

REAL TIME CRYING SIMULATION USING FLUID PARTICLES  
INTERACTION TECHNIQUE

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

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## ABSTRACT

The enhancement of emotional expression of virtual human in extreme situation such as, crying or sweating required physics effect that involved fluid behavior. The aim of this research is to utilize Facial Action Coding System (FACS) and Smooth Particle Hydrodynamic (SPH) methods to effectively provide an efficient display in computer facial animation. This research presents two 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 (AU's). Emotion facial expressions generated are based on independent action unit's combination. The SPH method technique is used to generate crying teardrops according to rules of physics. Each particle in tears drop is simulated and controlled by SPH rule. The created expressions include sadness and happiness by FACS then add the tears that followed the SPH method rules to provide an avatar tears displaying affectively as an extreme expression. The enforcement of the proposed system is able to fuse both FACS & SPH used in facial animation and fluid simulation, to create a system able to express, and implement the extreme expressions in facial animation. The results obtained in this research, were generated tears consist of 100 particles and achieved an average 55.5 Frame per Second (FPS) and were considered it as the final result, the values that used in this research is 0.0108 N./m<sup>2</sup> for pressure, 1 kg/(m·s) for viscosity, 1 m/s<sup>2</sup> for Gravity as a physics parameters that affect the tears, the position of the tears source is set at the middle and outer end of each eye. Modeling the muscles movement for extreme expressions such as, crying or the rest of expressions. In future work, this research seeks to reveal what kinds of muscle actions are important in crying and laughter in order to work on providing more detailed features in facial animations, while maintaining real-time execution.

## ABSTRAK

Penyerlahan ekspresi emosi manusia maya didalam keadaan ekstrem seperti menangis dan berpeluh memerlukan kesan khas fizik yang turut melibatkan sifat cecair. Tujuan kajian ini adalah bagi menggunakan Sistem Pengekodan Aksi Muka (FACS) dan kaedah Kelancaran Partikel Hidrodinamik (SPH) dalam menyediakan kesan yang efektif dan cekap terutama pada paparan animasi muka di computer. Kajian ini membentangkan dua teknik dalam menghasilkan ekspresi ekstrem dalam 3D animasi muka, sistem pengkodan aksi muka yang dilakukan untuk menerangkan dan menghasilkan ekspresi muka. Ini mengecilkan aksi mimic muka kepada unit kecil yang dikenali sebagai Unit Aksi (AU's). Emosi pada mimik muka yang dihasilkan adalah berdasarkan kepada kombinasi uni-unit aksi yang bebas. Teknik kaedah SPH digunakan untuk menghasilkan titisan air mata yang menangis berdasarkan hukum fizik. Setiap partikel di dalam titisan air mata ini disimulasikan dan dikawal oleh peraturan SPH. Mimik muka yang dihasilkan oleh FACS termasuklah dalam keadaan sedih atau gembira yang kemudiannya telah ditambah dengan titisan air mengikut peraturan kaedah SPH bagi memaparkan air mata pada avatar lebih efektif. Penguatkuasaan dalam sistem yang dicadangkan dapat menggabungkan kedua-dua FACS dan SPH dalam animasi muka dan simulasi bendalir untuk menghasilkan sistem yang dapat mengekspresi dan mengimplimentasikan mimik muka animasi yang ekstrem. Hasil daripada kajian ini ialah titisan air yang dihasilkan terdiri daripada 100 partikel dan mencapai purata 55.5 bingkai per saat (FPS) yang kemudiannya dianggap sebagai keputusan akhir. Nilai yang digunakan didalam kajian ini ialah  $0.0108 \text{ N/m}^2$  untuk tekanan,  $1 \text{ kg/(m.s)}$  untuk kelikatan,  $1 \text{ m/s}^2$  untuk graviti sebagai parameter fizik yang mempengaruhi titisan-titisan air mata, posisi punca kedudukan titisan ditetapkan ditengah dan di luar hujung setiap mata.

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## CHAPTER 1

### INTRODUCTION

#### 1.1 Introduction

In the recent years that has been observed evolution in the field of graphics computer, especially those relating to the drawing the computer characters model, including computer animation, such as, motion of objects, geometry, texture, lighting adjust, acceleration rendering, facial animation and so on, for example, how to move those characters (body , face or both) and the methods those used to express them and trying to reaching the graphics that more realistic which is similar to the human in terms of general appearance and facial expression (Wijnand and Egges, 2009). Facial expressions such as sadness, anger, joy, fear, disgust, and surprise, which are a basic human expressions, which is seeking researchers in computer graphics field to develop in order to be more realistic and more obvious to the user.

Facial animation now has more interest from the past 25 years. That can be defined as a one of the computer graphics fields to simulate the facial animation for human in computer graphically as realistic way in computer interactive games and applications.

As an abbreviation on the history of the emergence and evolution of facial animation, in the early seventies, specifically in 1970 was initiated interest and work on facial graphics by computer and is considered the first work of this area. K-

dimensional data has been represented as a proposed by (Chernoff, 1971) to draw two-dimensional face in computer. In 1972 was establishment of the first three-dimensional animated by Parke (Parke, 1972), one of the scientists his name Gillenson create an interactive system to assemble and edit line drawn facial images. Then, Parke developed in 1974 a parameterized three-dimensional facial model. The first physically based muscle-controlled face model developed by Platt in The early 1980.and techniques for facial caricatures was developed by Brennan.

Then a film ``Tony dePeltrie'' in 1985 was a milestone in facial animation, Where it was the first animated short film of its kind in the world, so that the computer facial expression and speech animation was Intervention as essential elements of the tale of the events of the story.



Figure 1.1: Tony dePeltrie avatar

Waters developed a new muscle based model in the late of 1980, the abstract muscle action model developed by Magnenat-Thalmann and his fellow, and Lewis and Hill coincide oncoming to automatic speech. In the 1990 have seen heightened activity to develop of facial animation techniques and the use of computer facial animation as a key for stories as shown in the story of the film ``Toy Story''.

Throughout the last contracts, facial modeling and animation was achieved a measure of realistic asymptotic for photographs. Even though the sights instructors will still be capable to discover minor defects in both animation and rendering of the modern feature films such as Final Fantasy the general quality and the particularly the modeling and the texturing are impressive extremely. However, several many-years gone to the modeling of every individual character from that film. Attempt to model a real person becomes more complicated than that: the replacement of artistic license to establishment of geometry and the textures to "look good" by the application to create models that "look real."

Emotions are close related to each other. Concern is the less severe form of fear, contempt is a lightweight version of disgust, and the rigor is a lightweight version of anger. Research in this area has shown that humans can identify the six emotions global (as maintained before). But there are more ambiguous expressions that human have. When any person combines more than one expression along, that will be the new work for research proposals. Further, physical states such as passion, sleepiness, pain, and physical exertion tend to be much more difficult to identify. So if any working to prove that the emotion that the people trying to describe is recognized, people must depend on the general position or animation of the character. Shyness, for example, is created with a slight smile and downcast eyes. But this could be misinterpreted as embarrassed or self-satisfied.

In addition to all of the above can consider that one of the hot topics in Computer Graphics is a Computational fluid dynamics. The capability to produce realistic fluids numerically has gained an increased interest the last decade. Some of the emotions are accompanied by the appearance fluids on the human face such as sweating, crying at sadness or laughing until cry and some of research work to simulate these complex emotions but still not reality and close to human emotions.

The extreme expression is the area that comes from combining to areas along like combining the facial animation methods with fluid method to generate the fluid simulation like sweating or tears and so on. Some of the prevue works focusing on the facial expression to make it more realistic like using MPEG-4 for move the lips smoothly for speech. Another researchers focusing on the fluid simulation by applying the physics parameters like use the SPH to simulate the water running in real behavior. This research is use both of the facial animation method and fluid simulation method to creating the facial animation and expression extremely.

## **1.2 Problem Background**

A significant issue that has remained unsolved in computer graphics is the construction and animation of realistic human facial models (Lee, Terzopoulos, and Waters, 1995). Facial animation is a research subject for nearly 4 decades. The pioneer work of different approaches happen to be suggested to enhance the different aspects involved with facial animation (Parke, 1972). Due to the complexness of human facial anatomy, and our natural sensitivity to countenance, this can be a tightly defined problem, but fixing it is not easy (Deng and Neumann, 2007).

Computer animation has lately acquired recognition in lots of programs, including web pages, video games, movies, as well as other human computer interface designs. To be able to make these animated Figures lively and convincing, they might require sophisticated facial expressions and motions. Typically, these animations are created entirely by skilled artists. Although the standard of by hand created animation continues to be best, this method is slow and pricey. Motion capture performance of stars and stars is a technique that tries to accelerate this method.



One trouble with this method would be that the taken motion data cannot be edited easily. Recently, record techniques happen to be accustomed to address this issue by understanding the mapping between audio speech and facial motion. New facial motion could be synthesized for novel audio data by re-using the motion capture data. However, since facial expressions are not patterned during these approaches, the resulting facial animation is realistic, yet expressionless.

A significant unsolved condition in computer graphics may be the construction and animation of realistic human facial models. Typically, facial designs include been built meticulously by manual digitization and animated by random parametrically controlled facial mesh deformations or kinematic approximation of muscle actions. Fortunately, artists can now digitize facial geometries by using checking range sensors and animate them with the dynamic simulation of facial tissue and muscles. However, they require considerable user input to create facial types of people appropriate for animation (Williams (1990), Hill et al. (1988), Pieper (1991), Weil (1982), Yuille et al. (1989)).

Exhibiting facial motions for example crying or laughing is tough to attain in simulations and games. Not just due to the complicated simulation from the physical qualities for example muscle motions or fluid simulations, but additionally because one should understand how to control these motions on the greater level (Wijnand and Egges, 2009).

One of the most challenging tasks is the achievement display facial motions with high accuracy and close to reality, such as laughing or crying in the simulations and games. The movement of the muscles and simulation of the fluid are not only the problem caused by complexity of simulation, but also there is knowing how to manage these motion in high levels (Wijnand and Egges, 2009).

One of applications of fluid animation is a tear. Tears are an essential part of crying when someone is sad or so happy until cry. This research studies the ability to generate tears to be interactive with the user and the surroundings, as opposed to

preprogrammed, to increase immersion. Therefore, using a texture will not be sufficient to generate tears in an interactive environment. To simulate tears, this research needs to simulate fluids in a realistic way. One of the best ways to simulate the fluid particles is using the Smoothed Particle Hydrodynamics (SPH) method that will be talking about it and explain it in Chapter 2. Table 1.1 concludes the weakness of some related works with the titles of the references.

Table 1.1: The vulnerabilities of some related works.

<b>Title</b>	<b>Author /Year</b>	<b>finding</b>	<b>The vulnerabilities</b>
Expression of Emotions using Wrinkles, Blushing, Sweating and Tears.	Celso and Jonathan (2009)	A real-time model for the expression of emotions in virtual humans using wrinkles, blushing, sweating and Tears.	There are several factors not covered in this research which influence the magnitude and whether these physiological manifestations occur when experiencing the corresponding emotions such as blushing, sweating and tears. Also comparing only static images of the virtual human.
Real-time 3D crying simulation	Wijnand and Egges (2009).	A real-time crying simulation framework, by using an extended SPH approach, optimized for crying fluid simulation	The method for simulation the tears-skin interaction is limited. Extreme expression like laugh until cry is not covered in this work. Important muscle motion in crying animations is also not covered.
Creating emotions and facial expressions for embodied agents	Bui (2004)	Talking head which is able to speak, to display lip movements during speech, proposed a fuzzy rule-based system to generate facial expressions from emotional state.	there is no psychological realism on the system

Table 1.1: Cont.

Data-driven Appearance Model for Human Fatigue	Joseph et al, (2011)	Simulating set of squats, jumping jacks or walking up a flight of stairs, individuals start to pant, sweat, lose their balance, and flush due to exertion and exhaustion on an animated character greatly enhances a motion's realism.	The research model focuses on certain fatigue effects. Muscle deformation, facial expressions, Wrinkles and eye movement are not covered in this research as important aspects affecting human exercise motion
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### 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 premise in this study can be considered as following:

*How we can use the FACS and SPH method to provide an efficient display in computer facial animation effectively?*

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?

- How to simulation tears during the extreme expression?
- How to explain the tears properties?
- What are the tears physics parameters?
- What are the requirements to build this system?

#### **1.4 Research Aim**

The main aim for this study is how to emulate the human tears that is close to the reality by designed a proposed system to simulate the sadness until crying or laughing until crying which generate tears.

#### **1.5 Research Objective**

- To study and analyze different models of computer facial animation techniques with its expressions and fluid simulation technique.
- To design and enforce proposed system that able to fuse the both Facial Action Coding System (FACS) and Smooth Particle Hydrodynamic (SPH) that used in facial animation and fluid simulation.
- To develop a simulation model of the FACS and SPH.

#### **1.6 Scope**

This study scopes are elucidate below:

- Express the emotions in facial animation by used the FACS proposed method.
- Simulate the fluid particles (Tears) by using SPH as a proposed method.

- iii. Five inputs (physics parameters) and one output (Frame per Second) Measure in real time performance.
- iv. The FACS and SPH will be designed and applied using Microsoft visual C# 2008 as a programming language and the XNA library.

## **1.7 Research Significance**

The significance of this study to propose system that closed to the reality. Because of the current avatar (current researches) focus on the facial animation only. The goal of this study is to add some of fluid to the facial animation to simulate the facial expression that closed to the reality.

## **1.8 Thesis Organization**

Five Chapters are formation this dissertation. Which are, Chapter 1 includes introduction, problem background, problem statement, aim of this study, objectives, scope and significant of this research. Chapter 2 includes introduction, facial expression, theory of emotion expression, facial animation as media for emotion expression, facial animation techniques, extreme expression, fluid interaction techniques, tears in fluid .then followed by Chapter 3 which contained facial expression, emotion expression theory, facial action coding system and action unit, rendering facial expression, extreme expression, fluid generation, SPH interaction, tears rendering and evaluation and testing. The end of this Chapter will be the thesis writing. Then the Chapter 4 shows the implementation and discusses the results and what is the effect of changing the parameters on avatar behavior, also the critical analysis on FACS, then the testing and evaluation is describe in the last of this Chapter. Finally, Chapter 5 includes the conclusion, contribution and future work.

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