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|  | **Title :** **Project Registration & Progress Review** | | **FF No. 180** |  |
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| **Department: Information Technology** | | **Academic Year: 24-25** | | | |
| **Semester :7** | | **Group No. :9** | | | |
| **Project Title:** **Automated Structural Damage Detection and Classification in Concrete Structures and Bridges Using CNNs** | | | | | |
| **Project Area: Deep Learning, Computer Vision, Image Processing, Structural Health Monitoring** | | | | | |
| **Group Members Details:** | | | | | |

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| Project approved / Not approved  **Guide Project Coordinator Head of Department** |

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| **Project Synopsis** |  |  |  |  |  |  |
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| * **Introduction**   Structural damage detection is critical in maintaining the safety and integrity of concrete buildings and bridges. Traditional methods of inspection, including manual visual assessments and specialized equipment, are time-consuming and often limited in scope. With the increasing age of infrastructure and the need for regular inspections, there is a growing demand for automated systems that can efficiently detect and assess structural damage. This project focuses on leveraging deep learning techniques to address these challenges. By employing the SSD (Single Shot Multibox Detector) model, this project aims to develop a real-time system for detecting and classifying various types of damage in concrete structures and bridges.   * **Review Of literature**   [1]This paper provides a comprehensive survey of deep learning (DL) techniques for crack detection in asphalt pavements, highlighting advancements in DL-based methods over traditional image processing and machine learning approaches. The authors review key DL architectures, including ResNet and DenseNet for crack classification, Faster R-CNN for object detection, and U-Net and GANs for pixel-level segmentation. They found that these DL models offer superior accuracy and efficiency compared to earlier methods, particularly in handling varying crack characteristics and challenging backgrounds. However, challenges such as class imbalance, the need for extensive labeled data, and accurate crack width estimation remain significant issues. The paper also discusses emerging trends, such as semi-supervised learning and Vision Transformers (ViT), as promising areas for future research to enhance crack detection capabilities. Overall, this survey underscores the potential of DL in advancing pavement maintenance and highlights areas for further investigation.  [2] This paper introduces BridgeNet, a novel deep learning framework designed for automated multiclass surface damage detection in bridge inspections. The authors employ advanced techniques such as the Swin Transformer and CARAFE upsampler, integrated with a transfer learning approach, to enhance the accuracy and efficiency of damage detection. A new dataset, BridgeDamage, is also introduced, featuring over 2800 annotated images capturing diverse types of damage across various bridge components. Experimental results demonstrate that BridgeNet significantly outperforms traditional methods and state-of-the-art models like Mask R-CNN, achieving improvements of 33% in mean Average Precision (mAP) and 26% in mean Intersection over Union (mIoU). This work underscores the potential of deep learning, particularly with the inclusion of Transformer-based architectures, in advancing the automation and accuracy of bridge inspections under complex real-world conditions.  [3] This paper provides an extensive review of the field of Structural Health Monitoring (SHM), emphasizing the evolution from traditional damage detection methods to advanced Deep Learning (DL) approaches. SHM is crucial for the maintenance and safety assessment of civil infrastructures, which deteriorate over time. Initially, researchers focused on identifying structural damage through changes in modal properties using vibration-based techniques. These traditional methods, however, often struggled with real-world environmental noises and uncertainties, limiting their effectiveness. Recent advancements have seen a shift towards DL, particularly convolutional neural networks (CNNs), which offer robust, automatic feature extraction from data such as images and vibrations. DL approaches have shown superior performance in detecting and localizing structural damage, overcoming limitations of manual feature extraction and traditional machine learning methods. The paper also highlights the increasing role of DL in handling large datasets generated by sensors, improving the accuracy and efficiency of SHM processes. The review culminates in an exploration of various DL algorithms, including supervised, unsupervised, and semi-supervised learning modes, and their applications in SHM, offering insights into future directions and challenges in the field.  [4] This paper reviews the recent advancements in applying deep learning (DL) to bridge health monitoring, highlighting its potential in improving damage detection through analyzing vast amounts of data collected from structural health monitoring (SHM) systems. Traditional methods like visual inspections and model-based approaches are limited by their labor-intensive nature and inability to timely reflect structural changes. Data-driven methods, including DL, offer a more automated and accurate solution by leveraging techniques such as convolutional neural networks (CNNs) and recurrent neural networks (RNNs) to identify anomalies and structural damages from vibration data and images. The paper discusses the effectiveness of various DL models in distinguishing between sensor faults and structural damages, as well as handling challenges like imbalanced data and non-stationary ambient excitations. It also addresses the limitations of DL in SHM, particularly the scarcity of labeled data for training and the complexity of implementing these advanced techniques in real-world scenarios  [5] The paper "Structural Health Monitoring and Damage Detection through Machine Learning approaches" by Priyanka Singh, Umaid Faraz Ahmad, and Siddharth Yadav provides a comprehensive review of the current state of Structural Health Monitoring (SHM) using machine learning (ML) techniques. The authors discuss the significance of SHM in maintaining the integrity and safety of civil structures like bridges, dams, and high-rise buildings, emphasizing the benefits of early damage detection and assessment. The paper highlights the advancements in sensor technologies and the use of deep learning methods, such as deep convolutional neural networks (CNNs) with transfer learning, for accurate damage identification. Additionally, the authors explore the application of data anomaly detection methods to filter out noise and improve the reliability of SHM data analysis. Overall, the paper underscores the importance of integrating modern ML approaches in SHM to enhance the efficiency and accuracy of monitoring and maintenance processes for civil infrastructure. | | | | | | |
| * **Problem statement and Objectives**   + Define the problem and its relevance to today's market / society / industry need   Traditional methods for detecting structural damage in concrete buildings and bridges are often labor-intensive and prone to human error. There is a need for an automated, real-time system that can accurately detect and classify damage to enhance safety and reduce maintenance costs.   * + Describe the Solution.   The proposed solution involves developing a real-time damage detection system using the SSD (Single Shot Multibox Detector) deep learning model. The system will analyze images of concrete structures to detect and classify various types of damage, such as cracks, spalling, and corrosion. By training the SSD model on a dataset of annotated structural images, the system will provide accurate and timely damage assessments.   * + Explain the uniqueness and distinctive features of the product.   This project is unique in its use of the SSD (Single Shot Multibox Detector) model for both detection and classification of structural damage, ensuring high accuracy and efficiency. Unlike traditional methods, this automated system offers real-time analysis, reducing the time and cost associated with manual inspections. Additionally, the SSD model's ability to handle multiple types of damage in various conditions in a single pass sets it apart from other solutions. This single pass approach allows for faster processing and immediate results, making it highly suitable for practical applications in the field.   * + How your proposed / developed product solution is different from similar kind of product by the competitors if any.   Our solution uses the SSD (Single Shot Multibox Detector) model for real-time, accurate detection and classification of structural damage in concrete buildings and bridges. The SSD model operates as a single pass algorithm, allowing it to detect and classify damage in one go, making the process significantly faster. It is unique in its real-time analysis, ability to classify multiple damage types, user-friendly interface, and advanced post-processing, making it more efficient and reliable than traditional inspection methods. This single pass approach ensures quick and precise results, setting our solution apart from competitors.   * + List out the objectives. * To develop a real-time structural damage detection system using the SSD deep learning model. * To achieve high accuracy in detecting and classifying different types of damage in concrete structures and bridges. * To leverage the SSD model's single pass algorithm for faster and more efficient damage detection and classification. * To create a user-friendly interface for engineers to utilize the system in field inspections, particularly useful for inspecting high-rise or multi-storey buildings where capturing photos of defected structures allows the model to automatically detect and classify damages. * To validate the system's performance using a diverse set of images and scenarios. * To contribute to the field of structural health monitoring by providing a scalable and efficient solution. * **System Architecture**   Draw System Architecture.  dE  Image Acquisition  (Cameras/ Drones)  Image Preprocessing  (Resizing, Normalization)  Model Training  (Train SSD on annotated dataset)  Damage Detection  (Real-time Analysis using trained SSD model)  Post-preprocessing  Generate Results  User interface (Upload Images) | | | | | | |
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**FF No** **180**

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| Group No. |  | | |
| Activity | Review Schedule | Progress Review Report submitted | Signature of Guide |
| Review 1 | Mid Sem. Semester | Yes / No |  |
| Review 2 | End of Semester | Yes / No |  |

Format of Progress Review Report:

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| **Review No.: 1 Group No.: Date:** |
| **Progress Review Report** |
| **Signature of Guide:** |

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| **Review No.: 2 Group No.: Date:** |
| **Progress Review Report** |
| **Signature of Guide:** |