# 2. Methodology

## 2.1. Virtual Anatomy Puzzle Overview

In order to facilitate this interactive, educational curricula, we have developed a 3D anatomy puzzle prototype, which prompts the user to assemble various anatomical systems in a virtual environment.

The Virtual Anatomy Puzzle game is comprised of three functional modes. The first mode serves as a tutorial, familiarizing the user with the interface, hardware and controls. This tutorial consists of a series of alignment exercises using an asymmetrical singleton object, successively introducing the user to all of the degrees of freedom ultimately available in the full control scheme. By analyzing the collected metrics of speed, accuracy, and throughput from a users’ performance with the alignment exercises we can evaluate a users’ motion interactions with virtual environments using a Fitts’ Law experiment \cite{raynal2013towards}. We can also supplement the users’ movements with tracked eye data, and evaluate their visual interactions with the virtual environment.

The second mode is a so-called Free Play Mode, which allows unguided and unlimited manipulation and further exploration of the anatomical models, with annotations present on all objects. This exploratory free play is intended to strengthen user preparedness and familiarity with the task prior to any assessment or constraints. This is especially beneficial for those who embark upon the game with a limited knowledge base or little experience manipulating objects in a 3D virtual environment. Exploratory free play is a functionality common to similar, existing digital anatomical tools.

The assessment or “Quiz Mode” is a highly controlled and guided experience, which challenges the user to recall both the name and position of randomly selected pieces of the anatomical model in the fully completed assembly. The task begins by loading three “keystone” models at random, which are permanently grounded, meaning that the user cannot manipulate them. A selection of five additional models is subsequently loaded, and the user is prompted to select a one and attach it to the grounded assemblage. The user is given four attempts to maneuver the model into the proper position. Doing so will trigger a “snap” event, wherein the manipulated piece is successfully attached to the grounded model if it is within a certain tolerance of the correct position. If a correct solution has not been achieved in four attempts, the model is automatically snapped to the correct position and orientation. The game point based, more attempts it takes for a user to make a successful “snap”, the fewer points the user receives. This puzzle assembly task is intended as the foundation upon which a useful pedagogical tool can be constructed (Fig. 2 and Fig. 3). From this “Quiz Mode” we hope to evaluate the training a user experiences, with respect to 3D spatial anatomy, while playing our game. A user’s learning will be assessed based upon how many points the user receives.

## 2.2. Platform Architecture

### 2.2.1 Hardware

3D imagery will be presented on a stereoscopic table-top display, constructed from a rear-projection screen stretched across a wooden frame. The frame is positioned parallel to the floor, and a BenQ projector capable of displaying frames at 120 Hz is positioned beneath, projecting upwards. The user is equipped with active-shutter glasses --- which block alternating frames and allow for the stereoscopic illusion --- and a Wii remote controller, which allows the user to manually interact with the virtual environment. The viewer and controller are tracked using a Northern Digital Polaris Spectra tracking system. Small, retroreflective spheres --- placed at the corners of the table, along the frame of the glasses, and along the controller --- allow the Spectra to track the position and orientation of the remote controller and the viewer’s head with respect to the table using infrared light pulsed at 60 Hz.

### 2.2.2 Software

Our software platform was built using the WorldViz Vizard toolkit. The Vizard toolkit provides a framework for rapid prototyping of 3D applications, with ready-made interfaces for many of the commercially available virtual reality, motion capture, eye tracking, CAVE/Powerwall and 3D projection systems available today. While the Polaris Spectra tracking device is not directly supported, plug-ins for open-source servers, such as the Virtual Reality Peripheral Network (VRPN), are also included. VPRN and the associated Vizard plug-in facilitate communication between and control of the tracking device. However, due to a bug in the VRPN Polaris Spectra driver, the resulting position and orientation data are currently considered unusable. Until a solution is found, we have written a script to parse the log file generated by Northern Digital’s own sample API executable.