Low-cost 3D scanning technology based on active stereovision

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Abstract

Technologies for 3D digitization of cultural heritage without contact have gained popularity in the recent years. The use of optical 3D scanning systems for digitizing and helping in a long term preservation of artwork has become a reality. These scanners provide a digital replica of the art piece in 3D in a format that enables a posterior characterization through specific computer tools by the professionals of cultural heritage. Furthermore, cultural institutions are using these technologies for mass digitization of their art collections for addressing storage issues and also exhibiting them on-line through the Web.

In this work we present a low-cost optical technology for measuring the 3D shape of objects together with its realistic RGB color texture. In the simplest setup, a DLP-based projector and two identical color cameras with megapixel resolution positioned in a standard stereo configuration scan the object. The measuring principle is based on stereovision combined with the projection of structured light patterns. Four shifted fringe patterns are projected onto the object to get the corresponding phase map and common phases are identified in the pair of cameras, where finally 3D data is obtained by triangulation based on the epipolar geometry and the system's calibration parameters previously computed. The RGB color information is retrieved from the images captured when the object is illuminated with a uniform field from the projector.

A 3D scanner prototype based on this technology has been developed for digitizing objects with sizes around 0.5 x 0.5 mm^2 over 180 degrees and RMS accuracy below 0.5 mm. Two lateral low-cost sensing units, each with two megapixel color cameras and a DLP-based projector scan the left and right sides of the object. Both 3D views are then precisely stitched with the aid of the system's calibration parameters. Technical issues in regard to the scanner calibration and retrieval of the 3D cloud of points (X,Y,Z) together with the RGB color texture of the objects are described. Measurements of different body parts of a female mannequin including the face and breast are shown to demonstrate the scanning capabilities of the system in an object that resembles human sculptures. From the 3D shape measurements, distances, areas and volumes of selected features of interest are also extracted.