SEM Remote Control with a 3D option

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The remote control of a scientific instrument is a topic gaining more and more attention between the instrument users and operators.
The project presented in this article starts from the mix of two separated research works and evolves first obtained results. The mixed works are the realization of an application to remote-control Scanning Electron Microscope (SEM), and the implementation of a procedure to reconstruct 3D surfaces.

The remote control application is a server/client application [1], and [2]. The main aspect of this server/client application is that it has been designed and developed to work on public network. The remote commands implemented on the client application concern the connection to the server application, the connection to the microscope, the management of microscope controls, the communication with the local operator and the video streaming of specimens' images. Excluding last feature, the communication between client application and microscope is real-time in every case. Then, on the base of these favourable results, and considering the 3D reconstruction tool characteristic, this has been easily added to the remote application. In fact the 3D tool extracts the third dimension from back-scattered electrons [3]. This method for reconstructing the depth map in the SEM is founded on 4-Source Photometric Stereo (PS) technique which is based on the so-called reflectance map that uses several images of a surface, taken from the same viewpoint but under different lighting directions, to estimate the relative surface depth at each image point. The image acquisition process may require or specific instrumentation (4-sector, independent channel axial BS detector), or very standard SEM configuration and specimen rotation/translation. In this last case an alignment procedure had been developed [4]. To simulate different lighting conditions in a standard SEM it is necessary to rotate the specimen under the fixed detector and to acquire sequentially four images of the same specimen upon imposing three 90° rotation steps on the specimen, and then rotating back the images: a sequence of four pictures of the same area will be obtained, each of them illuminated from a different lighting direction. All these microscope operations are executed on remote control without any delay, then the 3D reconstruction tool is perfectly available in our remote control application. Fig. 1a and Fig. 1b show an example of 3D reconstruction using this technique.

The results above described demonstrate that it is possible to remote control a SEM on public network, both for conventional and not conventional operations, even if the video streaming is affected by network limits. Starting from this point, a new research project has taken place. The topics of this project are more than one: on one side it is important to reach the real-time video streaming on public network, on the other side it will be useful to realize a structure where share instruments though tools for conventional and not conventional remote operations on public network. The first point will be handled considering new internet communication protocols, new telecommunication network features, like wide band and low latency, and developing a dedicated video encoder starting from the existing compression standards. The second topic starts with the design of the structure to share instruments and resources; the best solution is probably a layered structure. The reason is that, as explained before, a remote user has to perform different operations

before and during the instrument remote control. Using a layered configuration it should be possible to divide these operation on the base of the instrument interaction level, and then guarantee a higher protection of shared instruments. Giving to each layer a specific role, it is possible obscure the layers that contain the application interfaced directly with the instruments, and make accessible by remote users only the layers with the Graphical User Interfaces (GUI) of the applications to remote control the instruments with conventional and not conventional operations. Moreover, this layered structure allows an easier configuration of the remote control, because the same GUI could be used to remote control several instruments, as well as the same tool for not conventional operations. Fig. 2 shows an example of possible layered structure, with the explanation of layers functions.

References

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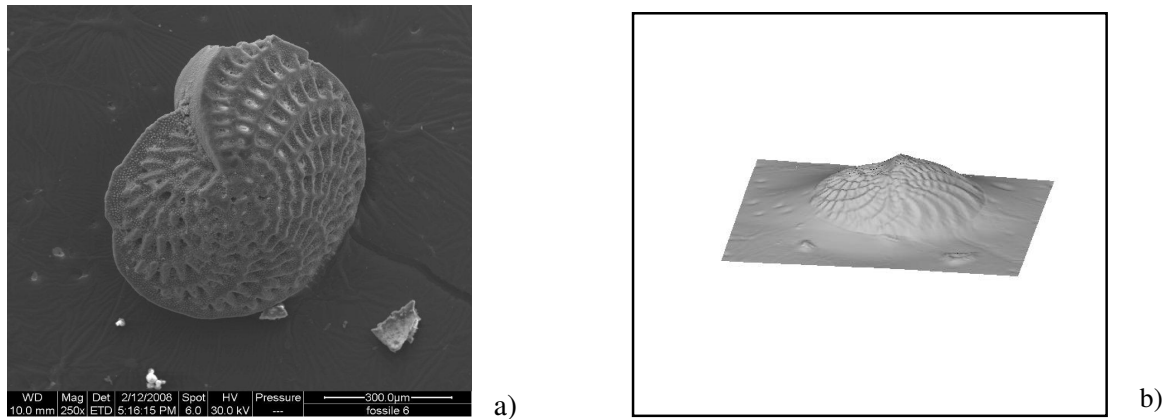
a)

b)

FIG. 1a: The image of a shell fossil at the Scanning Electron Microscope operating in high pressure. 1b: The shell fossil surface 3D reconstruction obtained by the method briefly explained in this paper.
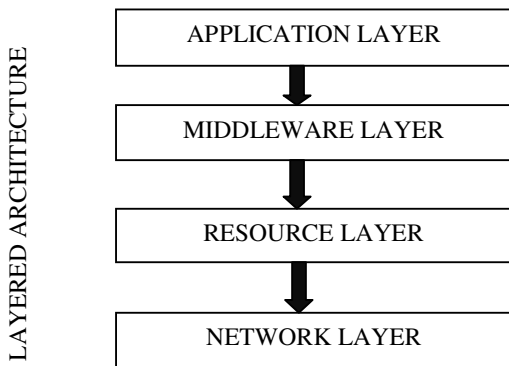

FIG. 2: Example of layered structure.
The Network connects all resources and contains the interfaces with the local control. The Resource layer groups resources such as computers, storage systems, instruments, sensors, electronic data catalogue, data base. The Middleware layer is the layer where there are all the tools that allow the interaction between the grid resources available. The Application layer is the only one accessible by the user. Here there are the User Interfaces of the available applications.