Project Number: 3 项目编号：3

Project Title: Enhancing Spatial Fidelity in Virtual Reality: Adaptive Viewpoint and Scene Scaling for Improved User Comfort

项目名称：增强虚拟现实的空间保真度：自适应视点和场景缩放，提高用户舒适度

Project Clients: Dr Peter Wagner, Professor Juno Kim

项目客户Peter Wagner 博士、Juno Kim 教授

Project specializations: Software Development;System/game Development;Human Computer Interaction (HCI);

项目专长：软件开发；系统/游戏开发；人机交互 (HCI)；

Number of groups: 2 group

组数：2 组

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Background: 背景介绍

Head-mounted display (HMD) virtual reality (VR) has become an increasingly popular medium for immersive experiences, spanning entertainment, education, training, and rehabilitation. However, a significant proportion of users still experience discomfort that inhibits prolonged or repeated VR use. While much research has been dedicated to improving visual resolution and aligning visual simulations with postural positioning, an often-overlooked factor is the spatial alignment of virtual environments with real-world sizes and positions.

头戴式显示器（HMD）虚拟现实（VR）已成为越来越受欢迎的沉浸式体验媒介，涵盖娱乐、教育、培训和康复等领域。然而，仍有相当一部分用户在长时间或反复使用虚拟现实技术时会感到不适。虽然许多研究都致力于提高视觉分辨率，并使视觉模拟与姿势定位相一致，但虚拟环境与现实世界的尺寸和位置的空间对齐往往是一个被忽视的因素。

In interactive VR applications, spatial fidelity is crucial for haptic feedback and proprioceptive alignment. The perceived and actual positions of a user's body, limbs, and hands within the virtual environment must be accurately mapped to ensure a natural interaction. Unlike 2D environments, where size perception is predominantly influenced by visual cues, 3D environments require a careful calibration of both viewpoint projection and object scaling to match real-world user experiences. Misalignment can lead to discomfort, disorientation, and diminished presence, negatively impacting the overall VR experience.

在交互式虚拟现实应用中，空间保真度对于触觉反馈和本体感觉对齐至关重要。用户的身体、四肢和手在虚拟环境中的感知位置和实际位置必须准确映射，以确保交互自然。二维环境的尺寸感知主要受视觉线索的影

响，而三维环境则不同，需要对视点投影和物体缩放进行仔细校准，以符合真实世界的用户体验。不对齐会导致不适、迷失方向和临场感减弱，从而对整个 VR 体验产生负面影响。

Requirements and Scope: 要求和范围：

Develop a Unity VR application that enables real-time manipulation of object scaling and positioning within a scene.

开发一个 Unity VR 应用程序，可在场景中实时操作对象的缩放和定位。

Implement a customizable viewpoint projection centre that aligns with users' natural eye positions and field of view.

采用可定制的视点投影中心，与用户的自然眼位和视野保持一致。

Conduct user testing to evaluate the effectiveness of these manipulations

进行用户测试以评估这些操作的有效性

Provide an interface for users to fine-tune spatial settings accordingly

为用户提供界面，以便对空间设置进行相应的微调

Required Knowledge and skills:

所需知识和技能

Dynamic Spatial Manipulation: Enable real-time scaling and positioning adjustments of objects within the VR scene.

动态空间操作：可对 VR 场景中的对象进行实时缩放和定位调整。

Viewpoint Projection Centre Control: Implement adjustable viewpoint settings to match the user's natural visual perspective.

视点投影中心控制：实现可调整的视点设置，以符合用户的自然视角。

User Calibration Interface: Develop an intuitive UI for users to fine-tune spatial settings based on their physiology.

用户校准界面：开发直观的用户界面，以便用户根据自己的生理特点对空间设置进行微调。

User Data Logging & Analysis: Implement a system for collecting user feedback and interaction data to refine spatial alignment settings.

用户数据记录与分析：实施收集用户反馈和交互数据的系统，以完善空间排列设置。

Expected outcomes/deliverables:

预期成果/交付成果：

A fully-recompilable Unity VR project an necessary assets that allow dynamic spatial manipulation of objects and viewpoint adjustments.

完全可重新编译的 Unity VR 项目和必要的资产，允许对物体进行动态空间操作和视角调整。

Recommendations for integrating spatial customization features into commercial VR applications.

将空间定制功能集成到商业 VR 应用程序中的建议。