Computer platform for remote monitoring of distributed installations in rural areas using GISs.

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Abstract. For the development of rural areas, many drillings has been installed by the States. However, once these drillings are installed, unfortunately, they do not benefit from effective monitoring despite the huge budgets invested. This paper proposes a computer platform for remote monitoring submerged pump allows extracting water from of the drilling at the castle. Solar panels or Generators groups are often used for pump operations, especially in remote areas where the use of an alternative energy source is desired. The volume of water pumped in a given interval depends on the total amount of solar energy (supply voltage) available in that time. The objective is to measure the supply voltage of the submerged pump and compare this voltage to normal. If there is a voltage difference, an alert message is sent to the equipments remote monitoring center. The proposed solution consists of a central server for processing measures connected to an acquisition unit that monitors a set of sensors. If a failure is detected, the faulty equipment is first identified and the installation is located to facilitate the maintenance team's intervention.

Keywords: Remote monitoring, database, GIS, installations, drilling, pump.

1 Introduction

Faced with the development of hydraulic installations, scattered in rural areas and their difficult access, better management policy and remote monitoring, must be concern of the state. The submerged pumps, generally used in drilling, are installed at great depths. These pumps suffers from numerous failures that are difficult to determine. Failures of these pumps result in lack of water in rural areas. This water is necessary for the life of men and animals living in remote rural areas of Senegal. Therefore, it is important to monitor these equipments remotely to detect failures in real time. Many works have been proposed in the literature for remote monitoring of drilling equipment [1-5]. These works often are interested in performance study photovoltaic systems using solar radiation or monitoring water level. And these works only make it possible to remote monitoring where all installations are on a single site, in this case the position of the installation to be monitored does not pose a problem. In this work, the objective of this paper is to propose platform for remote monitoring of submerged pumps in remote areas where the access is often difficult. This platform is based on the GIS. The particularity of GIS is that data is geo-referenced and organized in thematic layers. We use GIS, which is an analysis tool that allows faulty equipments to be located, in order to facilitate identification of the area to maintenance teams.

2 State of art of the remote monitoring techniques and positioning

The advancement of telecommunications and electronics technologies has opened up interesting prospects in the use of remote monitoring for securing installations. These technologies solve emergency call situations and potentially reduce maintenance costs. They should also make it possible to anticipate the occurrence of failures through real-time monitoring within the framework of the management of an installation. Many works have been proposed in the literature for remote monitoring [6, 7, 8]. Bianchini et al. worked [6] on the Condition based maintenance (CBM) through vibration monitoring. This paper [6] shows the experimental campaign results, which are the basis to conduct CBM on pumps, in terms of: (1) definition of the typical vibration values of new pumps, not available even by producers, plant managers and standards, and (2) identification of the parameters which influence pump vibration, fundamental to data processing and the setting of proper alarms.

Daniel scott et al. works [7] treat the Software Design of an Intelligent Water Pump (IWP). IWP measures and reports the functionality of handpumps and volume of water extracted on two-hour intervals daily. Besides monitoring water extraction, handpump performance, and borehole health, the IWP system processes data to alert stakeholders of failure or degrading conditions (imminent failure).

In the Candelieri A et al. works [8], the authors are concerned with Pump Scheduling Optimization in Water Distribution Networks, targeted on the minimization of the energy costs subject to operational constraints. Results on the Anytown benchmark network proved that the optimization policy/strategy identified through Approximate Dynamic Programming is robust and, therefore, able to deal with real time data without any distributional assumption.

These works often are interest to performance study photovoltaic systems or monitoring water. Indeed, work found in the literature was limited because most part of it only addresses the remote monitoring of installation located on the same site (single site remote monitoring), so that the position of equipments to be monitored is already known. As part of this work, we are interested in remote monitoring of distributed installations. As a result, we use GIS, which is an analysis tool that allows equipments to be located. The coupling of the GIS and the computer platform that we have developed should facilitate the management of equipment, thanks to more efficient methods of analysis.

In this work, we use sensors to measure the supply voltage of the submerged pump. The data processing module compare the supply voltage to recommended voltage levels. If there is a voltage difference, an alert message is sent to the equipments remote monitoring center.
This paper aims to make the existing remote monitoring systems for the submerged pump in rural areas more efficient and cost effective.
Our contributions focus on three points. After analysis, we first proposed a platform architecture. This proposed approach was been then applied concretely to the case of a drilling installation. Finally, the architecture has been implemented.

3 Our contribution for proposed monitoring system

3.1 Architecture proposal for remote monitoring of the submerged pump supply voltage

The submerged pump allows to extract water from of the drilling at the castle. It is powered in rural areas either by a generator group or by a solar panel. The performance of PV based water pump depends upon solar intensity of respective date and time [9]. The voltage used by the submerged pump must be equal to that provided by the group or solar panels. Following a failure of the panels or the group or some cable failure connecting the pump to this equipment, it happens that submerged pump not capable of doing to function. The consequences of a possible lack of water are undergo by users of drilling in rural area. The bodies responsible for monitoring these installations are not informed in time about the failures. Few information is available to maintainers on failure modes, their effects and failing components. Therefore, it is necessary to monitor them remotely to detect failure. We present the architecture in the Fig. 1..

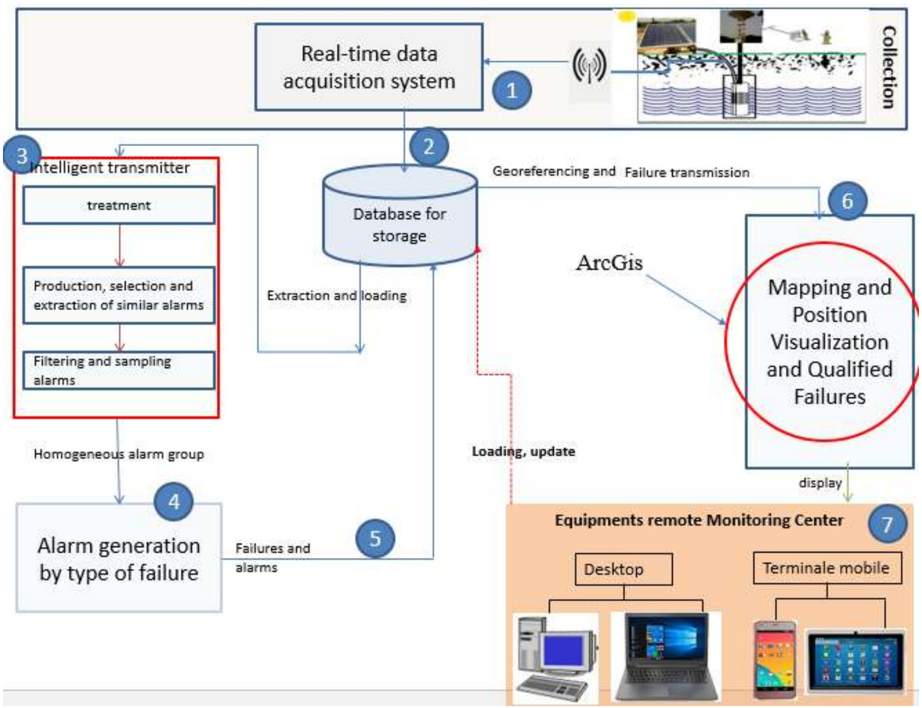

Fig. 1. Core architecture proposal.

Our system contains multiple grids of solar panels or Generator group distributed in rural areas to feed the drillings. Where each grid is connected to various sensors to measure the energy supplied for powering the submerged pump that draws water from the drilling at the castle. The output of the classic sensor is fed to the acquisition central, which is in turn connected to a wireless network. The acquisition central treat all the received data from the sensors. If a failure detected, the acquisition central send message to equipments remote monitoring center. The data can be send via sms to users. The user can remotely monitors the pump via a smartphone using Terminal application. These informations are stored in remote database. This database is connected to ArcGIS. ArcGIS allows us to reference and map all failing pumps. Monitoring system is implemented and tested. The protocol used for sending the data is based on technology zigbee or LoRa in the rural area that are not covered by the internet. In the areas covered, we will use the 3G or 4G. Simplified example of the remote monitoring chain.

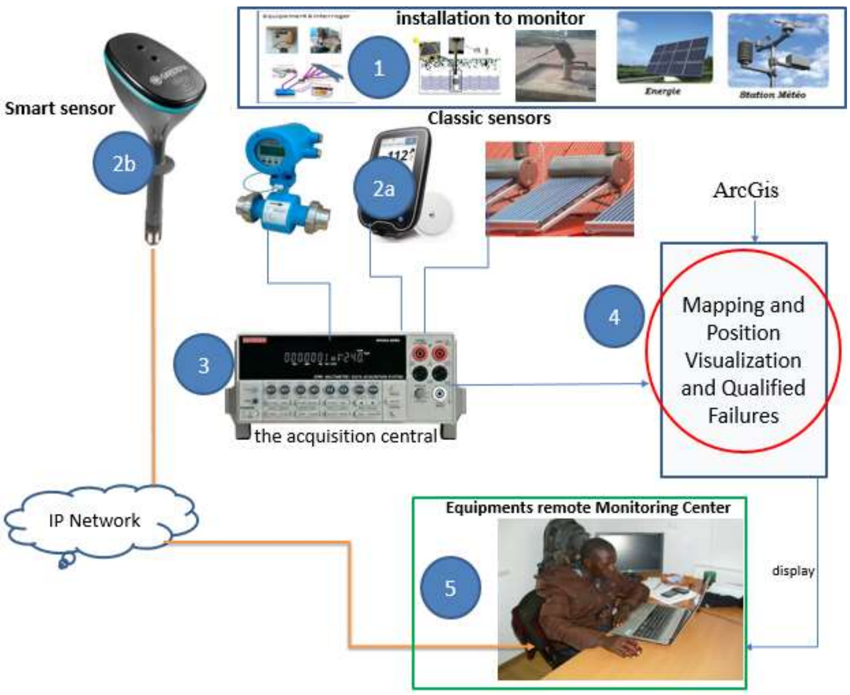

Fig. 2. Simplified example of the remote monitoring chain.

3.2 The organization of the data

The particularity of GIS is that data is geo-referenced and organized in thematic layers. These thematic layers can stack theme that correspond to categories of data. There are different types of data among which:

- Data on the layout mapping of the distributed submerged pump that represents all the pumps installed in rural areas.
- Road network data to facilitate field maintenance operations. They make it possible to know how the site is positioned relative to the road is what it is accessible or not, to calculate the distance between the center of remote monitoring compared to the site of implantation of the equipments
- Data on the computer network and remote monitoring elements that allow the location of facilities and the implementation of remote monitoring.

It is possible to superimpose two or more layers. Which will allow during the edition of the map to make visible or invisible such or that layer according to the requests that we will have to make. These data are stored in a database.

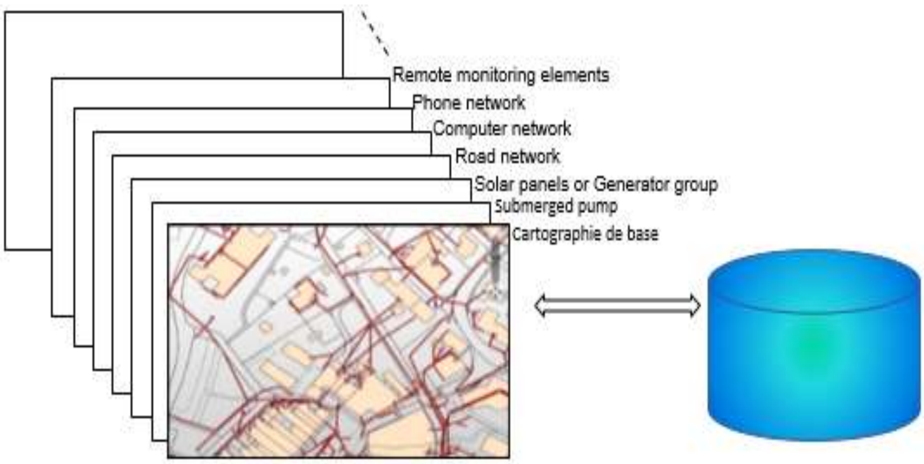

Fig. 3. Organization of the data.

During exploitation, these data are arranged in tabular form and constitute attribute tables. The diagram below is a numeric field model that represents the area where the equipment is located and behind which we have the attribute tables.
This table contains information about the equipment such as: installation location, type, service life, characteristics, supplier name, date of installation, etc.

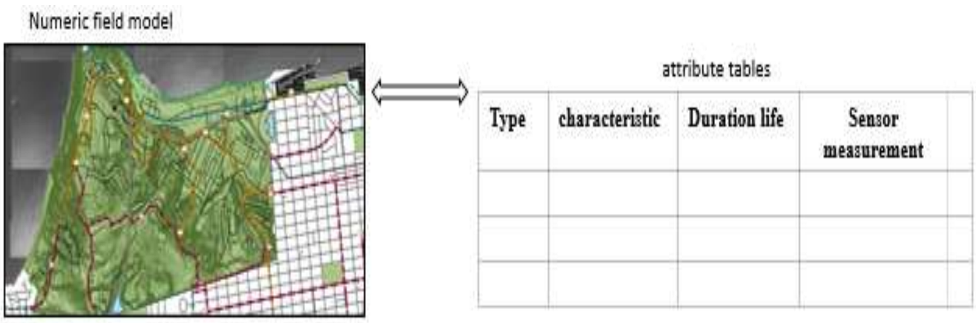

Fig. 4. Numeric field model and attribute tables

3.3 Approach of detection of failure of the submerged pump in the drilling installations

In order to maximize the water to be pumped out in the drilling, the energy supplied for powering the submerged pump must be sufficient. If this energy is insufficient, it can prevent the pump from functioning. So it is necessary to monitor the supply voltage of the submerged pump for avoiding water outage. The objective is to obtain measured rated voltage (w) by the sensor equal to its normal voltage (N) (the energy supplied for powering the submerged pump of 220 V). The pump may not work properly if the difference between the measured tension and normal tension (d = N-w) is negative.

The voltage using by the submerged pumps can decrease naturally with the time. This decrease is explained in the case of panels by the deposition of dust on photovoltaic solar panels, which causes a reduction in the current and voltage generated by the photovoltaic generator. We can see two types of failure. Failures are due to the lifetime of the installations and failures caused by the lack of follow-up.

The failure function F (t) represents in [10] the probability that a system has a failure before time t and is expressed according to:

$$F(t) = P(T \leq t) = \int_0^t f(t)\,dt \qquad \textbf{(1)}$$

With F (t) the probability density function [10]. It indicates the failure distribution over the entire time interval t considered; the higher its value, the greater the number of failures occurring at time t is important.

We also need to implemente algorithm for monitoring sensors installed in the field for datas acquisition, in addition to pumps monitoring. These sensors according to the programmed Times base interval must constantly sent measurements. If between two or more Times base the sensors do not send any data, we can think about the failure of the sensors concerned. For the monitoring of all sensors installed, we propose the following algorithm:

$$T = \underset{1 \leq k < xm}{\mathrm{Max}} \{Pk\} \qquad \textbf{(2)}$$

With T = the total failure probability of the sensors in the network, xm = the total number of sensors and Pk, the probability of finding a faulty sensor in the network.

In all of these cases, the system processes data and if a failure is detected it alert stakeholders of failure or degrading conditions.

3.4 Implementation of the platform and test

Scillab is the software that we have used for simulate. To simulate, we need a description program of the model to simulate. We used the rand () function that automatically generates values that simulate measurement sensor outputs.

X = rand (t, u), generates random values, with t being assumed to be the measurement times base and u the measurement output of the sensors. In the execution of this program, we have respected the various stages of operation of the acquisition central. The time step is managed by the multithreads programming technique in java. This allows the program to sleep for a desired time t.

Y = (1: t), is a line matrix that counts from 1 to t. This line matrix is supposed to be a regular measurement time interval (measurements made every hour for example).

Every day measurements are made. Every hour the sensors send measurements to the acquisition central. For the representation graphic of output measurement we use the Plot2d ( ) function.

The supply voltage of the pumps is one-phase type. It is stall to an operating point of 220 V. All measurements values will also be transmitted in the remote database in the measurement table.

Table 1. Zoom on failures detected in real time

measured values by sensors		Failures detected
Sensor 1	286.12794	Yes
Sensor 2	151.41496	Yes
Sensor 4	220.00000	No
Sensore6	38.35097	Yes
Sensor 3	220.00000	No

If there are no failures, it is not necessary to build the fault card. But as soon as a fault is detected, automatically the fault card is designed to present all the submerged pumps that are faulty as well as the localities where they are installed.

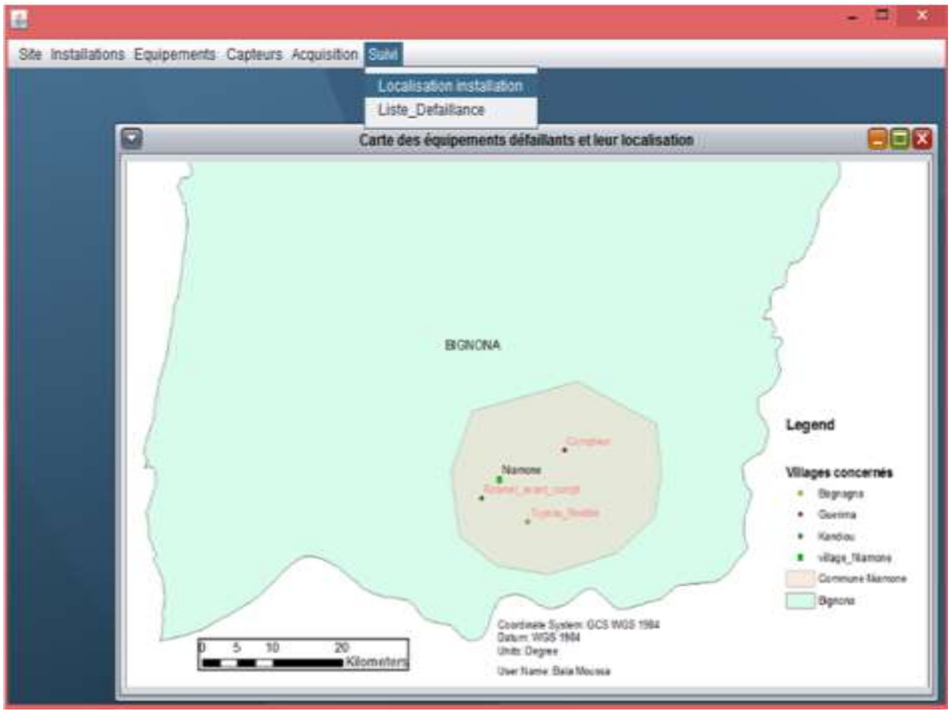

Fig. 5. Zoom equipments cards that present failures

On reading this map, we will see that in the municipality of Niamone in the villages of Bagnagna, Guerima and Kandiou the submerged pump is not active now.

4 Conclusions and perspectives

We reviewed the work done in this article. Thus, the answers given to the questions and their contributions are been give. The limits of these answers and the direction of our future work are also given. In this paper, we propose a computer platform using GISs for remote monitoring submerged pumps in remote area. The platform is only make to detect failures in the drilling installations. In this moment, our platform not yet resolve the remote maintenance problem. We note that this implementation is not complete. Indeed, we have limited for the moment (moment writing this paper) to the realization of some prototypes with regard to drillings installations. Knowing that work needs to be continued for other types of installations and until the final deployment of our platform. Future work should use of these research results in various sector like schools installations, health, energy etc.

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