Anatomy Builder VR: Comparative Anatomy Lab Promoting Spatial Visualization through Constructionist Learning

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ABSTRACT

Anatomy Builder VR is a comparative anatomy learning application that examines how a virtual reality (VR) system can support spatial visualization through embodied learning methods. The backbone of the project is to pursue an alternative constructionist pedagogical model for learning canine anatomy. The main focus of the project is to identify, sort, and assemble bones in the canine and human orientations using 3D scanned human and canine bones.

CCS CONCEPTS

• **Human-centered computing~Virtual reality** • *Applied computing ~ Interactive learning environments*

ADDITIONAL KEYWORDS AND PHRASES

Anatomy education, virtual reality, constructionist learning, canine anatomy

1 INTRODUCTION

Spatial ability is the capacity to understand, reason and remember the spatial relations within an object, amongst objects, or between an object and space. This involves not only understanding the outside world, but also processing outside information and reasoning with it through visual representation in the mind. Advanced spatial abilities are required for success in STEM (science, technology, engineering, and mathematics). Understanding life's structure requires a high degree of spatial ability, especially the both intrinsic- and extrinsic- dynamic nature of the structure. Anatomy is a great example why proper spatial ability is highly required in life science education. In undergraduate anatomy education, the structure of the human or animal body has long been taught through cadaver dissection [1]. Cadaver dissection definitely provides tangible knowledge of the shape and size of the organs, bones, and muscles. However, dissection offers only a subtractive and deconstructive perspective (i.e. skin to bone) of the body structure. Because of the nature of cadaver dissection, students are rarely able to understand the dynamic spatial relationships between structures. For example, they struggle to accurately visualize movement that results from specific muscle contraction [2, 3]. Consequently, many students have difficulties mentally visualizing how movement of a structure affects other parts of the body. Even with the availability of 3D interaction tools, mentally visualizing movement remains problematic. Most of them still provide simple navigations of the structure and do not support students' active manipulation of anatomical contents to promote 3D spatial understanding [4]. We propose that *embodied/constructionist learning* methods, while assembling and directly manipulating objects and structures in a virtual environment, will promote development of embodied, multi-modal mental simulation of complex structures.

2 Anatomy Builder VR

Anatomy Builder VR (Figure 1) is a comparative anatomy lab that students can examine how a virtual reality system can support embodied learning in anatomy education. The backbone of the project is to pursue an alternative constructionist pedagogic model for learning canine anatomy. Direct manipulations in the program allow learners to interact with either individual bones or groups of bones, to determine their viewing orientation and to control the pace of the content manipulation. This program consists of dynamic lessons of human and canine anatomy contents, sand box room and game room.

2.1 System Description

WOODSTOCK'97, El Paso, Texas USA

DOI: 10.1145/123_4

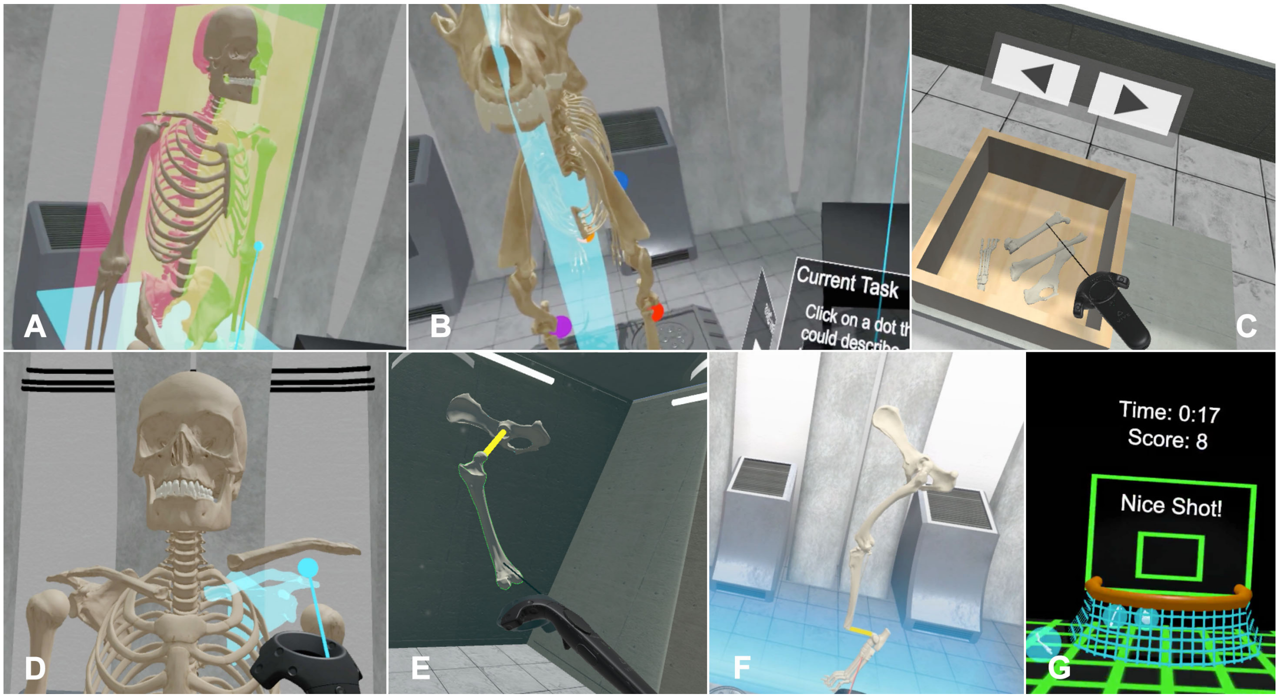

Figure 1. A. Selection of a bone, B. Sorting bones, C. Snapping bones, D. Assembling a skeleton, E. Muscle Placement, F. Muscle movement in Anatomy Builder VR

The Anatomy Builder VR program utilizes the HTC Vive virtual reality platform. The platform comes with a high definition head-mounted display (HMD), two motion controllers, and two infrared tracking stations. The project has been developed in Unity3D. All scripting is done in C#. Unity's development environment allows for easy integration of the Vive with pre-built scripts and API. This allowed us to rapidly develop a functioning prototype and begin to design the user specific interactions. Interaction with the virtual environment is primarily done with the Vive controllers. The controllers have several buttons that are available to be programmed for various interactions.

2.2 Interaction Tasks in Anatomy Builder VR

In Anatomy Builder VR, students can learn human and canine anatomy through structured lessons that allow them to interact with dynamic anatomy contents. They can assemble human and canine skeletal systems. Within the Anatomy Builder VR environment, there is an "anti-gravity" field where the user can assemble the skeletons. Interaction tasks for Anatomy Builder VR include:

- *Understanding anatomical planes and directional terms*: This helps students to be able to visualize positional and spatial locations of structures and navigate directionally from one area to another. (Figure 1A & B)
- *Recognition of bones*: Providing all viewing angles is crucial for the identification of objects. Therefore, natural head movement is required to be able to inspect individual objects. (Figure 1 C & G)
- *Selection of bones*: The selection of virtual bones is the prerequisite for 3D interaction. Placing a bone in the anti-gravity field suspends it in place (Figure 1 C)
- *Transformation of bones*: The transformation task includes translating and rotating 3D objects. Since this is the task that the student is required to spend most of the time on, the success of learning spatial relations highly depends on the selected interaction technique. (Figure 1 D)
- *Snapping of bones*: Selecting and transforming a set of 3D bones is a process to assemble bones in the right positions. Picking up a bone and placing its joint near a connection on an already field-bound bone will make a yellow line appear. When the user lets go of the controller trigger, the two joints snap together. The user repeats this action until the skeleton is assembled to satisfaction. (Figure 1 E & F)

ACKNOWLEDGMENTS

This work was partially supported by the Tier One Program at Texas A&M University, "Creative Anatomy Collective".

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