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Research Paper

A Study on Potential of Big Visual Data Analytics in Construction Arena

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Abstract

In most construction and Infrastructure management projects, it is important to ensure and maintain the performance, safety as well as quality in the work to execute the construction in expected period , for monitoring the above parameters i.e. Performance, Safety, Quality and as well as Security, requires data to analyze, determine and test the algorithms, due to eternal increase amount of captured data thorough modern improvements in technology i.e. devices, camera equipped vehicles, Sensors, etc. accommodates an innovative scope to capture present status of construction sites at a less cost analogized to more alternative techniques such as laser scanning technique. Vast endeavours on documenting as-built status, nevertheless, stay at retrieving the visual data and updating Building Information Model (BIM). Hundreds of images and videos are captured but most of the data becomes scrap without proper localize with plan document and time. To take full benefits of visual data for construction status analytics where performance analytics is also included in it, three aspects (reliable, relevance and speed) of capturing, analysing and reporting visual data are captious and tracking development in construction sites needs two direction communication between field crew and management so that performances and changes issues related to task management, completion and outlook can be convey effectively. This paper deals with the investigation of current techniques for influence with help of arising BIM and big data in performance monitoring at construction from reliable, relevance and speed.

Keywords: *Big Visual Data; Images; Safety; Quality Control; Construction Performance Monitoring.*

1. Introduction

Big data is a term that describes the large volume of data or complex that traditional data processing applications are inadequate to deal with them and challenges are Acquire, Process, Manage, Generate, Capture, storage, sharing and visualize. Nowadays Big Data is processed for analytics of various parameters in each and every field of work like Research, Education, I.T, Banking, Construction, and Manufacturing etc. With help of some big data technologies it is been processed and characteristics of big data are 5V's i.e. Volume, Variety, Velocity, Value, Veracity as shown in fig.1. Where the data is large and complex in volume as well as type and nature of data, the speed of generation and process of data with respect to time, ability to understand and manage the data and quality of captured data respectively. Coming to Big data at construction sites, the data generated from progress, quality control, safety monitoring, data from Devices or sensors and as well as Resources which are used in construction i.e., 5 M's Manpower, Money, Machineries, Material and Market where 5 M's are interlinked to each other by means of management. The above-generated data leads to increase attention on high performance and good quality of work at the site. Besides the camera, the network has received increased attention in recent years. Mainly camera networks made more attention towards some of the applications like quality control, progress tracking, safety monitoring, as-built documentation and site security at construction sites. Other current developments are the distribution of consumer smart devices with built-in cameras, such as smartphones, tablets, and camera-equipped unmanned aerial/ground vehicles such as drones. These camera-enabled platforms have led to an exponential development in the generation of large volume of data i.e. Images and videos that are being captured and recorded on construction periodically basis and big data can be different types as shown in below fig.2. The captured or recorded data can be in higher number with use of unmanned aerial/ground vehicles for generation of data .eternal increasing volume of digital images provides an outstanding opportunity to the visual capture of the actual status of construction sites at a fragment of the cost compared to other alternative methods such as laser scanning. Most attempts at documenting executed status at collecting visual data and managing BIM. Hundreds of images and videos are captured during the construction but most of the data become useless due to improper localized with plan document and time. There is a need for a method that would localize the huge amount of visual data with respect to BIM, through this they can provide useful as-built status with accurate location. The main challenges associated with localization process of images with BIM which includes 1) precisely aligning images with BIM, 2) aligning through reconstructing a 3D point cloud from image collections and 3) developing alignment using BIM as a constraint to improve Multi-dimensional reconstruction. While capturing, analyzing, and reporting the visual performance data are investigated in the duration of construction from three perspectives:

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1. Reliability- accuracy, and completeness of the collected data
2. Relevance- usefulness to short-term period planning
3. Speed- collecting, analyzing and reporting at a velocity to enable decision making in coordination meetings

In summary, this study includes the potential of using the resulting integration information model to visually identify location and orientation of a user in n-dimensional by means of big visual data and BIM by the comparative study on different methodologies of literature.

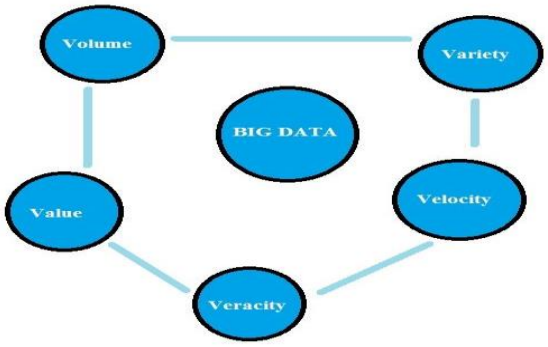


Fig.1:5 V's Characteristics of Big Data

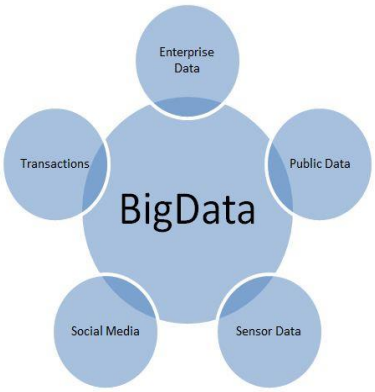


Fig.2: Sources of Big Data

2. Review of Literatures

Kevin K.Han et al [1] studied on current strategies for leveraging emerging big visual data and BIM in construction performance monitoring from three aspects i.e. reliability, relevance and speed and Characterizing gaps in knowledge via case studies such as gaps in knowledge in collecting, maintaining big visual data as well as BIM driven visual data strategies i.e. image to BIM alignment, point cloud to BIM alignment and Ubiquitous interaction with as-built and BIM and concluded about potential of big visual data used in conjunction with BIM for Construction Performance Analytics.

Seokho Chi et al [2] done research on automated image-based safety assessment method for earthmoving and surface mining activities through 3-Steps process as follows: Analysis of data collection devices & Image-Based Object Identification and Tracking Algorithms, Determination of safety rules for Automated Spatial safety assessment of Earthmoving and surface mining activities as well as identification of safety risk by means of safety rules, testing the problem by means of object identification and tracking and explained what spatial data is required for testing and determination. They concluded that object identification and tracking algorithms are suited to detect, classify and track on-site moving resources.

Pingbo Tang et al [3] done research on characterization of laser scanners and algorithms for detecting flatness defects on concrete surfaces through by means of three different types of scanners and algorithms where each scanner and algorithms work differently and efficiently. The algorithms are based on their noise filtering approaches in 3-steps of algorithms and algorithms as follows range filtering (RF), deviation filtering (DF), and sliding window (SW). They concluded that the three algorithms are shown equal or better detection performance in all test cases and elongation distortion and localization issues of defects may occur.

SangUk Han et al [4] done research on vision based motion capture and recognition framework for behaviour based safety management and framework consists of the identification of critical behaviour, the collection of relevant motion templates and site videos, the 3D skeleton extraction from the videos, and the detection of unsafe actions using the motion templates and skeleton models and they concluded that proposed framework can potentially be applied for site videos, by resulting information-the number and type of unsafe actions-can be used to provide workers with feedback on their behaviour, and also to examine the impact of safety related management actions on behaviour modification through a comparison of worker's behaviour before and after the managerial actions.

Seokho Chi et al [5] done research on automated object identification using optical video cameras on construction sites, this research paper mainly focuses on the exploratory method for automated object identification using standard video cameras on construction sites and method supports real-time detection and classification of mobile heavy equipment and workers. The algorithms present in this method is background subtraction which extracts motion pixels from an image sequence, the pixels are then grouped into regions to represent moving objects and finally regions are identified as a certain object using classifiers and they concluded this method would provide benefits on-site monitoring with reduced human intervention, lower device cost than one of the other sensors, and applicability to existing monitoring devices such as video cameras, CCTV and webcams .

3. Comparative study of various methodologies

For purpose of good performance and quality as well as Safety at the construction sites, we have to opt proper method for monitoring important parameters of construction sites i.e. Safety, Quality, Performance, security ….etc. in this section, we are going to explain and comparing various methodologies from literature section. After studying all pieces of literature we focused mostly on characterizing big visual data for construction performance monitoring, slits in knowledge in gathering and managing big visual data, slits in knowledge in BIM-driven visual data analytics and Emphasizing the opportunities with big visual data in construction arena are discussed below.

3.1Characterising big visual data for construction performance monitoring

According to National Consortium for data science in 2012, "big data" or massive data collections is historically transforming every sector of the society – business science, medicine, construction, and government [11]. Big data is a vast term with different definitions but there are common characteristics. Most widely used characteristics that characterize big data term are volume, variety, and velocity or 3 V model [12]. There are other rising "Vs" that are described by different data scientists, such as veracity, value [12-14] on basis of requirements and recommendations by firms and companies. The big data characteristics are decreased to 3 V's or 5 V's. Veracity can't precisely impact on visual data because of visual data captured as in real-world scenario i.e. as-is conditions. While capturing the real world objects as images and videos .they can certainly have some bad qualities such as blurriness and misinterpretations but they still appear as real-world objects i.e.(as-is conditions). Words and text can have different meanings and can change their meanings as time evolves [14]. These characteristics

of value, nevertheless, are not applicable to visual data because the matter won't change .again interpretation of a captured visual data might change but not the value of pixels representing real objects in real world. The pixels represent objects form features that are used for big visual data analytics. In summation, big visual data have to be illustrated differently because the use of the database is not directly implemented on detecting meaningful patterns out of visual data. The only way to place visual data in form of tables is to put attributes of place analyzed data or exchangeable image file (EXIF) tags. There is no alternate database solution that can capture and provide meaningful real-time enquire on raw visual data at the best knowledge of author's**.** The 3 V model i.e. Volume, Variety, and Velocity are applicable for defining big visual data. Volume can define and characterize visual data for each construction project because of large volume of visual data generated and captured over the duration of construction where Visual data collected during daily execution (see fig.3) can be a number of terabytes and if a company has to manage hundreds of project then the volume may grow up to petabytes. Variety also characterizes and defines big visual data because they come in different formats and lastly, velocity can characterize and defines visual data because of continuously collected images throughout the duration of construction. The next two sections discuss challenges associated with gathering and managing big visual data and covers challenges and practical benefits associated with BIM-driven visual analytics

3.2 Slits in knowledge in gathering and managing big visual data

Big visual data require a systematic way of gathering and managing data. A file size of a captured Visual data i.e. images or videos varies from a few hundred kilobytes to a few megabytes depending on its resolution. Hundreds of thousand images can add up to gigabytes to terabytes. To help visualize what it means to have big visual data. There are some challenges while gathering and managing big visual data as follows an unordered set of images and limited visibility per element due to time-lapse captured data from fixed location.it should be overcome from this challenges for further analysis and processing of captured data.

3.2.1 Unordered set of images

Captured Visual data i.e. images and videos captured by digital cameras and smartphones are taken at various locations by field personnel such as superintendents, project engineers, and subcontractors. To streamline the process, owners and general contractors also hire construction documentation service providers or use camera-equipped Unmanned Ground Vehicles (UGV)/ Unmanned Aerial Vehicles (UAV) to professionally capture the real world object and document them. In the old scenario, captured visual data especially images are typically uncalibrated due to their unknown locations and orientations. Somehow this problem can be overcome by means of GPS coordinates and Ground Control Points (GCP), not in the case of an orientation of the camera, where it leads to the errors. Some mechanisms like BIM, are not based on geo-referenced in many cases. Where the techniques like BIM will have own coordinate system and manual registration is evitable. Aligning an unordered set of capture data with BIM can be done by initiating a point cloud (Structure from Motion) and selecting correspondences between the point cloud and BIM.

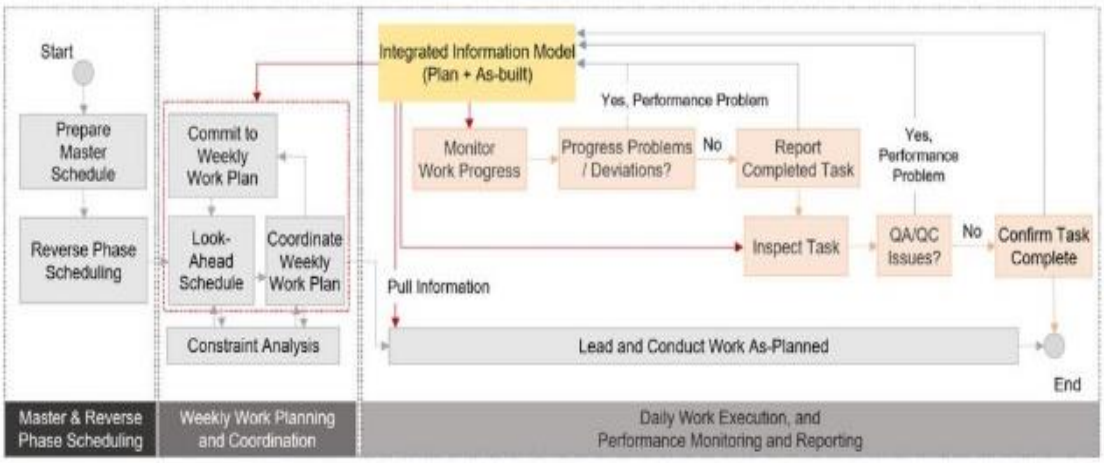


Fig.3: The integrated Project model for supporting planning and daily execution and reporting. Ref [15]

3.2.2 Limited visibility per element due to time-lapse

Using fixed cameras- with or without features of pan/zoom/tilt property for providing live-stream video feed or time-lapse images of a job/work site is very common nowadays. most of the literatures focuses on time-lapse photography for monitoring and manage the construction mostly on visualization of ongoing operations and tasks, improving situational awareness, documentation[16] and visualizing progress deviations against BIM with captured data of time-lapse from fixed locations regularly have challenges related with obstructions and limited visibility

The best implementation for managing and sharing files during construction include file managers that are cloud-based or the protocols i.e. File Transfer Protocol (FTP) using servers.

One way, these presently applicable solutions not designed for handling with thousands of files within a single folder and not suitable for quick inspection, visualization and filtering of a long list of visual data .furthermore , in research arena , big visual data have been concentrated on processing a large set of datasets in a lump-sum manner e.g:ImageNet .

3.3 Slits in knowledge in BIM-driven visual data analytics

Today, almost all personnel on a job (or) work site are familiar with smart devices and they are readily available to capture visual data. The main problems lie in site conditions for identifying suitable and proper locations for time-lapse cameras that covers all areas and minimizes occlusions [1] as well as orientations for capturing data from as-is condition via smart devices or finding areas that need to be scanned via camera-equipped UAVs such as drones [6]. A common rule when it comes to the arrangement of time-lapse cameras is that the instrument should be considerably higher than work being recorded for capturing wide coverage field in order to avoid and minimize obstructions by foreground actions. These considerations lead to better views and clarity in physical relationships, and large image surfaces for monitoring construction. Some of these

circumstances apply to ground cameras i.e. smart devices (especially smartphone) and UGVs, in case of smartphone images, a complete view of an area or an object of interest has to be captured by multiple images. By producing point clouds we can have mosaic of multiple images by means of captured data from UAVs or smart devices

To analyze construction performance, a real-world condition needs to be distinguished to an as-planned condition. One way to achieve this is to align visual data with BIM, which involves working manually –e.g., selection of correspondences between visual data and BIM and for automated registration , the alignment process is very big challenge for big visual data because big visual data analytics would not be feasible without a way to scale up this alignment process by automation or semi automation, although alignment of visual data to BIM can be done in various conditions such as time lapse captured data from fixed locations where it needs for automated registration, alignment of time lapse images as well as 3D to 2D registration and various aspect ratios of visual data analytics i.e. sequenced data , object detection and ubiquitous interaction with as-built and BIM.

3.4 Emphasizing the opportunities with big visual data in construction arena

Image-based 3D localization with BIM margin to unique and extraordinary opportunities for new communication, taking advantages of Multi-Dimensional Visualization i.e. 2D or 3D. This section presents features of big visual data in construction and related techniques. Firstly, the data is gathered and managed by means of smart devices, Time-lapse camera or live videos at fixed locations, UAVs/ UGVs through owners and project management (OPM) teams and field personnel such as subcontractors and trades as shown in fig.9 about the high-level overview of data collection and localization. On the other hand, data gathered by field personnel tend to the emphasis on low-level activities and issues of their own scope. There are localized by means of 3D & 4D images and aligned with BIM with individual solved perspective-n- point (PnP)

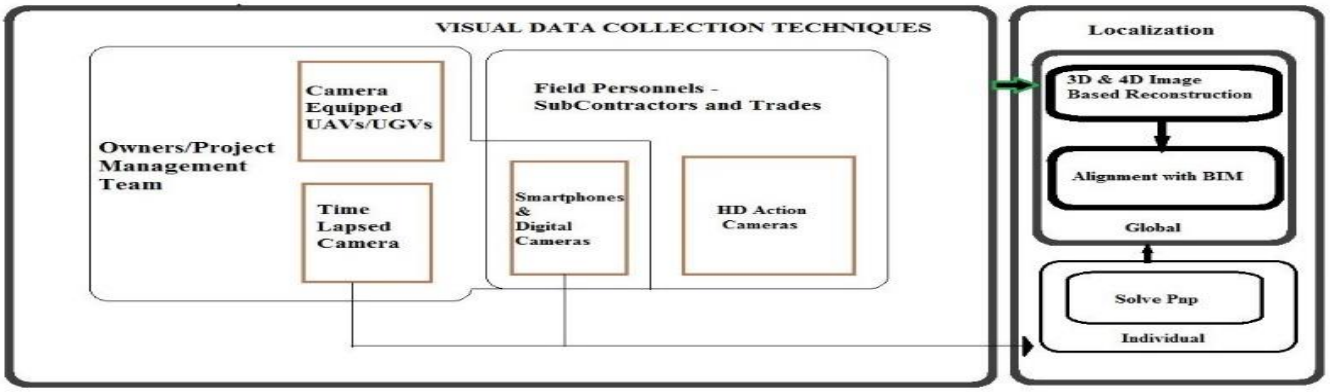


Fig.4: overview of visual data collection and localization

4. Proposed approach and system

From studies of literature, the mechanism and methodologies proposed by Kevin K.Han et al [1] in his study can be useful for monitoring performance, and to somehow safety and Quality control are monitored by means of ubiquitous interaction with as-built and BIM, and object identification features where the quality and safety can be controlled by means of object identification with alternate to the laser scanning and vector analysis methods, which are one of the popular methods. While localizing the visual data with BIM, it requires method called ground control points (GCP) system rather than GPS coordinates, where GPS coordinate system leads to inaccuracy in the localization of visual data with BIM. Authors presenting 3 stages of visual data analytics as there are main four stages in visual data analytics in construction arena are Visual data collection, Visual data processing, Visual data Alignment, and Visual data updation as shown in fig.5 and discussed below.

4.1 Visual Data Collection

It is an important stage among the four stages, where the data is gathered and managed somehow. In this stage, while collecting (or) gathering data from sensors, social media, enterprise and other sources should be free from errors and misinterpretation. In case of visual data from smart devices such as Time Lapse camera, UAVs/UGVs, Smartphones, and action cameras, the orientation and focus of smart device should be as much as better to cover more area of work/job field and minimize the errors and faults while capturing data.

4.2 Visual Data Processing

It is an important stage after collection of data where the data is processed by means of different operations such as classify/transform/sort/merge/calculation and summarizing. The error rate in visual data is based upon the stage of visual data collection, where the error handling can be done by the choice of opting type of smart devices or sensors for capturing data and error can be minimized by means of placing the smart devices in optimal position where the equipment can cover vast area.

4.3 Visual Data Alignment

It is a final stage where the data can be aligned and localized between as-built and as-planned conditions by means of various methods and mechanisms. Building Information Modelling (BIM) is the better method than others. From literature studies, BIM covers a different aspect of construction i.e. Construction Performance Monitoring, Safety and quality control.

4.4 Visual Data Updation

It is a level which is consolidated in Visual Data Alignment stage, where the data is updated and managed after each and every tasks/ activity is completed or lagged. Still this 4 Stages of visual data analytics is in theoretical study, it needs to be done through real-world applications

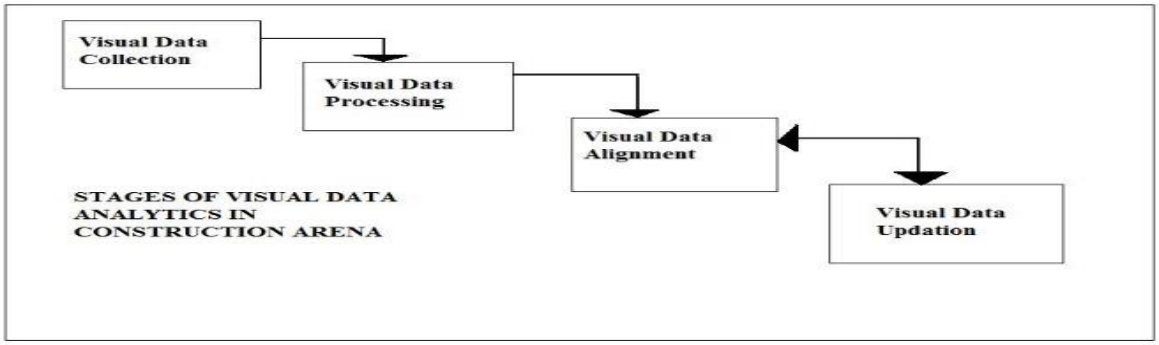


Fig.5: overview of 3 stage of visual data analytics in the construction arena

5. Conclusion and Future Work

This paper discussed the potential of big visual data analytics in the arena of construction, in conjunction with BIM for construction performance analytics with respect to safety and quality. In an endeavor to frame a roadmap for research in big visual data analytics in the arena of construction, comparative studies of different methodologies and 3-stage models are discussed. The above 3-stage model will be more beneficial to all mechanisms, especially BIM and it is theoretical study and needs to be done through real-world applications. It will be a future scope in the construction arena. All developing countries need to focus on visual analytics in the construction arena. It can be very useful at aspects of marketing, cost-benefit analysis as well as discussed in this paper about performance, safety and quality.

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