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Method of photogrammetric measurement automation using TRITOP system and industrial robot

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ABSTRACT

This paper deals with a method of TRITOP photogrammetric system automation. Unlike the methods of optical scanning systems automation, this area has not been studied well yet. The method of photogrammetric measurement automation via the TRITOP system and an industrial robot is presented. The work is focused on the communication between the main parts of the measurement chain – camera, control computer, industrial robot and robot controller. The crucial part of the communication is based on the gPhoto2 utility, which enables a remote operation of the camera. Programs for the automation are written in Python programming language in the TRITOP software environment. Hardware communication is carried out via USB and Wi-Fi. To verify the measurement system and its repeatability, test measurements have been performed and compared to manual measurements of the same object.

1. Introduction

The use of photogrammetric methods has been a current topic for several decades already. Theoretical photogrammetric methods have been known for more than a hundred years. In the last thirty years the main research has been focused on digital photographs and methods of image processing for obtaining the photogrammetric information [1]. At the same time (mid-1980s) the photogrammetric methods are becoming economically and technically efficient for industrial use [2]. Current commercial photogrammetric measurement systems (such as GSI, AICON, GOM) are automated to such a level that even a non-specialized worker is able to carry out such measurements [2].

The present research is primarily focused on the full automation of optical measurements (with the use of triangular laser scanners or structured light scanners). These systems are either based on the robotized movement of the scanned part and a fixed scanner [3,4] or on the robotized movement of the sensor and fixed part [5,6].

In technical practice the photogrammetric systems are used for quality control during the beginning of a series production or for random parts quality control in offline inspection. These systems are also used for the First Article Inspection in plastic parts production, in sheet metal production for edge shape inspection or for sheet metal forming [7]. Another application is deformation analysis measurement [8]. In the above mentioned examples there is no need to have information about the whole part; as the positions of selected points or elements are sufficient.

The difference of this work from other present research is in its focus on the automation of the photogrammetric based system. It brings the possibility to only measure the 3D co-ordinates of individual points on an object. Besides, the photogrammetric system is cheaper than most of the scanning systems; the system works solely with a digital single-lens reflex (DSLR) camera. There is also an advantage over the contact measuring methods, where one has to take into account errors related to the positioning of the part on the measuring machine (CMM) for the measurement [9,10]. The advantage of this method is also in the photogrammetric system used. The TRITOP system is well known and widely used, not only in many technical but also architectural applications [11–13].

2. Proposed system and methods

The proposed automated measuring system is based on the TRITOP photogrammetric system developed by the German company GOM GmbH. The TRITOP system consists of one DSLR camera, contrast coded and uncoded points, scale bars and appropriate software (in this case, the TRITOP 6.2.0-5 version of the software was used). The process of measuring with the TRITOP system starts with preparation of a measured object. Uncoded points are placed on the object, coded points and scale bars are placed in the area to be photographed and the whole scene is photographed from multiple positions and angles. The images are transferred to the PC wirelessly or via flash memory card and exact co-ordinates of all coded and uncoded points are computed in the TRITOP software.

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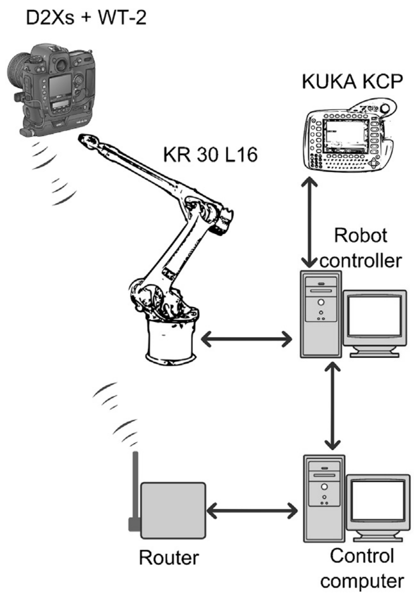

Fig. 1. Diagram of the measuring system.

2.1. Components of the measuring system

A diagram of the automated measuring system is shown in Fig. 1. The two main components are a DSLR camera (Nikon D2Xs) which is mounted on an industrial robot (KUKA KR 30 L16) and they are shown in Fig. 2. The components that control the system and manage the co-operation are a control computer and a robot controller together with a robot control panel. For the correct functioning of the system, it was necessary to propose a method of communication between the control computer, camera and industrial robot.

2.2. Communication between control PC, camera and industrial robot

The TRITOP system has its own environment that enables the user to record macros or to write more complicated scripts for automation. For that reason, the whole communication is established with scripts written in this environment. The script contains commands for the robot control PC to drive the robot to the position of the measurement and commands for the remote control of the camera, its shutter release and sending the images via Wi-Fi. The USB port is used to build a communication between the control PC and the robot, i.e. the robot control PC. The communication between the control PC and the camera is done via connected Wi-Fi router.

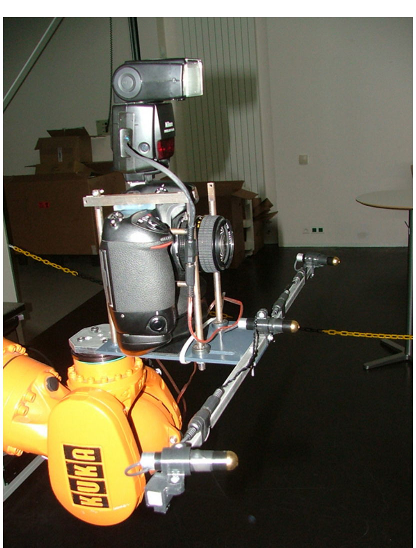

Fig. 2. Main components – robot and camera.

The use of industrial robots is already known from another application – the automation of scanning with the ATOS 3D scanner (for example of the use see [14]). The ATOS system is a product of the same company, GOM GmbH, and both systems contain the same environment for automation support. Moreover, the ATOS system contains advanced tools for automation including, among others, a module for the simplified obtaining and saving of the robot positions. Therefore it is possible to apply the commands for operation of the robot from the ATOS system to the TRITOP system. The commands have their own specific format and every command for every single robot position contains parameters for robot type, communication port, speed, acceleration, and the robot position itself.

2.3. Software solution of the camera and PC communication

For the remote controlled shutter release, the gPhoto2 Linux open source set of digital camera software was used [15]. It is developed under the terms of the GNU LGPL license [16], therefore also available for commercial use. The gPhoto2 software supports several hundred types of cameras; some of them are supported only for mass storage, others are supported for remote controlled shutter release. For communication with the cameras, the gPhoto2 software uses ports and protocols – Serial, USB, Disk and PTP. In the developed solution the modified PTP/IP protocol enabling communication via Wi-Fi was used.

In case of the Nikon D2Xs camera, the communication via a USB port functions without any additional adjustments. The Nikon WT-2 Wi-Fi adapter is used to build up communication over the PTP/IP protocol and via Wi-Fi. The additional necessary parameters are:

- Name of the protocol used – ptpip:
- Name of the camera taken from the list of supported cameras – “Nikon D2X SLR (PTP mode)”
- ID of the camera, so called GUID, hexadecimal string which specifies the camera
- IP address of the device (camera or Wi-Fi adapter)

The above-mentioned parameters are stored in the settings file in the gPhoto2 folder. Every time the gPhoto2 software is run this setting is loaded.

In order to run the commands of the gPhoto2 software in the TRITOP environment, the Python subprocess module had to be used. This module gives access to the processes executable only in the Linux shell.

2.4. Measuring laser pointers

During the measurement, the camera is operating in full manual mode. It also means that the camera is focused on a fixed distance, and the fixed distance from the measured object has to be held during the measurement. The assembly of the measuring laser pointers is used in order to help do that. The assembly is made up of Dural profile and three laser pointers attached to it (at the ends and in the middle). The middle laser pointer is attached in the fixed position and the other two can be turned. For a particular measurement, the two side laser pointers are turned to meet with the middle one on the measured object in one spot. In the robot positioning process (described later) the correct distance is checked by the method described above.