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Classification of Behavioral Lexicon and Definition of Upper, Lower Body Structures in Animation Character

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Abstract

This study focuses on the behavioural lexical classification for extracting animation character actions and the analysis of the character's upper and lower body movements. The behaviour and state of characters in the animation industry are crucial, and digital technology is enhancing the industry's value. However, research on animation motion application technology and behavioural lexical classification is still lacking. Therefore, this study aims to classify the predicates enabling animation motion, differentiate the upper and lower body movements of characters, and apply the behavioural lexicon's motion data. The necessity of this research lies in the potential contributions of advanced character motion technology to various industrial fields, and the use of the behavioural lexicon to elucidate and repurpose character motion. The research method applies a grammatical, behavioural, and semantic predicate classification and behavioural motion analysis based on the character's upper and lower body movements.

Keywords: *Behavioural Lexical Classification, Upper & Lower Body Classification, Animation, Motion Capture.*

1. Introduction

This study focuses on extracting behavioral lexicon needed in character animation and defining the upper and lower body structure of characters, as well as applying cross-functional movements. The diffusion of digital technology is enhancing the future value of the character animation industry, and offering various universal possibilities that transcend realistic representation. Behavioural lexicon is derived from predicates that are possible in Korean language actions based on natural language, including speaking, listening, writing, and reading [1]. Predicates in a sentence serve to describe what the subject is doing or their state, as they are verbs or adjectives that indicate the actions or state of the subject. In the pre-production stage of animation, such as during scenario creation, predicates play a crucial role in defining the character's actions and states. They are also used as benchmarks for directing character behaviours and emotions over time when constructing storyboards and scenes that visually represent the story.

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This role is driven by the widespread positive perception of using digital characters to enhance user engagement in various fields. For example, in the gaming industry, character motion application technology demands more sophisticated character movements than traditional game formats to facilitate immersive user experiences within the game world. In films or animations, character visualization techniques can now express characters more naturally and vividly than before. This advancement allows the provision of various tools and features such as real-time visualization-enabled game engines and virtual studios. The application of character animation technology is also expanding in education, marketing, sports, safety, and simulation industries. This expansion originates from digital animation movements that mimic the actual movements of humans or animals, satisfying the audience's vicarious pleasure through transcendent imagination. Characters can make learning more engaging in education, enhance product awareness in marketing, assist with motion analysis in sports, and be utilized for accident prevention training in simulations. The use of character animation technology in these diverse areas is contributing to the comprehensive growth of the industry. Consequently, the character animation industry is anticipated to play an increasingly vital role in conjunction with the advancement of digital technology. Nevertheless, in comparison to the progress made in character animation's visualization technology, the research related to the classification of the behavioral lexicon for describing animation movements, as well as the definition of characters' upper and lower body structures for data retargeting, is still lagging behind.

The inferences from these research questions are as follows. Firstly, a classification and method of language capable of describing character movements are needed. This enables the portrayal of specific character actions in the scenario and storyboard development process. Secondly, an understanding of human movement must be established, and based on this, the upper and lower body structure of animation characters must be defined and classified. As a result, motion capture technology can be employed to efficiently use and recycle character motion data for the upper and lower body. Thirdly, character upper and lower body motion data can offer the same effects as pre-visualization, and through this, similar actions can be understood and applied. Furthermore, it emphasizes the importance of foundational research in integrating storyboarding and pre-visualization in the pre-production stage.

The necessity of this research arises from efforts to solve these problems and holds the following academic significance. Firstly, the linguistic expression of character movement enhances the effective use and reuse of motion capture data. Secondly, the advancement of character motion technology acts as a key element in enhancing the competitiveness of the animation industry, and this research provides the basis for it. Lastly, character animation creation is a creative field that finds complex problems and solutions at the intersection of art and engineering. Utilizing behavioral vocabulary allows for the explanation, modification, and reuse of character movement, and comprehensively covers various aspects of animation production.

Therefore, the goal of the research is to explore the method of describing character behavior suitable for animation scenarios, to classify and define the segments of a character's upper and lower body, and through this process, to propose the feasibility of data reuse. The scope of the research includes the extraction method of action-related vocabulary for animation application, and for this, a method of classifying verbs and vocabulary based on the fundamental components of Korean sentences will be proposed. Furthermore, the classification, definition, and application for motion testing of a character's upper and lower body structure are limited to the scope of this research.

The research method consists of three parts. Firstly, it proposes a behavioristic lexical classification method for character action description, relying on grammatical, behavioral, and semantic frameworks. The grammatical classification analyzes the possibility of depicting character action in Korean, focusing on the grammatical function of the predicate. The predicate, primarily consisting of verbs and adjectives, serves as the central word in a sentence, symbolizing actions, states, and relationships. The predicate vocabulary is distinguished based on given actions, states, and relationships. Behavioristic classification involves the analysis of character actions invoked by the predicate, utilizing key components of Korean sentences to evaluate the potential of actions. The complex argument structure of Korean sentences, pertaining to user criteria for invoking character actions, is not explored in this study. Semantic classification scrutinizes the purpose and result of character actions, expressing information through associated vocabulary. This method aims to clarify the meaning and intention between vocabulary and actions and may encompass experiments to observe character actions. Secondly, the research examines the upper and lower body structure of the character to define it, and then performs character setup work to integrate it with motion data. The 3D authoring tool utilized is Maya, and character rigging is executed using the HIK (Human IK (Inverse Kinematics)) method. Thirdly, tests are conducted for the cross-application and utilization of character actions using the defined upper and lower body structure of the character, in order to apply extracted character motion capture data. The motion capture equipment utilized is OptiTrack's Prime 41 system, with 24 optical cameras used to extract the actions. Additionally, the tests for applying and utilizing the actions are carried out using the animation functions of the 3D authoring tool Maya.

This study carries significant ripple effects through foundational research required for invoking motion-capture actions using character behavioral directives and the reuse of separately animated upper and lower body movements. By employing this method, animation content developers can glean ideas for similar actions or predict narrative motions based on the types of data that have been databased. The research process will be carried out in five stages as per the research methodology outlined in Table 1.

Table 1. Research procedure

Step 1	Step 2	Step 3	Step 4	Step 5
Preceding Studies	Theoretical Review	Vocabulary Classification (grammatical, behavioral, semantic)	Upper, lower body classification and application	Result
Literature Review				

2. Related studies

2.1 Character Animation

In the past, CG production technology was primarily employed in Science Fiction (SF) and Fantasy genres to visualize fictitious elements such as future science technologies, supernatural elements, and magic. These technologies gave viewers a unique experience and a visual realization of their imaginations. Recently, not only has content been produced relying on various digital implementation techniques, but the need for visual differentiation in film has also escalated, often demanding portrayals that are even more realistic than reality itself. Notable Korean examples include "Mr. Go"(2013), "ROARING CURRENTS" (2014), "Northern Limit Line" (2015), "Carter" (2022), and "Along with the Gods: The Two Worlds" (2017). For international films, examples include "Toy Story" (1995), "Star Wars 9" (2019), "Dawn of the Planet of the Apes" (2014), "Avengers: Endgame" (2019), "Black Panther: Wakanda Forever" (2022), "Transformers: Rise of the Beasts" (2023), "Jurassic World: Dominion" (2022), and "Avatar: The Way of Water" (2022).

In the research trends on implementing animation, motion technology is positioned as a key concept of 'generation and application', serving as a fundamental tool for data creation across various industries like animation, film, and gaming. This technology can be categorized according to two objectives: observation-based motion capture and statistical learning-based motion capture.

J. W. Song, J. Y. Noh(2014) proposed an efficient method of performing retargeting while preserving the original motion using nonlinear optimization techniques [2]. S. S. Lee, K. H. Um, K. E. Cho (2008) conducted research on middleware related to the design of autonomous behaviors in artificial intelligence characters. This research encompassed aspects such as information acquisition, decision-making, and action execution [3]. X. B. Peng, P. Abbeel, S. Levine, and M. V. de Panne(2018) made significant strides by merging the adaptability of physics-based animation with common motion characteristics. They utilized this approach to train characters to intelligently respond in interactive environments, such as walking in a desired direction or throwing a ball at a user-specified target, by coordinating the character's movements with their respective task objectives [4]. H. S. Chung, S. J. Lee(2007) introduced a method for searching for similar movements using fuzzy string searching. They achieved this by defining a standard XML-based format, known as the Motion Capture Markup Language(MCML), to integrate data from various motion capture sources [5]. S. W. Park, J. H. Lee(2021) underscored the significant importance of developing stable neural network models in comparative experiments. These experiments aim to create varying hit reaction patterns by using physics simulations based on the given hit reaction motion data [6].

The process of classifying character structure and the components of the upper and lower body parts originated from content like Massive Multiplayer Online Role-Playing Games (MMORPGs), where in-game characters perform tasks. Game platforms have a distinctive trait of producing real-time visuals in a hardware rendering format, leveraging game engines as authoring tools that are optimized for game development, as illustrated in Figure 1.

Figure 1. Game character selection screen [7]

Recently, the animation industry has seen a diverse range of efforts to create videos using the features of game engines. This trend is driven by the high-quality images and real-time outputs enabled by the advancements in video output hardware. The aim of this study is to structure the upper and lower bodies and detailed parts of characters, which allows each separate body part to utilize independent data. E. J. Kim, S. J. Park(2011) analyzed the GUI design associated with character customization in the top 16 commercially available games ranked within the top 50. They found that users could customize, on average, six parts such as the basic appearance, face, body type, clothing, armor, and other aspects [8]. The research by B. C. Kim, C. H. Roh(2016) is also notable, which involves pre-processing in 3D authoring tools to assemble the necessary modeling data for character part configuration in game engines according to their respective characteristics [9].

According to the '2022 Animation Industry White Paper' from Korea Creative Content Agency, the advancement of animation technology is necessitated by current trends. Factors such as the rapid content consumption environment, the virtuous cycle structure of reproduction through profits, the contraction of capital, and a decrease in works, all converge into a vicious cycle, like production cost-cutting and worsening labor conditions [10]. Hence, fundamental research related to character motion control could provide insights to address these complex issues.

2.2 Linguistics and Lexical Classification

The main areas of research in linguistics can be divided into phonology, which deals with sound systems and rules [11]; morphology, which analyzes form structures [12]; and syntax, which studies sentence structures. Semantics, which analyzes the meaning of sentences, and pragmatics, which studies the principles and actual usage scenarios of language, serve as fundamental elements in analyzing and planning the movements of characters in animation [13]. From this perspective, semantics researches the meaning of vocabulary, its recursiveness, and overall meaning, based on the structure, form, and cognitive semantics of language. In contrast, pragmatics focuses on how universal cognition is realized through language [14]. In the context of natural language search methods or processing within internet search engines, semantics and pragmatics can provide alternatives for expansive research in response to the demands of the era.

2.3 Behavioral Lexicon and Animation Actions

The planning and directing of animation actions are associated with the following aspects. From the perspective of the relationship between behavior and vocabulary, animation actions have a close correlation with linguistic expressions. Behavioral lexicon can be utilized to describe and modify the actions of animation characters. Lexical elements can aid in accurately conveying and expressing the characteristics of animation actions. From the viewpoint of motion analysis and behavior recognition, this process involves the analysis and recognition of animation actions, signifying the detailed investigation and interpretation of an animation character's actions. Through this, the understanding of animation actions can be enhanced, and furthermore, behavior recognition is a technology that automatically recognizes and classifies animation actions. Such technology can assist in automating and improving the actions of animation characters. From the aspect of applying behavioral lexicon, this can be used for understanding and modifying animation actions. By using the behavioral lexicon to describe and attribute characteristics to animation character actions, the planning and direction of animation actions can be concretized and advanced. Considering these aspects when establishing and executing the planning and direction of animation actions will assist in effectively implementing animation character actions.

3. Theoretical Background

3.1 Korean Linguistic Behavior

Language is a form of communication grounded in a symbolic system of form and meaning [15]. To infer a behavioral lexicon based on natural language, one must understand the basic sentence structure of Korean. Discussions about the structure of Korean sentences can be found in many studies conducted by Korean grammar scholars. Notably, H. S. Kim(1998) differentiated three basic sentence types [16], B. H. Ham(2020) examined the types and characteristics of Korean sentence forms [17], and S. M. Yeom(1977) emphasized the usefulness of sentence components and the significance of sentence form practice, rather than the importance of basic Korean sentence forms, from an educational perspective [18]. However, this study is not a discussion on basic Korean sentence forms or proper grammar usage; instead, it focuses on understanding sentence structure to establish the relationship between the subject and predicate for the purpose of generating and directing the actions of characters. Therefore, the basic sentence forms provided by the National Institute of Korean Language are adopted [19]. Furthermore, the components of a Korean sentence consist of seven features: subject, predicate, complement, object, adverb, modifier, and interjection [20]. The primary applications are demonstrated in the following examples.

- Subject + Predicate : Haein (Subject) sings (Predicate).
- Subject + (Essential) Adverb + Predicate : Haein (Subject) goes onto (Predicate) the stage (Adverb).

• Subject + Object + Predicate : Haein (Subject) sings (Predicate) a song (Object).
• Subject + Complement + Predicate : Haein became an idol.
• Subject + Object + (Essential) Adverb + Predicate : Haein considers Super Junior as family.

In this study, the primary components that form a sentence, such as the subject, predicate, object, and complement, are of high research importance for generating and directing the actions of characters [21]. Detailed information can be examined through the explanation in Table 2 presented below.

Table 2. Main Components of Korean Sentences

Order	Components	Definition
1	Subject	A component of a sentence that becomes the subject, indicating action, state, or property (Who, What)
2	Predicate	Explains the action, operation, state, or property of the subject (How to do, how it is, what it is)
3	Object	The object of the action indicated by the predicate (What, Whom)
4	Complement	A component required by the predicate other than the subject (Used when the meaning is not complete with only the subject and predicate)

The use of major components of Korean sentence forms serves as the main sentence framework for directing a character's actions, enabling the formation of directive words for animation.

• Subject + Predicate : Haein (Subject) sings (Action description).
• Subject + Object + Predicate : Haein (Subject) sings (Action description) a song (Object).
• Subject + Complement + Predicate : Haein has become an idol (Action description).

As auxiliary components of a Korean sentence, 'modifiers' and 'adverbs' serve to elaborate on the contents of the main components. In the case of modifiers, they embellish nouns, while adverbs embellish verbs. Ambiguous modifiers and actual generation and directing of a character's actions require separate functional roles for animation [22]. In particular, the formation of a secondary environment to embellish the contents of the main components or audio-visual effects such as special effects are necessary. Examples of using 'modifiers' and 'adverbs' are as follows.

1) Subject + Modifier + Predicate
   • Autumn is the 'reading' season.
   • I met my 'old' friend.
2) Subject + (Essential) Adverb + Predicate
   • He is 'in the classroom'.
   • Time flows 'very quickly'.

In the case of independent components, they can be used in independent dialogues without forming relationships with any components of a sentence, such as calls, exclamations, and responses [23]. This presents a challenge in generating and directing a character's actions, with usage examples as follows.

1) Independent word + Subject + Predicate
   • Oh my, Haein (Subject) is singing (Predicate).
   • My goodness, what is happening?

3.2 Predicates and Behavioral Lexicon

In Korean sentence structures, the predicate freely describes the actions of characters. To call the character animation actions written in text, the state description of the subject is required. The character description state according to the rules in Table 3 lays the groundwork for calling preprocessed animation motion data from motion capture through 'natural language processing' techniques and is a secondary research target for developing a search UI for ease of use. In animation, behavioral lexicon refers to a set of words and expressions that describe a character's actions and interactions. Additionally, it plays a crucial role in illustrating and conveying a character's intentions, emotions, and causal relationships.

Table 3. Character Description State

Subject	Object	Adverb	Complement	Modifier	Predicate
Haein					sings
Haein		on stage			gets
Haein	song				sings
Haein			as an idol		becomes
Haein	super junior	as family			considers

The extraction of the human behavioral lexicon was carried out by categorizing 10 types of verbs, as presented in Table 4, resulting in the collection of 14,788 verbs. The subsequent study will involve the selection of verbs suitable for implementing animation actions based on the research methodology. The validation of the data will be determined by comparing the animation types derived from the performances of actual actors with the observations of viewers.

Table 4. Verb List [24]

Order	Title	Subcategories	Quantity
1	Single-word verbs		358
2	Standard derived verbs		3,756
3	Compound verbs		3,907
4	Intransitive verbs		6
5	Transitive verbs		23
6	Modal verbs		15
7	Irregular conjugation verbs		180
8	Verb conjugation forms	Verb conjugation forms	131
9	Cultural language verbs	Cultural language verbs	1,954
10	Standard language verbs	Single-word verbs	102
		Derived verbs	3,756
		Compound verbs	422
		Modal verbs	13
		Unlisted verbs	84
		Non-standard verbs	81
Sum			14,788

3.3 Categorization of Behavioral Lexicon

The linguistic forms of expressions carry meaning for communication. The usage of predicates follows grammatical classification methods and forms a close relationship that constitutes the foundation of behavioral lexicon. Additionally, the equivalence between language and actions enables not only linguistic communication but also facilitates the perception of visual empathy through character actions, allowing for a more intuitive conveyance of meaning. In movies and animations, the portrayal of characters' performances serves as an important device for eliciting distinctive emotions and conveying sentiments. Therefore, the essence of the ‘behavioral lexicon’ pursued in this study lies in the ability to indicate actions through verbs or express states through predicates. The term ‘behavioral’ can be defined in terms of philosophical behaviorism [25], referring to the singular response and pattern of character actions in accordance with predicates.

3.4 Behavioral Lexicon and Mediation of Actions

The creation of animation character movements is informed by clues drawn from human sensory memory. While an empirical (a posteriori) approach uses judgments made on acquired knowledge, it tends to be highly subjective rather than universally applicable. On the other hand, a priori knowledge, based on perception or sensory prediction, resides in the innate emotional forms and synthetic cognition that precede all experiences. This approach encompasses infinite expressive possibilities. In other words, elements of empathy that allow audiences to perceive the core essence of a story are manifested through character movements, acting as subjective conduits of sympathy and empathy.

Prior to taking actions or during thought processes, human imagination transcends binary concepts of good and bad. The thought processes of characters, who serve as primary subjects, entail various complexities and require connections between motives and actions. Such portrayals of causal relationships can be deciphered through the comprehensive production processes, which include scenario composition, animation direction, and the deliberate creation of character performance. These processes facilitate the identification of structural issues for enhancing character animation implementation.

Recent studies have attempted to identify numerical values within the limited range of character movements quantitatively by integrating 3D authoring tools (Maya, Blender, 3ds Max), artificial intelligence (AI), game engines, and motion capture. These efforts commonly aim to automate character movements based on anatomical characteristics or employ simulations using the limited movements of each joint. Research within this context also encompasses the transformation of motion data, extracted from motion capture, through the deep learning process of AI, as well as identifying similar movements via pre-loaded motion patterns. Middleware research and development efforts aim to ease the use of various authoring tools and ensure data compatibility in the production process, attracting significant attention from creators. These initiatives are rooted in the need for a structural understanding of managing character movements, classifying behavioral lexicon, and building databases that align with the efficiency of production timelines and problem-solving endeavors. The ultimate goal is to address issues such as categorizing animation movements performed by characters, re-establishing technical validity, finding ways to repurpose animation data by leveraging the efficiency of digital processing technologies, and simulating movements that closely mimic human emotions.

Therefore, this paper proposes a framework that establishes a parallelism between text describing human behavior and the representation of animated movement. This goal is achieved by categorizing the movements of an animated character’s upper and lower body based on human kinetics and generating text artificially from this process. Consequently, it replicates the character's movement data that was originally extracted from motion capture.

4. Categorization of Behavioral Lexicon

4.1 Grammatical Classification

The classification of behavioral lexicon is conducted based on the grammatical function of predicates. This is necessary in scenario planning for character movements, as it requires grammatical expressions that can indicate actions and states. Animation storytelling involves the macro-level distinction of the beginning, middle, and end, with each scene forming a stage that incorporates movements representing perspectives and camera motions. Therefore, it is crucial to have expressions that enable objective perception in the portrayal of movements. Independent words such as interjections, exclamations, and responses, which do not have a direct relationship with any sentence component, as well as onomatopoeic and mimetic words, are excluded from this study as they do not characterize character movements.

Table 5 provides samples that evaluate the feasibility of actions and the similarity of movements as described by predicates, along with visually perceptible movements. 'Feasibility' and 'Similarity' are pivotal factors in characterizing animation movements. While an action might be physically achievable, it may also be subject to an ambiguous duality from the audience's perception.

'Feasibility' assesses whether an action performed by an animated character is realistic and achievable within human physical and biological limitations. This assessment is crucial in animations that aim to replicate natural movements. 'Similarity' gauges how accurately an animated action mirrors real human motion. For instance, when a character is depicted as running, the analysis focuses on the degree to which that action imitates the motion pattern and mechanics of an actual human running. This element significantly contributes to enhancing realism and evoking empathy in an animation.

Table 5. Grammatical Classification Examples

Category	Predicate	Action		Description
		Feasibility	Similarity	
Jumps	Jumps up	○	×	jumps up from B to A
	Jumps down	○	×	jumps down from A to B
	Jumps off	○	×	jumps off from A
Eats	Enjoy eating	○	×	Eating with Enjoyment
	Tasteless eating	○	×	Eating without Taste
	Eat quickly	○	○	the act of eating food rapidly
Runs	runs slowly	○	×	runs slowly
	runs fast	○	×	runs fast towards the finish line
	runs with difficulty	○	○	runs with difficulty over a long distance

Consequently, these two elements are instrumental in augmenting the liveliness of character movements during the process of designing and implementing them within animations. Such endeavors are evident in attempts to bring abstract expressions, intrinsic to animation, into tangible reality, as exemplified by Walt Disney's 12 principles of animation. Given the inherent challenges in simulating realism and evoking a sense of authenticity in animation, these principles strive to instill life and realism into animation and fortify the emotional bond between the audience and the characters [26]. Furthermore, these principles ensure that character movements, while adhering to the laws of physics, are simultaneously exaggerated or stylized, enhancing the audience's perception of these movements as more realistic.

4.2 Behavioral Classification

The process of determining how to describe the movements of an animation character begins by distinguishing key elements such as the subject, object, complement, and predicate to instruct the character's behavior. This process involves structuring information necessary for the implementation of animation actions according to the directives of the predicate, with adjectives, adverbs, and other modifiers used to enhance the content of the main components.

Table 6 shows that a detailed description of the movement and consideration of the context in which the movement occurred allows for a more refined representation of the animation character's actions. This suggests that storytelling and interactions between characters will become more abundant. Observing and analyzing the movements of animation characters is the core of this method. Animation creators observe the character's movements in detail, capturing the speed, direction, and intensity of the movement, and utilize it as a way to describe the action. The process continues with the selection and classification of vocabulary used to describe the movements. In this step, the possibility of action implementation through the selected vocabulary is confirmed. Finally, there is a verification step for the action vocabulary classification system. In this step, the consistency and accuracy of describing the character's movements using the same vocabulary classification system by other animation creators are evaluated.

Table 6. Examples of Behavioral Classification

Subject	Object	Adverb	Complement	Modifier	Predicate
Haein					sings
Haein		stage			gets on
Haein	song				sings
Haein			as an idol		becomes
Haein	super junior	as family			considers

4.3 Semantic Classification

To understand the semiotic purpose of animation actions, it is necessary to analyze the concepts of 'Feasibility' and 'Signification' as illustrated in Table 7. In this paper, Feasibility refers to the notion of assessing whether an animation action can be realistically implemented. It signifies whether the actions of the animation characters coincide with the physical limits of humans and can be realized. For example, if a character performs a specific action, the legitimacy of the action is assessed by whether it falls within the range that a human could actually perform and conforms to physical constraints.

Table 7. Examples of Behavioral Classification

Division	Predicate	Motion		Motion Description(Visual)
		Feasibility	Signification	
Stumble	Stumbled	○	○	To trip or lose one's balance while walking or running, usually resulting in an awkward movement or almost falling.
Lurch	Lurch	○	○	The sudden gust of wind made him lurch forward.

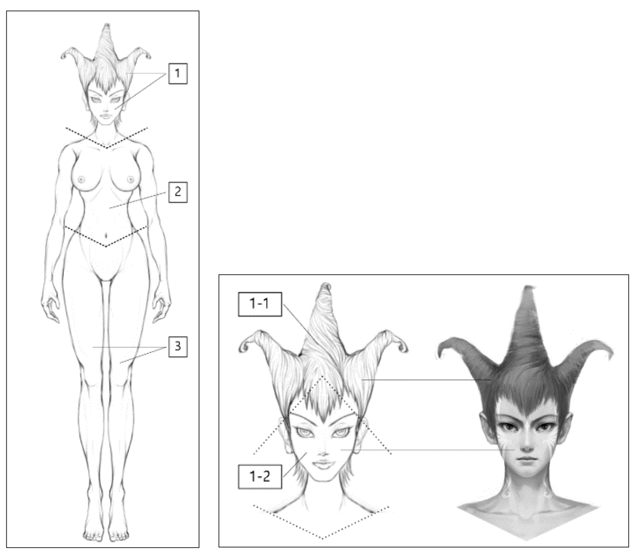
Therefore, it is possible to ensure that the character's actions align with the meaning of the behavior directed by the scenario, or to prevent the character's actions from conveying a completely different ambiguous meaning, even if they are similar to the directives of the scenario.

Signification is the concept of understanding what an animation action intends to convey, and it is used to express specific meanings, emotions, situations, etc. The actions of characters serve a role in visually conveying the development of the story, character's personality, emotions, etc., and at this time, it signifies whether the action can deliver the intended message or emotion to the audience. Laban's concept of 'Effort' is defined as an internal driving force for the expression of living movement, characterized by elements such as flow, space, weight, and time [27]. These elements provide important discussion points in the implementation and recognition of animation actions, fundamentally supporting feasibility and meaning.

Feasibility and Signification play a crucial role in the analysis and design of character actions, considering aspects of audience perception, the realism of actions, and the conveyance of meaning in their evaluations.

4.4 Classification and Application of Upper, Lower Body in Character Structure

Character movements begin with the meaning of actions directed by the verb, considering purpose, validity, and similarity. For example, verbs with related meanings such as action, state, experience, and cognition can be grouped into upper and lower concepts of movement, allowing the formation of associations between related actions. In movies or animations, it can be observed that the movement of the character's upper body overwhelmingly exceeds that of the lower body. This is because the upper body movements, including facial expressions, have a significant impact on the narrative and acting in animation. Lower body movements are primarily dependent on basic poses like 'standing,' 'sitting,' 'lying down,' 'leaning,' and other movements can be understood as gestures derived from basic poses. Such coherence is essential in animation production when dividing shots into close-ups, medium shots, and full shots from the perspective of framing height or practicality in storyboards. It raises questions about the use of separated upper and lower body movements and the reusability of actions.



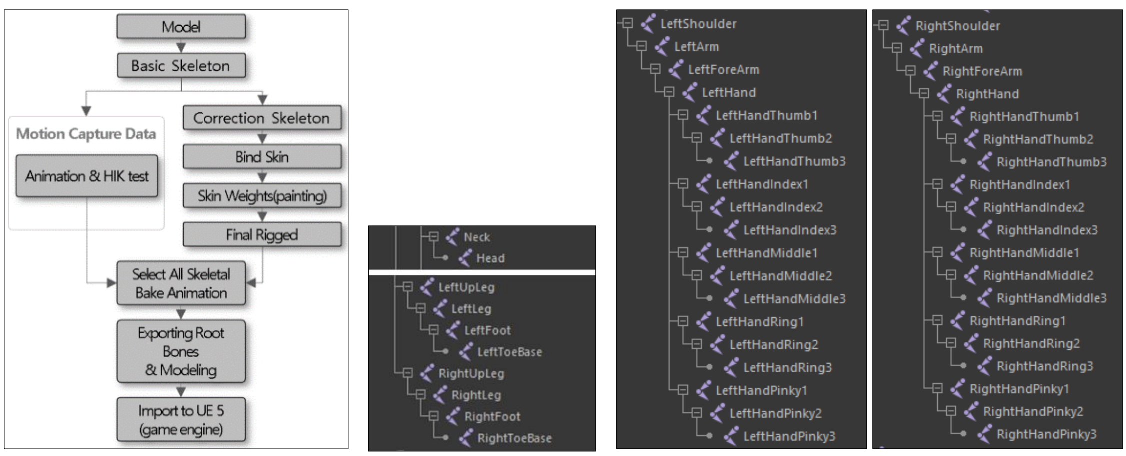
(a) (b)

Figure 2. Upper, Lower Body Structure Definition

(a) Definition of Division of Upper • Lower Body Structure; (b) Definition of Head Structure.

Based on the analysis of complex character movements in commercially used content such as films and animations, this study divided the character's body parts into upper and lower sections, in accordance with (a) Definition of Division of Upper and Lower Body Structure in Figure 2. The purpose of this division is to facilitate cross-use of standardized upper and lower body movements or motion reuse through motion database construction. Additionally, motion data can be exchanged based on the skeleton root. This approach utilizes the concept that the upper skeleton includes the motion data of the lower skeleton. Consequently, this foundational study suggests that the criteria for upper and lower data can be expanded into various movement patterns, considering human behavioral movements. Also, (b) Definition of Head Structure, cases <1-1, 1-2> representing the head structure can separately structure the motion of the lower structure dependent on the upper body. Furthermore, it justifies structuring facial expressions as a separate subgroup to convey the character's emotional expressions. These elements can be treated as independent entities during modeling and texture changes, allowing highly efficient technical processing.

(a) Character Setup Diagram in Figure 3 involves the process of creating rigging data for the 3D character model, including the creation of skeletons using HIK function in Maya. This process defines how captured data is linked to the character's skeletons. (b) Head & Lower Body Structure, and (c) Upper Body Structure in Figure 3 consist of 42 skeletons in the upper body and 8 in the lower body, making up a total of 51 skeletons. This format utilizes the basic skeleton structure provided by Maya to implement character rigging, providing the complexity and flexibility required for the character's actual movements. Through this method, the data was applied to the motion in MAYA, a 3D animation authoring tool, allowing the motion capture data to be mapped more accurately to the character model, and effectively inserting the desired animation output. This process played an important role in realizing the character's natural movements and enhancing the realism of the animation.



(a) (b) (c)

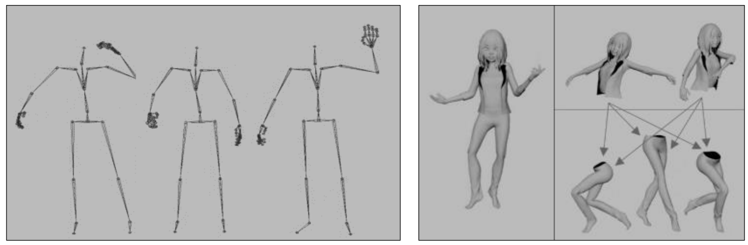
Figure 3. HIK Structure Definition

(a) Character Setup Diagram; (b) Head & Lower Body Structure; (c) Upper Body Structure.

4.5 Cross-Application and Utilization Methods of Motion Capture Data

The OptiTrack Prime 41 model, a motion capture system, employs 24 optical cameras to precisely track Reflective Markers affixed to the joints. It translates the position and motion information of each character's skeleton into XYZ coordinates to extract animation data. This extracted data, as illustrated in Figure 4, allows the retargeting of motion data to subjects according to the character's skeleton structure divided into upper and lower bodies, utilizing the Maya 3D animation authoring tool. Figure 4 (b), titled "Cross-Application of Motion Capture Data to Upper and Lower Body," depicts the extraction of various dancing animation data using motion capture, and this can be applied interchangeably to the character's upper and lower body. A key aspect of this research includes the ability to cross-apply motion data for the upper and lower body as needed. The movement data of the upper and lower body skeletons are interdependent yet exist as separate and independent entities, and the motion data can be exchanged and utilized, focusing on the root of the character's skeleton. This approach can substantially improve the applicability and reusability of joint movement data for character actions, and thus can be utilized as an essential asset in animation.

The application of motion data to a character's skeleton operates on the principles of upper and lower hierarchy. While the upper skeleton encompasses the information of the lower skeleton, the latter can independently receive unique motion information. Consequently, a distinctive feature of animation frame retargeting research lies in offering valuable opportunities for the reuse of intricate animation data for body parts like the head, hands, and feet. This is achieved by differentiating between the upper and lower parts of the body, using the root as a bifurcation point, and recognizing the lower parts' dependence on this structure.

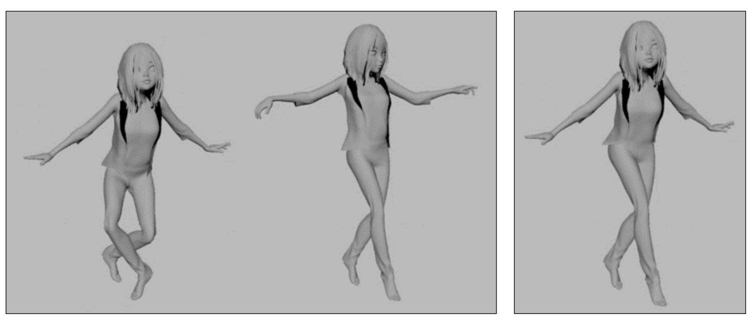


(a) (b)

Figure 4. Application of Motion Data to Upper • Lower Body of a Character

(a) Insertion of Motion Capture Data; (b) Motion Capture Data to Upper•Lower Body

The experimental results in Figure 5 demonstrate the ability to manipulate and retarget the motion data of a character's upper and lower body separately. That is, the movements of the upper and lower body are set to be independent of each other, and independent motion data has been applied to each part.



(a) (b)

Figure 5. Independent Retargeting of Upper • Lower Body Motion Data

(a) Independent Motion Data; (b) Cross-Application of Motion Data to Upper•Lower Body

(a) Independent Motion Data captured two dancing motions and retargeted them to the same character in Figure 5. (b) Cross-Application of Motion Data to Upper•Lower Body embodies the essence of the experiment by grafting two independent motions, retargeting the left dance motion to the upper body, and the right dance motion to the lower body in Figure 5. Through this, more complex and diverse movements can be created, and the possibility of reusing previously captured motion data was confirmed. Additionally, this technology provides the flexibility to rapidly prototype and experiment with complex character movements, and to easily apply and combine various movements to the same character or model. Such independent retargeting techniques play a vital role in enhancing the efficiency and creativity of animation production, and can be applied in various fields.

5. Conclusion and Suggestions

This study proposed a review of behavioral vocabulary and the classification and application of character behavior. Three specific tasks were performed as fundamental research to support this claim. First, a preliminary survey extracted 14,788 Korean behavioral vocabulary descriptors derived from natural language. Furthermore, through concepts of grammatical, behavioral, and semantic classification, issues related to lexical description, the feasibility of behavior execution, and the visual semantic perception of the audience were discussed. Second, a methodology was presented to differentiate and classify the upper and lower body of animation characters by referring to human kinesiology principles. Third, the successful depiction of standard animation in the retargeting of upper and lower body data from motion capture was confirmed. Also, it was verified that the character's upper and lower body movements could be reused, and the behavior captured from a body with separated upper and lower halves could be appropriately applied to animation characters.

The academic contribution of this study lies in proposing the separation and recycling of animation characters' upper and lower bodies through a unique combination of behavioral vocabulary and motion capture technology. This leads to increased efficiency and creativity in the animation production process and offers a new research direction exploring the reusability and flexibility of motion data. Consequently, this study will act as foundational research, and its impact will lie in the reuse of motion separated into the upper and lower body through character behavior directives captured in motion. This approach will enable animation content developers to access similar behaviors and ideas through a database or even predict descriptive types of actions. It also shows the possibility of capturing similar behaviors for use in digital storyboards.

This study lacks discussion on the analysis and organization of descriptors not used in everyday life, the creation of actionable motion data based on descriptors, discovery and validation methods for similar behaviors, and handling gender and age differences in gestures. Therefore, further research is required: firstly, to study the compatibility of animation modeling and texture data extracted from other groups' upper and lower body parts; secondly, to develop an algorithm to associate vocabulary and behavior according to the Korean word order; and finally, to facilitate research on the development of a natural language-based UI that allows users to describe character behavior and summon related animation data, and on a 3D viewer capable of data output. Lastly, the construction of a motion database using motion capture is essential.

References

[1] M. C. Song, K. S. Shin, “A Study of Pre-trained Language Models for Korean Language Generation, ” *Journal of Intelligence and Information Systems*, 28(4), p.309, Dec 2022.
DOI: https://doi.org/10.13088/JIIS.2022.28.4.309

[2] J. W. Song, J. Y. Noh, “Body Motion Retargeting to Rig-space,” *Journal of the Korea Computer Graphics Society*,20(3), p.10, Sep 2014.
DOI: https://doi.org/10.15701/kcgs.2014.20.3.9.

[3] S. S. Lee, K. H. Um, K. E. Cho, “A Design of AI Middleware for Making Interactive Animation Characters,” *Journal of Korea Game Society*, 8(1), pp.91-95, Feb 2008.

[4] X. B. Peng, P. Abbeel, S. Levine, M. V. Panne, “DeepMimic: Example-Guided Deep Reinforcement Learning of Physics-Based Character Skills,” *ACM Trans. Graph*., Vol. 37, No. 4(143), pp.1-4, Aug 2018.
DOI: https://doi.org/10.1145/3197517.3201311

[5] H. S. Chung, S. J. Lee, “Storing and Retrieving Motion Capture Data based on Motion Capture Markup Language and Fuzzy Search,” *Journal of Korean Institute of Intelligent Systems*,17(2), p.273, Apr 2007.
DOI: https://doi.org/10.5391/JKIIS.2007.17.2.270

[6] S. H. Park, J. H. Lee, “A Comparison of Deep Neural Network Structures for Learning Various Motions,” *Journal of the Korea Computer Graphics Society*, 27(5), pp.74-75, Nov 2021.
DOI : https://doi.org/10.15701/kcgs.2021.27.5.73

[7] League of Legends game, Epic Games, www.leagueoflegends.com

[8] E. J. Kim, S. J. Park, “A Study on GUI Design of Online Game Character Customizing,” *Journal of Korea Multimedia Society*, 14(2), p.313, Feb 2021.
DOI: https://doi.org/10.9717/kmms.2011.14.2.307

[9] B. C. Kim, C. H. Roh, “Design of an Avatar Assembly System based on a Commercial Game Engine,” *Journal of Digital Convergence*, 14(12), PP. 491-493, Dec 2016.
DOI: https://doi.org/10.14400/JDC.2016.14.12.489

[10] H. R. Cho, *2022 Animation Industry White Paper*, Korea Creative Content Agency, pp.20-31, 2022.
[11] M. K. Lee, "Accomplishments and Characteristics of Korean Phonological Studies in the Journal of Korean Linguistics," *Journal of Korean Linguistics*, 93(0), pp.343-390, Mar 2020.
DOI: https://doi.org/10.15811/jkl.2020..93.011
[12] B. K. Koo, "Korean Language Society 60 Years and Korean Morphology," *Journal of Korean Linguistics*, 93(0), pp.403-406, Mar 2020.
DOI: https://doi.org/10.15811/jkl.2020..93.012
[13] S. J. Park, "Korean pragmatics and Korean language education," in *Proc. 2009 The 11th National Conference of Korean Association for Language and Culture Education*, pp.90-91, Oct 2009.
[14] Y. C. Jun, "Korean Semantic Studies and Semantic Theories," *HAN-GEUL*, (313), pp.8-16. Sep 2016.
DOI: https://doi.org/10.22557/hg.2016.09.313.5
[15] Cheong, Y. N., *A Study on Semantic Classification System of Korean Utterance Verbs*, Ph.D. Thesis. pp.1-6, Korea University, Korea, 2016.
[16] H. S. Kim, "On the Establishment of Basic Sentence Patterns in Korean," *The Korean Language and Literature*,122(), p.43, Dec 1998.
[17] B. K. Ham, "Review on Korean Sentence Pattern" *Journal of Dong-ak Language and Literature*, 81(), pp.75-103, Jun 2020.
DOI: https://doi.org/10.25150/dongak.2020..81.003
[18] S. M. Yeom, "On the Basic Sentence Patterns in Korean," *Eomunhak*, (), pp.59-75, Nov 1977.
[19] National Institute of Korean Language, *Korean Grammar for Foreigners 1*, CommunicationBooks Inc., pp.54-80, 2005.
[20] H. S. Lee, "Major Sentence Components," *New Language Life*, 13(4), pp.151-153, Dec 2003.
[21] Y. G. Jang, "A study on the Korean Basic Sentence Patterns" *International language and literature*, (8), p.7, Dec 2003.
[22] N. H. Choi, A.Y. Lim, "The Roles of Character's Functionality and Character's Attractiveness on Emotional Response of Spectators," *Journal of Industrial Economics and Business*, 24(1), pp.542-544, Feb 2011.
[23] S. Y. Park, "Korean Independent Words and the Syntactic Representation of Discourse Information," *Journal of Korean Linguistics*, 89(0), pp.26-27, Mar 2019.
DOI: https://doi.org/10.15811/jkl.2019..89.002
[24] Korean Verb Vowels extraction, https://ko.wiktionary.org/wiki
[25] D. Y. Kim, "Analysis of Single Subject Research Trends Related to Verbal Behavior Analysis," *Behavior Analysis and Supporting Research*, 9(1), pp.28-29, Apr 2022.
DOI: https://doi.org/10.22874/kaba.2022.9.1.27
[26] J. H. Lee, "Robert Zemeckis's Realistic Animation and Audience Acceptance," *Journal OF The Korea Contents Association*, 12(6), pp.144-145, Jun 2012.
DOI: https://doi.org/10.5392/jkca.2012.12.06.142
[27] S. H. Shim, S. H. Cho, T. I. Lee, "Development of Experimental Animation through Evaluation of Emotional Movements," *Journal of Digital Design*, 8(1), 300-301, Jan 2008.
DOI: https://doi.org/10.17280/jdd.2008.8.1.028