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Hard Hat Detection

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Abstract: In 2012, 775 deaths were recorded, and many more were injured on construction sites in the United States. Of this, 415 deaths (54%) were caused by falls, slipping, walking and falling objects. To reduce mortality in construction sites at these types of events, the Occupational Safety and Health Administration (OSHA) provides Fall Prevention and OSHA-10 training to construction workers. In addition, security personnel monitor whether employees are using protective equipment (PPE) properly. Data show that construction deaths have dropped by 2% per year since 1994; however, the owners are not satisfied with this result. Various studies have shown that falls are a major cause of death in construction. One study showed that half of all deaths due to falls were due to employees not using PPE or not using it properly. In addition, studies have shown that with proper use of hard hats, deaths from falls, slipping, walking, and falling objects can be reduced. The study developed and tested a strong hat acquisition tool that uses image processing techniques to determine if employees wear strong hats. The tool sends warning messages when employees do not use hard hats.

Keywords: Hard Hat , Construction Site , Work Place Safety , Workers .

1. INTRODUCTION

In the United States, many people work in the workplace under unsafe conditions, and thousands lose their lives each year. In the US, 4,383 fatal workplace injuries were recorded in 2012; on average, this was the death toll of 89 people per week and about 12 deaths each day. Construction activities are among the 10 most deadly activities. The mortality rate — the average death toll and the total number of hours worked by all workers — on construction sites in 2012 was 3.4. The death rate reflects the death toll of 100,000 full-time employees. According to OSHA.The mortality rate in some developing countries is much higher than in developed countries. For example, in the Republic of Korea, the mortality rate in the construction industry is more than double that of the United States. This high mortality rate in construction in developing countries had the construction managers involved. In addition, the construction industry in the US, the largest industry, had the highest rate of deaths and injuries. Bureau of Labour Statistics data from 1990 onwards showed that the national mortality rate began to decline (by 2% per annum) from 1994; however, it is growing in Nevada. In 2011, the construction industry had the second-largest death toll in the United States.

Of the 4,383 fatal accidents in the workplace in the United States in 2012, 4,175 were injured in the private sector and about one-fifth (19.30%) of private sector deaths were recorded in the private construction industry. The main causes of damage to the building site were falls, slippery, hit objects, electric shocks, and traps between/between objects. Specifically, mortality in construction projects due to collapse accounted for 34.6% of the total building mortality; this percentage was 49.9% in the 1980s and the first half of the 1990s. Table 1 shows the percentage of fatal falls by type of activity over the past six years. The number of fatal falls and the percentage of fatal falls from the roof, stairs, scaffolding, and stage has increased since 2007.

In many fall cases, workers fell on high ground and hit their heads on hard surfaces. An investigative report showed that half of the falls were recorded from a height of less than 3 m; in addition, 57% of falls occurred from stairs, roofs, buildings, and platforms. Sturdy helmets are designed to withstand shocks and objects as well as to be in contact with electrical hazards. If workers wear the hard hats properly, half of all fatalities and the high number of deaths due to slipping, walking, and falling objects can be expected to decrease. In another study that investigated the death toll from the construction and use of PPE, the results showed that 47.3% of victims of death may not have used PPE or may not have used it properly.

Figure 1 shows a typical construction site. On the left, all the staff members are wearing hard hats except one, who is holding his strong hat in his hand. On the right, two workers do not wear tight hats while working in a flat. These types of images transferred from construction sites can be analyzed

to determine whether workers are complying with safety regulations. In this study, a software tool was developed to automatically detect workers wearing tight hats on the construction site.

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The National Institute for Occupational Safety and Health has investigated injuries caused by falls on construction sites. The data showed that, from 1980 to 1994, falls were the leading cause of workplace deaths. In construction sites at the time, falls from stairs, scaffolding, buildings, and other structures and falls from one level to another were 12.3 percent, 13%, 34.7%, and 16.6%, respectively, from 1980 to 1994; from 1982 to 1997, they were 8.8%, 18.7%, 63.8%, and 8.8%, respectively. From 1980 to 1994, a set of data on falls due to collateral was compared between 11 categories (e.g., construction, agriculture, mining, manufacturing, manufacturing, and transportation). Data from the study showed that 49.9% of all deaths were due to falls, with a mortality rate of 3.89.

Figure 1

A typical construction site where some workers did not use a hard hat and some used it improperly.

To reduce injuries by enforcing work-related safety laws, the US government established the Occupational Safety and Health Administration (OSHA) in 1970. OSHA prepares workplace safety guidelines and provides safety training grants to construction workers to train them in value. to use PPE effectively. In addition, OSHA monitors construction sites to ensure that contractors and owners adhere to safety regulations to avoid site damage. For various reasons, workers in construction sites sometimes fail to comply with OSHA rules and regulations, for example, under extreme weather conditions or because of stress in meeting the last working days.

As a result of OSHA involvement, many provinces have reduced risks in the workplace; however, security engineers and construction managers are not satisfied with the current system of visual monitoring to assess employees' use of PPE. They want a new way to monitor employees fully. With conventional visual monitoring, security engineers sometimes fail to force construction workers to use their sturdy helmets because they could not monitor workers on an hourly and daily basis. However, if security engineers can monitor employees in real-time using local video streaming, safety rules regarding hard hats can be applied more effectively. This can reduce the risk of death from falls, slipping, tripping, and falling objects. This study developed a tool to identify employees who do not wear tight hats on site.

In order to develop a tool that automatically finds employees who do not wear tight hats in real-time video, the viewing method was used. Visualization is a new software tool that monitors employees in real-time and sends warning messages to affected employees if safety rules (wearing tight-fitting hats at this stage) are violated. This method contains

(1) A closed-circuit television (CCTV) camera was installed in the construction site,
(2) a wireless/wireless network for transferring videos captured by a CCTV camera to a server (office computer),
(3) server at the nearest office,
(4) Pictures of the construction site are continuously displayed on office computers. By using real-time images, the software system detects whether employees are using their sturdy hats properly. When the system finds a worker in a building without a hard hat, the system starts warning messages. This tool was developed using image processing software.

This current study is an extension of previous studies in the field of building security perception, computer vision, pattern recognition, and online transmission . The tool was developed using image processing technique to detect the employee's face and then using the edge detection system and partitioning methods to determine if the employee has a strong helmet. The software tool was developed by a concerted effort by construction engineers and computer science specialists and then tested in the Construction Management Laboratory at the University of Nevada, Las Vegas (UNLV).

2. Literature Review

The literature review to frame this study focused on two main areas, computer visualization and image processing. The papers reviewed in these areas are summarized as follows.

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2.1. Computer Visualization

Teizer and Reynolds learned and designed a "smart hat" to prevent construction workers from coming into contact with heavy equipment, using radio frequency (RF) technology. The silicon microprocessor wireless was attached to hard hats and heavy tools. As workers approached the heavy equipment, as described by the microprocessor, the system sounded a loud alarm to warn them. The authors say that when construction workers and large machinery share the workplace and safety concerns are high, this technology is very useful.

The authors investigated the function of the RGB-D sensor to track an employee and / or object in terms of three parameters : (1) 3D motion of the employee's body position, as followed by the sensor; (2) 3D rotating angles of body parts; and (3) sensory sensitivity analysis regarding body movement. These three databases were collected during experimental studies. To compare these databases, another database was also captured, using VICON's six 4 mega-pixel sensors, which are considered to provide the most accurate results. Comparative results showed that the RGB-D sensor area difference was 10.70 cm, and the rotational angle difference was 16.20 degrees. However, differences in results related to movement analysis were not significant.

2.2 Image Processing

Shrestha et al. developed a framework for construction safety visualization and developed and tested an edge detection algorithm. The framework included the installation of a set of CCTV cameras, a powerful server at the site office, and equipment to send warning messages to safety-related personnel once the program detected workers not wearing hard hats in the construction sites. The server was a powerful office computer equipped with two algorithms, edge detection and segmentation. This study developed the segmentation algorithm in order to identify the worker and hard hats.

In this study, Curio et al. used an image-processing method to detect a walking pedestrian. The program concluded that a walking pedestrian in the image needed to satisfy two conditions. The first condition was that the image matched the outline of a human; the second condition was the periodic movement of legs while walking. Taking an image using two cameras, stereovision could be produced. Stereovision could be used for short-range and midrange distances from the camera to the pedestrian.

Tsai et al. studied the detection of defective traffic signals by using an image-processing technique. The recognition of the traffic sign types, the exact location of the sign for inventory purposes, and identification of signboard conditions—retroreflectivity, faded sign colors, tilted signs, and sign boards blocked by objects—could be identified using the program. In the detection process, traffic signs were identified in terms of their shape, color, background, and legend. A crucial step for the image-processing algorithms was to separate the images that contained traffic signs from those that did not. During the program execution, first, the traffic sign is detected and, second, recognition is achieved. This study dealt only with traffic detection.

Canny developed an edge detection algorithm, which had five distinct steps.(1)Smoothing: this is a blurring of an image. Every image has some amount of noise in it, and a Gaussian filter is used to smooth it.(2)Finding gradients: these are edges in a grayscale image where the grayscale intensity changes the most. This is identified by determining the gradients.(3)Nonmaximum suppression: the maxima in the gradient image are preserved, and the rest is erased.(4)Double thresholding: the pixels that remain after Step (3) are marked with their strength, pixel by pixel.(5)Edge tracking by hysteresis: strong edges and weak edges connected with strong edges considered "certain edges."Park et al.conducted research to determine whether the person at a construction site is actually a worker. A worker was confirmed by fulfilling two conditions, the outline of a person and the presence of PPEs. The program developed in this study analyzed the video frames of the construction site by using an image-processing technique to separate moving objects from background images in order to identify the outline of the person. After the person was detected by analyzing the pixels of the images, the person was identified as a worker or not. In this experiment, a worker wore a vest and a hard hat, which has a higher pixel rate than a person wearing normal dress. From the differences in pixels, the system determined whether the person was a worker.

Han et al. used a vision-based motion detection to track unsafe working behavior of construction workers, using video camera images. A 3D model of a worker was developed using images from two different cameras. The 3D model was analyzed to figure out whether the worker's movement was safe. However, this study did not apply a real-time image-processing technique.

Tharindu et al. detected workers at construction sites using an image-processing technique with a Kinect sensor. Using video camera images, the program identified the location of the workers. To ensure that the image was a construction worker, the person detected by image processing needed to have a hard hat on. The hard hat was detected using pattern recognition.

Escorcia et al. detected workers and their actions at construction sites using Kinect sensor technology. An algorithm based on machine-learning techniques was used for this study. The video-log images were analyzed to determine the accurate actions of the construction workers. This program is useful to assess productivity, safety, and occupational health in indoor environments.

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2.3 Gaps in the Literature

A lot of research on staff recruitment has been done. Some researchers use sensors attached to hard hats and other body parts to track them; however, the construction worker and the acquisition of solid hats in real time using the image processing method is a new method. It is advantageous to use image processing over the sensor system to detect workers and objects. Studies have shown that sensors used to track objects lacked precision. However the image processing method can accurately detect workers and objects. In addition, no research has been done on the discovery of hard hats in real time.

3. RESEARCH METHODOLOGY

A visualization is a new approach. Today, a visual approach, used as a practical tool, can be very helpful in automatically locating construction workers and their PPE. Contains a collection of CCTV cameras installed on the site, a network connection between the cameras, an office computer (server), a server that acts as an office data analysis computer, office computer displays, office-built warning speakers. website, and cell phones to send security warning messages. Visualization is divided into three parts: image input, image analysis, and image output. For image capture, a set of high-resolution CCTV cameras are installed on-site, take real-time photographs and send them to an office computer using a wired or wireless network. Installing cameras with optimal rotation, stereovision can be reached which can determine the exact location of personnel and/or objects. Cameras use charged-couple devices (CCDs) to capture high-quality video. Video is transmitted to the office computer using a local area network (LAN) or wireless network.

For image analysis, the transmitted video is categorized by digital images. Video is a combination of a few images. In this program, a one-second video is split into 32 images; then, each image is analyzed using the image processing method. When 32 images are analyzed, this is one-second video analysis. During image processing, an employee can be identified using a variety of methods, for example, pedestrian recognition or facial recognition. In this study, facial recognition was used. When an employee is facing the camera, his or her face is found in a photo or in a series of photos. This is considered to be the work of a construction site. Because more than one camera is installed on the site, the employee's face can be viewed as a preview of one of the cameras.

As shown in Figure 3, once the system has detected an employee, the face recognition system calls for a hard hat detection system, which checks if the hard hat can be seen in the image. As with face recognition, various methods of obtaining strong hats have been developed. Two methods — using a sensor chip in a solid hat and an edge detection method — are commonly used. In this study, the edge of the material inside the upper head region which apparently includes a hard hat is drawn using a curve finding system. When the system receives a hard hat, as shown in Figure 3, the system recognizes that "Safe Mode" exists. Then, the program performs the same process on other images; otherwise, it satisfies the conditions to extract the image output.

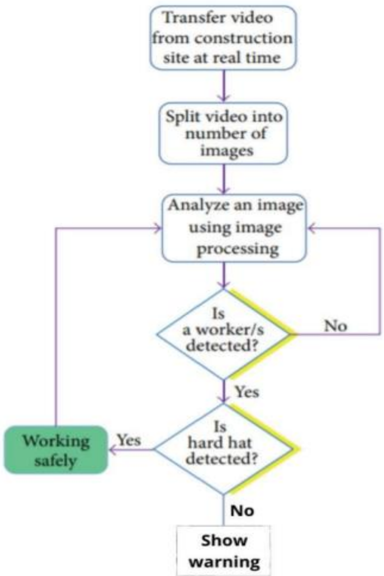

Figure 2 :Framework for identifying hard hats with a worker.

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Regarding image output, if the workers are working without using hard hats, a warning message is triggered to three places: the office computer displays, the cell phones of concerned personnel (e.g., the construction manager and safety officer), and the speakers installed at the construction site. To deliver these messages, the program may use any of three kinds of probable networks: LAN wired networks to the office computers, a LAN wireless network, or wireless cell phone data. Details of the visualization technique are explained in Figures 2 and 3.

4. FACE DETECTION PROGRAM DEVELOPMENT

Face detection is an important step in the visualization technique. Two methods, sensor chip and face detection, are usually used. For the visualization technique using image processing, face detection is used. During data analysis, the face detection program checks the presence of faces in each and every image of the site surveillance. In this program, an important assumption in face detection to be considered is worker detection. Once the program detects one or more faces, it calls the hard-hat detection program. If any faces or workers were not detected in image, it repeats the same procedure in other images.

Figure 3 shows a worker's face that is detected. In this program development phase, in order to track whether a face is detected, a black rectangular box around the face is displayed, indicating that a face is detected. Figure 4 (right side) shows a blue rectangular box at the upper head region of the person, which indicates that the program is searching for a hard hat on the head.

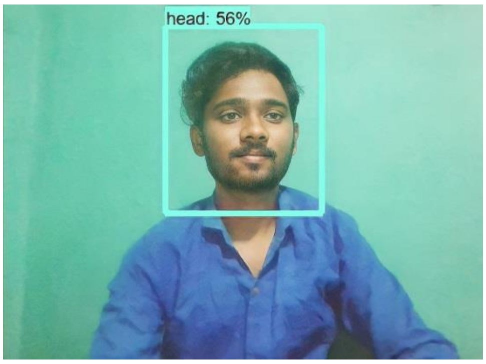

Figure 3: Implementation of the face detection program

5. HARD-HAT DETECTION PROGRAM DEVELOPMENT

In the visualization technique (Figure 2), after the face detection program, the hard-hat detection program is implemented. The objective of a hard-hat detection program is to detect a hard hat by checking if a hard hat exists at the upper head region of that person. During the implementation of this program, the following steps are executed.

(1) Focus on the upper head region, up to 12 inches above the face.

(2) Apply the edge detection program on the upper head region, which converts the digital images into outlines of the objects. The process of converting images into outlines of the objects has three stages. First, the program uploads an image; Second, the RGB image is converted into a grayscale image, as . Third, the program converts the grayscale image into outlines of the objects as a product of the edge detection algorithm.

(3) Hard-hat detection involves two conditions being fulfilled: first, the outline of hard hat is a square, as shown in figure, and the second, the color of the hard hat is red.

(4) The hard hat tilt angle is found by a dot product of the cord-line row vector with the row vector ; the cord line is the line joining the ends of semicircles formed.

(5) The results of dot product, calculated in Step Four, refer to the degree of the hard-hat rotation with respect to the -axis; the values zero and nonzero (in between −1 and 1) indicate that the hard hat is perfectly straight up and rotated with some angle, respectively. If the hard hat is found rotated, then it is rotated by about the axis to convert into the normal position.

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(6) If logos or any special initials are presented in the hard hat, the hard hat is easier to detect.

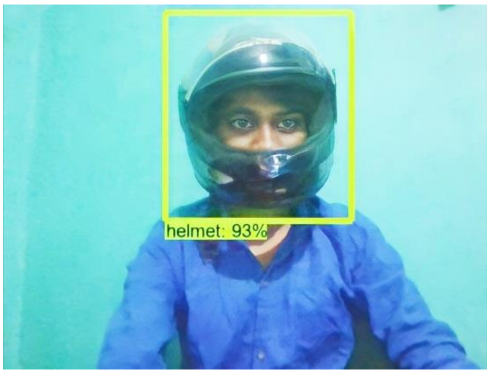

Figure 4: Implementation of the edge detection program.

6. CONCLUSION

In this study, the software tool was developed at Microsoft Visual Studio 2012. During the development of the software tool, for the first time, the system separates real-time video sent from a CCTV camera installed on the site to a total of 32 images each. second of video. Then, a face recognition system is applied to each image to identify the employee. The face detection system uses a feature similar to Haar. When the system gets a face, it calls for a system to get a hard hat to get started. This system identifies a solid hat by completing two conditions, the red colour of the solid hat and the frame of the solid semicircle hat. To get a solid hat frame, the system uses an edge-finding algorithm.
System development is in the early stages. Thus, under certain conditions, the system may fail to detect firm faces and hats. A set of CCTV cameras needs to be installed in areas that will allow the camera to take a picture of the employee in front; However, cameras cannot take forward-looking images while the employee is looking down while working. In such cases, the system cannot detect solid faces and hats yet. In addition, when using a hard hat acquisition system, where the difference between the hard hats and the back colour is not high enough, the edge access system cannot provide a clear framework for hard hats. If an employee is moving too fast, sometimes, the system fails to recognize the employee properly.

The development of this system will help save time, costs, and health of workers in the area; however, at this stage, it will not completely reduce injuries and deaths in construction. Other factors, such as employee behavior, types of personnel, types of hazardous work, and the level of skilled and trained staff, all influence the number of injuries and deaths in construction. Therefore, it is necessary for building safety engineers to perform in-depth analysis, including risk analysis, in order to reduce the number of construction hazards. The tool developed from this study will help safety engineers detect complete deaths in construction sites.

Further Reading and Recommendations. In this early stage of system development, appropriate conditions have been considered. This system was used in the laboratory environment to test whether the system was able to detect the author's hard hat in real-time. Currently, efforts are underway to test the software in a real-time construction environment by installing CCTV cameras and transmitting real-time images. Another extension of the program is to see if staff members are wearing vests; The third extension includes adding an employee recognition system based on the employee framework and general leg movements as you walk. In addition, the use of data management for all employees in such a way that the system is able to record all employees' accounts of safety violations is being considered. Further research will continue until the system is able to better identify.

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