



IEEE 3DBP INDUSTRY CONNECTIONS

POSITION, POSTURE, AND POSE DEFINITIONS FOR 3D BODY PROCESSING

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POSITION, POSTURE, AND POSE DEFINITIONS FOR 3D BODY PROCESSING

ABSTRACT

The interchangeable use of the terms *position*, *posture*, and *pose* causes confusion for 3D body processing (3DBP) applications. This paper reviews current definitions and contextual use of these terms to suggest standardized nomenclature for *posture* and *pose*. This paper also reviews and discusses possible standard definitions for *location*, *body regions*, *landmarks*, and *anatomical relationships*. With large language models being central to artificial intelligence (AI), standardized terminology is imperative to all digitization efforts. Replicating, or cloning of, actual posture is a known challenge inhibiting cloned human body models, optimized virtual try-on, and critical fit assessment. *3DBP applications need to be sophisticated enough to accept and utilize unique actual postures, in a given pose, which may vary drastically from a predetermined norm.* The discussion builds off of current ISO standards to an open discussion for standards toward posture-improved human body models inclusive of widely varying morphology.

1. INTRODUCTION

When characterizing the human body within the realm of spatial representation, there exists a tendency to use the terms *position*, *posture*, and *pose* interchangeably. However, this interchangeability causes a challenge for industries engaged in 3D body processing (3DBP), where the primary objective is to articulate the specific state of a human body at any given instance. Given the dynamic nature of the human body, wherein dimensions and shapes undergo fluctuations during movement, the imperative lies in articulating a precise understanding of the human body's state at a given moment in time.

The words *position*, *posture*, and *pose* are the common terms used to reference the state of the human body. These terms, however, are frequently interchanged with no common understanding of nuances between these terms. Hence, it is language itself that has proven problematic for generative artificial intelligence (AI) models [1].

Establishing a standardized lexicon is crucial for fostering a comprehensive understanding of the human body's state at a specific moment, especially within the realm of 3DBP technologies. This necessity becomes particularly pronounced in the context of advancing apparel-generative AI models, where precision in articulating the human body's dimensions is paramount. As the digitization of apparel relies heavily on accurate representations of 3D humanoid dimensions, this paper aims to scrutinize the terms *position*, *posture*, and *pose* with commonly accepted nomenclature and ISO definitions. By delving into the origins of these terms and their associated concepts, the objective is to formulate a lexicon tailored to the unique requirements of the apparel industry, ensuring clarity and specificity essential for the development of effective generative AI models. The humanoid definition from Glascoe et al. [2] can be summarized as any physical representation or digital (virtual) representation that can manifest human-like characteristics, such as motion, shape, or other physical attributes of a human.

ISO standards are recognized internationally. As such, they are a source for understanding the context of word usage. In describing the digital environment, the ISO standards commonly use the word “virtual.” In IEEE standards, “digital” is used. In this paper, the authors will be using digital (virtual) to describe the digital environment and definitions.

In further sections of this paper, the authors will present their recommendations for a more discrete and consistent set of labels and definitions that should be adopted.

2. BACKGROUND

The ambiguous terminology, currently faced in apparel [3], is the result of utilizing existing words in a new context. Both posture and body shape may be observed as the relationships among regions of the body in 3D space that affect body measurements, but digital (virtual) practice urgently requires a non-heuristic understanding of these factors which are known to affect fit. Based on the understanding that apparel fit is largely dependent on the hang of fabric from the human body [3], the comparison of the values, location, and orientation of measurements and landmarks with the same relationships is key to categorizing human body shapes to achieve garment fit [4].

Before exploring appropriate nomenclature for current technology, the authors reviewed the historical context. The study of the physical structures of the human body and its relationships, within the science of morphology, is called anatomy. Common online available dictionaries were used for reference such as the Oxford Languages Dictionary [5], with an international English focus, along with the Merriam-Webster Dictionary [6], which has an American English focus. Since the common usage of computers, there are many new terms in the English language, and many existing terms are now used in different ways. It was felt that it would be useful to include Webster's New Collegiate Dictionary [7], published in 1949, for its precomputing perspective. The definitions for anatomy are similar between the dictionaries.

The definitions for anatomy (used only as a noun) are as follows:

- "the branch of science concerned with the bodily structure of humans, animals, and other living organisms" (n) [5],
- "a branch of morphology that deals with the structure of organisms" (n) [6],
- "the science or branch of morphology, which treats the structure of animals or plants" (n) [7].

The definitions of morphology (used only as a noun) are as follows:

- "a branch of biology that deals with the form and structure of animals and plants" (n) [6],
- "the branch of biology dealing with the form and structure of animals and plants" (n) [7].

Position, *posture*, and *pose* definitions were reviewed, and all three words were found to have both noun (n) and verb (v) forms and origins from the same Latin term *ponere* "to place."

Since the biomedical field analyzes the posture of humans, summary papers were reviewed for any guidance that could be brought into the apparel industry. Biomedical sources [8], [9] for the definition of posture brought a different perspective than what was found in the dictionaries for common word usage and is discussed.

The words *position*, *posture*, and *pose* were used in the ISO documents to describe scanning or measurement conditions. The ISO standards referenced were ISO 20685-1:2018 A.2.4 Subject Position [10]; ISO 7250-1:2017, Section 4.1 Conditions [11]; ISO 8559-1:2017, Section 4.1.4 Posture [12]; ISO 18825-1:2016, Section 2.3.1, Virtual body pose [13]; and ISO 19774, V.20 [14].

This paper will review the *position*, *posture*, and *pose* of a human body with reference to body regions. Subtleties in the relationship of and orientation between body regions are expected. It is these subtleties for which a common lexicon is lacking. While a lack of limbs is a possibility, it is considered natural for humans to have these body regions in common.

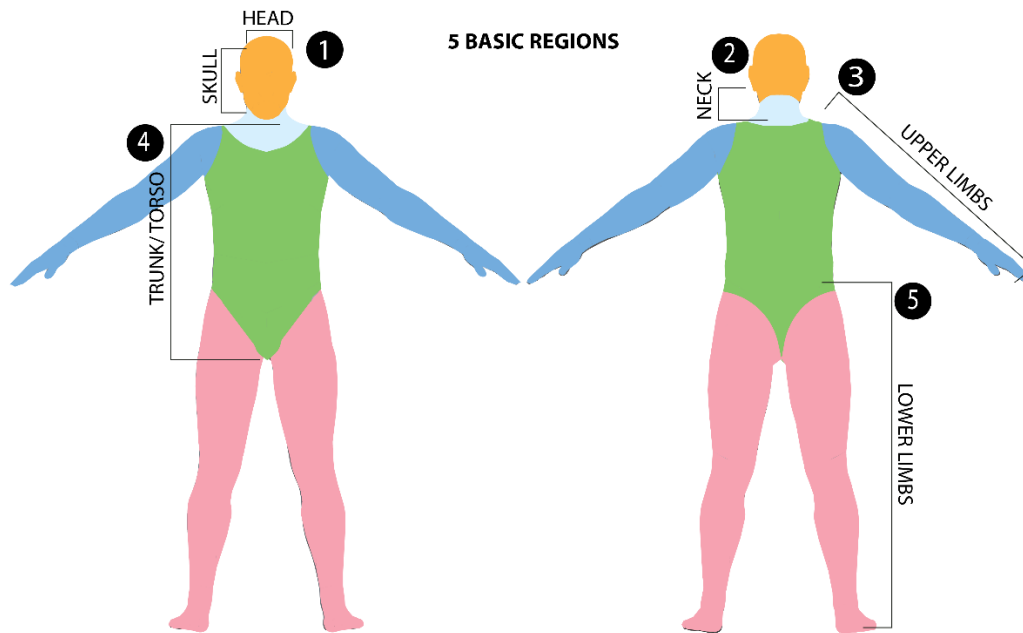
2.1. BODY REGIONS

When discussing human anatomy, a pragmatic approach involves initially dissecting the figure into distinct body regions. Numerous definitions of these body regions exist, varying in both the number of sections and the content ascribed to each. In the context of the human body standing upright in the standard anatomical position, this discussion will compare five selected examples of body region delineations. These are not inclusive of all versions of body region determinations.

2.1.1. BIOMEDICAL

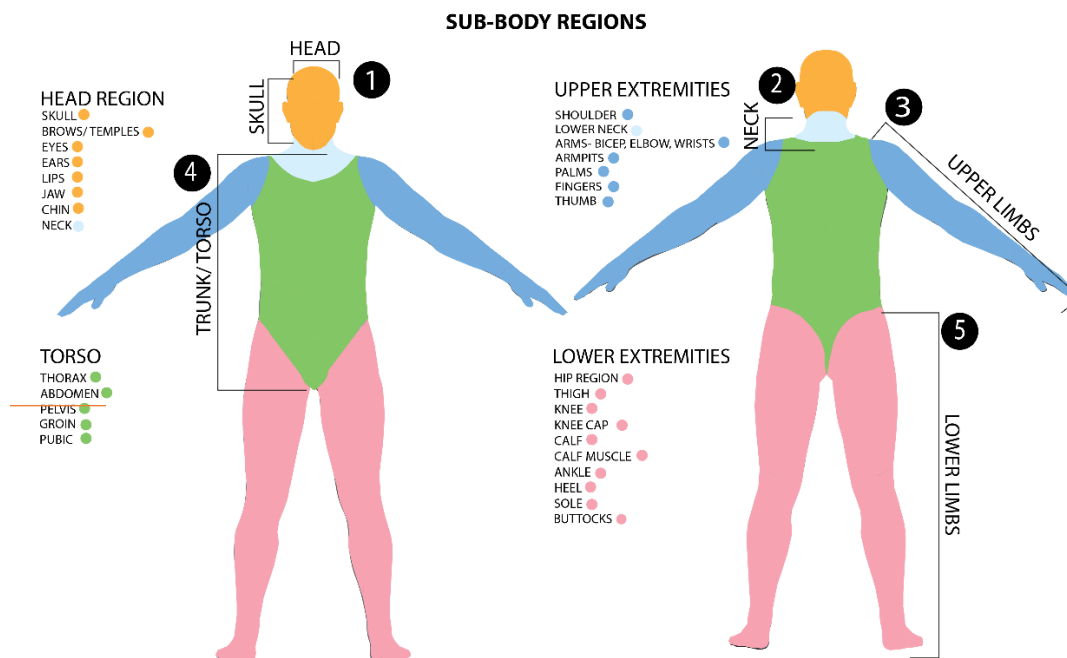
A common biomedical perspective [15] is to divide the body into five regions of head, neck, torso, upper extremities, and lower extremities (see Figure 1 for a simplified diagram). This example also notes the subregions (see Figure 2). The head region is the skull (top and back of the head) and face. The upper extremities include the arms, armpits, and shoulders. The lower extremities consist of legs, buttocks, thighs, knees, ankles, and feet.

FIGURE 1 Five biomedical body regions



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FIGURE 2 Five biomedical body regions including sub-body regions



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2.1.2. ISO USAGE

The ISO example of ISO 18825-2:2016 [13] defines ten virtual body regions: neck, shoulder, chest/bust, waist, abdomen, crotch, upper arm, forearm, thigh, and calf (see Figure 3) based on the landmarks defined. The head, hands, and feet are not included in ISO definitions. This is because the head, hands, and feet are covered with hats, gloves, and footwear, which are not considered garments by the apparel industry.

FIGURE 3 ISO 18825-2:2016 example: ten virtual body regions



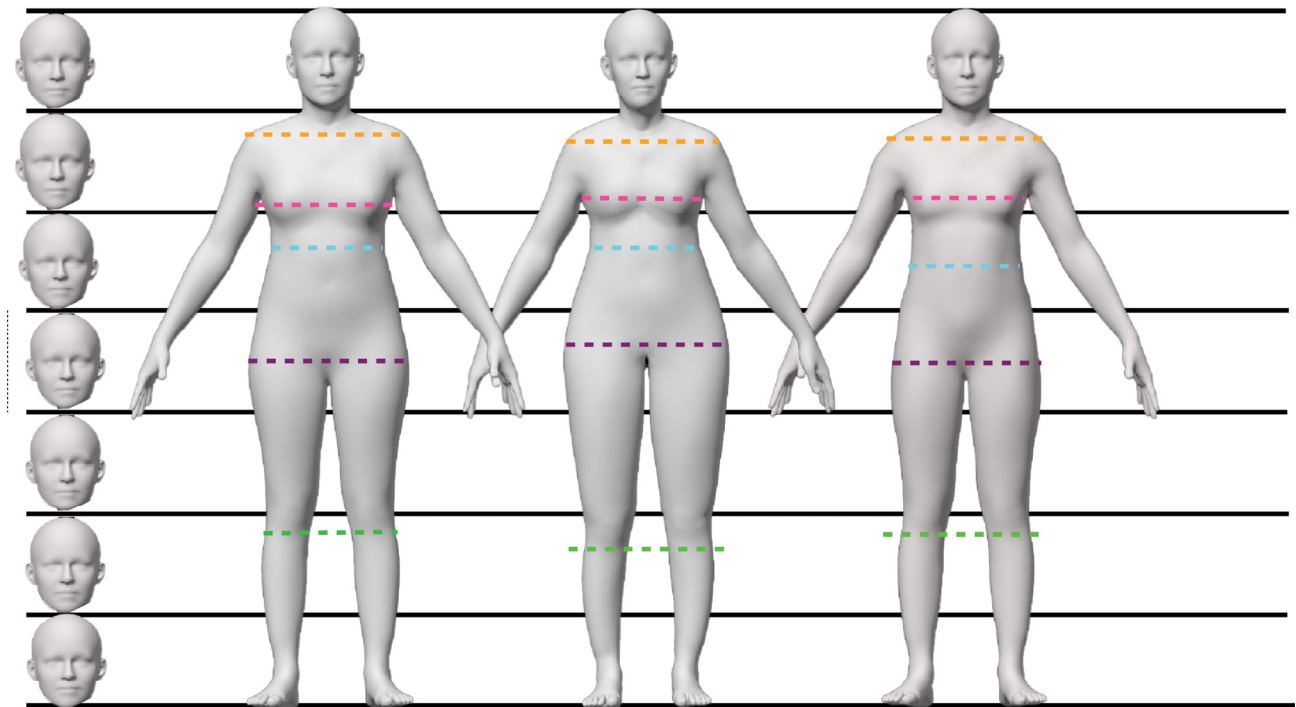
- 1) virtual neck, 2) virtual shoulder, 3) virtual chest, 4) virtual waist, 5) virtual abdomen, 6) virtual crotch, 7) virtual upper arm, 8) virtual forearm, 9) virtual thigh, and 10) virtual calf.

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2.1.3. HEADS AS PROPORTION OF BODY HEIGHT

The “eight-heads” theory is an arbitrary definition of human body proportions and is often used by the apparel industry to create fashion drawings. Head height acts as a measuring device for the comparison of body proportions [16]. Accordingly, the entire body is ideally divided into eight equal parts, which are equal in height to the height of the head, commonly called “eight heads.” The first head is the crown of the head to chin level with the eighth head being from the calf to the tip of the toe. These are irrespective of body segments; they are horizontal divisions only. This is a problematic division in differently proportioned bodies. Although the apparel industry creates fashion illustrations utilizing the eight-heads theory, a seven-head height is closer to actual human proportions [17]. Human proportions vary greatly so the eight-head standard is useful as a basis for comparison rather than an actual measuring system or proportional imperative. However, depending on a body’s proportions, based on the head height, sometimes a body is considered between seven and eight heads in height as shown in Figure 4. As an example, different leg lengths and torso curves shown in Figure 4 show that body proportions may not exist at the same height or at the same number of heads.

FIGURE 4 Heads proportion theory with seven heads models shown



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2.1.4. BODY SEGMENTATION IN MACHINE LEARNING

The technique of using body regions for understanding and modeling body scans has also been used in machine learning. Body segmentation uses feature points to subdivide the body into regions: upper and lower limbs, head, torso, etc. Pose detection uses a wireframe of joints defined from body segmentation which is driven from feature points. Feature points (landmarks) are common between body segmentation and pose detection, although methods may vary. Landmarks are described in detail in Section 2.2. An example of the variation of the methods is in distinguishing the boundaries for the limbs. Some methods include the shoulder area with the arm (as depicted in Figure 5), while others include the shoulder with the torso, separating the arm at the axillae. Similar discrepancy is found with the legs. Some use an angled line to include the hip joint (as depicted in Figure 5) while others separate the leg with a plane at the crotch. Datagen [18] has a general overview of body segmentation or parsing for reference. For interoperability, it is paramount that feature points be passed with humanoid mesh data. Due to varied methods of feature point assignment, humanoids will vary between scanning providers. Body curves can be used to create a wireframe that can be utilized to describe the body shape instead of relying on a body mesh directly. Body regions are then created by a computer science technique called patching. The body regions relevant to joints can be used to identify *posture* and *pose*.

FIGURE 5 Subdivision of body into regions (patches) from wireframe

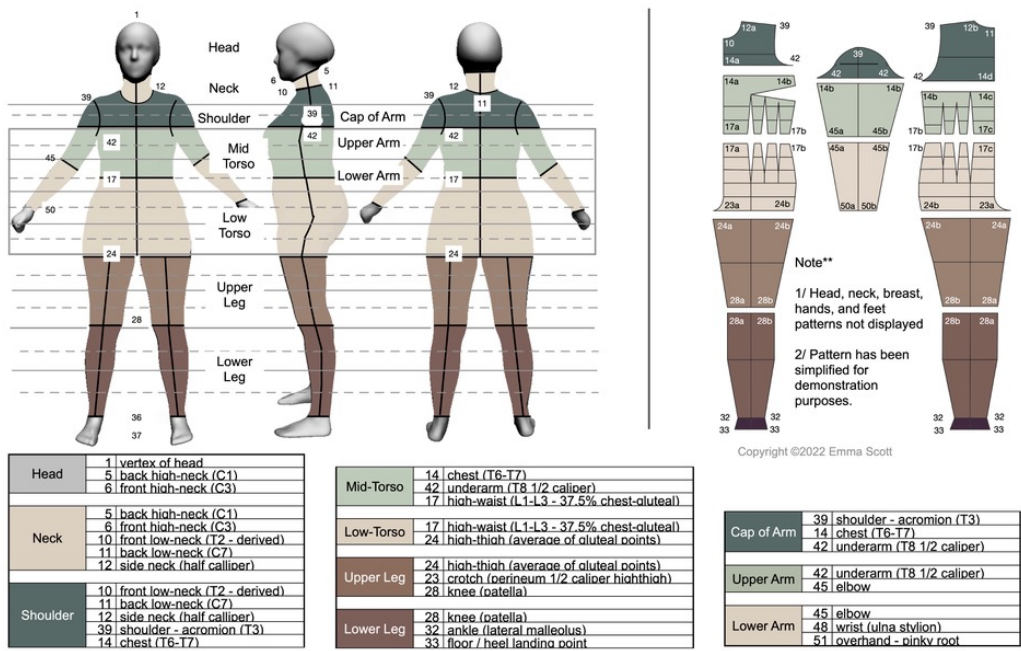


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2.1.5. BODY REGIONS TO PATTERN BLOCK

Body regions with a pattern design focus from Scott et al. [19] concur with ISO standards of segmenting the body into body regions but suggest skeletal subdivision of the body is best used to achieve this division (see Figure 6). An example of a skeleton subdivision is to divide the torso between the axillae and gluteal folds into eight divisions to facilitate the assignment of the waist area. This method may be considered analogous (as it applies to all humans, irrespective of body category that has been given), and therefore, irrespective of body shape or garment design. For apparel product development, the waist area denotes where the upper body pattern block ends and the lower pattern block begins. Instead of providing loose definitions of body regions, this pattern block method provides a detailed definition of all the key landmarks required for the sectioning lines that divide the body surface into different regions or patches. The waist area has many definitions as noted by Gill et al. [20], which may be dependent on the body shape or garment worn.

FIGURE 6 Body regions for pattern blocks



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2.2. LANDMARKS

Landmarks are generally described as points on the surface of the body used to determine body measurements. Landmarks were utilized in Sections 2.1.2, 2.1.4, and 2.1.5 to define body regions and as noted may be loosely defined. The authors will look at the ISO usage and another summary paper for the definitions and usage.

2.2.1. ISO USAGE

The ISO standards Online Browsing Platform [21] was used to search the word “landmarks.” Since the word “landmarks” can describe objects like buildings or mountains, “landmarks” related to 3DBP have adjectival nouns or noun modifiers for clarification. The adjectival nouns of “measurement or virtual body” are used to describe the type of landmarks that are used for humans or humanoids. The adjectival noun of “anatomical” is utilized for a human only. Levels describe a horizontal plane across the human body or humanoid (Figure 7).

The definitions from the ISO standards Online Browsing Platform [21] are as follows:

“Measurement landmarks: *Points located and placed on the human body’s surface or on a computer manikin used for measurement of distance or displacement [Source: ISO 15536-2:2007, 3.5]” [22].*

“Anatomical landmark: *Point clearly defined on the body that can be used for determining anthropometric measurements [Source: ISO 20685-1:2018, 3.6]” [10].*

“Virtual body landmarks and levels: *Points that define the characteristic of the body of the user in the virtual standing position.*

Note 1 to entry: For example, points of bone prominence, peak points on a convex or concave surface, or points like the bust point can be virtual body landmarks.

Note 2 to entry: On a physical body, a virtual fit mannequin or a physical fit mannequin, the landmarks and levels are defined in the same manner.

Note 3 to entry: Some of the landmarks are evaluated in terms of their levels.

Note 4 to entry: When a physical body or a physically fit mannequin is 3D scanned, markers for the landmarks can be put on it to extract their positions.”

[Source: ISO 18825-1:2016, 2.2.4] [13] and [Source: ISO 20947-1:2021,3.6] [23].