

ERCIM “Alain Bensoussan” Fellowship Scientific Report

Fellow: Frédéric Larue
Visited Location: Fraunhofer Institute Intelligent Analysis and Information Systems,
Sankt Augustin, Germany
Duration of Visit: 9 months

I - Scientific activity

The work performed at Fraunhofer Institute Intelligent Analysis and Information Systems (IAIS) was part of collaboration with the Deutsches Museum Munich (museum of technologies). The goal of this project was to provide to museums tools enabling them to create virtual copies from real cultural artifacts, which can be used as surrogates for study, or during exhibitions, in order to prevent on one side the destruction or the alteration of valuable cultural items and to enable on the other side their interactive manipulation.

The Deutsches Museum Munich project was divided into two different parts. The first one concerned the development of a museum’s exhibit about an old optical tool, the *Fraunhofer Spektralapparat*, a kind of spectrometer built in 1814 by Joseph Von Fraunhofer (1787–1826), who gave the name to the Fraunhofer Gesellschaft. It is thanks to such a tool that the famous *Fraunhofer lines* (dark lines appearing in the light spectrum due to absorption caused by some chemical elements) could be extensively studied for the first time.

The basic idea was to provide to museum visitors interaction possibilities enabling them to reproduce virtually the experiments performed by Fraunhofer. A user should be able to manipulate the virtual spectrometer without any risk for the original one exhibited just next to the virtual one. A user should study the effect of the refraction phenomenon while observing a light ray through prisms made of different kinds of glasses. Our motivation was to provide, through the use of new technologies, a better understanding to visitors thanks to their direct involvement in such interactive and edutaining (while entertaining) solutions. This exhibit called the *Virtual Fraunhofer Spektralapparat* is on display in the *Zentrum Neue Technologien* (New Technologies Centre) of the Deutsche Museum since its opening on the 19th November 2009. A visitors’ evaluation is currently in progress in the Deutsche Museum for measuring the impact on visitors and for providing feedback with respect to the aforementioned expectations.

The second part of the project targeted the development of a 3D digitization solution particularly for Musial institutions. Since museums are already taking photographs of existing or new museum objects for archiving and inventory purposes, the main idea was to have a tool able to deal with those data, without requiring any additional effort. A software package for the reconstruction of 3D models from sets of pictures was developed, based on the principle of the *visual hull*: after an automatic calibration step providing, for all pictures, geometric information about the camera optics and pose, a *silhouette-based volume carving* is performed. What is called silhouette is the sub-part (set of pixels) of a picture where the photographed object

projects on. Obviously, since each pixel belonging to the silhouette corresponds to an infinite number of 3D points in space (all points of the line of sight going through this pixel), they cannot be directly used for an accurate 3D reconstruction. But, on the contrary, there is a guarantee that no point of the object projects out of the silhouette, which means that the picture's regions other than the silhouette itself necessarily correspond to the projection of free space areas surrounding the object. The reconstruction algorithm then proceeds as the carving of a stone block: in the beginning, the whole block represents the 3D model, and the parts that project out of at least one silhouette are removed. Thus, each additional picture enables to remove more points, by progressively carving the remaining block, and obviously, the more pictures are available, the better the reconstruction becomes. Once all pictures have been processed, a classification of the 3D space into two regions is obtained: the inner and outer parts of the objects. A 3D surface is finally obtained by extracting the interface between these two regions. Moreover, *projective texture mapping* is used to add pictorial details onto the reconstructed object for visualization purposes.

Besides the development of software solutions, a business case is currently under development at the Fraunhofer IAIS institute to study market opportunities, and finally to find out potential customers among Musial institutions.

Even if the reconstruction approach has been applied to the *Spektralapparat*, there is currently no connection between both parts of the project, namely the exhibition settlement and the 3D digitization. One of the next goals for this project could be to merge both. Other possible future works arise from the digitization part: the use of *multi-view stereo* approaches to refine the obtained 3D model, as presented in the most recent research works, is considered with a great interest, even if these approaches are still either not robust enough or too slow to satisfy our objectives. The reconstruction of a more advanced model of *view dependent textures* is also necessary in a medium term, since the visualization part is still a weak point of the developed software.

II- Publication(s) during your fellowship

None.

III -Attended Seminars, Workshops, and Conferences

None.

IV – Research Exchange Programme (12 month scheme)

Not concerned.