Virtual Fingers: Interactive Manipulations of Shadowgraph based on Inverse Kinematics

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Abstract: Shadowgraph is the featured traditional folk culture and art in Taiwan. The author has conducted the related researches such as digital interactive narration and storytelling of Shadowgraph. The study presents interactive manipulations for operations on inverse kinematics (IK) motion design of Shadow Puppets via multi-touch interface with the virtual fingers in order to enhance the operational perception of Shadow Puppets. Research findings show the interaction design of Shadow Puppet motions by IK and help the innovative development of shadowgraph, enhance the perception of Shadow Puppet operation and construct new cultural value in digital time.

Key words: Shadowgraph, Inverse Kinematics, Shadow Puppets, Virtual Fingers

1. Introduction

Shadowgraph is the featured traditional folk culture and art in Taiwan. In Taiwan society of early times, there was one common activity of entertainment, art and culture: Shadowgraph (also called Shadow Theater). It combined traditional drama style and presented the traditional folk art by lighting and shadow. Shadow Puppet style of traditional shadowgraph technique is one of the main factors of the vivid performance of shadowgraph. In "Hand Puppet Theater", another popular traditional art in Taiwan, Hand Puppets are the favorite collections of the fans. Design of the puppets not only attracts the audience, but also demonstrates the characters' personalities. "Mirror Man", the antagonist in the well-known Hand Puppet Theater "the swordsman of YunZhou: Shih-Yen-Wen", always dress with leaf hat, mask and golden thread cloth. His mysterious and invincible image confronts the decent role of Shih-Yen-Wen. It enhances the tension of the theater.

Shadow puppets is a kind of performance art with hand manipulated, and made by a certain of material (such as cow leather) to consumes time and efforts to produce it. In previous works of studying the performance art of Tunghua shadowgraph theatrical company in Dashe Township of Taiwan, research findings could be summary that three levers are used to control the motions of shadow puppets [8]. One is called "balanced lever (middle lever)" which is set at the front of the necks of shadow puppets. It functions to balance the body and control singing and varied poses [4]. The other two levers are called "motion lever (hand lever)" which is set at two hands of shadow puppets. The purpose is to control shadow puppets' hands for the necessary motions. The operational principle of Inverse Kinematics is "bones chained" to construct "branched armatures" structure and connect the objects with Parent-child relationships into animation. The bones are set in the shapes of different objects. By controlling the branches of Shadow Puppets, the motions of the objects are established by moving, rotating, stretching. When the bones move, the related bones of the objects will result in the motion. Simple interaction presents the animation of Shadow Puppets' joints.

The previous study had developed inverse kinematics (IK) of shadowgraph to manipulate shadow puppets' motions. The study presents interactive manipulations for operations on IK motion design of Shadow Puppets via multi-touch interface with the virtual fingers in order to enhance the operational perception of Shadow Puppets.

2. Shadow Puppets by Manipulating Manually

Different types of Shadow Puppets show varied characteristics of motions [3]. Civil and military officers are different. Military commanders and military officers come on the stage from the right of the curtain. The operator controls the main lever by right hand and the side lever by the left hand. The civil officers come on the stage from the left curtain. The levers are contrary to those of military officers.

There are generally seven kinds of technique:

- Military Shadow Puppets (Shadow Puppets of military commanders are also called "Tiao Chiao Tsai" in Chinese). It shows the flexible motions of the feet and fists.
- (2) Regarding Shadow Puppets of military officers (such as the generals), the operator must control them with two hands. They control the main lever with right hand and side lever with left hand. The end of the main lever is at the palm of right hand. With the operation, the bodies and feet can move forward and backward.
- (3) As to left Shadow Puppets of female leads: the operator holds the main lever by left hand and the end of the lever is at the palm. Side lever is controlled by right hand. When female Shadow Puppets come on the stage, their motions should be slow and light with small steps. The puppets bow a little to show the grace of ancient females.
- (4) As to Shadow Puppets of civil officers (squires or Shadow Puppets with officials' robes): Control of levers on the left and right hands is reversed. The operator controls the main lever with left hand and the end of the lever is at the palm. Main lever is controlled by thumb and forefinger, middle finger and wooden lever is controlled by ring finger and little finger; side lever is controlled by right hand for the motions of arms.
- (5) Shadow Puppets of jester (servants): servants and subordinates; when the servants come on the stage, the operator controls the main lever to quickly move forward and the side lever follows immediately and wiggly. Thus, images and motions show the hurry.
- (6) Shadow Puppets of soldiers: they are mostly operated by one lever and they usually appear in the great fighting. The operator usually holds three to four levers with one hand. The wooden lever is grabbed by one hand and controlled by thumb, forefinger and middle finger which move up and down. Shadow Puppets' arms demonstrate fighting and waving.



Figure.1 Shadow Puppets of animals by manipulating manually

(7) Shadow Puppets of animals (such as elephant): the operator controls the main lever at the head with one hand and side lever at the tail with the other hand. Thus, the body of elephant can move up and down. There are

varied animals, such as a rabbit, a cock, a giraffe, and the operation is similar. Main lever is at the head and side lever is at the tail or the neck [2]. (see Figure 1)



(a) Fighting of Sun Wukong



(b) Shadow Puppets close to the curtain



(c) Soaring up and turning of Sun Wukong



(d) Positions of Shadow Puppets and levers Figure.2 Types of motions of Shadow Puppets (Source: compiled by this study)

In addition, according to the basic operation skill of Shadow Puppets, when walking, Shadow Puppets' hands will move forward and backward and the lower part will shake. Their motions follow the rise and fall of the ground. Levers usually are not installed on Shadow Puppets' feet which will sway regularly. If Shadow Puppets are not close to the ground, when they move forward, their feet will slightly bend backward. When they stop, the feet will drop naturally and sway. Thus, according to primary observation, the operation of Shadow Puppets is below:

- (1) Touchdown: Although the operator controls the motions of Shadow Puppets, the Shadow Puppets' roles should match the scenario. Except for the flying animals, human beings and animals should stand on the ground. The operator presses the lever with little finger and ring finger. Shadow Puppets' feet should be on the ground and the feet should sway quickly and touch the ground to meet the reality (see Figure 2a).
- (2) Close to the curtain: in the operation of Shadow Puppets, the control lever and motion lever should be straight and make Shadow Puppets to be close to the curtain. Thus, the shapes and beauty of the sculpture of Shadow Puppets can be clearly presented with lighting. Without being close to the curtain, Shadow Puppets will be shown with light shadow and the vivid performance will not be presented (Figure 2b). The similar effect can demonstrate the transition of Shadow Puppets on the stage. By the timing and process of light shadow, the atmosphere can be created.
- (3) Flying action: when Shadow Puppets fly, the operation of the side shows the vibration of the wings. The operator controls the head with operation lever and vibration of wings or physical turning by motion lever (see Figure 2c).

- (4) Turning action: the operator treats the lever at the head as the center of the circle and stays and turns the puppets on the curtain. Another lever is thus turned with 180 degree. Shadow Puppets will overturn from the left to the right (see Figure 2d).
- (5) Leg splitting, somersault and speaking action: besides the basic motions, there are also somersault and fighting. When one role is speaking, other Shadow Puppets should not move. Thus, the audience will recognize the speaking puppet.

A puppet can be any object that is animated by human control. Latshaw(1978) indicates that the three requirements for a puppet are (1) a form to be animated, (2) a person to do the animating, and (3) a method of control that uses all or part of the puppeteer's body, or an extension of it through rods, strings, wires, magnets, or a combination of these [7]. An imagination can be spreading as the simplest of puppets manipulated. In general performance of puppets, the index and middle fingers are used as "legs" while the remaining fingers are tucked back out of sight, and the legs stand on the ground. Finger-tips are wedged into the puppet's shoes. However, one person can be simulated with fingers/legs, and finger-tips/shoes by performing actions. In the other words, one person can be also simulated by hand puppet as shown in the demonstrations of Figure 3(a). The hand puppet consists of a head, neck, and hands attached to an empty costume. For this reason, the hand, fingers and forearm provide the skeleton inside; the wrist becomes the waist, and the forearm functions for the "legs", and consequently a variety of fingering positions are illustrated.





(a) the demonstrations of three hand puppet positions(b) simplest of puppets and cooperative organizationsFigure.3 The performance art of finger/hand puppet

Puppets actually have some advantages as sexual actors. As the same of above mentioned, a love scene by Sergei Obraztsov using the simplest of puppets, such as two-inch, unadorned spheres on the tips of his index fingers [1]. A puppet at ease will hold both hands together in front of the body. The visible gestures exactly will open out from this position, for examples, pointing, waving, reacting with surprise, etc. However, many puppets could be acted as the community members to show for a cooperative organization (see Figure 3b). The hand puppet is the ideal figure for a start, because so much of it is ready-made. The puppeteer's hand, finger, and forearm are not only the basis for the puppet body and limbs, but also the means of control.

3. Virtual Fingers: Interaction of Shadow Puppets

For traditional Shadow Puppets, there are three to four levers. Nowadays, for the concern of performance, it is simplified as two or one lever, and also simplified as the actions of finger puppet. In orchestra scene, the characters are set with one lever at the front of the chest by iron wire. Thus, the shadow can be reversed. One lever is set on the hand for the motions of hands. As to the martial scene, the level is installed at the top of the back of

chest (shoulder) for the martial art. There can be varied motions such as running, standing, sitting, lying and fighting (see Figure 4a).





Latshaw(1978) had described the actions for manipulations of shadow puppets [7]. In the diagram of Figure 4(b), in general, the parts of the human hand and arm have been relabeled to describe their functions in a puppet body. Though it may seem ridiculous to find the ribs located below the elbow and the brain extending from the neck, it is essential to translate the familiar moving parts into other terms before we can expect new patterns of movement. In interactive operation, operation of IK branches can simulate the motions of Shadow Puppets. Connection between the levers and Shadow Puppets' joints is shown in Figure 4(c) and the setting is on Shadow Puppets' shoulders and wrists. According to the setting of IK branch, it constructs the bones chained operation. The chains of Shadow Puppets' joints can be established by IK. Poses on timeline can simulate hands, upper limbs,

heads, bodies and lower limbs corresponding to levers of Shadow Puppets. Thus, Shadow Puppets can move freely. As shadowgraphs, the movements of the puppet body are organized in a hierarchy similar to that of the solar system. These movements may be described schematically as follows in the Figure 4(d). In the meantime, the movements of each arm are organized in a hierarchy from the shoulder to the elbow to the wrist and so on down to the tips of the fingers [9]. Similarly, the movements of the legs are organized in a hierarchy from the hip joint down to the tips of the toe. Figure 4 presents the concepts for interactive manipulations of shadowgraph based on inverse kinematics. Finally, we could implement the interactive models of manipulating the shadowgraph with virtual fingers as referring the human behaviors. As some cases of brief observations, a forefinger could be regards as the manipulations for head of shadowgraph. A thumb could be used to manipulate the one of hands, and thus a middle finger related to the other hand.

3. Future Study

The future study will concern on developing interactive models for the digital environment of interactive narration, which that IK motion design of Shadow puppets, combine multi-touch interface with the motions of virtual fingers and develop digital narrative operation of shadowgraph in order to increase the interactive operation perception of shadow puppets. The digital environment of interactive narration of shadowgraph, which will be divided into "one-man operation of Shadow puppets in the narration" and "two-men cooperation in the narration". Cooperative cooperation of Shadow puppets not only challenges the work division of the performers, but also guides the understanding of the behavior of the roles of Shadow puppets.

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