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Dementia-Prevention Serious Game Techniques using Finger Motion, Object Deformation, and Particle Mapping with Leap-Motion

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***Abstract*— Finger movements closely related to cognitive training have been found effective on preventing dementia. Dementia in aged people has been rapidly growing nowadays, which has to come with increase of medical cost to treat it. In this paper, we propose dementia-prevention techniques that can be useful in a serious game using a leap motion controller. To this end, we associate finger motions with particle movements as well as object deformation when interacting with a leap controller. This approach can be utilized in a serious game whereas currently most serious games seem to provide just touch interface for the treatment of dementia. Finally, we have shown experimental results as well.**

***Keywords*—dimentia, leap motion, motion recognition, game**

I. Introduction

Dementia, one of brain diseases affects a person's daily life such as loss of the capability of think and reason. Nowadays, more people tend to live longer than previous. Dementia has been steadily growing. While only a small portion of people between the ages of 65–74 have dementia, 47% of people are over the age of 85. Hence, medical cost definitely increases because the whole population with dementia has been rapidly growing. Dementia is a form of brain disorder.

A study reported that drawing a clock had been requested to the patients in order to diagnose dementia [1].

Some experiments were carried out to analyze the changes in cognitive ability and cognitive skills using the training program. The indications showed that cognitive ability could be improved [2]. Alzheimer's dementia was found more damaged than cognitive impairment when monitoring patients via virtual reality techniques, who had participated in the experiments including grip strength; stride length and walking speed [3].

Consequently, patients with dementia can be improved using a computer program. Moreover, a direct feedback of finger motions can effectively prevent dementia. The size of the current serious games is increasingly on the rise. Health and health care-driven serious games have drawn users' attention and interest. Currently released serious games seem mostly contingent on recovering memory, judgment and attention. Moreover, a user interface tends to be touch or indirect way rather than direct interface like Kinect or Leap motion. Also, medical serious games mainly rely on functional behavior of a variety of games. However, a variety of area such as cognitive therapy could be utilized in the functional scheme that was dependent on the touch interface as a user interaction [4]. There are two representative motion tracking devices such as Kinect and Leap motion. Leap is more suitable than Kinect for dementia medical treatment because Leap can sense finger motions. Also Leap provides higher frame rates than Kinect, which enables more interactive to applications [5]. Recently, leap motion gesture recognition based game has been reported as reflecting punch-style weight and physical characters to compute the game score as well [6].

To solve these limitations, we propose serious game techniques that use Leap motion. We provide particle mapping and object deformation techniques that can be interacted with finger motions. The proposed method consists of three key modules such as motion recognitions, particle and object mappings and prototypes. Gesture recognition is a function that understands meaningful gestures by analyzing user's finger motion. For this, a finger motion needs to be segmented into a vector, orientation and magnitude and so on. Particle mapping and object deformation a function responding to user's gestures.

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II. The proposed method

Our approach is composed of three key modules, named motion recognition, particle mapping and game prototype.

A. *Motion recognition*

In the motion recognition module shown in Figure 1 at first, finger motions using a Leap motion controller are sensed and tracked as time passes. Then acquired finger motions need to be used to make gesture recognitions. To be able this, we optimize the scripts, based on recognized motion information.

The fundamental idea of the approach begins with analyzing finger motions. The infrared sensors allow the user to acquire the motion vectors in finger motion tracking.

Gesture recognition also starts with analyzing finger motions to recognize a meaningful gesture. Each gesture has some parameters such as velocity, direction and magnitude. These parameters can be used to realize a degree of gesture for an object deformation or particle mapping. For instance, if a motion represents high velocity, then a high weight has to be applied to object deformation. We design the object deformation by employing multiplication of some weights. For this, we virtually build a panel on the boundary of the Leap sensor that enables us to decide orientation when a collision occurs.

We also define magnitude $D(v,\vec{o})$ defined in equation (1) that implies how much we deform the object.

$$D(v,\vec{o}) = \frac{v}{v_{max}} * w * I, \qquad (1)$$

where v is a velocity vector from a finger motion. I is an initial value. v_{max} is the maximum velocity through our experiments using Leap Motion. $\vec{o}$ is an orientation from a finger motion. w is a weight.

3D motion tracking information associated with motion API is used to create particles and to manipulate objects on the motion tracking positions, where a user makes a trajectory, called particle mapping that will be described in the next section.

B. *Particle mapping and Object Deformation*

In particle mapping and object deformation module, particle movement of the helical pattern, being composed of 3d coordinates spreads into 3d space. Object deformation also can be realized in which a user can make his or her finger motion interact with an object.

The particle mapping is explained first. We need to project 3d coordinates into 2d coordinates to optimize running time that is crucial to enhance interactivity. To calculate position *(x, y)* of a finger onto screen, we define equation (2).

$$x = r\cos\Theta \ , \ y = r\sin\Theta, \qquad (2)$$

where r represents radius with Θ angle. Radius r becomes gradually large when time passes because r is calculated by Fibonacci sequence. Random particles can be mapped into the trajectory. Also we can randomly select a motion that can be changed with particle appearance as well as rendering aspects. For instance, we can adjust life speed, the particle movement speed and color.

Also, we extend our gesture recognition that combines with object deformation. If a user make a gesture, then the gesture

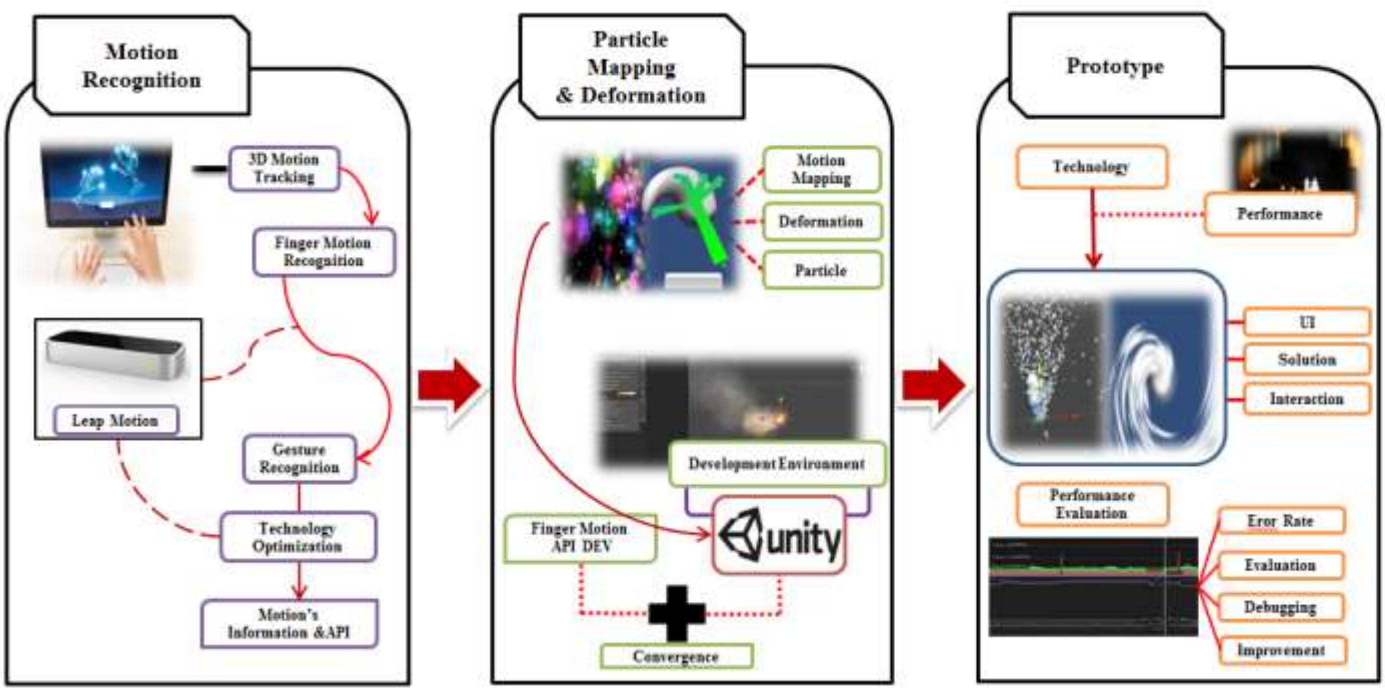

Figure 1 Methodology

is recognized as well as segmented to collect meaning parameters such as some velocity, orientation and magnitude mentioned earlier. These parameters taken into input values are combined to manipulate a target object as well.

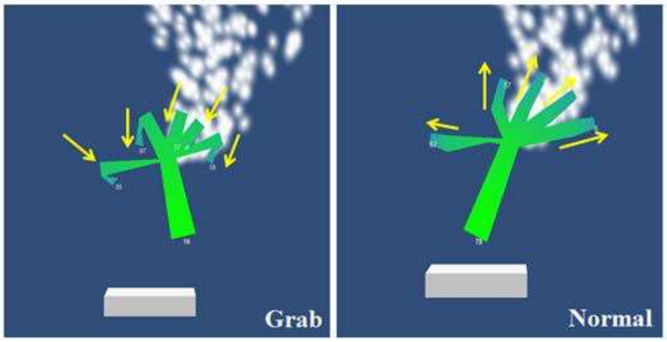

Figure 2 Left : Grab Gesture, Right : Normal Gesture

Figure 2 shows grab and normal gesture of hand. We can recognize Grab gesture in left while the right figure displays stretch of finger motions. Each gesture has a unique gesture identity number that associates with a target object.

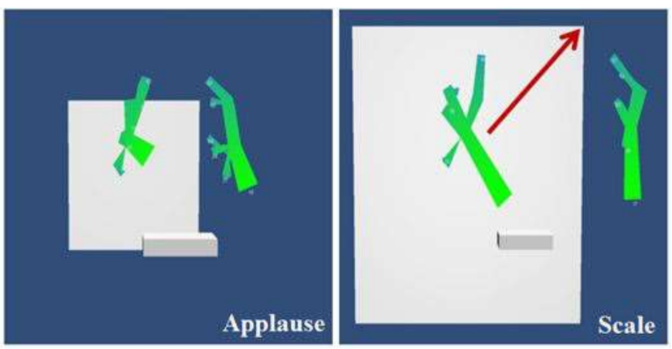

Figure 3 Left : Applause, Right : Scale up after applause

Let's show an example of object deformation with two hands. When a user applauds, then the object size can be double as shown in Figure 3. This is helpful for preventing dementia as well as boosting blood circulation.

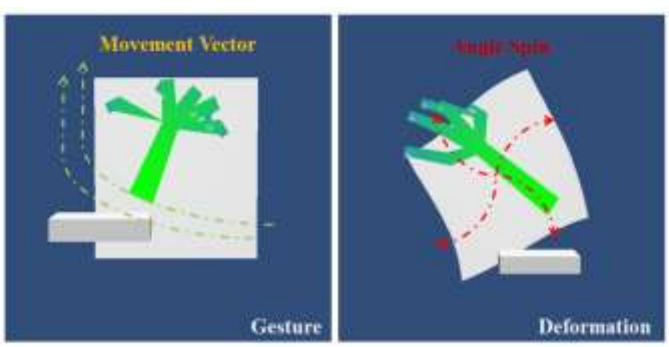

Figure 4 Left : Swing Gesture, Right : Object Morphing

Object Deformation was implemented using morphing API in Unity. We also added an object free form deformation when a user creates a free form gesture. For instance, Swing gesture makes the object be twisted as shown in Figure 4. The magnitude was calculated by equation (1). The higher value makes the object more twisted.

C. *Prototype*

In prototype module shown in Figure 4, we combine finger movements recognized in motion recognition with particles being created by particle mapping and object deformation procedure. The purpose of prototype is to find out potential that will be able to extend into a real serious game to prevent dementia. We have designed a prototype for the purpose of evaluating some perspectives with respect to real-time frame rate with Unity profiler and accuracy of motion recognition in eyes. Particles are associated some attributes such as colors, size, life time etc. For enabling this, we attach subsidiary technology and performance component. In consequence, a motion trajectory is spreading in the forms of spirals.

III. Results and Discussion

Some experiments have been carried out to implement our proposed method. For this, we have used an Intel(R) *Core*™ processor (*i7-3770* CPU at 3.40 GHz), a graphic card (NVDIA GeForce GTX 770), and 8.00 GB of RAM hardware.

Also we have built our method using Unity game engine. Unity provides multi-platform application, which is crucial to spread our method into various devices such as PC, smartphone, various tabs.

As shown in Figure 5, particle mappings have been observed as indicating that a set of motion vectors denoted by dotted arrows is corresponding with particles. The trajectory of particles has been found to come with motion vectors as a frame change. We analyzed frame rate (FPS) as well, because it represents how sensitively the simulation interact with a Leap motion controller.

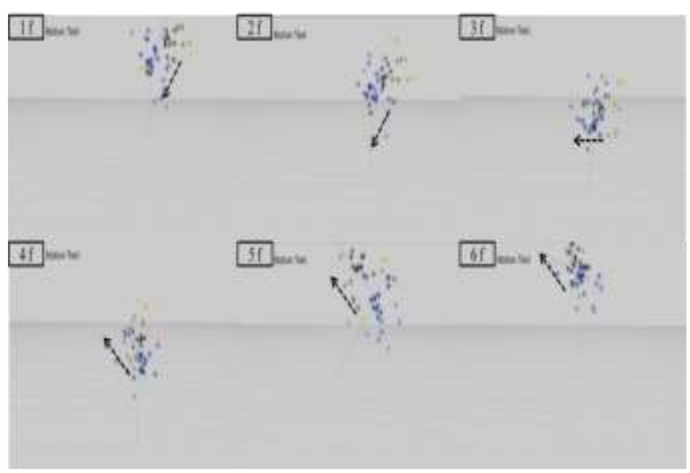

Figure 5. Trajectory of Particles

This property plays a crucial role in most game titles. More interactive response surely draws more immersive surroundings. To this end, we analyzed raw data through Unity profiler as shown. We sampled every fixed frame in peak. We have realized word reading function that sounds pronunciations when touching the world on the scene with Leap motion controller. According to the Unity profiler, we observe CPU usage becomes 74 fps while GPU usage is 240fps shown in Figure 6. Maximum vertices are measured up to 35,000 in rendering. In short, the rendered scenes for interaction with particle mapping can be playable enough in real-time. We come to a conclusion that the speed of destruction of particles and the number of objects in the scene affect frame rate.

IV. Conclusion

The work proposed here is to present dementia-prevention techniques that can be useful in a serious game using a leap motion controller. To make it work, we define motion tracking module that can track finger motions using a Leap motion controller. To view motions, we have merged the path of a motion into particles and object, called particle mapping and object deformation module. Finally, we show performance test. For the future works, we need to add more interesting motion visualization and to gauge efficiency to users as well.

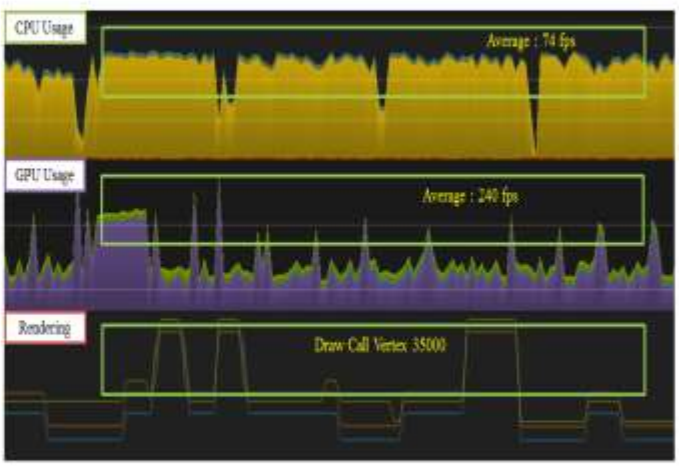

Figure 6. Performance test

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