# REAL-TIME AVATAR SWEATING SIMULATION USING TEXTURE BASED AND PARTICLE SYSTEM

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This dissertation is dedicated to my family for their endless support and encouragement.

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**ABSTRACT**

Displaying extreme expressions such as scared until sweating is not easy task to be achieved in 3D Games and the simulation of facial animation in real-time. Some difficulties faced by these researches, first the complex simulation for the physical properties of the muscles and emotions or the properties of fluids simulation and texture based simulation and secondly how to control the facial animation with one of the two sweating generators simultaneously in a good and efficient manner. This research present techniques for generating extreme expression in 3D facial animation. The facial action coding system is employed to describe and create facial expressions. It breaks down facial actions into minor units known as action units (AUs). Facial expressions are generated by combining independent action units. The created expressions include sadness, anger, happy and fear. Two types of sweats can be generated and combined with facial animation technique to generate facial extreme expressions. The first type of sweat animations is dropping sweats, when the fluid generation creates the sweats based on particle system. The other type of sweat is texture based, when the sweat is flowing along the surface of the skin on the forehead area for the face. The methods mentioned above are used to increase the realism of virtual human by provides real-time sweating simulation during the extreme expressions.

# ABSTRAK

Paparan ekspresi melampau seperti ketakutan sehingga berpeluh bukanlah tugas yang mudah untuk dicapai di dalam Permainan 3D dan simulasi animasi dalam masa nyata. Di dalam penyelidikan, beberapa masalah telah dihadapi, yang pertama adalah simulasi yang kompleks untuk sifat-sifat fizikal otot dan emosi atau sifat simulasi cecair dan simulasi berasaskan tekstur dan yang kedua adalah bagaimana untuk mengawal animasi muka dengan salah satu daripada dua penjana perpeluhan secara serentak dengan berkeadaan baik dan cekap. Kajian ini memperkenalkan teknik untuk menjana ekspresi melampau dalam paparan animasi 3D. Sistem tindakan muka pengekodan digunakan untuk menggambarkan dan mencipta ekspresi muka. Ia membahagikan tindakan muka kepada unit-unit kecil yang dikenali sebagai unit tindakan (AUS). Ekspresi muka dijana dengan menggabungkan unit tindakan rawak. Ungkapan yang dicipta termasuk kesedihan, kemarahan, gembira dan takut. Dua jenis perpeluhan boleh dihasilkan dan digabungkan dengan teknik animasi muka untuk menjana ungkapan melampau muka. Jenis animasi peluh yang pertama adalah peluh yang kejatuhan, apabila generasi cecair mencipta peluh berdasarkan sistem zarah. Jenis animasi peluh yang lain adalah berdasarkan tekstur, apabila peluh mengalir sepanjang permukaan kulit pada kawasan dahi ke muka. Kaedah yang disebutkan di atas digunakan untuk meningkatkan sifat nyata manusia maya dengan menyediakan simulasi masa nyata berpeluh semasa ungkapan melampau.

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# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction

Virtual human, has been developed in various forms of computer applications(Yee *et al.*, 2007). Currently, an avatar is able to interact naturally depending on the considerable progress in artificial intelligence, diverse sensing technology and advanced computer graphics(Lee *et al.*, 2010).

Facial animation is used in a large number of critical areas. It helps to bring humanity facts and representations of expressions to the reality of human, social reality and more significantly in the expression of many computer games most effectively, the field of medicine, interactive through multimedia and movies, and began to grow and increasing significantly in terms of importance and widely usage. Because of greater geometric details as well as through the better animation, virtual characters in computer games and simulations have become very similar to real situations. As a result of capturing the movements and methods for automatic blending, body and facial motions together can be viewed persuasively.(Tol and Egges, 2009).

Facial animation is one of the complex and effective communication tools in the field of creative animation that produces truthful virtual avatars or social agents. It is considered as a very challenging work at a high level because it needs animations on a high level at each event and the component of the face, like facial bones, and muscles of the face and lips synchronization during speech. Construction face of human at a high level accuracy requires great effort and time and skills at animation industry. On the other hand, it is very important because the expressions in the face include a lot of important information therefore, it is possible to observe the feelings of the people and their mental states. As the supervisor in Blur Studio's animated, Jeff Wilson said, “Generating credible facial animation is very vital because the face is essential to understand the emotions”(Liu, 2009; Wilson and Mike, 2005).

One of the most important purposes in the use of virtual characters in a 3D environment is the attempt to create an efficient communication to attract the user. To build this exciting type of contact between the user and virtual character, it is needed to provide a very important side in building this relationship which is the expression of emotions. It is possible to display a wide variety of emotions in virtual characters realistically, either by using diverse styles of motions in body(Egges and thalmann, 2005; Tol and Egges, 2009) or by different facial expressions(Gachery and Thalmann, 2001; Tol and Egges, 2009).

However, many emotions in most of the virtual characters in several computer games such as (Fallout3, 2009) is still very limited. Distinctive strong emotions, for example, screaming during anger, loud laughs and crying needs to provide a lot of displaying for expressions. For instance, whenever somebody is cries, the tear rolls on the surface of a person's face or when somebody is screams loudly in anger, it is possible that the face of that person becomes red.(Tol and Egges, 2009).

In Physiological Arousal, actually, emotions have a correlation with changes in the extreme light of physiological processes that occur inside the human body. In addition to the many changes that occur within the body that have been listed only, these processes are likely to be included in the variations that occur in the activity of sweat glands and salivary, the changes that occur in the levels of some neurotransmitters inside the brain, changes in metabolism, result of changes in muscle strain and finally, changes that will occur on the digestive system as a result of the revised digestion. There are other species of physiological processes that could lead to a change in the color of the face, piloerection, facial expressions and as well as other signs that represent emotion (Ettinger, 2008).

Finally, motions also contain behavioral responses. Emotions always motivate the human to express his feelings or act out. These expressions perhaps range from screaming or crying, as well as verbal expression, which represents laugh or smile. There are common signs of emotions which include tone of voice as well as the position and other types of physical language (Ettinger, 2008). Not all kinds of fear lead to a process of sweating in humans, the kind of fear which leads to sweating depends on the ratio of fear.

## 1.2 Problem Background

Facial modeling for humans is one of the fields of study which includes many of the complexities and challenges which has connections with many other fields like medicine ,engineering ,animation and computer graphic(Gladilin *et al.*, 2004).

In fact, the process of generating realistic synthetic faces in three-dimensional characters and trying to make it desirable has become something very important which attracted the attention of many researchers and it became a very big challenge for researchers in recent times to achieve. During the past few years and with the progress in the establishment and providing a variety of algorithms and techniques developed in Facial animation, currently, it is possible to create the geometry of the human face in detail through the ability to use 3D photometric techniques and scanners. A result of technological progress in the areas of modeling of the human faces the researchers have become less tolerant to ignore the imperfections in the animation and models that have been happening in the past(Ypsilos and Ypsilos, 2004).

The production of computer facial animation with appropriate and complex expressions is still difficult work and fraught with problems. The interaction with characters is very important to create effective connection with the user. Therefore, virtual characters use a variety of types of emotions such as facial expression or diverse body motions styles to perform this connection effectively, but these emotions seems to be affected slightly by the interaction of the user in some games. For example, a game that uses emotion to create a conversation with computer controlled characters is Oblivion(The elder scrolls iv:Oblivion, 2009).This game contains four instances of emotions that could represent a character. However these are represented only by using very fixed expressions. An example of this is shown in Figure 1.1.

**Figure 1.1:** Representation of the four static expressions that were used in the game Oblivion: Elder Scrolls IV(The elder scrolls iv:Oblivion, 2009)

However immersion is increasing because the impact by the user(Tol and Egges, 2009).In the most recent games, like (Fallout3, 2009) or (Grand theft auto iv, 2009), although these characters display a variety and different levels of emotions, but it seems that these emotions have difficulty to be influenced by the actions of the user. For example, the character that seems friendly always stays friendly, whereas characters that are not friendly always seem to represent a form of anger. Figure 1.2 views the character of Fallout 3 game, Where the difference between the facial expressions is very little, but these expressions in fact are not depending at all on the users' input (Tol and Egges, 2009).

**Figure 1.2:** The four expressions for the face in the character of Fallout 3 game(Fallout3, 2009)

They are closer to be realistic and the differences between the facial expressions are very little but it seems that these emotions have difficulties to be influenced by the actions of the user. In the examples that have been mentioned above, Emotions that have been viewed are through geometric animation for the face only. Therefore, many emotions in some of the virtual characters in this computer game are still quite limited. These characters need to support the displays of expressions such as loudly laughing, crying, sweating with scare in the best manner, on the contrary, in movies, when using this type of regular expressions in order to work to attract the viewer.

Weaknesses to display these affective emotions lead to displaying less realistic experience in terms of emotions.The process of generating these distinct expressions in real-time 3D is often more like a complex task. It needs the process of skin deformation and precise modeling for the muscles representation of facial animation in many applications through the method of geometric deformation, often through combination with a standard facial animation approach like the MPEG-4 facial animation standard. This standard uses a limited set of parameters to recreate and describe actual expression for the animator (Tol and Egges, 2009).

Another system, named FACS, works to describe the units of facial action effectively on the muscles of the human face. It was developed initially for the purposes of psychology, to perform the task of description and recognition of expressions and a process to link them with emotions. Examples of this type of procedures done by this standard are "Brow lowerer" or "Lip Tightener".after that, It was adapted to be suitable for use in the movies, to generate realistic expressions.

In these two methods, the work of the standard is deformations of the face and does not take into consideration the other emotions, like crying and sweating which result during anger or sadness or happiness (Description of the facial action coding system).

The construction and animation in a realistic manner in the real three-dimensional human faces are still significant problems in the field of computer graphics (ILIE *et al.*, 2011). In the field of facial animation synthesis, the existing technologies are still not able to build facial expressions, in an effective and more realistic manner and including the underlying emotional content(Zhang *et al.*, 2008).

Sweating, fear, anger, wrinkles, blushing and tears are a set of expressions in face that were used as the emotions to express the physiological emotions in human aspects (de Melo and Gratch, 2009). Whereas ,the simulation of sweat during the occurrence of fear is not representative of the expressive manner of reality compared with their representation during the 3D movie, which are represented in a very similar style to the reality.

**Table 1.0 :** Review Facial Animation researches.

| Author | Title | Year | Their work | Future work |
|---|---|---|---|---|
| Gladilin, E., Zachow, S., Deuflhard, P. and Hege, H | Anatomy- and physics-based facial animation for craniofacial surgery simulations | 2003 | A modeling approach for the realistic simulation of facialexpressions of emotion in craniofacial surgery planning | |
| Ypsilos, I. A. and Ypsilos | Capture and Modelling of 3D Face Dynamics | 2004 | This thesis addresses the problem of capturing, modelling and analysing 3D facial dynamics and provides a framework for the realistic synthesis of face sequences. | “Dynamic 3D face capture and representation” “Analysis of facial dynamics” “Targeted applications” |

| Author | Title | Year | Their work | Future work |
|---|---|---|---|---|
| Zhang, Y., Ji, Q., Zhu, Z. and Yi, B | Dynamic Facial Expression Analysis and Synthesis With MPEG-4 Facial Animation Parameters | 2008 | Explores the use of a coupled Bayesian network to unify the facial expression analysis and synthesis into one coherent structure to synthesize dynamic facial expressions | A more quantitative performance evaluation of our method is needed. This requires to establish a quantitative measure to quantify the quality of the reconstructed FAPs and their temporal development |
| Deng, Zhigang Neumann, Ulrich | Data-Driven Expressive Speech Animation Synthesis and Editing | 2008 | A data-driven system (eFASE) for an expressive facial animation synthesis and editing system is presented | Optimizing the facial motion database could improve the overall efficiency of this system, such as reducing the size of the facial motion database through clustering methods |
| Tol, W. and Egges, A. | Real-time 3D crying simulation | 2009 | A real-time crying simulation framework, by using an extended SPH approach, optimised for crying fluid simulation | Look at what muscle motions are important in crying and laughing animations in order to provide more detailed facial animations, while retaining the real-time constraint. |

| Author | Title | Year | Their work | Future work |
|---|---|---|---|---|
| de Melo, C. and Gratch, J. | Expression of Emotions using Wrinkles, Blushing, Sweating and Tears | 2009 | A real-time model for the expression of emotions in virtual humans using wrinkles, blushing, sweating and tears | developing computational cognitive models for blushing, sweating and tears |
| Lee, S., Carlson, G., Jones, S., Johnson, A., Leigh, J. and Renambot, L. | Designing an Expressive Avatar of a Real Person | 2010 | Development process for the Lifelike Responsive Avatar Framework (LRAF) and a prototype application for modeling a specific individual to analyze the effectiveness of expressive avatars. | Further investigation of how human can recognizes emotions within a context accompanying temporal changes over time and/or spoken information factors affect on avatar emotion is necessary in the future. |
| Zhang, Shen Wu, Zhiyong Meng, Helen M. Cai, Lianhong | Facial Expression Synthesis Based on Emotion Dimensions for Affective Talking Avatar | 2010 | Introduces synthesizing emotional facial expression on expressive talking avatar in emotional text to audio visual speech system | Implement a conversational engaging talking avatar for spoken dialog system. |

| Author | Title | Year | Their work | Future work |
|---|---|---|---|---|
| Mihai Daniel ILIE, Cristian NEGRESCU, Dumitru Stanomir | Circular Interpolation for Morphing 3D Facial Animations | 2011 | presented a novel shape interpolation method that gives very good results for mesh morphing 3D facial animations | The method could also be adjusted for other kinds of animations by dividing the mesh in a few parts and then applying the algorithm on each such part in particular |

## 1.3 Problem Statement

There are many extreme expressions that should be considered in facial animation such as, scared until sweating, sadness with cry, anger, shame, and pride in addition to combinations between some of expressions which happen together in some situations. According to previous studies that have been presented and through intensive observation this research reveals that the extreme expression is not researched well. Therefore it is required to generate some extreme expression to enhance the realism of virtual human.

The main questions of this study can be described as follows:

*How can we perform the realistic emotional facial expression of virtual human during the extreme expression?*

These are some research questions that can be derived from main research question:

- Why the existing facial expression in virtual avatar still need for some extreme expression?
- What are the elements that are needed to express the extreme emotion?
- How to simulation sweat during the extreme expression?
- How to explain the sweat properties?
- What are the requirements to build this system?

## 1.4 Aim of the Study

The aim of this thesis is to create real time sweating simulation of extreme expression on virtual human using texture based and particle based approch.

## 1.5 Objectives of the Study

The objectives of this study are explained below:

**1-** To study and analyze various techniques of computer facial animation techniques.

**2-** To design and implement a proposed system capable of integrating FACS with texture based or particle system.

**3-** To develop a facial animation system for the proposed approach.

## 1.6 Scope of the Study

The scopes of this study are explained below:

1- The FACS proposed method is employed to express the emotions in facial animation.
2- This thesis focuses on expressing the sweating effect according to emotion state.
3- The FACS and particle system with texture based will be designed and applied using Microsoft visual C# 2010 as a programing language.

## 1.7 Significance of the Study

The significance of this study is to propose a system capable of integrating the FACS, texture based and particle system in facial animation to provide efficient display in computer facial animation which will be able to express the realism in three-dimension games through better animation thus, entice the viewer.

## 1.8 Thesis Structure

This thesis consists of five chapters which are organized into the chapters as the following:

**Chapter 1** includes the introduction, problem background, problem statement, aim of the study, objectives, scope and significance of the research.

**Chapter 2** details out the literature review of the research. This chapter provides an introduction of facial animation. Facial animation techniques are divided into, traditional polygonal mesh, pose animation, and end with facial action coding system which is used to model the face and expressions in this research. Also this chapter describes the emotion expression followed by description of facial gesture generation and extreme expression. The sweat simulation is very important to be solved and simulated. It is divided into fluid simulation which uses the particle system to generate the sweat on the forehead area and texture based simulation which uses the texture to create textured sweating on the forehead area. The chapter ends with a discussion.

**Chapter 3** describes the research methodology that plays an important role as the research guideline. Research methodology is identified to sort the process of implementation and the developments that convene towards the research aims and achieve the requirements. In the first phase, preliminary investigation and data collection of Facial Animation were done. Next is a design phase of Facial Animation technique to express the four facial expressions (Anger, Happiness, Sadness and Fear). Then, the process of designing a system able to generate sweat depending on texture based and particle system was performed.

The next stage is designing a system capable to combine the facial animation technique with sweat generators techniques to get the extreme expression was also conducted. The final stage consists of testing and evaluation which is used to measure the techniques and evaluates the system.

**Chapter 4** details out the implementation for facial animation techniques and sweat simulation techniques in order to achieve the second objective. This stage refers to the research methodology as a guideline. Firstly, the chapter discusses how to implement facial action coding system (FACS) and Action Units. Next, an explanation of extreme expression is involved in this chapter. Then, this chapter explores the implementation of fluid generation followed by the implementation of texture based generator. After that, the integration of facial animation technique with one of the two sweat generators techniques have been implemented and explained in details. The final stage in this chapter is to implement the testing and evaluation process for the facial animation technique and sweat generators techniques to get a better idea about extreme expressions future.

**Chapter 5** is the last chapter of this thesis. The chapter provides the research's conclusion. It aims to find appropriate techniques and good solutions to overcome the issues addressed. Therefore, this chapter will describe the results and improvements made on the facial animation technique. This chapter also suggests the future work for facial animation techniques as well as extreme expressions improvement that should be carried out. These future works have potentials to be continued and it is recommended that to be done in the future in order to enhance and improve the system.

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