Detecting constructions' distortions and fluctuation

Mohamed Mahmoud ,Adham Mohamed , Ahmed Mostafa , Mohamed saed

September 2020

Proposal Version	Date	Reason for Change
1.0	22-September-2020	Proposal First version's specifications are defined

GitHub: https://github.com/JimmyHofa/Defects-detection-and-analysis-in-buildings

Abstract

Everyday buildings are becoming more exposed to fall apart due to the defects that happens due to a lot of reasons and side affects that affect on the building that make the owners of those buildings spend a lot of money and time for detecting the defects and checking on the infrastructure itself , The main idea of the proposed project is to save money and time by using a system that will detect the cracks and defects , and this will be done by using normal images , The system will take those images and start train them with some algorithms like CNN and SVM to reach to more accurate percentage the will make it more easier then in detecting the defects of the infrastructure.

1 Introduction

1.1 Background

Number of constructed buildings are in increase daily in worldwide especially in China , India United state as they are considered as top three countries as earlier before 20th century people suffered from the buildings defects as it end horribly as the owners consider that their buildings are durable due to the last of hundred of years as all structure segments break down at different rates and degrees depending on the plan, materials and techniques for development, nature of workmanship, ecological conditions and the employments of the structure , Imperfections result from the reformist crumbling of the different segments that make up a structure. Deformities happen through the activity of one or a blend of neutral factors, and those problems ended with horrible accidents till the mid of 20th century as a lot of scientists discovered that most of the errors that happen in the building structures are human errors and they also said that the neutral factors doesn't effect that much on the structure of the buildings like the human factors for example , Argyris and Schön in 1978 they analysed more than 2000 document errors from building and civil engineering projects , The purpose was to understand how errors occurred and most of the errors were human errors , At the end of 20Th century Australia published the first building standard inspector in 1997 and it was one of the first solutions but he couldn't be the perfect solution as he was only detecting the visible defects like cracks and stains but no one had any other solution until 2007 the inspectors started using cameras with gray scale images to identify the defects that cant be seen it worked for a long term but wasn't accurate enough but it costed a lot of money and time as it took from 3 to 7 months to study the defects that cant be seen and in this period the accident might happen , and by the time the detecting the defects became easier as algorithms became provided that helped them in detecting the errors but till now there isn't any accurate method made that can detect the percentage of the defects correctly , now we combined those methods that had been used till now to provide an easy and accurate way by using both of machine learning and image processing.

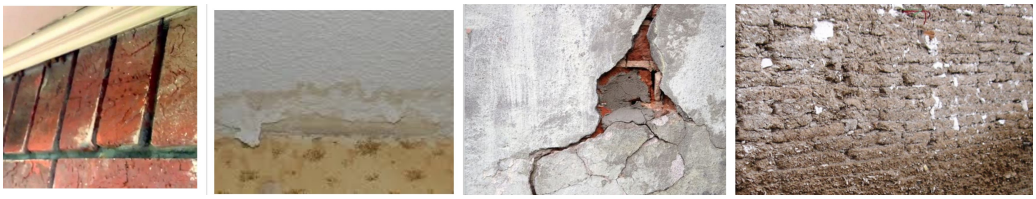


Figure 1: Some Types of defects

1.2 Motivation

1.2.1 CS Problem

Methods Used in image processing, machine learning and deep learning:

- CNN-CAM
- KNN
- Segmentation
- Median Filter
- 11-layers CNN Network
- 12 class CNN
- SVM

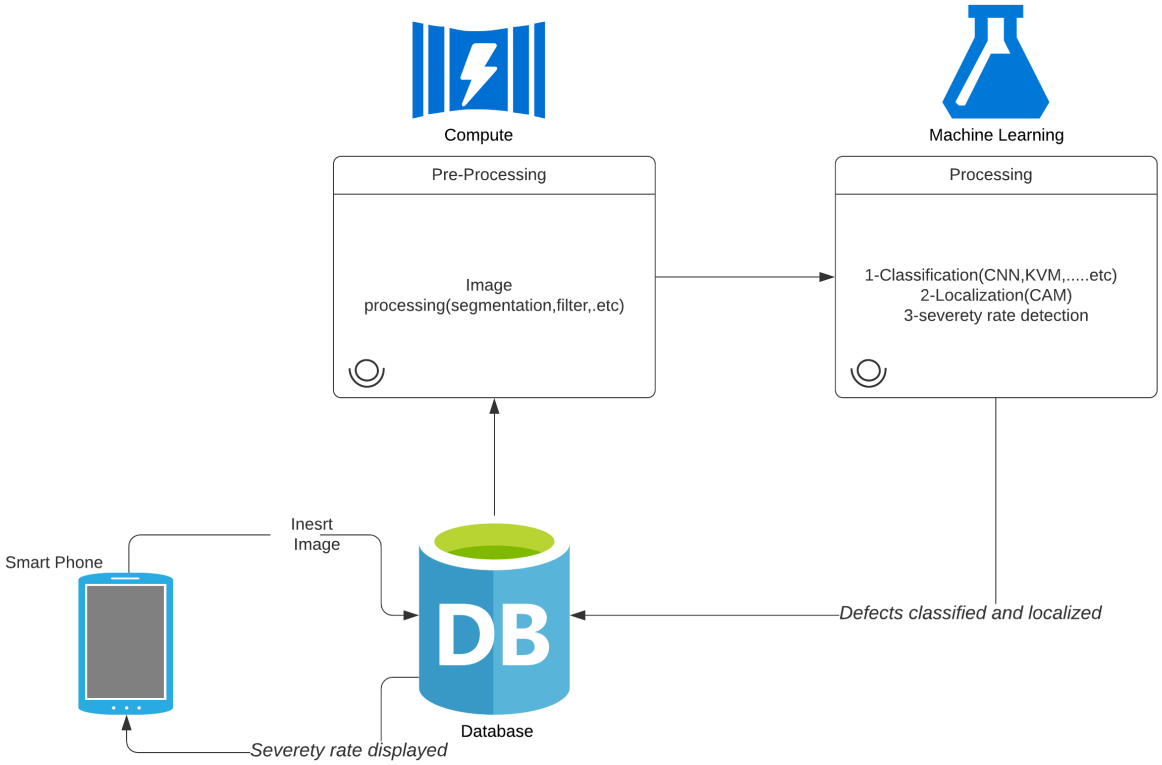


Figure 2: Context Diagram

Dataset Used:

- VGGNET on ImageNet dataset which is a set that contains 14 million annotated images and contains more than 20,000 categories to classify images containing mould, stain and paint deterioration.
- Images of different resolutions and sizes were obtained from many resources, including photos taken by mobile phone, a hand-held camera, and copyright-free images obtained from the internet. These images were sliced into 224 224 thumbnails to increase the size of our dataset producing a total number of 2622 images in our dataset. The data was labelled into four main categories: normal (image containing no defects), mould, stain, and paint deterioration

Accuracies:

Table 1. Classification Report.

	Precision	Recall	F1-Score	Support
Deterioration	0.82	0.86	0.84	183
Mould	0.90	0.91	0.91	183
Normal	0.99	1.00	1.00	183
Stain	0.89	0.79	0.82	183

Figure 3: Classificatio Accuracy

-

1.2.2 Academic

1.2.3 Business

According to statistics people that want to hire an inspector those days are paying a lot as most of the new buyers need to check if there is any thing wrong with their new place or an owner of a building want to check about the building state they wait for at least 3 months to give them the final results and its not accurate as

they neglect some unknown errors , by using our program it will help the users in :
1-Detecting all the types of defects can be scanned by only mobile cam .
2-There wont be inspector needed as this will save much money.
3-The program will notify the user with the name of the defect and how dangerous is it .
4-The accuracy will be more accurate .
5-The user wont stay for a long time to get the results of his scan .

1.3 Problem Statement

The problem that the project aims to solve is detecting the construction defects and detect the type of defect before facing any dangerous situations either if the defect is in the building itself or in the infrastructure and that will help in detecting the problem before the loss is too costly.

2 Project Description

2.1 Objectives

Our objective is to build a application system that can detect the defects at any building , identify the type of the defect as if it is (Void, Corrosion, Cracks, Stain Deterioration) and notify the user if its suitable to deal with or not , it will also help in:

- reaching more accurate results.
- making defect detection much easier.
- saving the money and time to hire an inspector.

2.2 Scope

2.3 Project Overview

2.4 Stakeholder

2.4.1 Internal

2.4.2 External

3 Similar System

3.1 Academic

1-Methods for Long-Distance Crack Location and Detection of Concrete Bridge Structures
This paper uses coordinate image processing system and median filter to enhance and detect images of long distance cracks in bridges, factories and buildings, the method of detection was divided into three parts

- crack measurement system processes the highest resolution image with a 55 model of median filtering.
- Mapping Relationship between the Observational Coordinate System and the World Coordinate System.
- Detection system for crack width and edge.

The system uses a high-resolution CCD camera with a self-made auto focusing device to realize auto focus. At a distance of 100 m from any angle using image processing and coordinate system mapping but the idea didn't help much because it uses high cost equipment such as (high magnification image acquisition system, two-dimensional electric cradle head device and a laser ranging system).
2-Estimation of concrete corrosion state using ULTRA-WIDEBAND RADAR signature
This paper observe and evaluate corrosion state of reinforced concrete using different homogeneous layers and analysis model , the used method is the ultra wide-band radar(UWB) to get a Gaussian pulse used as an incident pulse, as the pulse increase the corrosion rate(from rust) is higher.

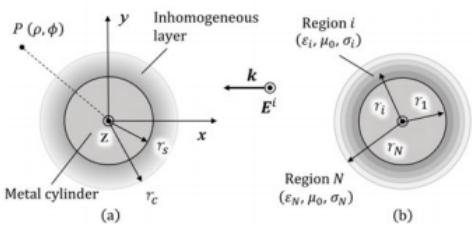


Figure 4: Analysis model. (a) A conducting cylinde covered with inhomogeneous lossy material, and (b) the multi-layer division model

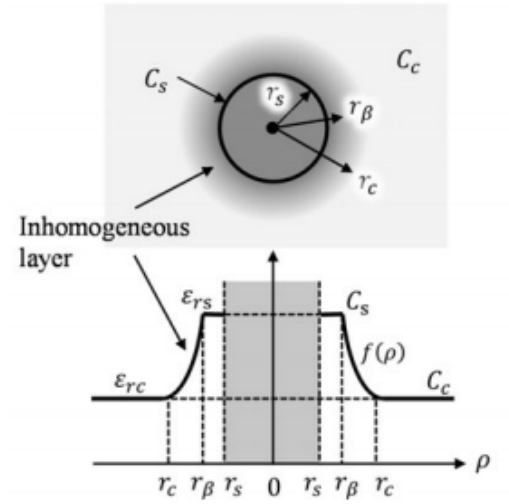


Figure 5: Corrosion model of reinforced concrete used for the simulation. The parameter distribution in the inhomogeneous layer .

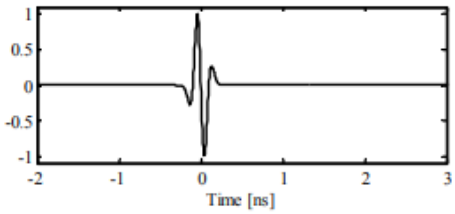


Figure 6: The third derivative Gaussian pulse used as an incident pulse.

The conclusion of this method was starting a corrosion process that the oxidation of the rebarsurface and corrosion state can be characterized by iron oxide (rust) layer formed at the rebar/concrete interface , the method wasn't helping as corrosion rate under 10 percent is hard to detect because of the reflection of pulses from corrosive layers so it is weak to detect. Also simulation was used instead of real life samples from concrete so it's advised to use other signal processing techniques and get real life samples instead.

3-Deep Learning for Detecting Building Defects Using Convolutional Neural Networks.

This paper detects the mould, deterioration, and stain using CNN-CAM and normal images. The proposed model has proven to be dynamic and able to accurately detect and localise building defects , the used method was CNN(VGG-16 network for classification)-class activation mapping (CAM) for object localisation(to increase precision after classification based on images from CNN), after using CNN to detect defects and localise them using CAM the accuracy became high,but this method didn't help as the biggest problem they faced was small data set so they used image augmentation techniques to generate synthetic data set large enough to train the models .

4-A fast and robust convolutional neural network-based defect detection model in product quality control.

This paper detect defects on images according to training data by using CNN 11 Layer Network the CNN was a simplified layers of network can be [Input - Conv - ReLU - Pool - FC] where the image data is divided into

each layer and formed at the end into CNN to detect defects in images , The 11 layers CNN method was is More accurate than other models like 12-class CNN, Statistical features, SIFT and ANN and weibull IN TPR But not in FNR with Average accuracy of 99.8 percent the only problem this paper faced was that the used method can only be used as a detailed background for CNN.
5-Inspection of Concrete Structures by a Computer Vision Technique and an Unmanned Aerial Vehicle.
This paper uses CNN'AlexNet' algorithm and masking with sliding window technique in such conditions due to variation in the image data set to detect cracks , These are handled very well by the 'AlexNet' CNN algorithm used in our proposed method, which results in 98.4 percentage but the problem was that They are using only 2 classes which cant help in increasing the percentage more than 98.4.
6-A fast and robust convolutional neural network-based defect detection model in product quality control.
The fast and robust automated quality visual inspection has received increasing attention in the product quality control for production efficiency the used algorithm is typical CNN architecture consists of several nested convolutional and pooling layers followed by fully connected layers at the end. A simplified types of network can be [Input - Conv - ReLU - Pool - FC], we propose a twofold joint detection CNN network to automatically extract powerful image features for defect detection. We evaluate this method on the DAGM dataset consisting of 6 different image categories, each of which differs from others on the background texture with accuricy 99.8 percentage,the problem was that this method only scan places like kitchens and bathrooms.
7-Learning Deep Features for Discriminative Localization.
This paper explicitly enables the convolutional neural network (CNN) to have remarkable localization ability despite being trained on imagelevel labels. While this technique was previously proposed as a means for regularizing training, we find that it actually builds a generic localizable deep representation that exposes the implicit attention of CNNs on an image.

3.2 Business Application

Paper Title	Method Algorithm	Type of Data	Accuracy
Methods for Long-Distance Crack ˜Location and Detection of Concrete BridgeStructures	crack measurement system Mapping Relationship˜ Detection System˜		
ESTIMATION OF CONCRETE CORROSION STATE USING ULTRA-WIDEBAND RADAR ˜SIGNATURES	by using the ultra wide-band radar(UWB)		
Deep Learning for Detecting Building ˜Defects UsingConvolutional ˜Neural Networks	CNN(VGG-16 network for classification) -class activation mapping (CAM)˜		
A fast and robust convolutional neural network-based defectdetection model ˜in product quality control	Using CNN,˜		
Inspection of Concrete Structures by a ComputerVision Technique and an Unmanned Aerial Vehicle	uses CNN'AlexNet' algorithm˜		
A fast and robust convolutional neural network-based defectdetection model ˜in product quality control	A typical CNN architecture algorithm˜		
Proposed System			

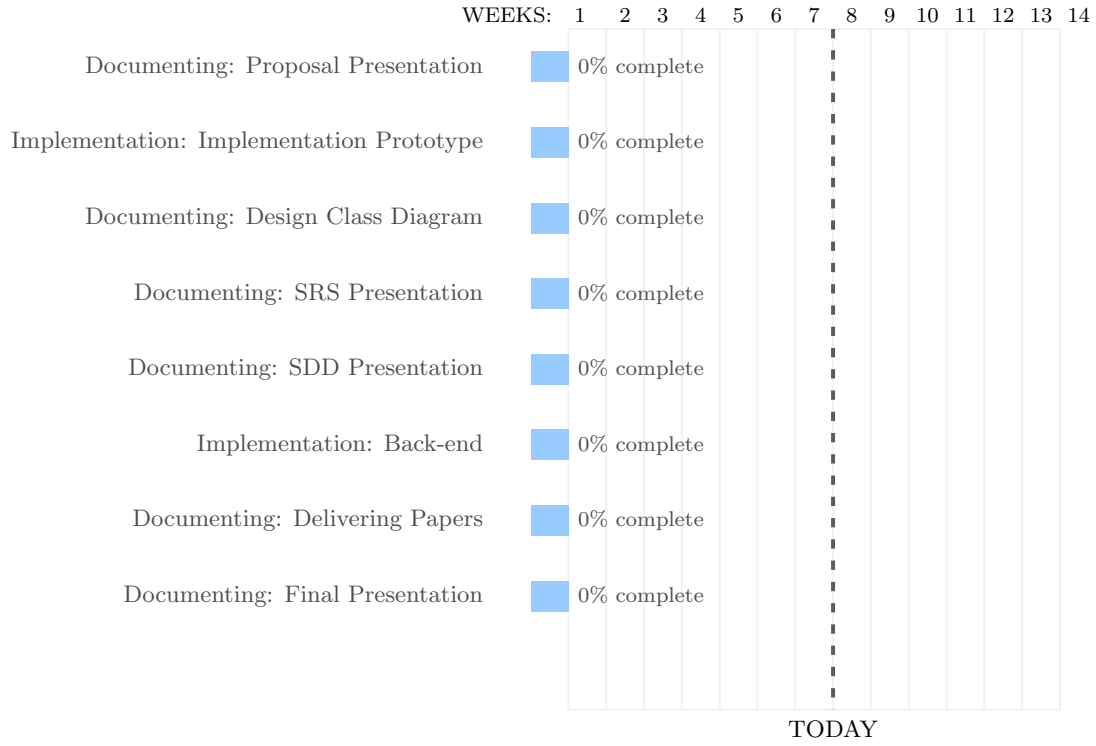
4 What is new in the Proposed Project ?

The new in the proposed project is there will be no need for inspectors to check the place as you can identify the defect by only your mobile phone and it will although notify you how dangerous it is and if it is suitable to stay at or need an immediate evacuation , it will save money , time and the accuracy will be more accurate .

5 Proof of concept

6 Project management and Deliverables

6.1 Tasks and Time plan



6.2 Budget and resource Code

Name	Price
Camera	Range of 100$

7 Supportive Documents

- https://ieeexplore.ieee.org/document/8492764
- https://ieeexplore.ieee.org/document/8899258
- https://ieeexplore.ieee.org/document/8681976
- https://link.springer.com/article/10.1007/s00170-017-0882-0

References

[1] Star, Susan Leigh. "The ethnography of infrastructure." American behavioral scientist 43.3 (1999).

[2] Aad, Georges, et al. "The ATLAS simulation infrastructure." The European Physical Journal C 70.3 (2010): 823-874.

[3] Foster, Ian, and Carl Kesselman. "Globus: A metacomputing infrastructure toolkit." The International Journal of Supercomputer Applications and High Performance Computing 11.2 (1997): 115-128

[4] Brown, Gerald, et al. "Defending critical infrastructure." Interfaces 36.6 (2006): 530-544.

[5] Limao, Nuno, and Anthony J. Venables. "Infrastructure, geographical disadvantage, transport costs, and trade." The world bank economic review 15.3 (2001): 451-479.

[6] Calderón, César, and Luis Servén. The effects of infrastructure development on growth and income distribution. The World Bank, 2004.

[7] Zhang, Xueqing. "Critical success factors for public–private partnerships in infrastructure development." Journal of construction engineering and management 131.1 (2005): 3-14.

[8] Abdel Aziz, Ahmed M. "Successful delivery of public-private partnerships for infrastructure development." Journal of construction engineering and management 133.12 (2007): 918-931

[9] Bessani, Alysson Neves, et al. "The CRUTIAL way of critical infrastructure protection." IEEE Security Privacy 6.6 (2008): 44-51.

[10] Alcaraz, Cristina, and Sherali Zeadally. "Critical infrastructure protection: Requirements and challenges for the 21st century." International journal of critical infrastructure protection 8 (2015): 53-66.

[11] Aradau, Claudia. "Security that matters: Critical infrastructure and objects of protection." Security dialogue 41.5 (2010): 491-514.

[12] Gordon, Chris, et al. "Combining reality capture technologies for construction defect detection: A case study." EIA9: E-Activities and Intelligent Support in Design and the Built Environment, 9th EuropIA International Conference. 2003.

[13] Park, Chan-Sik, et al. "A framework for proactive construction defect management using BIM, augmented reality and ontology-based data collection template." Automation in construction 33 (2013): 61-71.

[14] Sandgrund, Ronald M., and Scott F. Sullan. "The Construction Defect Action Reform Act of 2003." Colo. Law. 32 (2003): 89-91.

[15] Mills, Anthony, Peter E. Love, and Peter Williams. "Defect costs in residential construction." Journal of Construction Engineering and Management 135.1 (2009): 12-16.

[16] Lee, Jae-Young, et al. "A study on construction defect management using augmented reality technology." 2012 International Conference on Information Science and Applications. IEEE, 2012.

[17] Grosskopf, K. R., and D. E. Lucas. "Identifying the causes of moisture-related defect litigation in US building construction." Construction and Building Research Conference of the Royal Institution of Chartered Surveyors, COBRA 2008. 2008.

[18] Le, Quang Tuan, et al. "A virtual world based construction defect game for interactive and experiential learning." Int. J. Eng. Educ 32 (2016): 457-467.

[19] Cheng, Chia-Chi, Tao-Ming Cheng, and Chih-Hung Chiang. "Defect detection of concrete structures using both infrared thermography and elastic waves." Automation in Construction 18.1 (2008): 87-92.

[20] Guo, W., L. Soibelman, and J. H. Garrett Jr. "Automated defect detection for sewer pipeline inspection and condition assessment." Automation in Construction 18.5 (2009): 587-596.

[21] Lo, Tommy Y., and K. T. W. Choi. "Building defects diagnosis by infrared thermography." Structural Survey (2004).