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BIM-Based Facility management for water treatment plants using laser scanning

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Abstract

Lack of maintenance information pertaining to water treatment plant equipment may lead to many problems within the treatment system and affect its performance. A framework for using three-dimensional laser scanning to obtain equipment maintenance information for water treatment plants is presented. The framework core phase involves automation of information exchange in a three-dimensional computer-aided design (CAD) environment as the foundation for adopting a Building Information Modeling (BIM) approach. The framework supports the concepts of BIM-based facility management through the essential task of equipment information clustering according to maintenance intervals. Clustering according to daily, weekly, monthly, and annual maintenance plans are identified with potential applicability for additional extentions. Finally, a case study illustrates the benefits of using laser scanning technology in facility management.

Key words: asset management, BIM, facility management, laser scanning, water treatment plant

INTRODUCTION

There are many types of failures that may take place in water treatment plants. The most critical failures are those related to inhibiting the treatment plant from producing the amounts of water required and wasting valuable water resources. The traditional approach for mitigation involves interpretation of business targets into resource-related choices to properly arrange activities inside the system, thus utilizing arrangements of procedures, strategies and apparatuses. In Egypt, facility management staff usually use paper or data sheets to document the facility's maintenance tasks. In addition, most workers find it difficult to interpret conventional 2D computer-aided design (CAD)-based data used for facility maintenance activities as well as the added burden of repetitive tasks. To overcome such limitations, the building information modeling (BIM) approach can be used to create 3D information models for facility maintenance. Integrating facility maintenance data in BIM enhances the productivity of maintenance and administration work in facilities (Pocock *et al.* 2014).

BIM is not a solitary software application but instead the utilization of programming devices as part of a procedure. Its utilization can be connected to a wide range of benefits and not simply for structures (Sebastian *et al.* 2013).

By utilizing BIM in construction, engineers visualize the design through 3D models and pinpoint troublesome obstructions through the connection of data between the model and reality. This could decrease the costs and the risks of the project and encourage proficient individuals to accomplish more precise control, through simulation of engineering and consolidation of all of the works' details (Kassem *et al.* 2015). The absence of procedures for refreshing the designed model with as-built

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data is considered among the greatest difficulties for BIM in FM applications (Gu *et al.* 2008). Keeping the models updated is not very well characterized (Becerik-Gerber *et al.* 2011).

The use of BIM-supporting technologies such as 3D scanning is increasing. 3D laser scanning advances have been presented in the field of surveying and can obtain 3D data about physical objects of different shapes and sizes in a cost and time effective manner. Laser scanners enable a large number of points to be recorded in a few minutes. Because of their practicality and flexibility, these types of instruments can be broadly utilized in architectural, archeological and environmental surveying (Valanis & Tsakiri 2004). It can give faster, better quality and more exact investigations and highlight locations for further building study (Arayici *et al.* 2004). The 3D laser scanner focuses and ensures that physical objects are identified, and the laser beam is coordinated over the object in a firmly spaced grid of points. By measuring the time of laser flight, which is the time of travel of the laser light from the scanner to the physical object and back to the scanner, the position in three-dimensional space of each scanned point on the object is found.

FRAMEWORK FOR MAINTENANCE INFORMATION MODELING

The proposed framework starts with establishing a broad view of the water treatment network in Egypt. This view is primarily achieved through a Geographic Information System (GIS) using 'ArcGIS' software package. The GIS incorporates information about the Egyptian governorates and its regions as well as the population served. The second task involvesd selection of a case study for the proposed approach. The Sixth of October water treatment plant was used as a case study. It has a capacity of 400,000 m^3/day and serves a great deal of surrounding districts. With valued support from the Construction Engineering Technology Lab (CETL) – Faculty of Engineering, Cairo University; the Sixth of October water treatment plant was scanned in detail.

Planning of scanning

This activity was initiated by securing the layout of the site with all data gathered by means of CAD records and manual distance measurements. A Z + F 3D laser scanner was used to obtain a High-Density Point Cloud (HDPC) scan. Planning of scanning involves primarily identifying the number of scans required to record all the elements of the water treatment plant, from all directions, while keeping up a sufficient level of accuracy (HDPC density). The scanner has different density choices each relating to a period of sweep. High-quality scanning was chosen with 158 scans to be performed as shown in Figure 1.

3D laser scanning of the site

This activity begins with the registration of each individual HDPC created from the various scans. Z + F Laser Control is utilized to register the scans. The registration process is accomplished by distinguishing similar targets in the various scans. The registered raw HDPC is illustrated in Figure 1.

Developing maintenance information model

This activity involves developing a maintenance information model for the structure of the water treatment pumps, which is an important part of the water treatment plant. Important maintenance information was added in the form of tags on different parts of the water treatment pump structure as described below in the sub-activities.

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Figure 1 | Raw point cloud for water treatment pumps building.

Table 1 | Log sheet for pump maintenance

Equipment: Pump		Manufacturer:
Model:		Service:
Location:		Q (GPM):
Type:		H (Feet):
Task		Notes
Monthly	Make sure the motor is clean	
	Check the counters	
	Check the wear for the presence of rust or moisture and lubrication if necessary	
	Check electrical connections and operation through the control panel	
	Make sure the water sensor is clean of accumulations	
	Note the voltage and amp record	
Quarterly	Check the controller connections	
	Be sure to identify wear and lubrication needs	
	Make sure all parts of the pump are connected	
	Make sure that the gaskets are freely operated in full	
	See all safeguards	
	Check wires and insulation	
	Check the installation of the pipes	
	Make sure the connectors are flexible	
	Detect vibrations or annoying sounds	
Annually	Check the status of the motor ends	
	Check the mechanical torrent	
	Inspection of the base of the pump	
	Check the paint and paint situation as needed	
	Check the wear of pump	
	Check the wear of the motor	
	Check the condition of the motor	
	Check the amount of air generated from the unit	
Engineer Name:	Date:	

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Maintenance of pumps data collection

The maintenance information, obtained from each pump catalogue, included data such as country of manufacture, pump type and specific capacity as well as the types of maintenance to be performed on a daily, weekly, monthly and yearly basis.

Also, several meetings have been held with companies specialized in operation and maintenance to discuss how maintenance tasks are performed. Being the most important element within any water treatment plant, special consideration for the maintenance of pumps inside the stations was taken. The type of maintenance information required is listed in Table 1.

Post processing of the HDPC

This activity considers converting some of HDPC to regions and adding linked data as follows:

1. Selecting the region 'pump' in Recap360 and add the name of it 'pump A1'.
2. Continue in selecting all regions 'pump' and saving its name as shown in Figure 2.

Then all regions saved in HDPC were linked with data and maintenance instructions for equipment in the water treatment plant. To link the regions Autodesk Recap 360 was used as shown in the previous stage with data as depicted in Figure 3.

To simplify operation and maintenance, highlights of the most important elements in the water treatment plant was considered. For instance, objects with non-maintenance actions on a daily, monthly or annual basis remain in red; while those with regular maintenance are converted to green (see Figure 4).

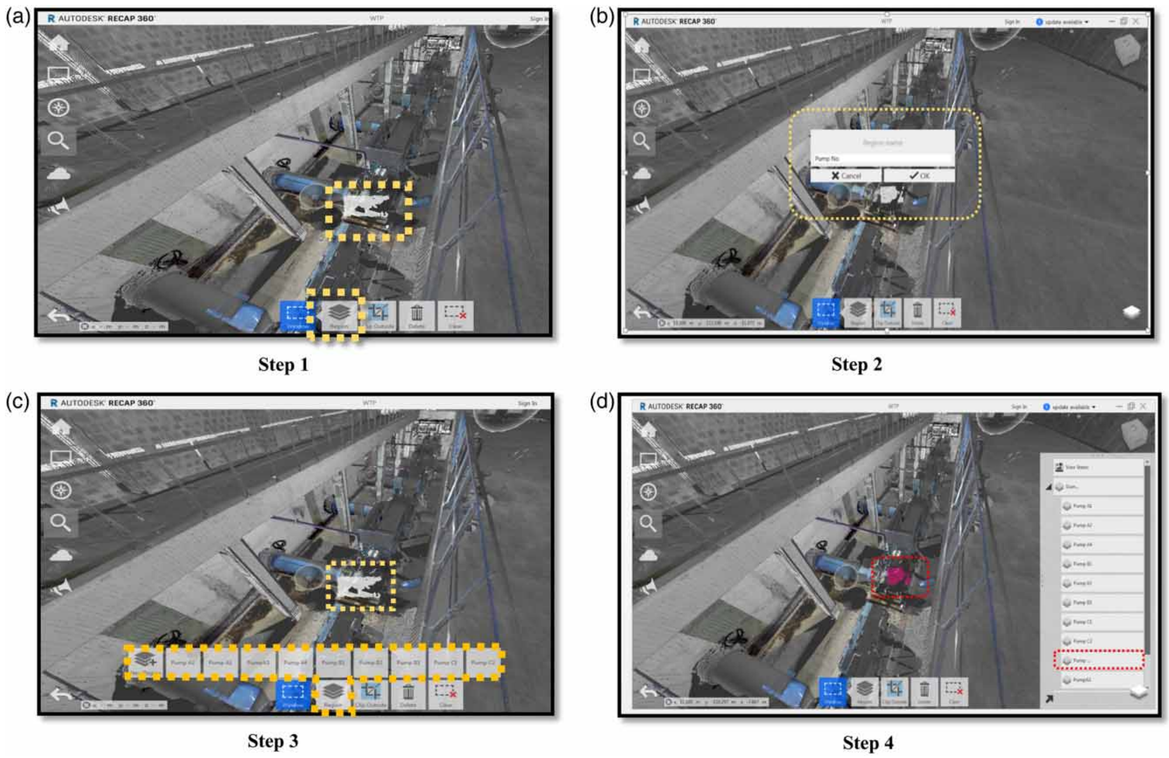

Figure 2 | Converting High Density Point Cloud to regions. (a) Step 1: Select the region. (b) Step 2: Add data about a region. (c) Step 3: Add all pumps as regions. (d) Step 4: Save all pumps as regions.

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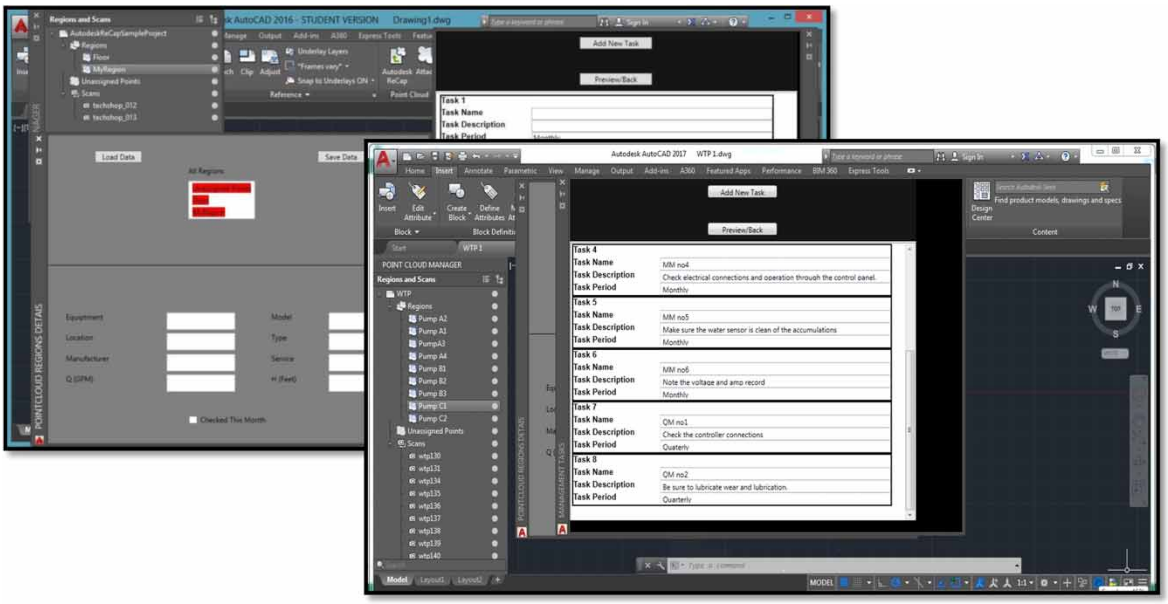

Figure 3 | Linking the HDPC regions with maintenance information.

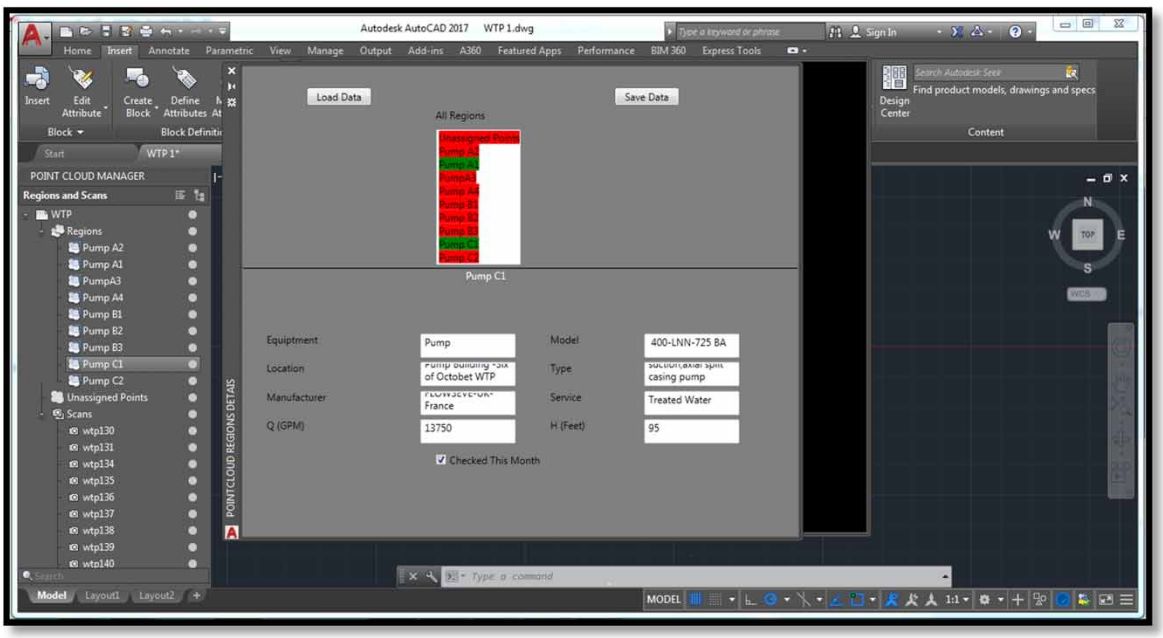

Figure 4 | Maintained and non-maintained pumps in the plant.

CONCLUSIONS

It is scientifically known that the efficiency of pumps decreases with time and one of the main reasons for this is the lack of periodic maintenance. With poor periodic maintenance, pump efficiency will decrease with time and more electricity will be consumed in order to pump the required amount of water. This paper presents a framework that links equipment maintenance information with point cloud images of water treatment plants obtained from 3D laser scanning, thus establishing a valued maintenance information model. The proposed maintenance information model uses CAD and 3D laser scanning as tools to establish a BIM-based facility management system. In this maintenance information model, data for the maintenance operations required for the treatment pumps of the water treatment plant, whether monthly, quarterly or annually, have been linked to HDPC. The

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model facilitates the process of efficient maintenance information visualization and provides a way to present maintenance service conditions in a visual, simple, and inexpensive way. This proposed framework will lower costs and reduce electricity consumption, as periodic maintenance, whether monthly or quarterly or annually, is a necessity for retaining pump efficiency.

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