A Close-Range Photogrammetry Data Acquisition System For Traffic Accidents

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Mohammed Taleb Obaidat
Jordan University of Science and Technology; Jadara University

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A CLOSE-RANGE PHOTOGRAMMETRY DATA ACQUISITION SYSTEM FOR TRAFFIC ACCIDENTS

Dr. Mohammed Taleb Obaidat
Associate Professor of Civil Engineering
Jordan University of Science and Technology (J.U.S.T.)
Irbid, P.O. Box 3030, JORDAN
Phone: 00-962-2-295111 Ext. 2125 or 2139
Faxes: 00-962-2-295018; or 00-962-2-7250222
E-Mail: *mobaidat@just.edu.jo*

ABSTRACT: A stereometric close-range photogrammetry data acquisition system was developed to collect and process traffic accident data using digital image-based format. The system integrates stereo-photogrammetry with image processing techniques and Geographic Information Systems (GIS). A pre-calibrated short-base dual camera setup is used for the purpose of image capturing of accident scenes from stationary locations. The system represents a trend toward automation of the measurement process and semi real-time solution by providing four-dimensional coordinates; i.e. three-dimensional (3-D) coordinates and time. A user-friendly road safety data acquisition system environment was developed for the purpose of data processing and analysis through the usage of an off-the-shelf hardware components including a Personal Computer (PC) and video technology. The system could transfer collision field data rapidly to the PC and produce accurate 3-D measurements and graphical display. Useful information might be extracted from the captured images including vehicle pathway mapping potential with time, vehicle speed, vehicle size and dimensions, depiction of road accident scene, road geometry, etc. The system has numerous advantages including reduction of workload on the road, observation of the accident scene in 3-D, court evidence, monitoring and documentation, etc. The geometric data extracted through the system, and the collected and visualized data could be utilized to build an integrated GIS. Through GIS, data could be preprocessed, managed, manipulated, analyzed, and displayed.

INTRODUCTION

The utilization of close-range photogrammetry techniques for police use and traffic accidents analysis was realized since the 1930s. Since 1960s, Japanese used stereometric short-base dual cameras that are rigidly fixed at the two ends of a stand, which are mounted on a special accident disposal vehicle (Ghosh 1980). The used cameras were of the normal-base setup type; i.e. the optical axes of the cameras are parallel (Obaidat *et al.* 1998-a).

The emerging trends in non-topographic photogrammetry included: improvement of precision and reliability, development of data-reduction methods, development of on-line and digital-based format systems, and improvement of multi-disciplinary work between photogrammetrists and other engineers and scientists (Karara 1989; and Obaidat *et al.* 1998-b).

Photogrammetry operational activities for police departments might include as-built drawings and curve analyses, inventory features, accident analysis, intelligence, and crime documentation.

For vehicle accident reconstruction, it is required to determine speeds prior and after collision. Moreover, physical evidence such as property damage for vehicles, tire marking and location of accident should be investigated. However, due to some restrictions such as weather conditions, traffic volume, and limited space of accidents scenes especially at intersections, a rapid method such as video mapping must be utilized to capture images for accident's scene (Obaidat and Abdullah 1996). Photogrammetry techniques are capable of yielding precise and accurate three-dimensional (3-D) information, compiling of on-line mapping, and having potential of real-time mapping.

The utilization of stereometric mapping strategy in police use can be effectively used to: 1) extract accurate measurement when making accident assessment; 2) reduce the work time and workload on the road especially during the peak hour's time; 3) visualize the accident scene in 3-D; 4) use stereo-images as evidence at the court; and 5) protect people assessing the accidents. On the other hand, it requires a user-friendly software packages, data-reduction schemes, and professional people to train the patrol police members to effectively use the stereometric-based systems for the selected application they need.

This paper focuses on the state-of-the-art of an integrated framework of a data acquisition system consisting of a stereo-photogrammetry system along with image processing techniques and Geographic Information Systems (GIS) in assessing traffic accidents. Stereo-photogrammetry is used to extract quantitative surface measurements, while digital image processing technique is used to perform recognition and automated tasks. However, GIS is a tool to present, display, query, and link database with digital images. Figure 1 shows a schematic diagram of the proposed system for accident mapping.

STEREOMETRIC MAPPING

Video technology has been replaced the traditional 35 mm film cameras due to its capabilities of real-time mapping and following-up the trends of technology toward automation and digital mapping. Therefore, it is proposed to use video cameras to map accident scenes due to their superiority if linking the images with highway database files using GIS (Lee *et al.* 1991). Therefore, videometry has a high potential capability of extracting quantitative measurements.

One of the camera arrangements, which can be utilized for accident mapping, is the usage of stereo camera setup mounted on a stand on a movable vehicle. Other option for mapping is to use stationary dual cameras, connected to central computers, mounted on a lighting pole located at the intersections to provide on-line videometry and digital images. The main geometric advantage of this technique is that it does not require control points in the mapped scene although it has appreciated measurement accuracy. A camera base, normally about one-meter, is selected with parallel cameras' optical axis to form normal-base camera setup. Therefore, cameras must be pre-calibrated using any camera calibration method such as 3-D laboratory field, or planar wall (Obaidat and Wong 1996).

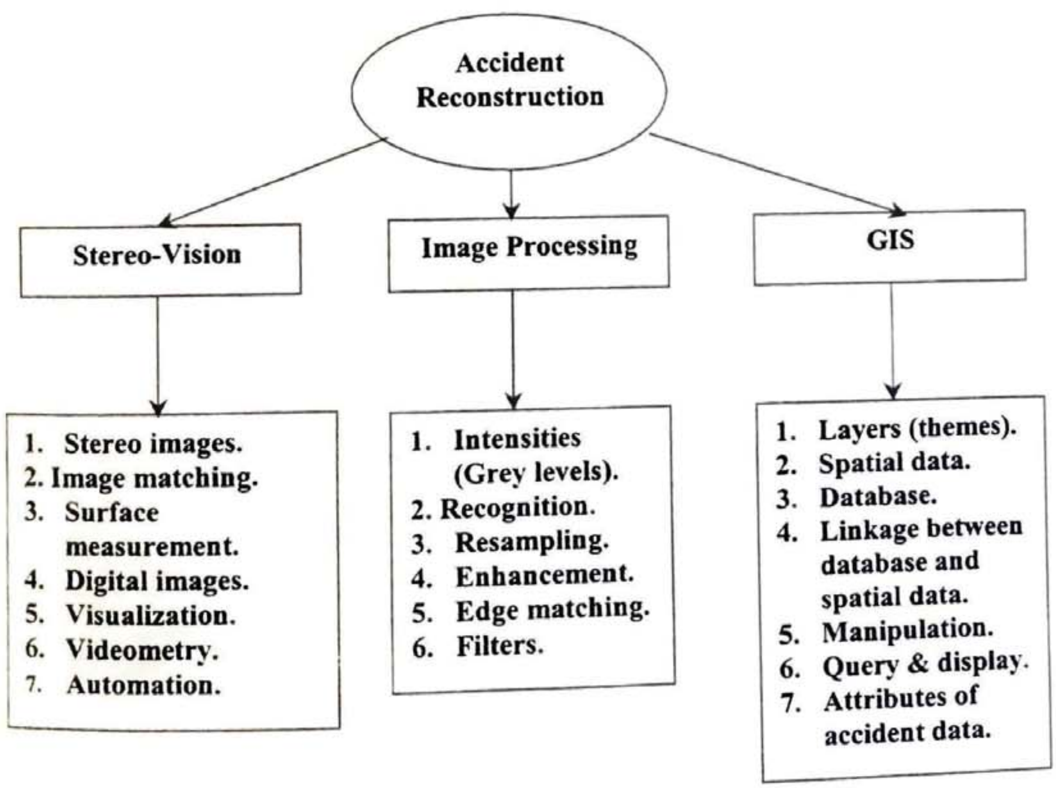

Figure 1: Proposed Framework for Accident Reconstruction.

The utilized stereometric system for the purpose of accident's scene mapping consisted of pre-calibrated stereo cameras (Charge-Coupled-Device; i.e. CCD) mounted on a stand with a base of about one-meter. The cameras are equipped with zoom capability to map accidents at different scales and field of views. Stereo images then could be digitized using a PC equipped with a frame-grabber to capture frame by frame digital images (one frame is about 1/25 seconds). Therefore, minimum time is required to map the accident scene; i.e. less than a minute for each perspective. Figure 2 shows a pair of stereo images for an accident scene acquired using a focal length of 8.5 mm. This accident occurred at an intersection; which is a common type of accidents in Irbid City, Jordan. These types of accidents normally occur due to ignorance of traffic priority at the intersections.

Figure 2: Stereo Images for Accident Scene.

Image coordinates could then be extracted and refined up to sub-pixels (less than 0.02 μm). Having the digital stereo images in two-dimensions (2-D) and the camera calibration parameters, the 3-D coordinates and quantitative measurements could be found for any point on the scene using the intersection algorithm (Karara 1989). The time can give a fourth dimension for accident occurrence; i.e. point location of accident and time. The monoscopic approach could be used for this purpose without the need to visualize 3-D of the accident scene (although it is possible to visualize the 3-D scene using the stereoscopic approach). Therefore, image coordinates and point location in 3-D for any point in the accident scene are found directly on the PC screen by simply pointing to the conjugate image points on the stereo images. The data reduction scheme, which requires algorithms and programming skills, therefore is substituting the usage of high cost cameras. Because of that, video cameras, which are available at almost every house nowadays, could be used for this purpose along with an efficient algorithms and developed user-friendly software packages (Shortis and Fraser 1991).

The accuracy and precision of the extracted measurements depends on: 1) camera calibration quality; 2) camera resolution and type; 3) scale and focal length used; 4) camera orientation and arrangement; and 5) image coordinates quality.

IMAGE PROCESSING

Once the digital image is available, it can be processed to extract useful qualitative and classification information. In traffic accident analysis and reconstruction, it is required to know some useful information that can be extracted through automated image processing techniques. These descriptive informations include brake marking on road, vehicle type and color, edge extraction of curb and lane marking, path of vehicles, simulation of traffic movement during accident occurrence, etc. The previous activities can be distinguished through the discrepancy of intensities between vehicles involved in accident and surrounding environment.

Some of the image processing activities include: passing low-pass filters, edge matching, edge extraction, image enhancement, reconstruction of 3-D of the mapped accident scene, recognition, resampling, image analysis, etc (Kim and Muller 1998).

Sequence of frames at the time of accident occurrence form a pathway of vehicle. Therefore, when image is presented in binary data, the path of each vehicle involved in traffic accident can be easily presented and displayed because the image is pixelized and each pixel's Grey level is known. Thus, traffic accident simulation and reconstruction are possible.

Image processing technique is advantageous for accident reconstruction because it offers an automation capability, real-time extraction of information, documentation potential, and following technology trends toward automation and digital mapping.

GEOGRAPHIC INFORMATION SYSTEMS (GIS)

GIS can be defined as a computerized system that integrates both spatial or vector files along with shape files into a database consisting of different attributes. Shape files consist of point, line, or polygon (area) data themes. GIS has the capabilities of compiling, storing, displaying, manipulating, querying, mapping, and presenting spatial information (Gamba and Casciati 1998).

In transportation engineering, GIS has numerous applications especially in transportation planning, maintenance, and pavement management systems. However, its applications in traffic safety are limited (Olsson 1998). GIS nowadays become as an effective tool for ultimate time and cost saving in many engineering applications because it can be effectively used as decision support systems.

The concept that will be illustrated here is to use data extracted from stereo vision and image processing as layers (themes) for GIS. The digital image will be used as a base map to reconstruct accident, however, other extracted data and information will form other themes with the possibility of superposition of themes.

Accident location has a point shape in GIS; therefore, it can be pointed out at the base map image by selecting a point feature in a GIS software package such as Arcview or Arc/Info. Global Positioning Systems (GPS) might also be used to locate the accident in a geo-referenced map with respect to global or geographic coordinate systems. GPS has the potential to give both temporal and spatial information about the accident scene. In this case, linkage is required between small-scale images, which have been mapped using close-range stereo photogrammetry, and the geo-referenced image. Thus, refined and detailed data could be queried at the location of accident. For example, hazardous locations can be identified easily by querying on locations having number of accidents more than a selected threshold value.

Database Attributes

A database has been established for accident's attributes. It includes data related to drivers involved in accidents, accident location, road condition, and vehicles. Table 1 shows the used attributes.

The fields and records of these attributes are the output of the stereo photogrammetry measurements, the image processing technique, descriptive, surveyed, and collected data. These records are entered to the database and linked to the shape file of every accident spot located on the base image.

Table 1: Accident Attributes for GIS.

Driver's Data	**Accident's Data**	**Road Condition**	**Vehicle's Data**
1. Age and Gender of first and second parties involved in the accident. 2. Driving license data. 3. Personal data: education, name, Address, etc. 4. History.	1. Location of accident. 2. Date and time. 3. Type of accident. 4. Cause of accident. 5. Pathway of accident. 6. Vehicles accident or vehicle-pedestrian accident. 7. Injury and fatality. 8. Severity level. 9. 3-D data.	1. Weather Condition. 2. Surface Condition. 3. Road type. 4. Road name and number. 5. Light and sight distance. 6. Geometry.	1. Type of vehicle. 2. Colors & model. 3. Braking System 4. License. 5. Speed. 6. Size.

Seven GIS layers were created for this purpose. They include a base map, spatial data of point shape for an accident, detailed pathway for vehicles involved in accident, driver's data, accident data, road condition, and vehicle data. Figure 3 shows the proposed GIS layers for accident database.

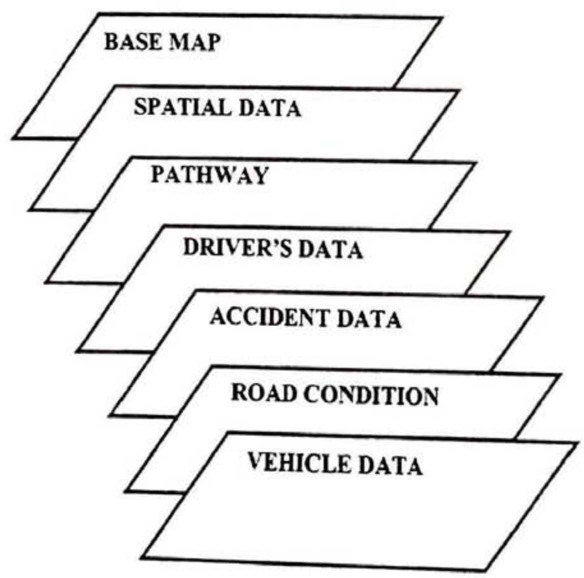

Figure 3: GIS Layers for Traffic Accidents.

Combination of layers or single layers display, query, representation of charts or statistics, etc, through Arcview software is possible. Therefore, using this integrated system, management, analysis, and decision making is supported through stereo images, database, and linkage between them.

SUMMARY AND CONCLUSIONS

The integration of stereo close-range photogrammetry, GIS, image processing, and GPS provides a new way of collecting and measuring accident data that can follows-up the trends of technology toward automation and real-time digital mapping. The system presented herein is an off-the-shelf traffic accident data acquisition system that can be incorporated and linked with shape and spatial GIS files. The attributes of accident database were categorized into four groups: data related to drivers involved in accidents, accident location, road condition, and vehicles. They were flexible in away that the addition of more quantitative and qualitative attributes is possible.

GIS themes were developed using seven different layers. These layers included a base map, spatial data of point shape for an accident, detailed pathway for vehicles involved in accident, driver's data, accident data, road condition, and vehicle data. The system, with the aid of the Arcview GIS software, is capable of querying, manipulating, displaying, analyzing, managing, deciding, mapping, presenting spatial information, compiling, and storing of accident data.

Its worthwhile mentioning here that, the effectiveness of using this system for traffic accident analysis depends heavily on the accuracy of the 3-D measurement of the stereovision system and the descriptive data input incorporated into the database.

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