Intelligent Three-dimensional Layout Design of Video Cameras in Substations

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Abstract. To solve these problems of unjustified installation, high cost, poor monitored effect, we develop three-dimensional layout design software of video cameras in substations. The key techniques, interface and functions of the proposed design system are introduced. The application to 220kV Ciwu intelligent substation of State Grid Sichuan Electric Power Corporation has shown that the design is effective and reasonable.

Introduction

Most substations of electric power corporations are guard-free. These cases promote extensive application of video monitoring systems and power environment monitoring system. Usage of video monitoring systems has been changed from simple security to monitor status of power system. Because the design aim of old video monitor sub-systems of substations is single, the video monitoring sub-systems only meet simple security, which miss monitoring on the status of main electric devices. In addition, video monitoring sub-systems are not enough, located inappropriately, often out of order and need be repaired extremely after 2-3 years [1]. Hence, it is very important to make a feasible platform to assess, simulate and rectify the number, location and blind angle of cameras and gyration devices installed in substations accurately before cameras are installed in substations [2].

Generally, there are three problems in video monitoring sub-systems of substations [3, 4].

(1) Distribution of video cameras is unsuitable. Several important areas are not covered. Function of video monitoring sub-systems is single. These video monitoring sub-systems only meet simple security function and don't meet the manufacture requirement of immediate diagnosis for abnormal cases which usually happen on substation devices and active prevention for accidents.

(2) According to the requirement of electric power corporation, normal cameras installed in substations are not enough. It is hard to meet actual requirement by designers' experience of arranging stationing location. Hence, auxiliary software for stationing design is desired.

(3) Designers, dispatchers and maintainer know less about actual situation. Traditional wiring diagram and plan figure don't provide necessary description of actual physical locations of substation and relations between devices for staff in new situation.

To solve these problems including unjustified installation, high cost, poor monitored effect which arise in existing intelligent substation, conventional substation, video camera and gyration device located in new substation of electric power corporation, we propose three dimensional design to intelligent auxiliary system of guard-free substation. The system is able to provide designers and maintainer a visual camera and a system of stationing evaluation for dynamic loop device before Installation and construction. Based on the system, staff can design an approving stationing plan.

Intelligent Auxiliary System

The three dimensional intelligent stationing design systems is integrated into synthetic monitoring platform of substation in manner of loose coupling. Synthetic monitoring platform of substation is composed of local intelligent auxiliary platform, video processing unit, environment processing unit, and camera along with attachments, power environment monitor sub system, fire protection sub system, access control sub system, light control sub system and security guard sub system. The physical structure is shown in Fig. 1.

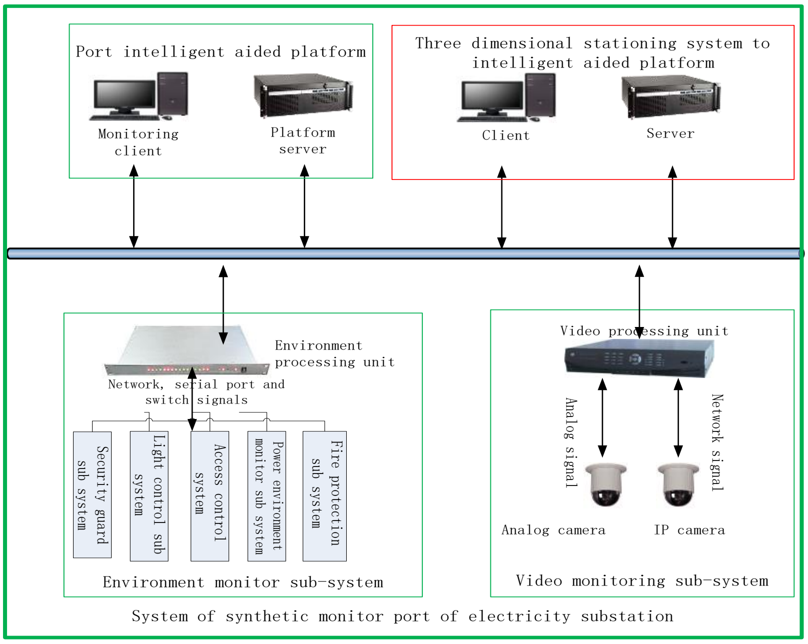


Figure 1. Structure of synthetic monitor local of substation

Local Intelligent Auxiliary Platform. Local system interacts with every level of central platform by local intelligent auxiliary platform. Information exchange of video controlling is based on SIP protocol. Data exchange of media is based on RTSP/RTP protocol. Information exchange of environment monitoring use 104 protocol [5].

Video Monitoring Sub-system. Video monitoring sub-system is composed of video processing unit, high-definition IP camera, standard definition IP camera, high-definition simulation camera, and control attachments and transmission attachments of every type of camera.

Video processing unit, which is the core of video monitoring sub-system, serves as a connecting link between the preceding and the following. It receives the control command sent by local intelligent auxiliary platform and sends videos to local intelligent auxiliary platform. In addition, it manages input and code of the front video and transmission, storage and control of video and audio by communicating with the front camera based on ONVIF protocol [6-8].

Both video processing unit and IP camera are connected to network switch [9, 10]. Video processing unit exploits Ethernet to manage cameras and transmission and control of videos.

Environment Monitoring Sub-system. Environment monitoring sub-system is composed of environment processing unit, security guard sub-system, light control sub-system, access control sub-system, power environment monitor sub-system and fire protection sub-system.

Three Dimensional Design of Intelligent Auxiliary System

Local intelligent auxiliary platform is integrated into three stationing design in manner of loose coupling. All aspects of management service, streaming media service and client local are involved. The system supports business integration and process reengineer of intelligent auxiliary system. Based on the system, significant breakthroughs have been made in these aspects such as three dimensional simulation presentation, visual three dimensional routing inspection, intelligent stationing analysis, etc. The details are shown in Fig. 2.

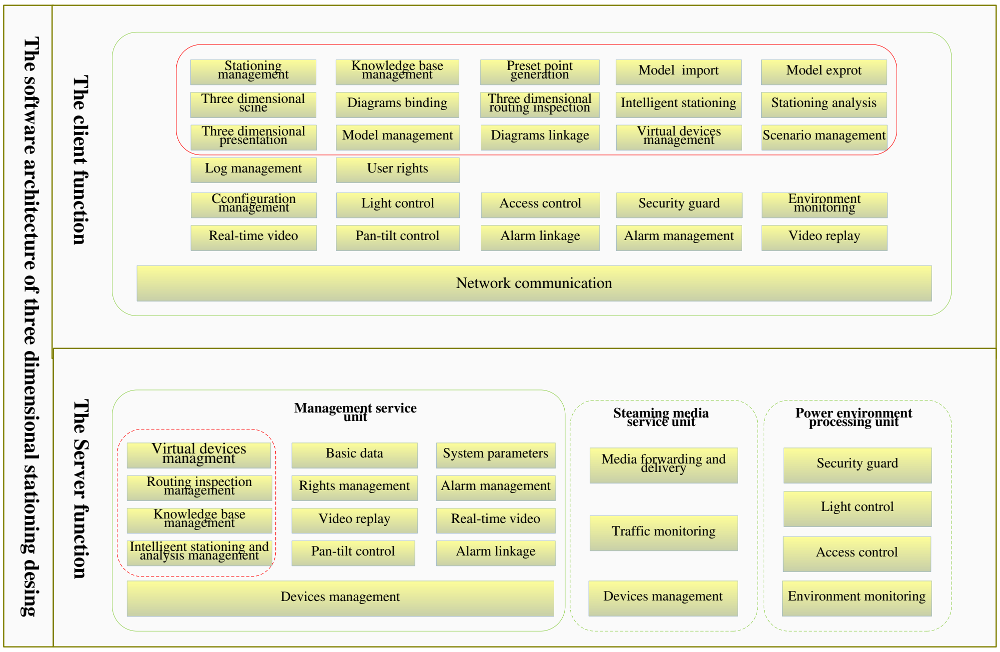


Figure 2. The software architecture of three dimensional stationing design

More services such as virtual devices management, routing inspection management, knowledge base management and intelligent stationing and analysis management are added to management service component. In addition, a number of functions are integrated into client side. These functions are import and export of model, three dimension presentation, diagrams binding and linkage, virtual devices management, scenario management, stationing platform management, model management, knowledge base management, intelligent stationing and analysis, etc.

Key Techniques. The system is based on local intelligent auxiliary platform of substation. The study focuses on camera intelligent stationing technology based on three dimensional simulation. In practice, we select Unity 3D and Qt as development tool and select AutoCAD 2014 as three dimensional model software.

According to existed two dimensional CAD diagram, we use three dimensional technology to model all service buildings located in substation, one-off devices including poles, transformers, switches, knife gates, etc., two-off devices including oil thermometers, Winding thermometer, etc., device room, master control room, relay room, high-pressure room and capacitor room.

Three dimensional scenario simulates all devices in substation well, which provides an operation platform for three dimensional real-time monitor and three dimensional virtual stationing.

According to related parameters of camera including the size of photoreceptor, focus length, etc., we simulate the monitor area of camera in the three dimensional scenario. Simulation parameters include focus length, zoom lens, resolution, rotation angle, light intensity, etc. We are able to control virtual pantile and add preset location based on these diagrams of shining area of virtual camera and monitor area of camera presented by analyzing parameters of camera based on optical theory.

In three dimensional scenario, the monitored objects are graded by monitor grade. System selects a camera in best location to generate preset point automatically by location of the monitored object. The preset point is represented by rotation angle which is composed of three coordinates x, y and z. The monitored objects include one-off devices such as transformer, high pressure reactor, circuit breaker, disconnecting switch, ground switch,35 kV parallel reactor(Oil type and dry type), 35 kV capacitor bank, etc., and part of two-off devices.

The generated preset point associates the monitored object automatically. Users can simulate to operate one-off device. The system can link the preset location of selected camera in time and then turn on virtual video and display the status of device.

When users select current device in three dimensional scenario, the system can locate the linked device automatically through 3D navigation table. Users may determine whether the system is asked to locate the linked device automatically through 3D navigation table. The implemented functions are shown in Fig. 3.

Figure 3. Location of device based on 3D navigation table

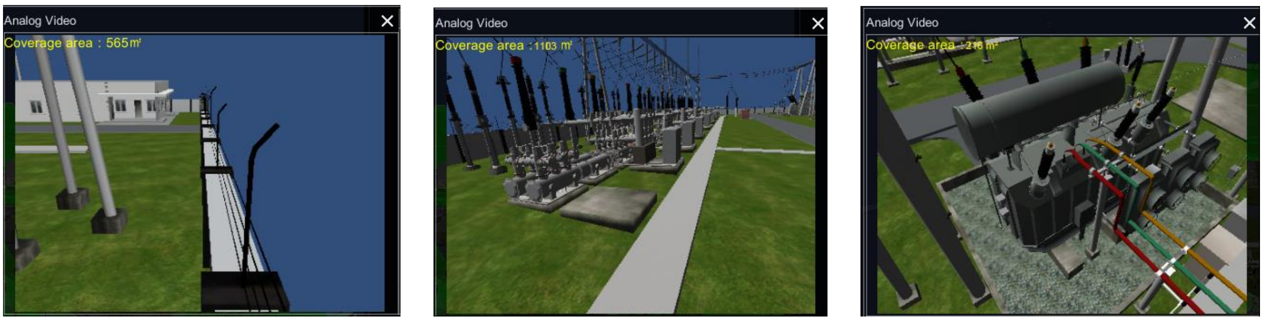
Interface Platform. To support efficient operation and Maintenance of intelligent auxiliary system of guard-free substation, intelligent auxiliary three dimensional design system exports parameters preset location and camera location.

These parameters of preset location include id, code of camera, name of preset location, focus length, angle of x axis, angle of y axis, angle of z axis, virtual image monitored in three dimensional scenario and x, y and z values of corresponding ONVIF protocol. The ball center of camera is the referenced coordinate origin of angle of x axis, angle of y axis and angle of z axis.

The location of camera is most important result of three dimensional intelligent stationing system. Spot setup and debugging staff install and employ the camera by location of exported camera. Also, staff can import the location of camera to other system for further processing and representation.

The location of exported camera is parted into two parts. The first part is coordinate location against the center of gate of substation and setup angle of camera. The second part is picture file of plane which camera is located in.

The exported interface of location of camera includes id, code of camera, model of camera, coordinate of x axis, coordinate of y axis, coordinate of z axis, horizontal angle and name of picture file. Coordinates of x axis, y axis and z axis are located in coordinate system whose coordinate origin, x axis, y axis and z axis are the center of gate, perpendicular to horizontal of gate, parallel to ground and parallel to horizontal of gate, respectively.



(a) (b) (c)

Figure 4. Three dimensional design of intelligent auxiliary system of Ciwu substation

Experiment Results

To evaluate the proposed system, we experiment on Ciwu substation. Ciwu substation is a GIS station. There is a transformer, 12 GIS 220kV intervals installed in 220kV device area. The circumference is about 414 meters. The farthest shinning distance of 1/3 CCD gun head shot is about 70 meters. Based on above rules and real situation, intelligent three dimensional auxiliary system is shown in fig. 4.

Summary

Against these problems including unjustified installation, high cost, poor monitored effect which arises in intelligent substation, we propose three dimensional design approaches to intelligent auxiliary system based on guard-free substation. We apply the proposed design to 220kV Ciwu intelligent substation and the result shows that the design is effective and reasonable.

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