# Micro Archiving and Interactive Virtual Insect Exhibit

Scott Fisher[1], Tatsuya Saito[2], Ian McDowall[3], Yuuta Nakayama[4], Mark Bolas[5], Kenji Kohiyama[6]

KEIO University, Kanagawa Japan

## Abstract

This system has been in development at Keio University in Japan and pulls together several techniques including Micro Archiving and interactive stereoscopic displays. The exhibit, shown at Siggraph, engages visitors who are invited to visualize and interact with microscopic structures that cannot be seen with the naked eye, but that commonly exist in our everyday surroundings. The exhibit presents a virtual world in which dead specimens of bugs come back to life as virtual bugs, and freely walk around – visitors interact with these virtual bugs and examine the virtual models in detail.

## Introduction

Micro-Presence is our term to describe the ability to experience the hidden reality that cannot be seen by the naked eye but that exists in our everyday surroundings.
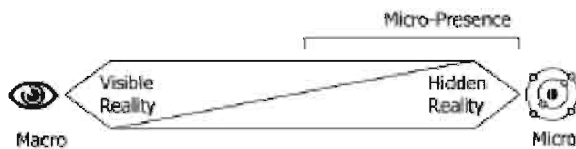


**Figure 1.** *Macro-Micro Continuum*

There are other terms that describe indirect experiences of presence. For example Tele-Presence [Fisher, '95] is a term to describe the technology that enables people to feel as if they are actually present in a different place or time. We define Micro-Presence as the technology with which people can feel as if they became minute and can observe and interact with things in the Microcosmic world.

A variety of groups have interfaced microscopy to virtual displays, particularly in the medical field. HP interfaced a stereo head mounted display to a binocular microscope looking at live insects. This work does not create a virtual model of the insects being examined however [Malzbender '00].

There are many instruments for 3D-model acquisition such as 3D Digitizers and Laser range finders. With these, it is possible to construct 3D model data without modeling objects laboriously by hand. With Con-focal Laser Scanning Microscopes, it is also possible to acquire the shape of minute objects. These instruments have drawbacks including limitations on the size of the intended target objects and lack of color information. There are also many algorithms for image-based modeling, but the target of most of these research efforts has generally been to acquire comparatively large objects ranging in size from tens of centimeters to a many meters like human faces, statues and architectural objects. These algorithms also need much processing speed to process the data. Currently, research efforts have started to focus on archiving real objects and the capability for these archives to be accessed and shared over the network thus enabling applications such as education, web based museums, and scientific collections. For these applications, additional tools for capturing 3D models of objects are desirable.

The Micro Archiving method uses high-definition digital cameras and special lighting. The basic technical concept of our system originates in the Image-based model acquisition method called 'Shape from focus' developed by Nayar in 1994.

## Micro Archiving Technique

Technically, Micro Archiving enables the automated construction of 3D models for use in digital archives of the Microcosmic world. Currently, the application contents of Virtual Reality, Augmented Reality and other new visualization media are dependent on the use of elaborate 3D model data and often require visually compelling virtual models. Constructing these 3D models is difficult, labor intensive, and time-consuming. Micro Archiving technology enables much easier acquisition of very accurate 3D models from images taken by digital cameras. The objects that Micro Archiving is best suited for are very small and detailed objects like machine parts, insects, and small plants.

Here is a brief explanation of the 'Shape from focus' concept: A conventional 'Shape from focus' system is composed of a Camera with focus adjusting facility to take an image of the target. If the depth of focus is shallow, all parts of the target cannot be focused at one time. While one part of

[1] sfisher@sfc.keio.ac.jp     [2] tatsu@acm.org     [3] ian@well.com

[4] t99685yn@sfc.keio.ac.jp     [5] bolas@well.com     [6] kohiyama@sfc.keio.ac.jp

the image is focused, other parts are not. Whether the part is focused or not is depend on the distance from the camera to the part. So, if it is possible to extract the focused part, then the distance from the camera to the part can be calculated. The process is as follows. The focus distance of the camera is adjusted to bring a slice of the object into clear focus and the distance is recorded. The system repeats this simple process until the target has been completely covered. As a result, many pictures have been taken of slightly different focused parts. The image-processing program extracts the focused part from each image and attaches distance data that can be calculated by the number of the image to each pixel. This process can acquire the solid shape of the surface of the target object. A main research topic has been on finding the best methods to correctly extract the focused part of the images. The existing 'Shape from focus' method uses the transition of the brightness of interested pixel in the images.
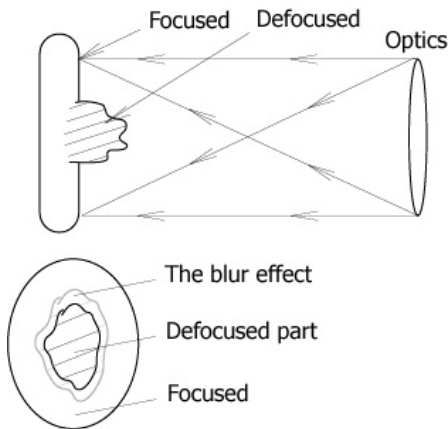


**Figure 2.** *The effect on the focused part.*

Generally, the brightness of the pixel reaches a peak when the target object is focused. So if the model of the transition of the brightness can be generalized, it is possible to extract the focused part. It is difficult, however, to generalize the transition, because the defocused part in the images effect on the focused part, and this effect is depend on the color and the brightness of the defocused part and many other conditions (Figure 3). Some research has been done on the generalization of the blur effect with Gaussian model, sum-modified-Laplacian (SML) and other operators.

Much research has been done on 'Shape from focus' but it is still difficult to construct a 3D model of very complicated structures like insects. To solve this problem, we introduced a simple but effective method to 'Shape from focus', by using special lighting. Figure 3 shows our system components. The system is composed of 3 parts, High-resolution digital camera, Target manipulation arm, and the lighting. This lighting emits a stream of light with a width of a few millimeters depending on the size of the target object. Initially the light is fixed horizontally to illuminate the top of the target objects. Then the camera is set to focus on the illuminated part. To obtain images of the whole object, the target manipulation arm moves the target object instead of changing the focus distance of the camera. The distance from camera to the focused part is constant, and the light always illuminates only the focused part. Therefore, the images obtained include only the focused part, and complicated calculations to extract this focused part are no longer needed. With this hardware pre-operation, the 3D-model extraction program can select pixels brighter than a certain threshold in order to find the focused part in each image as shown in Figure 4. This hardware pre-operation is more suitable for complex, bumpy objects like insects, machine parts and so on.
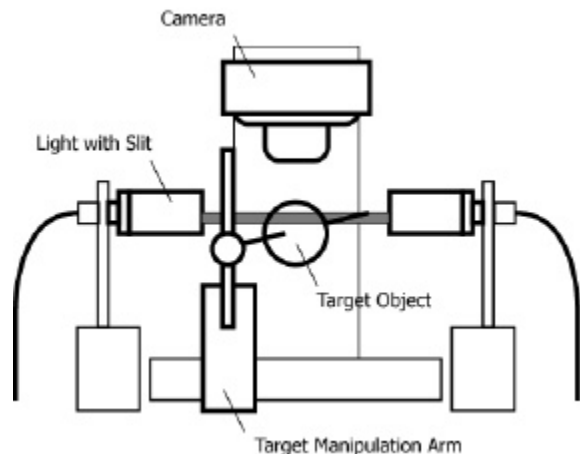


**Figure 3.** *The system component*

The system repeats the process of taking pictures of the target and then moving the target slightly with the target manipulation arm. Many images are taken, each of which include only a part of the target depending on the position of the target manipulation arm.

Figure 4 shows a transition of brightness in the pixels with special lighting. The blur effect that is shown in Figure 2 has been minimized. There is an

immediate sharp increase of the brightness. This sharp increase indicates that the pixel is focused. The program to extract the depth information needs to take only these parts into consideration. The 3D-model construction program attaches depth data that can be calculated by the position of the target manipulation arm to each pixel in every image.
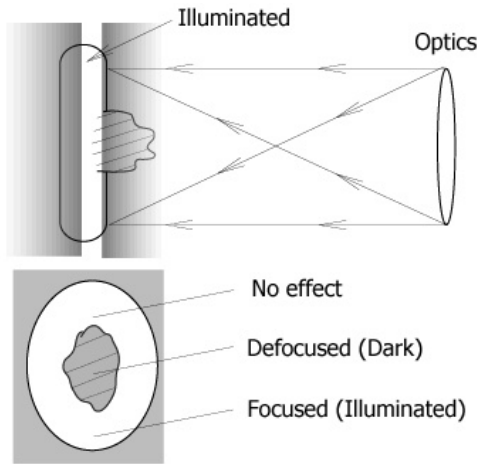


**Figure 4.** Slit Lighting

An "All-Focused" image of the target object can then be obtained by synthesizing all of the focused parts. This All-Focused image can be used for the texture data for the acquired 3D-model. We acquired data sets from 2 to 8 orientations and merged the data to create a more complete model and to reduce the number of "holes" in the models.
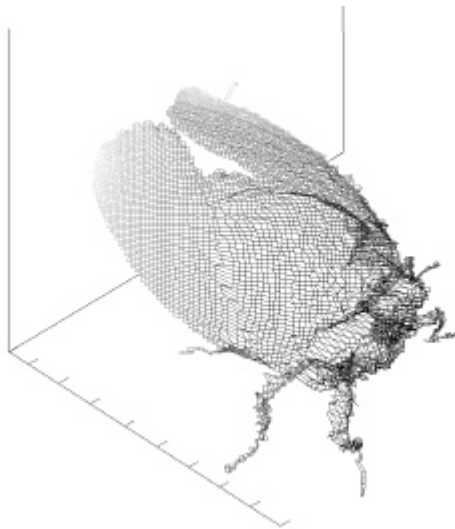


**Figure 5.** *3D model*



**Figure 6.** *An All-focused image*

Because the images are all taken from only one direction, the "other side" of the 3D model has no data. To solve this problem and to make the whole 3D model of the bugs, we are now working on the synthesis of complete models from several scans that are taken from different directions.

## Interface and Interactive Experience

In this exhibit, we use the Micro-Archiving technology to create a virtual zoo of insects in which visitors can not only look at the specimens but also can interact with them, and observe their minute structures. With this demonstration, we wanted to emphasize the microcosmic world that visitors might have never seen by displaying the very minute and beautiful structure of bugs in a unique and compelling way. The concept behind the display design is to present the appearance of a 19th century Naturalist's study which has been transformed to allows visitors to view the insect collection from new and unique perspectives.

## Interactive Methods

In addition to the 3D model capture process we have developed, the exhibit provided a forum for exploring some alternative interaction techniques. Visitors were greeted with the various props and trappings of the 19th century period and into this setting, we deployed a number of interactive stereo

displays. We created two stations which were each comprised of a desk type viewer, and a pedestal viewer off to one side.


**Figure 7.** One of the "offices"

Visitors sit down at one of the two antique desks and with stereo glasses can see a number of virtual insects walking around on the desk's surface. The insect models were created using the Micro Archiving techniques and rendered in real time in OpenGL on Wildcat graphics cards. One nice feature of the models captured by the Micro Archiving technique is that they are regular meshes and can thus be rendered at various resolutions without having to manually create levels of detail for each model. The walking animation is not based on the image capture techniques and was done by hand. The images are presented on high resolution stereo capable monitors which were carefully mounted in the surface of the antique desks. In the center of each of the desks on the display surface is a petri dish. The visitor uses the electronic tweezers to pick up an insect and put it "in" the petri dish. With an insect in the petri dish, the visitor then squeezes the bulb to take a "picture" of the insect in the petri dish. The picture taken "appears" in the column viewer and is rendered using a much finer mesh so as to show the high resolution capabilities of the Micro Archiving technique. The visitor controls the orientation of the insect through the use of a brass control which protrudes from the side of the column viewer.

## Video Tracking & Electronic Tweezers

The interactivity with the tweezers is two fold. First, the tweezers sense if they are opened or closed – the tips of the tweezers have metallic ends and wire attached so when the tips touch, a circuit is completed and the closed state is detected. The second issue is the position of the tweezers to determine which insect the visitor is trying to grab when the tweezers close. Rather than using a Polhemus or other 6DOF tracker, we made use of a simple 2D tracking technique. The 2D tracking was sufficient because the insects are restricted to a moving on a plane. We placed small infra red LEDs at the very tips of the tweezers.
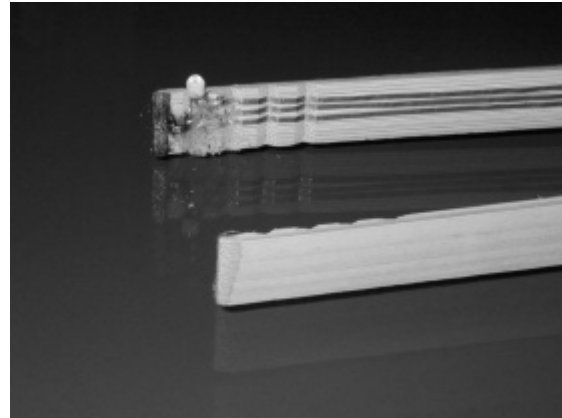

**Figure 8.** Tips of the Tweezers

By tracking the point of interest, we were able to get much better accuracy than one would have by tracking a reference point say in the base of the tweezers and then using their orientation to extrapolate the tweezers' end location. We also used the LED and video camera technique to calibrate the display area. LEDs are located in the corners of the desk display and are also "seen" by the video camera located up by above the desk looking down. The LED markers at the corners of the blotter are just used when calibrating the video tracking system. When in active use with the tweezers, the blotter LEDs are not lit so there is no confusion as to which LEDs are in view when someone is using the tweezers.
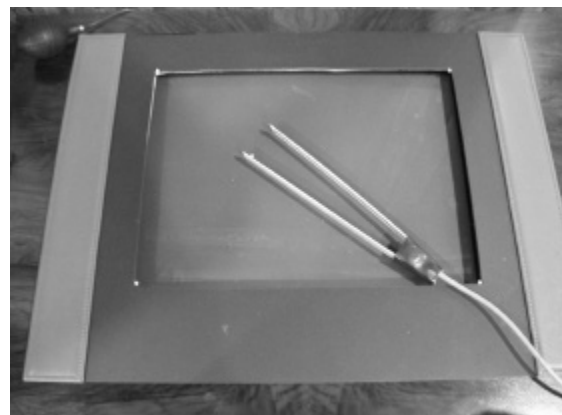

**Figure 9.** Blotter with LEDs in corners & Tweezers

## Bug Models and Walking Animation

The models are rendered at two different resolutions. On the desk where they are walking around, the mesh used for each insect is approximately 5,000 polygons. In the column viewer, the same underlying model is rendered with approximately 100,000 polygons and a large texture map. There were about a dozen insects of several types used in the demonstration and each of them was animated in a "walking" type mode by hand. While effective from the visitor's point of view, it would be better to have gathered real motion data for the insects so as to correctly (or nearly so) model their walking behavior. We not aware of any existing tools for capturing the real time gait of insects so this is left as future work.

## Stereo Displays - Interactive Desks

We constructed late 19th century "interactive" desks by cutting a rectangular hole and placing a high quality flat face CRT monitor in the hole. This was considered preferable to a projection type display because the equipment cost was low, and the setup easy. Also, because there is no head tracking in the system at the present time, it is advantageous to have the display be fairly small so there is less incentive for the user to move their head significantly. Head motion was also minimized by having participants sit at the desk on a non swivel chair. Models on the interactive desk were larger than the bugs are in real life – for example, a beetle that might be only 1cm in real life might be presented as being 5cm so you can see more of the detail.

## Column Type Stereo Viewers



Visitors could also look at the bug models at higher resolution in the vertical column type viewers. Once the visitor had picked up a bug with the tweezers, deposited it in the petri dish, and squeezed the bulb to "snap" a picture, the high resolution model was presented in the column type viewer. We based our aesthetic design on "column" stereoscopes circa 1860-70 which were floor standing.

Our viewer contains a monitor facing upwards, a first surface mirror, shutters from stereo glasses, and eyepieces. While we experimented with placing optics in the eye pieces to make the display appear further away, we found it worked just fine without these.



These viewers were used to give the visitor an even more enlarged view of the insect model. Thus, an insect that might be only 1cm in real life can be presented as appearing almost 30 times that size.



The column viewers also provided the visitor with the ability to interactively rotate the model and to zoom in on interesting features. Again, the interface was designed to fit into the late 19th century theme. A brass control protrudes from one side of the viewer and can be used to explore the insect model.

## Conclusions

In this research effort, we have developed a technology capability that easily enables the creation of high definition virtual 3D models that are especially useful in academic research areas

such as biology and zoology that need to observe, document, and archive small scale physical objects. Future objectives include the addition of a capability for rotation of the objects with smooth motion at high resolution, and further automating the capture process.

## Future Work

We are also developing other visualization applications of Micro-Presence. In the SIGGRAPH exhibition, we presented the Micro Archiving imagery with immersive virtual reality equipment. Similarly, Micro-Presence can be superimposed onto the physical world by using the technology of Augmented Reality/Mixed Reality. In addition, Micro Presence can be effectively used in a shared virtual workspace. For example, the Microscope is a common tool to observe Micro Presence but while using it, viewers are egocentrically immersed within their own world. By integrating Micro Archiving technology in a shared virtual workspace environment, collaborative work in can be undertaken in the microcosm.

In the near future, we anticipate that a visitor's experience in educational facilities, art museums, and science museums will become more interactive. It is difficult, however, to make facilities in which actual objects are exhibited interactively because the exhibits are often made up of expensive, fragile, or irreplaceable objects. So until now, these museums have been limited to providing an experience in which visitors are limited to passively examination of the exhibits. Today, with the advancement of high band width networks, it is also becoming more possible to use multimedia technology for educational applications such as on-line multimedia museums.



But virtual museums currently available on the network are mostly based on still images to display realistic exhibit contents. And to display entire virtual exhibits with many still images can easily require a few gigabytes of data space. Alternatively, a virtual 3D model provided in VRML format can be interactively displayed and viewers can easily move and rotate the exhibits to observe them from many viewpoints. But the images displayed in VRML are still low in photo realistic resolution and lighting quality and creating these virtual models is extremely time-consuming. With Micro Archiving technology, it is possible to easily create high definition virtual 3D models that are appropriate for research and academic use as well as for educational applications. With this technology it is possible to create a high definition, low bandwidth multimedia space in which visitors can freely participate and interact with the exhibits. Applications for entertainment use can also be expected. With Micro Archiving technology, it is also possible to easily create virtual 3D models that can be used for computer games, movies, and other interactive media that would benefit from high-quality photo realistic models.

## Acknowledgements

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