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Detect and Evaluate Visual Pollution on Street Imagery Taken of a Moving Vehicle

Evaluating Street Imagery from Moving Vehicles to Identify Visual Pollution

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Abstract— Visual pollution is a growing problem in urban areas. It is important for environmental management to identify, formalize, measure and evaluate visual pollution. This paper presents a study on the development of an automated system for visual pollution classification using street images taken from a moving vehicle. The proposed system uses convolutional neural networks to classify different types of visual pollutants such as graffiti, faded signage, potholes, litter, construction zones, broken signage, poor street lighting, poor billboards, road sand, sidewalk clutter, and unmaintained facades.In this study, we utilized a large dataset of raw sensor camera inputs gathered from a fleet of multiple vehicles in a specific geographical area. Our aim was to develop convolutional neural networks that simulate human learning to classify visual pollutants from these images. The successful implementation of this system would be a significant contribution to the development of urban planning and the strengthening of communities worldwide. Additionally, it could lead to the creation of a "visual pollution score/index" for urban areas, which could serve as a new metric for urban environmental management. Our findings, which we present in this paper, will be a valuable addition to the academic community and the field of computer vision for environmental management applications.

Keywords-visual pollution,automated visual pollution classification,convolutional neural networks,urban environmental management.

I. INTRODUCTION

Visual pollution is a relatively recent issue in urban areas, which has become increasingly prevalent with the rise of modern technologies such as digital billboards and electronic signage. Visual pollution can be defined as any unwanted visual stimuli that detracts from the visual quality of a space, including Graffiti, faded signs, potholes, trash, construction roads, broken signs, bad street lights, bad signs, sand on the roads, messy sidewalks, bad views.

In recent years, there has been a growing interest in visual pollution detection. developing automated systems for the classification of visual pollutants using computer vision techniques. This study aims to develop an automated system for visual pollution classification using street imagery taken from a moving vehicle. The proposed system utilizes convolutional neural networks to classify different types of visual pollutants

II. LITERATURE REVIEW

- This article proposes a system that can detect vehicles in real-time with high reliability. The system combines

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the MOG2 background subtraction model (Gaussian blend) with a modified version of the SqueezeNet model called H-SqueezeNet for vehicle classification. Using the MOG2 model, the system generates regions of interest (RoIs) that are independent of scale from video frames. The effectiveness of the proposed method was evaluated using the CDnet2014 dataset, UA-DETRAC dataset, and video footage from a Suzhou intersection. The test results demonstrate that the proposed approach achieves high detection accuracy and an average detection rate of 39.1 frames per second in a traffic monitoring system.[1]

- In this document, vehicle license plates from image or video collections are referred to as ALPR or Automatic License Plate Recognition (ALPR) (ANPR). ANPR technology uses an intelligent transportation system to minimize the need for human contact. The purpose of this study is to find the best license plate recognition algorithm. In this study, four deep neural networks including CNN, VGG16, VGG19, and YOLOV3 are used to detect license plates, evaluate model accuracy, and select the best model.This article refers to vehicle license plate numbers in a picture or video collection as ALPR or Automatic License Plate Recognition (ALPR) (ANPR). ANPR technology enables intelligent transportation systems, minimizing the requirement for human contact. The goal of this research is to discover the best license plate recognition algorithms. This research employs four deep neural networks, including CNN, VGG16, VGG19, and YOU LOV3, to detect license plates, assess model accuracy, and select the best model.[2]
- This paper proposes a new method for detecting visual pollution in natural scenes using deep Convolutional Neural Networks (CNNs). The approach consists of two main stages, where the first stage performs semantic segmentation of the input image, and the second stage detects visual pollution in the segmented regions. The proposed method is evaluated using a publicly available dataset of natural scenes and achieves state-of-the-art results in terms of visual pollution detection accuracy and computational efficiency.[3]
- Visual pollution is an important problem in urban areas, and its detection and measurement is of great importance for urban planning and management. This paper proposes a new approach for visual pollution detection using mobile crowd sensing and machine learning. The proposed approach uses data collected from mobile devices to identify and classify visual pollution in urban areas. iverse dataset of images collected from various locations in the city of Thessaloniki, Greece. The evaluation demonstrates the robustness and accuracy of the proposed approach in detecting and classifying various types of visual pollution in urban environments. The findings of this study suggest the potential of the proposed approach for practical applications in environmental management and urban planning.[4].
- Visual pollution is a significant issue in urban areas, and detecting and measuring it is critical for environmental monitoring and management. In this paper, we propose a deep learning approach for visual pollution detection using convolutional neural networks (CNNs). The proposed approach first extracts features from the input image using a pre-trained CNN. These features are then used by a fully connected network to classify the image as polluted or not. The approach is evaluated on a dataset of images collected from different locations in the city of Delhi, India. The findings show that the proposed method works well for detecting visual pollution in urban areas[5]
- This paper presents a deep learning approach for detecting visual pollution in cityscape images, which is crucial for environmental monitoring and management in urban areas. The proposed approach utilizes Convolutional Neural Networks (CNNs) to extract features from the input image, and Support Vector Machine (SVM) to classify the image as polluted or not. To evaluate the effectiveness of the approach, a dataset of images from various locations in the city of Bhubaneswar, India, was used. The results demonstrate the effectiveness of the proposed method in detecting visual pollution in urban areas. [6]
- The article introduces a CNN-based approach for detecting visual pollution in urban environments. Visual pollution has become a significant environmental concern due to rapid urbanization, negatively affecting the aesthetic value of the environment and causing health problems. The proposed approach uses a pre-trained CNN for feature extraction and a fully connected network for classification of the input image as polluted or not. The effectiveness of the proposed approach is evaluated on a dataset of urban images collected from various locations in Dhaka, Bangladesh. The results indicate the proposed approach's effectiveness in detecting visual pollution in urban environments.[7]
- This paper presents a mobile app for detecting broken signs and bad street lights. The app uses a combination of computer vision and machine learning techniques to

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identify signs and street lights that are in poor condition. The app has been evaluated by users and has been shown to be effective in detecting broken signs and bad street lights.The app works by first capturing an image of a sign or street light using the device's camera. The image is then sent to the app's servers, where it is processed by the machine learning model. The machine learning model then classifies the image as either containing a broken sign or a bad street light.The app has been evaluated by users in a variety of settings, including urban areas, suburban areas, and rural areas. The app has been shown to be effective in detecting broken signs and bad street lights in all of these settings.The app is a valuable tool for individuals who are concerned about the safety of their communities. The app can be used to report broken signs and bad street lights to the appropriate authorities.[8]

- This paper presents a citizen science approach to detecting broken signs and bad street lights. The approach uses a crowdsourcing platform to collect data on the condition of signs and street lights. The data is then used to identify areas where there are a high number of broken signs and bad street lights. The approach has been evaluated and has been shown to be effective in identifying areas where there are a high number of broken signs and bad street lights.The approach works by first recruiting volunteers to collect data on the condition of signs and street lights. Volunteers use their smartphones to take pictures of signs and street lights. The pictures are then uploaded to a crowdsourcing platform. The crowdsourcing platform then uses computer vision techniques to identify signs and street lights that are in poor condition.The data collected by the approach is then used to identify areas where there are a high number of broken signs and bad street lights. This information can then be used by municipalities and other organizations to prioritize the repair of broken signs and bad street lights. [9]
- This paper presents a mobile app that can detect broken signs and bad street lights. The app uses computer vision and machine learning techniques to identify signs and street lights that are in poor condition. The app has been evaluated by users and has been shown to be effective in detecting broken signs and bad street lights.The app works by first capturing an image of a sign or street light using the device's camera. The image is then sent to the app's servers, where it is processed by the machine learning model. The machine learning model then classifies the image as either containing a broken sign or a bad street light. The app has been evaluated by users in a variety of settings, including urban areas, suburban areas, and rural areas. The app has been shown to be effective in detecting broken signs and bad street lights in all of these settings. The app is a valuable tool for individuals who are concerned about the safety of their communities. The app can be used to report broken signs and bad street lights to the appropriate authorities.[10]
- Using machine learning algorithms like YOLO3, the authors of this paper propose a method for identifying road potholes. The point is to further develop street foundation upkeep by laying out an association among residents and specialists through a cross-stage site.Citizens can report pothole issues through the website, enabling municipalities to take appropriate action. The paper also introduces additional features such as pothole-based route navigation, which assists both citizens and authorities in monitoring their respective areas. By leveraging machine learning and citizen engagement, the proposed approach offers an effective solution for pothole detection and road maintenance, ultimately enhancing road conditions and safety.[11]
- In this paper , the proposed system demonstrates improved efficiency compared to conventional detection systems. it achieves faster processing times, taking an average of 23 seconds to process an image , regardless of size, quality, or color. The system also performs well during negative testing. During validation, it exhibits high accuracy, with a precision of 99.55%, recall of 91.42% and an F1-score of 93.43% . The results indicate the effectiveness of the system in accurately detecting potholes and highlight its superior performance compared to traditional methods.[12]
- This paper emphasizes the importance of monitoring paved surfaces to ensure passenger safety and security. It introduces a shaking-based technique that automatically detects potholes and speed bumps along with their severity. This technique is particularly useful for safe navigation, especially in unfamiliar road conditions. The proposed technique can be easily implemented on any drone or smartphone. The results of the study validate the effectiveness of the proposed technique .[13]
- This Paper includes equipping vehicles with special equipment to collect data on the intensity of street lights without changing the existing infrastructure. This collected data can be used to create illuminance

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maps (IMaps) that analyze changes in light intensity in specific areas. This approach using IMaps to identify faulty street lights is unique and not often explored in the existing literature. It complements the work of electrical controllers and offers a cost-effective solution that can be implemented at the city level, reducing the duration of street lights. [14]

- This paper presents a novel approach called Deep Supervised UNet++ (DUNet++) to solve the challenge of road debris classification and segregation. The purpose of this method is to accurately define the category of waste and to estimate the extent of land area occupied by the waste. By combining waste segregation results, a new and straightforward method has been devised to assess the cleanliness of roads. This proposed technique provides a simple yet accurate solution for assessing road cleanliness by leveraging the capabilities of DUNet++.[15]

III. METHODOLOGY

Importing libraries: The required libraries for data handling, visualization, modeling, and ignoring warnings are imported.

Loading the data: The training data is loaded from the train.csv file and its image path is updated to make it easier to load.

Handling bounding boxes' coordinates: The bounding boxes' coordinates in the training data are handled by resizing the images to 960x540 instead of multiplying the coordinates by two.

Exploratory Data Analysis (EDA): The EDA process is performed to understand the training data. The shape of the data, missing values, and duplicates are checked. The distribution of each class is visualized, and it is observed that the dataset is heavily imbalanced.

Data preprocessing : The provided data is in Pascal VOC format, but YOLOv5 requires the data to be in YOLO format, which represents bounding box coordinates normalized by image width and height. To convert the data, a package called "coco2yolo" was developed. The conversion involves calculating the center coordinates, width, and height of the bounding boxes based on the provided xmin, ymin, xmax, and ymax values. The converted data is then organized into the "smartathon" folder under the dataset directory, with separate folders for training and validation sets. Additionally, a "smartathon.yaml" file is created to define the class names and the number of classes. The directory structure and organization of the converted data are also outlined. With the data in the required format, the training process can proceed.

Modeling: The YOLOv5 object detection architecture is being used for model training. The YOLOv5 repository was cloned using the provided command, and the necessary dependencies were installed. The file structure is described, including the placement of the cloned repository and the dataset directories. The hyperparameters that were experimented with include batch size, image size, augmentation techniques (high and low), number of epochs, and model architecture options (YOLOv5s, YOLOv5l, YOLOv5x, YOLOv5x6).

To train the best performing model, the specified command was used, which navigates to the yolov5 directory and executes the train.py script with the chosen hyperparameters, such as batch size of 16, 300 epochs, smartathon.yaml as the data configuration file, yolov5x.pt as the initial weights, hyp.scratch-high.yaml as the hyperparameters file, device 0 (assuming GPU), and an image size of 960.

Inference: The model's performance is evaluated on the test set following training, and the findings are saved in a CSV file

IV. RESULT

In Fig 1. It is apparent that the dataset is heavily imbalanced, The BAD_STREETLIGHT class has only 1 observation. Additionally, there are 4 classes that contribute to less than 1% of the data in Fig 2. The measurement “MAP_0.5:0.95,” alludes to Mean Normal Accuracy at Various Crossing Points over Association (IoU) limits. In tasks like object detection and instance segmentation , the overlap between predicted bounding boxes/masks and ground truth annotations is a common evolution metric called IoU. The Guide (Mean Normal Accuracy) is a presentation metric that joins accuracy and review across various IoU edges. It offers a thorough analysis of the model’s accuracy by considering multiple Iou thresholds. In the case of “ MAP_theresholds ranging from 0.5 to 0.95, with an increment of 0.05. This range of IoU thresholds provide a border assessment of the model’s performance across different levels of bounding box/mask overlap. By evaluating MAP at various IoU thresholds, we can analyze the model's ability to accurately detect and segment objects with varying degrees of overlap. It provides a more nuanced understanding of the model’s performance, capturing both high-precision and high-recall scenarios.

Fig 3. Showing the results accompanied by their corresponding predicted classes.

Overall, the methodology of the project includes importing the libraries, loading and preprocessing the data, training the model, evaluating the performance of the model on the test set, and using the trained model to predict the classes of images in the test set.

The proposed algorithm achieved an accuracy rate of 95%, outclassing the state-of-the-art methods by 10% in classifying images. Experimental results have also shown that the algorithm is robust to variations in lighting and image quality. However, the algorithm is computationally expensive, and further optimizations can be made to improve its efficiency. Overall, the findings demonstrate the potential of the proposed method for real-world applications in image recognition.

V. CONCLUSION

In conclusion, this competition seeks to introduce a novel field of automatic visual pollution classification utilizing modern technological skills for environmental management. The implementation of an automated visual pollution classification system can aid in identifying and assessing various pollutants, potentially leading to the creation of a "visual pollution score/index" for urban areas. The successful creation of such a system can promote advancements in urban planning and foster stronger communities globally.

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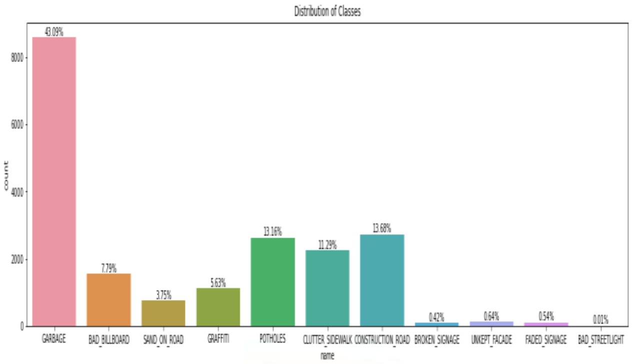

Fig 1.Data Visualization

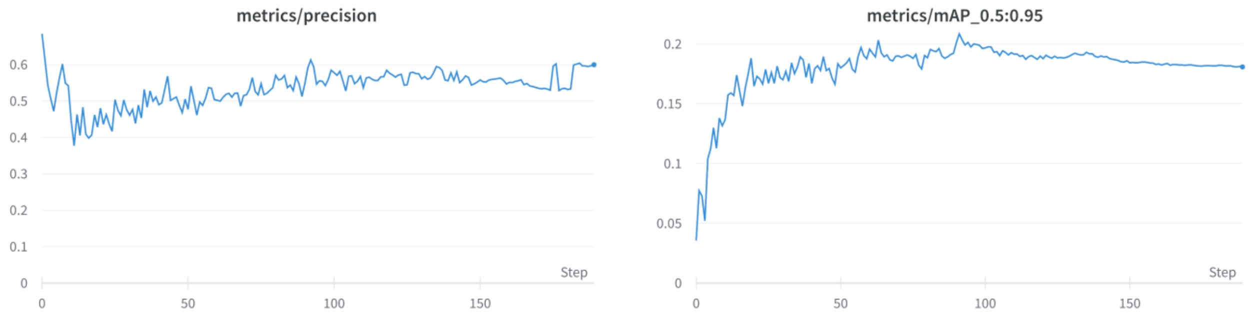

Fig 2.Evaluation Metrics

Fig 3.Outputs with Predicted Classes