西南交通大学
Southwest Jiaotong University

Optimized Organization and Adaptive Visualization of Complicated Mountain Disaster 3D Scenes for Diverse Terminals

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Introduction

Research Background

- China is a disaster-prone country, and annual disasters made a significant losses of lives and property to the country. The construction of disaster 3D scenes has great significance for simulation, analysis, prediction and decision-making in disaster.

Flood Disaster

Debris Flow Disaster

Landslide Disaster

Mountain Disaster

.....

Characteristics of Mountain Disaster

- Burstiness and location uncertainty
- Short response time
- Complicated and dynamic scenes

Requirements of Disaster Visualization

- Real-time and efficient visualization
- Clear and intuitive expression
- Assisting decision-making and rescue

Introduction

Research Background

Complicated Mountain Disaster 3D Scenes

- Various geographical entities
- Multi-source information
- Large-scale 3D data amount

+

- Macro + Micro
- Virtual + Reality
- Nature + humanity
- Static + Dynamic
- Continuous + Discrete
- Indoor + Outdoor

Fusion Modeling
+ Visualization
+ Analysis

Diverse Terminals

- **Personal Computer**, desktop and laptop computer
- **Mobile device**, tablet and smartphone
- **VR/AR device**, mobile VR/AR and PC VR/AR

Optimized Organization and Adaptive Visualization of Complicated Mountain Disaster 3D Scenes for Diverse Terminals

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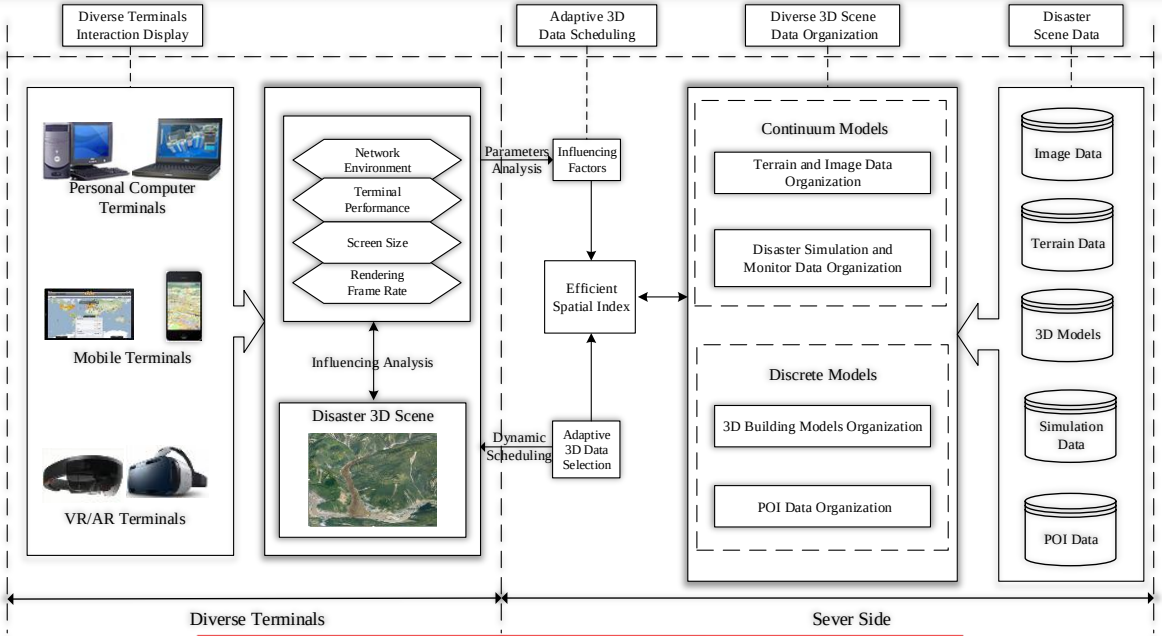
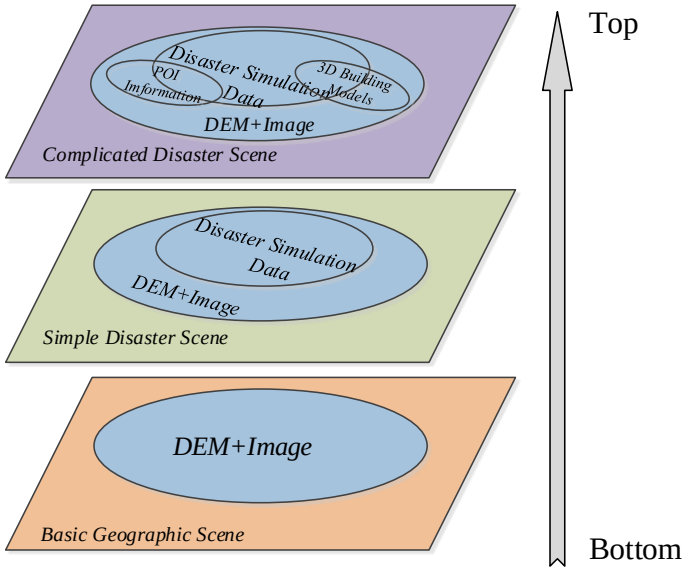
Optimized Organization and Adaptive Visualization Method

General Research Architecture

Complicated mountain disaster scenes usually contain image and terrain data, 3D building models, disaster simulation data, POI data and road models . So the optimized organization and adaptive scheduling of disaster scene data is the key point to the high efficiency and high quality 3D visualization of complicated disaster scenes for diverse terminals.



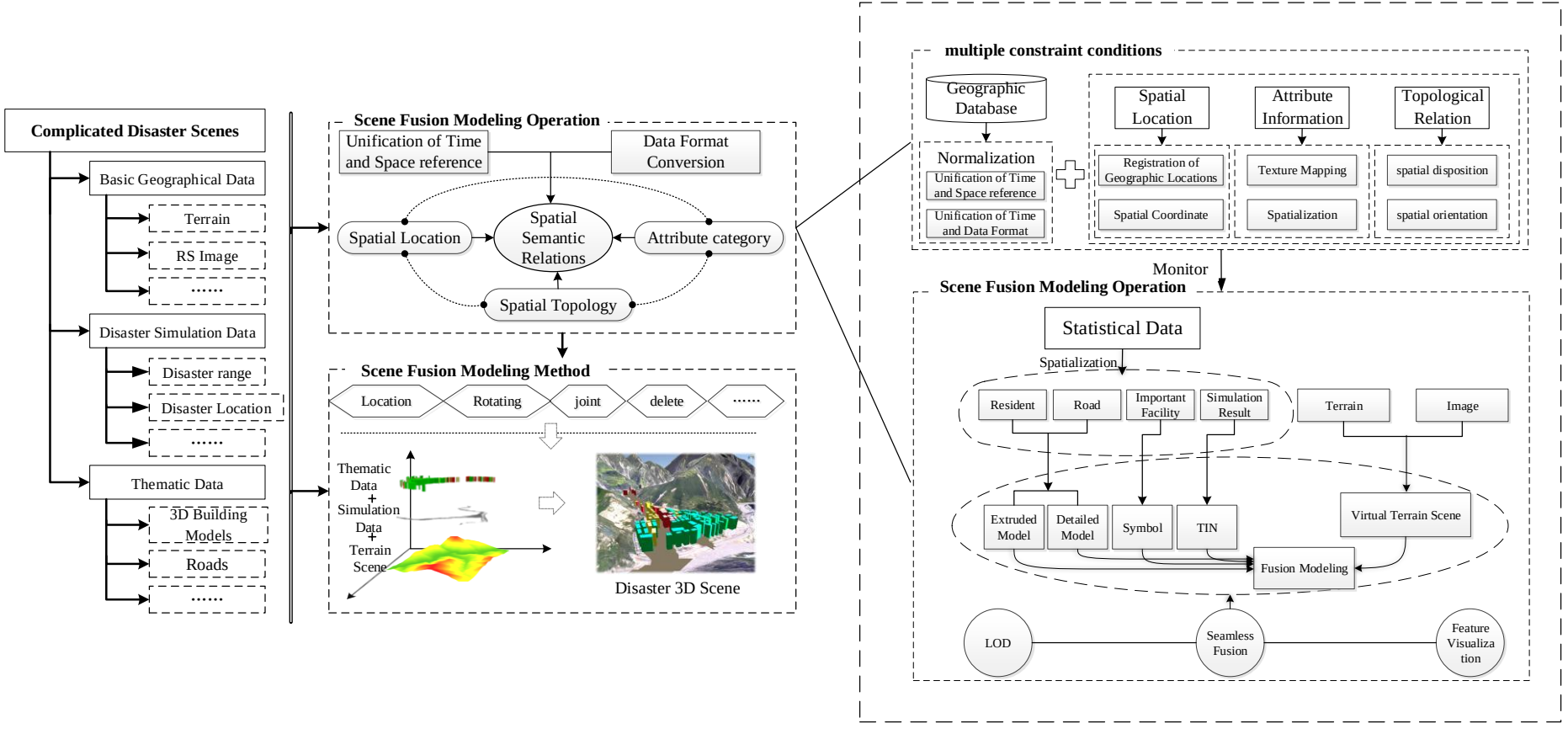
The General Architecture of Adaptive Visualization of Complicated Disaster Scenes for Diverse Terminals



Construction of Complicated Disaster Scene

Optimized Organization and Adaptive Visualization Method

Complicated Mountain Disaster 3D Scenes Fusion Modeling



Optimized Organization and Adaptive Visualization Method

Optimized Organization of 3D Building Models

Multi-level LOD Models

The detailed LOD *n*+1 model was hierarchically organized as LOD 0~LOD *n* hierarchical multi-texture resolution model. The texture of each LOD level of the model was reduced by 2×2 resolution. As the performance of terminals was decreased, the client could select lower texture resolution 3D model.

LOD 0(DSM)

LOD 1(blank texture)

LOD *n* (rough texture)

LOD *n*+1 (detailed texture)

Adaptive Quad-tree Division

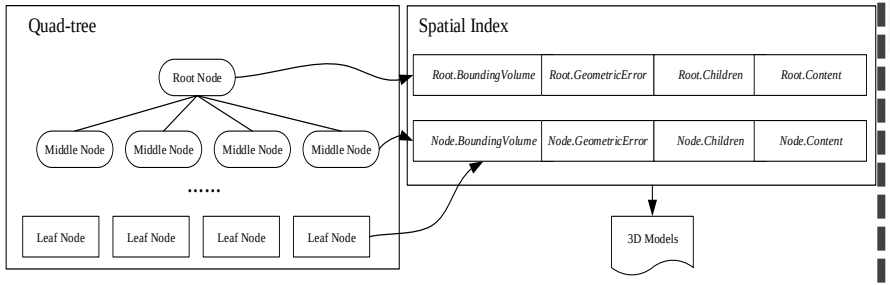
- Ensure the balance of the number of 3D models in each division region
- Avoid the 3D model at the edge of the 3D scene to be divided into different regions
- Maintain better topology and semantic information, and support the smooth transition of the multiple level of detail model.
- Maintain better global and local details, improve scene authenticity, and enhance visual rendering effect.

Optimized Organization and Adaptive Visualization Method

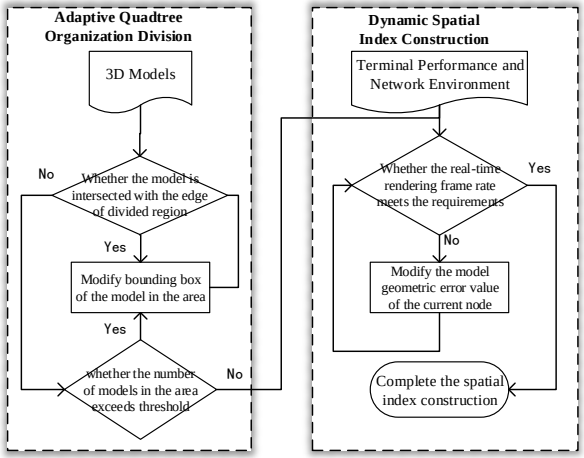
Optimized Organization of 3D Building Models

Attributes of Spatial Index

Attributes	Attributes Instructions
BoundingVolume	Defined Bounding Volume
GeometricError	Defined the Geometric Error When Rendering Current Node
Children	Defined Children Nodes Collections
Content	Define the Current Node Contents



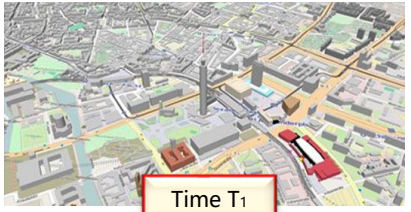
The Structure of Spatial Index and Quad-Tree Organization



Adaptive Quad-tree Organization Method

In the process of construction spatial index, the initial setting of the geometric error values in the index is determined by terminal type and network environment. The same geometric error value δ are set at the same level node of data, the relationship between the LOD level L and the geometric error value δ is shown in equation at bottom.

$$\delta_{L+1} = \delta_L/(\mathrm{L}+1)$$

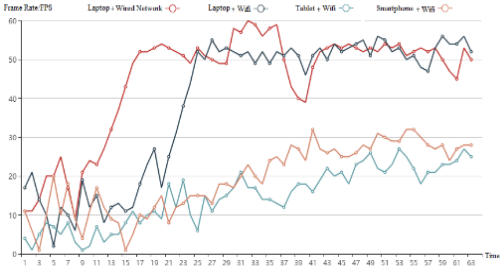


Optimized Organization and Adaptive Visualization Method

Adaptive Visualization of 3D Building Models

$$S(n,p,w,f,v)=\sum_{i=0}^{n-1}\left(\mathrm{LOD}i\times A_i(p,w,f,v)\right)$$

- The S function represents the overall 3D scene on the terminal;
- the parameter n represents the LOD level of 3D model;
- the parameters p, w, and f respectively represent the influencing factors of the adaptive visualization including the terminal performance, network environment, and the real-time rendering frame rate; the parameter v represents the current viewpoint information;
- the LODi represents 3D scene consisting of multi-level LOD hierarchy models; $A_i(p,w,f,v)$ represents the data proportion of the overall 3D scene with the LOD level i



		LOD0	LOD1	LOD2	LOD3	LOD4	LOD5
Laptop Computer	Texture Resolution	256×256	128×128	64×64	Blank Texture	×	×
	Geometric Error	150	75	50	37.5	×	×
Tablet	Texture Resolution	256×256	128×128	64×64	32×32	16×16	Blank Texture
	Geometric Error	90	45	30	22.5	18	15
Smartphone	Texture Resolution	256×256	128×128	64×64	32×32	16×16	Blank Texture
	Geometric Error	60	30	20	15	12	10

Optimized Organization and Adaptive Visualization Method

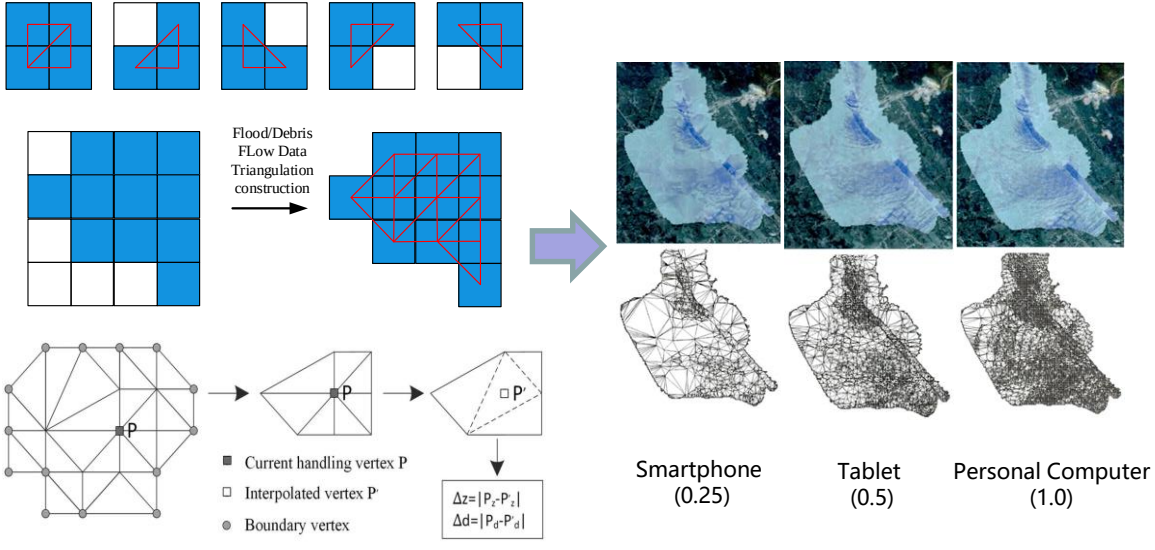
Optimized Organization and Simulation of Flood and Debris Flow Scene

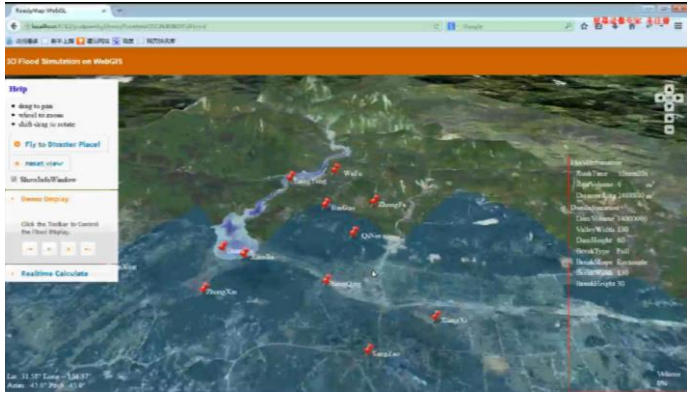
➢ **Real-time Simulation for High-performance PC**

Enable users to set simulation parameters on a client computer, these parameters are real-time submitted to the server and the output data are then synchronously transmitted to the client computer

➢ **Offline Simulation for Mobile Device**

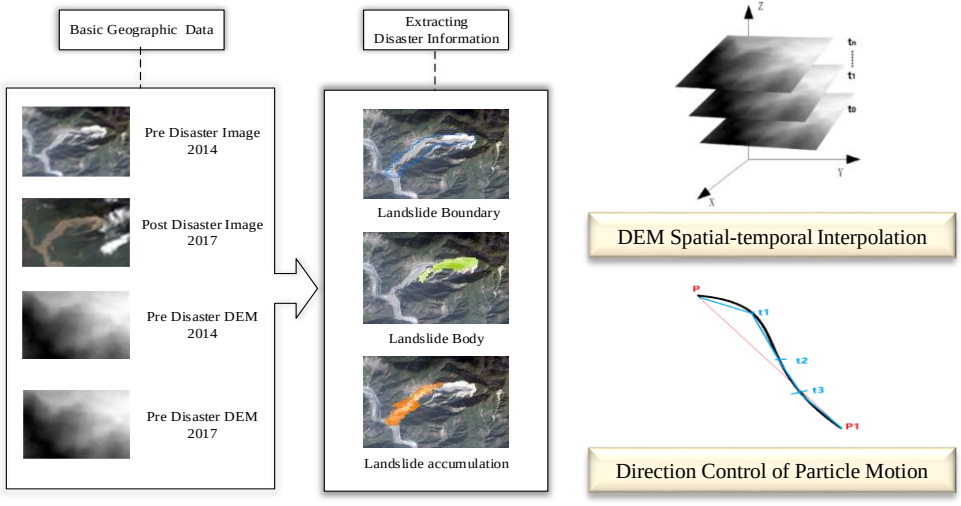
The server precomputes several common simulation and stores the precomputed data as a time series of multilevel debris flow surface models.

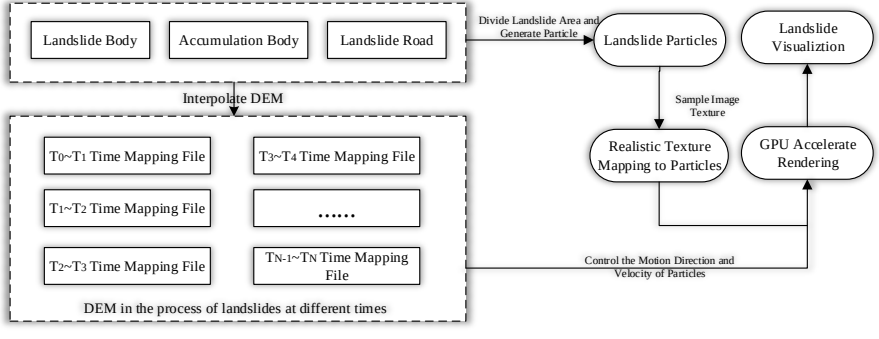




Optimized Organization and Adaptive Visualization Method

Optimized Organization and Simulation of Landslide Scene





- Extract the landslide boundary, body and accumulation body based on imagery and terrain data
- The landslide simulation results are interpolated to generate the spatial-temporal data and get DEM in the process of landslides at different times
- According to terminal's type to determine the size of divided landslide particles
- Use realistic texture mapping to enhance the reality of scene

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Visualization Experiments and Prototype System Implementation

Visualization Experiments

We chose the flood as typical mountain disaster and selected three types of devices as terminals for experiments. In the experiment, laptop was respectively connected to 4M bandwidth wired network and WIFI network, tablet and smartphone were connected to a 4M bandwidth WIFI network for experiments. According to performance and screen size of terminal, the rendering frame rate threshold of the laptop is 40 FPS, tablet is 25FPS, smartphone is 25 FPS.

	CPU	GPU	RAM		LOD0	LOD1	LOD2	LOD3	LOD4	LOD5	DOM	DEM	Flood (△d, △z)
Laptop Computer	Intel Core i7/2.6 GHZ	NVIDA Geforce960M	16 GB	Texture Resolution	256×256	128×128	64×64	Blank Texture	×	×	256×256	64×64	1
				Geometric Error	150	75	50	37.5	×	×			
Tablet	iPad A8/1.5 GHZ	Power VR SGX544	2 GB	Texture Resolution	256×256	128×128	64×64	32×32	16×16	Blank Texture	128×128	64×64	0.5
				Geometric Error	90	45	30	22.5	18	15			
Smartphone	iPhone A9/1.8 GHZ	Power VR GT7600	2 GB	Texture Resolution	256×256	128×128	64×64	32×32	16×16	Blank Texture	128×128	64×64	0.25
				Geometric Error	60	30	20	15	12	10			

Visualization Experiments and Prototype System Implementation

Visualization Experiments Results and Prototype System Implementation

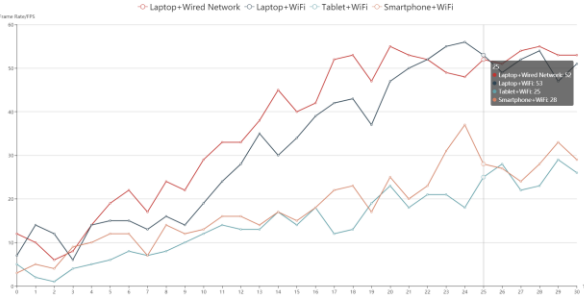
Laptop(far viewpoint)

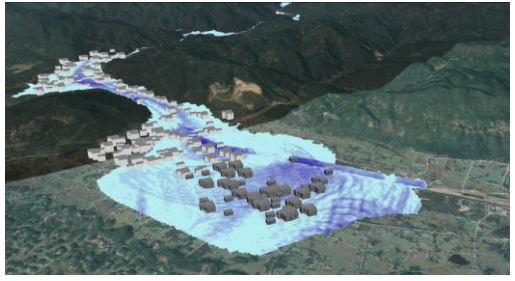
Laptop(medium viewpoint)

Laptop(close viewpoint)

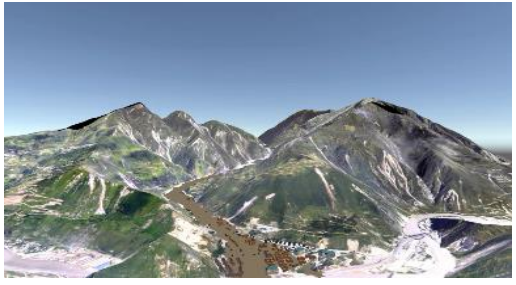
Smartphone

Tablet

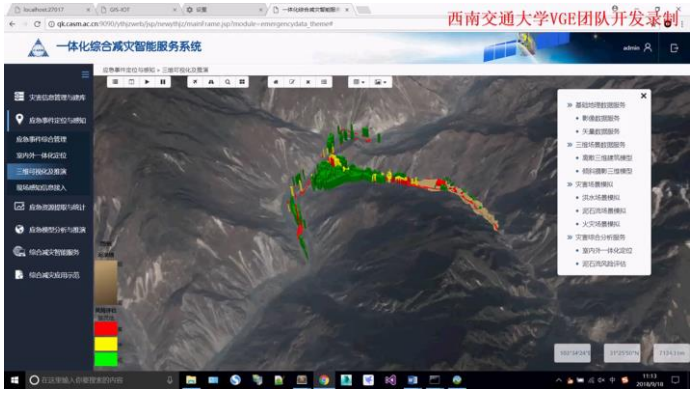




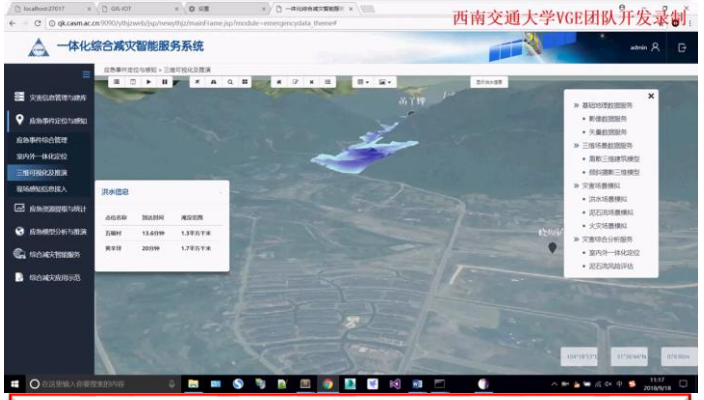
Flood Disaster Scene



Debris Flow Disaster Scene



Risk Assessment Analysis of Debris Flow Disaster

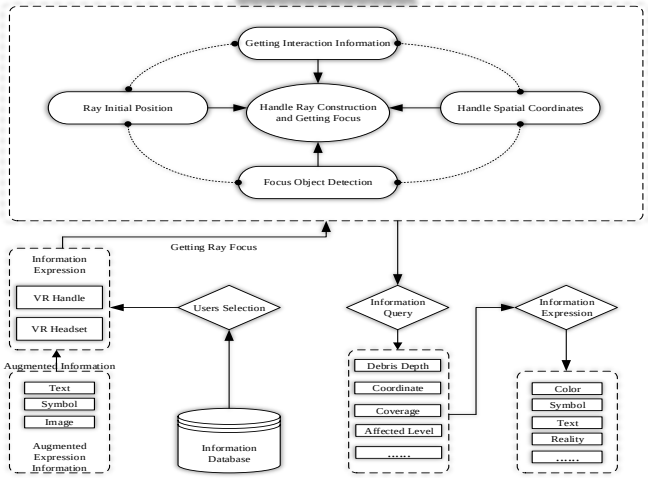


Inundation Analysis of Flood Disaster

Visualization Experiments and Prototype System Implementation

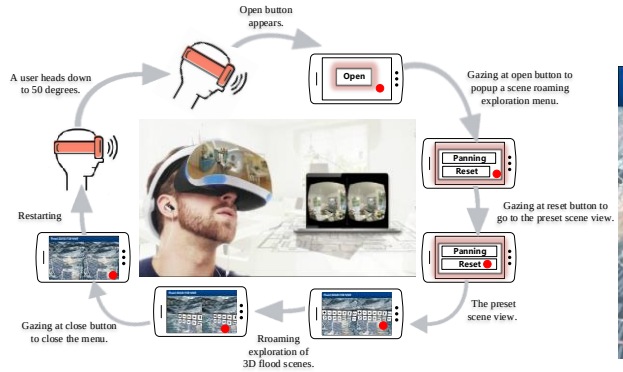
Interaction Method and Prototype System Implementation on VR Terminal

PC VR



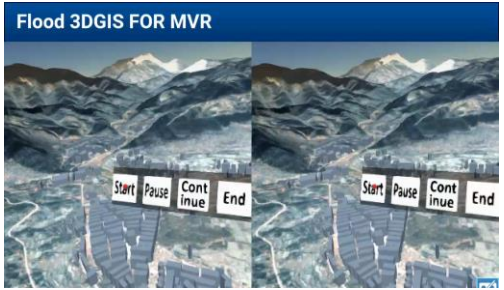
Interaction and Analysis Method Based on Handle Ray

Mobile VR



Interaction and Analysis Method Based on Gazing

Interaction on Mobile VR



Flood Simulation and Visualization on Mobile VR

Analysis on Mobile VR

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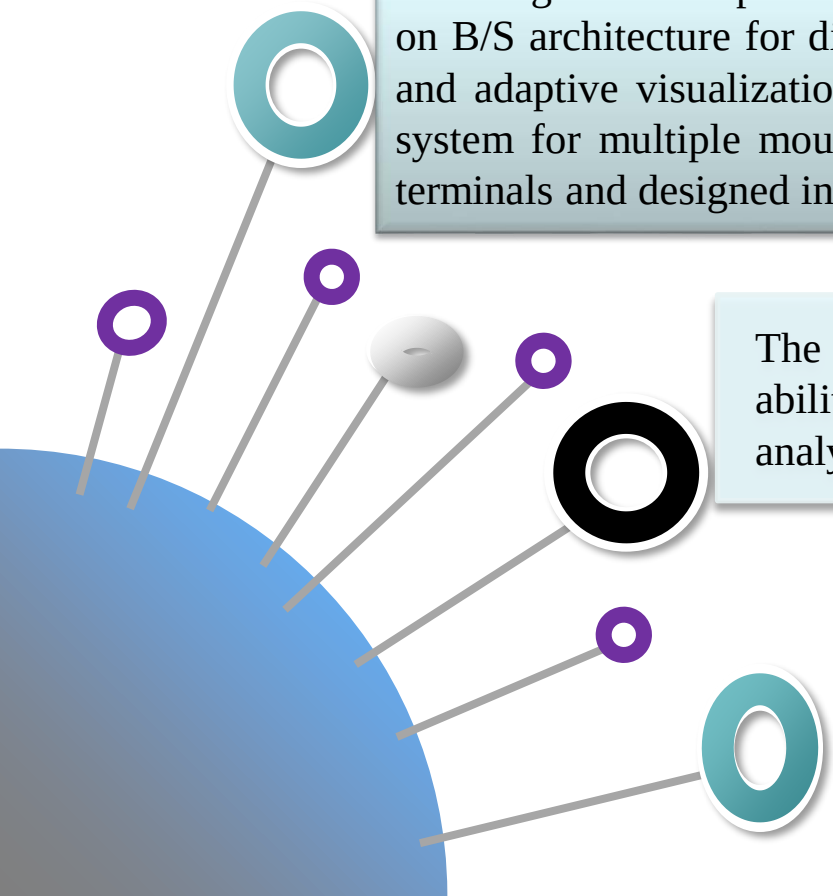
Conclusions and Future Work

We designed an adaptive visualization of complicated mountain disaster scenes based on B/S architecture for diverse terminals, and researched the optimized organization and adaptive visualization of typical disaster scenes data. We developed prototype system for multiple mountain disaster scenes visualization and analysis on diverse terminals and designed interaction method for PC VR and mobile VR.



The next step we will be to improve the prototype system's ability to process large amounts of 3D data and develop more analysis function.

The next step we will be to research more disaster, not only mountain disaster but also fire disaster, traffic accident, earthquake, building collapse and so on.


Thank you !