An Unconventional Approach to Healthcare (Geographic) Information Systems using a Custom VB Interface to AutoCAD

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Abstract. This article shows how to approach to complexity government in a healthcare structure, using biomedical and architectural skills together with informatics to improve healthcare management. The approach proposed in this work is different from the standard GIS approach because it tends not to separate graphical data and informative data.The developed system, called SACS, is a custom VB software that drives Autocad. It provides a mapping of every single hospital room in terms of beds, square meters, destination of use, functional area and many other details. Each room is considered as a part of a ward introducing the concept of Main Destination of Use (MDU). System reports can be used via web by the hospital top management as well as by the clinical engineer, who can assess parameters like the maintenance state of an equipment or its obsolescence, being aware of the hospital context in which this equipment has been used.

1 Introduction

The acronym GIS (Graphical Information System) is used for an IT system to produce, manage and analyze spatial data, connecting each geographic element to alphanumeric descriptions. It mainly manages and elaborates georeferenced data that is saved in an external database. In the last few years GIS has entered the public health management systems as well. [1] [2] [3]

The approach proposed in this work is different from the standard GIS approach because it tends not to separate graphical data and informative data.

In most hospitals' technical departments there are plenty of CAD mappings for the whole building estate. These drawings are mainly used for maintenance purposes, but (if up to date) they can become a great source of information for healthcare managers as well. [5]

Besides architectonical and fittings data (area, number of medical gasses connections, etc.) much more information can be found linked to the particular room (destination of use, ward beds, etc.) as well as information about the staff that uses that particular room (doctors, nurses, students). This data, if conveniently structured and linked to the Hospital Information System (HIS), can become a powerful data source for the technical management as well as to the top management. [7]

By integrating other information (first of all healthcare technology equipment) this cartography could become part and parcel of the HIS itself.

2 Methods

The proposed system, called SACS (an Italian acronym that means system for the analysis of the hospital equipment) consists of both a methodology (fig. 1) and a custom VB software that drives Autocad [4]. The DWG file is manipulated using SACS – that acts as a filter-interface to the CAD – to input the information gathered during the on-the-spot investigation. Then SACS is used to extract these data, link it to other data from the HIS database, publish reports and make HTML and DWF files that can be put on the hospital Intranet.
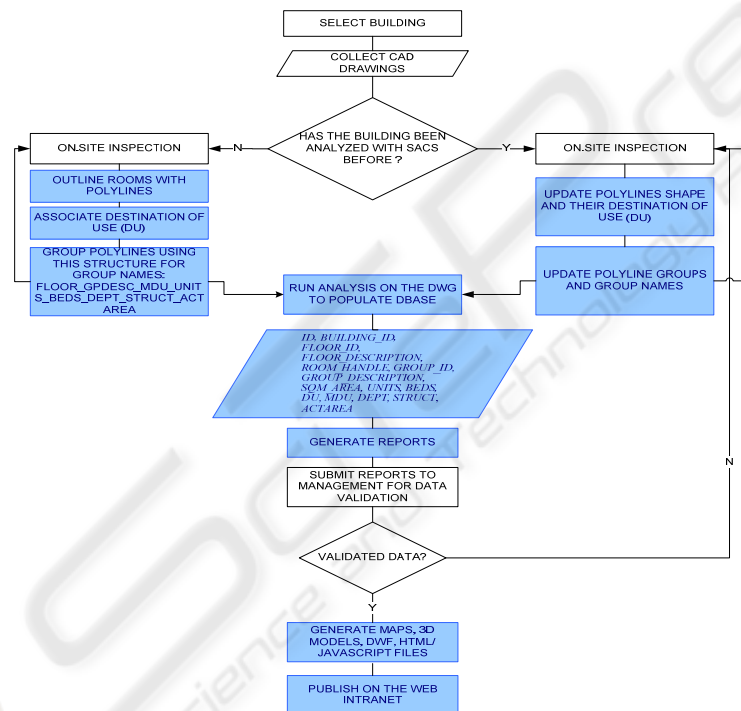

Fig. 1. Process flowchart. Blue steps are performed using SACS.

2.1 Data Input: Wards as Polylines Groups

The first hitch to overcome is the heterogeneousness of the cartography. This information is supplied by the technical/logistical department, by the safety department, or from external consultants in charge of inspection campaigns.

Without a prescribed standard, these CAD drawings are non standard under many aspects like the criteria used to name layers, the physical positioning of additional data, the updating level, etc. This matter is overcome by recasting each DWG file, creating a new reserved layer to SACS software, in which the rooms are outlined by closed polylines.

The purpose of this work was to insert the whole information directly inside the DWG file, forcing its use as a database. The external HIS database can still be used, but just as a "reading key" to translate the synthetic information held by the DWG file, using some support tables to describe the various parameters. This approach makes it possible to rebuild anytime the whole information having nothing but the DWG file.

Polyline colour is used as a parameter to identify the destination of use. Hence, the software is provided with a module to make multiple selections on the DWG file and to give to selected polylines a colour index (using the *colour* property of the *AcadPolyline* object) chosen by a list (*dbList*) of 22 destinations of use (*DU*) coming from a database accessed via ODBC.

One of the purposes of the proposed system is to compare the space reserved to the various functions with that suggested by literature standards. To do that, it must be introduced in the model the concept of "main destination of use" (*MDU*). This parameter considers each room in the operative context in which it is inserted. Therefore some rooms are linked together by a functional connection.

The software implements this approach by using Autocad *groups* feature. Polylines are grouped by homogeneous functional areas; group name is then used as an array of fields separated by underscores according to following syntax:

FLOOR_GPDESC_MDU_UNITS_BEDS_DEPT_STRUCT_ACTAREA

where
- *FLOOR* is the level inside the building, useful for multi-floor drawings
- *GPDESC* is a brief description of the polylines group
- *MDU* is the prevalent destination of use (each group is generally made by polylines with different *DU*)
- *UNITS* is the actual number of rooms in the group with DU=PDU; this number can be different from the mere automatic count of polylines and is intended to be use as a "fine manual adjust"
- *BEDS* is the total number of ward beds in the group
- *DEPT* is the department code (useful when the actual amount of structures that use the rooms is unknown)
- *STRUCT* is a combination of codes representing the operative structures that use the rooms. When they belong to different departments, the *DEPT* field is left blank.
- *ACTAREA* is a number code that represents the Activity Area. The whole hospital is divided by activity areas that belong to a single department.

2.2   Data Update and Output

The most demanding phase in the whole process is the first one, as described above in Section 2.1. Actually the proposed method shows its biggest power in the subsequent

steps, making really fast the updating step. This can be scheduled or made upon request of the management while relocating some hospital functions.

Besides, the software can be usefully employed by the head office together with technical department and clinical engineering department using a WHAT-IF method to make spatial simulations and to perform architectonical or technological renewal plans.

The information in each file, once processed as described, is extracted by the software and inserted in a support table via ODBC in order to generate some reports including key performance indicators [6]. Table fields are the following:

- *ID*
- *BUILDING_ID, much useful in pavilions hospitals*
- *FLOOR_ID*
- *FLOOR_DESCRIPTION*
- *ROOM_HANDLE, given by CAD as the polyline handle*
- *GROUP_ID*
- *GROUP_DESCRIPTION*
- *SQM_AREA, room area in square meters*
- *UNITS (see above – Section 2.1)*
- *BEDS (see above – Section 2.1)*
- *DU, the room destination of use*
- *MDU, the main destination of use of the functional group to which the room belongs*
- *DEPT (see above – Section 2.1)*
- *STRUCT (see above – Section 2.1)*
- *ACTAREA (see above – Section 2.1)*

Starting from this table SACS allows to publish detailed reports arranged by building (fig. 2) or by operative structure (useful to study the scattering of a functional unit in the hospital estate and to plan possible improvements.

Fig. 2. Sample numerical report.

2.3 Intranet

To make the information accessible via web using the hospital Intranet, the software takes advantage of AutoCAD's hyperlink feature. It is possible to associate to every single polyline an hypertextual link and then publish the drawings in a DWF format, visible with a web browser and a free plug-in (available on Autodesk website).

SACS uses the *hyperlink* property as follows: in the hyperlink descriptions it inserts an abstract of the information about the room and about the group to which it belongs (*DU*, *MDU*, *SQM_AREA*, *HANDLE*, *DEPT*, *STRUCT, etc.)*. In the hyperlink target it puts a string like this:

<div align="center">

GROUP_NAME & "#" & HANDLE

</div>

Then the software produces, for each polyline group, an HTML/JAVASCRIPT file called

<div align="center">

GROUP_NAME & ".HTML"

</div>

In this file, the data for the whole group and for the single polylines that compose the group are summarized. The JAVASCRIPT code is used to highlight in red the data for the particular polyline identified by the hex handle extracted from the URL starting from the "#" character.

The belonging of the polylines to the different groups is emphasized by means of a 3D solid modelling. Each polyline is associated to extruded regions which are coloured according to their destination of use. The height of these regions is used as a parameter to distinguish different room groups (fig. 3). Also these rendered three-dimensional rotating models are published on the web intranet. AutoCAD does not expose the VB method and properties for the rendering engine; therefore to export 3D images on a file the software uses LISP strings sent to AutoCAD via VB using the *sendcommand* method [4].
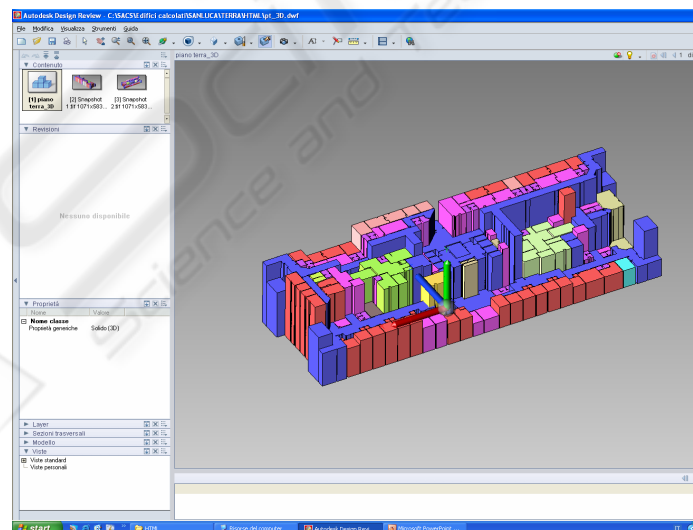

Fig. 3. Height used as a parameter to spot groups of rooms.

3 Results

The proposed system has been applied to Careggi hospital in Firenze, Italy. SACS mapped 10.589 rooms in 24 different buildings, equal to 206.940 square meters. Information acquisition and processing required the work of 8 people, full time, for about six months. System outputs have been put on the hospital Intranet website and has met with success by the top management who first asked for it and now uses it daily.

The outcomes of the project have gone far beyond the technical department and the healthcare management department. Actually, the information coming from the system is currently also used by training courses office, as well as by the hospital press office or by the safety office. Indeed, the main outcome comes directly by spreading the information both in aggregate and detailed forms using simple web pages. Software is quite flexible and allows selection queries on single rooms (as long as they are on the same DWG file) and gives numerical and graphical reports. Hence it is very useful as a support tool for the healthcare planning.

Careggi hospital has recently been remodelled using an organizing model "by intensity of care": all the hospital information systems (about patients, staff, healthcare equipment, etc.) are now referred to the single Activity Area (*see above – Section 2.1)*. The field ACTAREA is therefore especially useful to access and link information in other hospital databases.

Actually SACS acts also as a hospital geographic information system (GIS) for the clinical engineer. It allows him to reach, starting from a CAD drawing, the information about healthcare technology used in the single rooms, so enlarging his global view. He can assess parameters like the maintenance state of an equipment or its obsolescence, being aware of the hospital context in which this equipment has been used, in terms of environment and people.

4 Conclusions and Future Works

The proposed system is still under continuous evolution. It is under study a more detailed set of destinations of use that will become more than 40 compared to current 22. Each DU could be fragmented using an 8 bit sub-classification in order to assess accreditation issues. It is also under study the possibility to include some volumetrical data and technological issues like "air volumes per hour", "number of medical gasses connections", NFPA99–like codes and more.

The application of the presented method to different hospital settings would need a preliminary adjustment step, depending on the particular organizational structure of the selected hospital. Indeed, this phase should not affect very much the method itself or the system setup time. Therefore the system is quite hospital-independent.

Author is currently not planning to migrate to other programming languages or CAD software, but is weighing up the possibility to convert SACS to open-source.

Acknowledgements

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Appendix

List of abbreviations

CAD	Computer Aided Design
DWF	Autodesk Design Web Format
DWG	AutoCAD native drawing file format
HIS	Hospital Information System
HTML	HyperText Markup Language
NFPA	National Fire Protection Association
ODBC	Open Database Connectivity
SACS	italian acronym for 'system for the analysis of the hospital equipment
VB	(Microsoft) Visual Basic