

Atom'O'Scope: Interactive Visualization of a Nanotechnology Experiment

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Abstract

We developed a virtual laboratory that allows a nanotechnology experiment to be performed over the Web. We employed principles of information visualization, design and presentation to create an interface that is rich yet still simple to use, and that appeals to non-expert users.

1. Introduction

Scientists at the IBM Almaden Research Center have developed an instrument that can not only image the surfaces of materials on a nanometer scale, but is also able to directly manipulate individual atoms [1]. One of the exciting and accessible experiments that can be performed is, to manually grab and move atoms across a surface, and create arbitrary structures with single atoms as building blocks.

Since the instrument operates in ultra-high vacuum and at extremely low temperatures, the experiment can only be performed by people who physically visit the laboratory. Because of its high educational and inspirational value, the scientists aim to make it available to a wider audience and accessible remotely. The goal was therefore to create a virtual laboratory that allows control and visualization of the experiment over a network and in a collaborative way.

Teleoperation is an area of increasing importance. Interfaces for such tasks however are usually built for experts and focus on productivity and reliability. They employ fast networks, high-end graphics and large monitors [2].

Our requirement was to safely control the instrument, communicate the lab experience and visualize the experiment over a normal Internet connection, in a screen window of limited size, and for non-expert users.

2. Approach

The instrument probes the material by scanning a tip across the surface line by line. The resulting data grid is visualized using standard scientific visualization methods.

In [3] a similar system is presented. In addition to showing the data and operating the instrument, our approach also visualizes the abstract processes and concepts of the experiment, by drawing on ideas from information visualization. The application, named Atom'O'Scope, follows our design guidelines for interactive visualization systems [4]. It is an integrated application that uses multiple linked views and provides high interactivity. Focus&context techniques are used in the views, and transitions are animated to avoid the problem of change-blindness.

Finally we needed to communicate the experience that people get from visiting the physical lab. We used elements from storytelling to convey this information [5]. Real imagery from the lab is used to set the mood and to create a sense of place. This serves as a framework in which to embed the detailed action. Users are guided through a sequence of actions to create continuity between different stages of the experiment. A chat box allows collaboration between the controller and observers. A comic-like pointer can be used by the operator to explain interesting features.

In contrast to [6] we did not want to make the system invisible, but we aimed at revealing the technological complexity that underlies such an experiment.

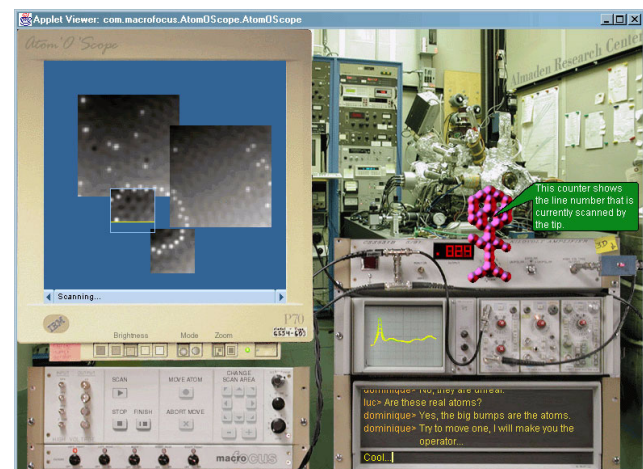


Figure 1: The Atom'O'Scope virtual laboratory. Arbitrary structures can be built by moving atoms across the surface.

3. Atom'O'Scope

The monitor is the entry point into the experiment. Users first have to log on in a command shell mode. After that, a height-encoded greyscale view of the surface is shown. Users can pan the scan area and change its size to explore the surface. A history of previous scans is maintained to ensure continuity (Figure 1). Help and status messages are shown in a slideable display at the bottom of the view. A row of buttons at the bottom of the monitor allow control of the visualization: brightness, encoding mode, animated zoom between full and current scan ranges.

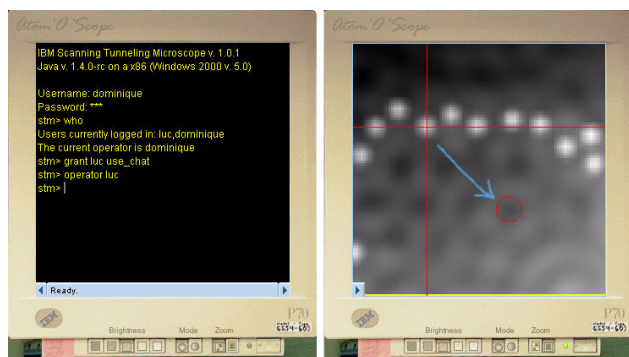


Figure 2: The 2D view. An atom is moved by simply positioning a crosshair cursor. The tip is engaged and the atom can be dragged across the surface to the desired position (blue arrow added for illustration).

Below the monitor the controls for scanning and moving atoms are located. Unavailable commands for a particular situation are ghosted out and disabled to ensure safe and self-explanatory operation and visualize afforded options.

A 3D view can be brought up. It uses the world-within-worlds paradigm to maintain context. The position of the light source used for illumination can be changed, to examine the details of the surface.

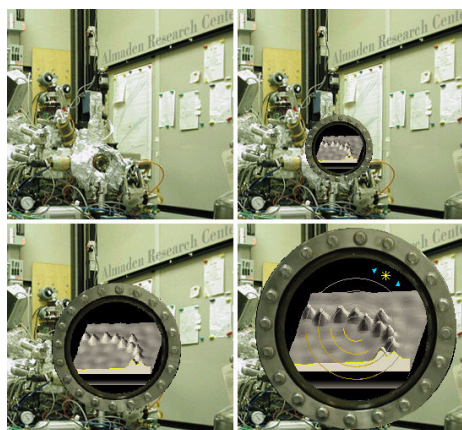


Figure 3: The 3D view is zoomed into place. It shows an alternate, more intuitive view of the scanned surface.

The oscilloscope shows a trace of the current scanline (Figure 1). An afterglow effect is used to expand the time horizon and convey the dynamics of the scanning process.

Only one person at a time can be operator. Privileges are set by issuing commands in the command shell window. Observers are still able to change the visualization settings, or use the chat box to communicate.

The Atom'O'Scope is implemented as a Java applet. We developed our own optimized graphics library to address performance, functionality and compatibility issues. The library features support for non-rectangular components, bit-mapped widgets, and fast voxel-based 3D rendering. In order to make the user interface predictable and controllable, care was taken to keep the application responsive, even when all views and animations are active.

4. Conclusion and Outlook

We have shown how a complex scientific experiment can be communicated and operated over the web by non-technical users.

We used principles from information visualization and design to convert the abstract processes and concepts of this experiment into a visual experience.

The Atom'O'Scope has been successfully used by IBM scientists to perform the experiment remotely in front of large audiences. In a next step it will be made available to a wider group, and will be used collaboratively by school classes or other select groups.

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5. References

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