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Real-Time Visual Simulation and Interactive Animation of Shadow Play Puppets Using OpenGL

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***Abstract*—**This paper describes a method of modeling to model shadow play puppet using sophisticated computer graphics techniques available in OpenGL in order to allow interactive play in real-time environment as well as producing realistic animation. This paper proposes a novel real-time method is proposed for modeling of puppet and its shadow image that allows interactive play of virtual shadow play using texture mapping and blending techniques. Special effects such as lighting and blurring effects for virtual shadow play environment are also developed. Moreover, the use of geometric transformations and hierarchical modeling facilitates interaction among the different parts of the puppet during animation. Based on the experiments and the survey that were carried out, the respondents involved are very satisfied with the outcomes of these techniques.

***Keywords*—**Animation, blending, hierarchical modeling, interactive play, real-time, shadow play, visual simulation.

I. Introduction

STORYTELLING has been around since ancient times in various cultures and languages longer than we generally realize. Many traditional storytelling shows are in fact synonymous with chants, songs, epics and poetries and normally accompanied by a musical orchestra. Storytelling has been a form of education and it is used to impart morals and values to the audience in most traditional societies. In many parts of Asia, shadow play (or Wayang Kulit in Malay) is one of the well-known traditional storytelling methods [1]-[5].

Over the past few years, numerous advancements in digital storytelling and virtual storytelling have been reported. These advancements, serve as guides for those working in the exciting world of virtual or digital storytelling as well as digital or virtual shadow play. Papous [6], Virtual Storyteller [7]-[8] and CONFUCIUS [9] are the examples of digital storytelling systems. Besides, a first experiment in the adapting an interactive storytelling technique to a mixed reality system has been carried out by [10].

The art of shadow play is slowly disappearing simply due to the lack of interest in the younger generation. There is a need for us to promote and provide greater accessibility to, and preserve this masterpiece using present technologies such as digital media. Currently, not much works are being carried out in virtual or digital shadow play even though extensive research has been carried out in other virtual or digital storytelling. Some efforts in digitalizing traditional shadow play include development of a framework for traditional shadow play [11], virtual ‘wayang’ using ‘IRIS Showcase’ [12], shadow rendering of Chinese Shadow Play [13], and motion planning algorithm for Chinese Shadow Play [14].

Most of the work involved off-line and non-interactive generation of shadow play’s play. Therefore, in this paper, a method of modeling shadow play puppet is proposed using sophisticated computer graphics techniques available in OpenGL that will ensure fast and interactive display in real-time environment. By taking the advantage of various computer graphics techniques available in OpenGL a variety of lighting and special effects are generated for virtual shadow play environment. Realistic animation for virtual shadow play that includes real-time elements is also developed.

II. Related Works

The virtual storyteller Papous [6] can express some emotions and tell a story. In general, the overall approach seems to fulfill the intended purpose. Papous can tell the stories in an expressive and believable way, just as real human storyteller. Besides, Papous allows direct changes of the scene tags as well as the illumination tags according to the environment. Furthermore, Papous can be seen as a virtual narrator who reads a text enriched with control tags. It has some limitations that must be improved. It does not provide a great deal of flexibility when it comes to use its parameters to express the emotions that the user wants. Besides, this system does not include a great degree of autonomy. Furthermore, the number of available animations limits the bodily expression.

In Virtual Storyteller [7]-[8], the characters are implemented as semi-autonomous intelligent agents. Its advantage includes the incorporation of the narrative and the presentation levels as intelligent agents rather than text-based story generation system. Furthermore, it uses an embodied, speaking agent to

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present the generated stories using appropriate prosody and gestures. One of the disadvantages of this system is that the knowledge bases are still quite limited.

CONFUCIUS [9], an intelligent multimedia storytelling system creates human character animation from natural language. One of the advantages is that collision detection, autonomy, multiple characters synchronization and coordination are applied to the storytelling system. Besides, CONFUCIUS uses Humanoid Animation (H-Anim) and MPEG 4 SHNC for the animation. H-Anim humanoids can be animated using inverse kinematic which can provide realistic animation. CONFUCIUS' character animation focuses on the language-to-humanoid animation process rather than considering human motion solely. CONFUCIUS has some limitations that must be improved. It depends too much on generation of 3D animation from natural language by automating the processes of language parsing, animation production and semantic representation which means that CONFUCIUS will not run if one of the parts does not work.

An interactive storytelling using a mixed reality system by [10] provides more interaction for the user by allowing the user to take part as one of the roles in virtual storytelling. However this work is still at an early stage and further experiments are required.

Chee and Talib [11] describe a practical framework for integrating the elements of the traditional shadow play environment in a virtual storyteller. This includes shadow rendering of puppets, challenges the mapping of the traditional shadow play to a virtual storyteller, and a methodology in undertaking such development. In virtual 'wayang' [12] the puppet can move anywhere but the arms and legs of the puppet do not swing while the puppet is moving. However the shadow for the puppet is quite similar with the puppet in the traditional shadow play.

Zhu et al. [13] used photon mapping to render out the shadow effect. However, the time taken to do rendering does not allow real time and interactive play. Nevertheless the rendering time is much faster compared to other methods such as radiosity. Furthermore, the work resulted in good shadowing features such as shadow effect, blurring effect, animation and illumination. Hsu et al. [14] used motion planning technique to generate the motions automatically and used RRT-Connect algorithm to incorporate motion patterns into the search process for the upper body of the puppet. Furthermore, they also used a post-processing procedure to generate the secondary motions where the lower body can comply with gravity and obstacles.

In conclusion, we can say that extensive research has been carried out in virtual/digital storytelling and there is a need for more research in the area of digital/virtual shadow play. The existing works on virtual or digital storytelling incorporate techniques and technologies such as intelligent agents, mixed reality system and inverse kinematics (IK) to make it more interactive, intelligent and realistic. These techniques and technologies may also be considered in digital / virtual shadow play.

The existing work on digital shadow play is not interactive and dynamic enough to allow interactive play by the user. Most of the existing digital shadow play needs the user to predefine the frames offline and the play has to be performed to generate in-between frames using commercial software. The frames are interchangeable in real time situation if there is a need to change the storyline. The user needs to state the expected storyline before hand to the animator. This would delay the presentation of the story because the process of changing any storyline is rather time consuming. A better way of presenting virtual shadow play is by allowing interaction and real-time play of shadow play. Thus, there is a need for more research in real-time generation of shadow puppet images and interactive animation of the puppets.

III. System Overview

A. Visual Simulation

As shown in Fig. 1, the overall methodology of our work starts with visual simulation before other steps. Visual simulation is concerned with puppet modeling and special effects such as lighting and blurring. Puppet modeling is required in order to ensure the correct display of the puppets in shadow play environment. We develop a real-time method for the modeling of puppets that allows shadow play to be played interactively. The existing methods of rendering such as photon mapping, shadow mapping and other rendering techniques are rather slow and time consuming as adopted by [13, 14]. Thus, the existing methods [13, 14] do not allow real time interactive play of shadow play and the storyline has to be predefined before the play can be generated.

In order to overcome these drawbacks, we propose texture mapping for the modeling of the puppet. Texture mapping allows us to glue an image of a brick wall to a polygon and to draw the entire wall as a single polygon. Texture mapping ensures that all the right things happen as the polygon is transformed and rendered. For example, when the wall is viewed in perspective, the bricks may appear smaller as the wall gets further from the viewpoint. Texture mapping has also been used in depicting vegetation on large polygons representing the ground in flight simulation, and the texture that makes polygons seems like natural substances such as wood or cloth and wallpaper patterns. Texture mapping can be applied to all primitives such as lines, points, polygons, images and bitmap. Textures can be mapped to surfaces made of a set of polygons or to curved surfaces, and can be repeated in one or both directions to cover the surface.

Then, blending techniques as provided in OpenGL are used instead of the normal rendering techniques as proposed by other researchers. Blending is a computer graphics technique that combines the incoming fragments of red(R), green(G), blue(B) as well as the alpha values which is then stored at a particular location [15]-[17]. The results of blending depend on the values of the incoming alpha and the value is then stored at the pixel. In this paper, we apply the blending technique to the puppet and make the puppet appears translucent. Before applying the blending technique, we need to apply texture mapping.

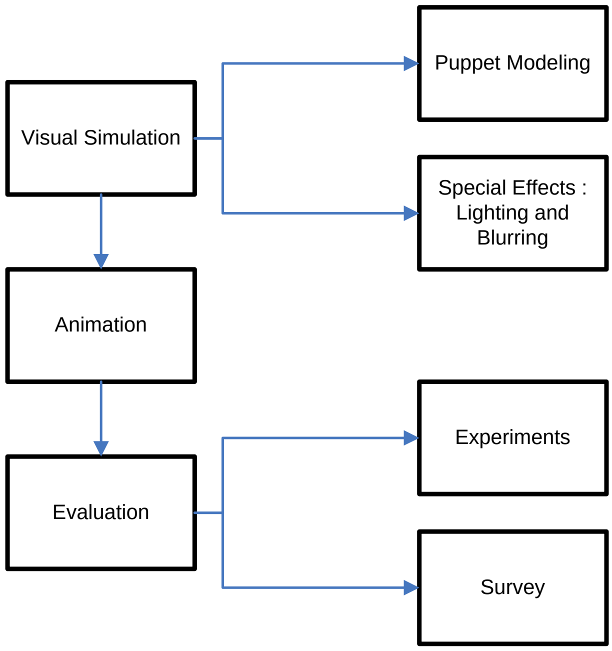

Fig. 1 The Process for Visual Simulation and Animation for Shadow Play Puppets

Lighting is the adjustment of the brightness of the light that is being changed either in a rapid motion or snail pace according to the necessities of the effects of the film. The Papous system [6] allows direct changes of the scene tags as well as the illumination tags according to the environment. Both, the scene and illumination tags are not interactive. In order to overcome the problem of achieving smooth transitions between different scenes and illumination patterns, a fader that acts like a theatre curtain is used. More research can be done in the area of lighting to produce special and unique effects in digital/virtual Shadow Play. We can make full use of accumulation buffer offered by OpenGL for the virtual shadow play environment. In OpenGL, we introduce blurring effect for the image and make the puppet which is a plane (2D) behave as though they are in various environment with lighting and blurring effects.

B. Animation

The animation stage is the second stage and the most interesting stage. Here we make the animation of the puppets more realistic. In [13], custom-made software is used to produce the animation through manual generation of key frames. Also, in-between frames are vividly generated through interpolation. In [14], RRT-Connect algorithm is used to generate the primary motion, which refers to the kinesiology of the upper abdomen, which is between the thorax and pelvis, and the pendulum model is used to generate secondary motion which refers to the scapula at the arms and the joints at the legs respectively. In this paper, we use geometric transformations and hierarchical modeling without the need to generate key frames in a pre-processing step. This model is adequate in modeling the movement of shadow play puppets as we are interested only in the arm/hand. On the other hand, Chinese shadow play [13, 14] requires modeling of both the upper and lower parts of the puppets.

C. Evaluation

Finally, in the evaluation stage which is the final stage, a survey together with a set of experiments are carried out to determine the acceptability and the quality of the techniques and methods derived in this work. The main objective is to gather the information and comments of the virtual techniques as opposed to actual shadow play. In the survey, questions and comments regarding the quality of the output are prompted to the respondents through a set of experiments.

IV. Puppet Modeling

A. Step by Step Implementation of Puppet Modeling

The first step of the implementation is to manually import a photo of the puppet into Photoshop CS. The purpose of using Photoshop CS is to cut the puppet into many parts such as hand, wrist, leg, body and so on. The cutting of the puppet into many parts is needed so that, we can use the hierarchical transformation technique can be used in order to allow the animation for the parts such as hand, leg, wrist or body. In our implementation, the puppet is cut into three parts namely body, hand and wrist.

After the cutting, texture mapping is used to import the image into OpenGL. Texture mapping is done by sticking or pasting the image on the rectangle created in OpenGL as shown in Fig. 2. Step A shows the first step which is creating the rectangle. Step B shows the image of the body of the puppet imported into OpenGL using texture mapping. Then another rectangle is created Step C for texture mapping of the image of Step D. The process is repeated for other parts of the cut image (example Step F in our implementation). Finally, Step G shows the whole complete imported puppet image which contains the body, the hand and the wrist.

The next step that needs to be implemented is blending. Blending combines the color of a given pixel that is about to be drawn with pixel that is already on the screen. Based on the alpha value, the colors can be changed. The purpose of using blending technique is to create shadow image that has the same effects as the shadow image of the puppets of the traditional shadow play. Blending provide fast generation of the image to allow fast real time interaction instead of using the rendering method because the time taken to do rendering does not allow real time and interactive play. Blending is initially disabled. So in order to enable blending function, we need to use glEnable(GL_BLEND). glBlendFunc() defines the operation of blending when it is enabled and it controls the effect of blending. Transparency is best implemented using blend function (GL_SRC_ALPHA, GL_ONE_MINUS_SRC_ALPHA) with primitives sorted from furthest to nearest. Transparency calculation does not require the presence of alpha.

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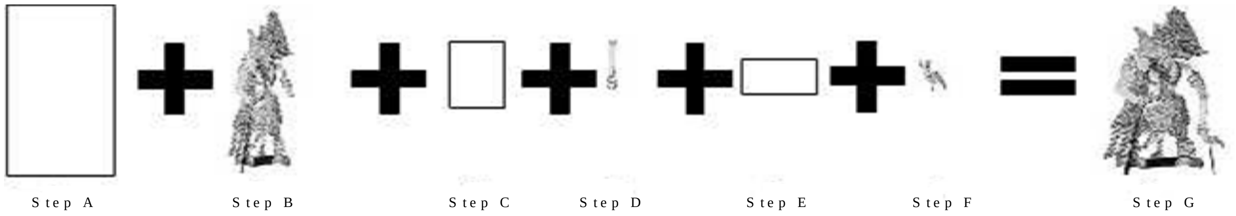

Fig. 2 Applying Texture Mapping to the Puppet

The incoming (source) alpha is correctly thought of as a material opacity, ranging from 1.0 which represents complete opacity, to 0.0 which represents complete transparency.

After blending is enabled, the incoming primitive color is blended with the color that is already stored in the frame buffer. glBlendFunc() defines the operation of blending when it is enabled and it controls the effect of blending.

The steps involved in our implementation are summarized as follows;

1) Create the first rectangle for body for the puppet.
2) Apply texture mapping on the first rectangle, which is the body for the puppet as the skin.
3) Disable the blending function on the first rectangle.
4) Create the second rectangle for the hand for the puppet.
5) Apply texture mapping on the second rectangle, which is the hand for the puppet as the skin.
6) Disable the blending function on the second rectangle.
7) Create the third rectangle, which is the wrist for the puppet.
8) Apply texture mapping again on the third rectangle, which is the wrist for the puppet as the skin.
9) Disable the blending function again on the rectangle.
10) Create the fourth rectangle that contains the first, second and third rectangles.
11) Enable the blending function on the fourth rectangle.

V. Special Effects: Lighting and Blurring

A. Creating Lighting and Blurring Effects for the Shadow Play

Firstly, a rectangle is created and applied a color such as black. Then this image is exported as a bitmap in Flash. We use the Color Panel in Flash to create some themes. A number of themes can be created. In the implementation, only three themes are Figs. 3 to 5 are the themes that we have created namely darkest theme, brightest lighting theme and moderate lighting theme respectively.

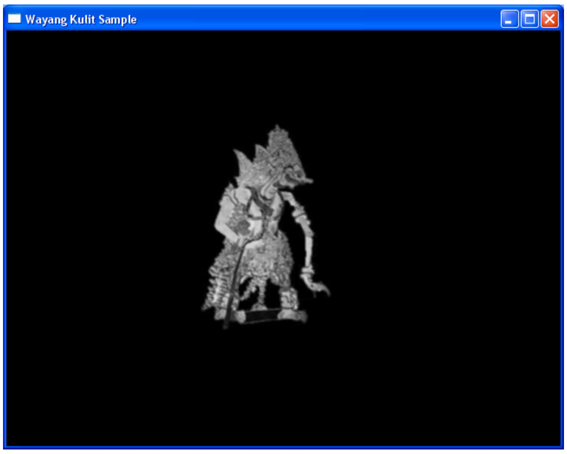

Fig. 3 Shadow Puppet with the Darkest Theme

Fig. 4 Shadow Puppet with the Brightest Lighting Theme

Fig. 5 Shadow Puppet with the Moderate Lighting Theme

After creating the themes, a rectangle in OpenGL is created and texture mapping on the rectangle. Then the blending function is disabled on the rectangle. The steps involved are as for the steps involved in puppet modeling as described in the previous section. We use the themes are used as the background for virtual shadow play.

OpenGL has a feature called the accumulation buffer. The accumulation buffer is simply an extra image buffer that is used to accumulate composite images. It is useful for some special effects such as anti-aliasing, depth-of-field, and motion blur. In our work, depth of field is used to produce blurring effects for the puppet in virtual shadow play as shown in Fig. 6.

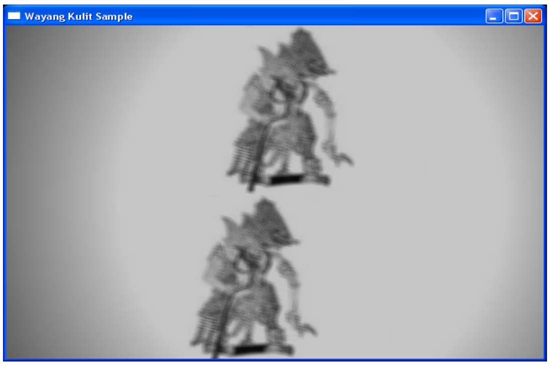

Fig. 6 Blurring Effect using Depth of Field

VI. Animating the Puppets

A. Animation

Now let us look at geometric transformation operations and the modeling transformation and hierarchical modeling that we can apply to objects to reposition or resize them. In modeling transformation, a puppet can be considered as an object that consists of hand, wrist, leg, and other components where each of which can be specified in terms of second-level components, and so on, down the hierarchy of component parts. Thus, the puppet can be described in terms of these components and an associated "modeling" transformation for each one that describes how that component is to be fitted into the overall puppet design. Geometric transformations can be used to describe how the hand, leg and wrist might move around in a scene during an animation sequence or simply to view them from another angle. In our implementation, only three objects are used namely body, hand and wrist.

The following steps are carried out to implement the animation of the shadow play puppet:

1) glPushMatrix pushes the matrices on the current stack down one level for the rectangle which contains the body for the puppet. Create the first rectangle for body for the puppet.
2) glTranslate translates the rectangle which contains the body for the puppet.
3) glPushMatrix pushes the matrices on the current stack down one level for the rectangle which contains the hand for the puppet.
4) glTranslate translates and glRotate rotates the rectangle which contains the hand for the puppet.
5) glPushMatrix pushes the matrices on the current stack down one level for the rectangle which contains the wrist for the puppet.
6) glTranslate translates and glRotate rotates the rectangle which contains the wrist for the puppet.
7) glPopMatrix pops the top matrix off the stack for the body for the puppet and this is followed by popping the hand for the puppet and lastly the wrist for the puppet.
8) Finally glutSwapBuffers() is applied to swap the buffer.
9) Steps 1 to 7 are then repeated.

VII. Evaluation

In order to evaluate the effectiveness and the efficiency (real-time elements) of the proposed approach for puppet modeling (shadow image), special effects (lighting and blurring), and animation of the puppet, a questionnaire has been designed to obtain feedback from various parties.

The main objective of the questionnaire is to gather the feedback and comments on the virtual techniques of shadow play as opposed to the actual shadow play. The questionnaire consists of three sections, namely puppet modeling, lighting and blurring effects, and animation. The respondents are required to rate their satisfaction based on a scale of 1 to 7 where 1 is the lowest and 7 is the highest degree of satisfaction in all of the questions. In puppet modeling, the first question is on shadow image of the puppet. The second question is on interactive and real time playing of virtual shadow play. In lighting and blurring effects, the question is on the virtual lighting and blurring effects for virtual shadow play. In animation, the respondents are asked on the realistic animation of the puppet and on interactive and real time elements of the animation.

For the first question which is on the effect of the puppet's appearance compared to the traditional shadow play, 95% of the respondents have given an average rating. In the second question, majority of the respondents (65%) have given the rating of 6 on the interactive and real time playing of the virtual shadow play. Most of the respondents (80%) gave the highest scale (7 out of 7) on the lighting and blurring effects of the virtual shadow play compared to the traditional shadow play. For the fourth question, only 7 respondents (35%) have given the highest rating (7 out of 7) and only 2% of the respondents gave the rating of 4 on the realistic animation of virtual shadow play compared to the traditional shadow play. For the last question, majority of the respondents (70%) are satisfied with the interactive and real time animation of the virtual shadow pay.

From the result of the evaluation, some useful and effective feedbacks are obtained. Many of the respondents think that the virtual puppet modeling is rather compatible to the traditional ones. The crafting of the outline of the puppets has properly shadowed the real puppet.

On the lighting effect, many respondents showed their agreements and were fascinated by the differences that can be made to the brightness. This is due to one distinct similarity that can be found between the theme for the traditional shadow play and our theme in virtual shadow play. Some respondents suggested further enhancement of the effects using the fade in and fade out techniques. For example, fade in technique is required when a puppet is about to appear on the screen and fade out techniques is required when it has to be disappeared. In addition, the respondents are satisfied in witnessing the extra and special blurring effects.

Lastly, on the animation, most of the respondents have rated an average rating. The movements of the arms are not so flexible. The respondents also added that the arms could not swing freely in a cyclic movement. A few respondents commented that, if cyclic movements could be applied successfully onto the wrist of the puppet, we could also apply the same method on the arms to produce the cyclic movements.

VIII. Discussion

The shadow play puppet in [12] can be moved anywhere but the arm of the puppet cannot be moved or animated. In our work, we can generate the same effect like in [12]. Additionally, we provide realistic, interactive and real time animation that also includes animation of the arms of the puppets.

The time taken to do rendering of the puppet in [13] does not allow real time and interactive play. The animator (or player) needs to render offline several key frames and used commercial software to generate in-between frames in order to provide a play for a specific storyline. In our work, flexibility and interactive real time capability are provided without having to preprocess key frames and generating in-betweens.

A mechanism that allows the arms of the puppet to swing naturally while the character is walking is provided by [14]. In our works, similar types of movement onto the wrist of the virtual shadow play's puppet have been successfully implemented. This method is also applicable to other parts of the body of the puppet, thus producing a better effect in expression and body languages. The difference is that in [14] some movements can be made at the same time such that the puppet could swing the hand while running. However, in Malaysian shadow play, the upper part of the body of the puppet always remains static. Therefore this particular approach is not into much consideration in our work. Furthermore, for the lower part of the puppet, they have to adopt a post processing approach so that the legs can swing like a pendulum and comply with the silhouette of the environments. Some how, in our work there is no such necessity for us to go through the same predetermined step. In [14], an attempt is made to create a shadow play animation with a key-framed based approach. However in our work, realistic and interactive motions can be generated and the reusability of different types of motions in real time using just hierarchical modeling is made possible. As it allows playing in real time, any last minute changes on the script of the shadow play could be changed and corrected on the spot without further hesitation.

Based on the evaluations and the experiments that we have carried out, our approaches and techniques are acceptable for visual simulation and animation of shadow play's puppet that allows real-time and interactive play of virtual shadow play.

IX. Conclusion and Future Work

In this work, we have provided several solutions are provided in visual simulation and animation of virtual shadow play's puppet. Firstly, texture mapping and blending techniques are used instead of rendering technique in order to allow fast and interactive display in real time environment. Besides, several techniques that use various themes (lighting) and special effects such as blurring to bring the right atmosphere to the virtual shadow play are proposed. Hierarchical modeling method is adopted in order to model a realistic animation for the puppet to include real time elements that allow playing of shadow play naturally in virtual environment. Previous works are not interactive and require manual pre-ordering of the play using key-framed approach.

For future work, a general baseline that creates the vertices exactly the same with the particular puppet in OpenGL can be used rather than creating a rectangle to apply texture mapping. Besides, we can also work on more special effects such as fade in and fade out for the puppet while appearing on or disappearing from the screen. This will give more realistic environment for virtual shadow play. Furthermore, a more realistic animation for virtual shadow play can be achieved using techniques such as inverse kinematics or physics element.

References

[1] P. Matusky, (1993) Malaysian Shadow Play and Music: Continuity of an Oral Tradition: Oxford University Press.
[2] V. N. Edward, (1980) Javanese Wayang Kulit: An Introduction: Oxford University Press.
[3] H. J. Salij, (1982) Shadow Play and other Stories: Heinemann Singapore.
[4] J. Liu, (1998) Chinese Shadow Puppet Plays: Morning Glory Publishers.
[5] C. David, (2008) Shadow Puppets & Shadow Play: Crowood Press.

[6] A. Silva, M. Vala, and A. Paiva, (2001) Papous: The Virtual Storyteller, Proc. Intelligent Virtual Agents 2001, pp. 171-180.
[7] M. Theune, S. Faas, A. Nijholt, D. Heylen, (2002) The Virtual Storyteller, ACM SIGGROUP Bulletin, Volume 23(2), pp. 20-21.
[8] M. Theune, S. Faas, A. Nijholt, D. Heylen, (2003) The Virtual Storyteller: Story Creation by Intelligent Agents, Proc. Technologies for Interactive Digital Storytelling and Entertainment, pp. 204-215.
[9] H. Ma, P. Mc Kevitt, (2003) Building Character Animation for Intelligent Storytelling with the H-Anim Standard, Proc. of Eurographics Ireland, pp. 9-15.
[10] M. Cavazza, O. Charles, F. Mead, X. Marichal, (2003) Users Acting in Mixed Reality Interactive Storytelling, Proc. 2nd International Conference on Virtual Storytelling, pp. 30-39.
[11] J. Chee, A. Z. Talib, (2006) A Framework for Virtual Storytelling Using Traditional Shadow Play, Proc. International Conference on Computing and Informatics (ICOCI 06), (CD Proc.).
[12] K. A. Rahman, (1999) Wayang "Virtual" Integration of Computer Media in Traditional Wayang Kulit (Shadow Play) Performance, [Online]. [Accessed 9th Feb 2008]. Available from World Wide Web: http://www.itaucultural.org.br/invencao/papers/Rahman.html
[13] Y. B. Zhu, C. J. Lee, I. F. Shen, K. L. Ma, A. Stompel, (2003) A New Form of Traditional Art: Visual Simulation of Chinese Shadow Play, International Conference on Computer Graphics and Interactive Techniques Sketches and Applications, pp. 1-1.
[14] W. S. Hwu, T. Ye, (2005) Planning Character Motions for Shadow Play Animations, Proc. of International Conference on Computer Animation and Social Agents (CASA'05), pp. 184-190.
[15] W. Mason, N. Jackie, S. Dave, (1997) OpenGL Programming Guide: Addison Wesley Developers Press.
[16] H. Donald, B. Pauline, (2004) Computer Graphics with OpenGL: Pearson Prentice Hall.
[17] S. W. Richard, S. Michael, (2001) OpenGL Super Bible Second Edition: Waite Group Press.