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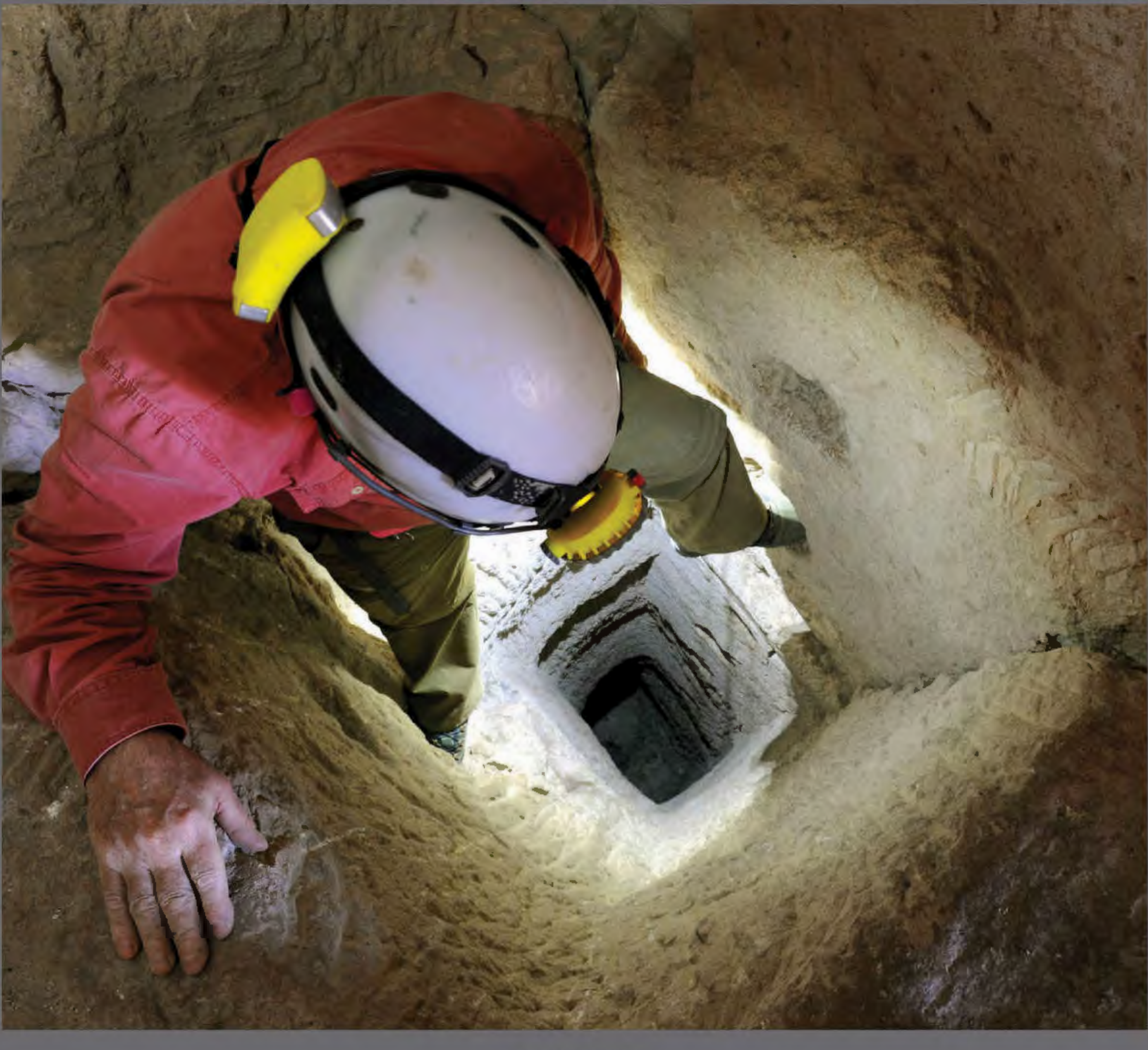

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RECENT DEVELOPMENTS OF 3D SCANNING IN REAL TIME

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Abstract
In the world of transversal technology migration, where usually scientific expensive devices and technology are exploited and developed for production of trivial consumer products. The increasing demand of video games (estimated around $80 billion per year) for better and faster performances, has led to developing new technologies, devices, peripherals, hardware and software. These eventually have been employed in the 3D scanning, replacing laser digital photogrammetric techniques and effecting both archival and research technology, by using mainstream hardware, depth sensors, RGB cameras, Microsoft Kinect hardware (used to digitize objects of varying sizes) or the similar ASUS "XTION" pro Live hardware, or other such as Kscan3d or Faro Scenect 3D and Skanect. All of these at extremely low cost. The application of this new technology resulted in several advantages (speed, possibility to monitor on real time the outputs, possibility to operate in difficult environments, availability at low cost), but has also some flaws (lower details and resolution). Needless to say, the immediate output of this new technology represents the future of 3D scanning, especially in archeology and speleology. The present article describes some of the above stages and the deriving results.
Keywords: scanning 3D; model; laser scanner; Kinect; "XTION" pro live.

Riassunto
Nel mondo della migrazione tecnologica trasversale, in cui i dispositivi e la tecnologia scientifica sono costosi, i dispositivi sono sfruttati e sviluppati per la produzione di prodotti di consumo, la scansione 3D può essere un esempio del contrario. La crescente domanda di videogiochi (stimato intorno a 80 miliardi dollari l'anno) con prestazioni migliori e veloci, hanno portato a sviluppare nuove tecnologie, dispositivi, periferiche, hardware e software che alla fine sono stati impiegati nella scansione 3D, in sostituzione delle tecniche fotogrammetriche digitali e laser usate sia per archivio sia per la ricerca tecnologica, utilizzando hardware tradizionale, sensori di profondità, telecamere RGB, hardware Microsoft Kinect (utilizzato per digitalizzare oggetti di varie dimensioni) o il simile ASUS "XTION" pro Live e altri programmi come Kscan3d, Faro Scenect 3D o lo Skanect. Tutto questo a costi estremamente bassi. L'applicazione di questa nuova tecnologia comporta vantaggi (velocità, la possibilità di monitorare in tempo reale il risultato, di operare in ambienti scomodi e la disponibilità a basso costo dei dispositivi) ma anche svantaggi (dettagli e risoluzione minori). Inutile dire che a nostro avviso che la visione immediato che si ottiene con questa nuova tecnologia rappresenterà il futuro della scansione 3D, in particolare in Archeologia e Speleologia molto vicino a noi.
Parole chiave: *scansione 3D; modelli; laser scanner; Kinect; "XTION" pro live.*

Introduction

The enormous power of the consumer market looks for very large dimensions, and as a consequence the mass production addresses the research costs not only toward a better quality or performance, but mostly to lower costs of production. This has happened, to provide an example, since 1960 in the automobile market, which got hold of the research and development projects in the car racing segment,(brakes, gears, etc.) to further develop these projects commercially, with a significant decrease in the related costs. The same applies to software. A proprietary software designed for a single customer can easily exceed hundreds of thousands of euros, whilst the same, when sold to the global market, will be around 150 Euros. Videogames have pushed the above evolution to both hardware and software segments, and generated an extraordinary push to the 3D appraisal of environments and image processing. For example, the development of data processing in computers has led to a low-cost access to graphics processors (GPUs) together with development of sensors (cameras and sensors of spatial depth) capable of handling an increasing amount of data, speeding up modeling processes, and narrowing the gap between expensive hardware or software and low costs ones. Depth sensors, designed to interact with Video Games, are now also applied to real-time scanning and digitization of objects and environments. Software designed for this purpose are now capable of recording from the depth sensor a mass of data, technically named "cloud" of points, which, once processed, generates a 3D model.
In this article, I will shortly illustrate some methods for scanning small areas, using a depth sensor designed for the computer, the Asus ""XTION" Pro Live" matched with software "skanect", and will evaluate the results.

Specifications

Hardware

The availability of supply of these devices is extended, but as mentioned above we will analyze the "XTION" PRO LIVE" (Fig.1), developed by the famous company ASUS®). The main features are an RGB camera with VGA 640x480 at 30 FPS with a resolution of SXGA 1280x1024 pixels coupled with a depth sensor to capture a range of points from 20cm to 3.5m. The

Device	Acquisition time (min)	Elaboration time (min)	Vertices number
XTION PRO LIVE	4:56	Not applicable as elaboration on real time	493,583
Laser scanner	17:54	47:34	992,289

Tab. 1: statement of result.
Tab. 1: prospetto dei risultati.

USB cable interfaced with the computer gives a very satisfactory mobility (1).
This device supports drivers that allow Windows, Linux, Ubuntu and OSX (Apple) applications. The physical dimensions in centimeters (18 x 3.5 x 5 cm) makes the device easily transportable along with a Toshiba laptop processor Intel core I7 at 2.8 MHZ and a graphics card NVIDIA GTX560M GPU.

Software

Currently on the market there are many software that can interact with this type of hardware to our experience we are going to analyze "SKANECT" (Fig. 2), developed by MANcptl and available at a very low price. The software, in order to scan an object or an environment must receive data from the sensor hand-held and must be moved slowly over the object, at a minimum distance of about 40 cm (2).
The sensor transmits the depth in the three axes (X,Y,Z) and the software processes the coordinates of the points within the environment. The program also monitors on real-time the detection of points in order to control the process. If the movements of the sensor are too fast, the process stops automatically and the user must resume operations from the last known position (as shown on the screen). After this the software, by means of some internal utility, or for further processing.

Comparison

In order to highlight the advantages and drawbacks of the procedure we performed a scan of a portion of a room (about 3 cubic meters) part of a Roman cistern, and then compared it with a conventional scanning with a laser scanner such as "Leica Scan Station C10" using flight time.
For comparison we used the above Toshiba laptop for data processing.
The main points of comparison are:
1. The acquisition time of the data (for "XTION" this is the time required to move the device around the sample and for the laser scanner the total time of acquisition);
2. Processing time data using the SKANECT and the native software of the laser scanner;
3. Number of vertices obtained, which indicates the accuracy of the model obtained.
Then data are summarized in Table 1.

Results

The first fact to come out from the data in Table 1 is the minimum time for processing to get the model to be part of the '"XTION".
Comparing the above table (Tab.1), we see how the detail of the model obtained from the laser scanner is much better, thanks to the resolution below the millimeter, compared to that of the "XTION" which is around 5-10 mm. On the other side, it is interesting to examine the time necessary in acquisition and elaboration.
The data show that the '"XTION" can be a useful tool, even if the model obtained, does not show the resolution of the other devic. Nevertheless, it is able to quickly capture the morphology of a specimen, and produce a digital model that requires minimum further processing.
A significant advantage of using the sensor "XTION" is the real time correcting process (for example holes in the collection of data) which allows a prompt correction, whilst the laser scanner, shows the model quality only

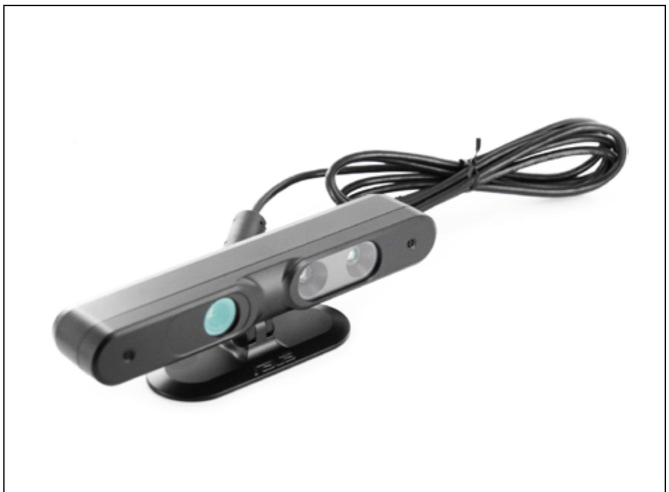

Fig. 1: ASUS ® XTION PRO LIVE image.
Fig. 1: immagine di "ASUS ® XTION PRO LIVE.

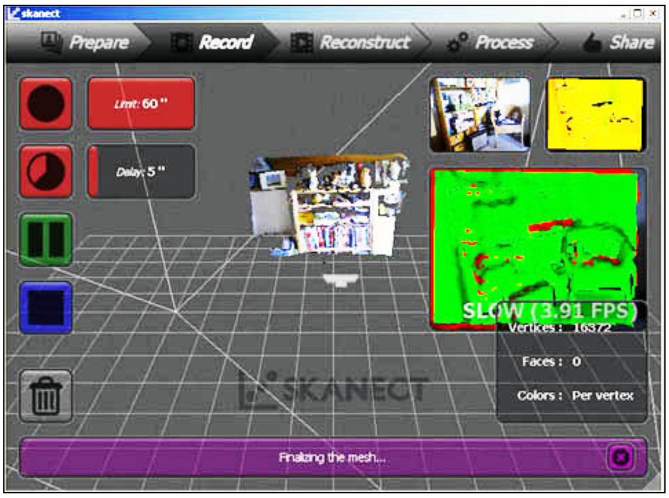

Fig. 2: software screenshot.
Fig:2 schermata del software.

after the long processing has been completed.
One drawback, the use of "XTION" and SKANECT is that the scan volume must be set before starting the acquisition. Increasing amount of volume decreases the accuracy of the scan.

Conclusion

In the event that there is no problem with funds, we may say "XTION" has some significant disadvantages compared to other scanning techniques (in particular a low resolution, and scan volume related to the software); however, it cannot be denied that the "XTION" allows a low-cost processing of morphology in underground environments. Furthermore, the sensor coupled with the SKANECT is undoubtedly faster than other devices, and allows processing data in real time having full control of the acquisition points, the possibility, to start the process all over again, once the final elaboration of the laser scanner shows unacceptable errors.
To bring our conclusion to an end, we can surely assume that in speleology, on account of: cost of equipment; transportation flexibility and easiness; real time advantages; need of precision in speleology surveying (not requiring accuracy below 1 millimeter accuracy),using the "XTION" is, in our opinion, the best choice by all means in terms of balance, costs benefits.

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