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3DR REVIEW

# Emotional Facial Expression and Tears Simulation: An Analysis & Comparison of Current Approaches

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**Abstract** The enhancement of emotional expression of virtual human in extreme situation such as, crying or sweating required physical effect that involved fluid behavior. The aim of this research is to analyze the facial action coding system and smooth particle hydrodynamic strategies to effectively provide an efficient display in computer facial animation. This research reviews and compares two major 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.

**Keywords** Facial expression · Crying simulation · Facial analysis · Composite facial features

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## 1 Introduction

In the recent years that has been observed evolution in the field of computer graphics. 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 [1–4]. 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.

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 [5–7] to draw two-dimensional face in computer. In 1972 was establishment of the first three-dimensional animated by Parke [8], one of the scientists his name Gillenson create an interactive system to organize and edit line sketch facial images. Then, Parke developed in 1974 a parameterized 3D facial pattern. 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 [9, 10].

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 the facial animation techniques with computer facial animation usage as a key as shown in the story of the film “Toy Story”. Figure 1 demonstrates the avatar of animation character “Tony de Peltrie”, which is considered as the godfather of all CGI characters.

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 conditions such as passion, sleepiness, pain, and physical effort inclined to be much more difficult to identify. Thus, if any working to prove that the emotion that the people attempting to describe is identified, people should depend on the general position or character animation. For instance, shyness is made with a light smile along depressed eyes. However, it possibly can be the misconceived as ashamed or self-satisfied [11, 12].

Fig. 1 Tony de Peltrie avatar

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 [13].

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 Smooth Particle Hydrodynamic (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.

## 2 Facial Expressions

The facial expression of human has been more attractive subject of study by the researchers recently. Especially, the problems of worldliness of facial expression beyond the cultures and origin in a few major facial expressions have absorbed substantial consideration. Charles Darwin in 1872 [14] presented the man and animals emotional expressions. Manipulate accurately among these problems and sowed the seeds for a following century to investigate, explain, and confirm his original theories [15]. The capability of modeling the human face and therefore animate and the delicate slight difference of facial expression still is an important challenge in computer graphics [15]. Regardless of a serious dependence on traditional computer graphics algorithms like rendering and modeling, facial modeling and animation remain determined, without extensively accepted answer. Facial animations in many cases are improved by performing ad-hoc techniques which are not without difficulty expandable and that rapidly become friable [15]. Moreover, in the next Sections will be the presenting of a structured approach, by explaining the principals of facial modeling and animation, and discussing some recent techniques.

The first 3D faces images which generated by computer called "Historically" and have been generated by Parke at the University of Utah in 1971. He commence by very unrefined polygonal head sketch that cause a flip-pack animation of the face opening and closing its eyes and mouth. Figure 2 demonstrates several images of this project.

In 1971, Chernoff presented his study in using computer to generate 2D face picture to represent a k-dimensional area [4]. With utilizing a plain graphical model of the face, a detailed encoding design was derived. In addition, Gillenson in 1973 at Ohio State University presented his research on an interactive system to generate and alter 2-D line-drawn face images, among the aim of producing a computerized picture identi-kit system [15, 16].

From 1974 through 1978, 3-D facial animation improvement was primarily inactive. However, during this time the improvement of 2-D computer-assisted animation systems goes on at the New York Institute of Technology, Cornell University, and later at Hanna-Barbera. These systems substantiate 2D cartoon animation, involving facial animation [15].

Platt In 1980, presented his research on a physically based muscle-controlled facial expression model [17]. Brennan at MIT, presented his study on methods for computer-generated 2-D facial caricatures in 1982 [18]. Furthermore, in 1982 at MIT, Weil demonstrated his research employing a video-disk-based system to interactively choose and mixed features of face [19, 20].

In 1985, Bergeron and Lachapelle produced a short animated film by the name of Tony de Peltrie, which was an important event in facial animation [21]. It was the first short animation which 3-D expressions of face and speech were a main portion of the story [15].

Waters in 1987 presented a novel muscle model technique for facial expression animation [22]. This technique allowed a diversity of facial expressions to be produce by managing the fundamental face musculature. In addition, Magnenat-Thalmann and colleagues in 1988, delineated a simple muscle action pattern [21].

In 1987, Lewis [24] and in 1988 Hill [25] reported techniques for speech synchronization and animation of face automatically. Tin Toy was another innovative short animation, which produced by Pixar and won an academy award. Tin Toy was a model of the abilities of computer facial animation. Especially, a model of muscle is accustomed to articulate the geometry of face of the baby into different expressions [26].

Optical range scanners invention like Cyberware optical laser scanner made a novel prosperity of data for animation of face. Williams in 1990, presented utilize of registered facial image texture maps for three-dimensional animation in face expression [27]. Blanz and Vetter in late 1990 used wide datasets with excellent laser scanned data for creation of itemized morphable facial patterns [28].

The new style of improved image processing and scanning technology assured to lead a new design of

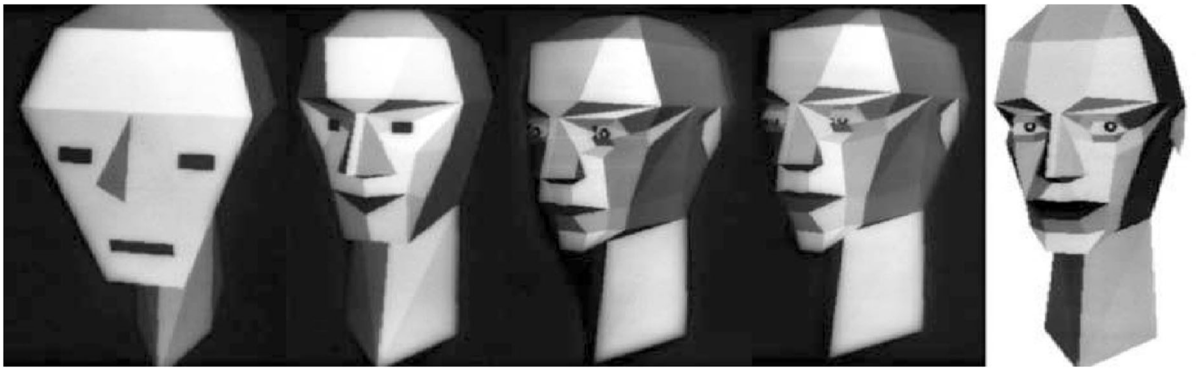

**Fig. 2** some of the initial 3-D faces models developed by Parke in 1971

facial animation. Lee, Terzopoulos, and Waters in 1993 depicted methods to make an outline of individuals into a face which is canonical represented and that known as physically based motion attribute [29].

The other development domain was in medical filed, which the aim was on surgical planning procedures and precise dynamical simulation of face tissue. Deng In 1988 [30] and later Pieper [31] in 1991 performed a finite-element pattern of skin tissue to simulate skin scratch and wound closure [32].

In the late 1990s there was a rise of interesting in facial analysis from video cameras which had two parts: first is to make the capability to follow the human face to produce realistic characters, and then to improve the capability to discover facial expression and in that condition extract emotional states. Two popular techniques, model-based [33] and optical flow-based [34, 35] techniques had some improvement in both areas [36]. Recently, the ability of creating visual substitute those are reliable enough to misled watchers into believing that they are almost close to real people [37].

Analyzing facial expression has been an interest to researchers in Psychology for decades. The psychological interest in this area is centered on understanding how humans transmit and receive information by their faces. It also looks at the effect of mental and physical disabilities on facial movement. The expression on the faces of patients suffering depression will often go through a number of stages relating to their illness. It is hoped that breakthroughs in treatment of patients will occur using facial monitoring of illnesses. Another area of interest to psychologists is facial deception; that is how to tell if a person is lying or not. When a person lies, it is easy to see some conflict in the expression on their face. There is more than one visible expression on their faces at that time. Perception comes naturally. Studying which movements agree and do not agree with each other will help to interpret facial movement [38].

### 2.1 Theory of Emotion Expression

Notwithstanding the large history of exploration of the emotion nature there is an obvious shortage of majority and consistency within the scientific groups on how we can demonstrate them and what emotions are? Kleinginna [39] represented more than 90 interpretations of emotions. Emotions have been clarified as condition of emotional feeling [40] as feeling conditions including positive or negative expressing emotion valence [41] as condition of automatic excitement [42] or different in making active the action character [43]. Furthermore, the undiscerning application of the term "emotion" has conduct to the indistinct discrimination between the terms ''emotion", ''feeling", ''mood", ''attitude", and others [44].

There is need of majority concerning the structure and demonstration of emotion. The two dominant aspects on emotions' structure are the distinct and successive techniques. Discrete emotion theorists, along Darwin's study, presented the being of six or more main emotions (happiness, sadness, anger, fear, disgust, and surprise), which are inclusively exhibited and identified [45, 46]. Dispute the being of main emotions contain cross-cultural all-inclusive for facial expressions and earlier events, and attendance of these emotions in other primates [44].

The successive method presumes the being of two or more dimensions in order for despite and distinguishes between distinctive emotions [47–50]. Wundt in 1904 developed the first dimensional model, which implemented for introspective and experimental methods to study personal experiences. Other research hers also performed and improved this model, which shows that people inclined to discern all sorts of meaning regarding valence (positive versus negative) and activation (active versus passive) [51].

Russell [48] presented the employ of autonomous bipolar dimensions of pleasure–displeasure, excitement, and dominance–submissiveness, instead of a few distinct emotion categories.

### 2.2 Facial Animation as Media for Emotion Expression

Some researchers [52–54] said that the rule-based system demonstrated below is established upon a group of theories of emotion and facial expression which has been named as "The Facial Expression Program" by Russell [55]. This program supposing that the emotions may be recognized distinctly from each other. A few numbers of these are called basic. Russell summarizes this examination as follows: every fundamental emotion is genetically resolved comprehensive and individual.

Ekman and Friesen represented the expressions for emotions and specific mixture expression. The feeling in each emission can be different in intensity. It is indicated in [52] that the expression can be vary based on intensity of emotion for each fundamental emotions. Therefore it is significant to develop a system on a representation that takes intensities into account.

#### *2.2.1 Facial Action Coding System (FACS)*

The FACS, improved by Ekman and Friesen [52] in 1975, decomposes facial actions to small units called action units (AUs). Each AU symbolizes a particular muscle movement, or a movement of a many muscles, a specific determinable facial position. Overall, FACS categorizes in 66 AUs that in union could produce specified and gradable facial countenance. Accordingly, over the past decade, FACS has been used widely in facial animation to assist animators clarify and produce lifelike facial expressions.

Notwithstanding that not designed for utilize in computer animation, this illustrative design has been greatly performed as the base for expression control. The FACS depicts the group of all possible basic AUs doable by the human face. For the example of this action units the inner brow raiser, outer brow raiser, and the lid tightener can be counted. Every action unit is a smallest action which cannot be split into other small actions [15].

Ekman reported that the FACS enables the depiction of whole facial conduct we have monitor, and each facial action we have assay. The main aim of FACS was to produce an extensive system that be able dependably depict all possible visually recognizable facial actions. The important in the earlier sentence is on extensive, visual, and action. FACS deals just with what is obviously apparent in the face, disregarding any imperceptible differences or any differences too delicate for dependable uniqueness. It just deals with action and not with any other apparent phenomena. FACS is involved just with the depiction of facial actions as shown in Table 1, not in inferring what the motions mean.

#### *2.2.2 MPEG4*

An MPEG-4 face model is animated with a set of facial animation parameters (FAPs). Each FAP is associated with a set of predefined vertices. A FAT contains maximal displacements of these vertices. The FAP and FAT together are used to determine the movement of these vertices, which results in a desired facial movement [56].

The cloning process of FATs is presented as explained in this section. First, the user has to choose corresponding landmarks between source and target face models manually. Using these corresponding landmarks, vertices of the target face model are mapped to the source face model resulting in a mapped face model. Then each FAT is applied on the vertices of the mapped face model. The result is inversely mapped to the target face model to create the deformed target face model. The difference between the vertices of the deformed and the original target face model is used to compute the FAT of the target face model [56].

The quality of the transferred animation completely depends on how many corresponding points the user selects and how the user selects these points. A manual process is also required to separate the vertices on the upper and lower lips to prevent mismanaging them [56].

## 3 Facial Animations Techniques

Facial modeling and animation expression works can be classified into two main groups of facial animation techniques, first, those which rely on image manipulations and second those which rely on geometric manipulations. Geometric controls contains key-framing and geometric interpolations [8], parameterizations [57], finite element methods [58], muscle based modeling [59], visual simulation using pseudo muscles, free-form deformations [38], Pighin et al. presented techniques for creating 3D facial patterns from photos of a human. Zhang et al. presented a geometry-driven facial expression system with utilizing an example-based method.

Blinn proposed bump mapping, which comprise of changing surface normal before lighting computation to give a visual impression of wrinkles, without deforming the geometry. The concept has been widely used after that, specifically for facial wrinkles [60]. Bando [61] used an interface to designate wrinkles particularly on the 2D projection of the 3D mesh by drawing a Bezier curve as the wrinkle furrow. Computing a specific mesh required a costly precipitation for energyy precipitation for energy minimization. The bump map can be obtained using composite physical-based simulations too [60]. Viaud [62] uses a mesh where the positions of possibly existing wrinkles are arranged with isoclines of a spline surface to directly deform the geometry for wrinkle. Oat [63] proposed an approach that includes

**Table 1** The single facial action units of the facial action coding system [27]

| AU | FACS name | Muscular basis |
|---|---|---|
| 1 | Inner-brow | Raiser frontalis, pars medialis |
| 2 | Outer-brow raiser | Frontalis, pars lateralis |
| 4 | Brow raiser | Depressor glabellae, depressor supercilli, corrugators |
| 5 | Upper-lid raiser | Lavator palpebrae superioris |
| 6 | Cheek raiser | Orbicularis oculi, pars orbitalis |
| 7 | Lid tightener | Orbicularis oculi, pars palebralis |
| 8 | Lips together | Orbicularis oris |
| 9 | Nose wrinkle | Levator labii superioris, alaeque nasi |
| 10 | Upper-lip raiser | Levator labii superioris, caput infraorbital is |
| 11 | Nasolabial-furrow deepener | Zygomatic minor |
| 12 | Lip corner puller | Zygomatic major |
| 13 | Cheek puffer | Caninus |
| 14 | Dimpler | Buccinnator |
| 15 | Lip-corner depressor | Triangularis |
| 16 | Lower-lip depressor | Depressor labii |
| 17 | Chin raiser | Mentalis |
| 18 | Lip puckerer | Incisivii labii superioris, incisivii labii inferiouis |
| 20 | Lip stretcher | Risorius |
| 22 | Lip funneler | Orbicularis oris |
| 23 | Lip tightener | Orbicularis oris |
| 24 | Lip pressor | Orbicularis oris |
| 25 | Parting of lips | Depressor labii, or relaxation of mentalisor orbicularis oris |
| 26 | Jaw drop | Masetter; relaxed temporal and internal pterygoid |
| 27 | Mouth stretch | Pterygoids; digastrics |
| 28 | Lip suck | Orbicularis oris |
| 38 | Nostril dilator | Nasalis, pars alaris |
| 39 | Nostril compressor | Nasalis, pars transversa and depressor septi nasi |
| 41 | Lid droop | Relaxation of levator palpebrae superioris |
| 42 | Eyelid slit | Orbicularis oculi |
| 43 | Eyes closed | Relaxation of levator palpebrae superioris |
| 44 | Squint | Orbicularis oculi, pars palpebralis |
| 45 | Blink relax | Levator palpebrae |
| 46 | Wink | Orbicularis oculi |

compositing many wrinkle maps and artist animated weights to produce a final wrinkled normal map. It requires manual tuning of the wrinkle map coefficients for each region.

### 3.1 Key Framing and Blend Shape Interpolation

"Gollum", from "The Lord of the Rings" which produced by Pixar, is a recent sample of physically creating a surface based model. Figure 3 demonstrates the model of character, which was at first shaped from clay and digitized [64]. This animation was performed by using key-framing technique, and like that many of particular facial expressions were produced and altered to be compatible motion capture detail from actor Andy Serkis [15].There are many techniques for facial animation. These contain key framing applying shape interpolation or blend shapes, performance-driven animation, parameterized models, and pseudo muscle-based, muscle-based, and language-driven animation [65].

The aim of the different animation approaches is to control the surfaces of the face over time, in order that

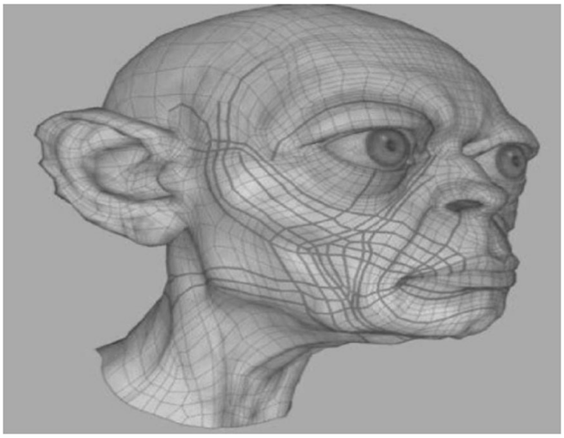

**Fig. 3** surface based model of Gollum

the faces contain the proper poses and expressions in every frame of the animated sequences. This procedure includes straightly, or deviously, controlling the surface polygon vertices or the surface control-point locations over time.

Key framing can be deal with the parameter values necessary to indicate the face poses, instead of directly to the face poses. "For every parameter, a time-tagged set of values is specified". At each frame time of the animation sequence, a function is estimated for each parameter. This function is generally a simple interpolation founded on the time-tagged key parameter values. The interpolation may be linear or may utilize an ease-in or ease-out function, or both.

Interpolation is the most famously utilized of the approaches. In uncomplicated model, it matches to the key-framing technique discovered in conventional animation. In key-frame or key-pose animation the desired facial expression is designated for a specific spot in time and afterwards for other spot in time some number of frames later. The algorithm will produce the frames in the middle of these key frames. Key-pose animation demands perfect characteristics of the model geometry for every key facial expression. This characteristic accomplished it a work-force intensive technique. Performance-based animation includes evaluating real human movements to drive artificial characters [66, 67].

Interpolation is a direction to control pliable surfaces similar to those utilized in facial models. Interpolation is apparently widely performed approach for facial animation. The concept of interpolation is quite uncomplicated. In the 1-D case, we are given two values and inquired to conclude a mediatory value where the requested mediatory value is indicated by a small interpolation coefficient $\alpha$.

$$\begin{aligned} \text{Value} &= \alpha(\text{value}) + (1.0 - \alpha)(\text{value}_2) \\ 0.0 &< \alpha < 1.0 \end{aligned} \quad (1)$$

As can see in Eq. 1, the concept is simply increased to more than 1-D by affecting this easy process in every dimension. The concept concludes to polygonal surfaces by affecting the system to every vertex clarifying the surface. Intermediate forms of the surface are achieved by interpolating each vertex between its two extreme positions as shown in Fig. 4 [15].

The moving of each surface control spot in small distance can change the face from one expression to other expression. The location of each spot is decided by interpolating between the excessive locations. The other popular technique is to use in blend shapes which are a form of surface shape interpolation. The surface is modeled into many shapes which the one of these shapes is the base shape and the others are target shapes. The distinction between the base and target shapes is demonstrated as vector sets. Whereas a combined shape is performed to the main shape, it takes on the target shape for that blend.

### 3.2 Parameterization

A parameterized model uses area interpolations, geometric transformations, and mapping techniques to control the features of the face. With pseudo muscle-based facial animation, muscle actions are simulated using geometric deformation operators. Facial tissue dynamics are not simulated. These techniques include abstract muscle actions [23], and freeform deformation [68]. In the muscle-based approach to simulate the facial muscles, Platt and Badler performed a mass-and-spring model [69]. Waters proposed a face model which contains two kinds of muscles: sphincter muscles and linear muscles [22]. For the skin and muscles he utilized the mass-and-spring model.

Many facial animation approaches have been studied which each one of them has a collaborated with control parameterization. Generally, the control model for the performing is closely connected to its

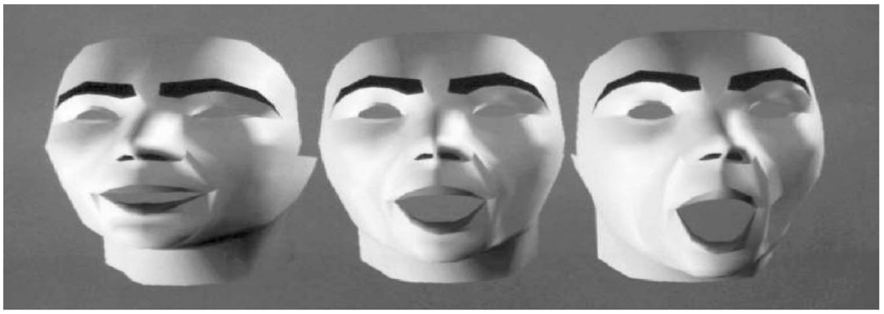

**Fig. 4** Expressions interpolation

underlying approaches. The facial animation control might be observed as control parameterization and control interface issues. Improvement of control parameterizations and improvement of animation system implementations must be separate.

### 3.3 Muscle Based

There are two types of muscles that performed: linear and elliptical sphincters. Linear muscle specified with two vectors: a bony connection and a skin connection. The sphincter muscles performed on the mouth to purse the lips and on the eyes. In this situation, a single spot specified the middle of the muscle contraction, and other spots specified the axes from which an ellipsoid area of influence implemented.

Additional reduction was essential for the animators while there are 50 muscle controls in all number of parameters in the face. The reduction obtained by implementing single control which principles many low level muscles to make smaller which called as macro muscles. The quantity of shortening is estimated by a scaling value for each low-level muscle. Suppose a shortening of macro muscle number 1 on the left eyebrow macro muscle extend 0.3 on the left1a, 0.5 on left1b, and 0.8 on left2a. Overall of 33 macro muscles were determined, and nearly 12 were in operation for majority of the animation [15].

## 4 Extreme Expressions

Human act some of expressions strongly like doing a set of squats, jumping jacks or walking up a flight of stairs, individuals start to pant, sweat, lose their balance and flush, feel in fear. Additionally, cry or laugh with tears appearance. All these expressions can named as extreme expressions.

### 4.1 Fluid Interaction Techniques

In the past decades, people were interested in realizing the real world by using computer in the field of computer graphics. Beside the visual effects used in movies and games demands more naturally and reality effects in animations and moreover in actual fluid animation. Nevertheless, traditional methods of fluid rendering using art workers are time consuming and not workable due to its complexity. The computer simulation methods based on physical model has become more interesting topic for researchers [70]. Fluid simulate method which is based on physical model uses the physical equation of fluid motion state and through numerical technique like Navier–Stokes equation.

Simulation in computation fluid dynamics (CFD) highlights the exact explanation of question itself and delivers a rational analysis and demands that the outcomes of computer simulation be capable to anticipate real fluid motion, however fluid animation concentrated upon the fluid visual effect that is produced to deceive the audience. The calculation of fluid animation in compare to the regularly performed method in CFD is much lower in precision but faster in time matter. Basically fluid simulation method generally performed the parameter model method which is able to demonstrate the actual liquidity effect. However, the simulation of fluid motion is using Navier–Stokes equation which is comprised by many equations such as continuity, momentum and energy Equations which are the most fundamental physical depiction for fluid motion. These equations can be explained as preservation of mass, second low of Newton and preservation of energy.

We can divide the techniques based on physics into two categories: Eular technique and Lagrangian technique. The Euler technique is a grid-based method, it initialize to analyze the occupied space from fluid of every fixed point and moreover investigate every point that is filled by fluid motion on the fluid velocity, pressure, density and other parameters. Lagrangian approach is established upon the particle technique. This approach analyses the every micro-group motion and analysis every changes of parameters in micro-group. It includes the speed, pressure and density. Since Euler technique stabilize monitoring point in region and physical quantity of fluid taken into account at distinctive times of alteration, the entire fluid area be able to perform the series of vector field.

### 4.2 SPH Method/Techniques for Fluid

SPH is a kind of interpolation technique for particle system, by way of initiating the refine kernel function to depict the influence of the inclosing particles. This technique also used widely to solve the great disfigurement of pliable objects and has been more interesting technique for fluid animation productions. Recently Le et al. [71] represented Lattice Boltzmann Model (LBM) for graphic and animation area. LBM technique is based on Lagrangian approach and do not purse any of the real particles. Due to smoothness in products as important challenge in each new technology, using SPH has become more suitable than Lennard-Jones interaction forces. Basically the SPH method intended for using to resolve the problem of simulate the stars.

When attempting to the basics it signifies a method to smooth discretely tried the attribute fields. This is accomplished via *smoothing kernels* $W(r)$. The kernel which defines a scalar weighting function near the position $X_i$ of particle $i$ via $W(|x - x_i|)$. In doing this, the kernel is symmetric put round the particle since it is only dependent upon the distance towards the particle. The kernel function must also be stabilized and therefore $\int W(|x - x_i|)\, dx = 1$. A well known option is the poly6 kernel [72].

$$W_{poly6}(r) = \frac{315}{64\pi d^9}\begin{cases} (d^2 - r^2)^3 & 0 \le r \le d \\ 0 & otherwise \end{cases} \quad (2)$$

Due to $r$ only seems squared with no square root needs to be examined. We've all of the elements to compute an even density area in the individual positions and public from the particles.

$$\rho(x) = \sum_j m_j W(|x - x_j|) \quad (3)$$

Get the intensity values of single particle; we are now able for the smoothed fields and Ai arbitrary characteristics of particulate as

$$A_s(x) = \sum_j m_j \frac{A_j}{\rho_j} W(|x - x_j|) \quad (4)$$

From the contaminants as a pleasant property of the formulation would be that the gradient of this area may be easily calculated by changing the kernel through the gradient from the kernel.

$$\nabla A_s(x) = \sum_j m_j \frac{A_j}{\rho_j} \nabla W(|x - x_j|) \quad (5)$$

In the formulation (network based) German mathematician, described by fluid speed V field, and the field density ρ and pressure $p$ field. Because of the evolution over time of these quantities by two equations, First Equation confirms the conservation of mass.

While the Navier–Stokes Equation formulates conservation of momentum

$$\rho\left(\frac{\partial v}{\partial t} + v\nabla v\right) = -\nabla\rho + \rho g + \mu\nabla^2 v, \quad (6)$$

where g is the outer body strength and μ the viscosity of the liquid. Using particle instead of static electricity network simplifies each of these Equations significantly. First, because the amount of pollutants is fixed and each particle contains a fixed block, and ensures comprehensive conservation and can also be overlooked for the first Equation altogether.

Secondly, the expression $\partial V/\partial t + V \cdot V$ can be replaced on the left side of the Navier–Stokes Equation derived by large dv/dt. The fact that the particle mobile and can move with the fluid, and a large core is derived from the speed the speed just be derived from particulate Timers. It shows that the convection in the long fifth · there is no need to fifth particulate systems.

The existence of 3 mass forces (unit [$N/m^3$]) left on the right hand side of the Navier–Stokes Equation modeling pressure ($-p$), external forces ($\boldsymbol{\rho}$g) and viscosity ($\mu^2$v). This indicates that $f = -p + \boldsymbol{\rho} g + \mu^2 v$ influences the momentum of change $\boldsymbol{\rho}$ of the particles on the left hand side.

$$a_i = \frac{\partial v_i}{\partial t} = \frac{f_i}{\rho_i}, \tag{7}$$

In a situation where $v_i$ is the constant velocity of particle $i$ and $f_i$ and $\boldsymbol{\rho}_i$ happens to be body mass force and the density region appraised at the position of particle $i$, respectively. However, do not apply a strict incompressibility just like the German mathematician situation. Forces are created simply press later, when versions density produced previously. This could be a clear way the matter and give bouncy behavior the liquid. Need to reality, you can predict and calculate the intensity of pressure on forces predicted or estimated density difference in speed using SPH correct Poisson Equation and then round particulate.

## 4.3 Tears in Fluid

All of the above is about SPH in general fluid. The tear is one of the fluids types but not include all the fluid parameters same as normal water or river and so on. The parameters that can affect the tears as a fluid contain the pressure, velocity, density, viscosity and finally the Gravity [1].

The pressure may affect the tears by changing the particles velocity, the particles direction, it is shows the spread of particles during the fall down. The pressure comes from two sources, the atmospheric pressure and the neighboring particles pressures. The Viscosity shows the dragging of the particles each other. Each particle has its own Density that different from one particle with others. The speed of the fall down for each particle can determine in region of velocity. Finally the gravity that affects the tears by forcing the particles to move down using the particles weights ($W_i$). All these physics parameters will work along together to gives batter results for this work simulation.

### *4.3.1 Viscosity, Density and Velocity*

Using the SPH control to the viscosity term $\mu^2 v$ again proves asymmetric forces.

$$f_i^{viscosity} = \mu \sum_j m_j \frac{v_j - v_i}{\rho_j} \nabla^2 W(|x_i - x_j|) \tag{8}$$

In view of the velocity field which basically varies from one particle to another, viscosity forces could basically rely on velocity uniqueness and not on absolute velocities and the density as mention in Eq. 3. Be mindful that, the regular path to symmetries the viscosity forces by performing velocity uniqueness.

A likely analysis of Eq. 8 is by observing the neighbors of particle $i$ from $i$'s moving frame of reference. From that the particle $i$ could be intensified and accelerated in such a direction of the relative speed of its environment.

$$\int \rho(x)dx = \sum_j \left( m_j \int W(|x - x_j|dx \right) = \sum_j m_j \tag{9}$$

From the contaminants as a pleasant property of the formulation would be that the gradient of this area may be easily calculated by changing the kernel through the gradient from the kernel.

Fluids in Eulerian method are delineated by a velocity area v, a density area $\boldsymbol{\rho}$ and a pressure area $\boldsymbol{p}$. Over the time, an Eq. 10 for evaluation of these quantities has been given.

. Using particles rather than a stationary power grid simplifies both of these Equations substantially. Since the amount of contaminants is fixed and every particle includes a fixed mass, mass transformation is assured and also the first Equation could be overlooked entirely.

$$\frac{\partial \rho}{\partial t} + \nabla(\rho v) = 0 \tag{10}$$

### *4.3.2 Particle Size, Rotation and Pressure*

Each particle has a different size by comparing it with the others. By giving the several sizes to the particles that make the teardrop a more factual look that close to the reality. Also, the rotation of each particle in all directions like what happens in the real word, both of these parameters was take in consider in this research and been set by constants values without using any equation.

Use of the SPH control referred to in Eq. 8 towards the pressure term—$p$ supply.

$$f_i^{pressure} = -\nabla p(x_i) = -\sum_j m_j \frac{p_j}{\rho_j} \nabla W(|x_i - x_j|) \tag{11}$$

Regrettably, this pressure is not symmetric as possible seen when couple of contaminants interact.

Since the demands in the position of these two contaminants are different generally, pressure forces will be asymmetric.

$$f_i^{pressure} = -\sum_j m_j \frac{p_i - p_j}{2\rho_j} \nabla W(|x_i - x_j|) \quad (12)$$

Therefore, position, velocity and pressure in particle due to carrying three quantity of mass require investigating and it is finishes in two stages.

Equation 13 supplies the density at the particle position. Afterwards, pressure could be calculated through the perfect gas condition equation.

$$p = k(\rho - \rho_0) \quad (13)$$

where $k$ is really a gas constant which is dependent around the temperature and $\rho_0$ may be the pressure of environment. Nevertheless, because of pressure force depends on gradient of pressure area, the offset does not have impact on pressure forces in mathematically way.

Despite that, quality of being incompressible is not mandatory like the Eularian situation. Pressure forces are simply created later on, when density versions have formerly produced. This can be clearly an issue technique and supplies a springy conduct in the fluid. With using SPH and fixing the Poisson equationn the prediction of densities and moreover estimation of divergence of velocity region is possible.

#### 4.3.3 Gravity

Gravity is not really part of SPH method, but it is necessary for this study simulation to make the tears come with more realistic behavior and results. The Eq. 14 shows the parameters that need to apply the gravity equation.

$$\mathrm{f}_{\mathrm{i}}^{\mathrm{gravity}}(\mathrm{X}_{\mathrm{i}}) = \rho_0 \mathrm{g} \quad (14)$$

where $\boldsymbol{\rho}_0$ is an initial density, **g** is an initial gravity.

Tears are an example of an aspect of crying that is not associated with expressions and geometrical deformation of the face. There are many researches were working on tears simulation as crying simulations such as Young who researched on crying, but there is no obvious difference between moods and conditions. He categorized the causes of crying such as: organic state, unhappy mood, disappointment, laughter and special events for tears direction. William and Morris [73] presented a record of crying situations involving occurrence or moods, including circumstances like intimates deaths, issues in love relations and depressing movies. Nelson [74] reported that crying in adult is usually relying on sadness, but there is a difference crying case in anger and sad cry. Furthermore, many researches have been studied the infants crying behaviors [75–77].

One of the important aspects of crying is tears which is represented in [78] for further details. According to this research, people can easily recognize the emotions related with crying if the subject makes tears. The sobbing is another aspect of crying which is the convulsive breathing in and breathing out with convulsion of the breathing muscle groups [79]. Moreover, the other aspect is increasing heart rate of blood to the head [80] and it would result in a person having a red face or blushing. The results of this research are summarized in Table 2. In this Table we rated the various aspects of crying on how important they are and on how difficult they are to implement. Importance is based on the visibility of the aspect and on human reaction on those aspects. For example, tears are very important because they trigger an emotional response so it is very important to implement, whereas increased heart rate is hardly perceived by an observer, so it is less important to implement [81–83]. Also, we listed the emotions and other contributing factors for each phenomenon .

**Table 2** The different phenomena of crying, along with their contributing factors, importance and difficulty to implement

| Phenomenon | Primarily happens with | Importance | Implementation |
|---|---|---|---|
| Facial expression | Every emotion | Very | Easy |
| Tears | Sadness, anger | Very | Hard |
| Increased Heart | Stress, anger | Rate almost none | Hard |
| Blushing | Shame, anger | Average | Easy |
| Sobbing | Sadness | Average | Average |
| Red eyes | Tears | Average | Easy |

As maintain before tears are an essential part of crying when someone is sad or angry. We want the generated 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. So to simulate tears, we need to simulate fluids in a realistic way.

## 5 Conclusion

In this paper, facial expression concept was explained with the theory of emotion expression. Facial animation as media of emotion expression has been introduced, MPEG-4, FACS and facial animation techniques has been explained in details, followed by discussions on the aspects of emotion expression. Also the aspects of generating Facial Gesture and aspects of generating extreme expression in facial animation were discussed. Due to uncomplicated integration in current frameworks on facial animation, the control of crying motions by animator is possible by performing some parameters which makes it easy. For more control, more detailed parameters can be altered, Besides, the simulation of tears presents as essential part of crying when the happiness or sadness happened. Furthermore, the concept of tears in fluid simulation has been studied.

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