

## 2. BUILDING PATHOLOGY - BP

'Building Pathology' [BP] is rarely used by those not associated with the building surveying profession. The most simple definition can be described as "...identifying faults / defects in buildings." BP is becoming more widely used to define the holistic approach to understanding buildings, in regard to their design, construction, use, and the various mechanisms by which their material and environmental conditions are affected. There are three issues to consider, as told by the Association d'Experts Europeens du Batiment et de la Construction, they are:

- Identification, investigation and diagnosis of defects in existing buildings;
- Prognosis of defects diagnosed, and recommendations for the most appropriate course of action having regard to the building, its future and resources available; and
- Design, specification, implementation and supervision of appropriate programmes of remedial works, and monitoring and evaluation of remedial works in terms of their functional, technical and economic performance in use. (AEEBC, 1994)

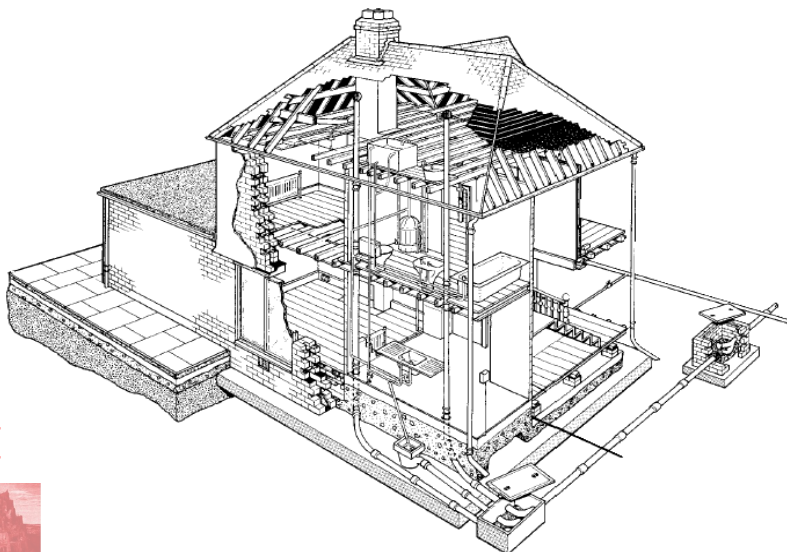
Recent research shown on two British television programmes [*Dispatches* on Channel4 and *Raising the Roof* on BBC2] has highlighted some major problems in surveyors carrying out surveys. Professor Malcolm Hollis, a well known leader in surveying technique research in the UK, showed how a number of surveyors failed to recognise a number of serious defects when they were secretly filmed carrying out a survey on a property (Hollis and Bright, 1999).

The CIB has a number of bodies that specialise in different fields of construction; the number specific to building pathology is W86. (<http://www.cibworld.nl/pages/ib/9904/pages/around/w086.html>) It is essentially dealing with learning from the past and the knowledge that can be disseminated from building failures and their treatment. The basic aim of the commission is to understand the degradation process, to define methods and tools in order to easily identify potential defects and to devise solutions to reduce the effects and to avoid any foreseen cost repair or maintenance.

Building pathology is of interest all over the world, both because it is associated with a basic human need, that is the need for comfortable shelter that lasts, and because, as it has been clearly demonstrated, premature failures cause an enormous waste of resources. The life-cycle cost of buildings exercise a major proportion of gross world product:

- Building activities represent approximately 40% of the world production;
- Solid waste production from building construction, demolition and the production of building products approximately represents 40% of the world solid waste production.
- Building failures generate approximately 10% of that life-cycle cost.

(<http://www.cibworld.nl/pages/ib/9904/pages/around/w086.html>)



As a result of these facts the identification of building failures could very substantially affect both the direct costs of a building and the environmental impact of the construction sector, in every country.

The figure opposite shows a typical UK house, which highlights the complexity of construction and thus the difficulty of identifying building failures.

*Figure 1 A typical UK dwelling showing the difficulties of surveying*



*buildings.*

The next section outlines the research field of Computer-Aided-Learning.

### **3. COMPUTER-AIDED-LEARNING - CAL**

The first adaptive CAL program was developed in the mid 1960's, (Suppes, 1966) who predicted that it would "...change the face of education in a very short time" and it could provide for every child "...the personal services of a tutor as well-informed as Aristotle." With the introduction of micro-technology, computers have gained a more prominent place in education. By 1981, Seymour Papert, declared that the 'worksheet curriculum' could be abandoned to allow "...children's minds to develop through the exploration of computer simulated microworlds" (Papert, 1981). By 1985, 80% of UK secondary and 95% of primary schools had some level of computing (Jackson et al, 1986). By 1986, Bleach had concluded that although generally welcomed, computers were little used - sometimes remaining idle for 80% of the time, and significantly less than television was used in primary schools (Bleach, 1986). The main use for computers was still used to automate mundane tasks.

By 1995, research had moved forward with Reinhardt claiming that "...this generation of technology promises more than just an improvement in educational productivity, it may deliver a qualitative change in the nature of learning itself" (Reinhardt, 1995). It is necessary to determine where the technology is being, and is going to be, used. If it is to be brought in the form of 'edutainment', or primarily by employers as part of their employee's training programmes, the effect will be very different to if it becomes an integral part of mass education.

#### **3.1 CAL in Education**

Where does CAL fit into education? Seymour Papert offered his view, "In the 1980's...I caught myself telling school establishments and administrators that what I've got with this technology is what they need. It's not what they need at all. It's the kiss of death. Its the end of education as an organised entity - of the school as we've known it" (Papert, Grillos, Norman et al, 1994). What Papert is essentially saying is that CAL does not fit into education as it is presently structured. In order for CAL to fulfill its full potential policy changes will have to be made by parties outside of the institutions. The British Government is already discussing, and implementing these policy changes to address this problem ([http://www.news.bbc.co.uk/hi/english/educational/newsid\\_64200/642843.stm](http://www.news.bbc.co.uk/hi/english/educational/newsid_64200/642843.stm)).

#### **3.2 Obstacles to the use of CAL**

The first obstacle is the lack of material resources. This becomes even more pressing when the revolution in CAL is seen as coming through networking, connection to the Internet and so other schools. Carol Twigg refers to the "...installed base of telecommunications technology in the schools, 80% of which is obsolete" (Twigg, 1995). The second obstacle is that the computer is not a magic machine that works itself. Research has concluded that the amount of time needed to develop CAL has been grossly underestimated, with at least 100 hours training per year required (Passey and Ridgway, 1994). There has been little evidence that educational institutions are prepared to expand the necessary time for training or expense of providing adequate ancillary support to develop CAL applications.

The third obstacle to note is the present lack of very good educational software available on the market. This research is aiming to tackle this problem by providing a CAL application for use at undergraduate degree level (Shelbourn, Aouad, and Hoxley, 2000) to help surveyors diagnose defects in buildings. Carol Twigg quotes Peter Drucker as saying, for any new technology to be successful it must do the job ten times better, as for example word processing does over hand-drafting a document (Twigg, 1995).

The next section shows how the field of Case-Based-Reasoning is used in the prototype application.

## 4. CASE-BASED-REASONING - CBR

CBR is an Artificial Intelligence [AI] paradigm, in which storing, retrieving, and adapting the solutions to previously encountered problems are used to solve new problems. CBR is based on the premise that expertise is experiential in nature. What separates an expert from a novice is the breadth of their experience. For example:

- a doctor who has seen an ailment many times before can quickly spot it in the next patient;
- an insurance underwriter who has seen many cases of bad risk for life or car insurance;
- a bank manager who has seen many bad debts and knows how to recover money easily;
- a lawyer refers to past legal cases in defending a new client;
- a mechanic who has heard many rattles can tell you why your car is rattling.

The CBR cycle can be simply described as a process of four 'R's:

- Retrieve the most similar case(s);
- Reuse the case(s) to attempt to solve the problem;
- Revise the proposed solution if necessary;
- Retain the new solution as a new case.

This cycle is illustrated in the diagram opposite. A new problem is matched against the cases that are stored within the case repository and the cases closest to the problem definition are retrieved. A solution suggested by the matching cases is then reused and tested for validity. Unless the retrieved case is a close match, the solution may be rejected or revised to match the problem. The revised case will be retained in the case repository for future use. The cycle is a continuous process and rarely occurs without human intervention.

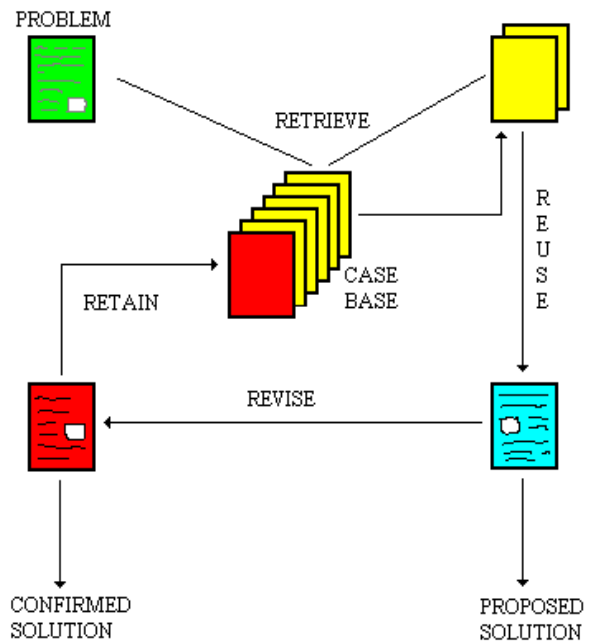


Fig.2 The CBR cycle. (Watson 1997)

## 5. VIRTUAL REALITY - VR

The use of VR is the main focus of the research. A roof space is portrayed as a QuickTime VR movie where the user looks for defects that could affect the components that make up the roof space. There are a number of different software tools available that can be used to develop this QuickTime VR movie; some of them are outlined in the next sections.

### 5.1 QuickTime VR Authoring Studio

This piece of software enables the creation of interactive VR scenes with point-and-click simplicity. It turns 2-dimensional photographs and computer renderings into 360-degree views. The software allows the control of setting up the camera, to blending the images together to produce the movie, and optimising the finished movies for the web or CD-ROM use. The movies are fully interactive, with zoom, animation and hotspot creation facilities to enable easy linking to other multimedia applications.

By simply inputting 'QuickTime VR' into any search engine on the Internet, you can quickly see the potential of these types of movies. At the 'Richard Rogers' site you can see how the 'Lloyds' building [London, UK] can be combined to show an interesting representation of how the building fits into its surroundings (<http://www.richardrogers.co.uk/html/lloydspan1.htm>). More information on this product can be found at the following website address.

<http://www.apple.com/uk/quicktime/qtvr/authoringstudio>.

### **5.2 Spin Panorama 2.0**

This is an innovative and easy-to-use software program that uses still images to make super-wide panoramic still pictures and 360-degree panoramic movies. The views and movies are created in four easy steps which novice and more experienced developers can easily follow. Many universities and other educational institutions are now using panoramic movies to show potential staff and students what the campus and buildings look like and the kind of facilities that the university has over the Internet (<http://www.dcs.shef.ac.uk/~guy/gallery.html>) and (<http://www.curdev.hull.ac.uk/html/quicktimevr.htm>). This resource provides these institutions with an excellent initial marketing tool as it enables more people to view its facilities without actually having to travel to visit the physical site. By incorporating 'hotspots' [parts of the movie that when clicked the user is taken to another movie or other information] the movies become a powerful educational and advertising tool. This is having a large input into the writers' application. More information on this product can be found at <http://www.pictureworks.com/spinpano/index.htm>.

### **5.3 VR Toolbox - PanoWorx**

This piece of software supports a wide variety of lenses and camera configurations to enable the easy capture of images. The software enables the import and export of files to both the 'Windows' and 'MAC' platforms. The size and position of the images is automatically adjustable, with picture blending achievable at four different levels, and sharpened to produce a perfect 360-degree movie. This piece of software has been used by 'Lego' to promote some of its products. By clicking on the different products shown on the website the user can use the QuickTime VR 'object' and 'panorama' movies to look at their potential purchase (<http://www.sharpturn.co.uk/lego.htm>). More information on this product can be found by clicking <http://www.vrtoolbox.com/ToolPANO.html>.

The software outlined could have been used to produce the VR movies for this project. After comparing the software the writers' chose the QuickTime VR Authoring Studio software to develop the movies. The essential points of this software are:

- ease of use;
- panorama movie creation;
- object movie creation;
- linking panorama and object movies into QuickTime VR scenes;
- asset management for complex projects; and
- web and multimedia content creation.

The next section will outline the prototype in more detail and show how the different fields above are linked together.

## **6. THE PROTOTYPE**

The prototype uses theories and practices from other authors as well as those areas outlined above. Research undertaken at the University of Salford in using CBR and VR to devise a training tool to inspect different scaffolds, is being sought as a good guideline as to the architecture for the writers' prototype system (Oliveira, Watson, and Retik, 1997). The architecture for the building pathology application is shown over the page.

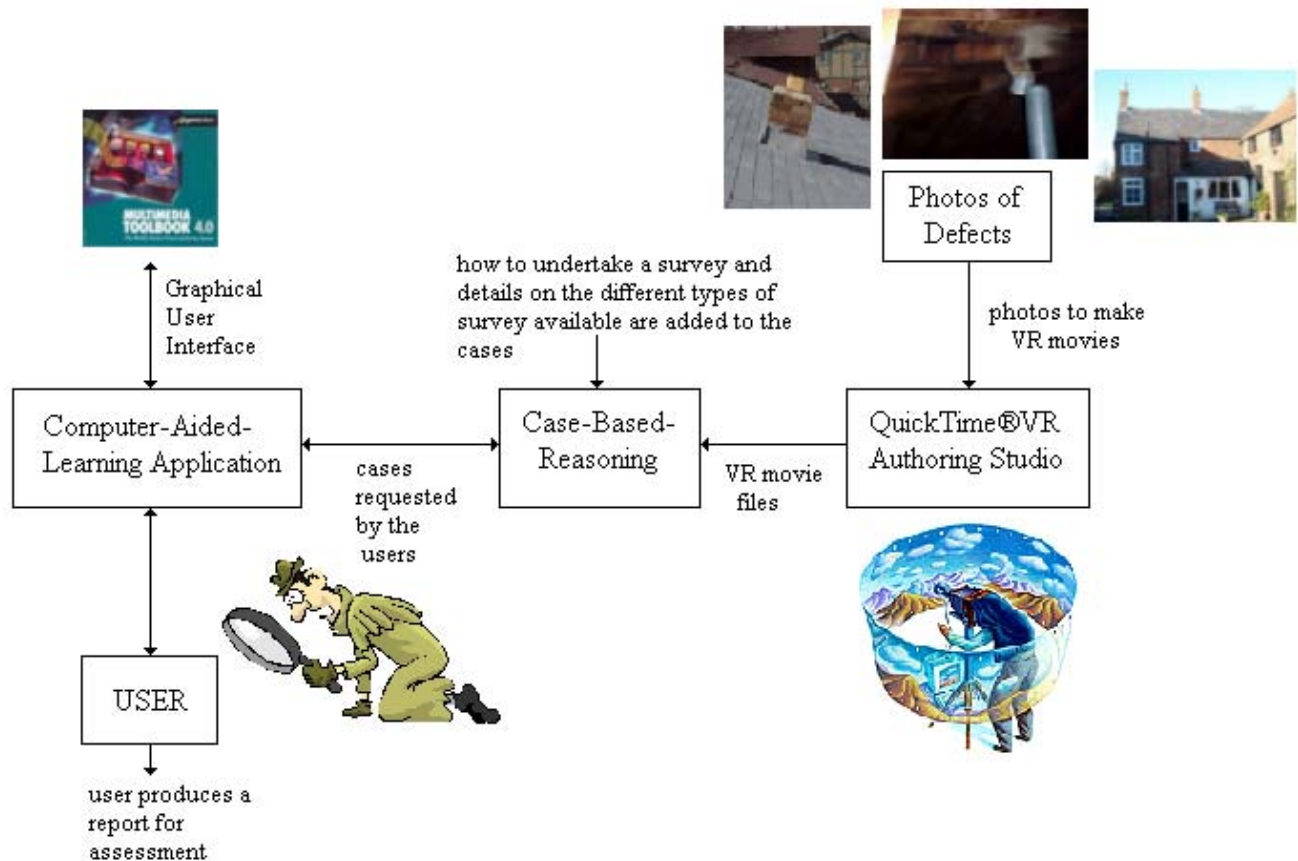


Figure 3 The architecture of the prototype application.

It was decided very early into the project that the prototype application would have to concentrate on a certain part of the building to show that the principle outlined could work. After some discussion it was decided that the roof space would be used to test the architecture of the system. From Figure 1 above you can see that trying to develop the whole house in the first instance would have been a large task.

Information on different aspects of surveying buildings is shown in the application. Some of these are outlined below.

## 6.1 Types of Survey

A surveyor will usually undertake one of four different types of survey when a client commissions them. These are shown in the next few sections.

### 6.1.1 Home Buyers Survey and Valuation

This is an economically priced survey in a standard form that focuses on:

- the general condition and constructional type of the building;
- matters and defects that the surveyor judges to be either urgent or significant;
- market valuations of the property as it stands and when repaired [if appropriate];
- how much the property should be insured for.

### 6.1.2 Building Survey

This gives the client a highly detailed report and is suitable for all properties, but it is usually commissioned for older, larger, more complex, dilapidated or much altered buildings. The survey

typically provides:

- a comprehensive appraisal of the means and materials of construction;
- a technical analysis of significant defects revealed and advice on appropriate further actions;
- identification of less significant defects, general disrepair and shortcomings in the physical condition, maintenance and design of the building.

A valuation can often be included in this type of survey as an 'optional extra'.

### 6.1.3 Valuation Report

This concentrates on the valuation of the property and as such is not classed as a survey. A private valuation report is commissioned where the value of the property has to be formally established by a qualified person. Reasons for a valuation report include:

- mortgage purposes;
- house purchases, where condition is not an issue;
- matrimonial disputes;
- court orders;
- compensation and insurance claims;
- Compulsory Purchase Orders;
- Capital Gains and other taxation matters.

### 6.1.4 Single Issue Report

This type of report is often asked for as a result of a 'building survey' and highlights specific problems associated with the property. The detail of the report is the same as a building survey, but only on the specialist subject requested.

The screen shot below is taken from the prototype application and shows the 'survey types' page of the application.

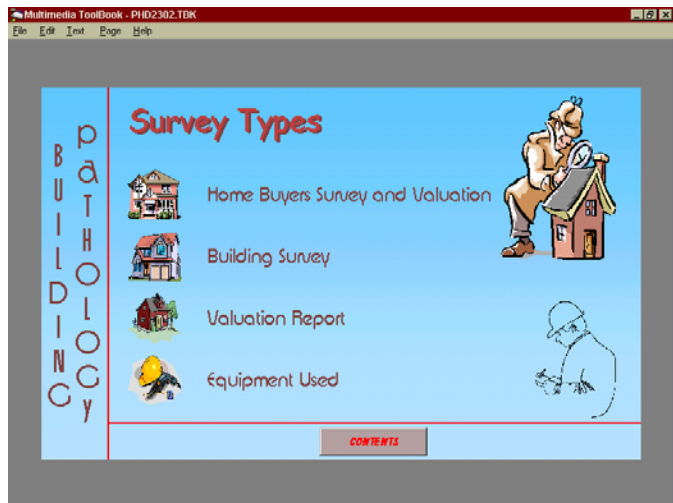


Figure 4 The Survey Types page from the prototype application.

## 6.2 How to use the application

The application is designed around the Graphical-User-Interface [GUI] using the Multimedia authoring software called 'Multimedia ToolBook 4.0' from Asymetrix (<http://www.asymetrix.com>). The user can choose to view some introductory information, about 'What is...?', 'Who is it for?', and 'Why is it needed?' After reading this information the user can then go to the main parts of the application.

There are pages specifically about the property, where it is located and details about the layout, etc. The next set of pages are the survey types pages - already described above section 6.1 and Figure 4. The next section is the QuickTime VR movie page. Here the user can view the 360-degree movie and gain information on the general construction of roof spaces and the components that make up a roof space. The screenshot over the page shows this [Figure 5].



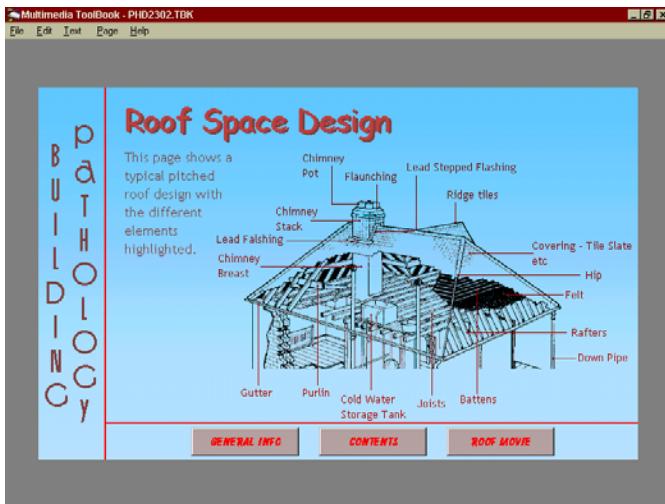


Figure 5 Screenshot of the roof design information page.



Figure 6 Screenshot of the defect cases library page of the prototype application.

The user can click on each component of the roof in the movie to gain information on the type of defects that can affect this component. The screenshot above [Figure 6] shows the main cases library page in the application.

The screenshot shows the different sections that the user can click in to gain defect information on that particular component. The information is retrieved from the CBR software. The cases are actually stored as word documents with text and graphical information contained within them. In the application pages there is some generic information that the user can read the bare facts on defects that could occur in roof spaces. The screen shots below show some of this information [Figure 7].

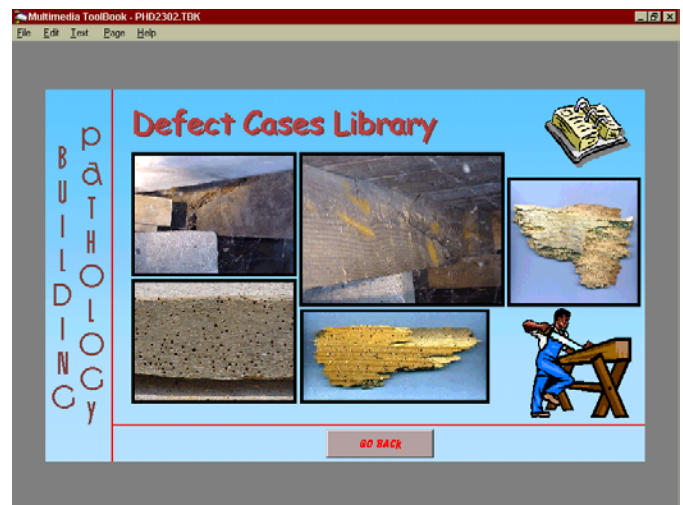
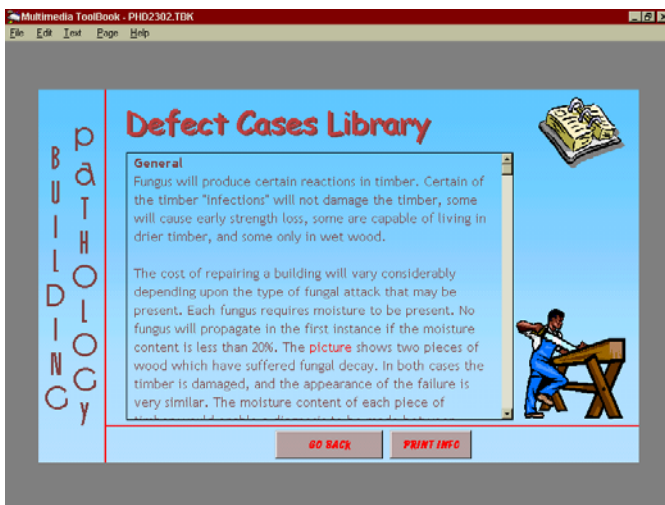


Figure 7 Pages showing some general defect information on timber contained within the application.

The next few photographs show some of the photos that will be incorporated into the defect cases stored within the CBR software and linked to the prototype application.



*Figure 8 Some photos of defects that could occur in a roof space.*

In the photos above you can see how the design of buildings can be strange sometimes. The first photo shows a chimney that has been built perpendicular to the roof instead of vertical. The last two photos are taken from the case property. The middle photo shows the old timbers in the roof and the final photo shows the roof bowing between the two chimneys. This could be a result of adding felt to the roof and changing the original roof covering with no real consideration as to the extra weight on the old timbers.

The application is tested by the users filling in a questionnaire, which can be printed - along with a great deal of other information in the application - or filled in on the application. The questionnaire is designed to enable the user to reflect on what they have learnt from the application. The next section outlines how the research can be taken further.

## **7. FURTHER RESEARCH**

The next stage of the research is to test the application with external practitioners to gain their thoughts and experiences. These external practitioners will give results and feedback that can be analysed to make improvements to the application.

The research could be carried forward and made into a commercial piece of off-the-shelf software. This type of VR development is very time consuming, as the other rooms in the case property have to be modeled and cases written to support these rooms. The final application will help industry and educational institutions to train surveyors in the identification of defects when they are carrying out surveys of buildings. The application will also help to overcome some of the problems outlined within this paper.

## **8. CONCLUSIONS**

This paper has shown how CBR and VR can be linked to help surveyors evaluate defects in buildings, in particular roof spaces. It has described what building pathology is, and explained some of the initiatives set up to help the field of building pathology.

The paper has discussed the fields of CAL, and how CBR and VR are linked to train building surveyors in the task of diagnosing defects in buildings. It has particularly concentrated on some of the different VR software development tools, the different types of survey available, and has given details of photos and screenshots of how the prototype application works. It has concluded with testing the application and future developments of the application are highlighted.



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