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AN EXPERIMENTAL INQUIRY INTO THE USE OF VIRTUAL REALITY IN THE DESIGN PROCESS FOR HYDRAULIC EQUIPMENT

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Abstract
Hydraulic engineering aided design is analysed through the use of simulation and VR technology, including the creation of a three-dimensional simulation prototype of a structure, the development of a design knowledge base that includes design criteria and an optimization strategy, and the exploration of human-computer interaction. In order to achieve 2D and 3D CAD drawing, construction simulation, and engineering quantity computation, a hydraulic engineering assisted design platform is built in accordance with the design flow of hydraulic engineering.
Keywords: Virtual Reality, Aided Design Platform,Simulation, Hydraulic Engineering.

1 Introduction
Most hydraulic projects are situated in wilderness areas characterised by a wide range of topographical, geomorphological, geological, hydraulic, and other environmental characteristics. The inherently complicated nature of hydraulic project design, the need for large amounts of labour and energy in the design process, and the absence of an efficient supporting platform [1] are all exacerbated by the fact that most hydraulic projects use different methods for designing their projects. Research into digital hydraulics is gaining momentum with other related fields like as virtual reality, GIS, 3D data visualisation, and object-oriented design and programming. In reality, the vast majority of them prioritise third-person exposition over the development of third-person settings. On the one hand, these features are useful in project accounting and presentation, but on the other, they are mostly irrelevant in the development of hydraulic projects and the provision of project safety guidance [2]. While some studies expand on the foundation of foreign large-scale 3D software, propose 3D parameterized equity design techniques, and attempt to apply them in practise, others give little thought to the parameterized prototype design techniques of hydraulic project objects, the conceptual design involved in contemporary design, or the assisting simulate-platform for hydraulic project design[3]. In the study of virtual environments for simulating the Yellow River, for instance, the system developed by Liu Guifang et al. takes full advantage of the benefits offered by both three-dimensional scenery and two-dimensional maps, combining the former's readability and realism with the latter's macro-based properties, integrities, and compactness. In truth, its primary function today is still the evocative description of settings. Virtual simulation systems for large-scale flowing area scenery are the subject of a vast number of studies [4]. Their primary interests are in real-time drawing, visual modelling — specifically, simulating the movement of water — and the online dissemination of large-scale topographic sceneries that include moving water.

2 System frame design

The hydraulic project simulation platform incorporates the five parts: 1) virtual simulation environment, 2) knowledgebase management, 3) interactions between person and computer, 4) assisted design, 5) optimization and simulation of design decisions. The structure of the platform is shown in chart 1. In the chart, the virtual environment part is responsible for the construction, storage and rendering of the three-dimensional scenery. Knowledgebase management contains the functions of entering, storing, retrieving and inferring of the knowledge. The interactions part encompasses the display of the real-time rendering results of the virtual scenery, the exposition of the model information, management for the establishing of scenery and entering of the project parameters. The assisted design part practices related calculations and design of the hydraulic project according to the project environment, entered parameters and creates the three-dimensional models of the dam and its affiliated constructions dynamically. The platform system frame is in Figure 1.sluice, station building, water retaining building 3D model.

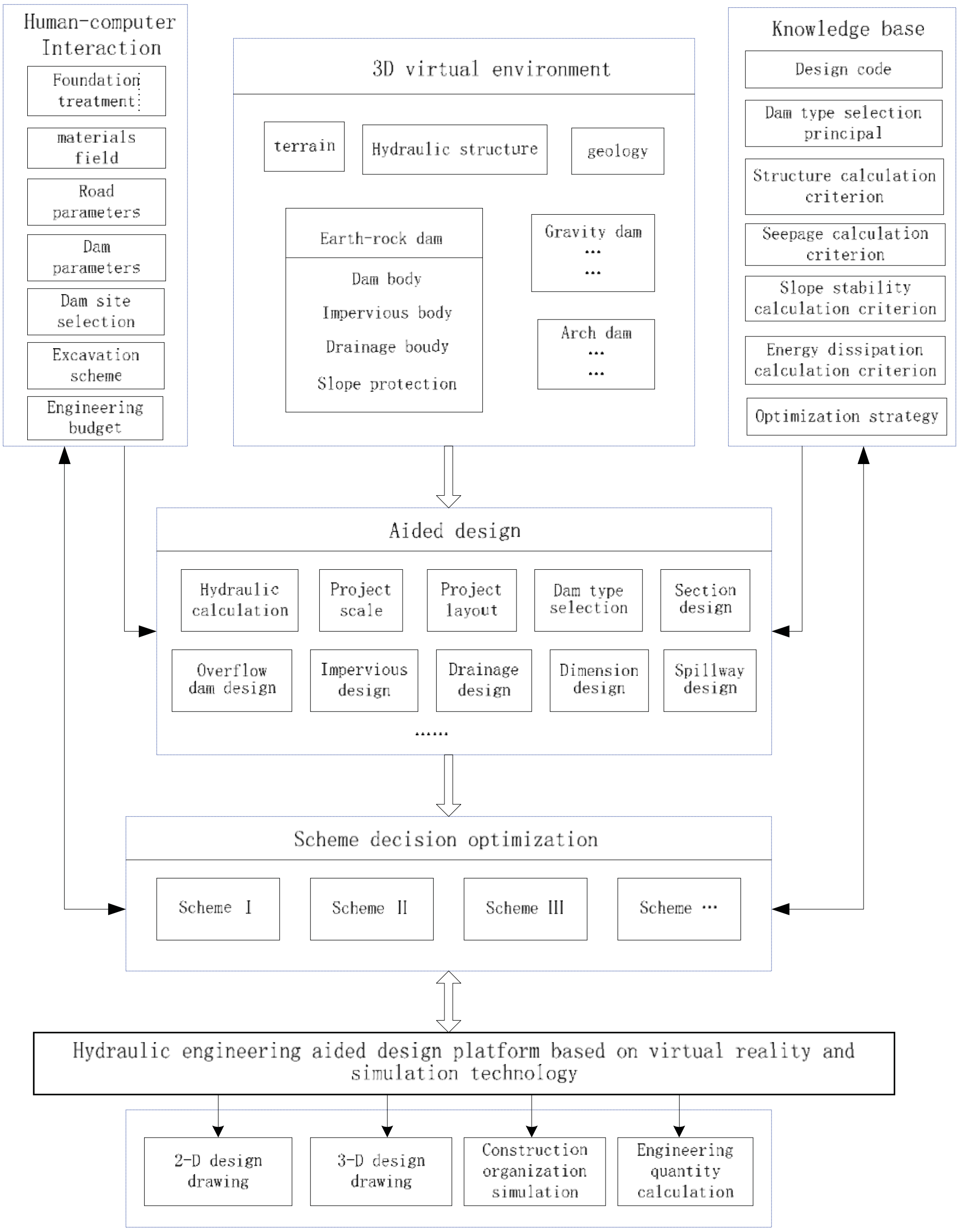

Fig.1. Aided Design Platform System Frame.

3 Technology of hydraulic engineering designbased on virtual reality

3.1 Hydraulic engineering virtual environment

Hydraulic engineering virtual environment is the digital representation of real engineering environment in the computer. As to facilitate visualization integration operation, virtual environment model requires all true 3D models, including topography, geological structure, geographical landscape of virtual geology environment, also includes 3D model of buildings which are mainly for building a prototype system, providing the initial prototype for the latter part of artificial interaction design, including embankment, spillway, sluice, station building, water retaining building 3D model. Model not only includes geometric size, texture and other visual attributes, but also contains engineering computation attribute for material, density, mechanical.

1) The virtual simulation environment of terrain andgeology

On the classification of objects in virtual scene modeling, geological 3D model uses Hierarchical Subdivision of triangular to mesh structure geological attribute information storage according to the region, and according to the needs of three-dimensional visible or engineering calculation to schedule real-time and to generate a local model details. Terrain information use the DEM data and remote sensing of holographic image to make the LOD model automatically. Natural scenery is introduced by artificial construction. In view of the key problems of hydraulic engineering

visualization design, study the rapid modeling method and constraint model of the components like the geometry of virtual terrain, geological structure, geographical landscape, construction site, station building, and water retaining building. Based on the research of virtual component modeling, the technology of connection and assembly, solve the key technical problems of hydraulic engineering design visualization model. The virtual simulation terrain environment is in Figure 2.

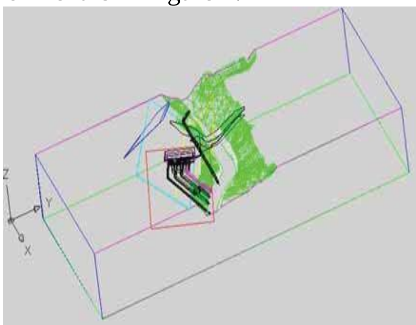

Fig.2. Virtual Simulation Terrain Environment

2) 3D simulation prototype model of the dam

The conventional dam involves the earth-rock dam, gravity dam and arch dam in the hydraulic engineering design, and the earth rock dam involves core earth-rock dam and oblique earth-rock dam. The master node of the dam includes dam, anti-seepage body, drains, slope, dam, spillway, dam road, overflow type, spillway, corridor and other model child nodes,and these nodes with multiple attributes are modified by the knowledge base to initial value and artificial interaction design. There are four parts in the procedure, such as, ① the prototype parameters semantic model construction ② the driving mechanism of model parameter ③ spatial structure ④Third-party software to build the 3D model for hydraulic project.

3.2 hydraulic engineering design knowledge constructions

Dam hydraulic engineering knowledge， which meets theneed of problem-solving about dam's site and type selection and in the process of dam's designing and constructing, is an interconnected knowledge piece collection which is stored, organized, managed and used in computer by way of some knowledge representation. These knowledge-chips include both the hydraulic engineering field related to theoretical knowledge, factual data, and contain heuristic knowledge by practical experience. Building Hydraulic Engineering Knowledge needs systematic collection and collation and classification preservation of the existing hydraulic information and knowledge in accordance with some methods, which would provide efficient retrieval or call means. The main contents include the expertise of guidelines and optimization strategies of the programs in the part of the hydraulic project design. According to the project scale, identified design code; established dam design criteria, dam type selection principles, structure calculation criteria, seepage calculation criteria, slope stability calculation criteria, energy dissipation

calculation criteria, and optimization strategy, etc. Knowledgebase of calculation results can be compared and interactively provides design choices.

3.3 Interactive virtual design and simulation

Interactively, using the optimization strategy in the knowledge base, make comprehensive analysis of the schemes in the aspects of engineering quantity, project investment, project cycle, construction difficulties, weather and management and maintenance to identify the best design. In addition, use virtual simulation technology to make preview emulation of the engineering complex degree, the engineering construction, construction scenario and completion scenario, and simulate the general construction organizations of the best design.

1) Study on interactive virtual simulation

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The core of "Hydraulic engineering aided design platform" is through the simulation of hydraulic projects, establishment of water project construction and operation of three - dimensional, dynamic, real-time, virtual visual simulation environment, to enable project participants to this environment intuitive and clearly to see the project totally or partially, dynamic or static, in the course of history or reality, and future real - world scenarios, requirements set forth their views, and can find out all kinds of information. Decision- making level can also be in the shortest possible period of time to get the most up-to-date and accurate information, so that the event to make quick judgments about the future and take appropriate countermeasures. For foundation treatment, materials field, road parameters, dam parameters, dam site selection, excavation scheme, engineering budget interaction.

2) Aided design

Hydraulic calculation, project scale, select the appropriate design standards, based on topographic - geological circumstances determine the layout of human - computer interaction, dam type selection, dimension design, impervious design, drainage design, overflow dam design and spillway design. The aided design procedure is shown in Figure 3.

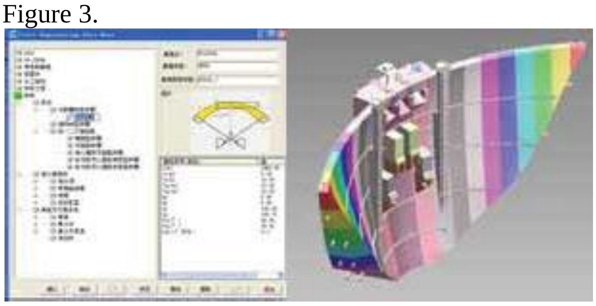

Fig.3. Aided Design Procedure.

3.4 Scheme optimization and simulation

For multiple trial design for quick results, and by means of human - computer interaction, in the knowledge base of comprehensive utilization of optimization strategies to optimize multiple programs for comprehensive analysis and rapid implementation of virtual simulation comparison, so as to determine the best design and simulate multiple scenarios of engineering construction, optimize overall construction organization design scheme. The virtual dam is shown inFigure 4.

Fig.4. Virtual Dam

3.5 Software Development

This Software is developed by using object-oriented development model based on Component, the development environment is Visual C++.NET. The system consists of three-layer structure: data access layer, business logic layer, and the presentation layer. The design is based on interface between layers; the module is realized by dynamic link library. Data communication is realized by shared memory or pipe. The PostgreSQL9 is used to store the spatial data and business data of the data access layer, The 3D model data is stored in Open Flight format, The exchange documents of computer-aided design use the general format of STEP; consistent access interface is designed according to the different functional requirements on the business logic layer, different implementations can be dynamically loaded and replaced; The three-dimensional scene model is managed by three-dimensional graphics application library OpenSceneGraph on the presentation layer, then the interaction pretention design is realized based on WinForm. The graphical representation method is researched in the STEP standards, and the B-rep in the neutral file is analyzed. The STEP feature extraction system, including the entity information extracting module and the entity information

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processing module, is designed by researching the geometric information and the representation of the topology information. A complete and consistent description about the product data in the product life cycle and data exchange are realized by researching the data exchange technology of the complete product model. So that without human interpretation the information can be shared and received directly by the application system, and Cross-platform design and data exchange would be realized.

4 Conclusions

This project uses virtual simulating technologies to implement assisted design and simulation throughout the entire hydraulic project design process, from establishing the three-dimensional prototype to building a knowledgebase based on design rules, calculating rules, and optimising strategies. Finally, it implements the assisted hydraulic project design with the interactions between people and computers being referred to in order to realise optimization of design decisions. The initiative has the potential to significantly enhance the effectiveness of hydraulic project planning and development.

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