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Research Paper

3D accident reconstruction using low-cost imaging technique

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ABSTRACT

This research is about the implementation of close range photogrammetry (CRP) technique to investigate the traffic accident scene. CRP technique representing and measuring the 3D objects using data stored in 2D photographs. It is non-contact measurement requiring multiple pictures capture to measure objects of interest. Currently, a police officer uses a conventional technique to collect data on traffic accident scene using tape measurement in order to reconstruct the accident scene. The development of camera technology increases the efficiency, stability of consumer grade digital cameras for photogrammetric applications. This development can help police officer to apply a CRP technique for data collection on traffic accident scene. CRP technique offers fast data acquisition, and only need one officer during data capture. This research is to investigate traffic accident scene using the imaging technique. The methodology of this research used a measuring tape and total station for data acquisition on traffic accident scene. This research also evaluates the accuracy of data based on mathematical model standard deviation and root mean square error (RMSE). Based on this research, the implementation of CRP in accident reconstruction is very effective because can achieve a cm-level accuracy in range 40 m traffic accident scene.

1. Introduction

Close Range Photogrammetry (CRP) is a technique representing and measuring 3D objects using data stored on 2D photographs. It also a non-contact measurement requiring multiple pictures captured at the scene for measuring feature points of interest. The technology is best applied by using a good quality digital camera for fast, accurate and permanent 3D data recording. This technique has been used for many applications such as in deformation survey, modeling buildings, medical, reverse engineering purposes, accident reconstruction and crime investigation. CRP cost, reduce time on-site and processing data and effective for small or large projects. The CRP technique has been developed rapidly based on the current technology [1,4].

A separation of instrument components for data recording and data processing are location, time and personnel between on-site recording of the object and data evaluation in laboratory. For conclude that, this technique acquired a very time consuming from recording until processing and many stages of processing cannot completed on site [6]. In the development of technology in imaging has been developed a CRP to a new-era. Using a new technique that called digital photogrammetric systems, that their capability can solved a problems on analogue photogrammetric systems. A fully automatic analysis on targeted points has been replaced the manual procedures for measurement and orientations. The digital processing has been limited in stage of processing from recording until processing a data on computer [2,15]. This technique also acquired a minimum one person to do a photogrammtery work from recording until processing. The new technology has been developed using software to processing, without need others adds-on software to process the data. After data through a phase that called CRP data processing. A final product will be in a graphical form either 2-dimensional or 3-dimensional and in others words an object modeling in software or computer. An analysis in CRP is do based on their applications, user requirements, and what product to produce and others. A general analysis that common used is a derived a dimensions, for example areas, lines, distances and surface definitions. This analysis can be done using a specific CRP software which able to complete the task until the end [9,22]. Before make an analysis the photogrammetric processing will produce a product to do some analysis. After photogrammetric processing, the

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product is divided into two sections. Firstly coordinate, from processing a images, the photogrammetry technique can transform image coordinate to a real coordinate from this data, a user can make analysis on distance, area, surface data, a processing to acquire control data on certain area or object and images and lastly, user can make a comparison with a design that reconstruct on object model. Secondly, orthophoto image represent the graphical information which produced from the processed aerial photo. The CAD format can be used by several users for example the architecture user can used to reconstruct an old buidling, redesign the model, do a measurement and sell it to the public [20,21].

Today, a using of consumer grade camera in photogrammetry has been using widely around the world by photogrammetric or not-photogrammetric in photogrammetric applications. These cameras are ubiquitous, have ever higher resolution and are quite suitable for medium accuracy measurement at, say 1:5000 to 1:20,000 level required in architectural and archaeological recording, forensic measurement, engineering documentation and in numerous other applications domains [3,5]. The improvement of photogrammetry data processing includes computational models, orientation in the software system and automated image measurement that has been designed for use with low-cost digital cameras. This led to an easily to process a data because most of the software nowadays, has been fully automated image processing in CRP [7]. An innovation of imaging technology from 2-Dimensional to 3-Dimensional has brought a CRP to a new level as a tool of imaging analysis [11]. Besides, this photogrammetric can represent a 3D mapping of traffic accident scenes, which commonly termed as an Accident Reconstruction. 3D mapping can make a technical investigation such as analysis of vehicle collision event dynamics, provision of evidence in court hearings and vehicle speed determination [31].

Creating of 3D mapping traffic accident scene required only one officer to do this work from collecting a data on accident scenes using the low-cost camera and later on, processing the data on the computer and the final product is a 3D mapping of accident reconstruction. An innovation of software technology in CRP also has made that this software not limits to photogrammetric only [12]. It can also use by none-photogrammetric, this is because mostly software outside there has been fully automated not same in earlier of CRP introduced that mostly using a manual technique with limitations of hardware and software that very expensive and limit to the photogrammetric only. Another advantage of this latest software, it user-friendly and can integrate with third-party software for other uses [13,14].

CRP has been widely used in mapping field, however the accuracy of the product is still a big issue. After, some people has been done their research about this, It can be concluded that CRP applies to objects ranging from 1 m to 200 m in size, with accuracies under 0.1 mm at the smaller end (manufacturing industry) and 1 cm accuracy for the larger end (architecture and construction industry) [17,18]. According to previous research a Hybrid Measurement approach for CRP discuss a hybrid measurement approach which involves fully automatic network orientation with targets while at the same time supporting follow-up semi-automatic and manual operations such as feature point and line extraction and surface measurement via image matching. The term “Hybrid Measurement” is referring to a CRP measurement approach that incorporates automatic 3D measurement of targeted points. To achieve this automated network orientation it is used retro-reflective targets and highly controlled illuminations conditions [23,27]. This technique can measure the precision in image space of 0.03–0.05 pixels. This technique is developed for a new software example Photomodeler and iWitness that focus on maximum ease of use with a minimal prerequisite for knowledge of photogrammetry (Fig. 1).

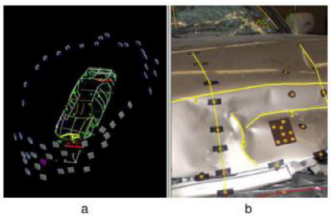

Fig. 1. The hybrid network (a) automatic network orientation and (b) manual digitizing of 3D line feature labelled 2, 3 and 4.

Digital CRP is a technique to acquire 3D spatial information with doing a measurement on the image without non-contact to object. This technique has been popular to use widely over the worlds because fulfilling of requirements in the survey in aspects accuracy, cost, time, user-friendly and manpower. Digital CRP is appropriate to a variety of applications such as monitoring of slope displacement, industrial measurement, forensic analysis, deformation survey, and etc [19,28,29]. From the previous research a CRP for accident reconstruction is the important issues to deal with. It’s including near-planar network geometry in the image, high automated processing and fully automatic camera calibration. Two innovative developments are undertaken to enhance the applicability of CRP and consumer grade camera to accident reconstruction. The aim of accident reconstruction is to reconstruct motor vehicle collision scene either 2-dimensional or 3-dimensional. Traditionally method use to collect a data on traffic accident scene such as using a total station that led to a higher cost and takes a long time at an accident scene to capture a data [8]. iWitness system that a new software use in close range photogrammetry that their capability is automatic on-line computations that occurred automatically in the background with every image point referencing. This software generated attributed point clouds which are preserved to export object coordinate data in DXF format. Using this system, a camera station is not needed on the accident scene because it can support photogrammetric orientation process use of evidence markers. The evidence markers should be placed evenly at the specific object in order to get accurate results during processing. The markers are used to be a reference during image matching process. The size of marker depends on the object size and distance of camera from the object. The markers should be placed at the position that can be viewed by the camera station during image acquisition.

CRP software is used to measure photographs taken at the scene and to prove whether bus driver or woman that guilty. This article also discuss a chronology of police officer that take a data on traffic accident scene with interviewed some witnesses at an accident scene to determine the accuracy assessment that gets from doing an analysis [25]. Before doing an analysis five images has been selected from traffic accident scenes that have been captured by a police officer. The camera used for CRP must be calibrated to achieve a good accuracy. To determine their errors using a CRP software either accept the tolerance limits or not. To proves the facts that whether bus had moved over the curb and encroached sidewalk area the four points photogrammetric was measured on the top surface of curbing close to the impact occurred. This point was created for define the curb horizontal plane and provides a 3-dimensional vertically extended plane directly over the sidewalk or curbing & perpendicular to the street space [26,30]. As a result, the accuracy of several check distances that already measured on site accident using a steel tape and Nikon D70 photogrammetry survey revealed that measurement accuracy was better than ¼ (RMS 1-sigma level).

Dechant [10] investigates of an actual accident were a metro bus hit a woman that standing on the side walk. CRP software is used to measure photographs taken at scene and to prove whether