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Artificial Intelligence Enabled Safety for Construction Sites

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Abstract - *Safety can be defined as absence of danger or eliminating the situations that could be fatal. As construction industries working environment is very complex and thousands of workers are being injured or killed in accidents every year, so safety needed to be taken into consideration. There is a high need of monitoring the workers and warn the construction workers at the site. The process of safety should start from planning stage itself. Building Information Modeling (BIM) can also help to improve the safety planning in a construction sites. BIM helps in checking the clash detections that can occur while construction and many safety hazards at that time can be avoided by planning for it beforehand. Since manual checking may cause some error a real time detection of behavior of the workers may help to reduce the accidents in the construction sites. With the help of AI (Artificial intelligence) safety in construction sites can be monitored at ease. Computer vision is used for developing the model for safety. By training the model by a quantum amount of images our model will help in analyzing the safe and unsafe conditions in a construction sites and thereby it will help in reducing the accidents at the construction sites to an extent. Once the AI model is being developed by proper training it can be integrated with BIM model for earlier planning. This paper presents a novel method for the real time detection of unsafe act and unsafe conditions of workers using Artificial Intelligence.*

Key Words: **Unsafe act, Computer vision, Construction sites, Artificial Intelligence, Real time detection, Image analytics, BIM**

1. INTRODUCTION

Safety is defined as the absence of danger at sites or eliminating the situation which will be fatal. Thousands of construction workers are injured or killed in construction accidents each year. Accidents are unexpected occurrences, which breaks the sequence of events. Thereby a loss in the production of the company occurs. Not only in terms of production but also the project schedule and every single aspect of the work in the construction sites will be affected. Accidents lead to two types of expenses-direct and indirect expenses. Direct Expenses includes medical, insurances, compensation, legal expenses etc. Indirect expenses has the following effects like it breaks the functioning of project, productive time is lost, affects the morale of workers and leads to administrative costs.

Artificial Intelligence (AI) is the study of computer science which focuses on developing software or machines which exhibits a human intelligence. The main goals of AI include deduction and reasoning, knowledge representation, planning, natural language processing (NLP), learning, perception, and the ability to manipulate and move objects. With the help of AI the monitoring activities in a construction sites can be done at ease.

Building Information Modelling (BIM) is a process not an application. It's based around models used for the planning, design, construction and management of building and infrastructure projects faster, more economically and with less environmental impact. These BIM models are different from CAD drawings that may be 2D, 3D or even 4D. These models are made up of intelligent objects that stay updated throughout the design for each and every changes made. Accordingly the schedule for the work will be obtained which will help in ensuring the safety of workers in construction sites.

The modern world is enclosed with enormous masses of digital visual information. To analyse and organize these devastating seas of visual information, image analysis is the requisite. The most useful would be the methods that could automatically analyse and detect the semantic contents of images or videos. The contents in the images would determine the significance of the images .One important aspect of image content is the objects in the image. So there is a need for object recognition techniques.

For improving the construction safety and health, a continuous monitoring is required. For which a robust method is by using Computer Vision (CV) techniques. This CV have been applied for extracting the safety related issues in a construction sites, and this can be regarded as an effective solution for the real-time observation of unsafe acts in a construction sites. Here by collecting the real-time images from the construction sites we will train our AI model so that it predicts the unsafe acts in a construction sites once the training stage is over. And thus the safety officer manual monitoring work will be reduced and any miss of observation will also be rectified by our model.

The remaining paper is structured as follows. The next section will outline the methodology for the work, literature related to use of computer vision in construction sites, use of BIM and object detection techniques. Then the method used for formulation of the model and our model is tested with a set of images which detects the safe and unsafe act in the construction sites. Finally conclusion is presented.

2. LITERATURE REVIEW

i. Hongling Guo et al. (2018) studied the real time unsafe behaviour of the workers at the site. For the same he studied the dynamics motion of the workers. The study is done with the help of video clips from the site. The video clips are being cut into small clips and then the dynamic motion of each worker is being compared with the predefined unsafe parameters.

ii. Shuang Dong et al (2017) provides an effective approach to an automatically identify PPE s misuse behaviour in specific conditions, issue timely warnings and capture worker responses. The warning and response data were then analysed to assess individual safety performance and locations over time for effective safety behaviour

iii. Jee Woong Park et al (2016) this paper reviews the industrial practices and state – of -the-art technology in safety monitoring. In this they emphasise the need for using BLE and studies the real time unsafe behaviour of the workers in the site and reporting and sharing of the detected relevant participants in a timely manner.

iv. Satish Kumar & V K Bansal (2013) gives an overall idea about construction issues in India and the possible solutions. The main objective behind this paper was to create awareness among practitioners about various safety-related practices in the construction industry.

v. Li and Poon (2013) he gives an overall idea health and safety issues in the construction industry. He studied the complexities and about the fatalities in the construction sites. On the other hand, a successful safety record contributes to higher morale, profitability, turnovers and margins.

vi. Cigularov et al (2013) gives an overall idea of the issues that are affecting the construction safety works. He suggests that the factors due to which the unsafe conditions occur may be due to lack of training to the workers, lack of attention paid by the corporate leaders, or may be due to the lack of competence at the level of workers

vii. Eadie R (2013), Stowe etal (2014) BIM can enable site safety management system in construction industry. BIM when combined with RFID can help in finding the blind spots while using multiple cranes. The use of BIM with cloud computing techniques has been suggested for maintaining construction health and safety purpose.

viii. Kwang-Pyo LEE, Hyun-Soo LEE (2012) In this they give an idea about finding the real time safety issues in the construction site. Here they predefined the unsafe areas and receivers are kept at that area and that will intimate the workers with the help of an alarm that they are entering in to an unsafe region

ix. JoonOh Seo,Sang UK Han, Sang Hyun Lee,Hyungkwan kim(2015) Suggested that in construction sites a continuous monitoring of unsafe act and unsafe conditions needed to be done for the timely elimination of potential hazards. Here they derived the major role of computer vision techniques for identifying unsafe acts and unsafe conditions and they are classified into (1) scene based (2) location based (3) action based risk identification. This is achieved by object identification, object tracking and action recognition. Object identication is related to the scene based identification. Object tracking helps in the tracking of any moving objects with in the sites and action recognitions looks for the posters of the workers.

x. Weili Fanga,b, Lieyun Dinga,b,□, Hanbin Luoa,b, Peter E.D. Lovec(2018)In construction companies the major accident occurs due to fall from height. Even though the workers are made aware of the importance of wearing the harness while working at height, they may not use it. This may be done intentionally or non-intentionally. In this paper they are using two CNN models to determine whether the worker is wearing the harness or not. Here the author develops a Faster R CNN model to find the presence of the worker and develop a Deep CNN model to detect the harness. After the testing he came to know that the precision and recall for faster R CNN was about 99% and 95% and that for CNN model was about 80% and 98%.

3. BUILDING INFORMATION MODELLING (BIM)

BIM (Building Information Modelling) is an intelligent 3D model-based process that gives architecture, engineering, and construction (AEC) professionals the insight and tools to more efficiently plan, design, construct, and manage buildings and infrastructure.

3.1. SAFETY PLANNING USING BIM

Using BIM the model can be obtained earlier to the respective authorities. By developing a BIM model we checked for clash detection and necessary steps for avoiding the safety hazards during the construction can be eliminated at the design stage itself.

From the schedules obtained by simulating the structure and thereby converting to 4D model, we can obtain the necessary resources for each day's work. By obtaining such a result from the model we can plan in advance for the necessary safety equipment's to be available at the construction site.

3.2. ARTIFICIAL INTELLIGENCE ENABLED BIM

Artificial intelligence is a booming trend in this era. So let us think of a method to integrate our BIM model with AI. This will also help in developing a proactive system. We will train a system with similar projects and then our system will be in a condition such that it can predict the safety hazards in the building at a particular time well in advance to the

construction time. So that it will help us to make a million safe working hours with zero fatality and LTI hours.

4. COMPUTER VISION

In a very general sense computer vision is about automated systems making sense of image data by extracting some high-level information from it. Computer Vision is the sub-field of Artificial Intelligence that works on computers to see, identify and analyse the image in the similar way as the human vision system. Humans see the object through the eyes and analyse objects in the field of view with the help of neurons of brains evaluating the properties in a rapid procedure. The capacity of analysing and interpreting things that we see is a result of the continuous learning of things by the brain since our birth. Accordingly, our biological visual concept is applied to computers artificially to give them capability to see and learn to analyse the image similar as humans. This process involves the image processing steps and the various machine learning algorithms processing in a synchronized manner. The image data can come in a large variety of formats and modalities. It can be a single natural image, or it can be a multi-spectral satellite image series recorded over time. Likewise, the high-level information to be recovered is diverse, ranging from physical properties such as the surface normal at each image pixel to object-level attributes such as its general object class

Computer Vision service provides developers with access to advanced algorithms that process images and return information. To analyze an image, you can either upload an image or specify an image URL. The images processing algorithms can analyze content in several different ways, depending on the visual features you're interested.

4.1. TAGGING IMAGES

Computer Vision returns tags based on thousands of recognizable objects, living beings, scenery, and actions. When tags are ambiguous or not common knowledge, the API response provides 'hints' to clarify the meaning of the tag in context of a known setting. Tags are not organized as taxonomy and no inheritance hierarchies exist. A collection of content tags forms the foundation for an image 'description' displayed as human readable language formatted in complete sentences. Note, that at this point English is the only supported language for image description. After uploading an image or specifying an image URL, Computer Vision algorithms output tags based on the objects, living beings, and actions identified in the image. Tagging is not limited to the main subject, such as a person in the foreground, but also includes the setting (indoor or outdoor), furniture, tools, plants, animals, accessories, gadgets etc.

4.2. OBJECT DETECTION

Object detection is similar to tagging, but the API returns the bounding box coordinates (in pixels) for each object found. For example, if an image contains a dog, cat and person, the Detect operation will list those objects together with their coordinates in the image. You can use this functionality to process the relationships between the objects in an image. It also lets you determine if there are multiple instances of the same tag in an image. The Detect API applies tags based on the objects or living things identified in the image. Note that at this point, there is no formal relationship between the taxonomy used for tagging and the taxonomy used for object detection. Ata conceptual level, the Detect API only finds objects and living things, while the Tag API can also include contextual terms like "indoor", which cannot be localized with bounding boxes.

4.2.1. Limitation

It's important to note the limitations of the object detection feature so you can avoid or mitigate the effects of false negatives images.

- Objects are generally not detected if they are very small (less than 5% of the image).
- Objects are generally not detected if they are arranged very closely together
- It is difficult to detect the images that is not having the proper lightings
- The angle of taking images also needed to be taken in to consideration

4.3. PRECISION AND RECALL

In pattern recognition, information retrieval and binary classification, precision (also called positive predictive value) is the fraction of relevant instances among the retrieved instances, while recall (also known as sensitivity) is the fraction of relevant instances that have been retrieved over the total amount of relevant instances. Both precision and recall are therefore based on an understanding and measure of relevance.

5. IMAGE ANALYTICS

Image analytics is the automatic algorithmic extraction and logical analysis of information found in image through digital image processing techniques. With an explosion of image data, which makes up about 80 per cent of all unstructured big data, there is a growing need of analytical systems to interpret images, which is unstructured data to machine readable format.

5.1. OBJECT BASED IMAGE ANALYTICS

Object-Based Image Analysis (OBIA) employs two main processes, segmentation and classification. Traditional image

segmentation is on a per-pixel basis. However, OBIA groups pixels into homogeneous objects. These objects can have different shapes and scale. Objects also have statistics associated with them which can be used to classify objects. Statistics can include geometry, context and texture of image objects. The analyst defines statistics in the classification process to generate for example land cover. The technique is implemented in software such as eCognition or the toolbox.

Object-based image analysis is also applied in other fields, such as cell biology or medicine. It can for instance detect changes of cellular shapes in the process of cell differentiation.

6. RESULTS AND DISCUSSIONS

No: of images used for training: 1000

Obtained Precision: 90%

Obtained Recall: 93.2%

Obtained mAP : 91.3%

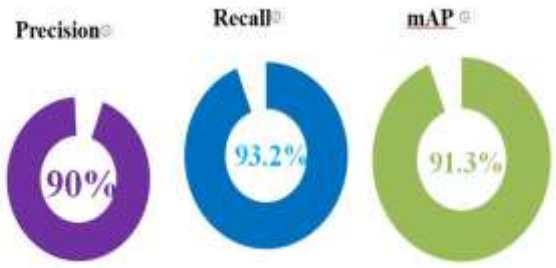
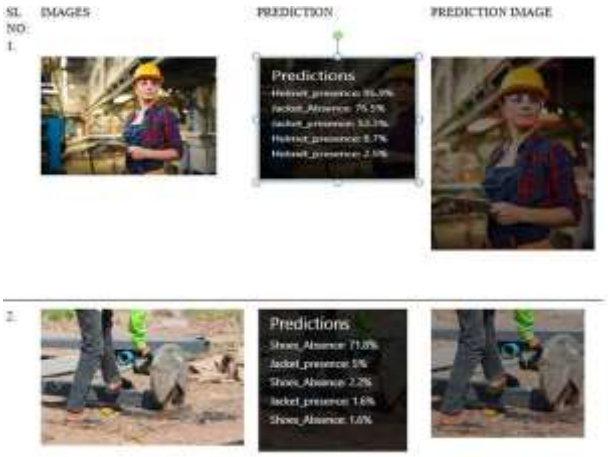


Table 1: Tags Used

TAGS USED	No: Of images
Helmet Presence	170
Helmet Absence	190
Jacket Presence	170
Jacket Absence	150
Shoes Presence	180
Shoes Absence	140

7. SAMPLE PREDICTION RESULTS



8. CONCLUSIONS

- The model was trained with 1000 images with 90% precision.
- A proactive system is been developed by using Building Information Modelling. This was done by simulating the model with the time and a visualisation of the same was made from this, which made the system proactive.
- A reactive system is being developed by using image analysis , by training the system with images and the prediction results were validated .
- When tested with images it was able to predict the absence of the PPEs.
- The model accuracy could be improved by training it with more images.

9. REFERENCES

[1] S. Zhang, J. Teizer, N. Pradhananga and C. M. Eastman (2015), "Workforce location tracking to model, visualise and analyse workspace requirements in building information models for construction safety planning", *Autom. Constr., Vol. 60, 74-86*

[2] S. Zhang, J. Teizer, J. K. Lee, C. M. Eastman, and M. Venugopal (2013), "Building Information Modelling (BIM) and Safety: Automatic safety Checking of Constructionn Models and Schedules", *Autom. Constr., Vol. 29, 183-195*

[3] T. S. Abdelhamid and J. G. Everett (2000), "Identifying Root Causes of Construction Accidents", *J. Constr. Eng. Manag. Vol. 126, No. 1, 52-60*

[4] Hongling Guo, Yantao Yu, Qinghua Ding and Martin Skitmore (2005), "Image-and-Skelton-Based Parameterised Approach to Real-Time Identification of Construction Workers Unsafe Behaviors",

[5] Ashraf N, Sun C and Foroosh H (2014), "View invariant action recognition using projective depth", *Comput. Vision Image Understanding, 123(6), 41-52*

[6] Ball K (2010), "Workplace surveillance: An overview", *Labor Hist., 51(1), 87-106*

[7] Cheng T., Teizer J., Migliaccio G. C. And Gatti U. C. (2013), "Automated task-level activity analysis through fusion of real time location sensors and worker's thoracic posture data", *Autom. Constr., 29(1), 24-39*