Surprise As a Facial Expression on Animation — Examples from Ghibli Studio Animated films

驚訝在面部表情動畫中的運用—以吉卜力工作室動畫影片為例

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【Abstract】

The face can communicate various visual information including personal emotion, cognitive state and intentions. Basic facial expressions typically recognized by psychologists are happiness, sadness, fear, anger, disgust and surprise [1]. Surprise as a facial expression is by far the least discussed category among 6 basic expressions. From the psychological point of view, significant contribution has occurred in automatic recognition of facial expression [2,3,4]. A common approach of measuring facial expression is widely utilized, which is Facial Action Coding System [5]. Along with the optical motion capture technology developments; doing 3D computer facial expression became an easier task compared with the traditional hand drawing animation. In this study, several animated feature films produced by Ghibli studio are selected as the subject. 3D computer facial animation can achieve a high level of accuracy and efficiency. Surprise happened to be the most dramatic and instantaneous of all emotions. Precision to human facial expression in the sense, would somehow limit the exaggerated effect to impact viewers. Also, it's an expression that virtually impossible for an actor to perform. If it's expected, it's not surprise at all. In this paper, I will dress the main characteristics of the selected animations.

Keywords: Facial expression, surprise, optical motion capture, face recognition

【摘要】

我們的臉部能夠表達多種的視覺訊息如個人情緒、認知狀態和動向。心理學家所認知的基本面部表情有快樂、悲傷、恐懼、生氣、厭惡和驚訝等六種 [1]。其中驚訝是這六種之中最少被論及的一種。對心理學家的研究而言，自動化面部表情辨識系統已經有顯著的貢獻[2,3,4]。一種廣泛地被運用在測量面部表情的方法是面部動作編碼系統(Facial Action Coding System)[5]。同時隨著光學動態捕捉科技的進步，與傳統手繪動畫比較起來，利用 3D 電腦動畫來製作面部表情成為比較容易掌握的方法。在本文中，吉卜力工作室所製作的動畫片被選來作為研究的對象。用 3D 電腦動畫來製作可以達到面部表情的高精準度和效率。然而就驚訝這個面部表情而言，是在所有表情中最戲劇性和即時性的一個。精準度在這情形之下反而多少減少了誇張效果對觀眾產生的衝擊力。而且，它也是一個幾乎演員非常難成功地表演的表情，畢竟如果是有心理預期的話，它就不會成為真正的驚訝。在這論文中，我將討論被選到的這些動畫片的特色。

關鍵字：面部表情、驚訝、光學動態捕捉、面部辨識

【Motivation】

Animation is one of the most popular and creative areas of film making today. The mainstream technology we used to created animation is 3D computer animation tools. The charm of traditional cell animation dominated the viewers mind for decades and will still play a key role in the future. For instance, Ghibli studio has produced many brilliant, vivaciously animated films for the past 20 years. Lead by animation master Hayao Miyazaki, Ghibli has produced films that are timeless treasures. Ghibli has also influenced mainstream film makes like Lucas and Speilberg. Worldwide audiences, regardless of age and nationality, admire their animation films.

As an animator myself, have studied 3D computer animation skills for years. The essence of animation behold in artistic vision always inspires me. In my initial work, the goal is to find the answer to the question. **How do facial expression animation accomplish its function?** In order to answer this question, I watched numerous animations using different techniques. I decompose them frame by frame, investigating the secrets used by animators.

【研究動機】

在今天的電影製作環境中，動畫片是最普遍受歡迎而且最能發揮創造力的一種類型。現今製作動畫片的技術主流已是 3D 電腦動畫。傳統手繪動畫的魅力多年來深植觀眾的心中而且在將來仍將扮演一個重要角色。例如吉卜力工作室所生產的許多充滿活力的優秀作品受到肯定二十多年。由宮崎駿和高火田勳所領軍的吉卜力工作室本身就像是無價之寶般的珍貴。吉卜力工作室也影響了主流製片如盧卡斯和史匹柏等人。全球的觀眾，不論老少或國籍都深深讚賞他們的作品。

筆者本身做為一個動畫師，學習 3D 電腦動畫也有一段時日。動畫本質中的藝術性始終是啟發我的動力。在原本的假設中，我想找出答案的問題是：動畫中的面部表情如何達到其作用。為了找出這個答案，於是我看了不少的運用各種技巧的動畫片。一格一格來看並加以分析，藉由此方法以找出動畫師所運用秘密。

1. Introduction

Ghibli studio is a Japanese animation team founded by famous animators Hayao Miyazaki and Isao Takahata. The studio creates very numberious high quality animated movies, which is rather unique, since most Japanese animation studios target on TV series. They consistently surpass Disney movies in box office records in Japan and have won countless awards.

Ghibli was established in 1985, to make the film, “Laputa: The castle in the sky”. Studio Ghibli was established in 1985 as a subsidiary of Tokuma Shoten, but became a division of the company after being absorbed in 1997 due to Tokuma Shoten's deteriorating business. However, the beginning of the studio can be dated back to 1983, when Tokuma Shoten (Tokuma Publishing, Co., Ltd) decided to produce ""“Laputa: The castle in the sky”. Tokuma is a Japanese publishing company which publishes "Animage", an animation magazine, in which Miyazaki had been serializing the mangam “Nausicaa”since 1982. After the success of "Nausicaa", Tokuma and Miyazaki decided to make their second movie, "Laputa", and they established Studio Ghibli.

Ghibli means "hot wind blowing through the Sahara Desert". The name was used for Italian scouting airplanes during World War II. Miyazaki, who loves airplanes, named his studio after it.

Hayao Miyazaki, co-founder of the studio, is considered as one of the greatest animators and directors in the history of Japanese. Since his first major feature, Nausica of the Valley of the Winds, made in 1984, his features' popularity continue to rise, becoming the most popular films in Japan; loved throughout Asia and highly appreciated in the Western world.

They produced famous films including Totoro(1988), Kiki’s delivery service(1989), Only yesterday(1991), Porco Rosso(1992), Pom Poko(1994), Whisper of the heart(1995), The princess Mononoke(1997), The spirited away(2001), The cat returns(2002) and etc.

Their animations have remarkable reputation and popularity all over the world. Japan is the only country can share a market with dominant US. Their animation would be an excellent source for me to analysis and discuss in this paper. The tools they used is not a subject in this study, as a matter of fact, it’s also a commercial secret for them. Since the computer animation tools are able to render in a 2D look similar with the traditional style. It became irrelevant to the topic.

2. The expression of surprise

Surprise is the most dramatic and dynamic expression of all expressions. We don't get many photos of surprise. We recognize it easily, but we barely study its components. On occasions when unexpected events happened, surprise was triggered by the sudden mental surge. The frontalis raised the eyebrow, opening the eyes widely. And orbicularis oris just completely relaxed, or the lips pursed together with a small oval shape.

When surprise with fear, the risorius/platysma on the face raises the skin upwards. It stretches mouth sideways, making the mouth squarish shape.

When surprise with joy, the zygomatic major lifts the mouth, causing the face seems to be smiling.

Variations of surprise were often seen in our daily life. The emotion fades away instantaneously. It often mixed with other emotions including joy, sad, anger, disgust and fear. The main features were consistent on every individual over time.

Figure 1. The key muscles for surprise expression

1. Frontalis: It originates from the top of the skull; inserts in skin underneath eyebrows. When the surprise occurred, it pulls eyebrows upwards, casting forehead wrinkles.
2. Levator palpebrae: Starts from orbit, attaches to upper eyelid. It raises eyelid, showing white around iris.
3. Corrugator: Originates on nasal bridge; attaches to skin under middle of eyebrow. It functions in correlation with frontalis in surprise.
4. Orbicularis oris: Goes around the mouth. The mouth is open as wide as possible. O-shaped or oval shaped in general. There is no muscle tension here. The jaw drops due to its own weight.
5. Zygomatic Major: Originates on zygomatic arch; inserts into mouth corner. It works as the smiling muscle.
6. Risorius/Platysma: Originates on rear of the jaw, inserts into mouth corner.
7. Triangularis: Originates over lower side of jaw, attaches into mouth corner.

Figure 2. Facial features for surprise

3. Study: Animated skills about surprise in Ghibli Studio's animations.

3.1 Data collection

Original data were collected from various DVD distributions [11~18] of Ghibli Studio. Subjects in the selected video were viewed carefully frame by frame to investigate their differences. Since the goal of this study is to explore their artistic performance in terms of expressive interpretation and timing control. The analysis is not quantification orientated. Manual comparison for the characteristics of the facial expressions stimulates more questions to be answered. Clearly, animators back then developed their facial expression style through keen observation, experience accumulation or other effective approach. Techniques for 3D computer facial animation, for instance, optical motion capture, is not even an available approach for them. Their tedious work on drawing countless keyframes and in-between frames had polished their patience and skills. The achievements were obtained through their try and error dedications. Somehow, their works were well accepted by the worldwide audience. Their secrets have hidden in every fraction of their work, awaiting us to unravel and decipher. I found it amusing as I review them over and over again. I sincerely felt that I recreate the whole sequence through my eyes, learning more subtle clues in the process gradually.

The measurement unit is based on NTSC system that is 30 frames per second. In other words, the duration of 1 frame indicates 1/30 second in time.

3.2 Difference between several surprise expressions

Strong evidence for stable individual differences in facial expression has been found [19], which could be one of the explanations to their different facial features (see figure1. 2. 3.). Surprise is often associated with other emotion simultaneously, either with joy or fear. Surprise only surmounts other emotions in excessive amplitude for a brief moment. Therefore, it could be also because of the different emotions get in involved in various scenes. For those artists who create their expressions, they must be aware of the subtle differences in either eyes or mouth

shape. They intended to draw their mouths shape in various forms for their personalities. It could be because they choose artistic styles deliberately, too. However, in most cartoons we have ever seen, the corners of upper lip and lower lip were drawn rounded. Unlike us, the surprised O shaped or oval shaped mouths are angular towards the corners.


Figure 1. Ghibli Studio, Only yesterday, 1991


Figure 2. Ghibli Studio, Spirited Away, 2001


Figure 3. Ghibli Studio, The cat returns, 2002

3.3 Surprise related body movements

Table 1 is the shot of the baby girl first met Totoro [10]. She is extremely curious about Totoro. She reaches her arm to pad Totoro's tail. Totoro lifted its tail in responds to her. She is surprised to see that which

further strengthen her curiosity. She is excited rather than frighten by its sudden move.

After discreetly examine the sequential images, we could learn that the duration from figure 4-2 to 4-9 is the moment she saw Totoro's reaction. It's a fleet moment, which only last less than 1 second. Figure 4-10 is the image showing her surprising look, which lasts for 1 second. The figure 4-11 has her cheerful smile for more than 2 second.

As Totoro lifts its tail, her ponytails sway swiftly. Neither the wind nor the tail caused the phenomenon. It's a helpful subsidiary to the main action. Presumably, audiences hardly see her subtle reaction on her face, particularly on the side view. Animators depict her emotion through her hair. We generally don't perceive hair as a controllable unit of our body parts. The hair is endowed with energy and expression in animations.

Table1. Ghibli Studio, Totoro, 1988

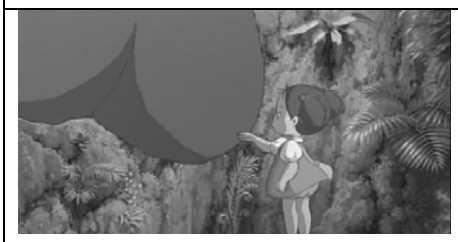
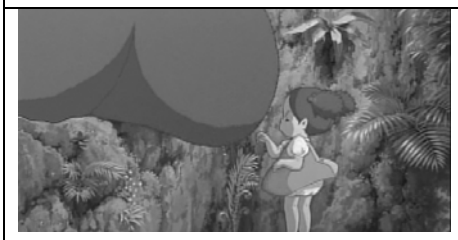
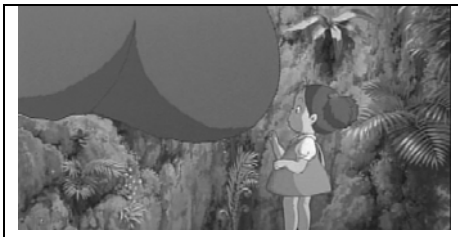
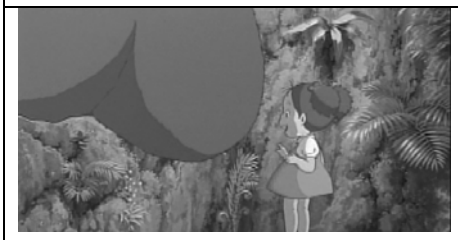
Image	Duration in frames	Note
 Figure 4-1.	1	
 Figure 4-2.	3	
 Figure 4-3.	2	

 Figure 4-4.	3	
 Figure 4-5.	2	
 Figure 4-6.	3	
 Figure 4-7.	4	
 Figure 4-8.	4	
 Figure 4-9.	4	

 Figure 4-10.	30	
 Figure 4-11.	70	

This shot is from Kiki's delivery service[11]. Kiki is a witch under her training period by the age 17. In the training program, she is required to leave her hometown for a year.

In this sequence, she borrowed a broom from an unknown pedestrian. Her friend is in danger, so she is trying to fly the broom using her magic power. The camera then cut to the pedestrians who witness the moment.

We unravel several tricks by examining this particular shot. Surprise is the most instantaneous of all emotions. For most people, the nature of the spontaneous reaction is to hold the body back. We could try to explain that the people who lean forwards try to look better. But animators make some of characters lean their body backward, while some lean forward. It's a rather interesting arrangement. Especially in motion graphics, the rhythm caused by the motion is an important factor to cast the style. People in this scene undulate like a wave in the ocean. (Figure 5.) If animators simply animate all of them backwards, it wouldn't be a visually appealing shot.

Figure 5. Ghibli Studio, Kiki's delivery service, 1989. These arrows indicate the direction of their body movement. The hidden curve makes the composition rhythmical and dynamic.

In conclusion, facial expressions never stand alone in character performance, no matter in actors or cartoon characters. Besides commonly known body gestures, animators use hairs, dress and other visual attachments to enhance the overall visual effect. The range could go beyond our imagination. It's probably why we were always fascinated by magical animation contents.

3.4 Surprise with joy

The whole act is about 3 second in duration. We could find out several extremes or keyframes from the analysis. They are figure 6-6, 6-10, 6-14, 6-19 and 6-21. In the study, we notice how her mouth is drawn in a very exaggerated manner and her eyebrows slanted outwards.

Table 2. Ghibli Studio, Totoro, 1988

Image	Duration in frames	Notes
 Figure 6-1.	8	Firstly, the camera cuts to her face in a medium shot. The girl is surprised to see her new residence, which is a rotten wooden house.
 Figure 6-2.	4	She blinks her eyes using 4 frames, including 2 frames with eyes closed. Also, when she closed her eyes, her shoulders started to shrug, as an auxiliary act to emphasize her emotion.
 Figure 6-3.	4	When she opens her eyes, the animators portray her eyes open in two steps. The first open pause is nearly wide open for 4 frames (figure6-3), and fully open for 9 frames afterwards (figure6-4).

 Figure 6-4.	9	If we pay more attention to examine the difference between these two images (figure 6-3, 6-4), we could find the teeth discrepancy on them. It is a subtle expression to enhance the surprising look. The following action is her blinking eyes again. It takes 4 frames again. In general, for a regular person to blink his/her eyes will spend around 4 to 6 frames. (see figure6-2)
 Figure 6-5.	About 5 second	She opens her eyes again, this time she also has 1 frame for nearly open and the wide-open eyes afterwards. She remained her eyes wide open while she started to talk and turn around (figure6-5). In the end of the shot, she ran away and the camera cut to another shot. It's about 5 seconds for this part. Her emotion didn't count as joy in this shot yet. It's still hard to have eyes wide open for 5 second without blinking. Unless we deliberately control our eyes open, it's unlikely to keep it for more than 3 second.

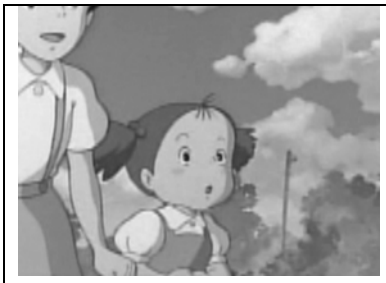
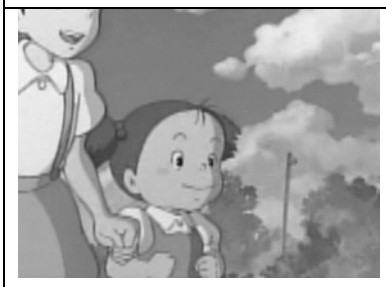
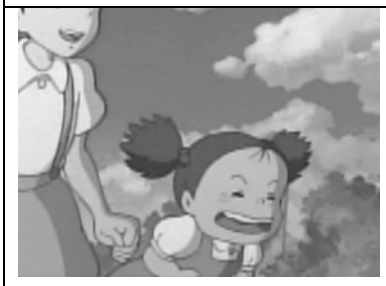
 Figure 6-6.	27	Her younger sister's reaction, on the contrary, she is confused to begin with. Then she is excited to shout "Oh! Boy" in front of the house. The anticipation act is her confused face with an "O" shape mouth and she also looks around (figure6-6).
 Figure 6-7.	4	The deformation of her mouth started from a slight open mouth till figure 6-8 In a broader definition, these actions are considered as part of anticipation to shouting.
 Figure 6-8.	2	
 Figure 6-9.	4	

 Figure 6-10.	4	
 Figure 6-11.	1	The following figures show how the shouting is animated.
 Figure 6-12.	3	
 Figure 6-13.	4	In the process of the baby girl shouting, She opens her mouth vertically. As you can see clearly in this image. It's considered as one of the keyframes.
	3	

Figure 6-14.		
 Figure 6-15.	4	
 Figure 6-16.	4	
 Figure 6-17.	4	
 Figure 6-18.	3	After she opens her mouth vertically, she transforms her mouth wide open horizontally.

 Figure 6-19.	17	This frame has a longer duration, which displays her energy being released at this moment.
 Figure 6-20.	3	
 Figure 6-21.	12	Starting from figure 6-21, it's supposed to be a recovery act from previous action.
 Figure 6-22.	3	

3.5 Surprise with fear

In many occasions, surprise came along with fear. Fear will soon take over the emotion over surprise in a fraction of second. The muscle transition is obviously different from cheerful surprise. General rule for fear is the Orbicularis oris is tensed in various forms. So the mouth didn't appear in relaxed oval or O shape. Different individual has

different way to express their fear. The emotion is also mixed with others such as shocking, anger or sadness. Let me demonstrate some examples below.

In this shot (Figure 7.), all of the villagers thought that the baby girl was missing. They started a full-scale search around the whole village. By the end of sunset, she is not found yet. They discover a lost slipper instead. When the old woman presented it to her sister with great terror, she is probably pre pared to take the worst consequences. When she asked the baby girl's sister "Is it hers?". (Figure 7.) Her face already looked surprised. Then the camera cut to the young girl's face. After she denied it, everyone around relaxed a little bit. Either she said yes or not, they would be surprised somehow.

Normally, we assumed the surprise resulted from unexpected occurrences. However, there are occasions like this, when we encountered some misfortunate situations. We simply refused to adapt the distressing state. Surprise is triggered by the intensive anxiety, emotional outburst may release at that moment.

In this case, the old woman is exactly under the circumstance. Although she has the surprise face, her jaw didn't drop loosely. And her mouth didn't make the typical "O" shape. We could explain it as the fact she is not shocked.

Figure 7. Ghibli Studio, Totoro, 1988

Table 3 is another clip from the cat returns [18]. Haru Yoshioka is a 17 years old student who saved a cat called Loon one day. The cat happened to be a prince of the cat kingdom. In order to show their appreciation towards Haru, they did many favors to please her. She was invited to the cat kingdom. The kind treated her with a formal dinner party, trying to convince her to marry the prince-Loon. She is reluctant to take that offer.

The scene took place in the party. The king brought up the marriage issue again. She refused him by saying she is not a cat. The king responds her that she has become a cat. Then the servants brought her a mirror. She is frenzy at this shot.

Figure 8-1 is the moment she is looking at the mirror. Her surprising face started from figure 8-2. As we can see, figure 8-6 is the first extreme frame, which has the biggest mouth in height. She continues to shake her body and face during figure 8-9.

In this version, her head obviously blow up in scale a lot. For a regular person, nobody is able to do so.

Table 3.

Image	Duration in frames	Note
 Figure 8-1.		
 Figure 8-2.	4	
 Figure 8-3.	3	

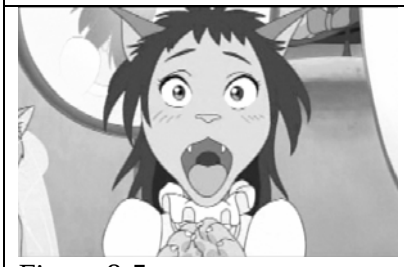
 Figure 8-4.	2	
 Figure 8-5.	3	
 Figure 8-6.	2	Extreme pose here.
 Figure 8-7.	3	
 Figure 8-8	2	It could be longer than this duration since the camera cut to another character.

 Figure 8-9	56	

Table 4 is a clip from Pom Poko[14].

The film starts with a group of Tanukis investing an abandoned house. They were happy to find a house to live. But they discover their living resources are diminished due to peoples' construction plan. They fight for their decreased living area. Since they possess the magic power to transform into humans, they try to disguise themselves to scared people away.

In this clip, a Tanukis pretended to be weeping woman by the road. The policeman passed by her and asked her condition. The Tanukis turned around with a blank face, which looks like a ghost. As we expected, the policeman was shocked and ran away immediately.

In the sequential images, we could see his shocking face starting with figure 9-2. He takes a brief breath (figure9-3 and figure9-4) and then back off. This breath is sure a very intuitive response. The duration of the act is only 5 frames in length. It's about the time to blink the eyes once. As I play the clip many times, I still couldn't perceive this act well. In other words, there are many steps we do when we are shocked. We do them in a split of second without realizing them.

In figure 9-14, the frame didn't really hold unchanged. He was obviously trembling for nearly 1 second. The next move is he tried to get himself back on his feet and ran away. The shot stands for a version of bigger body movements.

Table 4

Image	Duration in frames	Note
 Figure 9-1.	1	
 Figure 9-2.	1	He stares at the unbelievable face.
 Figure 9-3.	3	According to Darwin, two factors that follow surprise are a desire to see what happened and a preparation for nimble action, which requires a deep inhalation [20].
 Figure 9-4.	2	

 Figure 9-5.	3	
 Figure 9-6	2	
 Figure 9-7	3	
 Figure 9-8	2	

 Figure 9-9	3	
 Figure 9-10	3	
 Figure 9-11	2	
 Figure 9-12.	3	

 Figure 9-13	3	
 Figure 9-14.	26	This frame seems to last a second. But it didn't remain still. His body is trembling and shaking.
 Figure 9-15.	3	
 Figure 9-16	3	

 Figure 9-17.	2	
 Figure 9-18.	3	
 Figure 9-19.	5	
 Figure 9-20	2	

 Figure 9-21.	3	
 Figure 9-22	23	There are some similar body movements after this. He ran out of the frame.

4. Conclusions

This study focuses on the cell animation techniques for facial expression. Traditional skills have many remarkable outstanding achievements in the past. Meanwhile, computer animation using advanced technology is pushing the threshold further. The artistic talent is the essence for a successful animated film regardless of their techniques. Traditional animators may or may not know the muscle structure underneath the facial skin. Through their dedications and experiences, they convey effective messages across to the audiences. 3D computer animation tools overwhelmingly take over the market of traditional animation field recently. Even production houses like Ghibli Studio embraced and highly appreciated the technology. The fundamental understanding for the idea of how facial muscles worked and the principle of facial expression is still the key to a successful facial animation. Accuracy of a facial expression is one thing while the effect of it is another. That's the idea between simulation and animation. Computer tools are well known for its computing power, rendering algorithm and consistent precision. There are many other advantages besides those. But after all, animation as an art form, the artistic creation is the top priority of all considerations. Fortunately, available tools today don't restrain artist talent nowadays.

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