SURFACE CRACK DETECTION

KN BALASUBRAMANIAN
2019506017

Concrete Cracks Detection Based on Deep Learning

- **Author**: Wilson Ricardo Leal da Silva et al.
- **Year Published:** 24-JUN-2018
- **Problem Identified:** This CNN based model was constructed because the UAV model which was in use already required collection of larger datasets, it was costlier and didn't provide more objective analysis.
- **Method:** The model was built using deep learning CNN image classification algorithm. Model VGG16 was used as a basis for development of this model.

- **Advantage:** This model is built upon a pre-trained open source model VGG16, so, a great level of generalization and learning capabilities were found.
- **Disadvantage:** This model is only capable of detecting patch level cracks i.e when larger images are split into several blocks of 256x256 pixels.
- **Result:** For the datasets used, the best experiment model yielded an accuracy of 92.27% showcasing the potential of using deep learning.
- **Architecture:**

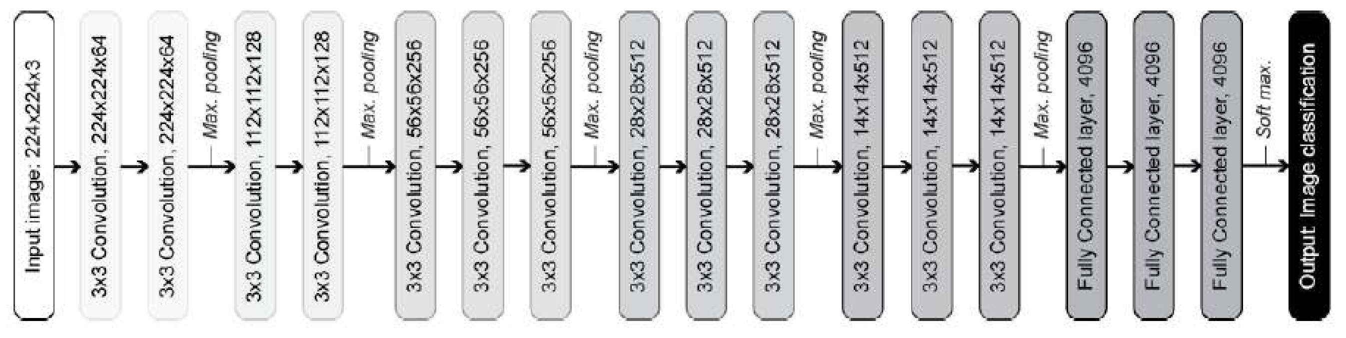


Figure 2. VGG16 architecture - the last layer was re-trained based on the transfer-learning approach.

Artificial Neural Network-Based Automated Crack Detection

- **Author**: Jung Jin Kim et al.
- **Year Published:** 16-NOV-2020
- **Problem Identified:** Before this model, the damage investigation and inspection methods was performed in small scale facilities usually visual examination by a inspector These can interfere with the subjective of the inspector and many errors may occur.
- **Method:** The model used involved three stages of image processing. In the first and second stage ANN was used and in the third stage thinning and tracking algorithms were used to analyse its characters.

- **Advantage:** This method inspect crack for concrete ground structures with high accuracy, speed and convenience.
- **Disadvantage:** This model was trained with limited data Accuracy was investigated using one-sized images.
- **Result:** The performance of the proposed method was tested using various datasets and the results showed good performance with minimal error percentage.
- **Architecture:**

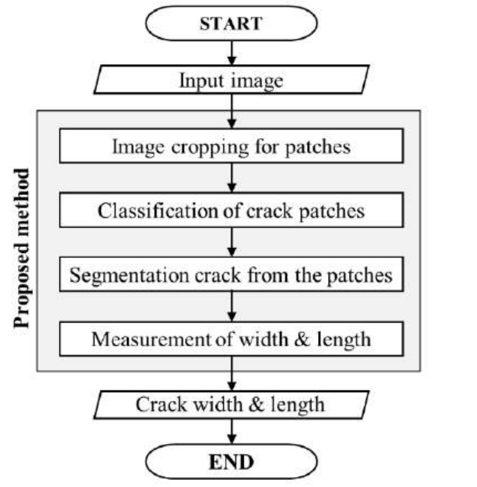


Figure 1. Workflow of the proposed method.

Identification of cracks on a surface by a restricted Boltzmann machines algorithm based on consumer-grade camera images

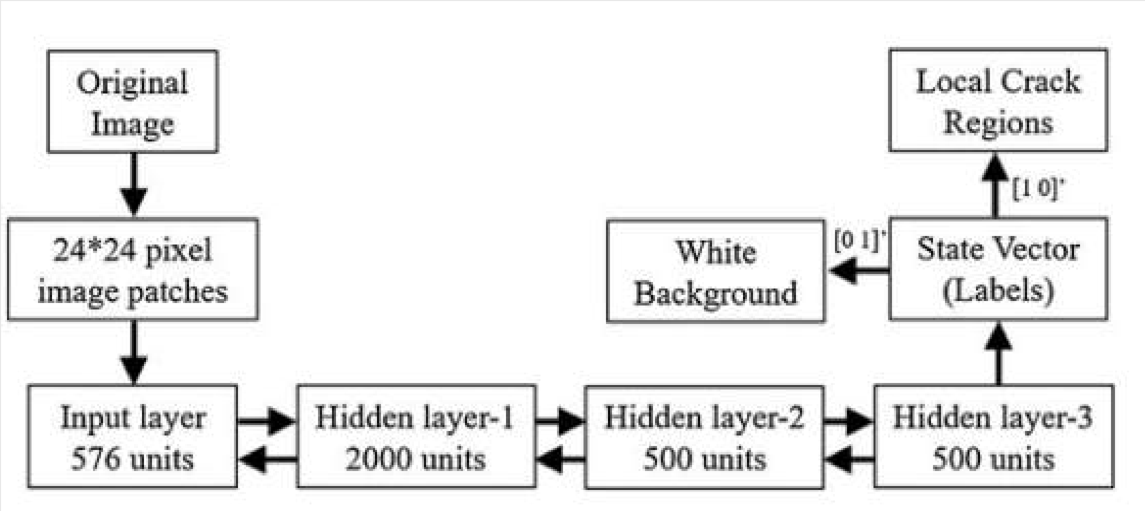
- **Author**: Yang Xu et.al.
- **Year Published:** 04-AUG-2017
- **Problem Identified:** Regular nondestructive testing such as, ultrasonic technique and acoustic emission technique were used. But these were complex and expensive. These cracks will decrease the life span and structural reliability.
- **Method:** This method was built using deep learning ANN model incorporated with restricted Boltzmann machine algorithm. They used multiple RBM layers to learn and abstract the features.

- **Advantage:** This method does not require incorporation of various sensors and is less dependent on expert experiences and detects crack with higher accuracy.

- **Disadvantage:** The element based proportion of correct identification decreased with low resolution.

- **Result:** When the number of iterations or epoch increased the error percentage started to drop below 10.

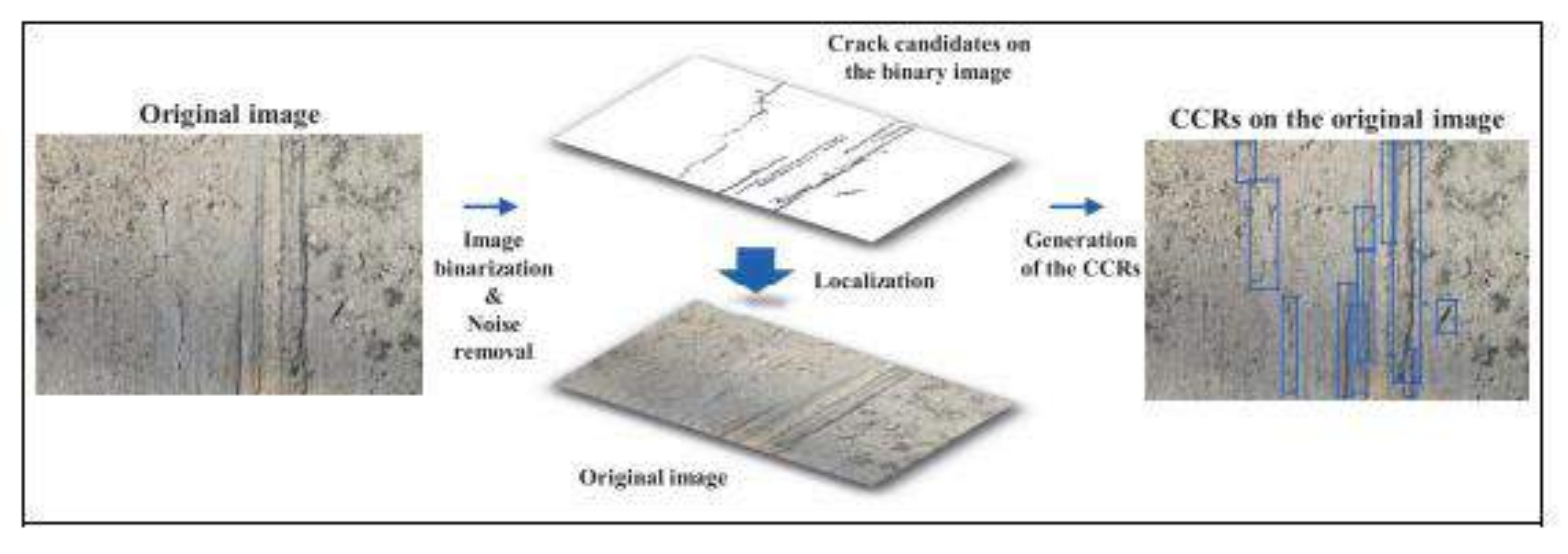
- **Architecture:**



Crack and Non-crack Classification from Concrete Surface Images Using Deep Learning

- **Author**: Hynjun Kim et al.
- **Year Published:** 23-APR-2018
- **Problem Identified:** Concrete cracks are visually examined an records information like existence, location and width. Manual inspection are ineffective in terms of cost, safety and accuracy.
- **Method:** The model was constructed based on speed-up robust features and CNN. This method also classifies the noisy images as crack or without crack. Image binarization is used to extract the crack regions.

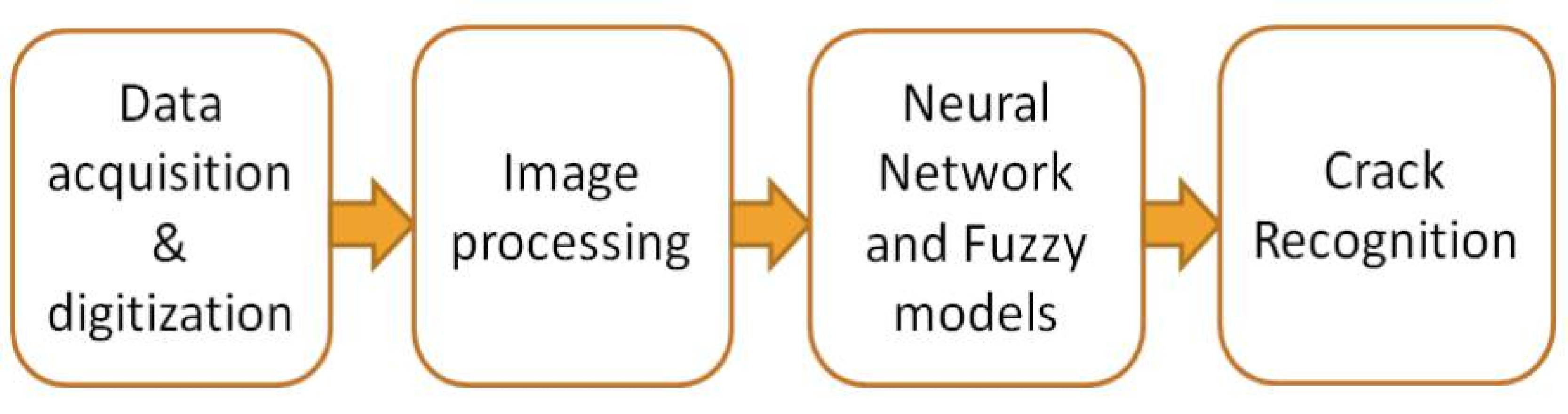
- **Advantage:** This method identifies crack in actual as well as noisy images. This method identifies the existence and location of cracks on surfaces.
- **Disadvantage:** In this model, the geometric pattern and statistical properties are inadequate to distinguish cracks.
- **Result:** The accuracy of about 93% was obtained when CCN method was applied to CCRs to extract the features.
- **Architecture:**



Crack Detection in Concrete Surfaces using Image Processing, Fuzzy Logic, and Neural Networks

- **Author**: GK Choudhary et al.
- **Year Published:** 18-OCT-2012
- **Problem Identified:** Manual inspection involves skilled labour, it is time consuming, very costly and added to this inspection cannot be performed in inaccessible and dangerous areas.
- **Method:** This model presents fuzzy logic and ANN based models for accurate crack detection. This model has used image and object approach to classify the image as a whole and to classify the object in a image respectively. This model has been tested with around 205 images.

- **Advantage:** Object approach was better than image approach. Neural Network model was best in it's performance.
- **Disadvantage:** Due to fragmentation of cracks , sensitivity of models were low.
- **Result:** With the increase in number of hidden layers the accuracy started to change from 86% to 93% .
- **Architecture:**



ROBUST IMAGE-BASED SURFACE CRACK DETECTION USING RANGE DATA

- **Year** – 10/12/2019

- **Authors** - Shanglian,Zhou

- **Problem Identified**

In Image-based automated crack detection,Image intensity data for crack detection, assuming the crack pixels are darker than their surrounding pixels. However, when the intensity image suffers from shadows, blemishes, or poor contrast betw
surrounding surface, this assumption is cor

- **Architecture**

The crack detection results are examined through a precision-recall analysis, which successfully demonstrates the effectivenes and robustness of this methodology.

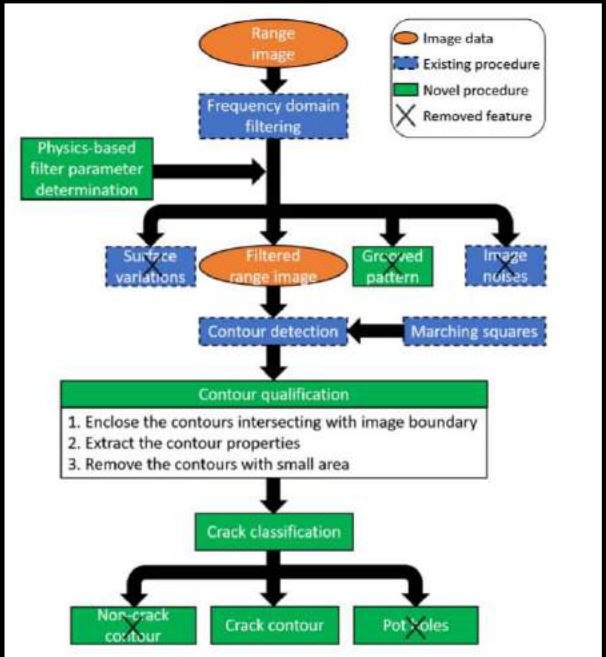


Fig. 2. Flow chart of the proposed crack detection methodology.

Methods Used

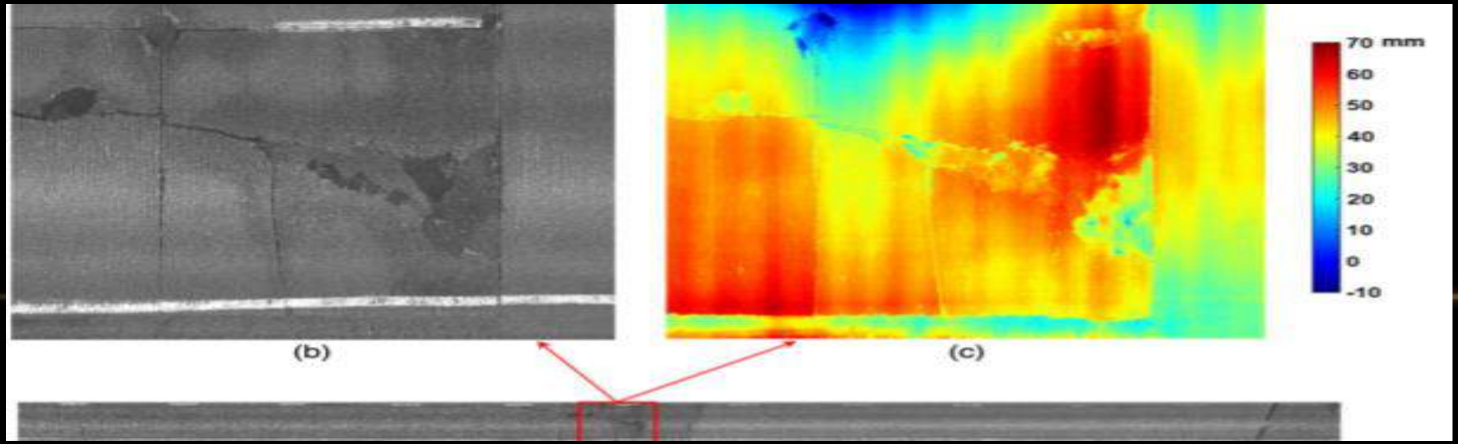
A systematic crack detection methodology based on contouring analysis and a set of logics and criteria is proposed to extract enclosed crack boundary and provide accurate detection results under noise contamination and surface variations.

Advantages

The filter parameters are designed based on the physical characteristics (e.g., crack width, groove spacing, and orientation), thus having less subjectivity.

Disadvantages

Experimental study of crack detection on bridge deck surfaces is performed. Scope for experimental errors is high.



AN IMAGE PROCESSING TOOLBOX FOR CRACK DETECTION AND CHARACTERIZATION

- **Year** – 27/30-OCT-2014
- **Authors** – Henrique Oliveira
- **Problem Identified**

There are no available protocols or standardized methods for evaluating the performance of the developed systems and to compare the published approaches, leading the authors to consider different protocols, despite someexisting harmonization efforts .Thus, the availability of the CrackIT toolbox intents to contribute to the advancement of crack detection and characterization using road pavement surface digital images, by sharing a development and evaluation platform.

- **Architecture**

It is built in Matlab and the CrackIT toolbox

intents to contribute to theadvancement of crack detection.

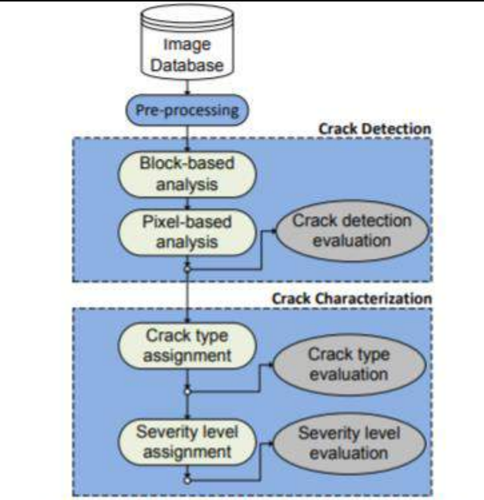


Figure 1: *CrackIT* toolbox architecture.

Methods Used

The toolbox, in the Matlab environment, includes algorithms to pre-process images, to detect cracks and characterize them into types, based on image processing and pattern recognition techniques, as well as modules devoted to the performance evaluation of crack detection and characterization solutions.

Advantages

The proposed model super passed the associated works in terms of **testing accuracy**. It achieves decent performance in the experimental study.

Disadvantages

dealing with very thin cracks (of less than 2 mm width) can be a difficult task,

as many false positives may appear, notably

due to the difficulty of distinguish cracking

from raveling distresses.

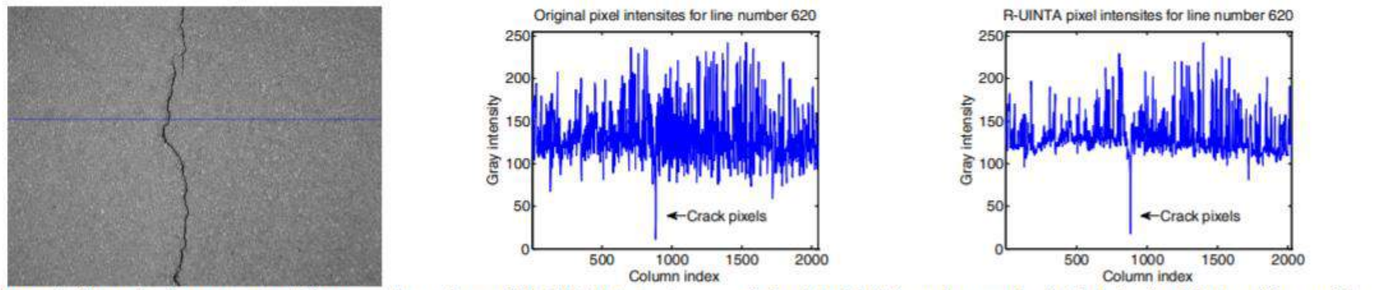


Figure 2: Sample image smoothing results using of R-UINTA strategy: original (middle) and smoothed (right) pixel intensities, with crack pixel intensities almost unaffected.

ROAD CRACK DETECTION USING DEEP CONVOLUTIONAL NEURAL NETWORK

- **Year** – 25/26-SEPT-2016
- **Authors** - Zhang,Fan Yang,Yimin Daniel Zhang,Ying Julie Zhu
  Yimin Daniel Zhang,Ying Julie Zhu
- **Problem Identified**

The traditional framework for crack detection designs a variety of gradient features for each image pixel, which are followed by a binary classifier to determine whether an image pixel contains a crack or not. This method isnt very helpful as error of estimation is quite high.

- **Architecture**

The proposed model is built by fine-tuning the pre-trained deep learning model, The architecture of the ConvNet. In general, the ConvNetis considered as a hierarchical feature extractor, which extracts features of different abstract levels and maps raw pixelintensities of the crack patch into a feature vector by severalfully connected layers

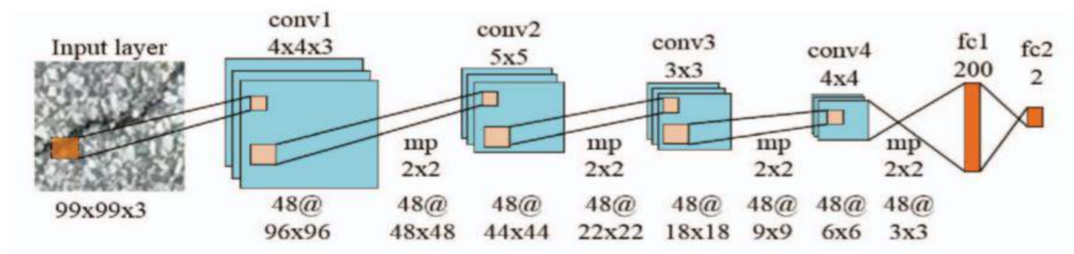


Fig. 1: Illustration of the architecture of the proposed ConvNet.

❑ Methods Used

Deep-learning based method for crack detection is proposed in this paper. A supervised deep convolutional neural network is trained to classify each image patch in the collected images.

❑ Advantages

The Boosting method can detect the cracks with a higher accuracy.

❑ Disadvantages

Sometimes However, some of the background patches are classified as cracks, resulting in isolated green parts

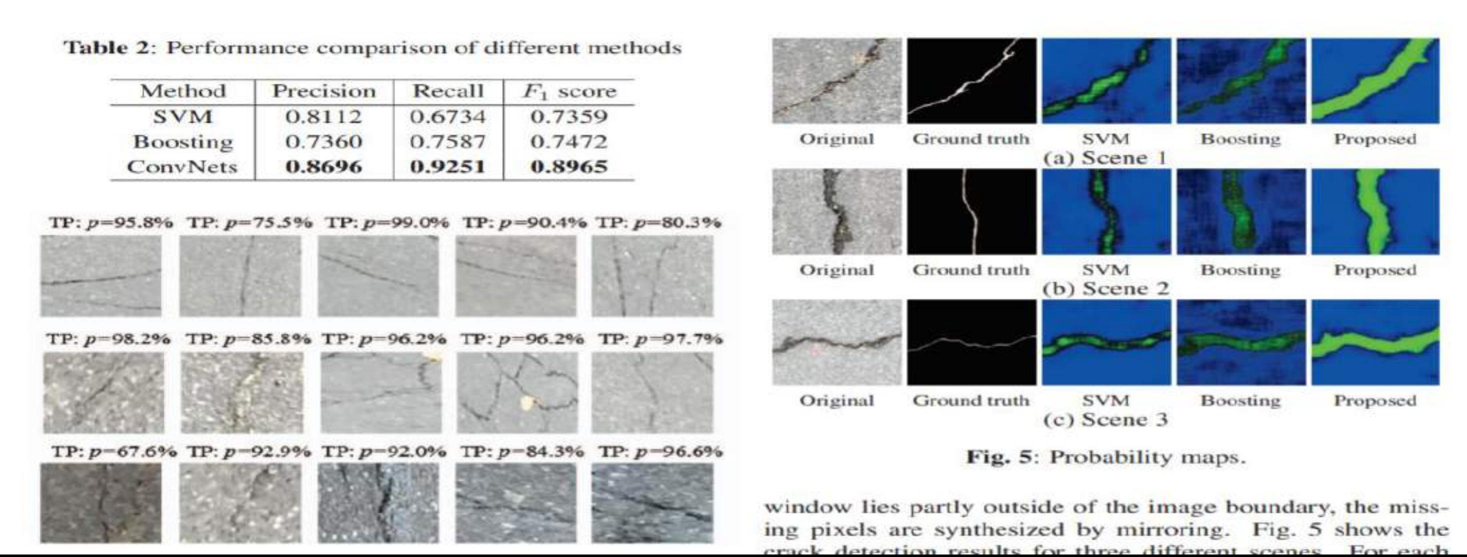


Table 2: Performance comparison of different methods

Method	Precision	Recall	F_1 score
SVM	0.8112	0.6734	0.7359
Boosting	0.7360	0.7587	0.7472
ConvNets	**0.8696**	**0.9251**	**0.8965**

Fig. 5: Probability maps.

window lies partly outside of the image boundary, the missing pixels are synthesized by mirroring. Fig. 5 shows the

CRACK DETECTION FROM A CONCRETE SURFACE IMAGE BASED ON SEMANTIC SEGMENTATION USING DEEP LEARNING

- **Year** – 18-OCT-2020
- **Authors** - Tatsuro Yamane , Pang-jo Chun
- **Problem Identified**

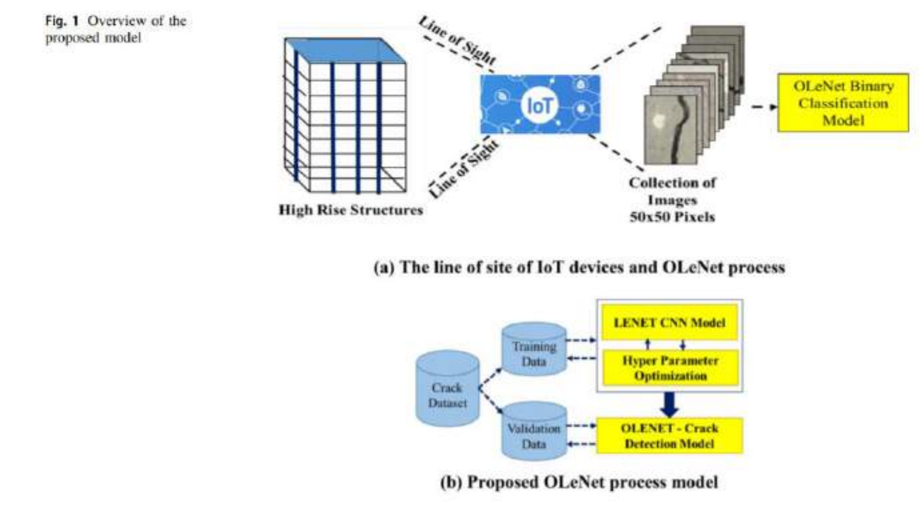
Low accuracy ,and physical mathods that are time consuming and

and presence of external influence like traces of tie rod holes etc

- **Architecture**

Semantic Segmentation Using Deep Learning

Also uses the oleNET binary classification model(two convolutional layers were added to the convolutional block of OLeNet. These convolutional layers enhance the property of spatial invariance to recognize the key features in the crack images



❑ Methods Used (2 stages)

Due to the wide applicability in inspection of concrete structures, there is considerable interest in the development of automated crack detection method by image processing. However, the accuracy of existing methods tends to be influenced by the existence of traces of tie-rod holes and formworks. In order to reduce these influences, this paper proposes a crack detection method based on semantic segmentation by deep learning.

❑ Advantages

The accuracy of developed method is investigated by the photos of concrete structures with lots of adverse conditions including shadow and dirt, and it is found that not only the crack region could be detected but also the trace of tie-rod holes and formworks could be removed from the detection result with high accuracy.

❑ Disadvantages

Sometimes Since the network is achieving the limitation of the dataset performanceother components tend to not work well

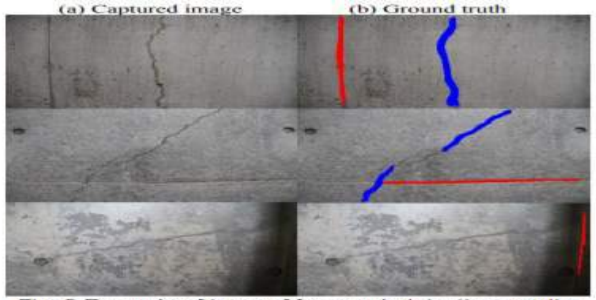


Fig. 9 Example of trace of formwork detection results.

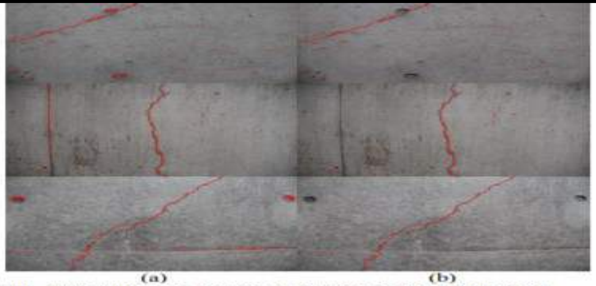


Fig. 10 (a) Images before excluding falsely detected areas; (b) Images after excluding falsely detected areas.

SURFACE CRACK DETECTION USING DEEP LEARNING WITH SHALLOW CNN ARCHITECTURE FOR ENHANCED COMPUTATION

- **Year** – 23 January 2021
- **Authors -** Bubryur Kim, N. Yuvaraj, K. R. Sri Preethaa & R. Arun Pandian
- **Problem Identified**

The proposed model enables the employment of deep learning algorithms using low-power computational devices for a hassle-free monitoring of civil structures. The performance of the proposed model is compared with those of various pretrained deep learning models, such as VGG16, Inception, and ResNet and is better than them.

- **Architecture**

Deep learning with shallow CNN architecture for enhanced computation

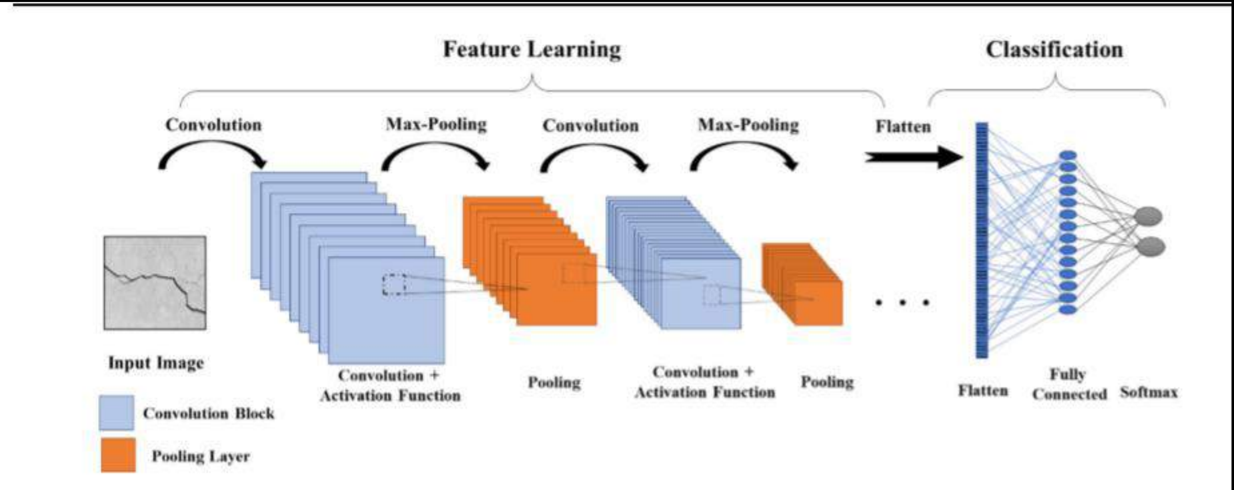


Fig. 2 Operating principle of the CNN architecture

❑ Methods Used

The proposed model enables the employment of deep learning algorithms using low-power computational devices for a hassle-free monitoring of civil structures. The performance of the proposed model is compared with those of various pretrained deep learning models, such as VGG16, Inception, and ResNet. The proposed shallow CNN architecture was found to achieve a maximum accuracy of 99.8% in the minimum computation. Better hyperparameter optimization in CNN architecture results in higher accuracy even with a shallow layer stack for enhanced computation. The evaluation results confirm the incorporation of the proposed method with autonomous devices, such as unmanned aerial vehicle, for real-time inspection of surface crack with minimum computation.

❑ Advantages

Higest accuracy of about 99.8%

❑ Disadvantages

However, these vision-based techniques require high-quality images as inputs and depend on very high computational power for image classification,Therefore can be a little hard to find

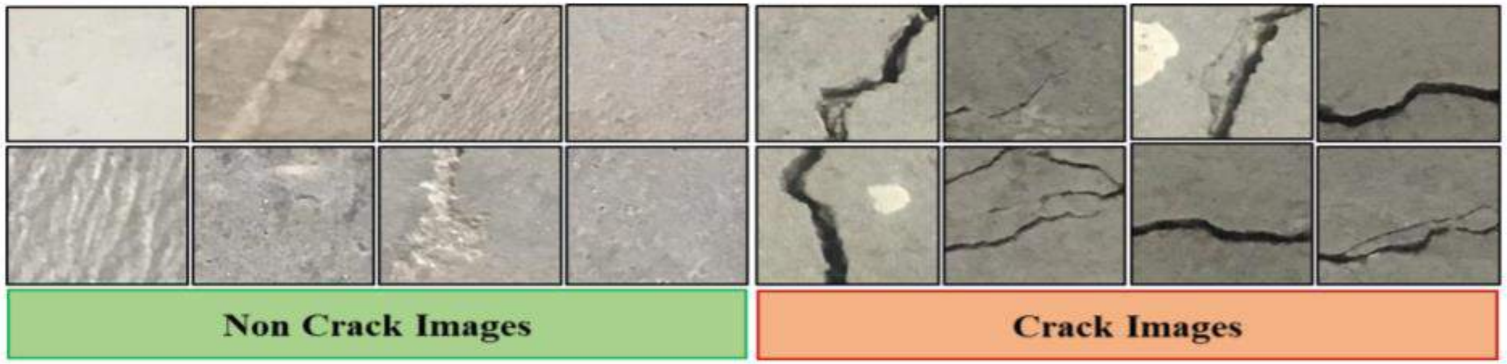


Fig. 11 Sample collection of crack and non-crack images

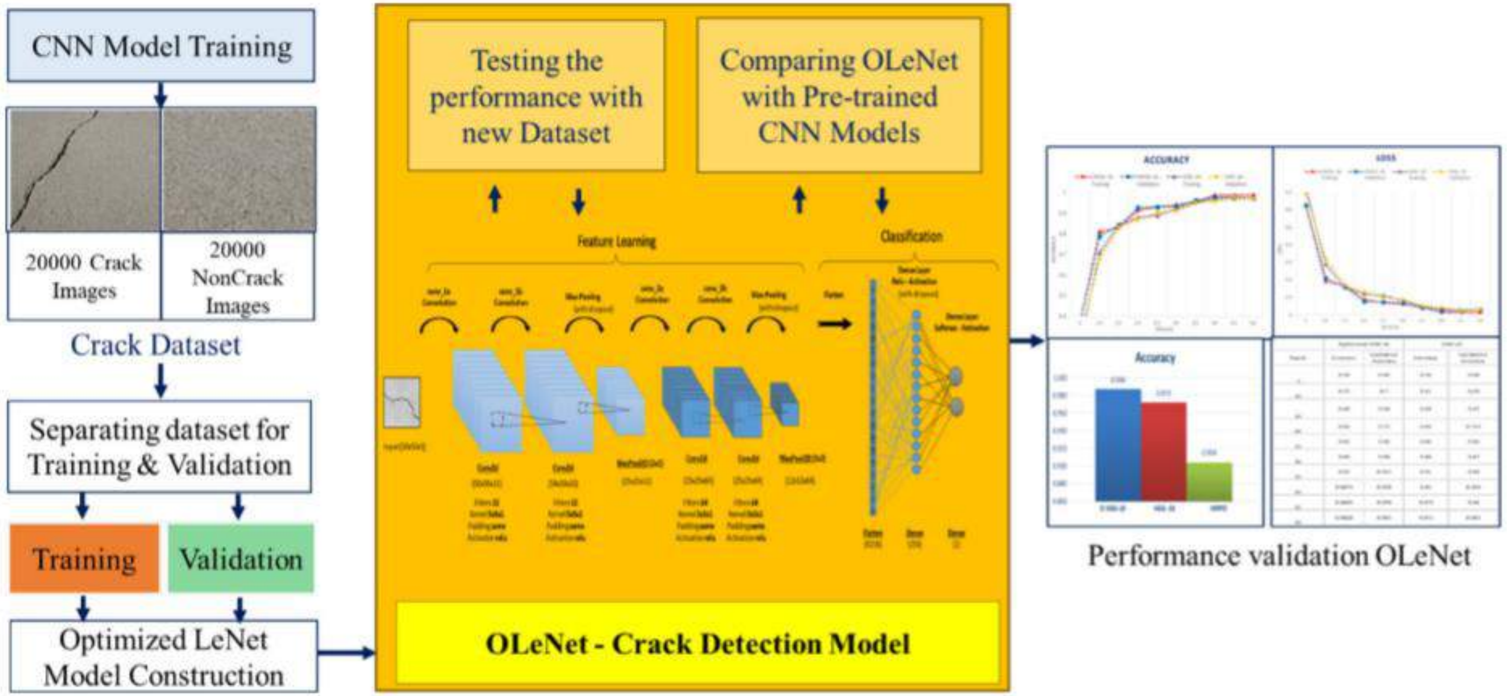


Fig. 12 Proposed OLeNet architecture for crack detection

SUMMER PROJECT TEAM 4

MONISHA V
2019506053

COVERED PAPERS

1) Pavement surface crack detection using the Gabor filter

2)Induction Thermography for Surface Crack Detection and Depth Determination

3)Automated Crack Detection on Concrete Bridges

4)Surface crack detection by flash thermography on concrete surface

5)Surface Crack Detection for Carbon Fiber Reinforced Plastic (CFRP) Materials Using Pulsed Eddy Current Thermography

Pavement surface crack detection using the Gabor filter

M. Salman, S. Mathavan,
K. Kamal, M. Rahman

O***ctober 6-9, 2013***

The **Gabor filter** is proven to be a highly potential technique for multidirectional crack detection that was not done previously using the Gabor filter. Image analysis using the Gabor function is directly related to the mammalian visual perception, hence the choice of this method for crack detection. Results reported in this paper concentrate on pavement images with high levels of surface texture that makes crack detection difficult. An initial detection **precision of up to 95% has been reported in this paper** showing a good promise in the proposed method.

Induction Thermography for Surface Crack Detection and Depth Determination

Beate Oswald-Tranta

9 February 2018

This paper presents several investigations on the influence of different experimental and material parameters on surface crack detection. However, important emphasis was placed on how the position is obtained and on how the depth of a crack can be estimated from the detected signal. In the first part of the paper, finite element simulations are carried out to show how experimental parameters, such as excitation frequency and pulse duration, as well as material parameters and the properties of the crack, such as depth and inclination angle, affect the results. Four different cases were investigated: cases where the penetration depth was small, cases where the penetration depth was similar large as the crack depth, and these in combination with cases where the crack was perpendicular to the surface, and cases where the crack lay under a given inclination angle. For each of these combinations, experimental results are presented. Several samples with artificial and "natural" cracks were measured, and the results are compared with the simulated ones.

Automated Crack Detection on Concrete Bridges

07 October 2014.

Prateek Prasanna et al.

The STRUM classifier for crack detection on bridge decks provides a method of inspection for use in on-site robotic scanning. Since automated scanning generates large image datasets, This article has been accepted for inclusion in a future issue of this journal. Content is final as presented, with the exception of pagination. 8 IEEE TRANSACTIONS ON AUTOMATION SCIENCE AND ENGINEERING automated analysis has clear utility in rapidly assessing bridge condition. Moreover, the results can be quantified, archived and compared over time. The methods of this work shows the first application of automated crack detection to robotic bridge scanning. The new algorithm uses a feature **set that shows 90% accuracy** on thousands of tests cracks. Additionally, geographically separate datasets have been provided for testing and training. A thorough evaluation of multiple features and multiple classifiers on real world data validates the methodology. A coherent spatial mosaic, along with the crack density map, serves as a new tool for inspectors to analyze bridge decks.

Surface crack detection by flash thermography on concrete surface

F C Sham, Nelson Chen and Liu Long ***1 May 2008,***

The method is useful for building appraisal since the maximum crack width in which detailed investigation is not required is 1 mm. However, the thinner cracks, ie microcracks with widths smaller than 0.5 mm, can only be observed by active thermography with water as the stimulus instead of pulse. Water molecules fill up the micro-cracks and due to their difference in heat capacity, different reflected radiation is measured by the infrared camera and shown on the thermal images. However, water cools down the temperature of the whole cement panel and an unclear thermal image recorded. The solution is to add external heat energy on the inspected surface in order to increase the temperature difference so that clearer identification of micro-cracks can be observed. Therefore, FT is still being applied when pre-stimulated by water and a satisfactory result is obtained and presented. This study also compares the effectiveness of different commonly used image processing techniques for crack detection. It shows that the sheared image subtraction method is more effective than Sobel and Canny edge detectors on eliminating image noise and enhancing spatial gradient. It sharpens the contrast of surface cracks while retaining most of the object features in the thermal image.

Surface Crack Detection for Carbon Fiber Reinforced Plastic (CFRP) Materials Using Pulsed Eddy Current Thermography

Liang Cheng and Gui Yun Tian

23 May 2011

In this paper, a PEC thermography system has been proposed and, for the first time, implemented for notch detection in CFRP samples. The method allows the user to observe the eddy current distribution in a structure using infrared imaging and detect defects over a relatively wide area. Both numerical simulations and experimental investigations have been performed. Directional conductivity in CFRP makes the eddy current distribution different from metallic materials. The notch as a surface crack was detected and observed using PEC thermography through both simulation and experiment. It has been proven that the PEC thermography technique is feasible for surface defect detection in low conductivity composite materials and is not limited to the sample surface, such as in flash thermography. Through the simulation and experimental results shown , it can be seen that the heat is mainly generated at the notch.

Summer project
Team-4

sandhya.s
2019506080

28/09/21

Surface crack detection using deep learning with shallow CNN architecture for enhanced computation

Author: Bubryur Kim et al year published: 24/02/2021

To detect the surface crack,the architecture used here is CNN LeNet ,Inception,VGG16 and ResNet architecture.The CNN is used for surface concrete detection.

To Achieve the maximum accuracy for the crack detection with minimum computation,the hyper parameters of the proposed model were optimized.

For analyzing ,accuracy score,precession,recall and F- measures are used.

Vision-Based Concrete Crack Detection Using a Convolutional Neural Network

Author::Young-Jin Cha and Wooram Choi Year published::2017

To address this challenge, this paper proposes a new visionbased approach for detecting concre
cracks using a convolutional neural network
, The prepared datasets are fed into a deep CNN architecture with eight layers including convolutio
pooling, ReLU, and softmax.
Vision-based approaches have emerged as the alternatives because the results provide intuitively
comprehensive information compared to sensor-based methods. Several modal identification meth
using high-speed cameras have been proposed

Autonomous concrete crack detection using deep fully convolutional neural network

Year published:2018

Author:Luqman Ali
et.al

A vision-based method for concrete crack detection and density evaluation using FCN is proposed.

Most of the previous studies have proposed methods based on image classification of an object are detected using bounding box

To improve the proposed method (i.e FcN) to make autonomous crack density evaluation more robust.

The accuracy level achieved here is 90%

Performance Evaluation of Deep CNN-Based Crack Detection and Localization Techniques for Concrete Structures

Author:Luqman Ali

Year published::2021

This paper proposes a customized convolutional neural network for crack detection in concrete structures. The proposed method is compared to four existing deep learning methods based on training data size, data heterogeneity, network complexity, and the number of epochs.

The algorithm used -edge detection in concrete crack identification. The experiment were conducted using python from two publicly available datasets.
The minimum number of epochs helps in reducing the computational time of the model
Moreover, a greater number of epochs may sometimes lead to overfitting of the models

Thank you!!

SUMMER PROJECT

REQUIREMENTS

By Sivani S

Covered Papers

1) Deep Learning-Based Crack Damage Detection Using Convolutional Neural Networks (2017)
2) Automated Road Crack Detection Using Deep Convolutional Neural Networks (2018)
3) Concrete Cracks Detection Based on Deep Learning Image Classification (2018)
4) Autonomous concrete crack detection using deep fully convolutional neural network (2019)
5) Structural crack detection using deep learning–based fully convolutional networks (2019)

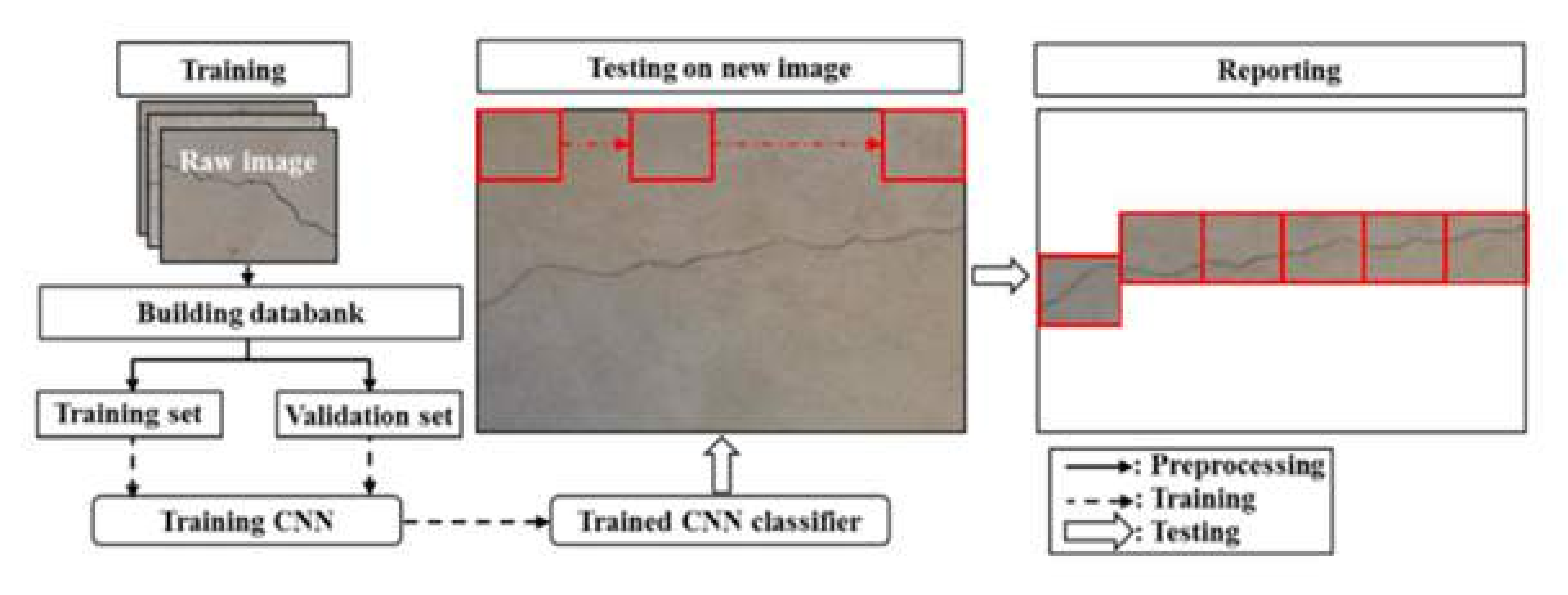
1) Deep Learning-Based Crack Damage Detection Using Convolutional Neural Networks (2017)

Author: Young-Jin Cha et.al.

A vision-based method using a deep architecture of convolutional neural networks (CNNs) has been used for detecting concrete cracks even in realistic situations like lighting and shadow changes.
CNN architecture typically consists of several convolutional blocks and a fully connected layer. Each convolutional block is composed of a convolutional layer, an activation unit, and a pooling layer.
Cracks and corrosion are easily identifiable.
The need of large data set is a diasdvantage.

Accuracy : 97%

Architecture



2) Automated Road Crack Detection Using Deep Convolutional Neural Networks (2018)

Author: Vishal Mandal et.al.

Deep convolutional neural network based on the YOLO (You Only Look Once) v2 framework.

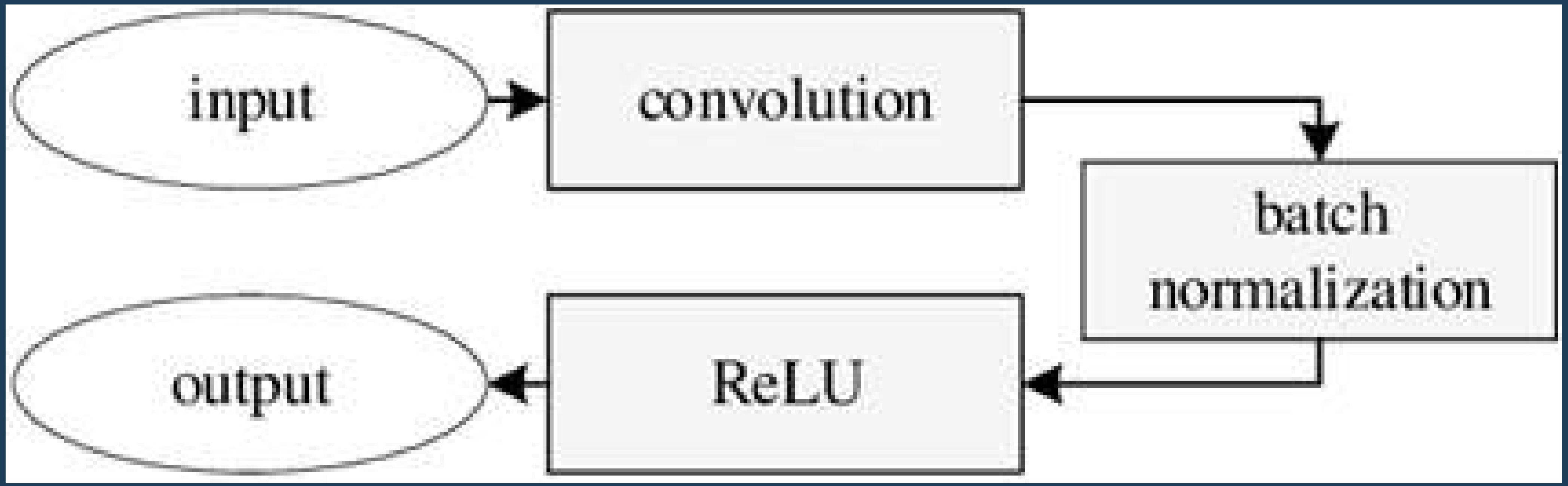
To identify road anomalies in need of urgent repair, thereby facilitating a much better civil infrastructure monitoring system.

Transfer Learning has been used to speed up training and improve the performance of YOLO.

It struggles with transverse cracks due to insufficient number of images with transverse cracks in the training database.

Accuracy : 87%

Architecture



3) Concrete Cracks Detection Based on Deep Learning Image Classification (2018)

Author: Wilson Ricardo Leal da Silva et.al.

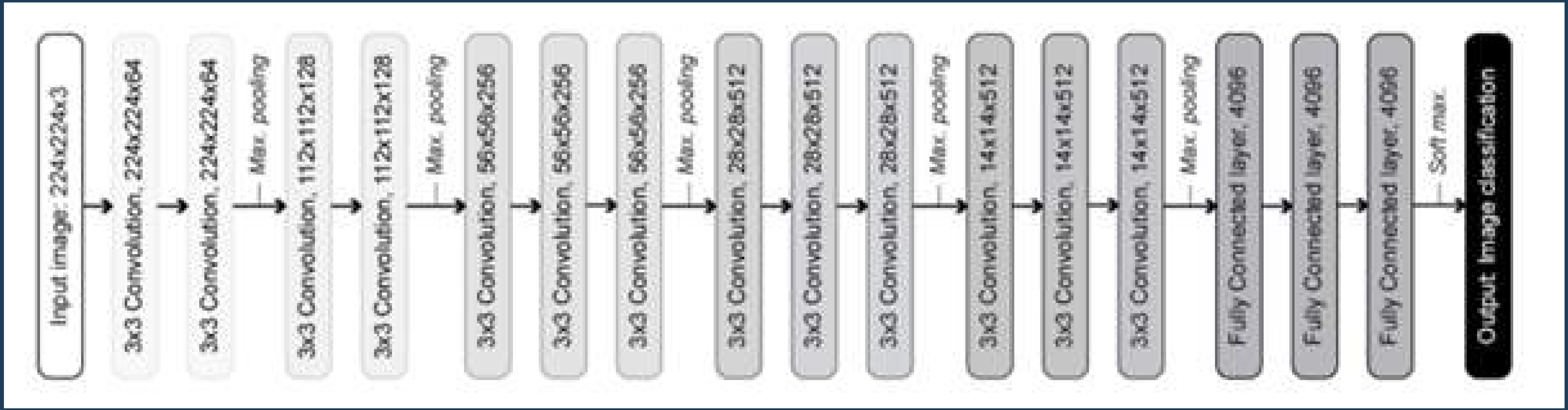
Deep learning Convolutional Neural Network along with image processing method is used for detecting cracks on concrete surfaces.

Its features helps in detecting damages such as cracks in concrete in a robust and reliable manner.

When compared with vision based method, the accuracy is less.

Accuracy : 92.27%

Architecture



4) Autonomous concrete crack detection using deep fully convolutional neural networks (2019)

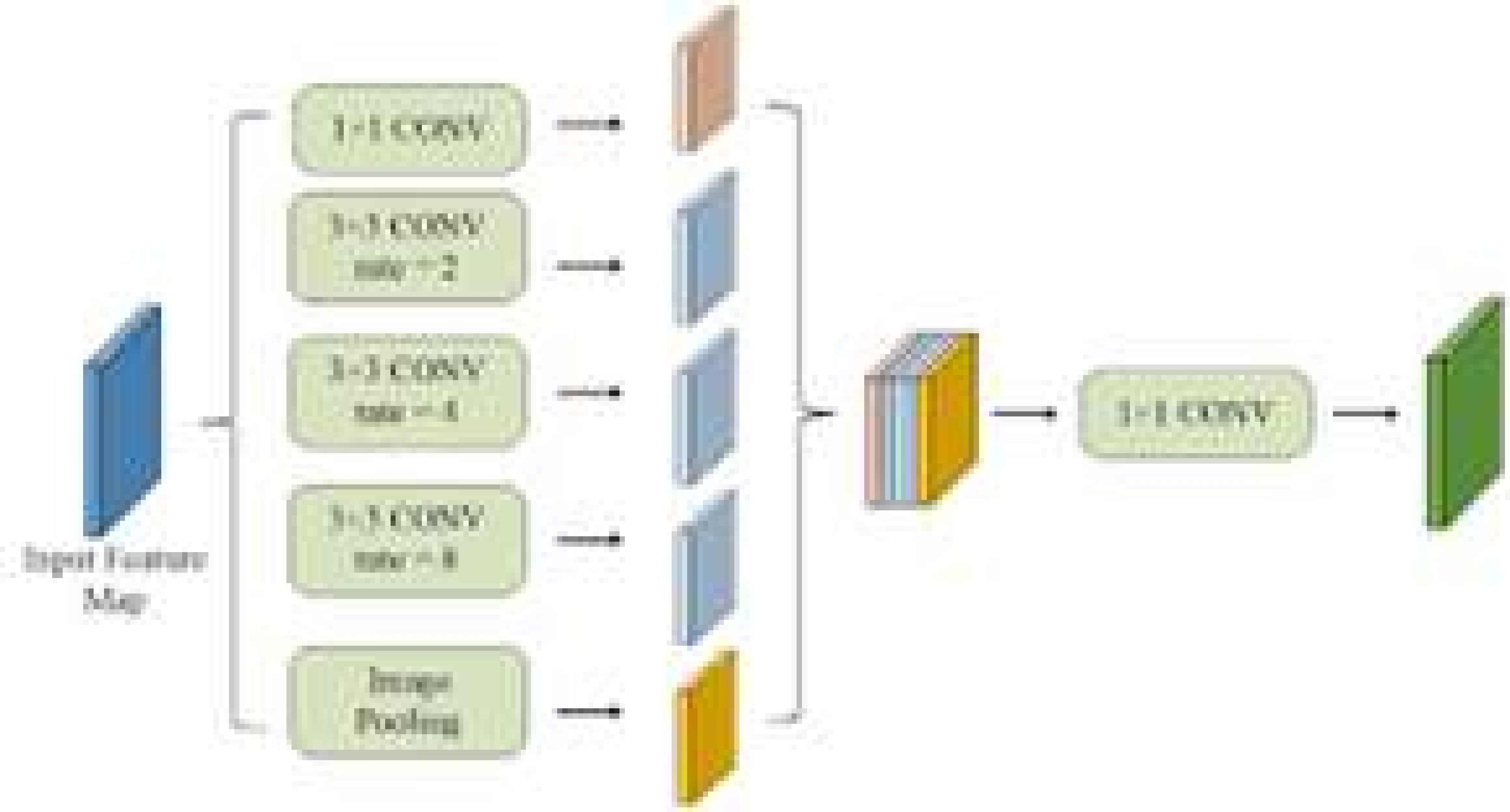
Author: Cao Vu Dunga et.al.

i)Pre-trained convolutional neural networks for crack image.
ii)Fully convolutional network for semantic segmentation classification.

To detect cracks and to evaluate crack density.
Drawback is that it needs more complex networks.

Accuracy : 90%

Architecture



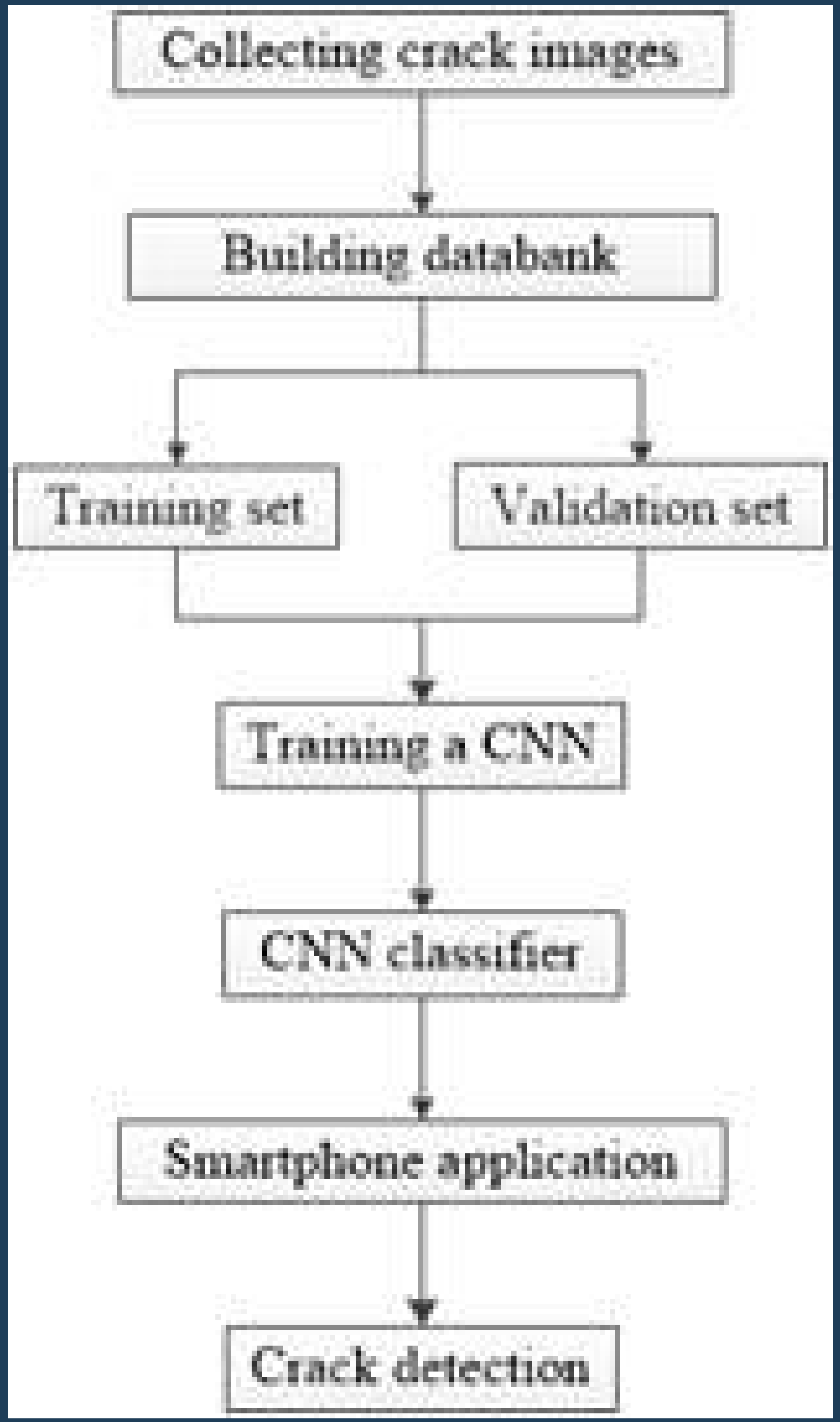
5) Structural crack detection using deep learning-based fully convolutional networks (2019)

Author: Xiao-Wei Ye et.al.

A deep learning based FCN called Ci-Net (Context-Integrating Neural Network Model) is proposed and trained for structural crack identification.
It was found that C i-Net exhibits a better performance in detecting structural damage.
It is inconvenient when images are taken by cameras with different pixel resolutions because it needs certain size.

Accuracy : 93.6%

Architecture



THANK YOU

Thankyou

GROUP 4

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BHAGYA NARAYANAN

SIVANI S

MONISHA V

SANDHYA S