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Original Article

Integration of Laser Scanning and Three-dimensional Models in the Legal Process Following an Industrial Accident

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ABSTRACT

Background: In order to obtain a deeper understanding of an incident, it needs to be investigated to "peel back the layers" and examine both immediate and underlying failures that contributed to the event itself. One of the key elements of an effective accident investigation is recording the scene for future reference. In recent years, however, there have been major advances in survey technology, which have provided the ability to capture scenes in three dimension to an unprecedented level of detail, using laser scanners.
Methods: A case study involving a fatal incident was surveyed using three-dimensional laser scanning, and subsequently recreated through virtual and physical models. The created models were then utilized in both accident investigation and legal process, to explore the technologies used in this setting.
Results: Benefits include explanation of the event and environment, incident reconstruction, preservation of evidence, reducing the need for site visits, and testing of theories. Drawbacks include limited technology within courtrooms, confusion caused by models, cost, and personal interpretation and acceptance in the data.
Conclusion: Laser scanning surveys can be of considerable use in jury trials, for example, in case the location supports the use of a high-definition survey, or an object has to be altered after the accident and it has a specific influence on the case and needs to be recorded. However, consideration has to be made in its application and to ensure a fair trial, with emphasis being placed on the facts of the case and personal interpretation controlled.

1. Introduction

Accidents occur, resulting in life-changing effects. However, industry is committed to reducing accidents, with improved health and safety performance, aiming to eliminate incidents at work. An accident can have wide-ranging implications, particularly if there has been a fatality. A recent survey undertaken by the Health and Safety Executive revealed that 118 people were killed while at work in 2011/2012 [1]. However, in addition to fatal incidents, 40 million working days were lost through work-related injuries, costing UK businesses £2.5 billion [2]. The problem is not restricted to the UK, with an estimated 4.6 million occupational accidents occurring every year in the European Union, resulting in a loss of 146 million working hours [3]. Accidents have considerable physical and financial implications, and studies have shown that for every £1 a business spends on insurance, it can lose £8–36 in uninsured costs [2].

Considering these figures, it is clear that there are humanitarian and financial benefits that can be achieved through managing risks more effectively. In recent years, this has been largely understood and businesses have focused greatly on health and safety, working with additional legislation. This can be demonstrated by examining fatal injury statistics. In the UK, it can be seen that in 1981, a total of 441 people were fatally injured while at work, compared with 118 between 2011 and 2012, as previously stated [4]. There are a number of possible factors that have contributed to this reduction, such as improved accident investigation and analysis [2]. However, accidents are still occurring, and the number of fatalities across all industries is still significant. Further improvements can still be made by concentrating on

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reducing the reoccurrence of similar accidents, complementary to investigation and analysis.

1.1. Developments in digital data acquisition

There have been considerable advancements in sensor development in recent years, allowing the capture of the real world in unprecedented levels of detail [5]. One such development is terrestrial laser scanning utilizing laser measurement to remotely measure spatial data. In addition, horizontal and vertical angles are measured on the instrument using electronic encoders. Modern terrestrial laser scanning instruments can perform this operation up to 1 million times a second [6], resulting in a comprehensive dataset, referred to as a point cloud.

The point cloud in many applications requires postprocessing for the end user to extract relevant information [7]. One such commonly used algorithm is iterative closest point, largely used to join the captured point clouds together [8,9]. With this in mind, throughout the development, there have been considerable advancements in software applications used to process the data obtained. It is now considered commonplace for three-dimensional (3D) point cloud data to be incorporated into many Computer Aided Design (CAD) packages. The data collected can be used to create 2D plans or 3D models of a scene where 3D laser scanning is likened to taking a photograph with depth information [10]. Furthermore, advancements in computer hardware have provided the ability to perform complex surface reconstructions to create highly accurate 3D models [11].

1.2. Use of digital data in accident investigation

In recent years, there have been considerable technological advancements in everyday activities, which have created increased reliance on the use of digital data [12]. Development of smart phones is a perfect example to illustrate this, providing the user with a magnitude of different functions, including taking phone calls, storing data, and accessing the Internet, with a vast amount of applications available on a device small enough to fit in a pocket.

In many cases, technology is driven by consumer demand for the products, with companies continually developing new products to gain an edge over their industry rivals. However, the legal system can be slow to accept the technology. The delay is largely due to the need for the development of legislation surrounding the admission of digital evidence within the judicial system [13]. This, in turn, can create complications within the accident investigation process when new technologies are incorporated, particularly if there has been a breach of the law in the events surrounding the incident.

Increased focus on technology and computing specifications has led to the development of surveying techniques capturing the world in unprecedented levels of detail, through the use of laser scanning and modern photogrammetric techniques. Laser scanning has provided the ability to capture millions of 3D survey points of an accident, and systems have been used extensively to record major crimes or road traffic collisions [14–17].

Members of the jury often rely on oral evidence presented by the prosecution and the defense. In legal proceedings, witnesses will be called to give evidence on behalf of the court. Witnesses can be ordinary people who hold information that is relevant to the court, or they can be experts who have been called to provide evidence related to their specific expertise. In certain cases, expert witnesses may have to provide complex descriptions regarding the events, environment, and relevant scientific data. It has been found that images can be used to provide clear and easily accessible explanations of complex events without sacrificing accuracy [18]. Further integration of computer-generated technology has begun to play a part within the modern courtroom to aid in the explanation and demonstrate possible hypotheses [12,19,20].

2. Materials and methods

2.1. Case study: fatal accident, 2010

In 2010, an elderly lady died after disembarking a passenger ferry at a quay, when she fell from some quayside steps into a river below [21]. The steps and landing platform within a quay are shown in Fig. 1.

Subsequent to the incident and upon recommendation of the Health and Safety Executive, a number of changes were made to provide a safer means of access and egress to the ferry. Changes made to the steps are shown in Fig. 2.

The authors were asked by the Health and Safety Executive to attend and survey the scene, provide a physical record of the environment, and demonstrate the various revisions that had been made to the steps after the incident, in the form of a 3D model.

2.2. Laser scanning

It has become accepted that the use of 3D data in accident investigation can help in analyzing what has happened [14]. For

Fig. 1. Steps and landing platform.

Fig. 2. Changes made to steps following the incident.

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