

# Physical Rigging Procedures Based on Character Type and Design in 3D Animation



Mohd Rosli Arshad, Kim Hae Yoon, Ahmad Azaini Abdul Manaf, Muhammad Azmin Mohamed Ghazali

**Abstract:** *In 3D (Three-Dimensional) animation pipeline, the term rigging is commonly used to describe the process of creating skeleton system inside the finishing 3D character geometry and assigning animation controllers for animators to animate the 3D character. In order to establish a fluidity movement on the character, the proper setting must be planned and the flexibility of the controller must be setup properly. However, the discussion and understanding about rigging setup for specific 3D characters from previous researcher is very limited. Hence, the process of rigging will take longer time to complete especially for novice rigger artist. This study will explore the fundamental process of character rigging system and identify the method and techniques for rigging characters based on their anatomy designs. The analysis of this study will look on the conceptual design of the character; how to implement proper techniques and workflow based on the primary and secondary data provided in this study. The findings in this paper indicate common techniques for human rig object in 3D characters is using Biped, CAT or auto rigs. From our experiment, we found biped or CAT rigging is the best setting for the animals and realism characters. Custom rig is suitable for cartoony characters. Rigging system for anthropomorphism character is a bit different from the human rigs system. Anthropomorphism character requires several modifications on their physical appearances in which adding or subtracting the limb that physically taken from specific animal or any objects. For this type of character, we suggested to use biped rigging system. However, for complex anthropomorphism characters with many form structures, the study of movement, exaggeration and bone limitation must be analyzed before deciding the proper technique for rigging. Hence, the chain rig system is the best option for this type of anthropomorphism character. Therefore, rigging in animation is the process assembling the skeleton system into the character. The use of proper rigging style will determine how the character move and pose in final animation.*

**Keywords:** *Character Rigging; Character Design; 3D Character; Character Animation*

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## I. INTRODUCTION

Character design means the process of creating and establishes new character by the character designer. This process is one of the many complex tasks in animation pipeline. After the story construction, the artist starts to develop and design the appearance, style and concept for the character. It consists of conceptual design; identifying character identity and creating character personality that will drive the storytelling. According to Wyatt [1], he stated that, “the design of the character must be established early on in the process. They are the main vehicle through which the story will be told, and they must be designed with this in mind.” The importance of character design and the appealing designs in animated films is significance in order to portray a specific mood or emotion in the storyline. Sajjad.S [2] supported this statement by saying the combination of basic shapes and colors relied heavily on character design and the appealing designs contributes to a sense of emotional engagement between the visual and the audience.

Rigging or Bones Setup in 3D characters can be defined as the process of creating skeleton system inside the character. Once the modeling artist finished the modeling stage, further steps will be taken by the artist who is responsible to assemble the skeleton or bones system, commonly known as Rigger Artist. Normally, the main task that the rigger artist needs to do is to develop a skeleton system that consists of bone object, assign controller for each bone and skinning the 3D mesh which is defined as the process of attaching character limbs to the bones. In 3D animation pipeline, rigging is the most important step in order to create the fluidity of the character movement. All 3D geometry that needs to be animated must have a proper rigging setup in order to control the flexibility of movement for each joint during animation processes. This control system is called rigs [3].

There are several types of rigging system in order to rig the character animation such as traditional bone object, biped and Character Animation Toolkit (CAT). Bone object rigging refers to a standard rigging technique where rigger artist has to place bone objects piece by piece into the character body. These bone objects are linked to each other and once the bones have fully setup, the rigging process is complete. This rigging setup automatically generates a hierarchy system of bones. Hierarchy system means that all bones construction is connected through parenting and child concept. The parenting bones can be rotated, moved and scaled.



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The characteristic of character rig setup depends heavily on the design and the complete form of the 3D model. It will determine how the character move and perform in the animation stage. In this study, we will explore the process of rigging techniques and identify how character type and design will influence the rigging styles. The problems faced by most rigger artist especially the novice at the beginning stage is to identify the proper rigging styles and bone controllers in 3D model. Each character that has been created comprises of difference shapes and physical designs. Hence, rigging structure can be different for each character. For example, character types such as human character with different height and sizes, animal character with asymmetrical shapes and mechanical object characters. All of these 3D characters need to be assembled with different rigging structure. Therefore, this study will explore the technique on how to setup a fully 3D character rigging with the knowledge of character variation and design as the first step before creating 3D rigging. Furthermore, this research will also highlight basic knowledge of rigging such as techniques, types of rigging and basic rigging structures.

## II. LITERATURE REVIEW

### A. Character Type and Design in Animation

The creation of character design in animation is closely related to many aspects in human society. The process of designing the animated character has become an important process not only for visual but also bounded to many specifications that advent from myths and legends and inspiration from history, culture and everyday life. By definition, character means the mental and moral qualities distinctive to an individual (“character”). It is also to determine how the person looks, acts, speaks, and even interacts with others [4]. From the development of the storytelling in animation, designing good animated characters requires a coherent and consistent character design skill and the artist need to consider many restrictions to develop suitable characters in the story. Most of the successful animation stories and their characters are inspired from myths, fantasies, lifestyle and superheroes from storybooks or comics that are being translate into the art of digital animation [5]- [6]. Creating an appealing character design in animation has been both a distinct challenge as well as an area for exploration for animators throughout animation’s history. Appealing designs contribute to a sense of emotional engagement between the visual and the audience.



Fig. 1 The Incredibles 2 (2018)

Character design and rigging technique in animation plays a significant role in order to get a perfect 3D character setup. For example, if the character is an animal, we need to consider the aspect of limb movements or if the character is human, the aspect of size and proposition is the main factors. The concept and designs will determine the character appearance, personality and performance, which dictates how it moves and acts in the final animation. Designing a character is a huge task. Design means making decision about the character. This decision includes; the height of the character, the textures that will applied and the type of clothes they will wear [7]. Besides that, the visual research about the character must be first conducted to determine the shape and design of the character. Fig.1 shows the different shapes and sizes for animation characters. Colors also have a similar unwritten effect on visual interpretation. Creating characters with an appealing and suitable color palette can make immediate impact in grabbing and holding a viewer’s attention [8]. Choosing the right color to be placed on the character can create huge effect to convey character personality to the audience. Color is one of the platform to deliver the message of visual communication. Each color represents or symbolizes the strength of the character. For example, bright colors are often used for friendly characters, dark colors for villain. For emotion, red color is used to describe anger and fiery; blue can be expressed as a cool and calm character.

### Basic Shapes

Basic shapes play a vital role in producing good character design. For professional character designer, they will start with basic shapes as a starting point to develop any character. Round, square or triangle shapes can be used for the basic character structure. This element is useful for getting a clear shape and form for characters that have been designed. In design, character shapes play an important role to convey the character meaning and the personality to the audiences. For example, round shape represents good character, friendly, and weak. Triangle shape normally for villain character that shows evil personality. While a rectangular shape usually for strong and heroic character. This statement was supported by Melling [9], which she suggested that a lot of very successful character designs are made up from simple shapes and size. Each shape has its own meaning attached to it. For example, round shapes as soft and approachable and more angles shapes as dangerous and shady as shown in Fig.2.

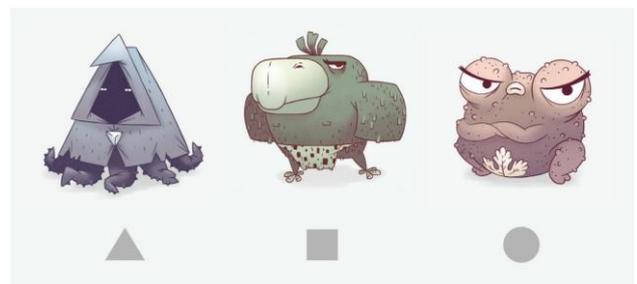


Fig. 2 Basic character shapes

**Exaggeration**

Fig.3 highlights the importance of exaggeration in designing a good character. This element is very effective to give an appealing look to the character. Melling’s [9] explained that outrageous proportions or exaggerating the length and size of body parts, even with smaller details like fingers can really help to build the personality of the character. The advantage of having exaggeration really can help the character appearance looks stronger, clumsy and evil through the exaggerating features of the physical appearance. Similarly, Wyatt’s [1] point out that a good character designer must have excellent knowledge of anatomy and understand how bodies move in order to exaggerate proportions.

It is apparent from the previous studies that design plays an important role in revealing human emotion towards animation contents. Thus, the characteristics of design and color aesthetics is significantly important and serve a promising effect to the viewer’s emotion due to the fact that the content can be created as imaginatively as possible [10].



Fig. 3 Exaggeration

**B. Character Rigs**

In 3D Animation Essentials book by Andy Beane [3], he highlighted, “Riggers need a deep understanding of the inner workings of whatever software and hardware they are using, as well as a firm grasp of computer scripting and expression writing. Knowledge of anatomy, human or animal, is also useful”. Rigger artist needs to study a lot of things. Not only to understand on how to assemble a technical rig in virtual; they must be able to analyze and experiment the rigging system so that the character can be animate perfectly. Animating an articulated 3D character requires manual rigging to specify its internal skeletal structure and to define how the input motion deforms its surfaces on the 3D models [11]. Generally, most animators use a pre-generated and customized rig to animate their characters, such as the Biped tool in 3ds Max, Rig for Maya, or Cryptic Studio’s CrypticAR [12]. For more advance auto-rigs, Setup Machine, Face Robot and MetaNode rigging will be use [13]. Rigging process in 3D animation can be define as a process of setup bones system and attaching the character mesh bodies that later can use for animators to animate the character [14]. Moreover, the character that been rigged must be equipped with helper kit tool to deform static mesh into moveable character.

In order to make the rig perform nicely, the skeleton must be setup according to bone hierarchy [15]. Bone hierarchy

refers to the bone arrangement; where all the bone is connected to each other just like a tree branch. For example, thighbone is connected to the shinbone and shinbone connected to tip finger. Pelvis is a center point of the hierarchy or root where it is close to the center of gravity (COG) which is the central of weight in a human body. In character animation or rig character, the central of gravity is located at pelvis area, which make it the best place to become the center of bone chain [7]. The fundamental of rigging setup is show in Fig. 4.

**Parenting**

Parenting is referred to a relationship between parent bone and children bone. All rigs setup is based on a hierarchy system that have been arranged sequentially in order to create proper articulated objects. This hierarchy forms a relation between parent and child objects [3]. For example, if we create a bone chain; first, we must create a parent bone and attach to the child bone. For multiple bones controlled by single parent bone, we must attach two or more child bones together to create sibling bones (See Fig.4). According to Avgerakis [16], the first bone, by default, is assigned as a parent, whereas the second bone become the child of the first. If we look at the leg bone, foot become the child, shin become the parent, and shinbone become the child to thighbone. Once the bone structure is complete, then each bone of individual body part must be named for formal recognition in the subsequent steps. For example, the individual bones on left arm for the biped character are named as *Left Shoulder*, *Left Elbow* and *Left Forearm*.

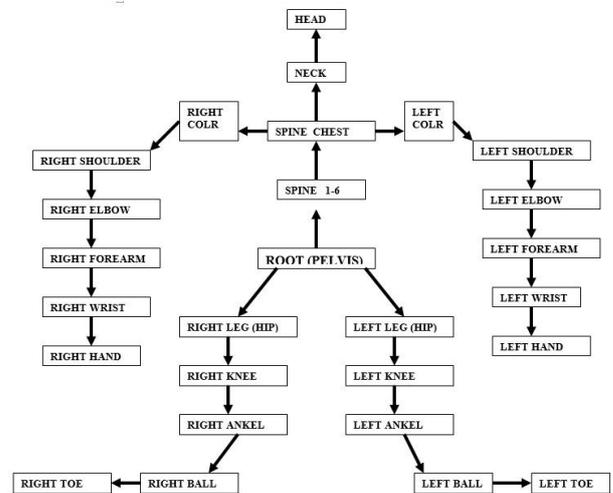


Fig. 4 Hierarchical Bone Structure for Biped Character

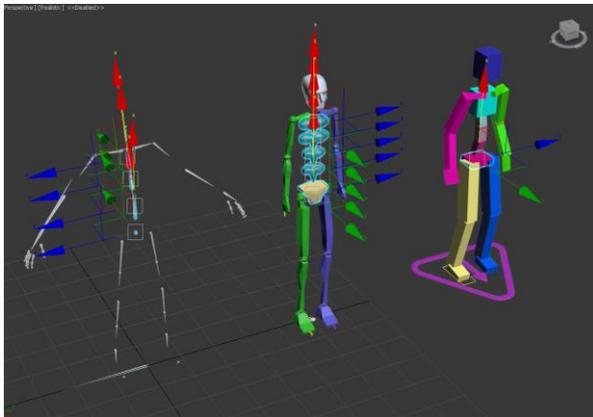
**Rigging Types**

In order to develop virtual bone, rigger artist has to know the right method to develop a rigging system. 3D programs such as 3ds Max, Maya and Blender, provides a selection of rigging systems that available for them to choose. For example, in 3ds Max; there are three types of rigging system such as chain rig, biped rig and Character Animation Toolkit (CAT) or auto rig.



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Chain bone rigging system is the basic rigging type that very often used by the rigger artist. Biped and CAT is a custom rigging that available in 3D software such as 3ds Max. Both systems allow rigger artist to make custom settings and modifications depending on the character shapes. Neale's [17] stated, "Biped has been an excellent tool and there are many productions still using it". Biped has a simplicity that makes it very easy to set up". Additionally, rigging have two types of classification, which is character rig and mechanical rig. Mechanical rigging refers to the process of assembling rig into inanimate object such as machines, robot, electronic part, vehicles, motors and others. Fig.5 illustrate the different types of rigs for 3D character. All rigs need to have a specific control system in order to create a smooth and mechanical movement in virtual world. Maestri's [18] added, when creating a rig for a 3D object, rigger artist should know how it should move and perform and the rigger artist should be able to identify how each part is connected and interact with each other.



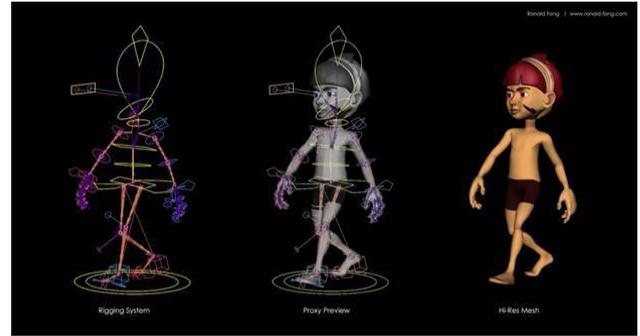
**Fig 5: Three types of rigging available in 3ds Max**

### Forward Kinematic (FK) and Inverse Kinematic (IK)

Forward Kinematics (FK) and Inverse Kinematics (IK) is another term used in rigging system. FK is a default method to manipulate the bone system in hierarchies. In this technique, animators usually need to animate parts of the bone individually. For example, if we want to move the hand, the shoulder have to rotate first, followed by the elbow and wrist. FK manipulates the characters from the top of the hierarchy downward [7]. On the other hand, IK's allows animator to manipulate children bone directly and the parent bone will follow accordingly. It is opposite from the FK system where the child bone can affect the parent bone whenever it moves. IK is the articulation of joints in the reverse order of their original hierarchy [3].

### Skinning

After building the skeleton, attaching the skeleton onto the character mesh is the last procedure in the rigging system. This procedure is called Skinning or Enveloping. Skinning can be described as the process on how the bone effects the deformation of the object. In skinning, the deformer enable the rigger artist to assign values to each vertex from the geometric object. The movement of joints will affect the 3D meshes that are connected to the skeleton hierarchy [3]. (See Fig. 6)



**Fig 6: Final Rigging Setup for 3D character.**

## III. METHODOLOGY

For the purpose of this study, our experiment will be based on the guideline proposed by Bhati, Z., Shah, A., Waqas, A., & Malik, H. A. M [19]. They suggested two basics standard criteria for rigging system in animation rig production. They list out the actual requirements and proper rigging system that has to be accomplished before it could be used for animation purposes. These are the fundamental rules that have to be identified in order to make the rig work:

### Rig Criteria

1. The rig should be consistent; meaning that when animating, the controls should not break the rig apart or follow transformation in an unorthodox manner.
2. The rig should have predictable behavior and all the controls should behave and operate exactly the way they are intended to work.
3. The control structure should be as simple as possible and not cluttered with multiple controllers and manipulators hanging about for the animator.
4. The rig should be easy to use with minimum number of controls and maximum functional management.
5. The rig has to be lightweight and fast in interaction.

### Animation Criteria

1. The rig must be built while considering that how the character should act and perform, as to bring out his personality.
2. It is essential to know what the director wants from the character and what is the story. What are the requirements and the motions needed when the character is performing, i.e. jump, fall backwards, martial arts fighting, swimming, flying, etc. All of these requires a special consideration while setup the rigging system.
3. It is also important to get feedback from the animator regarding his needs and requirements of the controls and functionalities of the rig. After all it will be the animator who will eventually use the rig

From the guideline above, the authors will explain details on the rigging workflow, which underlines the proper process that needs to be followed and how to produce a proper rig before it can be utilized by the animator. Hence, we propose this 3D rigging conceptual model diagram shows in Fig. 7 to analyze rigging process in this study.



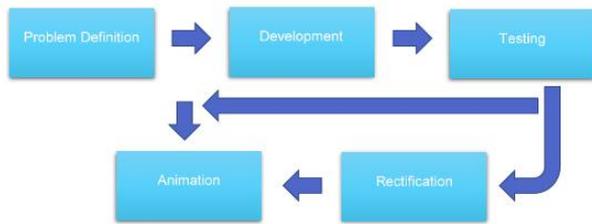


Fig. 7 3D rigging conceptual diagram

### A. Problem Definition

Problem definition stage is a starting point for the rigger artist to develop and identify the skeleton in object animation. This stage can be categorized as a preparative phase that can guide the creation process. The rigger artist has to identify the problem and analyze all the factors that needs to be considered before he even begins to develop the bone structure. Findings from this stage will help to determine the bone structure procedures for the character based on the given description, story constraints, and animation requirements.

### Character Description

The character description is the main source of information for the character. It usually presents a short biography of the character that commonly infers what is shown in the actual story [20]. Character description will guide and describe everything about the character information such as gender, height, physical, proportion, etc. In order to create a rig system for the particular character, rigger artist needs to analyze the design and 3D model details before deciding which rigging type and structure is suitable for that particular character. For instance, if the 3D model looks like a monster character, rigger artist has to create a special bone structure that is suitable for the character.

### Story Constraints

Story constraints is one of the important factors that has to be considered before the rigging setup begins. This factor will lead the rigger artist to understand on the flexibility of character performances in the story. In character design, an artist needs to analyze this story constraint to make sure the visual style of the character will perform according to the story structure. Lioi's [20] added, the story constraints are general information about aspects of the story and the overall project, which greatly influence the visual style adopted for the design. In rigging stage, this constraint plays an important role to determine the rigging style for the character. Some characters require a special move or action in the story.

### Animation Requirement

Another factor is animation requirement. In animation production; game animation, film animation and interactive apps animation dominates the industries. These types of animation require specific characters and rigging style. In film animation, the rigger artist needs to develop the skeleton that is able to replicate the real movement similar to real life such as human, animal, and other living creatures in real world. More importantly, the *Principles of Animation* play a vital role in achieving the sense of animation movement and the fluidity of the motion. For this reason, rigger artist needs to

setup some additional features on the rig and the model deformation in order to determine stretching limitation. Other method used in most production house is MOCAP (Motion Capture) system to imitate realistic motion. MOCAP is the device that use markers to capture movement and motion from the camera. Then the data will be recorded and transferred into the computer and ready to be assigned to any 3D characters. It is widely used in game development. Berezina's [21] stated that MOCAP is a sampling and recording motion of humans, animals and inanimate objects as 3D data for analysis, playback and remapping.

### B. Development

Once all the requirement has been identified, the rigging development stage will begin.

### Skeleton System

In this stage, rigger artist starts to build a skeleton system based on requirement of the previous stage. Chain bone rig are commonly used in production to develop basic bone structure. This bone system allows a rigger artist to develop bone manually by creating a series of joints in a bone hierarchy system. While, Biped and CAT rig can be categorized as pre-set rigging system that allow the rigger artist to make several modifications on the rigging structure. Both of these systems have an efficient layer system that enables the transferring data from the MOCAP. This is why game animation production preferred to use biped and CAT rigging system on their rigging character pipeline. As Bradley's [22] said, "Just like 3ds Max's older biped system, CAT can easily work with motion capture".

### FK and IK Systems

The next step in making 3D character is to setup FK and IK system (See FK and IK explanation in literature review section). This method is based on rotation system; if we rotate the parent bone, all of the children will be followed. If we rotate the shoulder, all of the bones such as upper arm, arm, and hand below will follow the rotation. In IK's method, this system is opposite from FK, IK provides us the ability to move at the end of the children bone or end effector.

### Facial Rigging

Facial rigging is the final animation setup for the expression and lip sync of the character. Just like body, facial also need some deformer system to deform the facial shapes. The morph target method of facial animation setup involves the use of blend shape [21]. There are two types of facial rigging, which is morph targets and normal skeleton or deformer-driven manipulation. Morph target system uses blend shape to turn the face into the particular face pose or expression. To create this system, at the modeling stage, modeler need to make some copies of facial and sculpt them into the different facial expression. The rigger artist has to create a GUI's slider as a controller for face expression. The second rigging technique is deformer-driven manipulation. This system uses same method with body rigging which is use bone to deform the shapes.

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By using this system, animators can animate manually and creates desirable expression but this technique is quite complicated compare than morph target. Cantor's [23] has mentioned in his book, the advantage of this method is that you can pose a character's face into an unlimited number of distinct shapes.

### Skinning and Envelope

After completing the rigging system, connecting all these bones into the specific area in the 3D model is essential. Skinning or enveloping is a process where the model skin deformer will be attached to the bone and enables a rigger artist to assign a value to each vertex of a geometry object so that the geometry object automatically connects to the skeleton hierarchy [3]. This requires the rigger artist to paint directly on the weight points of the mesh.

### Animation Controller GUI (Graphic User Interface)

Creating Animation Controller GUI (Graphic User Interface) is compulsory for the 3D character rigging. Before the character can be animated, rigger artist needs to create a visual icon on the specific joint in order to simplify the animation process. In this stage, rigger artist will connect the whole rigging system into the specific 3D controller icons. These icons work as a shortcut for the animator to control the animation process.

### C. Testing

The complete rigging must be checked and tested to iron out problems. There are many ways to test the character, but the common practice is to create walk cycle and pose test.

### Walk Cycle

Walk cycle involves the mechanics of motion. Walk cycle provide the best visual representation for overall movement of the character. It encapsulates all the elements in *Principles of Animation* and dealing with complex issues such as weight and timing. It is the best way to test the character rigging whether its functional or not and the best experiment for rigger artist to test the complete rig.

### Body Pose

The rig also can be tested using body pose and expression pose. In this method, character body and part is postured in specific manner. The limb is exaggerated until the maximum level to identify the reaching limit of the character's anatomy placement. In 3D animation, character pose is the essence for creating a visual representation of the character. Similar like body pose, facial rig system also can be tested by using blend shape or morph target. Therefore, this method is vital to avoid any errors in animation stage.

### D. Rectification and Animation

In 3D animation production, rigger artist and animator work very closely to ensure the character animation looks stunning. Sometimes, during the animation stage, animator may have issues with the character rig such as errors on the rigging system. In this case, animator have to refer back to the rigger artist to analyze and fix the problem. This process is called Rectification. Mesh issue is a common problem that often faced by the animator. One of the caused is the improper

topology setting. Topology is the process of building up the arrangement of surfaces on the 3D object. After problems have been rectified and fixed, the 3D rigging character is ready to be used for animation process.

### Analysis

A visual methodology approach is applied for this paper to allow the analysis to be carried out at the first stage of study. Visual methodology is used to understand and interpret images and include photography, film, video, painting, drawing, and cartoons. Visual methodologies are a new and novel approach to qualitative research derived from traditional ethnography methods used in anthropology and sociology [24]. The visual analysis will be conducted to interpret types of rigging system that has been used in the visual based on the guideline proposed by Bhati, Z., Shah, A., Waqas, A., & Malik, H. A. M, [19].

Next, we will proceed to the the experiments of three different types of rigging system available in 3ds Max software and tested to three different types of character designs. All the experiments we perform in this study will follow the procedures from our 3D rigging conceptual model diagram we proposed earlier.

## IV. RESULTS AND FINDINGS

From the previous section, we have proposed two stages of analysis for this study. Visual methodology is the first approach and followed by rigging experiment. For the first stage analysis, we will discuss the findings based on Fig.8 shown below. Several characters have been selected for the purpose of this study. Visual interpretation below represents rigging styles for animation characters.

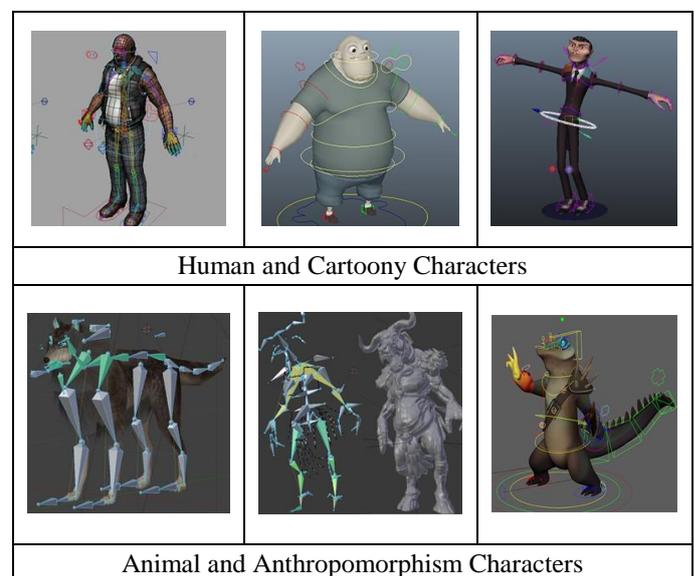


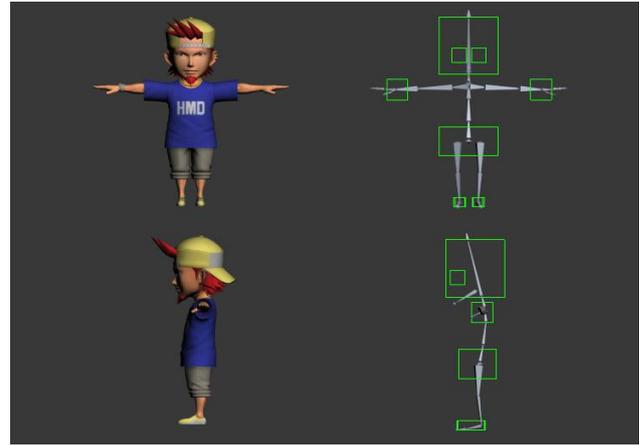
Fig 8: Types of Characters and Rigging Style

From our visual methodology and experiments, we will discuss our results in the sub-topics below.

**A. Types of Character Design and Rigging System**

**Human and Cartoony Character Rig Structure**

In animation world, human character can be divided into two categories, which is stylize and realistic. Stylize character mean, character that has been modified on their proportion, to make sure the appearance of the character looks more interesting. This is a common technique in animation character, where some of character limb will be exaggerate on their shape or size. Realism human character refer to the character that created according to the actual proportion and anatomy. This type of character usually used for real anatomy animation concept such as film, game, etc. Fig. 8 illustrate the basic setup for Human or Cartoony character. There are several ways to develop system rigging for human characters, such as using bone object, CAT, or biped. The suitability of rigging type depends on the purpose of the character and how the character will be presented. From observation, we found most of the common techniques for human rig object in 3D characters is using Biped, CAT or auto rigs. Auto rig is easy to setup and the process does not take much time. However, for cartoony human characters, the setup is a bit tricky and difficult because it is heavily depending on custom bone setup. The advantage of using chain bone is the ability to perform flexible movement of the character. This, in turn, create an illusion effect of exaggeration on the body and movement of the character. This technique gives freedom to rigger artists in which, they need to build bone hierarchy manually using bone object based on parent and child concept. However, the use of this technique takes longer time and very complicated to match the bone into the character geometry. From our experiment, we found biped or CAT rigging is the best setting for the realism characters and custom rig for cartoony characters. Fig.9 and Fig. 10 illustrate the human cartoony character that we had experiment and types of rig we proposed based on the designs. We conclude that human character rigs can be separate into several types based on physical features such as fat character, masculine character, skinny character and typical character. For fat character, it is important to assign special features at the abdomen area to visualize the secondary movement of the belly. For the masculine character, the process is quite complicated because we need to attach muscle simulation into bone, especially for the realistic animation. From the guideline discussed by Bhati, Z., Shah, A., Waqas, A., & Malik, H. A. M, [19] earlier, we found out, human movement can be predicted and the rig should be assigned based on the predicted behavior of the character and the control structure should be simple with minimum controllers. Most importantly is to consider how the character perform and act in the story to bring out the character personality. The rig should be setup according to the animator’s requirements and should not break apart while the animator is animating the character.



**Fig. 9 Human Rig Structure**



**Fig. 10 (Proposed Rig) Aladdin Characters (1992)**

**Animal Rig Structure**

Beside human character, animal is also a common character used in animation. There are many animation films using animal as character, such as Madagascar (2005- 2014), Ice Age (2002-2016), Rio (2011-2014). Like human character, the construction of the rigging system for the animal have several techniques. The most important criteria in rigging animal character is to understand the proportion and muscles movement of the character. From our visual interpretation in Fig. 8, we found the easiest method to apply into animal character is to use biped, CAT or Character Animation Toolkit or preset rigging system that available in 3D animation software such as 3Ds Max and Blender. CAT is easy and less time consuming to develop their system, where rigger artist needs to match CAT skeleton to the character mesh. Besides that, this system also allowed rigger artist make some modification on character limb. Fig. 11 present a simple setup for animal characters using chain bone in our experiment. From the guideline, we think; animal character is not easy to rig because of the unpredictable behavior of the muscles and asymmetrical shapes of the animal character. It is opposite from the human character that the performance and how the character move can be planned by the animator. Hence, we suggest the easiest setup for the animal is using biped or CAT’s. Fig.12 presents the proposed chain bone setup on animal characters.



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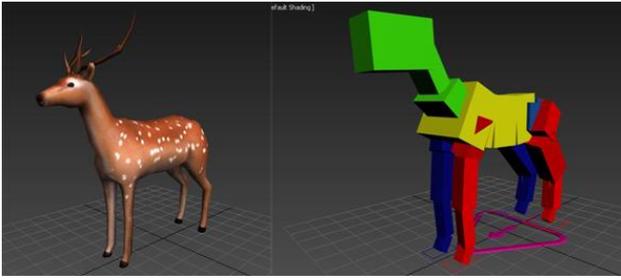


Fig. 11 Animal Rig Structure



Fig. 12 (Proposed Rig) Ice Age Characters (2002)

### Anthropomorphism Character and Rig Structure

Anthropomorphism mean, giving human characteristic to non-living object or non-human such as animal, plants, etc. The use of human characteristic to non-human characters also deal with the character personality, emotion, physical and environment. According to Horowitz's [25], anthropomorphism is the assignment of human characteristics to objects, events, or nonhuman animals and widely used in animation, either in 2D or in 3D. Anthropomorphism characters requires a detail study on the design proposition, bone length, joints rotation and bone limitation to imitate movement in real life. We think the design and anatomy of the character should be analyzed before determining the appropriate rig for the anthropomorphism character. Fig 13 illustrate several types of anthropomorphism characters.

Rigging system for anthropomorphism character is a bit different from the human rigs system. Anthropomorphism character requires several modifications on their physical appearances in which adding or subtracting the limb that physically taken from specific animal or any objects. However, the basic anatomy is still according to human proposition. Fig. 14, basically demonstrate the experiment for anthropomorphism character rigging structure based on human character, which is the bone structure that has been assigned according to the posture and limbs of the mouse character. Here, we need to add more bone structure to the tail and abdomen. Furthermore, for the facial rig; the bone must be added for the jaws and ears. For this type of character, we suggested to use biped rigging system. This type of rigging is easier to setup and rigger artist only needs to assign the set of rigging provided and skin it to the character mesh and make some adjustments to the limb. However, for complex

anthropomorphism characters such as four-legged animal and two-legged animal with many form structures, the study of movement, exaggeration and bone limitation must be analyze before deciding the proper technique for rigging. Hence, the chain rig system is the best option for this type of anthropomorphism character. This process similar like human cartoony characters mentioned in a previous section. Fig. 15 displays a proposed rig setup for complex anthropomorphism character.



Fig.13 Anthropomorphism Characters Zootopia (2016)



Fig.14 Anthropomorphism Rig Structure



Fig.15 (Proposed Rig) Zootopia Characters (2016)

## V. DISCUSSION AND CONCLUSION

Rigging in animation is the process assembling the skeleton system into the character. The use of proper rigging style will determine how the character move and pose in final animation. Rigging techniques in 3D used the same concept similar like a stop motion animation, where the character need to be rig with metal wire or called armature and the character body were covered in clay or other materials. In digital technique, rigger artist creates the rig in similar manners in order to bring the character to life. In 3D animation, rigging plays an important role as a tool to deform the digital static character mesh.

From our observation and experiments that we had conducted in this study, we found using CAT rigging or auto rigging system is easiest way to setup compared to the manually rigging or chain bone rigging as discussed in literature review section. In term of character body type and design, we discovered that the process and rigging setup for any shapes and forms are quite similar. The only difference is to identify the specific joints from the 3D model to create actual proportion and anatomy. For the rigging system process, we expressed the opinion that the artist should look on the aspect of character design and character movement to determine the rigging style. These includes; types of the character, character shapes and how character will present in actual animation. There are several ways to develop rigging system, which is bone object rigging, CAT rigging, and biped rigging. Bone object is manually rig and has a lot of freedom in order to develop a hierarchy system. Meanwhile, CAT and biped is a preset rig setup that already available in 3D software. The use of CAT and biped rigging is easier and less time-consuming compared to bone object. Rigger artist only needs to adjust the bone structure that available in the rigging system and assign it to the 3D model structure based on type and shape of the character.

The other aspect that needs to be considered is the understanding of construction of the character anatomy to ensure that the character rigging system for cartoony and anthropomorphism characters should not be confused with actual character rigging system for realism human or animal anatomy. Rigger artist needs to do essential research before setting up the rigs. This includes character description, animation requirements and the overall looks of the character. This understanding can facilitate the task of making the rigging system works.

As a result, the following characteristics can be used to help the process of character rigging in any character type and design suggested by Bhati, Z., Shah, A., Waqas, A., & Malik, H. A. M [19] for procedural rigging system:

1. The rig can be created in any standard pose.
2. The right side of the widgets is automatically mirrored reflecting the position of the Left side of the character.
3. The entire body rig is independent and isolated from other parts.
4. All the body parts are rigged automatically according to the animator requirements.
5. Seamless matching from FK & IK switching is performed using the technique discussed in (Bathi, 2013)

6. As the rig has been designed in a structured manner thus it provides the functionality of mirroring the characters poses and also saving the poses and transferring the poses from one character to another as the underlying architecture is the same.
7. The Leg and Arm rigs have the ability to stretch along with the ability to lock the Knee or Elbow movement.
8. Extremely fast and clean rigs, with minimum no of nodes and expression for real feedback in viewport.

We hope this study will benefit people from creative industries who deals with 3D animation characters especially for new rigger artists who need to get some proper guideline in preparing themselves in completing their tasks. From our findings, we believe that the rigger artists need to equipped themselves not only on the software skill but also creative skill in order to make the character functional for the animator to animate the character in digital 3D space. Thus, the proper rigging system is the crucial steps to make the character appearances unique and attractive to the audiences. Finally, we would like to suggest further study on rigging techniques for mechanical and non-living characters. It would be beneficial for future study.

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