

### 3. “Young Russian Math” Contest – Summary (by Ilya Makarov)

The **object** of our research is a model of distortion for virtual space reducing simulator sickness in Virtual Reality Head-mounted displays (VR HMD). The **subject** of the research is the problem of mapping Virtual and Physical Reality under preserving of geometrical and perceptive constraints of locomotion in VR. We use machine learning, optimization **methods** and differential geometry notions for determining numerical conditions on mapping. We aim to **create** a model of first-person shooter video game, for which we aim to present a new model of movement wearing VR HMD. The resulting method requires real-time processing of arbitrary virtual 2D map and reconstructed floor map in a real world space under the following constraints (see [4]):

- Conformity;
- Local isometry;
- Global surjectivity;
- Exterior boundary constraints;
- Interior obstacle constraints;
- Relaxed local bijectivity;

Walking in a real world allows high immersion virtual reality applications than alternative locomotion, such as teleportation, illusion of relative motion and external controllers. One needs to take into account diverse variety of geometrical room constraints, such as walls and obstacles in the virtual and real worlds. We study an algorithm for matching a given local neighborhood of a player in a virtual world and reconstructed local area of a human in physical world. A 2D map between the virtual and physical room floor minimizing angular and distal distortions. We need to conform the virtual world locomotion and boundaries of the physical room navigable area. We study the idea suggested in [4] for the construction of such maps with global surjectivity in order to work for any virtual map, and local injectivity for obstacle-avoiding locomotion while maintaining disambiguation of user walking interface. Our main goal is to improve the suggested method allowing working only with local neighborhood in both, real and virtual world, which should allow real-time processing of any virtual and real world maps.

#### **Future Research Project**

We aim to construct a mapping of local neighborhoods of virtual player and real human navigable surrounding area in order to satisfy requirements for VR navigation and real-time processing of such an obtained distortion. Suggested in [4] geometrical and perceptual constraints leads to non-convex optimization problem with the lower bound NP for time complexity. Thus, we require relaxing some conditions, considering smaller navigable surroundings and solving the problem of synchronizing mappings while at least two persons are in the same area of sight. The theoretical problem in the current form is not solvable in real-time, while the practical importance of solving such problem has great importance to the modern systems of entertainment content delivery and new ways of storytelling. We aim to formulate new mathematical constraints combining practical purposes of such method with real-time algorithm of mapping virtual and real worlds.

#### **Possible Use in Educational Process**

The results of this project will be a topic for course and diploma projects while some results are already achieved by the students from the Faculty of Computer Science and the Faculty of Mathematics at NRU HSE.