VR Based Experiments on Crowd Evacuation

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1. Three phases of VR/AR development, VGE, VGExperience
2. Modeling and VR simulation of Crowd Evacuation
3. Concluding Remarks (VR for GISci and Society)
1.1 Three Phases of the VR development

Head-Mounted Immersive VR techniques for the public open a new VR era and a new virtual world.

2016 is the first year of VR/AR.

VR 1.0: Since 1950s; In 1956, Morton Heilig invented Sensorama (3D interactive devises); in 1965, Sutherland Published an article on “Ultimate Display”;

VR 2.0: Since 1990s; In 1989, Jaron Lanier in VPL Research Company, coined the term “Virtual Reality”;

VR 3.0: Since 2014? In 2014, Facebook acquired the Oculus company;
Pokemon GO, a AR based game developed by Nitendo and Niantics

The market value of the Nitendo company is less than 20 billion US $, and increased by 80% after a week of the game online, and in July 19, 2016, it estimated as 39 billion US $.

According to Survey Monkey, the number of active game players per day arrived at 21 millions US $.

According to VOA News on Nov. 12, 2018, the London's Imperial College Business School is using Holographic Technology to present lectures to Students.
1.2 Development of Virtual Geographic Environments

In 1997-1998, we (with Prof. Hui Lin) developed the concept of virtual geographic environments regarding the VR's impact on GIS and geography.

Virtual geographic environments refer to environments concerning the post-humans and 3-D virtual worlds, which can represent and simulate the geographic environments.

Since 1997-1998, a group of GIS scientists in China are persisting to the study on exploring VGE for about 20 years.

In October 14, 2017, a special committee of VGE in the International Society of digital earth was founded

National VGE Conference every 2 years in China
1.3 Virtual Geographic Experiences

VGExperience 1: immersive Interaction with a beautiful global earth (HTC Vive VR Head-mounted display)

VGExperience 2: immersive Interaction with a regional city (UAV based modeling, HTC Vive VR device)
VGExperience 3: immersive Interaction in a school and classroom (Oculus cv 1/ Gear VR)

AR-based VGExperience 4: Augmented Reality (Hololens MR)
Chances and challenges of VR GIS

VGE = VR + GIS

1. Sensing and cognition of a new space
2. Interaction (Body based, Motion Capture)
3. Mobile AR interaction and cognition

1. Content Production (3D data, Data Processing for VR, VR Video modeling)
2. 3-D data model and organization
3. VR realtime rendering (90 fps)
4. 3D Mapping of vectors in VR/AR
5. Big data processing and analytics

1. Geo-collaboration
2. Crowd computing and simulation
3. Public participating VR

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Based virtual geographic environments, we can conduct computing and **virtual geographic experiments** to explore geographic processes such as crowd evacuation in case of fires in inside buildings.

① **Social force** based modeling and simulation
② **Deep learning** based modeling and simulation
③ **VR experiments** based on social forces
④ **VR based collaborative** crowd evacuation for distributed multi-users
⑤ **AR based visualization** of crowd evacuation
2.1 Social forces based modeling and simulation

\[ m_i \frac{dv_i}{dt} = m_i \frac{v_i^0(0) e_i^0(t) - v_i(t)}{v_i} + \sum_{j \neq i} f_{ij} + \sum f_{iw} \]

The SFM consists of three components: a self-propelling force and two repulsion forces with other pedestrians and walls, respectively.

Findings: The result also shows that the impact of the accident was more serious when it occurred near the escalator exit than in the aisle.
Modeling, simulation and analysis of the evacuation process on stairs in a multi-floor classroom building of a primary school

Findings: A preferred layout is one where a building has classrooms with the same grade, so that blocking on the stairways is minimized, thus stabilizing the evacuation process.

Group behavior based social force model

Considering the avoiding behaviors among different social groups and the coordinate behaviors among subgroups that belong to one social group.
2.2 Deep learning based crowd evacuation

Agent

The theory is build an agent who has sensing ability and computation brain, the brain is a deep Q network. After the training of the Q network, the agent will get a reward when move a step. If the step is in right direction for evacuation, then the reward is higher. Using this method to implement the evacuation process.

Deep Reinforcement learning based evacuation simulation within a changeable and dynamic supermarket
2.3 VR experiment based on computing data by social force model (just for a single user)
2.4 VR based collaborative crowd evacuation for distributed multi-users

We design and develop a heterogeneous distributed virtual geographic environment for geocollaboration. Two types of distributed clients based on PC and all-in-one VR conduct the experiments of a fire evacuation drill in a subway.

2.5 AR based visualization of crowd evacuation based on 3-d printing school building
The future interesting and difficult research work in virtual experiments include:

① The relationships between social force model and deep learning model for crowd evacuation;

② The integration of the mathematical model based agents and the VR driving agents.

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Summary:

- Three phases of VR/AR development, VGE concept, examples of VGExperiences

- Two approaches of modeling (social force and deep learning) and VR/AR based simulation of Crowd Evacuation

With regards to the new information technology of VR/AR, big data, and artificial intelligence, some reflections about the future GIS, geography, and society.

In view of GIS, Development from Land Based to Human Centered GISci

GISci is involving in body-based sensing and interaction, virtual interaction and communication among people, as well as virtual social worlds.
In view of geography, **computing land-human relationships** need highlighted.

- Physical and digital Humans
- Physical and digital environments

**In view of the future of society:**

Virtual social geographic environments, virtual and real integration spaces and society, **post-humans**, and **virtual civiliation** are in incubation and evolving?

**VR/AR based worlds** will become important parts of **sustainable society**.

Liu Cixin: “I think VR will cause a revolution of human living state, it will lead to a second migration from the physical reality to future imaginary worlds.”

Thank You!

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