IMMERSIVE & CREATIVE TECHNOLOGIES

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"Rapid Scanning and Automatic 3D Reconstruction of Underwater Sites"

3DUNDERWORLD

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A plethora of work has already been done in the area of scanning acquisition and 3D reconstruction of objects and sites. In particular, many successful applications have been reported in the area of scanning and 3D reconstruction of cultural heritage objects/sites. This success is primarily due to the flexibility and the applicability of the 3D model representations to a wide range of applications such as computer games, virtual reality, simulations, etc. In particular, in the context of cultural heritage, archaeologists have been trying to employ these techniques to document artefacts and preserve the information they carry by protecting them from any damage caused by possible displacement or extraction from their original place for further study and safekeeping. In addition, such techniques offer reliability (no human error) and an economical advantage -since they require little cost to be employed- compared to manual documentation work, therefore helping in saving significant amount of time.

This project addresses the current technological limitations and difficulties associated with the documentation and recording of underwater archaeological sites and seeks the solution in the development of an innovative system for the rapid scanning and automatic 3D reconstruction of underwater archaeological sites. The proposed system has multi-disciplinary nature since it will provide hardware setup and a software toolset of advanced techniques for the acquisition, processing and modelling of underwater terrain and structures, not only for computer science and underwater archaeological research, but also for all the disciplines related to underwater exploration, thus directly contributing to the growth of the industry on the island of Cyprus. The project is organized into four main components: (1) Development of Underwater Scanning Apparatus, (2) Data Acquisition, (3) Pointcloud Generation and, (4) 3D Reconstruction.

Firstly, we investigate the design and development of an underwater scanning apparatus capable of operating in shallow as well as deep waters. Unlike existing techniques which rely only on passive sensor technologies, we focus our effort on incorporating active sensor technology. Secondly, using the developed scanning apparatus we acquire data from underwater archaeological sites in Cyprus which exhibit many of the difficulties commonly associated with underwater documentation and recording.

Thirdly, we develop efficient and scalable techniques for the storing, merging of multiple data sets, and pre-processing of the data for the reconstruction. Fourthly, we examine the design and implementation of a software package which, given the data acquired on site, will automatically reconstruct a compact 3D virtual model of the site. The 3D virtual model will then be qualitatively and quantitatively evaluated and compared with the results produced by other methods of mapping of underwater archaeological sites.

In summary, we seek the development of a novel and robust method for the rapid scanning and 3D reconstruction of underwater archaeological sites. It is expected that the system will be automated, requiring minimal user interaction to set-up, while its performance will be independent (and unbiased) of the current lighting conditions. Furthermore, we pursue a simple process that will allow non-specialized, untrained personnel to operate the apparatus.

As a result of the process, we have developed three prototype scanning systems:

- The first prototype relies on the combination of active and passive sensors and consists of a projector and a USB or DSLR camera. The generated results are of high fidelity, however the process requires

that the system and the object(s) of interest remain motionless for the entire duration of the capture i.e. 20-30 seconds. This is clearly not the case when considering dynamically-changing environments such as those found underwater.

- The second prototype leverages recent advancements in high-speed acquisition technologies and replaces the DSLR camera with a Phantom Miro Ex1 high-speed camera capable of capturing up to 1000 frames per second. In this case, the acquisition process requires that the object(s) of interest remain motionless for less than a second; a more realistic requirement when considering motion underwater. Theoretically, the acquisition time can be reduced even further however, the maximum operational frame-rate of the projector limits us from reducing the duration of the process.
- The third prototype relies on a laser-emitting device and a pair of cameras. The laser-emitting device replaces the projector since the projector requires a considerable amount of power to operate; which is extremely difficult to achieve in deep waters. Moreover, the laser-emitting device requires minimal power to operate therefore overcoming the previous requirement of having sufficient light to operate the system. Single- and triple-stripe variants of the prototype have been developed.

Examples of some of the results produced with the aforementioned prototypes are shown below. Most of our prototypes are made publicly available as Open Source Software. A comprehensive list of the results can be found on the project's website: http://www.3dunderworld.org Videos of the results can be found at our Vimeo channel: http://vimeo.com/theictlab