BUILDING A VIRTUAL HAND FOR SIMULATION

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Abstract

In this paper, one of the advanced technology in the field of human-computer interaction is known as the virtual hand. At the first, we have to know the grasping behavior. The virtual hand simulation can give experience grasping behavior and natural interaction. Many of HCI researcher said that one day the interaction between human and computer will be more natural, easy to use and less error. We only focus on 3D hand gesture. We use the engaging virtual application that supports 3D hand gesture in order to test whether the combination of grasping will provide the desired effect or not. We present the result from usability evaluation experiments. And finally, we want to shows that the 3D hand gesture can be grasping naturally look like the human hand.

Keyword: Human Computer Interaction, Virtual Environment; Grasping Behavior Virtual Hand Simulation, 3D Hand Gesture, Virtual Application.

Introduction

The virtual environment in a three-dimensional environment is used by someone to be able to interact directly with virtual objects in a natural and efficient way in the environment. Development in the human-computer interaction field has introduced novel technologies that allow users to interact with computer systems in increasingly natural and intuitive ways; applications implementing them demonstrate increased effectiveness and realism. Usually, new alternative interfaces have to be more accessible with short periods of learning and adjustment. They have to offer more natural human-machine interaction. There are four types of these applications, which are human-robot interaction, entertainment, medical systems and assistive technologies, and crisis management and disaster relief. Any hand gesture recognition approach will not work properly for every application because every hand gesture recognition technique is affected by environment, application domain, and human cultural background.

Virtual hand model as main part of virtual hand simulation as a subsystem of the virtual environment ideally should be build up as real as possible and make natural any movements during the operation, therefore modeling section has an important section of the whole developing process. So I intend to elaborate the modeling section in is this thesis. Virtual hand complete virtual manipulation tasks need to meet at least those conditions: the authenticity of virtual hand and the virtual environment and virtual reality environment similar degree, but also help to generate a virtual hand look naturally and interact virtual environment with high consistency, making the operation closer to the natural interaction and efficiency.

The main problem to be discussed in this paper is virtual hand research as a simulation for users to provide the best possible experience, making 3D hand as similar as possible and hand movements like human hands. Then whether the collaboration used in virtual hand is the good combination that can provide ease in the virtual assembly. In this paper, I want to explore whether virtual hand can be grasping naturally like a human hand.

The objective of this research is to get the output results of experiments. The results obtained from this experiment are expected to be useful as a reference for other researchers in conducting research or development in the field of multimodal input related to:

- Implementation of virtual hand on a virtual assembly system, or could be wider in multimodal research inputs used in fields such as Virtual Environment.
- Identifying Virtual hand Simulation on a virtual assembly system to create naturally and easily learn.

Structure Of Virtual Hand Simulation

Virtual Reality

Virtual reality (VR) technology emerged in the 1980s, with the development and marketing of systems consisting of a head mounted display (HMD) and datasuit or dataglove attached to a computer. These technologies simulated three-dimensional (3-D) environments displayed in surround stereoscopic vision on the head mounted display. The user could navigate and interact with simulated environments through the datasuit and dataglove, items that tracked the positions and motions of body parts and allowed the computer to modify its output depending on the recorded positions. This original technology has helped define what is often meant by "virtual reality": an immersive, interactive three-dimensional computer-generated environment in which interaction takes place over multiple sensory channels and includes tactile and positioning feedback. According to Sherman and Craig (2003), there are four essential elements in virtual reality: a virtual world, immersion, sensory feedback, and interactivity.

Computer Simulation

A computer simulation is a computer program that contains a model of a particular system (either actual or theoretical) and that can be executed, after which the execution output can be analyzed. Computer simulation is also the name of the discipline in which such models are designed, executed and analyzed. The models in computer simulations are usually abstract and either are or involve mathematical models. Computer simulation has become a useful part of the mathematical modeling of many natural systems in the natural sciences, human systems in the social sciences, and technological systems in the engineering sciences, in order to gain insight into the operations of these systems and to study the effects of alternative conditions and courses of action. It is not usually an aim in computer simulations, as it is in virtual reality, to do realistic visual modeling of the systems that they simulate.

Human Hand

We have to know the structure of a real hand and the composition in order to build a 3D model that imitates a human hand. The fingers are the components that experience the contact with the grasped object. Finger movements are much more evident and in some cases, an approximation that ignores the latest ones is enough.

Autodesk 3Ds Max

Autodesk 3ds Max, formerly 3D Studio, then 3D Studio Max is a professional 3D computer graphics program for making 3D animations, models, games and images. It is developed and produced by Autodesk Media and Entertainment. It has modeling capabilities and a flexible plugin architecture and can be used on the Microsoft Windows platform. It is frequently used by video game developers, many TV commercial studios and architectural visualization studios. It is also used for movie effects and movie pre-visualization. For its modeling and animation tools, the latest version of 3ds Max also features shaders (such as ambient occlusion and subsurface scattering), dynamic simulation, particle systems, radiosity, normal map creation and rendering, global illumination, a customizable user interface, new icons, and its own scripting language.

Cal3D

Cal3D is an open source character animation engine that is very commonly used in open source and virtual environment projects. It originated as part of World Forge, an open source multi-user virtual worlds project, however, it has become an independent project. It provides a full range of animation functionality and is designed to be easily integrated with other engines.

Vizard VR

The Vizard VR Toolkit is a software for creating, rendering and deploying interactive3D content. It is developed by WorldViz, a company that offers various virtualreality solutions, such as motion tracking and interactive virtual experiences for large audiences. It comes in six different editions, from free to enterprise. While the free version's execution time is limited and projects are water-marked, the enterprise version offers all Vizard features and unlimited execution time. In this paper the free version is used. The main format used for rendering 3D models is Open Scene Graph (OSG). WorldViz offers content examples on their website and Vizard includes several 3D models, such as plants or a sky2.

Microsoft Visual C++ and Open Inventor

Microsoft Visual C ++ is a product Integrated Development Environment (IDE) for programming languages C and C ++ developed by Microsoft. Visual C ++ is one part of a package of Microsoft Visual Studio. This language is a complex programming language. It features tools for developing and debugging C++ code, especially code written for Windows API, DirectX and.NET Framework. These packages are often installed independently of- applications, allowing multiple applications to make use of the package while only having to install it once.

Virtual Hand Input Device

Figure 1. 3D mouse for controlling

Virtual Hand System is a 3D environment system, in order to realize and make the interaction between a user and system its need an intuitive input device that compatible with the 3D environment. Therefore, its fit with a 3D environment and comfortable in use. To achieve that goal then Virtual Hand system using a 3D mouse as input control device.

Virtual Hand Modeling

System Requirement

Functional Requirement

This use case is the final objective of simulation that can provide the assembly part activity as one of its features. However since this system still being developed and studied until latest system the assembly parts feature hasn't yet complete implemented in the system feature, therefore there will not provide/ explained the hand control activity diagram, release part activity diagram, assembly part activity diagram and view control part activity diagram in this thesis.

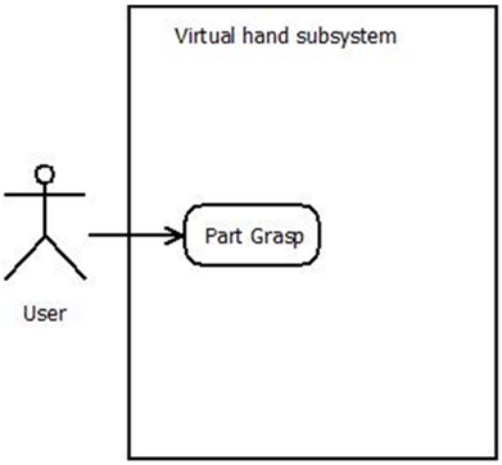


Figure 2. Use case diagram of virtual hand subsystem

- Use Case Name : Virtual hand subsystem
- Description : The user gives grasping command on selected grasping gesture; The virtual hand subsystem grips on the selected gesture.
- Actor : User
- Precondition : The user has been in the simulation and has entered into the scene
- Basic Flow of Events: The user chooses any gesture to issue a grasping command.
- Alternative Flow of Events: -
- Post-conditions : If successful then 3D hand will grasp according to selected gesture.

1. Grasping The Parts.

Virtual assembly system provides the data of selected parts(shape, feature) to virtual hand subsystem. Virtual hand subsystem chooses the right gesture matching the part's feature to grasp selected object and then finally virtual hand do grasp the part with the right gesture as expected.

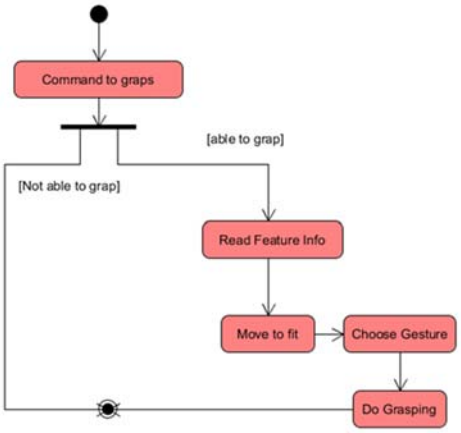


Figure 3. The activity diagram of grasping part

Non-Fuctional Requirement

1. Usability

Virtual hand subsystem can reach the level that the interaction behavior between it and human is natural, at the same time this subsystem is an high intelligent system. When the user interact with the virtual environment by using virtual hand, all these advantages make the system becomeeasy to use, low training cost and low operating load.

2. Reliability

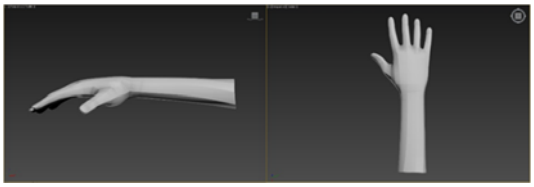
Virtual hand subsystem should be robust, reliable, and have a strong fault tolerant ability as the main human-computer interactive way of the virtual assembly system..

3D Hand Modeling

3D hand model builds with the help of a geometric hand model. The system consists of several stages. First, the hand model has to be created for mesh as the shape of the hand size. Secondly, we add the skeleton with making bones by a size based on hand size and fingers; calculate the similarity of the bone with hand model and the input bone using bone menu and match it.

Hand Mesh Creation

The primary thing a 3D character is made of would have to be geometry. A broad definition of 3D geometry would be an object that can be edited and rendered. 3ds Max includes a few basic 3D geometric objects called primitives. One of the primary primitive objects we use is a box.



(a) Front view (b) Top view

Figure 4. 3D hand mesh creation in 3Ds Max

Hand Skeleton Structure

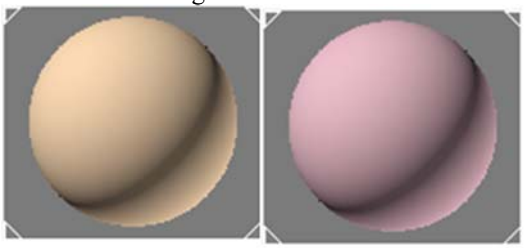
The hand skeleton is attached to the forearm through the eight carpal bones of the wrist and consists of the five metacarpals of the hand palm, and the phalanges of the digits: two in the thumb and three in the index, middle finger, ring finger and the pinky. This sums up to 27 bones in total, not counting the small sesamoid bone of the thumb.

(a) Front view (b) Top view

Figure 5. 3D hand bone structure in 3Ds Max

Skin Texturing

The part of a model is the texture. This is the image that will define what the rendered surface will look like.



(a) Skin texture (b) Nail texture

Figure 6. Material for texturing hand in 3Ds Max

Design of System Development Process

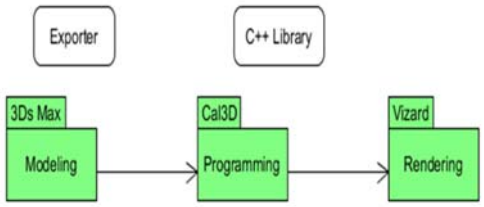


Figure 7. System Flowchart Diagram

Cal3D as C++ Library

Cal3D is open source, cross-platform skeletal animation engine that supports a variety of three- dimensional modeling tools including 3ds Max. After completed modeling in 3D model software, including animation after construction, then use of Cal3D exporting data. Cal3D have its own data format, classes and methods to build through its source code can be read out internal data. Render the model in the rendering component is completed, data is read Cal3D provided.

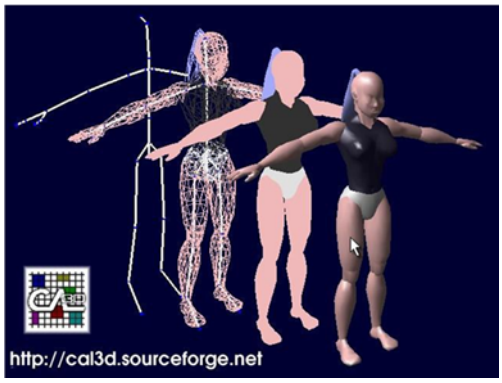


Figure 8. Structure model in Cal3D

3.3.2. Vizard as Inspector Simulation

In Vizard, we can make use of scene-global variables and can manipulate all objects whenever necessary. In the script one can add 3D models to the scene as well as program functionality. Vizard does not provide a visual mode but comes with various tools to aid visual editing, such as an object inspector. In this inspector we can view a 3D model and its individual parts. Parts can be deleted and added, but can not be created from scratch. The object inspector also functions as a converter to save 3D models from other formats in the OSG format that is used by Vizard. To create new Open Scene Graph (OSG) models, we can use external OSG editors. Since Vizard does not provide a visual mode, locating and scaling objects is not as intuitive, but is very precise. We can use the bounding box of an object to retrieve its size and place it accordingly. The virtual pedestrians are moved by adding walk actions to their action queue. In Vizard, a method that is called in every frame does not exist. The avatar automatically uses the walking animation for walking actions.

Virtual Hand Simulation Testing

This virtual hand simulation is focusing on hand manipulation these are hand grasping parts as Hand subsystems. The results in grasping parts are many of parts in the environment even some parts has more than one features that create different hand gesture crawl depend on part's feature shape, therefore it makes a bunch of combination of hand manipulation interacting with each part's features in grasping subsystem simulation. As results, there were some of the simulation in this system then so the testing case is filled up

4.1. Grasping Subsysytem

There are a lot of elements in the environment even some parts have more than one features that create different hand gesture crawl depend on part's feature shape, therefore it makes a hand manipulation being interacted with each part's features in grasping subsystem simulation. but in this thesis, we do not make the hand to grasping a part's features. the hand will be grasping without part's and we want to see when the hand grasping there is any abnormal thing on our hand when grasping.

4.2. Virtual Hand Testing

Virtual hand complete virtual hand tasks need to meet the ideal conditions of using virtual simulation which is authenticity the high hand and the virtual environment and virtual reality environment similar degree, but also help to generate a sense of naturalness virtual hand and the form and nature interact with the virtual environment interact with high consistency, making the operation closer to the natural interaction.

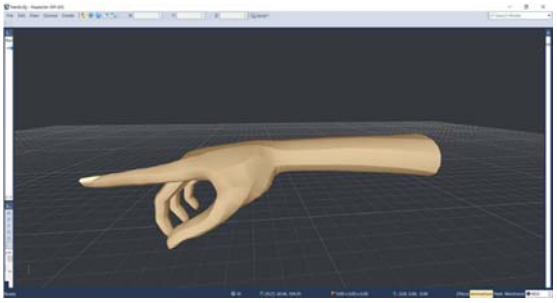


Figure 9. Pnt grasping correct gesture

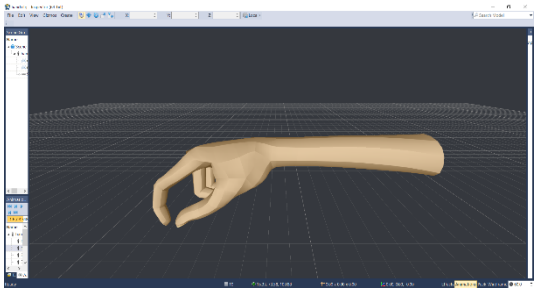


Figure 10. 2fNip grasping correct gesture

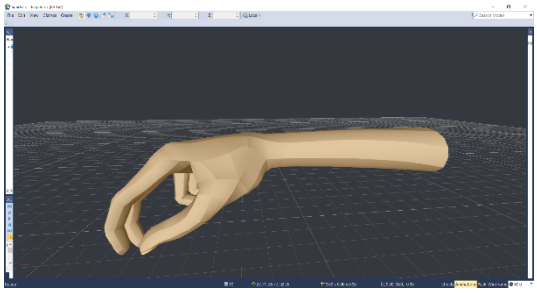


Figure 11. 3fNip grasping correct gesture

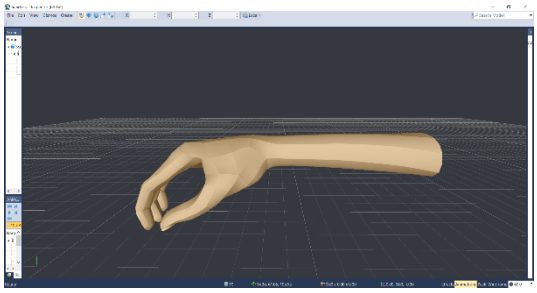


Figure 12. 4fNip grasping correct gesture

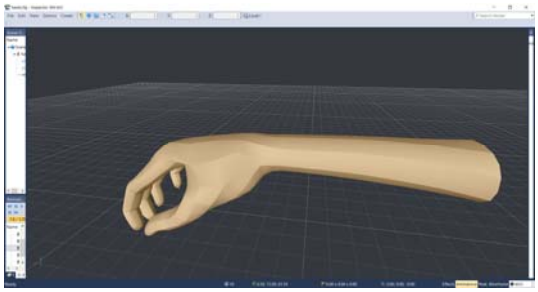


Figure 13. 5fNip grasping correct gesture

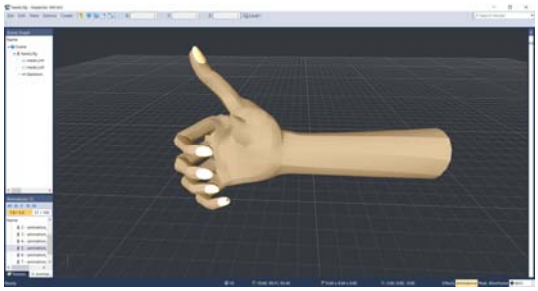


Figure 14. Agrasp grasping correct gesture

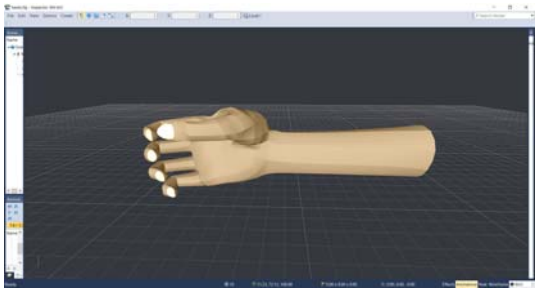


Figure 15. Pgrasp grasping correct gesture

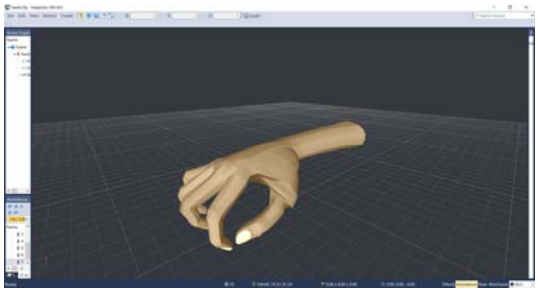


Figure 16. Ggrasp grasping correct gesture

Virtual Hand Testing Abnormal Captured

For every hand gesture are there is no errors with the hand gesture when grasping but there is any abnormal thing on the hand when grasping, we will see the abnormal of our hand. Bellow On figure 4.10 using 5fNip hand gesture. While the hand grasping, there is a abnormal with pinky nail. Infact, there is any abnormal thing with another hand. Also some of hand gesture still has abnormal such as Agrasp hand gesture and Ggrasp hand gesture.

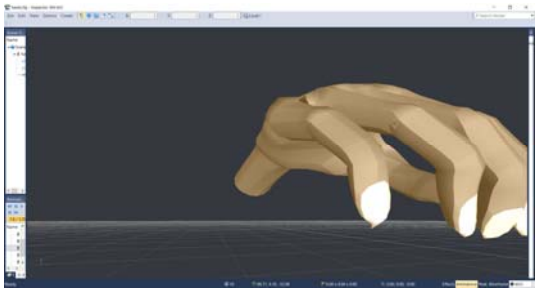


Figure 17. 5fNip grasping abnormal captured

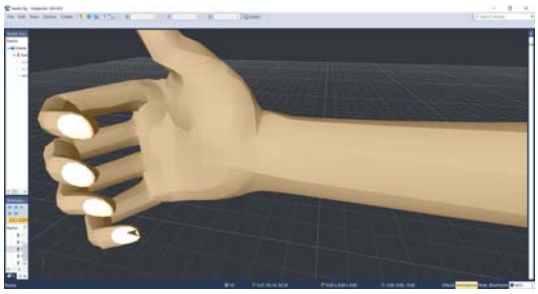


Figure 18. Agrasp grasping abnormal captured

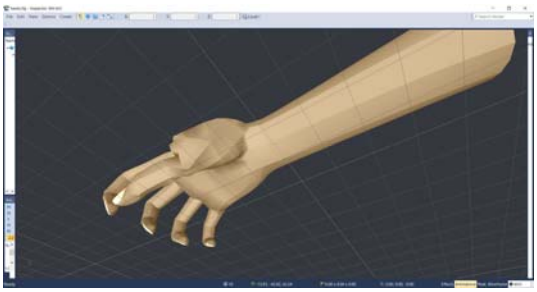


Figure 19. Ggrasp grasping abnormal captured

Functional Testing

The testing process is done in a way to virtual hand simulation on a computer. I will use the black box testing methods to see if the functions of the hand grasping are working properly or not and also know where there is any abnormal thing in the virtual hand.

Environmental Testing

Virtual hand simulation was tested using a laptop :

- Laptop specification:
- Display-1920 x 1080 pixels
- CPU – I7-4720HQ 2.60 GHz
- RAM - 8 GB
- VGA – NVIDIA GEFORCE GTX 950M
- OS - WINDOWS 10

No.	Name of Hand Gesture	Activity	Expected Hand Gesture Result	Test Result
1.	Pnt	Normal	Pnt	Correct
2.	2fNip	Normal	2fNip	Correct
3.	3fNip	Normal	3fNip	Correct
4.	4fNip	Normal	4fNip	Correct
5.	5fNip	Normal	5fNip	Abnormal on pinky nail
6.	Agrasp	Normal	Agrasp	Abnormal on pinky nail
7.	Pgrasp	Normal	Pgrasp	Correct
8.	Grasp	Normal	Grasp	Abnormal on thumb finger

Scenario Testing

Testing is performed using laptop ASUS ROG G550JX. The hand gesture tested include:

Testing Result

After the testing phase, black box on the virtual hand simulation wich has been run, it can be concluded:

1. The hand runs well on laptop because at the time of making the author uses laptop to find out the errors on grasping and others.
2. The gesture of the hand runs well as, taking the Cal3D data on inspector, featuring combine Cal3D data into one and run it while displaying hand in vizard 5.

No.	Name of Hand Gesture	Activity	Expected Hand Gesture Result
1.	Pnt	Normal	Pnt
2.	2fNip	Normal	2fNip
3.	3fNip	Normal	3fNip
4.	4fNip	Normal	4fNip
5.	5fNip	Normal	5fNip
6.	Agrasp	Normal	Agrasp
7.	Pgrasp	Normal	Pgrasp
8.	Grasp	Normal	Grasp

Conclusion And Future Work

Conclusion

This paper discussed Building a Virtual Hand for Simulation. One of the main objectives of the Virtual System, which is developed and studied is to obtain realized the interaction behaviors of the hand and system in a virtual environment. Therefore to realized that interaction, proper hand modeling as it's main part on the environment is absolute. So then the discussion on hand modeling is provided here.

Future Work

The weaknesses and limitations of virtual hand will be developed in the research study. For future work to continue this research, we propose:

1. The virtual hand can be developed to add more hand gesture.
2. The virtual hand can be developed to grasp some object or parts.
3. The virtual hand can be developed to grasp with input device

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