The 3D Wunderkammer
An Indexing by Placing Approach
to the Image Storage and Retrieval

Krešimir Matković,
VRVis Reserach Center,
Donau-City-Strasse 1,
Vienna, Austria
matkovic@VRVis.at

Johannes Siglaer, Martin Kompast,
Thomas Psik, and Ina Wagner,
Institute for Design and Assessment of Technology,
Vienna University of Technology
Karlsplatz 13/187/1, Vienna, Austria
{ jsiglar, mkompast, tpsik, iwagner} @ pop.tuwien.ac.at

Abstract

The explosion of storage media size, and spreading of the internet in the last decade resulted in a huge amount of images and multimedia material an average user has to deal with. Traditional use of filenames and directories is just not sufficient any more. In contrast to the keywording and some kind of content based image retrieval, we introduce a novel approach of storing and retrieving images, and other multimedia material using indexing by placing *mechanism. The idea is to let the user place the images in the 3D environment, where the user can find the images easily again. The images can be collected, modified, grouped together,... The principles described in the paper are implemented in the 3D Wunderkammer system which is a multi-user client-server application. The server is completely written in Java and the client runs in a standard Web browser with a standard VRML plug-in.*

1 Introduction

An average user is confronted with the large amount of electronic images today. Explosion of storage media size, and spreading of the Internet in the last decade, made it possible for an average user to collect a huge amount of images and other multimedia material. More and more professionals, traditionally dealing with a lot of images, like architects for example, are switching to the electronic images today. It seems this trend will continue in the near future. Unfortunately, traditional ways of archiving images are not sufficient any more. Thumbnail view, for example, is quite useful for moderate number of well organized images, but as image number increases, this method becomes more and more inappropriate. Another method often proposed is keywording, but there are not many of us willing to extensively keyword each of our images. Finally there are numerous content based image query systems [5, 4, 1, 9, 3].

3DWunderkammer system described in this paper offers a novel way of storing and retrieving images. It is not an archiving tool only, it also has a strong inspirational component. 3D Wunderkammer is developed in cooperation with architects, and it is tested by architects and artists. The original idea emerged from the architects' work-flow, but the resulting tool is universally applicable. The 3D Wunderkammer is a visual environment in which multimedia materials can be placed, stored, encountered, found, displayed and integrated with the flow of work. It is created interactively, with users placing their own collections of multimedia material - scanned images, sound, video, 3D objects. Although the system supports all of these materials, we will focus on the images in our description. The user navigates in the 3D world and places material. The user can determine position, orientation, size and transparency of the image. In this way the user enriches the environment by adding images, and simultaneously the images are enriched by the environment. Since the whole system is a multiuser system, images placed in the environment by other users will add completely new dimension to the originally placed images. The whole world is divided in easily recognizable modules, such as the skyscraper city module, the medieval city module, the seaside module,... The modules are positioned on the grid which makes orientation easier. Dividing the world in the modules, and designing the modules carefully, makes the whole environment full of dense landmarks which is very appropriate for *indexing by placing* principle exploited in the 3D Wunderkammer. The whole system can be considered as a dual system which can be used as archiving tool and as a tool than can help an artist to be inspired and to see

images differently taking into account the image surroundings. It is interesting, that although some users tried to use it as a pure archiving tool, all of them were amazed by the second quality of the tool, and all of them have found the environment is enriching their images.

Besides placing the images, the tool offers the user a lot of functionality. Images can be collected during the tour, and viewed afterwards in various modi, keywords can be assigned to the images, various query mechanisms are implemented, making it possible to search for similar images, or images close to the certain points,...

As far as we know 3D Wunderkammer is the only tool approaching image archiving and retrieval in this way. Using the 3D world gives the user much more space, and although we currently have more than 2000 images in our system, there is a lot of free space left. Actually, most of the world is still empty, and tens or hundreds of thousands of images could be easily placed in our, not that complex 3D world. Some of the principles used in the 3D Wunderkammer and the field work are already described in [2, 6, 8]. This paper focuses on the archiving aspect, and describes the technology used to implement the 3D Wunderkammer.

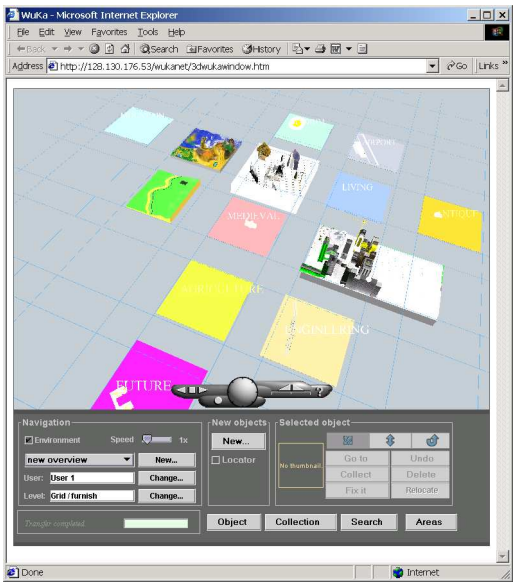

Figure 1. Overview of the 3D world used by the architects

2 Indexing by Placing, Grid Structure

Very often when we are looking for something in the real world we are actually using *the indexing by placing* principle. If we are in a new city and looking for a city hall or dome we will certainly not be looking for them in the suburbs. If we are looking for a cup, or a plate in an unknown house, we will search for them in the kitchen first. Imagine our world without such coarse, predefined structure. 3D Wunderkammer follows this principle. The 3D Wunderkammer is intended to be visual indexing landscape for primarily visual materials. The images are ”weak indexed” by their position in the environment. The 3D world must be logically created [7, 10], with easily distinguishable modules in order to make it possible to retrieve images fast. Fast retrieval is one of the most important archives qualities. Furthermore 3D environment must not be too strong or dominant, it is only a place for users materials. Once images are placed in the 3D world, they will enhance the world, and actually create a new world inside the existing one. If the original world is too boring, or if it lacks significant landmarks the whole system will fail. Figure 1 shows a possible 3D world. The modules are organized in the grid structure and can be easily exchanged, or configured according to users needs. The grid structure showed itself to be very easily configurable and easy to memorize at the same time. The user orientation in the 3D world is crucial in our application, and the grid structure helps users a lot. An architecture bureau will have different arrangement of modules in the grid from a school version of Wunderkammer, or of a

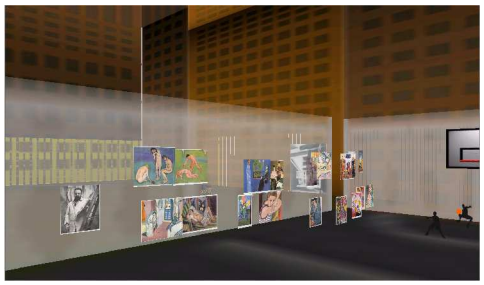

Figure 2. 2D Images placed in the 3D world

version used in a multimedia office. Examples throughout this paper are made using a setting designed for use in an architecture bureau.

The main idea of the 3D Wunderkammer can be explained using the following example. Let us assume the user wants to place a new image in the 3D Wunderkammer. She chooses an image and coarsely decides where to put it. Now she navigates through the 3D world, looking for the most appropriate place for the image. When the place is found, she places the image in the environment controlling the size, orientation and transparency of the image. Figure 2 shows images placed in a 3D world.

Afterwards, when she wants to find a particular image, and remembers the image, but not it’s name, she will just have to think where she would put such an image, navigate to this place and hopefully find it. We were amazed when

Figure 3. Thumbnail view of a collection

an user tried to retrieve an image after six months, and succeeded immediately. Note that placement of the image is subjective, and maybe another user would put the image somewhere else. Actually, since the 3D Wunderkammer is a multiuser system, during the use of the tool the user is often surprised with the images seen on the way. The subjectiveness makes the whole world more interesting, it surprises the user, and let her think why this image is on this place. This helps in seeing things differently, which is a well known inspirational technique. The inspirational environment is the second aspect of the Wunderkammer, which is continuously interleaved with the archiving approach, on which we focus in this paper.

3 Collections

During navigating through the 3D world the user can easily collect the images she likes and create collections. There can be multiple collections, making it possible for the user to classify images in some way. Once created, collections can be examined in three ways. The most simple one is requesting thumbnail views of the images in the collection. The user can request additional information on the images in the collection. The second way is observing the images in an exhibition room. The exhibition room is an automatically created 3D room, with the images simply placed on the walls. The user can navigate in the room (the easiest way is just to turn around), and examine the images. Finally, the images can be viewed on their original location, taking the user automatically on the tour through the 3D world, stopping in front of the images that are in the collection for a desired amount of time. The stopping point is the same as the viewpoint of the original ”author” of the image when she placed the image. This gives the user a possibility to see the image in the environment exactly in the same way as the person who placed the image. Figure 3 shows an example of thumbnail view of a collection and figure 4 shows the exhibition room mode.

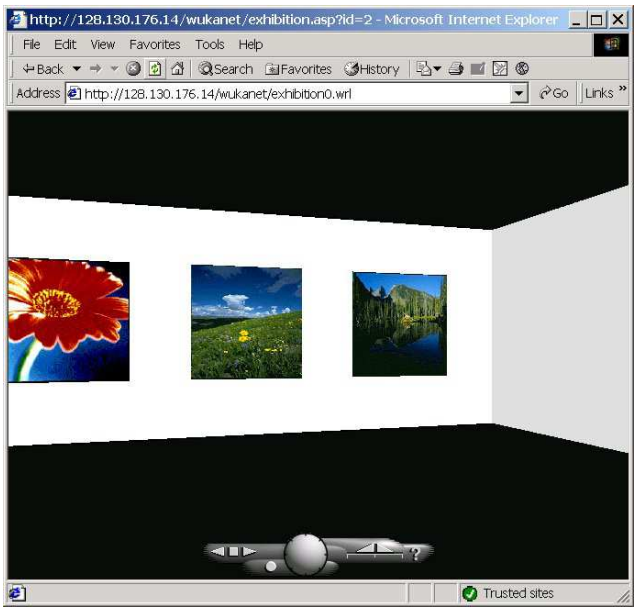

Figure 4. Exhibition room view of a collection

4 Additional Features

Besides collections we incorporated numerous additional feature which makes the use of 3D Wunderkammer easier and more intuitive. In order to make it possible to assign short description and keywords to the image, we allowed the user to set the author name, date, comment,... We also developed a set of predefined attributes which can be assigned to the image. The set is again quite architecture oriented, and can be exchanged for another group of users. Using a predefined set, makes the query more precise, and reduces subjectivity in description (like sun, sunny, sunshine, which could be possible keywords from different users for the same image). Of course reducing the set, limits the users, but the gain in consistency was more valuable than loss caused by keyword set limitation. The fieldwork showed that the decision to offer a predefined set of attributes was the right one. It was not used always, but far more often then the possibility to assign keywords arbitrarily. Figure 5 shows the dialog used for defining the search criteria, when the user wants to search the images using assigned attributes.

Not only searching using attributes, but searching for the images that are placed in a certain area can be done. This yields to surprising results sometimes. Since the main principle used in the system is indexing by placing, the neighboring images will almost always have some connection. The connection is not always visible on the first sight, but it is often possible to get a clou how the images are related

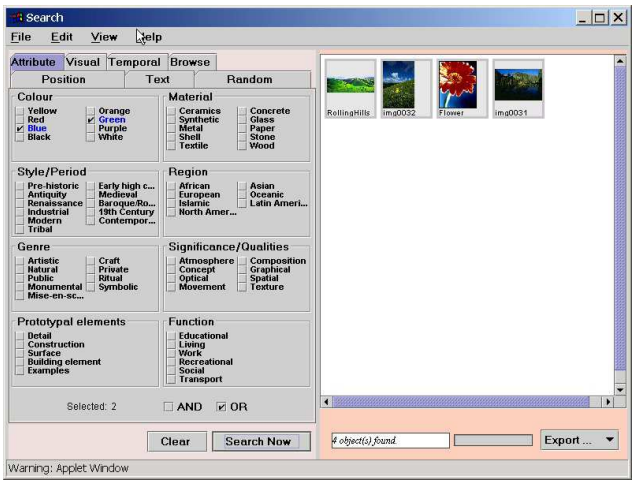

Figure 5. Search dialog in Attributes mode lets the user select the attributes from a predefined set

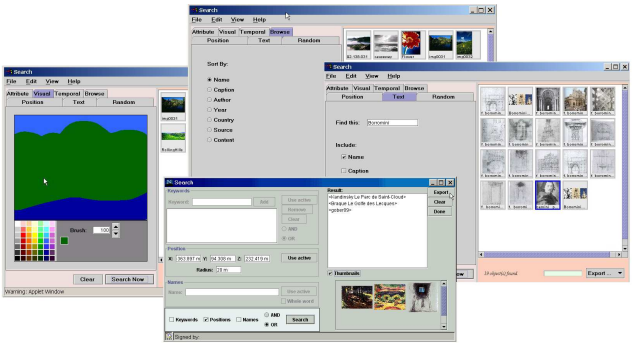

Figure 6. Dialogs used for the visual, the area and the keyword query.

after a second thought. Finally there is a color layout query implemented in the tool. Here the user sketches a color layout as she remembers, and the system searches for similar images in the 3D Wunderkammer. The results here can be surprising as well, which adds additional quality to the tools inspirative component.

Results of all queries are displayed using the thumbnail view and the user can easily ”visit” the image in it’s original location. Figure 6 shows different dialogs used for various query mechanisms.

5 Implementation

The 3D Wunderkammer system is implemented as a classical server-client solution that can be run over the Internet as well as on any Local Area Network Intranet. All data elements needed for building and monitoring the virtual environment, are located on a central server and can be delivered to any client machine. The data stored includes VRML scenes, object data (images, videos, sounds, 3D objects), program functions in the form of Java classes, scripts, HTML pages,... The 3D world itself is in VRML format, and a standard VRML browser in a web browser is used on the client side. In order to add all additional features needed in 3D Wunderkammer standard RMI (Remote Method Invocation) mechanism is used. The web browser is used to display 3D world and additional user interface elements. Besides the main window, numerous additional windows will be started automatically in order to bring additional data to the user, or to access additional functionality (image query, adding attributes, uploading images to the system,...) Figure 1 shows the main window, figure 7 shows only the control part of the main window in more detail. Various additional windows are shown in figures throughout the paper. The whole system consists of 3D Wunderkammer server, the administration client, the upload client and 3D Wunderkammer client, which will be described next. The image grouping in the VRML scene which is used to increase performance will be described as well.

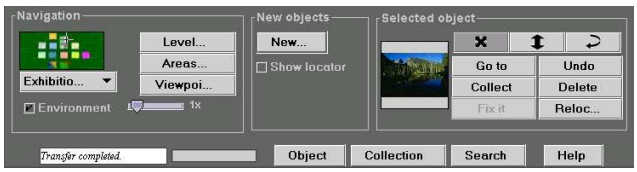

Figure 7. Control part of the main window

5.1 The 3D Wunderkammer Server

The core of the system is the 3D Wunderkammer server. It provides all the services necessary for operating the Wunderkammer system, such as processing database queries, executing image manipulations, managing shared files, etc. No client application can be executed if it isn’t able to establish a reliable connection to the 3D Wunderkammer server. All information describing the state of the various 3D Wunderkammer clients (geometrical data, object contents and attributes, level information, etc.) is stored in a central database which is managed by the 3D Wunderkammer server. This means all data manipulations are done via the server application: A client must not directly access the database but may only send requests to the server for executing specific instructions (adding new records, altering or deleting existing records, etc.). In this way the 3D Wunderkammer server can coordinate all client requests what is a necessary prerequisite for a consistent overall system

state. Of course this architectural concept excludes database ”copies” on local machines which probably would increase the system performance but which at the same time would be very hard to syncronize.

The server uses Java RMI Server with Database Access (JDBC-ODBC bridge). Relational Database stores all objects, areas, levels, collections, user information, etc... The server makes the content available for the clients via HTTP. A Java Server program monitors bi-directional communication with the client component - applets. It enables the mutual exchange of any kind of structured information between server and client and works in parallel to the WWW server software (which only performs the upload of static files). The server program is also used for creating logs of all program executions, for exchanging information between different users, and for administrating all data.

5.2 The Administration Client

Since the task of managing all 3D Wunderkammer accounts may become very difficult when the number of users rises, an Administration Client has been implemented. With the help of this application a privileged user (the administrator) can control all settings of the 3D Wunderkammer system. It allows the definition of new accounts as well as the adaption and deletion of already existing accounts; individual access rights for each level and user may be set; from any machine new levels with all necessary files (3D objects, textures, images and movies, etc.) can be uploaded to the 3D Wunderkammer server, etc. Like the Wunderkammer Server the Administration client is written completely in Java. But unlike the server application it is based on the Java Web Start technology, what means that there is no need to install it on local machines. Instead of that it is loaded over the network each time the user launches it, e.g. by clicking a link in a web browser.

5.3 The Upload Client

The Upload Client makes use of the Java Web Start technology, too. This client is used for transferring image, movie, 3D, and sound files from the users local machine to the server machine. For that purpose not only individual files but also detailed information describing these files (author, caption, country, etc.) are uploaded to the server. The server application adds this information to the database and optimizes the files for further usage. The 3D Wunderkammer architecture requires that each object has to be transferred to the server machine before it can be placed in the 3D world. While this implies a small overhead at first it involves the possibility of using it with any valid user account and from any local machine connected to the 3D Wunderkammer Server.

5.4 The 3D Wunderkammer Client

The component a user works with most of the time is the 3D Wunderkammer Client. It provides access to various 3D Wunderkammer worlds, it makes available all the functions for arranging, collecting, and keywording objects, for managing collections, viewpoints, areas, etc. The 3D client is a combination of a VRML viewer and a Java applet, both of them embedded into a conventional web browser. Communication with the VRML-scene is realized via the External Authoring Interface (EAI), and communication Client-Server is realized via Java-RMI with predefined interfaces. The 3D Wunderkammer Client can be launched from any computer connected to the Internet, without the need of installing a local copy. As many client instances as wanted can be executed at the same time, thereby allowing the sharing of any information.

5.5 Adding nodes to the VRML scene

Each new image the user adds is a new node added to the VRML scene. In the first version of the 3D Wunderkammer, each new image was simply added to the end of the scene using a predefined VRML prototype, which contained LOD information. In this way far away images are not rendered in order to increase the frame rate. The system functioned well for small number of images, but estimating the LOD level became to slow for large number of images. In order to overcame this problem, we divided the whole scene in the logical groups, so that each module contains 3 times 3 areas. Each area is represented with a separate group in the VRML scene, and has its own LOD. When the user places new image, the group, the image is added to, is selected according to the image position. In this way the browser always has to check just a relatively small number of LODs which does not depend on the number of images that are currently in the 3D Wunderkammer.

6 Using the 3D Wunderkammer

Using 3D Wunderkammer is easy. Once the system is started the user can easily navigate using the standard VRML browser, and if she sees an interesting image clicking on the image will show all image data in the object window. Figure 8 shows the object window which appears when the user clicks on an image in the 3D world.

If the user is interested in collecting the image, simply clicking on the collect button in the control panel (figure 7) will add the image to the currently active collection.

While travelling, the user may wish to position a certain image in a specific place. If the locator function is active, the locator (kind of placeholder for the new image) will be shown in front of the user. The user still can navigate, and

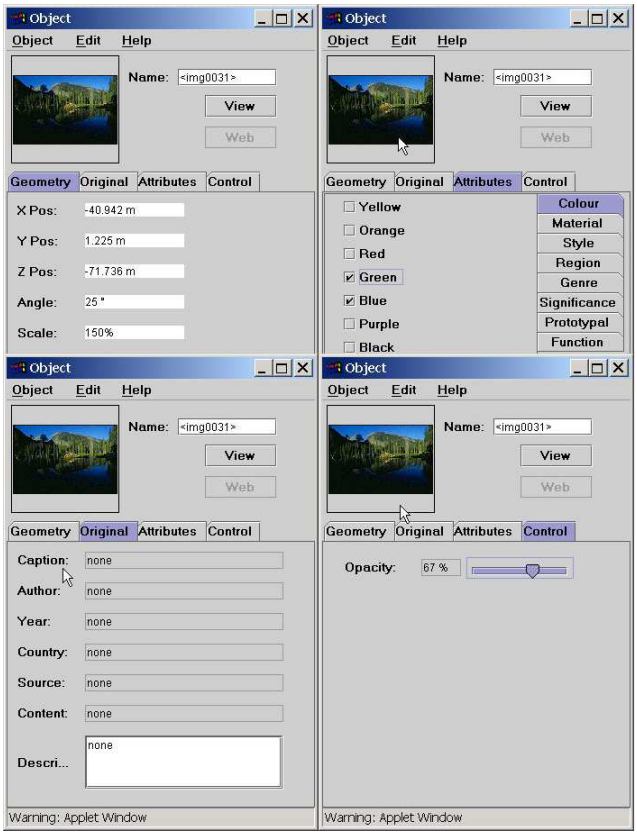

Figure 8. Object window displaying various object data

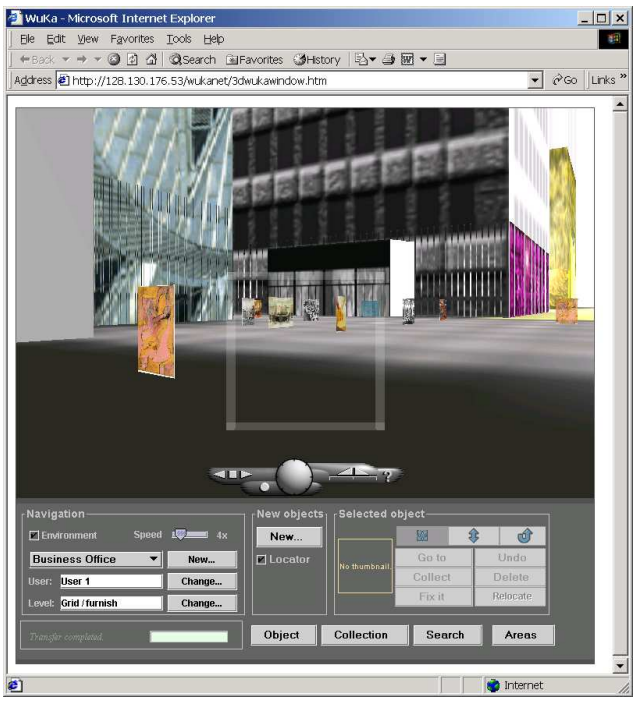

Figure 9. The locator helps the user in estimating the position of the new image

the locator keeps its relative position to the user automatically. Figure 9 shows the locator implemented as a transparent frame. When the user finds position for the new image simply pressing the ”add new object” button on the control panel, activates a new window. Now, the user can choose an image to be added, or even more images in which case one of the predefined templates may be used for positioning images relative to each other. Once placed, the image can be rotated, scaled, the transparency of the image can be adjusted, or the user can take the image with herself and place it somewhere else. Figure 11 shows the ”add new object” window. The original ”author” of the image, the person who placed the image in the 3D world, has the right to adjust the image afterwards as well. Images belonging to other users can be viewed, all data for those images are accessible, but none of the properties can be changed.

If a specific place within the 3D Wunerkammer is especially meaningful for a user she can define an area. The area can be used afterwards to search for the images, or it can be potentially used for an automatic placement, where, e.g. all new images of the user X would automatically appear in a certain area. There can be arbitrary number of areas, which are all accessible for all users. The areas are only logical areas, and the area boundaries are not seen during the use of the system. An area is defined as a sphere in the 3D world, and the user can see the sphere during the area definition. Figure 10 shows area definition window, and main window showing the area during the definition phase.

In order to make the system more interesting few guided tours are added to the 3D world. Helicopter rides are very useful for the first time users having no impression of the world. There are currently two helicopter rides implemented one global ride across all modules, and one city ride, flying over the city only. Furthermore, there is an elevator ride in an skyscraper which helps the new user in orientation, and brings dynamics in the 3D world in the same time. The 3D world can easily be exchanged, and each group of users (e.g. architecture bureau, multimedia company, ...) can have its own world best suiting its needs. Even an arbitrary VRML scene placed anywhere on the Web can be used as 3D World in the 3D Wunderkammer. The multi user feature, enabling other users to place images next to our own shown itself to be an important aspect of the 3D Wunderkammer. Some users find it annoying on the first sight, but after a while, they consider ”foreign” images as enriching elements giving their own images some new qualities.

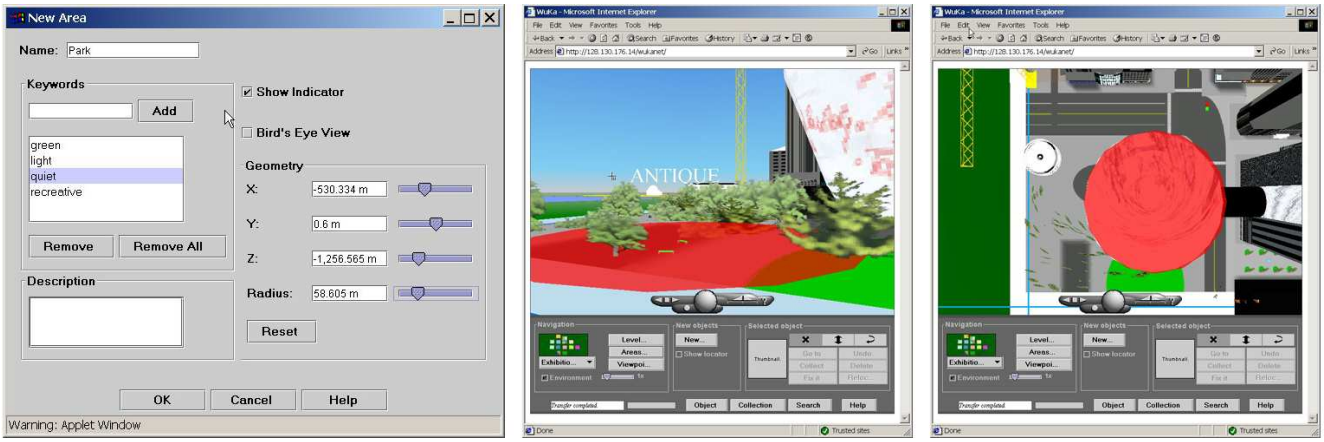

Figure 10. Defining and describing an area

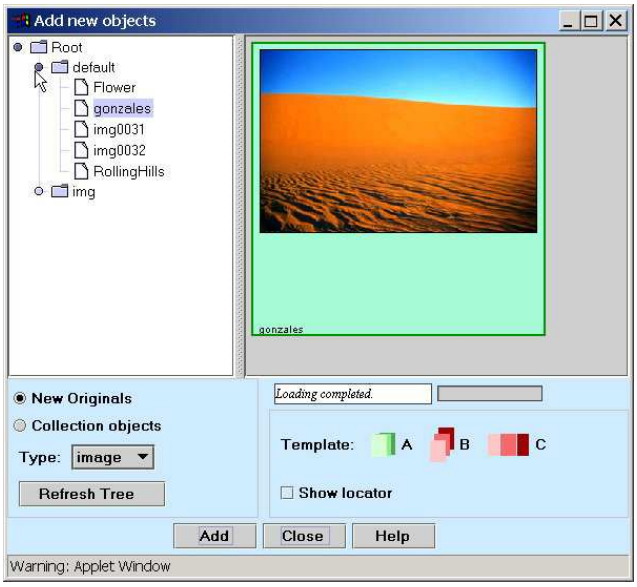

Figure 11. The "Add new object" window

There is also a possibility to create a private level, with restricted access, but this feature was really seldom used in the practice. Figure 12 shows few examples of images placed in the 3D world.

7 Conclusion

The 3D Wunderkammer started out as an architect's special tool in support of inspiration and concept formation. It developed into generic tool opened to many different uses, with its specific graphic design reflecting the purpose and priorities of its users. From its beginnings it has dual purpose. On one hand it is intended to be an inspirational environment, and on the other hand it is used for storing and retrieving multimedia materials. We focus on the second aspect in this paper. The amount of images that can be stored in the system is enormous. Currently there are more then 2000 images in our system, and it is still empty. The novel idea we present in this paper is the use of *indexing by placing* mechanism as a weak indexing for image storage and retrieval. The user can place the images in the 3D environment, which is full of landmarks. The images can be rotated, scaled, and the transparency of the images can be adjusted. All principles described are implemented in the 3D Wunderkammer system which is a multi-user client-server application that can be run over the Internet as well as on any Local Area Network Intranet. Besides the images, the system supports sounds, videos and 3D VRML objects. The 3D Wundekammer is used in an architecture bureau where the architects use it either as an archiving, or as an inspirational, or as a combined tool on the daily basis.

8 Acknowledgements

We would like to thank Rüdiger Leiner for his help in developing the 3D Wundekammer. Furthermore we thank all of our colleagues who helped in writing this paper and developing the 3D Wunderkammer. This work was partly sponsored by the Desarte - Esprit LTR Project NO 31870, and ATELIER Project IST-2001-33064.

References

[1] G. A. The virage image search engine: an open framework for image menagement. In *Storage and Retrival for Image and Video Databases IV*, volume 2670 of *SPIE proceddings series*, pages 76–87, 1996.

Figure 12. Various examples of placing images in 3D worlds

[2] M. Büscher, M. Kompast, and R. Leiner. The architect's wunderkammer: Aesthetic pleasure & engagement in electronic spaces. *Digital Creativity*, 10(1):1–17, 1999.

[3] J. P. Eakins and M. E. Graham. Content-based image retrival, a report to the jisc technology applications programme, www.unn.ac.uk/iidr/research/cbir/report.html, 1999.

[4] M. Flickner, H. Sawhney, W. Niblack, J. Sahley, Q. Hiang, B. Dom, M. Gorkani, J. Hafner, D. Lee, D. Petkovic, D. Steel, and P. Yanker. Query by image and video content: the qbic system. *IEEE Computer*, 28(9):23–32, 1995.

[5] C. E. Jacobs, A. Finkelstein, and D. H. Salesin. Fast multiresolution image querying. *Computer Graphics (Proceedings of Siggraph '95)*, 29(Annual Conference Series):277–286, Nov. 1995.

[6] M. Kompast, R. Leiner, and I. Wagner. Die wunderkammer als inspirations- und erinnerungsraum. In M. Fassler, editor, *Ohne Spigel Leben*, pages 313–330. W. Fink Verlag, München, 1999.

[7] M. Kompast, R. Leiner, and I. Wagner. Multiple voices in the graphic design of a visual information system. In *Proceedings of PDC2000 Participatory Design Conference. Designing Digital Environments*, pages 202–211. New York, 2000.

[8] R. Leiner and I. Wagner. Connecting qualities of social use with spatial qualities. In *Proceedings of the First International Workshop on Cooperaticve Buildings (CoBuild '98)*, 1998.

[9] A. Pentland, R. Picard, and S. Sclaroff. Photobook: tools for content-based manipulation of image databases. *International Journal of Computer Vision*, 18(3):233–254, 1996.

[10] S.Benford, R. Ingram, and J. Bowers. Building virtual cities: applying urban planning principles to the design of virtual environments. In *Proceedings of ACM Conference on Virtual Reality Software and Technology (VRST'96)*. Hong Kong, 1996.