유비쿼터스게임의 상호작용 구성요소 개발을 위한 촉각응용

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Tactile Sensing for Virtual Interaction as a Part of Ubiquitous Game Development

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요 약

유비쿼터스게임을 디자인하고 개발하기 위하여 현실세계과 가상세계와의 자연스럽고 다양한 상호작용이 필요하다. 이는 물리적인측면 뿐 아니라 상황변화에 알맞은 대응 감지기술을 필요로한다. 이를 위하여 가상세계와의 유저인터페이스 모델을 정의하고 이를 구현하기 위하여 텍타일감지 시스템을 제작하였다. 텍타일 데이터는 외부환경에 민감하므로 신호처리방법을 사용하여 잡음을 제거하고 유저인터페이스를 위한 데이터 형태로 외부입력을 분석 추론하였다. 이는 일반적인 게임에서 사용하는 마우스나 키보드에 따른 입력과 전혀 다른 형태의 입력으로 유비쿼터스환경에서의 플레이어의 상황대응에 대한 중요한 정보를 제공하여준다. 구현한 시스템을 통하여 가상공간상에 존재하는 공에 작용한 힘을 3차원적으로 분석하여 힘의 위치, 크기, 분포, 방향 등을 분석하는 방법을 제시해 보았으며 이같은 실세계 정보 분석을 통하여 가상공간상에서 3차원적인 자연스러운 반작용이 가능하도록하는 가능성을 보였다. 이같은 방법들은 유비쿼터스 게임의 상호작용 개발을 위한 기초자료로 사용될 수 있다.

ABSTRACT

In order to design and develop a ubiquitous game, it is necessary to develop a natural and flexible interface between the real world and the virtual world, based on social and physical context awareness. We design user interface model and the tactile sensing system that performs virtual interaction and collection of the sensor data. It is sensitive so the collected data should be filtered, rearranged and analyzed. This information is quite different from stylus input, keyboard, button or mouse for interaction. We detect kicked 3D force position of a ball, moment of area, moment of inertia and modified ball shape using tactile sensing system and analyzed data. The results demonstrate that the proposed approach is desirable and robust as well as the results can be used realistic actions and reactions considering attack force and to make interesting environments for ubiquitous game.

키워드

ubiquitous game, interface, tactile sensing, actions and reactions

Ⅰ. Introduction

The rapid development of information technology has brought a new paradigm: the ubiquitous. If the ubiquitous world is realized, there a man, a computer and things can get together. In the ubiquitous era, users can get free access to each and every kind of information with any instruments whenever they like and wherever they are[1].

Then life would be more convenient. Up to now the information technology has been utilized as a means of P to

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P(person-to-person) communication. The information technology, however, extends to machines and things, and the new information paradigm of ubiquitous turns up to make possible P to M(person-to-machine) and T to T(thing-to-thing) communications[2]. The concept of ubiquitous computing was defined by Mark Weiser, a scientist of Xeros PARC: basic technology that immediately provides users with necessary information or service while spatially and functionally connecting all objects including human beings that exist in the real world space[3]. According to his ideas, computers will be everywhere in the future and be connected with wired or wireless networks seamlessly, so that the environment which immediately provide users with necessary information or service will be constructed. To make it real, a variety of computers should be effectively connected to the real world, and the user can use computing resources without inconvenience or reluctance whenever they like and wherever they are. In order to construct the ubiquitous computing environment with these features, the following techniques are necessary: Pervasive Sensing that detects information around the users and their environment with sensors hidden in the objects of the real world, whose form the users don't have to recognize, Context-Awareness that effectively share a variety of environmental information which is collected by sensors and computers scattered around users' everyday life, and produce a context for the users and their environment, Interlocking between database and networking that provide users with necessary information or service while functionally and spatially connected with information collection, processing and communication, and AR(Augmented Reality) that smoothly link physical world with virtual reality[4]. AR is a method to gather and use a variety of information that could be obtained through users' senses in an augmented world which is produced by fusing real and virtual worlds. It has overcome the problems of VR(Virtual Reality) which had weak points of low resolution and insufficient information expression. Its features demand that dialogue and interaction between the user and the system be carried on in real time, and both the real world and the virtual world be arranged exactly in the same order. [5] These features can be applied to the design and production of ubiquitous games such as Smart Playing Cards[6], AR Quake[7], Touch-Space[8], and Game-City[9]. Flexibly natural interaction and effective interface between the virtual world and the real world is still far from being sufficient. Especially, the shape, size and direction of force in the physical world can be appropriately expressed in a virtual world in accordance with physical laws. AR can apply action-reaction events to objects, and then quantitatively and qualitatively excellent interaction will be possible in a virtual world. We do research in this paper into tactile technique for virtual interaction that can be utilized to produce ubiquitous games under the ubiquitous environment.

Ⅱ. Ubiquitous Games

The game industry now lies in the field of digital entertainment in which high information and technologies are concentrated. It's one of the promising industry that have been rapidly growing and might be going to lead the industry of culture contents in the 21st century. The industrial, economical significance of the game industry cannot be overemphasized. It is really important as it is. The grafting of ubiquitous computing technique on to games will not only create a new type of value added industrially, but also apply new and various ubiquitous computing techniques extensively and practically[10]. The ubiquitous game pays attention to the original concept of the ubiquitous, but at the same time tries to make games aware context and natural interface that should be based on social and physical sense data needed for natural intera -ction[11-12]. In short, the ubiquitous game combines ubiquitous computing with computer entertainment. The game developing environment has been changed to follow the ubiquitous, and therefore the process of game design should be changed too. The old game design is divided into such parts as storytelling, graphic design, character design, level design, and interface design. In a ubiquitous game, however, the space of storytelling extends to the physical world. The different contexts between real and virtual worlds should be recognized, and the game design should make natural interaction possible between them[10-11].

2.1. User Interface

In the real world the interaction between a human being and the world can be expressed with language, sound, gesture, movement, gaze, facial expression, touch and force. The intention and cognition of a participant in a virtual world can also be expressed with the same set of factors. The complex mental expression of human beings in reality is rendered by mapping with the virtual agent in the virtual world. The mapping is carried on with a metaphor, which is actually the simplified model of a real thing. The metaphor is transmitted to the virtual agent in the virtual environment through both physical and logical sensors to signify the participant's intention. The participant, in turn, recognizes the consequence of interaction between the player and the virtual environment through logical and physical effectors. Fig. 1 shows the example of system configuration for user interface of virtual world[14-15].

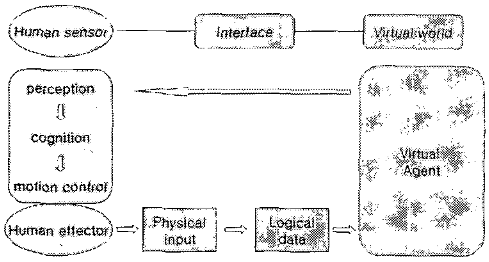

Fig. 1. Conceptual system configuration for user interface

According to the concept, we built system that has bidirectional interaction between game player and virtual world using tactile data. The tactile sensor and application circuit detects touch, pressure, force and provides the tactile data for extracting the information which affects on action and reaction between real world and virtual world.

2.2. Tactile Sensor and application circuit

There are several types of tactile sensors[16] that could play a role in place of human tactile sense. A tactile sensor developed by Dario and his coworkers uses pyzo and pyro electric effects. It is durable, has a wide range of measurement, and can even detect temperature and pressure. But it can't divide complex electric effects. We use a light-weighted and small, and has a simple application circuit. The force sensing sensor has a feature that the resistance value is reduced in accordance with the pressure on the surface. This resistance value can be read into the system to detect touch and pressure. This is an array type of sensor and has the structure of two-dimensional columns and rows. It has the advantage of checking the level of pressure for each taxel, which is the minimum unit of identifying pressure or touch on the tactile sensor, scanning input and output values of each column and row. Using this information, force added to things in a game or the virtual reality can be classified and applied, and qualified information can be supplied to get tactile feedback for a player. We built a system for which information is provided, through a force sensor, to have effect on the virtual environment, and where action and reaction among virtual objects can be carried on. Fig 2. shows system configuration for tactile sensing. Sensor application circuit needs DAC(D/A converter) for reference voltage and multiplexer for column and row address output because conductance is changed according to external pressure value by object. Sensor output is amplified and filtered by amplifier and filter circuit for interface and noise rejection. This analog output is converted by 12 bit ADC(A/D converter). System controller sends this data to Game PC according to control signals. All signal processing controlled by system controller. The system detects tactile sensing, which capture the pressure distribution in contact area of two objects. Based on this tactile information, the center force or the contact area etc. between a human being and object can be calculated. This information can then communicated to a game to create a physical- virtual world interaction.

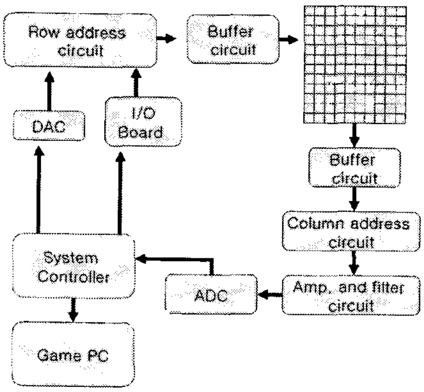

Fig. 2. System configuration

Ⅲ. Analysis of Sensor Data

3.1. Identifying a sensor contact surface

The types of surfaces detected by a sensor can be classified into a point, a plane surface and a curved surface, in accordance with the sensor structure and the contact surface characteristics. The contact surface has its own size of contact. Formula (1) shows the relationship between a radius and the amount of displacement when objects of various shapes are pressed on a tactile sensor. The mathematical expression of it is shown in Formula (1). [16] (r: radius, x : sensor displacement)

$$a_{cone} = \sqrt{2} \cdot \pi x^2$$
$$a_{Henisphere} = 2 \cdot \pi \cdot r \cdot x$$
$$a_{Blunt} = \pi \cdot x^2 + 2 \cdot \pi \cdot r \cdot x \quad (1)$$

3.2 Sensor data processing

Assume that the output of the tactile sensor is a two dimensional array of values with i rows and j columns. Each touch sensitive points produce an output τ_{ij} which can have a value between $t_{\min}$ and $t_{\max}$. The sensor t_{ij} is converted to a binary value τ_{ij}[16-18]

$$\tau_{ij} = 0 \text{ if } t_{min} <= t < t_{threshold}$$
$$\tau_{ij} = 1 \text{ if } t_{threshold} <= t < t_{max}$$

The image processing technique can be used to express taxel images effectively, or to employ image data for the tactile feedback. Raw data could be used, but if many noises distort original data, the simple RAC(row and column) filtering is used to reduce the noise. RAC filtering is column and row threshold value for tactile sensing using minimum continuous number of taxels. Pressures or movement noises occur frequently around the edge on the tactile image of the sensor, so the filtering value should be set on a base level of minimum continuous number of taxels P_{th} in rows and columns. Fig. 3 shows example using RAC filtering. The value of is P_{th} set to 2.

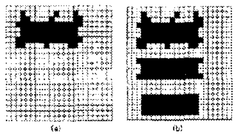

Fig. 3. Initial tactile sensing output and filtering image

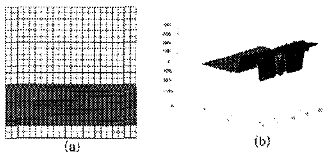

Fig. 4. 2D and 3D output of tactile sensing

Fig. 4(a) shows sensor output after preprocesing (RAC filtering(P_{th}:2)), (b) shows pressure distribution. Each row, column taxel displays pressure information and this information provides player's attack force and position. This information is quite different from stylus input, keyboard, button or mouse for interaction and immersion. So the information could be quite helpful to develop ubiquitous games under the ubiquitous computing environment. Sensor with an output above the threshold are assumed to be in contact with the object and those below not in contact. Moments of area are defined as: $m_{pq} = \sum_i \sum_j i^p \cdot j^q \cdot \tau_{ij}$ Thus total area of contact is :

$$A = m_{00} = \sum_i^{n-1} \sum_j^{n-1} \tau_{ij}:$$

$$j_0 = \frac{m_{10}}{m_{00}} \sum_{i=0}^{n-1} \sum_{j=0}^{m-1} j * t_{ij} \quad i_0 = \frac{m_{10}}{m_{00}} \sum_{i=0}^{n-1} \sum_{j=0}^{m-1} i * t_{ij} \quad (2)$$

A measure of the position of the tactile image can be found by determining the location of its center of area in both row and column coordinates: Orientation can be estimated by tracking variation in the axis of minimum moment of inertia θ_0 of the image:

$$\theta_0 = \frac{1}{2} tan^{-1}[\frac{2(m_{00} * m_{11} - m_{10} * m_{01})}{(m_{00}m_{20} - m_{10}^2) - (m_{00}m_{02} - m_{01}^2)}] \tag{3}$$

Ⅳ. Applications in game

Most of the games ignore pressure detection and accurate action and reaction because of cost. But realistic games including VR games, ubiquitous games must consider pressure detection and it's application for scene environment. If we know the pressure data, they will be very useful for making natural game scenes according to physical laws. For example in the action games, attach areas can be divided into three parts, fatal area(head, heart..), dangerous area(abdomen, back,..), general area(hand, leg,..). If the main character attacks a certain area to enemy, the reaction will be different. At that time we use tactile data efficiently. This information can then communicated to a game to create a physical-virtual world interaction. This information is quite different from stylus input, keyboard, button or mouse. If we hit the ball, we extract information that hit position, pressure value and direction from tactile sensor and we can calculate the flying distance and control the ball position, status considering gravity and power and the result can be used in virtual world.

4.1. Action and reaction

In the soccer game, player kicks a ball for goal in. At that time many physical phenomena happened. One of them is kicking action and reaction. Fig. 5(a) shows ball kicking points and (b) shows sensing result. We can calculate momentum and impulse and flying distance using tactile data.

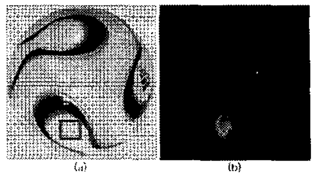

Fig. 5. Ball and tactile sensing image

$$F = ma,\ F = \frac{(mv_i - mv_i)}{t},\ F = \frac{(\Delta p)}{t} \tag{4}$$

$$(\Delta p) = F \cdot t \tag{5}$$

$$F = \sum_{i=1}^{N} F_i,\quad F = ma \tag{6}$$

$$F = \frac{m(v - v_0)}{\Delta t},\quad F \cdot \Delta t = mv - mv_0 (initial\ speed\ v_0 = 0) \tag{7}$$

$$v = \frac{F \cdot \Delta t}{m} \quad (\Delta t: contact\ time\ between\ foot\ and\ ball) \tag{8}$$

$$(flying\ distance\ of\ ball\ R:)\quad R = \frac{v^2}{g} sin(2 * \theta) \tag{9}$$

We get practical flying the distance considering air resistance, etc and this result can be modified reasonably for making interesting games in virtual world as reaction under ubiquitous envorinment. (confer Fig. 6)

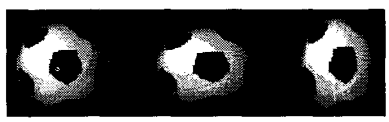

Fig. 6. Modified ball shape in virtual world

In 2D pong game we design ball reaction after the ball collided with a wall. We used axis-nonaligned vector reflection equation (4). This eq. can be used same kind of 3D games. (confer Fig. 7)

$$P = -v_i \cdot N', \quad V = v_i + P, \quad P + V = v_i, \quad v_f = P + (v_i + P) \tag{10}$$

$$v_f = 2 * P + v_i \tag{11}$$
$(v_i: inputvector \; v_f: outvector)$

If the ball is rotated, we used eq. 10 for getting centroid of the ball.

$$F = \sum_{i=1}^{N} F_i = \sum_i d^2 m_i \frac{x_i}{dt^2} = \frac{d^2}{dt^2} \sum_i m_i x_i \tag{12}$$

Here m_i is the mass of the material point i, and x_i

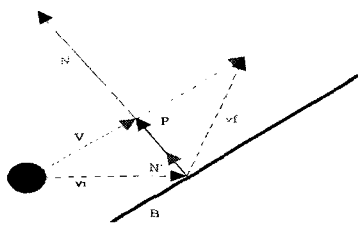

Fig. 7. Action and reaction of a ball

the position of the material point i. These values represent the pressure angle on each taxel of the sensor, and the centroid can be found. The position vector of the mass centroid is:

$$R_{cm} = X_{cm} i + Y_{cm} j + Z_{cm} k, \quad MR_{cm} = \sum_i m_i r_i \tag{13}$$

If we know the tactile sensing data, we use this information for making ubiquitous games under ubiquitous environment. Base on this tactile information, the center of force or the contact area etc between a human being and an object can be calculated. This information can then be communica -ted to a game to create a physical-virtual world interaction. The interaction is relevant for pervasive computing, because the mechanism with which games can also be applied to other applications.

V. Conclusion

The human sense of touch provides us with an important source of information about our surroundings. But tactile sensation was recognized less important than visual sense and auditory sense but it plays an important immersing role in virtual reality and computer game. We realized tactile detection system, data signal processing and force modeling for natural interaction between real world and virtual world for ubiquitous game. The system detects tactile sensing, which capture the pressure distribution in contact area of two objects. Based on this tactile information, the center force or the contact area etc. between a human being and object can be calculated. This information can then communicated to a game to create a physical-virtual world interaction. This information is quite different from stylus input, keyboard, button or mouse for interaction. Momentum and impulse are important physical phenomenon in games that can be calculated by tactile sensing data. Tactile information can be versatile to produce a ubiquitous game under the ubiquitous computing environment.

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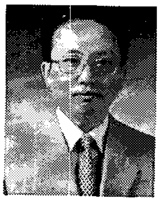
저자소개



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