International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249 – 8958 (Online), Volume-9 Issue-5, June 2020

# Automated Verification of Structural Engineering Assembly using Convolution Neural Network

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*Abstract*: ***Artificial Intelligence has mostly penetrated in every field of technology and our lifestyle in numerous ways. The contribution of AI in the field of Civil engineering which mainly focuses on planning, design and construction is enormous. The main objective of this work is to develop a system that will automate the process of detecting errors in the engineering plans or drawings of structures. The work adapts convolution neural network technique with the help of Inception V3 model to automate detecting of multiple errors using Artificial Intelligence. AI technique has proven to be more effective, accurate and less time consuming against the existing manual verification technique.***

***Keywords*** *:* ***Artificial Intelligence, Structural assembly, Deep Learning, Convolution Neural Network***

## I. INTRODUCTION

Artificial Intelligence (AI) is a way of making a computer-controlled robot, or a software think intelligently, in the similar manner as to how the human intelligence works. Artificial intelligence is a branch of computer science, involved in the research, design, and application of intelligent computer. It has become increasingly important in the modern world from search engines, video games, and financial algorithms to autonomous vehicles to provide useful services. This project also inculcates Image Processing Techniques which is one of the core domains of Electronics and Communication. Image processing is a method to perform some operations on an image, in order to enhance image or to extract some useful information from it. The civil engineering sector is highly dependent on structural assembly drawings. A structural assembly drawing is a type of engineering drawing it is a plan or set of plans for how a building and structure should be built. Structural assembly drawings are generally prepared by registered professional structural engineers. The traditional and current methodology adapted for transforming a structural design to an actual structure or a building consumes a significant amount of time. Errors or irregularities present in the structural design itself could lead to a lot of complications since it is done manually. Thus this project aims to automate the verification of structural assembly drawings using artificial intelligence and image processing techniques. The objective of the paper is achieved in two stages, the first one is using image processing techniques to extract desired data from the structural drawings using Python platform and Optical Character Recognition. The second stage uses a very effective domain of AI that is Convolution Neural Network (CNN) in order to verify the Structural Assemblies. AI helps in automating data collection and data analysis techniques along with Image Processing to improve several aspects of construction engineering and management for productivity assessment, safety management, idle time reduction, prediction, risk analysis, decision-making and optimizing construction costs.

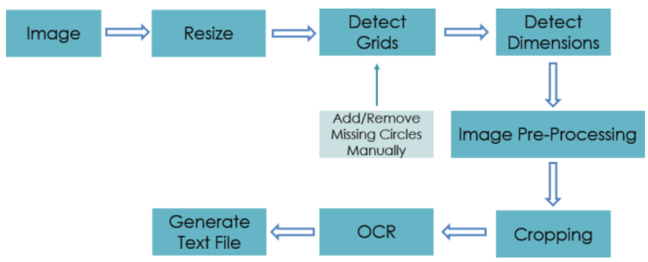


**Figure 1.1 Overview of the proposed work**

In this paper two segment approaches are undertaken, first segment is structural assembly drawing verification using image processing and the second segment is structural assembly verification using convolution neural networks. The drawings undergo few image processing techniques to achieve feature extraction. The output obtained from the image processing techniques is fed into the optical character recognition. The result of the OCR are obtained in a text file. The text file gives the dimensions between two consecutive grids. This is shown if figure 1.2 In the second segment a convolution neural network classifier is built on inception V3 model based on the technique of transfer learning shown in figure 1.3 The classifier model is trained and tested with various structural assembly images. In order to make it accessible to the user, the program is deployed onto a web portal. The web portal is designed with a feature to upload images, on uploading of structural assembly images the classifier classifies the assembly images into correct assembly or error in assembly. Along with the classification of assembly image the web portal also states a confidence score of around 0.69 with respect to the training images.

Revised Manuscript Received on June 30, 2020.
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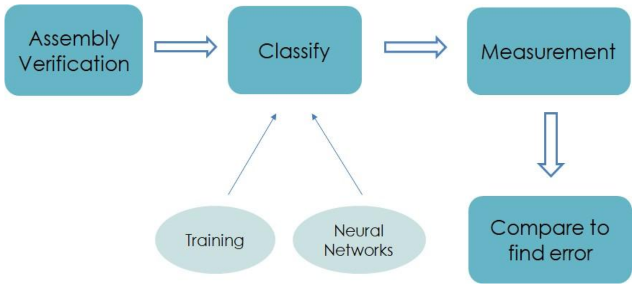


**Figure 1.2 Block diagram for Image processing segment**

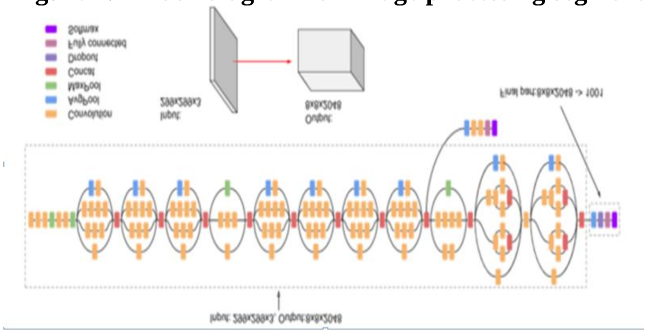

**Figure 1.3-CNN V3 inception model**

The objective of verifying structural assemblies is to check whether the assemblies are placed correctly and this is done by using inception v3 model shown in figure 1.3 and altering its last layer accordingly to train the layer with the images collected of structural assemblies.

## II. LITERATURE SURVEY

The paper deals with artificial intelligence and its sub domain hence the reference of many papers related to the field were taken

Tianmei Guo et.al [1] in their paper has used a simple convolutional neural network to implement image classification at a low cost. On the basis of the working of convolutional neural network , Different optimization algorithms were studied to find an optimum method for image classification.

Belen Ferrer et.al[2] in their paper has discussed a Noninvasive image based method which is a normalized experiment with safety norms in building construction have been discussed.

Pavol Bezak [3] in his paper has proposed a model which is capable to recognize the right object in the photographs of various historical buildings in the town The model designed was scalable and was able to learn more images from more datasets. omplex dataset of photographs of various historical buildings taken from various angles was considered to be the base for perfect validation..

Arthur Shi Xiao-Hua Yu [4] proposed a novel NDE (Nondestructive Evaluation) method for SHM based on Discrete Wavelet Transform (DWT) and Artificial Immune Systems (AIS).. Artificial Immune Systems could be trained by the “normal” data of buildings and there is no need to destroy the building so as to identify measurements of “abnormal” data for training, however, its performance is often limited by the curse of dimensionality issue.

## III. METHODOLOGY

A classifier is trained and built on the inception v3 model with the help of transfer learning approach. The Inception V3 model is simple classifier and a pre-trained model that can classify images into 1000 classifications. The data base used for the training is taken from image net . The model is chosen for the current work as it is easy and available Inception V3 is the third version after Inception V1 and Inception V2. The error rate of Inception V3 model was 3.5%. Transfer learning is one method used in deep learning. It basically makes use of auxiliary data to being trained with the existing model to help the new model achieve a better understanding of new image dataset and have improved results. Therefore, the auxiliary data and the target data supposed to be commonly related to each other. Figure 3.1 shows the idea of transfer learning. Transfer learning provides extra bonus over CNN with regard to time and accuracy.

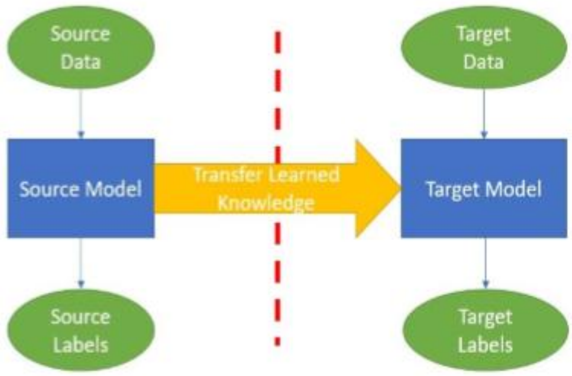


**Fig 3.1: Transfer learning concept.**

## Data set:

The dataset used for this paper consists of around 200 assembly images. Prior to shipping the steel columns and beams to the construction site they are temporarily assembled for verification. The images of this assembly are captured and taken as dataset for building the classifier on inception v3 model as shown in figure 3.2

**Figure 3.2: Assembly images.**

Fig 3.2 depicts the assembly images taken in various angels. These images are then used for training and testing the CNN classifier.

**Proposed approach:**

*Retrieval Number: C6124029320/2020©BEIESP*
*DOI: 10.35940/ijeat.C6124.069520*
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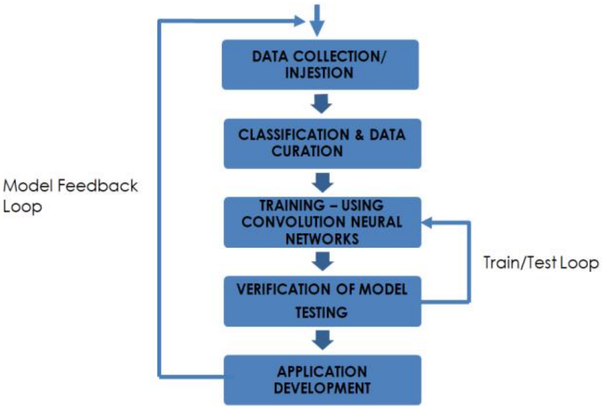



**Fig 3.3: Methodology for CNN model.**

## Data Collection:

Data is collected from the data set which involves around 200 images of the assembly in real time. The images involve various assemblies and components taken in various angles. Figure 3.4 depicts the input data set.

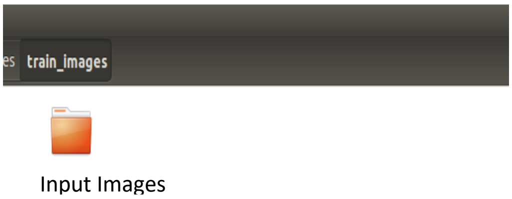



**Figure 3.4: Data set**

## Data Curating and Classification:

On completion of the data collection and storing.,the data is curated, in order to remove blurred images and certain images where the components can't be identified. Thus data curation is a must. After curating of the data the classifier need to be built using training images and training features which define the classification.

## Training

The basis of any classification lies in the training part of the methodology. Training features are extracted from the images and are set as training labels. Based on the training labels the data set are classified. Fig 3.4 shows the training of CNN model in the command prompt.

## Testing

Testing involves verification of the classifier. Thus a random assembly image is used for testing the classifier. This process in done in loop to attain accuracy stated as Train/Test loop. The output of the testing phase is shown in Fig 3.5.

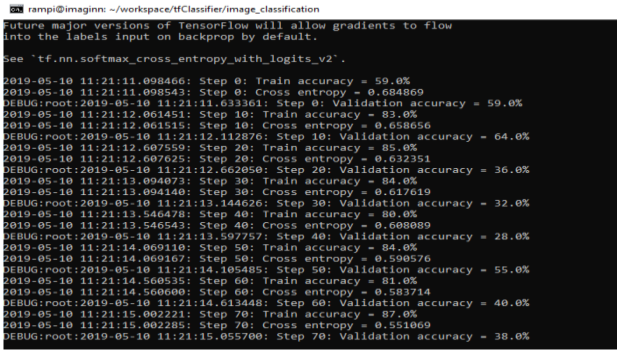



**Figure 3.4: Training of CNN model with data set.**

The CNN classifier model built is deployed onto a web portal to make it accessible. The web portal is deployed with a feature to upload the assembly image. After the assembly image is uploaded the CNN model classifies it and states on the Web portal whether the assembly is correct or there is error in assembly.

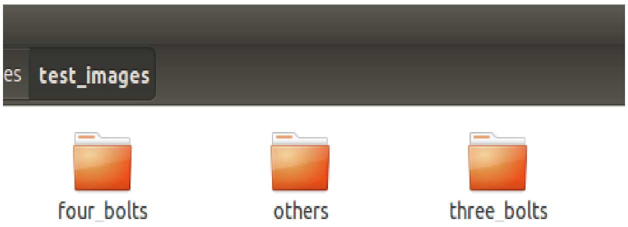
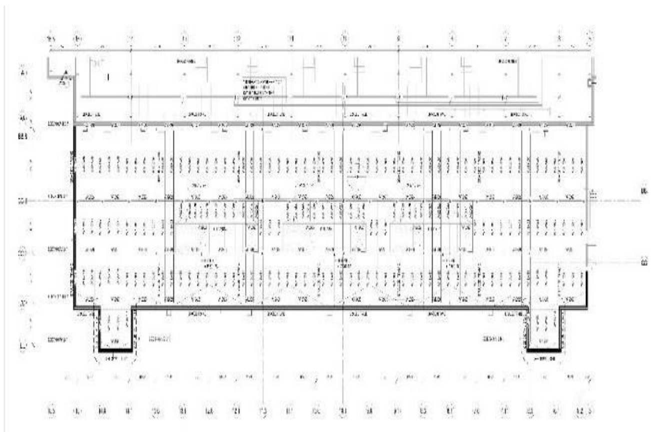



**Figure 3.5 output data set**

## IV. Result:

The main results of this work are carried out in two segments. The results obtained in the first segment that is, Structural Assembly Drawing Verification is performed using Image Processing techniques and is explained in steps shown in figure 4.1. This segment is carried out using PYTHON programming for the verification of structural engineering assembly drawings. This part uses few image processing techniques to attain high accuracy results in minimal time and expenditure along with the assistance of Optical Character Recognition (OCR) to extract the desired output

- Resizing




DOI: 10.35940/ijeat.C6124.069520
Journal Website: www.ijeat.org

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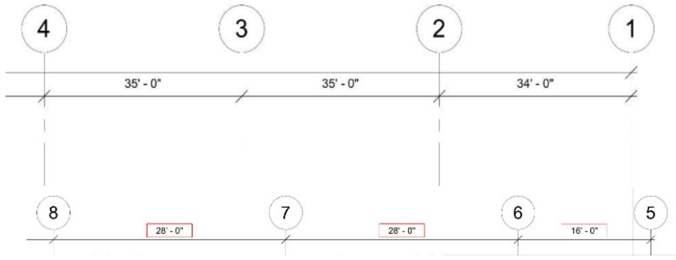
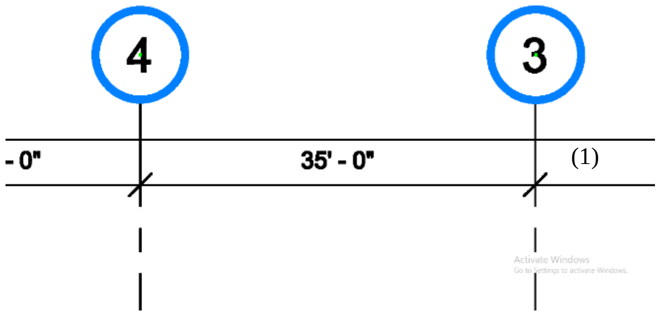
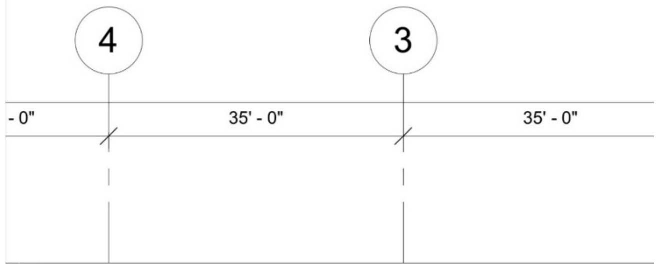



- **Grid detection**




- **Detect dimensions**

- **Cropping**




The second segment of this project is Structural Assembly Drawing Verification using CNN. The classifier is deployed on to the web portal that provides a features to upload new


**Fig 4.2(a): Correct assembly**

assembly images for testing. Upon the classification being completed the web portal states whether the assembly is correct or there is error in assembly. Fig 4.2(a) shows the correct assembly. Fig 4.2(b) shows error in assembly.


**Fig 4.2 (b): Error in assembly**

## V. CONCLUSION:

CNNs model is found to be more effective with regard to efficiency and time over the other methods of classification.. This is because the high accuracy achieved by CNN in image classification and ability to handle images with multiple layers. In this paper inception v3 and transfer learning approach is used to classify the assembly images. Web portal upon classification of images provides a confidence score. Cropping Confidence score is with respect to the accuracy of the uploaded assembly images with the trained data set. Table 1 depicts the confidence score with respect to Fig 4.2 (a) and (b).

**Table I: Confidence Score of assembly images**

| | Confidence Score for Correct Assembly | Confidence score foe Error in Assembly |
|---|---|---|
| Fig 4.2 (a) | 0.6934 | - |
| Fig 4.2(b) | - | 0.6785 |

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