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Model-Based Diagnosis for the Monitoring Large Concrete Dams

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Summary

The aim of this paper is to present a knowledge based system to assist surveillance activities for large concrete dams. The system is based on the knowledge gathered through out the whole life of the dam - including design, construction, operation and mainly the data coming from the monitoring system and visual inspection.

Keywords: Structure, Dams, Safety, Monitoring, Deterioration, Expert Systems.

1. Introduction

The lifetime of large structures, such as dams, spans for decades. During the whole period of operation it must be guarantee that the essential safety requirements are completely fulfilled.

The safety of existing dams has been always a major concern of managers responsible for the safety of the communities. The increasing number and ageing of those structures lead the scientific community to look for new means to tackle the problem of dam safety control.

To assess the dam safety one must rely on a comprehensive set of facts and information which is available since the design and tends to increase rapidly through out the years. The safety of a dam may be established on the basis of a certain distance between the present dam behaviour and the "dam expected normal behaviour", which is supported by the pre-defined behaviour models. As the dam properties may change during the course of their life, the behaviour models must be revalidated from time to time.

Through the surveillance activity the changes in structural behaviour can be monitored and any anomalous situation should be identified by a thoroughly analysis. The main purpose of the present system is to give the support for an automatic identification of any anomalous situation, which may endanger the dam safety and propose corrective actions to avoid major incidents.

2. Abstract

One of the main goals of the present research is to elicit engineering reasoning processes out of the dam experts, so that a computer model of that expert reasoning could be developed.

The various means used for surveillance are measurements, visual inspections, in situ tests and laboratory tests. Measurements must characterise the structural response to the continuously changing environmental actions. These actions are mainly characterised through the monitoring of the following quantities: water level in the reservoir, water and air temperatures, facing or internal temperatures and uplift or pore pressures. The key quantities to define the structural response are displacements, strains, stresses, joint movements and seepage discharges. Visual inspections are also a reliable way of detecting both malfunctioning and deterioration. Regular examination by experienced personnel is an important element.

The effective control of dam safety requires that the measured data be interpreted in the shortest possible time following the readings. The resources offered present computing technology allows for this analysis to be carried out almost in real time.

Thus, the system used to support the analysis must be activated whenever an observed quantity falls outside the tolerance band. In the present system, this is done through a set of complex causal networks associating abnormal values or trends observed in the monitored quantities was established. The causal networks will point to a set o scenarios to be investigated. Three groups of scenarios were defined: general (scenarios related mainly with the loads, design and construction), scenarios related to the dam foundation and scenarios related to the dam body.

The correct identification of a scenario depends on the description of the appropriate symptoms. Part of the ability of the expert system to focus the search for possible scenarios on the ones that might afflict the structure results from an automated identification of which symptoms are of primary importance and which are of secondary importance for the diagnosis of an abnormal behaviour.

Primary symptoms are sure signs that a particular scenario has indeed taken or not taken place, and therefore present strong evidence for the diagnosis of a particular type of scenario. Secondary symptoms provide some information about possible scenarios and represent weaker evidence for this particular scenario. Secondary symptoms become relevant when a fine-tuning of the diagnosis is required or if insufficient information is initially available to make a diagnosis.

Once a scenario is identified by the system through association of symptoms, the expert system compares its findings with a knowledge source containing a series of problems with possible recommendations. If a match occurs, the expert system displays the result.

Recommendations may consist of remedial measures, methods leading to further investigation to confirm a diagnosis, a preventive measure, or even a mere statement that no action is required.

In Portugal there are about 100 large concrete dams of several types in operation The system under development is being applied to a specific case of a double curvature arch dam in Portugal during its period of operation. It attempts to monitor a number of specific data values and spot abnormal values or trends suggesting remedy measures to solve or mitigate foreseen problems.

The software used in monitoring systems should enable to perform safety assessment and evaluation of any scenario in development using both standard conventional programs and the ones based on artificial intelligence. An interface to the data acquisition systems should exist in order to assure a real time analysis. From a software packaging point of view, the whole system should be faced as a corporate memory system. The event of the widespread use of the Internet, namely through WWW technology, suggests that such corporate memory systems should become available and accessible via Intranet.