users tactile sense and temperature in cyber space. Haptics in Virtual Reality is gaining widespread acceptance as a key part of Virtual Reality systems, adding the sense of touch to the previously visual only solutions. Most of these solutions use so called stylus based haptic rendering, where the user interfaces to the virtual world via a tool or stylus, giving a form of interaction that is computationally realistic on todays hardware.

The TI develops a 'wearable haptic device' to provide an interface between user and cyber space. See Fig. 3(a) and 3(b) below.

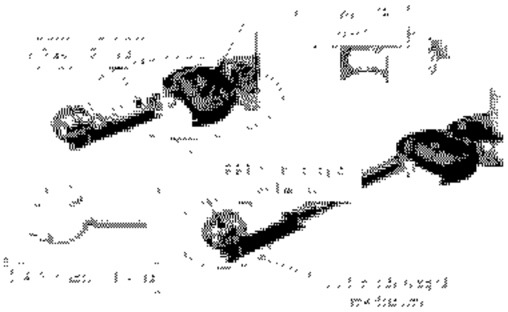

Fig. 3(a) Designing Wearable Haptic Device

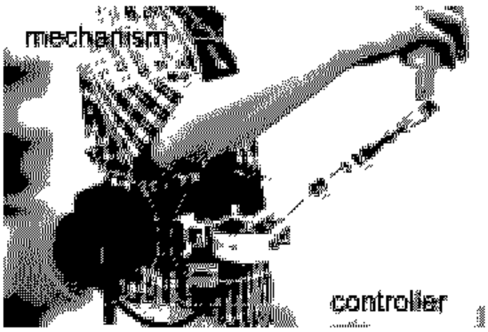

Fig. 3(b) Wearable Haptic Device in use

The wearable haptic device has been designed to eliminate any critical limitation in its movement and its weight so that user can wear it and move freely. It uses brake type force reflecting actuator which can be manufactured much smaller than the conventional actuators. The material of frame is aluminium. The controller is battery driven. All together, the haptic device weighs less than 2.5kg.

Another important aspect to bridge the gaps between users and cyber space is integrating the tactile sense. Fingers are one of highly sensitive part of human body. Hence it is useful to integrate a tactile reflecting device which can transmit user a sense of pressure, slippage and temperature onto the fingertip. A texture display is being developed by KAIST, Fig 3(c).

Additionally, sound rendering is an important issue to merge the real world in the computer generated world as well. Ear is one of the sensory organs of human. To generate sound while two bodies in the virtual world collide, exactly like in the real world can give user more information about the objects in the virtual world. Thus, with all sensory interfaces developed by TA user can interact with computers more intuitively.

Fig. 3(c) Designing a tactile display

4. Tangible Agent

Tangible Agent is an interface between Responsive Cyber Space and real world as shown in Fig 1. It is defined as an agent of which functions are

i. to sense the real world and augment the sensed environments to the predefined cyber space and/or give information to generate a new cyber space and
ii. to navigate the real world to sense it and/or interact with real world to do the user specified job or gather tactile information.

The definition of TA is similar to that of Autonomous Agent which is defined as a system situated within and a part of an environment that senses that environment and acts on it, over time, in pursuit of its own agenda and so as to effect what it senses in the future [4]. Typical characteristics of Autonomous Agent are

i. to perceive and interpret sensor data,
ii. to reflect events in their environment, and
iii. to take actions to achieve given goals[4].

From this, the reactiveness, that is, sensing and acting capability could be considered as the same characteristics between two agents. The difference is however that since TA is one of component technology for Tangible Space of which goal is seamless integration between cyberspace and real world, TA should provide its own reactive function while satisfying users with seamless integration. That is, the most important function for the TA is how to enable users to feel seamless sensation for the cyber space which is augmented and interacted with the real world by agent.

There are two major technologies for TA to do its role such as reality sensing and information augmentation and intelligent real world navigator with action capability. TA contains 'Intelligent Action Navigation', 'Reality Sensing' and 'Sensor Network based Location Awareness'.

The Intelligent Action Navigation provides a Robotic Agent that can satisfy users' needs. A so called physical avatar is being designed to sense and to provide users with information they require. The user can communicate with the physical avatar as naturally as he communicates with human. It can move autonomously through the environment where user is also located.

The Reality Sensing is sort of ubiquitous camera network. It recognises user's location and his ID through his ID tag. It also senses the whole environment where the user is being located.

The Sensor Network based Location Awareness develops an indoor GPS system. It should provide information about user's location and possibly his intention to clients who require these. The indoor GPS system consists of beacons and master module. The beacons emit ultra sound; the master module calculates its distance to 3 beacons and transmits it, for instance, to physical avatar to inform the location of the master module. The indoor GPS is depicted in the picture below, Fig. 4.

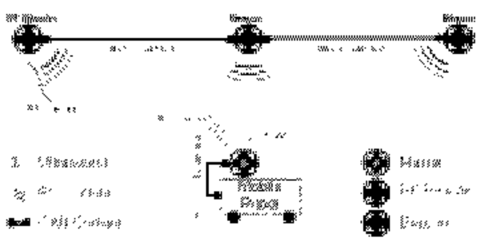

Fig. 4 Indoor GPS

5. Demo Room

As initiative we demonstrates the Tangible Space. The TFT (Task Force Team) created a 'Demo Room' as you can see in the picture below.

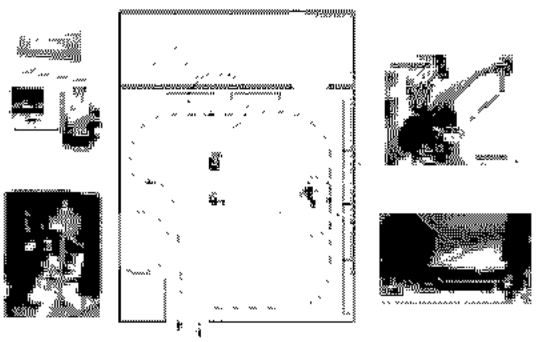

Fig. 5 Demo Room

The Visitor can move through the room and experience new interaction with the environment including the physical avatar. In the 'Demo Room', the motion and position of the visitor are tracked by the sensors i.e. indoor GPS and cameras, that are installed on the top of the room. These information are distributed to other computing units inside the room in real time.

First the visitor stops at Haptic Work Bench where he can perform painting and sculpturing using a Phantom haptic device. The user can manipulate any virtual object very intuitively and naturally. Thereafter he moves to 'Intelligent Booth'. With all information about the visitor the physical avatar is providing the visitor with information that the visitor might seek. Without any use of keyboard or mouse, the visitor interacts to the computer as naturally as he interacts to his physical environment. In other words, the computer senses his needs with his movement, gesture and voice. At last, the visitor stands in front of the screen wearing the 'wearable haptic device' to travel into the virtual sightseeing tour generated by computers. The visitor can also manipulate virtual objects in the virtual environment. The 'wearable haptic device' makes the Human Computer Interface as naturally as possible. The visitor can experience force feedback, tactile sense and aural feedback from the virtual world.

Acknowledgement

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