Valtellina alert system: towards an environmental risk diagnosis

Valtellina Alert System: towards an Environmental Risk Diagnosis

Système d'alerte de la Valteline: analyse de risques pour l'environnement

Warnsystem im Veltlin: Diagnose von Umweltrisiken

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SUMMARY
The paper describes the features of the system developed in the Valtellina area for the risk diagnosis following landslide events. In particular, it describes the development of advanced equipment that acts as intelligent assistant to the operator, supporting him in the complex activities connected with the risk diagnosis and using both graphical and numerical tools.

RESUME
Cet article décrit les caractéristiques et les potentialités d'un système réalisé dans la zone de la Valteline pour l'analyse en temps réel du risque lié aux éboulements. En particulier on décrit comment des instruments avancés ont été dévelopés pour aider l'opérateur pendant les complexes activités d'analyse et de prévision du risque en lui mettant à disposition des instruments graphiques et numériques ainsi que des modèles d'interpretation.

ZUSAMMENFASSUNG
Der Artikel untersucht und beschreibt die Eigenschaften und die Leistungsfähigkeit des Systems, das im Veltlin installiert worden ist, um die Gefahr von Rutschereignissen feststellen zu können. Die Entwicklung einer hochstehenden Instrumentierung wird beschrieben. Diese erlaubt dem Operator, die in graphischer und numerischer Darstellung anfallenden Messresultate zuverlässig auszuwerten.

1. INTRODUCTION

Following the landslides in Valtellina in July 1987, the Board of the "Regione Lombardia" and the Department of "Protezione Civile" appointed ISMES to develop systems to check and monitor the stability of the slopes effected by the landslide. On the basis of this assignment, ISMES implemented hydrogeological monitoring systems in the area of Val Pola and Valmalenco, together with the Decisional Informative System for alerting appointed officials of possible re-occurrency. Fig. 1 shows in brief the organizational-functional structure employed to acquire and interpret the monitoring data, as if was developed.

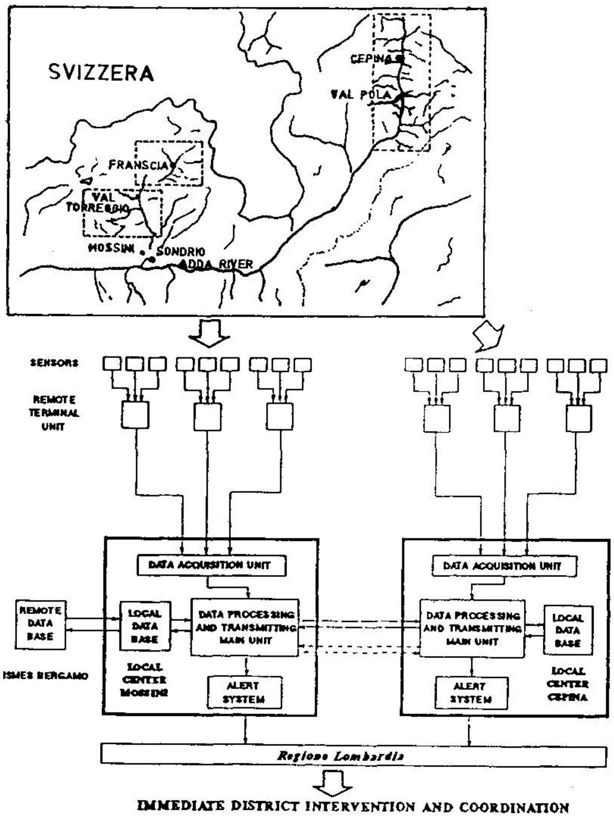

Fig. 1

The technical organizational structure includes a set of instrumental networks for controlling all the hydrogeological and climatic aspects of the site (slope instability, subsoil hydrology). The sensors are positioned at possible risk-creating area and are connected to the remote data acquisition units. The signals are trasmitted via radio to the central acquisition systems located in Cepina (for the hydrogeological monitoring of Val Pola and Presure) and in Mossini (for the hydrometeorological monitoring of Val Torreggio and Franscia, and for the hydrometeorological monitoring of Val Malenco and Alta Valtellina).

The data collected in the respective areas are processed by the Decisional Informative System for the "alert". The programs operating there check safety conditions providing a constantly updated description of the conditions of the site through the use of video terminals. The computer at the Cepina Centre is connected by telephone and radio to the analogous computer at the Mossini Centre, forming a single integrated system.

The following article describes and analyzes in detail the functioning of the Decisional Informative System for the "alert" with particular considerations to the methodology employed in its development. Such methodology characterizes the system as the first step in the evolutionary process aimed at the definition of an expert system for diagnosing the risk. The necessity of providing qualified experts, working in Valtellina, with an automatic instrument collecting and synthesizing the measurements, gave the opportunity of thoroughly investigating the theoretical study of a generalized architecture for systems supporting decisions indipendently of the specific application.

From a conceptual point of view such architecture is based on the close correlation between the moment of acquisition and the interpretation of measurements. From a practical point of view such a correlation finds expression in the employment of a model with a high level of automation.

2. WHY A MODEL WITH A HIGH LEVEL OF AUTOMATION?

The magnitude of measurements required and of geotechnical/hydrological parameters to be monitored are valid reasons in themselves to justify the use of an automatic system for the data acquisition and processing.
Additionally in order to analyze the acquired data rapidly and provide a quick diagnosis of risk situations it's necessary to have at one's disposal the use of high level tools such as territorials maps , graphs of trends and tables. These tools enable one to analyse in easy manner every information he needs.
The above mentioned requirements were verified in the development of the Decisional Informative System for the "alert" and in what has been employed within it to assure the reliability and the complete automation of the decisional process (no-break electric supply systems, remote alarm systems via radio. etc.).

3. WHY NOT A REAL "EXPERT SYSTEM"?

To answer this question it is necessary to consider the operational conditions of emergency that permitted the development of the system, but that also conditioned the methodological approach to the solution of the problem. In particular the necessity of collecting and checking the measurements on the site with the same timeliness with which the sensors were installed, together with the evolution of the situation (passing from one to three monitoring areas) hindered the possibility of projecting the system as an "expert one" carried out by means of specialized hardware and software tools. The initial approach was therefore of a traditional nature, aimed at the implementation of an automatic system for acquiring data and processing it with hardware and software tools typical of real-time precesses. During the development of the system, the conceptual problems at the basis of the "system to support decisions" took shape more clearly. Such problems have therefore changed the work environment by introducing methods and concepts close to expert systems.

4. NEVERTHELESS AN "EXPERT SYSTEM"

The complexity of the system and the variety of processes carried out tend however to define the system as an "expert" one. The procedures implemented are not based on a simple check of surpassing the threshold of the sensors, but on the automatic processing of interpretative models and therefore of predefined situations according to which the alert and mobilization thresholds are established. The system is also able to assure the surveillance and alert function by defining the whole of the probable diagnoses even in case of uncertainty or incompletness of measurements. The operator can then check such diagnoses by analyzing in detail the deductive process that the system employed automatically.
Finally, the sophisticated checks on the correctness of measurements, aimed at avoiding false or in any way altered diagnoses, emulates the behavior of the expert who critically analyzes the acquired measurements before considering them valid for the processing of alarm signals.

5. FUNCTIONAL ARCHITECTURE OF THE SYSTEM

The functional architecture of the system executed, divided into modules, is reported in the Fig.2. The complete functional block diagram is reported in Fig. 3.
The following is a detailed functional description of each single module.

5.1 Acquisition module

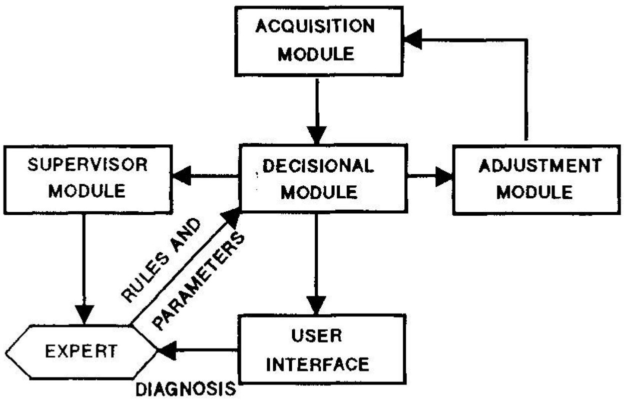

Fig. 2

The acquisition module allows the periodical and automatic collecting of measurements obtained by the different monitoring subsystems (hydrological, geotechnical). The data which are not acquired automatically are handled manually by means of controlled video masks.
The programs check the validity of measurements in order to transmit only reasonable measurements to the DECISIONAL MODULE.
The monitoring process is carried out in subsequential steps as relates to the following:

- instrumental validation, consisting of checking the correct operation of the acquisition unit, and verifying that the measurements remain within the limits both the full scale of the instruments and the physical range of the observed magnitudes.
- validation with the monitoring of tolerance bands, consisting of the verification that the acquired measurements respect the maximun allowed shifts compared to a reference function characteristic of the sensor. The reference function and consequently the tolerance bands can have a periodical or a constant trend, depending on the type of magnitude considered. For example temperature has a seasonal periodical trend, determined by a proper mathematical function; the mathematical function can be updated each time new measures join the historical data base.
- validation with the monitoring of the speed of variation, consisting of the verification that on a time base typical of every type of measurement there are no variations in the data value surpassing the pre-established thresholds. This allows the evaluating of the reliability of the measurement by filtering those values that, even though numerically correct, result in being inconsistent with the physical reality of the measured magnitude and therefore probably altered by occasional noises.

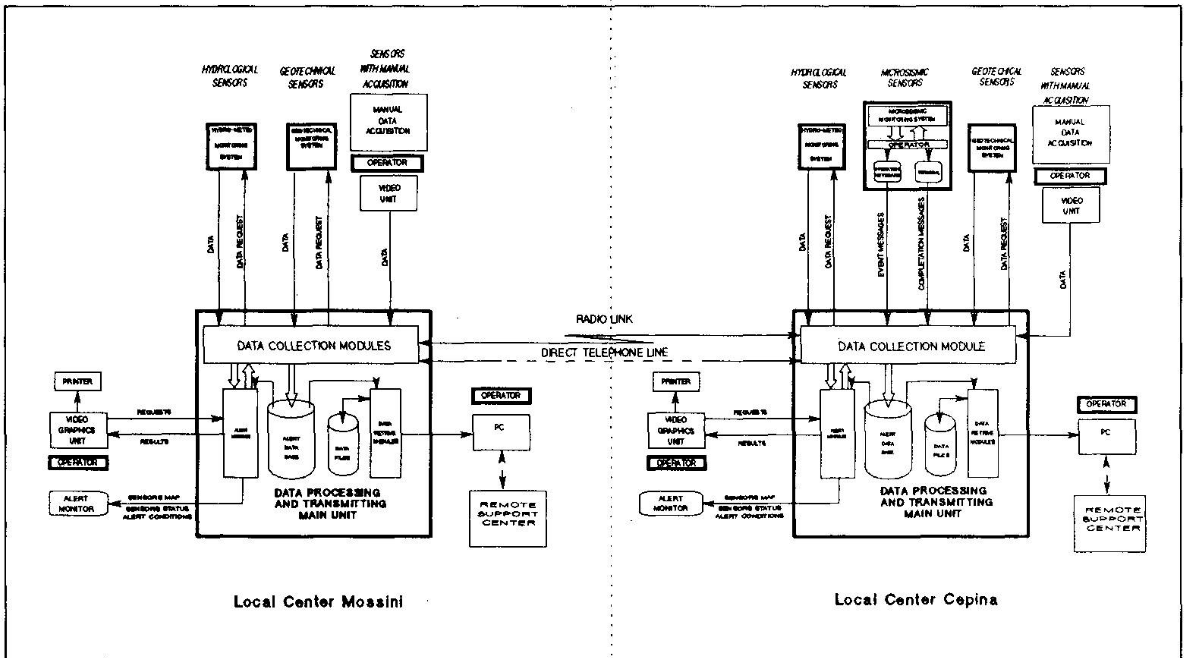

Fig. 3

5.2 Decisional and supervising module

After having been controlled and validated, the acquired data are stored in a temporary data base with a maximum storage capacity of 15-20 days.
This data base, updated in FIFO modality, is the required organizational support of the data for processing the "alert" procedures. This data base also serves in the production of graphics and reports which summarize the analyses of the measurements taken in a short period of time (15-20 days)
The storage operation consists of properly organizing the measurements received by each monitoring network, completing them with all the information required for the subsequent analyses, such as: the type of measuring network to which the data belong, the storage date, the validity codes of measurements, etc.
The interpretation of the data acquired by the sensors must emulate the capability of an expert at executing a comparative analysis of all the information received. For this reason the interpretation refers to analysis procedures, consisting of a group of rules defined by experts themselves, according to which it is possible to obtain an indication of the state of the situation.
The procedures, drawn up on the basis of possible predefined risk situations, allow the indication of dangerous conditions already present or in course. All the measures obtained by the monitoring systems are subject to controls to diagnose the possibility of surpassing the absolute measurements thresholds, thresholds of speed of variation and those of the acceleration of variation. When the system underlines the occurence of one of the risk-coded situations, it sends messages to the operator and to the monitoring systems; these are required to send data more frequently until the anomaly has stopped.
The alarms and pre-alarms are displayed on video-maps and are signalled to the operator by means of acoustic and light signals.
In the case of anomaly, the supervisor can decide on particular operations according to the information provided by the system. Such operations are parallel to the automatic procedures of adaptation that the system makes on the basis of the rules codified in the analysis procedures. This permits the possibility of manual interventions in critical or unexpected situations. When these manual interventions become repetitive, it is possible to automate them by coding the diagnosis and the consequent process.
The ADAPTATION MODULE is activated when a change in behaviour of the system itself is required.

5.3 Adaptation module

To describe how the ADAPTATION MODULE functions, the following should be considered:
- the phenomenon to be monitored often requires different frequencies of observation, depending on the phase being observed;
- the system employed for the surveillance is so complicated that it requires particular procedures in order to check its functionability.

These considerations are better explained below.

5.3.1 Different observation frequencies

In order to examine the concept deeply one can use the example of the cracking phenomena in soil and how cracks normally develop. In general, the phenomenon begins with a constant process. In the first phase, they are easy to monitor through acquisitions at pre-established intervals (usually once per hour). In subsequent phases the dynamics of the phenomenon, before the final collapse, acquire characteristics requiring acquisitions at much lower intervals (usually every 15 minutes). The problem is therefore that of being able to follow the phenomenon during its evolution automatically.

The solution could be in finding the maximum acquisition frequency in order to effectively reconstruct the evolution of any event regardless of the conditions; This could be done on the basis of an evaluation made by expert personnel or through previously established experiences.
This solution sometimes can not be implemented; in fact, when data acquisition at high frequency is not necessary, it provides the data base with an amount of useless information, slowing down the management of the whole system.
Hence one can note the importance of having integrated into the system the possibility of automatically adapting the acquisition frequency of the peripheral acquisition modules in accordance with the specific needs which arise throughout the evolution of the phenomenon. This type of operation assures the presence of only the necessary information required for a correct interpretation of the situations, at any given moment.

5.3.2 Checking the basic effectiveness of the system

Since the system is being implemented under critical conditions, such a territory subjected to landslides or other natural disasters, and since it must foresee such phenomena, it is extremely important to keep the condition of the system itself under control.
It has therefore been forecast to automatically make all the possible checks on the various hardware and software components of the system and, in case of their failure, to then be able to restore and re-adapt itself to the point of effectiveness.
With reference to Fig.4 it is possible to underline how the module "Management of Test Proceedings" verifies the correct use of the different processing software modules by operating them periodically and checking that each of them behaves as established. Each processing module is in turn responsible for the control of the peripheral units connected to it (printers, recorders, teletransmission units, etc.) through the performance of proper test sequences.

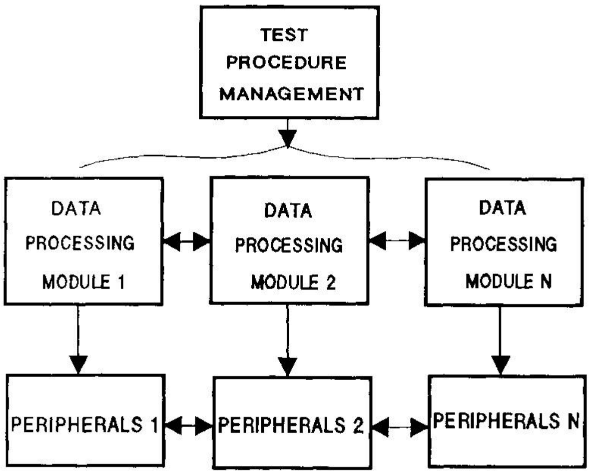

Fig. 4

In case of any particular mal-function, the system signals and records what has been diagnose and, when possible, it attempts to automatically restore the components which are out-of-service. Examples of this are software and hardware reset, the operation of spare parts or of alternative communication channels.
In the case of non-localized damages on specific equipment, the system can pass to a partial or complete initialization of its software madules.

6. USER INTERFACE

This consists of a set of modules through which the User can obtain all the basic information relating to the sensor measurements and to system conditions.
The data stored in the data base can be analyzed and visualized graphically or numerically on the alarm consolle. (Fig. 5)
The operator can interact with the system through selective entries protected by passwords in order to find out, visualize and, when necessary, update the informations contained in the data base.
Similarly the operator can interact with the system in order to update and

modify the data base of the channels and of their properties (qualified or non-qualified for processing of alarm procedures, manual or automatic acquisition, etc.)

The functions that the system is capable of, through the use of the map monitor video, are the following:

- viewing of topographic maps showing the areas under surveillance (Val Pola, Valmalenco) with the identification of the various zones which delineate the area and of the installed measuring positions (Fig.6, Fig.7)
- viewing, in a specific area of the monitor, of the channels in an alarm or pre-alarm state;
- viewing, in a specific area of the monitor, of the running condition of the different units integrated into the system: peripheral units, data acquisition systems, computers, etc.

Fig. 5

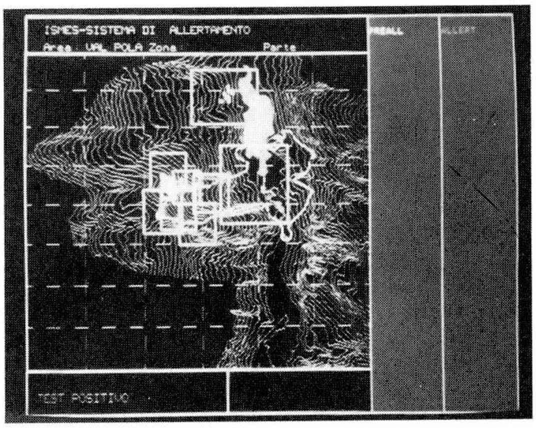

Fig. 6

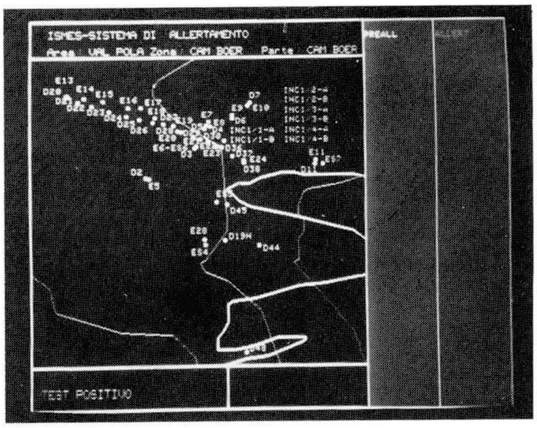

Fig. 7

7. SYSTEM EVOLUTION

It is extremely important to assure the development of all the rules that make-up the alarm procedures, through an accordance with the professional experience acquired over the years by the technicians. In order to facilitate such development, a synthetic language has been established, whose main structure is the recurrent control structure "IF-condition-THEN-action"; where the "condition" can also be a system of conditions and the "action" can either be the insertion of a further rule or the final diagnosis. The rules can be so stored by the expert by means of a program that guides him to the definition of "conditions" and "actions" according to a deductive logic, and then finally to the construction of a hierarchical structure. The program itself will control for it's consistency and completeness. "Conditions" and "actions" must be defined by a synthetic rather than a descriptive language. Hence one can note the necessity of creating a "dictionary" of passwords covering all the possible forecast conditions and actions and a "grammar" according to which such words must be connected. The person defining the rule has the task of checking its semantic correctness; the program itself provide a series of formal checks whithin the definition, presenting satisfactory hypotheses in order to check a particular thesis, by running through the hierarchical-structure by means of "backward chaining".