# Training Video on Low-Skilled Workers

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*Abstract: -*

Accident in construction sites are a result of several reasons such as the worker's training, lack of awareness, site working conditions, and the design of the project. An understanding of what is the best tool to enhance the worker health and safety awareness is a needed especially for low-skilled worker.
Since the steel structures construction continues to be one of the most hazard jobs in the construction industry, the visual training process to enhance the workers understanding becomes essential. The objective of this paper, which is part of my Ph.D. is to presents the development of a system that can demonstrate the hazards of site activities in an advanced visualization tool, the system can determine whether this activity exist in a given digital image by processing digital color information. For the development of the image processor, color image processing is employed instead of grayscale image processing commonly used in previous researches.

*Key-Words:* - Health and Safety, Construction Industry, Activity and Hazards

## 1 Introduction

Construction sites remain to be a hazards source for those on sites and other members of public. Workers may suffer from work related illnesses and possible fatalities while the public and especially children can be injured by exposure to badly controlled work activities. The duty to act responsibly in preventing unsafe practices lies with everybody related directly or indirectly to the working activity. Accidents can happen to everyone and none is spared from this probability hence careful consideration must be given to work decisions in a manner to eliminate these unsafe practices.
Safety is not just about its human side of caring for the health and well-being of workers. It has a significant financial side in the cost of downtime, insurance and lost man hours.
Simple precautions can result in reducing accidents or lowering their impact. Suitable protective clothing, following basic health recommendations, maintaining the site clean from debris and first aid knowledge can be effective in improving the working safety environment. Another important factor is providing proper specific training to the workers related to the jobs assigned to them.
The role of Health and Safety in construction sites should not be limited to the protection of workers but should be extended to cover the general public directly or indirectly in contact with these sites. An important objective of this role is the strict enforcement of the relevant laws and regulations. A significant reduction in fatalities and major injuries is being witnessed over the last years due to the improved adherence to guidelines and regulations as reported in the UK's Health and Safety Executive statistics and publications (Health and Safety Executive, 213) [1].
The importance given to the Health and Safety aspects in any construction project is due to several reasons such as the provision of a safe working environment which leads to employee's welfare, and construction cost control. While the first reason is clear to owners and contractors the later is usually overlooked. The estimated project's cost can be better controlled when risk and hazards are reduced or eliminated. Costs overrun will result in

diminishing the profit margin of the contract and renders it not attractive hence a dedicated commitment by all parties involved in any project will significantly impact its profitability (Emmons, 2006) [2].

This paper is structures as follow, it began with an introduction which cover a brief explanation, which then conclude a problem formation section, problem solution come next which cover four proposed solutions Usage of Animation for Health and Safety, Health and Safety Trainings Using Dramas and Animations, Time-Lapse Videos, and Equipment & Movie Making, before coming to a conclusion modeling program development is covered which is divided to three sections; The computer vision model program, Report modeling, and Training modeling.

## 2 Problem Formulation

Health and safety should be regarded as one of the key targeted objectives in any business and particularly in the hazardous construction industry. However following and abiding by the various rules, regulations, and guidance associated with its implementation can prove to be a relatively complicated task for construction management teams. In order to simplify the understanding and implementation of the relevant H&S rules it might be conducive to consider the underlying principles behind them (The ROSPA Occupational Health & Safety Awards, 2002) [3].

These principles fall under the following titles:

i) Health and Safety Management System:

A system should be in place which includes designations, policies, and work procedures. This system should clearly define accidents preventive measures and designate a person or persons whose job is to enforce compliance with H&S rules and deal with any possible legal obligations. The system should also set out clear steps for planning, monitoring, and controlling these measures.

ii) Hazards identification and risk assessment:

The process of risk assessment associated with the works' identified risks should be carried out in logical steps leading to the establishment of an approved system which helps to address these issues. These steps can be as follows;

- The identification and documentation of any activity which has the potential of causing harm to the workers or the general public.
- The estimation based on previous records of the probability of causing harm by the identified activity and level of severity of such harm.
- The establishment and enforcement of an adequate measures response protocol to the identified risks which should be updated and maintained using the relevant bench marks set out in the applicable Health and Safety Laws and Regulations.

iii) Informing and training workers to understand and apply these measures.

The implementation of Health & Safety guidance, regulations, and recommendations related to any specific type of work is a joint responsibility. The first step in this coordinated effort is between the work force and its safety designated staff. It is the Health and Safety departments' responsibility to establish a sense of commitment to safety practices in all members of the working force. However it is not enough to restrict the Health and Safety education and coordination to the immediate work site. Customers, clients, contractors, suppliers, and other related groups should also be involved in this effort. Furthermore the implementation of Health and Safety regulations and r5ecommendations should not be in response to accidents. It should be a proactive exercise which prevents accidents rather than respond to them (The ROSPA Occupational Health & Safety Awards, 2002) [3].

## 3 Problem Solutions

### 3.1 Usage of Animation for Health and Safety

The poor management of the Health and safety issues by companies resulting in insufficient staff training is the main cause of the high accidents rate in the construction industry. An efficient and credible visual training program can reduce accidents and save lives bearing in mind that 80% of the human memory skills are obtained visually. There are several visual tools that can be utilized in such a program amongst them are dramas and animations. Adopting the visual tools approach relieves the training program from the boring theoretical nature and makes it more attractive and enjoyable. This approach can present real construction accidents and demonstrate the mistakes that led to them and the preventive measures that should have been followed. Dramas and animations have a higher appeal with the low educated level of construction workers who finds it rather difficult to understand theoretical training given in workshops (Arsalan and Kivrak) [4].

## 3.2 Health and Safety Trainings Using Dramas and Animations

The training exercise by dramas and animation is used to present work place accidents demonstrating what went wrong and how to avoid it.

The first part of the exercise is the data collection of previously recorded accidents regarding their causes, numbers, and frequency. Statistical data published by governments, professional institutes, and nongovernmental organizations are available and can serve as basis for this exercise. The data is then grouped under several headings such as their frequency or their severity (Arsalan and Kivrak) [4].

In the second part accidents scenarios are prepared where construction accidents are defined in terms of causes, frequency, places …etc. These scenarios should also address precautionary and preventive measures which should be taken. .

The following part is the designing of the drama and animation in which an innovative effort is needed to create the material which is presented in different levels of importance and for various types of works. This approach will help in preparing specific different training dramas for each work category. Computer animations constituted from images and musical rhythms without a spoken language can serve an international audience (Arsalan and Kivrak) [4].

The last part is the applications of the dramas in the health and safety training programs and having their impact and results evaluated by the relevant health and safety departments in construction companies. A further advantage of this approach is the ability to create a specific accident scenario and preventive measure for a specific job activity and give the visual training on site before carrying the activity by the workforce.

## 3.3 Time-Lapse Videos

Time-lapse photography is a well known and established method used in recording the progress of construction activities. Rather than continuous filming which could prove to be expensive and logistically difficult, short interval photographs or videos with a fixed time span and duration are combined to create a movie representing the actual series of events.

This method can be used as Recording purposes e.g. weather, work progress, consumed materials …etc.

Management tool to evaluate performance for the purpose of control or improvement.

Planning base for similar future activities.

Marketing tool to possible clients or in exhibitions through the demonstration of working capabilities.

Training of staff.

## 3.4 Equipment & Movie Making

The animations and compilation of time laps images need to be converted into a movie in order to achieve its objectives. It is possible to resort to a professional commercial solution which is more suitable to bigger projects; however affordable means in the form of laptops and digital cameras can give satisfactory results at much lower costs. The movie creation process goes through the following steps:

* Image capturing: The starting activity in movies creation is the filming by still pictures or short videos at regular intervals throughout the duration of the monitored construction activity. The camera should be fixed at the same position and arrangements to connect to a power source or recharge facilities and surge protection should be provided. The number of images or videos can be determined by deciding on the length of the movie bearing in mind that a continuous movie requires 25-30 frames per second, which represents the setting interval between images, hence a five minute movie will require 7500-9000 frames. Image intervals can be controlled either by cameras equipped with the necessary software or by a PC connected to the camera. The images can then be stored on the camera or PC however those stored on the PC provide a better solution for future activities. It is advisable to create a backup copy of images or videos.

* Camera location: Some of the important principles in choosing a site camera location is that it should not interfere with works, in a protected zone from unauthorized access and weather, and positioned so as to have a clear and comprehensive view of the monitored activity.

* Time lapsing: Work activities are usually recorded on selected and not real time intervals. This implies a frame rate less than the acknowledged 25-30 frames per second. A 10 hour

movie captured at 1 frame per second can be viewed in 20 minutes. Such movies are not suitable for control purposes or to evaluate workers productivity however they are ideal for documenting and monitoring actual work in progress. It is worth noting that the acquired images interpretation is done by human observation and hence prone to errors. The way to avoid this is to automate the interpretation process to obtain unbiased automatically extracted information from images.

The question of the optimum frame rate becomes important in order that no step is completely missed by falling within the capturing intervals which was the subject of several studies.

(Abeid and Arditi, 2002) [6] Described the basics of time-lapse digital photography.

(Everett et al. 1998) [7] Emphasized the monitoring capability of time-lapse in construction operations rather than its use as a productivity measuring tool. They highlighted the benefits of this approach in documentation, claim resolutions, workers and public education, and fund raising.

(Everett et al. 1998) [7] Concluded that an interval frame rate of 1fps to 1fp5s is most common and sufficient for monitoring construction activities.

(Abeid and Arditi, 2002) [6] Recommend a recording rate of 60fpm (frames per minute equivalent to 1fps). They recognizes that various operations require differing details which are translated into corresponding frame rates however they fails to specify optimum frame rates required for each operation .

(Kang and Choi, 2005) [8] Analyzed the errors resulting from time-lapse movies which use different frame rates. They assigned a 70% confidence level to rate of 1 frame per minute for the purpose of monitoring construction operations.

The advantage of using time-lapse videos in controlling the time required to view a movie are very clear however the risk associated with human observations errors still remains.

Image Processing Techniques Applied to construction

Photogrammetry is an image processing technique which dates back to 1885. (Jauregui et al. 2003) [9] Noted that photogrammetric surveying can be used to generate three-dimensional object measurements out of its two dimension photographs. (Jauregui et al. 2003) [9] used this technique to measure bridge deflections.

(Trupp et al. 2004) [10] Used it to track excavation activities.

(Ordonez et al. 2008) [11], (Earlier, Knight andKaka, 1998) [12] measured flat elements under construction.

And (Hadwan et al. 2000) [13] applied it to modeling in lighting calculations.

(Abdmajid et al. 2004) [14], (Memon et al. 2005)[15], (Memon, Abdmajid and Mustaffar, 2006) [16] proposed the 'Digitalizing Construction Monitoring (DCM)' which integrates 3D CAD drawings with digital images interactively by extracting 3D digital images and comparing them with 3D CAD models hence extracting work progress information.

(Bayrak and Kaka, 2004) [17] proposed a similar application useing the library which contains the full list of elements of the 3D model of the building.

As soon as the construction phase is started, image capturing begins recording the actual state of the ongoing works and the images are transferred to a model operator whose duty is to generate a 3D model of the current construction state using the design library contents. Although the system provides a useful tool for the measurement of work progress, it still requires a significant human input.

(Lukins et al. 2007) [18] Highlighted the advantages related to a fully automated approach which is based on computer vision

(Alves et al. (2003) [19], (Alves and Bartolo, 2006) [20] presented a hybrid application combining photogrammetry and computer vision to generate a 3D computer model from existing building images.

The other important technique in image processing is computer vision. (Brilakis and Soibelman, 2005) [21] Defined it as the applications that extract information from visual data using video processing of digital image and video retrieval of content-based images.

(Abeid and Arditi, 2002) [6] Utilized the fact that an image is pixels collection filled with a color that is digitally defined, in order to define it as a 3D matrix (x, y, and color). The pixel coordinates are specified in the first two X and Y dimensions while the third dimension defines the pixel's color. The first two dimensions represent the coordinates of the pixel and the last dimension defines its color.

(Brilakis, Soibelman and Shinagawa, 2005) [21] noted that image and video processing' refers to tasks that try to restoring, enhancing, filtering, modifying, and compressing images for the purpose of extracting specific information., (Trucco and

Kaka, 2004) [22] stated that computer vision is concerned with recognition, measurement, indexing, and classification. (Trucco and Verri, 1998) [23] highlighted the overlap between image processing and computer vision as computer vision algorithms require preliminary image processing.

The temporary nature of a construction site does no encourage the installation of sophisticated systems for production monitoring.

(Constr, Engrg and Mgmt, 2005) [24] tested the concept's feasibility and confirmed its technical competence with the potential to output real time project control information which are accurate and of low cost. Manual monitoring of production cost, progress, and quality, results in being expensive, approximate, and time lagging which does not facilitate a closed control loop. A recommended operation for the application of the concept is the automatic monitoring of lifting equipment for the purpose of providing management with feedback information. The choice is based on the fact that all materials and components are transported by machines which are easily monitored. Based on that a concept of a system using a "black box" monitor and an electronic information model for buildings was developed.

(Shih, Lai and Tsai, 2006) [25] developed three levels of applications for a panorama image system for database management (PIDMS) for construction records management. Panorama images and videos were recorded using a set of panorama cameras for the management and inspection of manpower, machinery or working schedule. Contractors, construction site managers, system managers, designers, draftspersons, or general users can log in through a browsing interface. The system is based on functions, such as image labeling, real-time monitoring, browsing, video indexing, working drawing, and construction recording. The panorama videos and images represent maps for an Internet communication platform of daily records. The recorde is composed, such as texts, images, and numeric data serve as a panorama or image-based information system. The PIDMS increases the effectiveness and efficiency of supervision.

Also, (Brilakis and Soibelman, 2005) [21] focused on the image data of construction sites and presented a model for image retrieval that interfaces with established management structures construction data. The design of the model design is based on retrieving images from related objects in construction databases or project models using date, location, and material information which is extracted from the image content using techniques for pattern recognition .

Systems looking at buildings have become an active research area in computer vision. The attempted tasks range from basic presence detection, recovering position by model based fitting, 3D recovery of form, and image based property analysis. (Lukins and Trucco, 2006) [26] Presented a background of existing computer vision techniques focusing on the building industry and showed went on to show how these techniques can be used to look at dynamically changing structures. The primary motivation is the construction industry desire for full automation in following up the progress and changes made in projects of large scale. They also illustrated the challenges facing this task and conclude by suggesting further research directions in which computer vision could be applied for the assessment of construction progress.

The construction project's progress site assessment is often infrequent and error prone. Site images are very cluttered and rife with shadows, occlusions, equipment, and people thus becoming hard to analyses.

(Lukins and Trucco, 2006) [26] Presented a first prototype system using a fixed camera capable of detecting building site changes and classifying them as either actual structural events or as unrelated. They have exploited a previous building model in order to align camera and scene, which allowed identifying the image regions in which building components may. This alignment enables homing in on major change events and verifies the actual presence of a particular component. Their approach was placed within an emerging paradigm for integration in the construction industry.

(Trinh, Kim, and Jo, 2008) [27] Described an approach for buildings surfaces recognition. The natural characters such as surfaces and surface areas, vanishing points, and the wall region are extracted by analyzing the building's images. A building model described by these characters which are organized as a hierarchical features system is then stored in a database. The characters of a new image are computed and the new image is compared against the database. The best fit candidate is chosen by a novel approach cross ratio based algorithm to verify the correct match .

Fig. 5 A method has been presented that finds existence of site activity in images and allows generating video training for that activity. Its performance has been demonstrated on a range of real site images. The method simultaneously considers activities over all site location, scales and orientations, and was shown to reliably detect the site activities among complex backgrounds, and handle multiple occurrences of activates in a single image.

Fig.3.1 Steel Unloading

Fig.3.2 Transportation of steel Components to site

Fig. 3.3 Site Arrangement


Fig. 3.4 Personal Protective Equipment

Fig 3.1 to Fig 3.4 are extracted samples from a training video program done using 3D MAX animation program.

Fig.3.5a


Fig.3.5b

Fig.3.5c


Fig3.5d

Fig 3.5 the developed method to detect activity.

## 4 Development of modelling program (Code)

The development of the computer modelling program did not rely on existing packages and resorting to edit them to make them suitable for the model at hand. Alternatively all the components were specifically developed using various suitable programming languages for each package within the main program. Although this approach consumed considerable time and effort in getting acquainted with various programming languages and having to go through the checks and tests required to generate each package and ensure its compatibility with the others in the main program, however it eliminated the need to verify the suitability of an alternative adjusted existing package not originally related to the target model.

### *4.1 The computer vision model program*

The main screen's computing language was (c#) and the uploaded input data were existing digital (jpg) images of a real case study in Edinburgh UK of a steel construction site. The first main screen is shown in (Fig. 4.1)

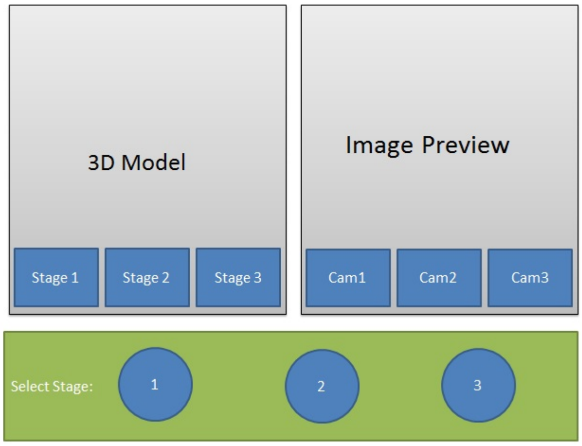


Fig. 4.1: Model's main screen

The screen shows on its right side each (jpg) image of the input data from three views taken by three cameras namely East, West, and South and the chosen view is shown on the (Image preview) space when selecting the respective camera icon. Most images have three views however few images at early stages of construction (stage 1) had east and south views only.

The BIM section on the left side of the screen was generated from combining the construction project's design and other available real construction information. The BIM system programming language used was (Novisworks manage 2015).

The Novisworks software offers a comprehensive solution for analysis, simulation, and coordination of project information. Its selection for the programming of the BIM was based mainly on its ability to simulate construction schedules in 4D. The 4D feature enables the development of construction sequences linking model geometry to time or date which renders it most suitable to the BIM analysis.

The construction activity was divided into three stages:

Stage-1: Pre work stage where there is no activity on site.

Stage-2: Steel structure erection stage.

Stage-3: Finishing works after completion of steel structure erection.

The respective stage selection icon is chosen based on the comparison of the image preview on the screen with the above criteria.

After the stage selection the second screen (Fig 4.2) is shown:

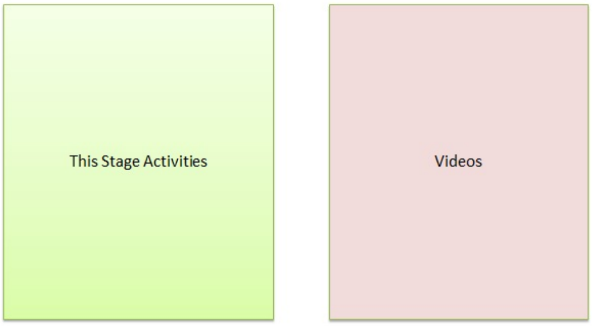


Fig 4.2: Stage Selection Screen

Selecting the Stage Activity will result in an output depending on the stage of the chosen activity. The screen shown in (fig 4.3) shall appear for a stage (1) activity.

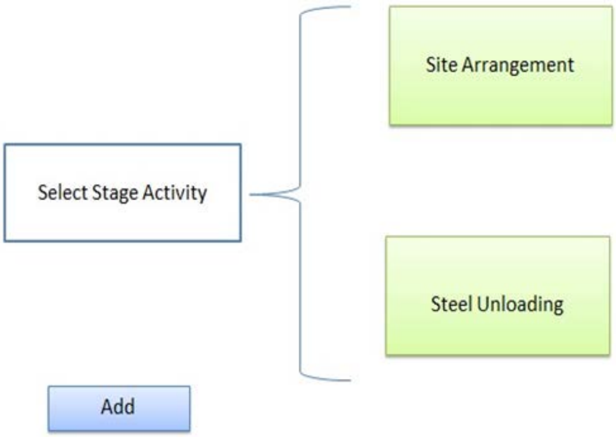


Fig 4.3: Stage 1 Activity Screen

The screen shown in (Fig 4.4) and (4.5) appear for stages (2) and (3) respectively.

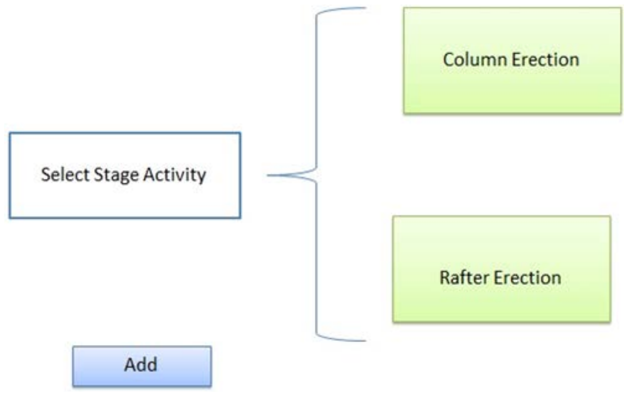


Fig 4.4: Stage 2 Activity Screen

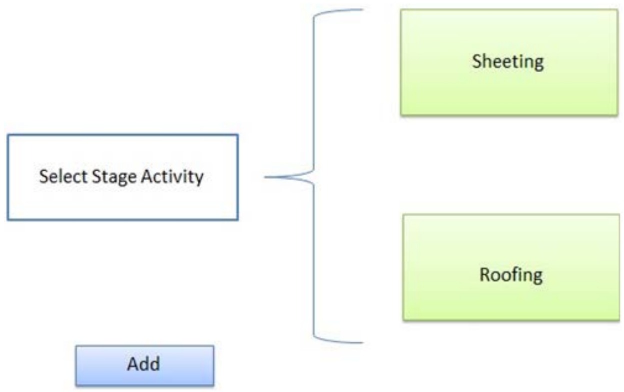


Fig 4.5: Stage 3 Activity Screen

### *4.2 Report modeling*

Selecting either activity on the screen shown in (Fig 4.3), (Fig 4.4), or (4.5), the program automatically compares the selected activity with the previewed image and detects whether this activity (Exist) or (Not Exist) using (matlab) image processing software. If the activity (Exist), then the activity's hazard identification form appears automatically as a (word document) on the screen and the user can choose to edit it or print it.

### *4.3 Training modeling*

Selecting (Videos) icon on the screen shown in (Fig 4.2) will result in six training videos appearing on the screen each of which was designed and developed using (3D MAX) software (Fig 4.6). The (3d MAX) software provides a comprehensive, integrated 3D modeling, animation, and rendering solution for visual effects and graphic designers.

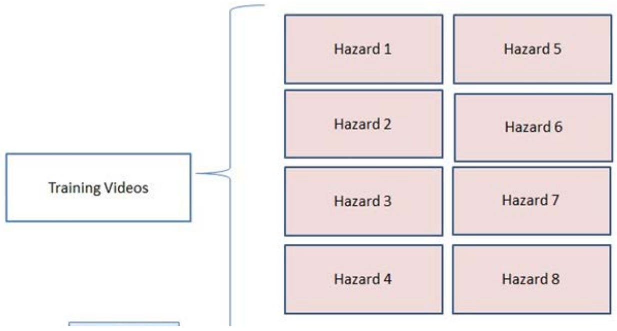


Fig 4.6: Training videos Screen

The video topics were carefully selected based on six main steel construction site activities. The OSHA codes were used to identify the hazards associate with each of the six activities. For each hazard an animation video was developed to reflect the International recommended regulations to minimize each particular hazard. The animation video is known to be the easiest, practical, and most efficient way to capture the attention of workers and enhance their awareness regarding the risks and their methods of mitigation.

## 5 Conclusion

A method has been presented which tracks the existence of site activities in images and allows generating training video for that activity. Its performance has been demonstrated on a range of real site images. The method simultaneously considers activities over all site location, scales and orientations, and was shown to reliably detect the site activities among complex backgrounds, and handle multiple occurrences of activates in a single image.

The study addresses the development of an integrated system relating visual data to project management control and follow up requirements. The chosen model was the BIM analysis. The digital visual data made available for the study were those of a building at the Edinburgh compass of Heriot Watt University. The large components in any construction project render the collecting and analysis of the data at their level formidable and non-realistic. Bearing this limitation in mind, the steel structure erection component was chosen for the analysis. This choice was due to the fact that this component can easily be distinguished and identified from the visual data. Another reason was its relation to the second objective of the study relating to site safety.

The integration of the computer vision analysis output with the CAD information and incorporating it within the BIM analysis required a software package that is not readily available and had to be developed during the course of this work. One of the targets set for this package was that it should not be particular for the purposes of this study but can be used for any similar application in another project with little modifications.

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