DATA MODELS FOR GEOMETRICAL PHYSICALITY AND MATERIAL INFORMATION FOR ON SITE IMPLEMENTATION IN SURVEYING

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Abstract

This article describes a new method of collecting and utilizeing the information needed for renovation of existing buildings. The method is called the RENO–system and it has been developed in Tampere University of Technology. The most remarkable properties of the system are the fully three–dimensional model of a building linked together with a relational data base management system to store material and other attribute information during on site surveying. In the system development special attention has been paid to efficiency: producing the three–dimensional model of a building is almost as cheap as producing the two–dimensional drawings by conventional methods. The new method can also be used solely for room and material inventory.

The three–dimensional CAD–program running together with the relational data base management system enables effective processing of the information. The RENO–system can generate graphical information suitable for the most common CAD–programs and the data base interface uses SQL–standard, from which the information can easily be transmitted to other programs. Of course the three–dimensional data can not be processed with a two–dimensional program, but in general the RENO–system can produce renovation information in any form required by customers.

The result of this research defines the data model to input the physicality of spaces. Also the result involves the definition of the surveying method for source information procurement in existing environments regardless of whether the object to be modelled is a building or part of town.

1. BACKGROUND

To improve the applications of different data models due to building modeling the procurement of source information should be a branch to be developed. It happens all too often that a design process for renovation is carried out without exact information about the existing building. Source information is often based on inadequate drawings that have been scanned for later computerization. Design work with insufficient data can lead to a situation where part of the design work has to be done on site. This may amount to an overlap in design. Regarding facility management the need

for information has a lot of connections to the field of the renovation. The information has to be flexibly modifiable and updatable so that the current position of the spaces is always under control. The way to handle and update information should not be based on pen and paper.

This study is concentrating on developing a method in procurement of source information from buildings. The aim is to create a surveying method and a data model which combines geometrical physicality and material information together directly during the inventory process carried out on the site. The data model should include the required information already on the site because any additional data created afterwards will cause extra expenses and tasks, and usually impair the accuracy.

The base of the system comprises two different surveying methods:
1) The interior surveying system based on geometric modeling with a tacheometer.
2) The facade surveying system which utilizes a stereo photogrammetry technique.
The fundamentals of the measurement have been carried out in recent years. The measuring methods are described in other publications in Finnish (Laasonen 1991) and in more short form in English (Laasonen 1993). The current work is proposing a better usability of related information.

2. REQUIREMENTS

When working on site, not in a laboratory the requirements of the data model are quite exacting. At first the most important thing is to know which information of the building really is needed. If we examine some theoretical models we notice quite soon that it is impossible to handle as much information as they include. There will be many problems: first in procurement of information and then in computer capacity when the data is processed and last in keeping the data updated. There is no sense in procuring data if it can not be managed because of the low know–how–level of computers. Even the level of computer technique is today quite developed you should anyway check the users level. For example: does the architect have any kind of CAD–system. The whole team should first be collected together and remembering the first requirement:

1) Do your homework: first the planning

The information should be classified into two different categories: 1) Information that will only be useful once 2) Information that can utilized in future in facility management. In the second case all the information collected for building should also be updatable in the future. This means that within the organization there must be a person (or persons) who is familiar with the content and responsible for updating the information accordingly. Even though it would be nice to have all possible data from the building, it is also important to remember the realities: If your organisation can not keep some information updated it has to be used only once and then move it to the archives. This kind of data can be used when renovation is planned with the special designing program. The data used in facility management must be updated all the time and it must be truthful: not the history or unfulfilled plan. If the data model is well planned then both kinds of information types can be procured at the same time and the separation done afterwards. To make all this possible we get the second requirement:

2) Use the most compact database you can

Many general details are connected to building which cannot be found on site. For example the name of the architect or the book–keeping and the taxable values must be obtained from the documents. Those are the basic data for the owner of the building but in this article we are concentrated to the data which must be collected on the site.

The scanning of old drawings is the most quick and economic way to have they in digital form. Unfortunately two dimensional drawing include very little information which is insufficient when we are discussing the facility management. A drawing is also a very poor basis for planning the renovation of a building. It is the rule, not the exception that in the old drawings there are a few deviations and inaccuracies compared to the reality. The third requirement is:

3) Obtain possible information on site

Even now we cannot be too expensive. The action is useless if it is nonprofitable. So the method used should be in balance of the amount with information. The most simple cases can be handled by pen and paper but very quickly more effectiveness will be needed. Many forms are designed to procurement of the data but why all of them are printed to the paper. The data is transformed to the computer anyway, so why not put it in at once. With the computer program the user interface can planned more easy and more instructions can be included. Also the reasonability of the data can be checked immediately. If the data is input to the computer from the papers by another person the errors of data will not noticed or they can not be repaired. Instead there is a possibility to cause more human errors.

The most dominate thing in the costs of the data collection is the accuracy. "Cheap is not good" can be formed "Cheap is not accurate". This is a more complicated thing than could be expected. When measuring a wall or a column they must be placed somewhere. It is anyhow not the absolute truth. If the accuracy is poor the model does actually mean that the column is somewhere there. If some ventilation of new walls are designed to join to the measured object the construction must be as flexible as the accuracy of measurement requires. Also the elements used in renovation should have the elastic joint parts. Also to save the time and money the fourth requirement is:

4) Select the method which is the most effective and accurate

Even if the right method is used the usefulness of the data depends mostly on how carefully the information is procured. Usually the users are prejudice to new systems which is a very natural reaction, especially when computers are in question. It is catastrophic for the system if the reliability is lost in the beginning because of the errors of the data. The most ideal is if user of the data can also procure it himself, but nearly as good, is the trained professional. Of course a good measurement program is as automatic as possible and leaves so few things to be remembered by measurer as possible. To avoid the unnecessary completion is the fifth requirement:

5) Do not save in craftsmanship

3. THE MODEL

In figure 1. is described the basic form of the data model. The surveying database is first transformed to the neutral file and then to the used computer environment. Depending on the environment used the material and the quantity database can be used separately or as single entirety when the link between them is not cut off.

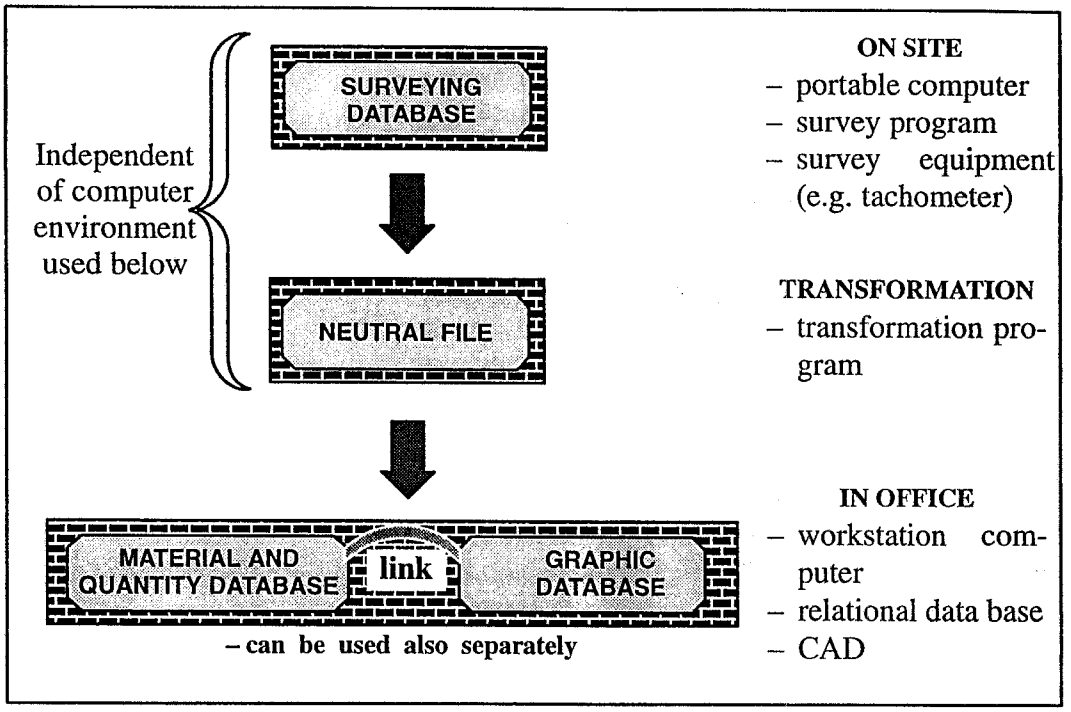

Figure 1. The basic composition of the data model.

Figure 2. describes the surveying database. To describe the connection between the boxes the general database method is used. In the model there are three hierarchy levels: the space information, parts of the construction and to the attributes of them.

The model is space orientated. In one building there are several spaces in which there are parts of the construction and technical furnishing and equipment. The surveying database is designed for information procured from visible objects because other investigations are take too much time to be done together with the inventory or geometric measurement. For example when the material is broken down the more thorough investigations are in question.

Because the visible surfaces and objects are measured the model will contain the same elements also. One room is limited by wall, floor and ceiling surfaces which are modelled three dimensionally. As a result the real placement and area of those surfaces is known. In the surveying database also the windows and the other holes are treated the same as any other part of the building.

The most important parts of technical equipment are electricity, water supply, heating and ventilation. Sometimes also firm furnishing are measured. The placement of them are measured with one to three points and the type of them determines the graphical appearance. So the type, the amount and the space where they are placed is stored to the database.

The condition information is based to a simple classification. The user can himself determinate the number of classes as necessary but in the basic solution there are three classes: 1) no needs for action 2) must be repaired during this season 3) broken, must be repaired immediately.

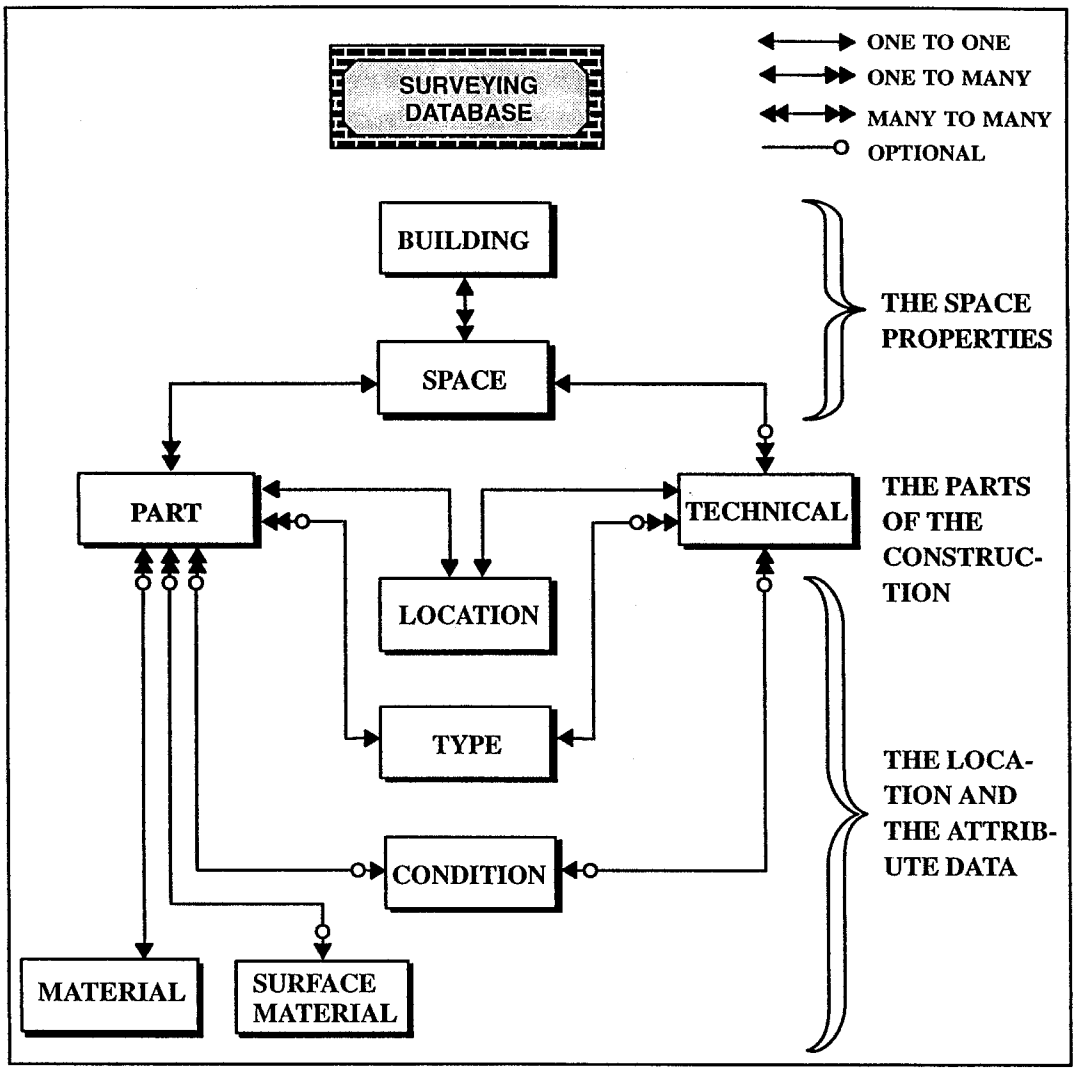

Figure 2. The surveying database.

The implementation is carried out in a relational data base environment. In order to reach a maximum flexibility, the system has to have a fully modular structure. Any module should be replaceable. For example the measurement equipment or the used CAD program can be changed.

The same database model is used in both cases: for the inventory and for the measurement. The term inventory is used when more inaccurate equipment is used and to separate inventory from the accurate measurement. The idea is to produce a model where the material and the geometrical data is joined together on the site and the link between them is stored automatically during transformation.

The measurement information is transformed to the neutral file mode. Because the simple and widely used standard is not yet published the standard ASCII form neutral file is used. A few transformation programs are designed for example to IBM/AES and AutoCad with available relational databases. If the data can be generally transformed by program to some computer environment the design of the transformation program is not a big problem. Therefore the profitability of the results is independent of the computing environment. The question is can the used program environment utilize that link between three dimensional CAD and the relative database. In practice that is often not the situation and that is why the quantity database is expanded so that it can be used separately.

Figure 3. describes the database where the all measured material and quantity information is collected. The biggest differences to the surveying database are the holes and the quantity information. The holes are now treated separately from the other part of the space because they are joined to the other surfaces. For example the window is the hole of one wall. The used transformation program can create this link automatically inside one room which means that the measurer has one thing less to remember: the holes can be measured in any order.

Also the quantity data is calculated automatically by the transformation program. From the surfaces the supposed width and high are calculated. The width is determined so that it is the longest distance between two consecutive measured points and the high is the longest perpendicular distance to any other measured point from the width line. The other calculated items from the surfaces are the circumference and the area. In the calculation of the area the surface is first divided into triangles. The method also provides a good approximation of the area of the surface which is not the mathematical plane.

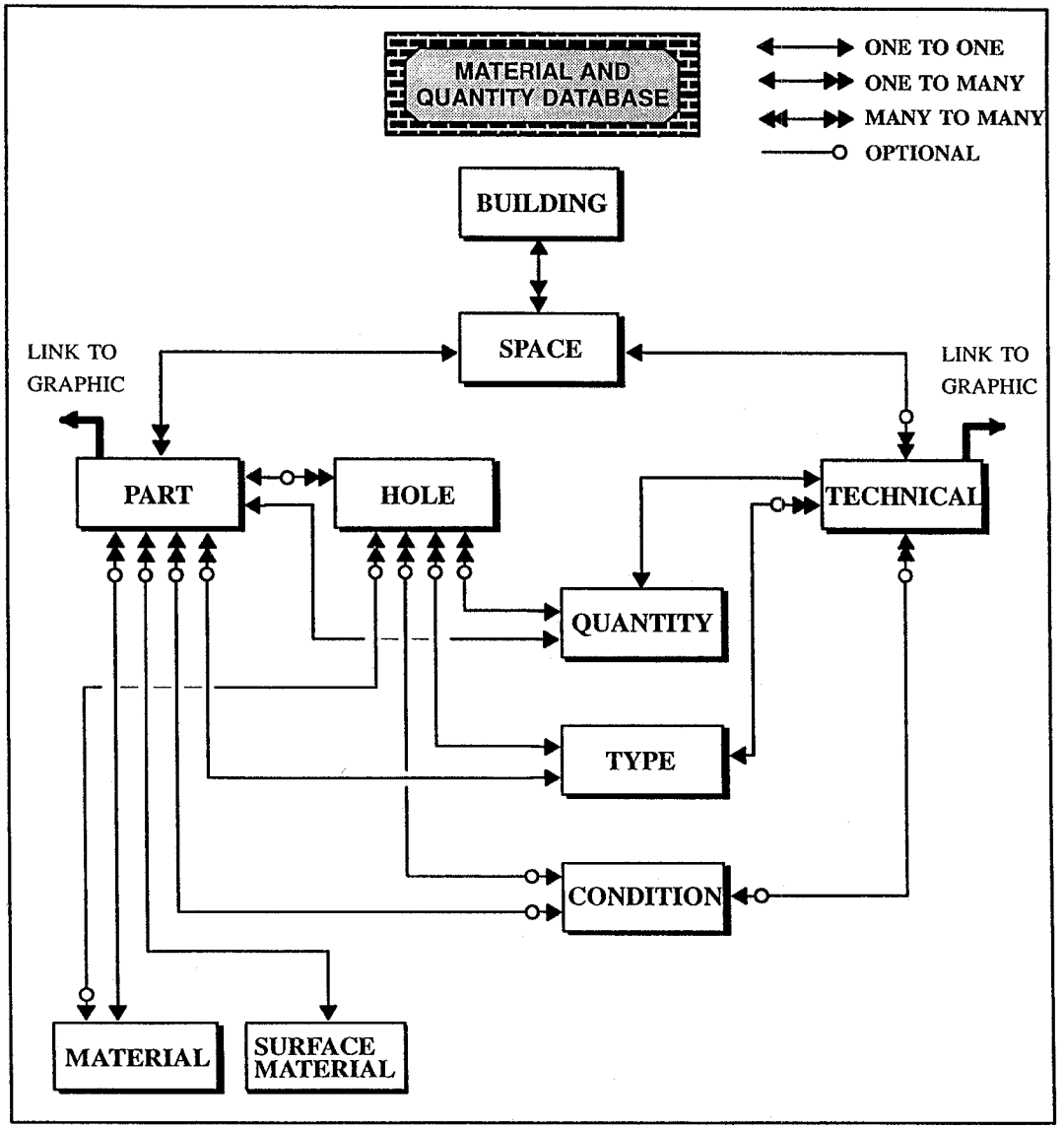

Figure 3. The model of the material and the quantity database.

As mentioned the output of measuring is the surface model of the building. The other way to model a building is to use the wall central lines. This kind of model is more

complicated because in building there can be only one room on the other side of the wall but in the other two rooms. The wall area of every room should be known and database used should be able to handle all those kind of situations. If one anyhow have that kind of computer modelling system the measurement information can be transformed also. Unfortunately the transformation cannot be made automatically but the connections between different wall planes must be shown for example by a mouse.

The same kind of problem is also in the presented model with the holes. At the moment the measured hole will be joined only to that room where is has been measured. You can always measure the same door twice from both rooms but then you would have too many doors in your database. The recommended way is to measure the each door only once and tell the connection of the door to the other wall and room afterwards using the self–programmed functions of the CAD–program.

Also the frame of the building is naturally measured but at the moment the frame database can not be automatically generated. The frame is measured as a three dimensional object using special methods. For example from a symmetric column only the visible side is measured and the transformation program generates automatically the other nonvisible side using the rules of symmetry. When this calculation is done the program can not always identify the polygon which determines the size of the column or the beam.

The physical implementation of the graphic database is usually a CAD program. It is not the only solution because in some database systems the graphic information is also stored to the database and the picture is generated every time from there when needed. This kind of solution is very quick if there is no need to use complicated graphical edition functions.

The link between the material and graphical databases means practically that there is one line in the database for every graphical element and that they are connected to each other by some indicator. For example the wall surface is represented in CAD–program as a three dimensional polygon and in the database the same wall is represented in one individually numbered row. The same number is also in the attribute data of the graphic element. The link offers the possibility to use the program which automatically updates the other information when the other is changed if computer environment is sufficiently advanced.

4. UTILIZATION

Today many firms are planning the modernisation of the facility management system. the thing done first should absolutely not be the procuring of a new computer or a program. The most important thing is to find out the contents of database which are suitable for organisation. The suitability depends on which information the organisation can keep updated. Sometimes the old work methods must also be changed to more effective usage. This and the use of the computers may cause a large need of education.

The second thing on the list is the procurement of the data. These two things fix also the project budget. The buying of a few computers is nothing by comparison. In fact the computer shopping should be in the last position in the list. It is much easier to buy something when you really know what you need. All too often the system is; first buy a computer program and then start to think what it actually does and is it suitable at all to the purpose in question.

The information about an existing building is needed in everyday maintenance. Planning budgets, taking care of tenants or following heating and water consumption demand perfect and current information. However, surveying a building is currently not done until the architectural planning of the renovation is going on. The inventory with the same database would offer the updated and accurate information. Today many large contracts are based to the estimation of the areas.

Sometimes the database of the building can be a product which is sold together with the house: an advanced customer wants to know what he or she is actually going to buy. In the other case the decision of the building's use in the future may be made without knowing the suitability of the building for that purpose. It is usual that the buildings are priced on per square meter basis. This could be very problematic if the accurate sum of the whole area is not known.

The tradition of requesting offers from contractors might change, because the bill of quantities could now be attached. The contractors' own estimation and survey are no longer necessary which should also cause lower prices. There is no sense the same asbestos to be removed from piping insulation is measured by every contractor who wants to give an offer for example.

The three–dimensional model can also be utilized in marketing an old building to the customers. According to the architects one of the biggest problems in discussing the utilization of an old building is that the customers do not get the right idea of a space from two–dimensional drawings. Also a site visit with the customer to an old and dirty building can cause a negative effect despite of all the explanations. But with the three–dimensional coloured pictures the customer's imagination is not tested too much.

The model is tested in some practical buildings with widths of between 2000 and 45000 m^2. The measurement data has transformed also to PC–environment where the graphic model has been in a two dimensional form. The experience has been very positive after the users have understood the idea of measuring and especially the accuracy. For example in a two hundred meters long building the high position of the floor varied four centimeters but still the designer wanted to ask if the measurement is done correctly. He was so used to the computer aided idea that the floor is the absolute plan.

At this moment many architect and engineering offices in Finland are quite small and their resources to investigate computer systems are limited. Therefore only a few of them have experience of three dimensional design but as soon as the know how level improves so will the measuring markets expand. Those how are going ahead will have the advantage in competition which is very hard to reach quickly by the others.

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