OTTO VON GUERICKE UNIVERSITÄT MAGDEBURG
FAKULTÄT FÜR INFORMATIK

Anatomy Education

3D Puzzle VR

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Motivation

1. Anatomy education is important
2. Using advanced technologies
3. Virtual Reality (VR) emerging technology
4. Supporting anatomy education
5. Based on the work of Ritter et al [1, 2, 3]
    - Solving 3D Puzzle of anatomy models in virtual environments

Scope

1. Developing a prototype solution
2. Using Virtual Reality as input/output device
3. A desktop Windows OS application

Tasks

1. Using visualization and advanced interaction techniques.
2. Arrange 3D parts of chosen areas:
   a. To make a proper structure
   b. Solve puzzle
3. Users can use both hands to interact with virtual 3D parts.
4. Drag and Drop objects
   a. At the right position
   b. Rotate objects.
5. Developed visual cues which supports the user.

Prototype

Interaction Tasks

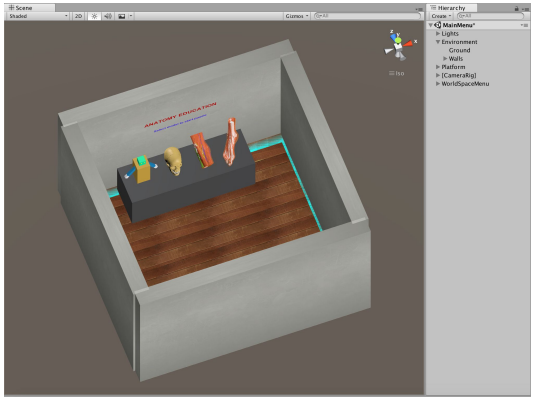
- Picking and dragging objects
- Rotating objects
- Scaling model up/down
- Snapping two objects
- Solving puzzle

User Interface

- Splitting model
- Restart puzzle
- Main menu

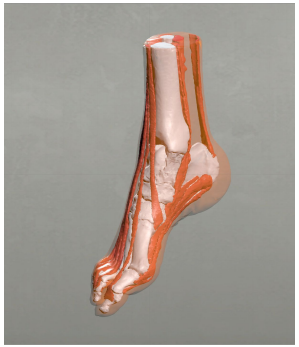
Framework

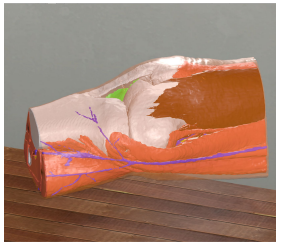
- HTC Vive - VR device with two controllers
- Unity Engine 5.4.0 (Win x64)
  a. Level Design
  b. Scripting
  c. Animations
  d. SteamVR Plugin
  e. Executable
- SteamVR plugin



Material

- Three regions of human body are used.
  - Skull
  - Knee
  - Foot
- Anatomist: Segmented and labelled Foot and Knee
- Patrick saalfeld: Converted segmentation masks into 3d models and fixed the pivot point issue in Autodesk 3ds max
- In Unity imported in .fbx format





	Skull	Foot	Knee
#Triangles	644.1K	1.7M	2.0M
#Vertices	398.7K	5.0K	1.0M
#Individual Parts	26	51	32
Types of Structures	Bones, teeth	Bones, Ligatum, Muscles, Skin	Arteries, Baender, Bones, Bottom, Ligatum, Muscles, Nerves, Skin, Tractus, Vastus, Venes

Details of all models used in prototype

Concept

1. Data structure

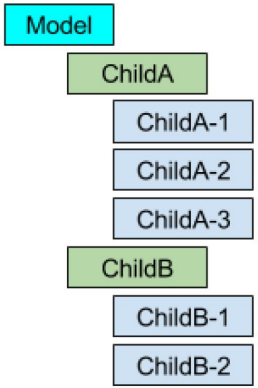
- Hierarchical data structure
- Naming convention

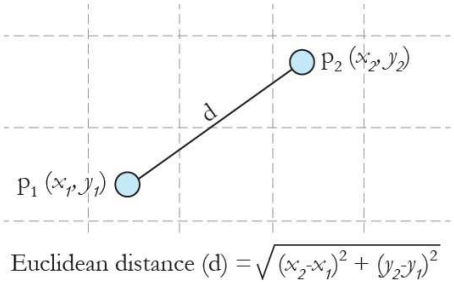
2. Relative distance

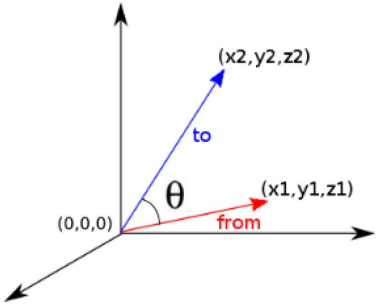
- Between all objects in reference to each other

3. Relative angle

- Between all objects in reference to each other







Concept

Pros

- Flexible snapping of objects.
- Solve the puzzle in any order.
- Solve the puzzle at any position in the VRE.
- Solve puzzle at any scale of the model.

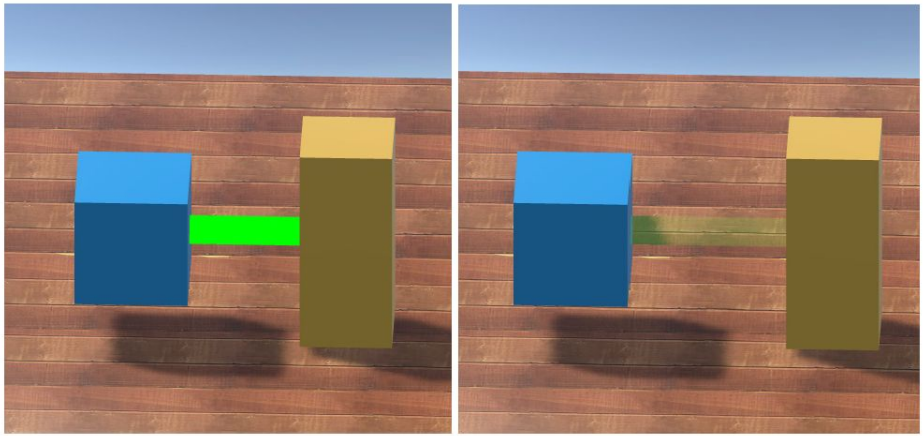
Cons

- No absolute position available when snapping.

Concept

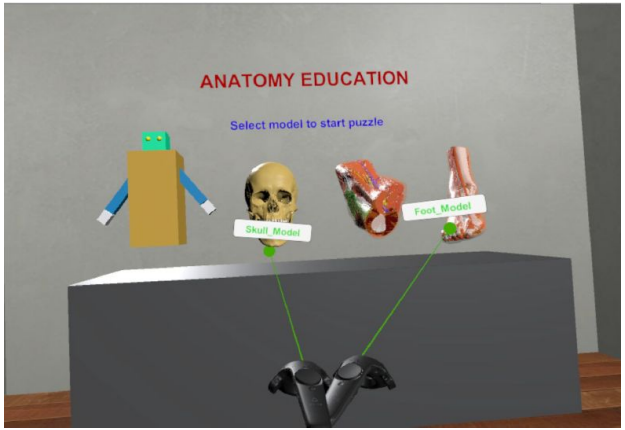
4. Beam

- Visualisation feedback
- **Color** shows distance
- **Opacity** shows orientation

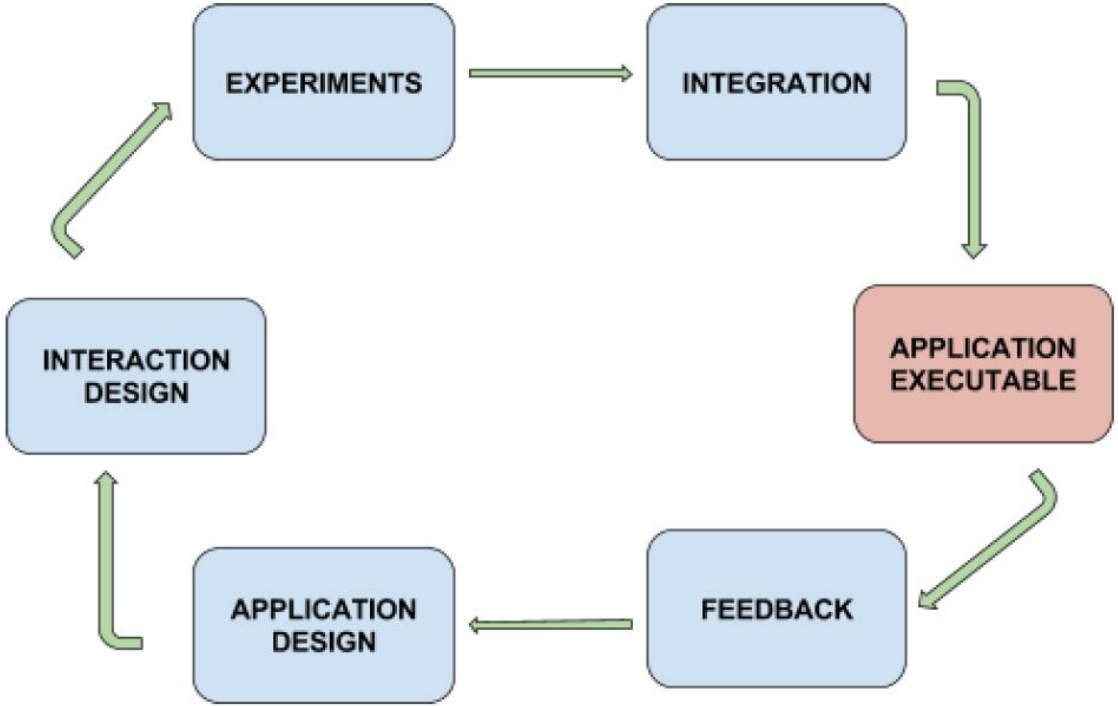


6. Pointer & Label

- **Points** in the direction of controller
- **Label** shows name of pointed object

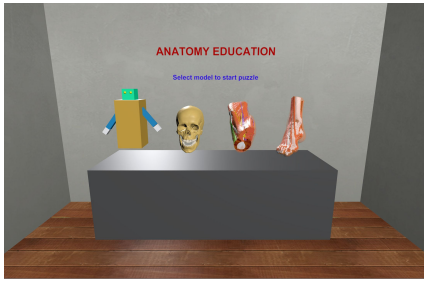


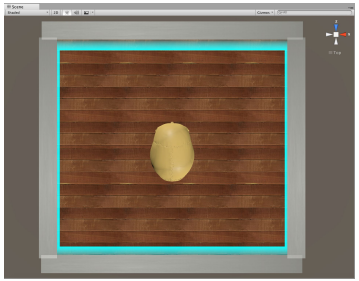
Methodology

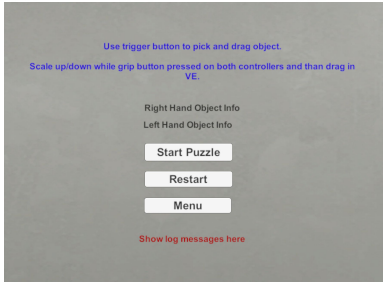


Unity Development

- **Level Design**
  - MainMenu.unity
  - PuzzleVRGame.unity
- **Interaction**
  - Two controllers of HTC vive
  - **Trigger** button to pick and drag object
  - **Grip** button for scaling up/down
- **User Interface**
  - Start Puzzle
  - Restart
  - Main Menu



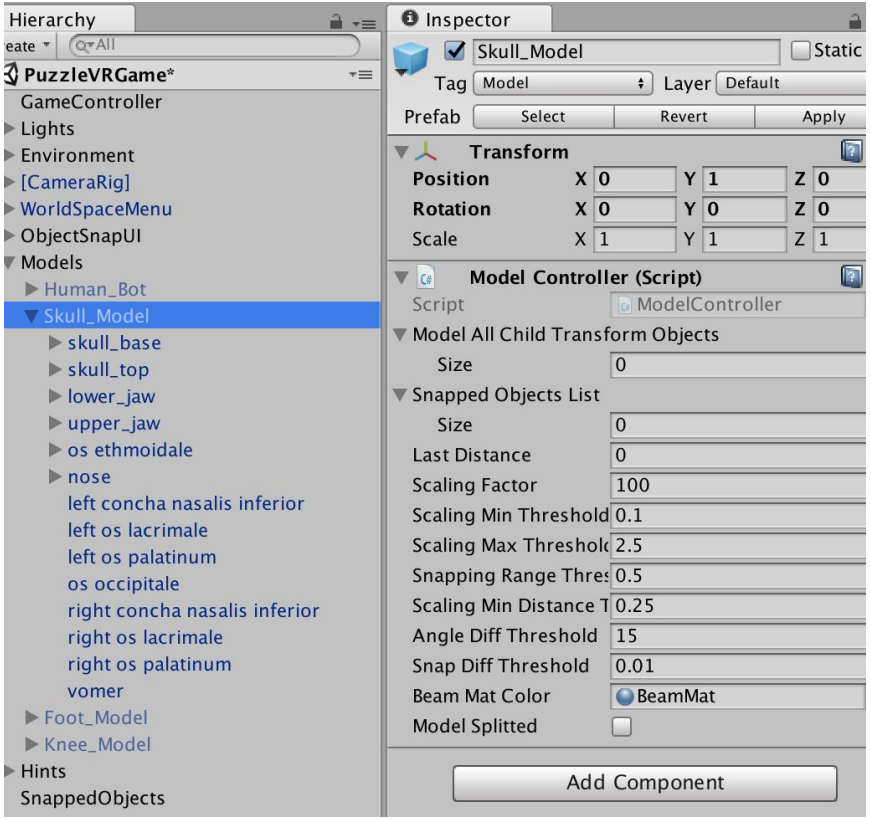




Models

Hierarchical

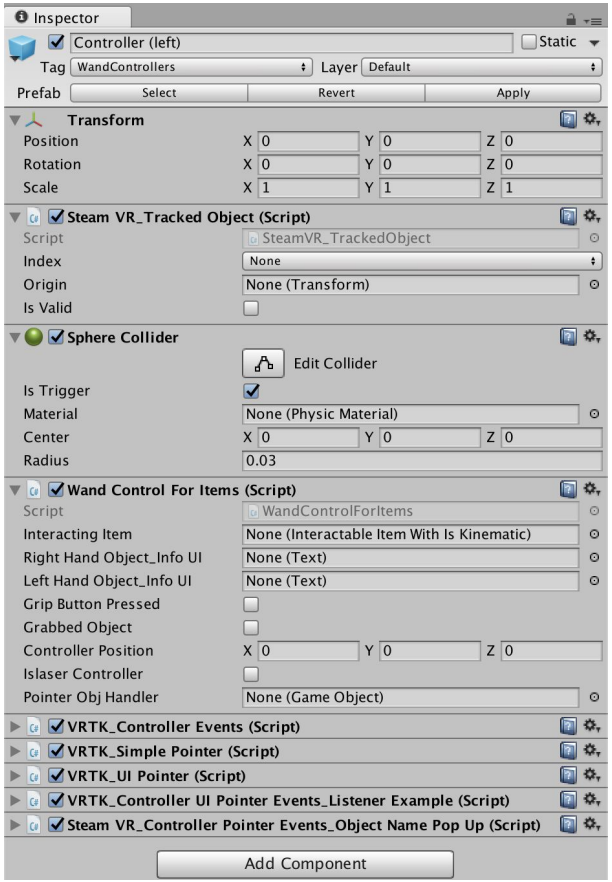
- Labelled objects
- Empty parents
- Transform set to <0,0,0>
- A script **<Model Controller.cs>**
- **Model** as “Tag”
- **Scaling** thresholds
- **List** of all interactable objects



Wand Controllers

Interaction

- A script **<WandControlForItems.cs>**
- One/Two handed interaction
- **Trigger** button to pick and drag object
- **Grip** button for scaling up/down
- **Pointer** from head of controller to the object
- **Label** on the pointed object



Evaluation

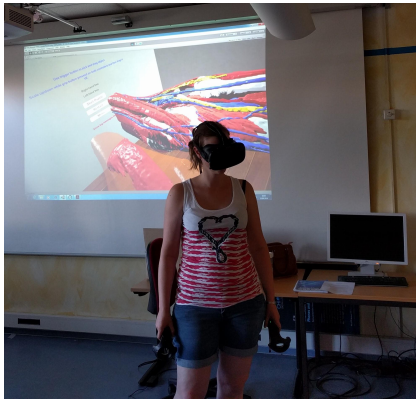
A pre-demo of prototype tested by Anatomist on 15th Sept 16

Positive feedback

1. Idea in VR is **beneficial**.
2. Moving around in VRE is **good**.
3. Basic interaction with model is **smooth**.
4. Scaling of model is **good.**
5. 3D Models are on **standards of anatomy**.

Negative feedback

1. 3D models have **too many parts**.
2. Explosion visualization is **complicated**.



Evaluation

Suggestions

1. Hints about the **controllers**.
2. Hints when two-objects can be **snapped**.
3. **Model** should be translated and rotated, before starting the puzzle.
4. Picking objects with **laser** would also be a good feature.
5. **Docking** points should be defined instead of relative distance calculation.

The suggestion 1 and 2 has been implemented after the evaluation.

Conclusion

General

- Using VRE to teach anatomy education can be a **potential** source of tool.
- No wait for **cadavers.**
- **Improves** learning curve.

Specific

- Using **relative distance** can cause instability in the snapping feature.
- **Direction** of objects in relation to each other is important as well.
- **No feedback** on completion of puzzle.

Future work

1. Add more **hints** about controllers.
2. **Tutorial** session.
3. Visualisation when two objects are close;
    - **Grabbed** objects color.
    - A **circular** beam for orientation.
4. Exploring model
    - **Translating** and **rotating** whole model.
    - **Press** and **hold** trigger buttons.
5. Picking far objects with laser
    - Same mechanism like in Main Menu.

Future work

5. **Docking** points can be defined
   - As part of each single object child and set to a specific position.
   - Trigger events can be used to check if the interacting object belongs to the docking point are not.
   - If it belongs, it can be connected using hinge joints.

6. **Direction** is an important factor in snapping while using distance and angle.

7. **Complete** puzzle feedback
   - Tracking the snapped objects status.

References

1. *F. Ritter et al., “Using a 3D Puzzle as a Metaphor for Learning Spatial Relations,” Proc. Graphics Interface 2000, Morgan Kaufmann, San Francisco, pp. 171-178, 2000.*
2. *F. Ritter et al., "Virtual 3D puzzles: A new method for exploring geometric models in VR," IEEE Computer Graphics and Applications, vol. 21, no. 4, pp. 11–13, 2001.*
3. *F.Ritter et al., “Virtual 3D Jigsaw Puzzles: Studying the Effect of Exploring Spatial Relations with implicit Guidance,” In Mensch & Computer, pp. 363-372, 2002.*

LIVE DEMO