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Smart Surveillance System for Illegal Garbage Dumping

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Abstract: *Effective garbage management is a key challenge faced by urban areas across the world Garbage dumping in unauthorized places is a common problem in most cities, and it poses a serious threat to public health and the environment. To address this issue, we propose a real-world surveillance platform that detects and reports instances of garbage dumping in unauthorized areas using vision-based action recognition techniques. Our approach involves training a deep neural network on a dataset of garbage dumping actions to recognize and classify instances of this behaviour in real-time video footage. The system operates in three stages detection, tracking, and classification. In the detection phase, we use object detection techniques to locate potential dumping events in video frames. In the tracking phase, we track the detected object across subsequent frames to obtain a trajectory that helps in understanding the context of the action. In the classification phase, we classify the action as garbage dumping or non-dumping using a convolutional neural network. Our system achieves an accuracy of 96.2% on a test dataset, demonstrating its effectiveness in detecting garbage dumping events in real-world surveillance scenarios. The proposed system can be integrated into existing surveillance infrastructure to improve the efficiency of garbage management systems and enhance public health and environmental protection.*

Keywords: Garbage dumping action, human, object relation, machine vision application, visual surveillance

I. INTRODUCTION

Vision-based garbage dumping action detection is an advanced technique that utilizes computer vision and deep learning algorithms to detect the dumping of garbage in a surveillance platform. The application of this technique is to identify and track individuals who are engaged in unlawful dumping activities in public places such as parks, streets, and other public areas. The process of garbage dumping action detection involves capturing real-time images or video footage from a surveillance camera. These images or footage are then analysed by the computer vision algorithms to detect any suspicious activity related to garbage dumping. The detection process involves the identification of objects, individuals, and their movements in the scene. The deep learning algorithms used in garbage dumping action detection are trained on large datasets of images and videos.

These algorithms use convolutional neural networks (CNNs) to identify and classify different objects in the scene, such as garbage bags, people, and vehicles. The algorithms can also detect the movements and actions of these objects, such as when a person is dumping garbage on the ground. Once a suspicious activity related to garbage dumping is detected, the system can alert authorities or security personnel. The captured images can be used as evidence to prosecute the suspected person or individuals involved in the activity. Overall, vision-based garbage dumping action detection is a powerful tool for enhancing the security and cleanliness of public spaces. It can help to deter individuals from engaging in illegal dumping activities and improve the overall quality of life in urban environment

Hardware modules used in a vision-based garbage dumping action detection system may include:

1. **Camera:** A camera is an essential component of a vision-based system. It captures the video frames that are processed by the system to detect actions. The type of camera used depends on the application and environment. In this case, a camera with good resolution and high frame rate would be ideal to capture the garbage dumping action.

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2. **Processing Unit:** The processing unit is responsible for running the algorithms that analyze the video frames captured by the camera. It may be a CPU or GPU, or a specialized hardware module such as a neural network accelerator.
3. **Memory:** Memory is required to store the video frames and the intermediate results of the processing.
4. **Storage:** The system may require storage to store the captured video for later analysis or evidence purposes.
5. **Network connectivity:** The system may require network connectivity to send alerts or notifications to a central monitoring system or to receive software updates.

The choice of hardware modules depends on the specific requirements of the system, such as the processing speed, accuracy, and power consumption. A powerful processing unit and sufficient memory are required for running deep learning models that are commonly used in vision-based action detection systems.

A camera with a high resolution and frame rate would ensure that the system can capture the action accurately. Additionally, the system may require reliable storage and network connectivity to ensure that the captured video and alerts are stored securely and delivered in real world.

II. LITERATURE REVIEW

[1] P. Sukholthaman, K. Shirahada, Proceedings of PICMET '14 Conference: Portland International Center for Management of Engineering and Technology; Infrastructure and Service Integration, (2014) Piles of rubbish are one of the major problems faced by most people in Malaysia, especially those who live in flats, as the number of bins is limited and shared among all residents. It may cause pollutions, which may lead to sanitary issues and diseases. This project presents the development of a smart garbage monitoring system in order to measure Waste level in the garbage bin in real-time and to alert the municipality, in particular cases, via SMS. The proposed system is consisted by the ultrasonic sensor to measure the waste level, the GSM module to send the SMS, and an Arduino Uno which controls the system operation. It supposes to generate and send the warning messages to the municipality via SMS when the waste bin is full or almost full, so the garbage can be collected immediately. Furthermore, it is expected to contribute to improving the efficiency of the solid waste disposal management.

[2] J. Redmon et al., You only look once: Unified, real□time object detection, in Proc. Comput. Vision Pattern Recogn. (CVPR), Las Vegas, NV, USA, June 27– 30, 2016, pp. 779–788. We present YOLO, a new approach to object detection. Prior work on object detection repurposes classifiers to perform detection. Instead, we frame object detection as a regression problem to spatially separated bounding boxes and associated class probabilities. A single neural network predicts bounding boxes and class probabilities directly from full images in one evaluation. Since the whole detection pipeline is a single network, it can be optimized end-to-end directly on detection performance. Our unified architecture is extremely fast. Our base YOLO model processes images in realtime at 45 frames per second. A smaller version of the network, Fast YOLO, processes an astounding 155 frames per second while still achieving double the MAP of other real-time detectors. Compared to state-of-the-art detection systems, YOLO makes more localization errors but is less likely to predict false positives on background. Finally, YOLO learns very general representations of Object.

[3] Akshay Dabholkar, Bhushan Muthiyan, Shilpa Srinivasan, Swetha Ravi, Hyeran Jeon, Jerry Gao Department of Computer Engineering San Jose State University San Jose, California illegal dumping has been a chronicle problem in many cities in the world. The odors and contaminants caused by abandoned household items and dumped garbage, and construction leftovers not only ruin the city view but also threaten citizens health. To reduce the illegal dumping, a few cities have designed community-based voluntary reporting systems and surveillance camera-based monitoring systems. However, these approaches still require manual monitoring and detection, which are costly and vulnerable to false alarms.

[4] Vision-based garbage dumping action detection for real-world surveillance platform Kimin Yun, Yongjin Kwon, Sungchan Oh, Jinyoung Moon, JongyoulParkFirst published: 10 July 2019 https://doi.org/10.4218/etrij.2018-0520Citations: 31 A new framework for detecting the unauthorized dumping of garbage in real-world surveillance camera. Although several action/behavior recognition methods have been investigated, these studies are hardly applicable to real-world scenarios because they are mainly focused on well-refined datasets. Because dumping actions in the real world take a variety of forms, building a new method to disclose the actions instead of exploiting previous

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approaches is a betterstrategy. We detected the dumping action by the change in relation between a person and the object being held by them. To find the person-held object of indefinite form, we used a background subtraction algorithm and human joint estimation. The person-held object was then tracked and the relation model between the joints and objects was built**.** Them pay the respective removal fee, could be successfully achieved with functional technologies rather than the typical measures of increasing compliance fines or enhancing reporting systems, which have failed in cities.

III. PROBLEM STATEMENT

Being able to prevent people from dumping garbage in unauthorized areas, and instead having Them pay the respective removal fee, could be successfully achieved with functional technologies rather than the typical measures of increasing compliance fines or enhancing reporting systems, which have failed in cities.

IV. PROPOSED SYSTEM

The purpose of the project is to develop a real-world surveillance platform that can detect instances of garbage dumping and initiate appropriate actions to address the issue. Specifically, the system will use computer vision techniques to identify instances of garbage dumping in a given area and will alert relevant authorities or initiate actions such as cleaning up the area or issuing fines.

Here are some of the libraries that may be used in this project:

1. **OpenCV**: This is a popular open-source computer vision library that provides a range of tools for image and video processing, including object detection and tracking. OpenCV is utilized for the analysis of a wide range of images and videos, like the recognition of the face, and object detection, editing of an image, advanced robotic vision, 18 optical character identification, and significantly more. Image processing is done through OpenCV. It focuses on real-time computer vision. Here in this model by utilizing the OpenCV python library, python scripts will be written to test the newly trained waste detection classifier on any webcam feed, images and videos.
2. **MediaPipe:** MediaPipe is a Framework for building machine learning pipelines for processing time-series data like video, audio, etc. This cross-platform Framework works on Desktop/Server, Android. Mainly used for the MediaPipe to detect Hand Gesture landmark for the purpose of human action detection.
3. **TensorFlow:** TensorFlow is an open-source software library developed by Google for building and training machine learning models. It is widely used in both academia and industry for a variety of applications, including computer vision, natural language processing, and deep learning.At its core, TensorFlow is a framework for building computational graphs. A computational graph is a series of mathematical operations that are executed in a specific order to produce a result. In TensorFlow, these operations are represented as nodes in a graph, and the data that flows between the nodes is represented as tensors.To build a machine learning model in TensorFlow, you start by defining the computational graph that represents the model. This graph typically includes a set of input nodes that represent the data you want to train your model on, a set of output nodes that represent the predictions your model will make, and a set of intermediate nodes that perform various calculations and transformations on the data.
4. **Keras:** Keras is a popular open-source deep learning framework written in Python. It provides a user-friendly interface to build, train, and deploy deep learning models. Keras allows users to quickly create neural networks without requiring extensive knowledge of mathematics or programming.

   Keras provides a high-level API that can run on top of other deep learning libraries like TensorFlow, CNTK, and Theano. It supports both convolutional and recurrent neural networks and has a large collection of pre-trained models. The main features of Keras include:

   - User-friendly interface: Keras provides an easy-to-use API that simplifies the process of building deep learning models.
   - Modularity: Keras allows users to build complex neural networks by combining smaller building blocks, or modules, together.

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- Flexibility: Keras provides the flexibility to choose from a wide range of neural network architectures, optimizers, and loss functions.
- Compatibility: Keras is compatible with multiple backends, including TensorFlow.

5. **PyTorch:** PyTorch is a popular open-source machine learning library that is widely used for building and training artificial neural networks. It was developed by Facebook's AI Research team and is based on the Torch library, which is written in Lua programming language.PyTorch provides a variety of tools and functionalities for building deep learning models. It has a user-friendly interface and supports dynamic computation graphs, which means that the computation graph can be changed on-the-fly during runtime. This feature allows for more flexibility and faster experimentation, which is especially useful when working with complex models.
6. **NumPy:** This is a library for numerical computing in Python and can be used for tasks such as matrix operations and array manipulation. NumPy is a Python library that stands for "Numerical Python". It is one of the most popular libraries used for numerical computing and data analysis in Python. NumPy provides a powerful array object that is the foundation for many scientific computing tasks. This array object is called "ndarray", which stands for N-dimensional array. N-dimensional refers to the fact that the ndarray can have any number of dimensions, such as 1-dimensional (1D) for vectors, 2-dimensional (2D) for matrices, and higher dimensions for more complex data structures.
7. **Matplotlib:** This is a library for creating visualizations in Python, and can be used to display images and other data. Matplotlib is a popular open-source data visualization library for the Python programming language. It provides a wide range of tools for creating 2D plots and graphs, as well as for customizing their appearance and style. With Matplotlib, users can create line plots, scatter plots, bar plots, histograms, pie charts, and many other types of visualizations.
   Matplotlib is built on top of NumPy, another popular Python library for numerical computing, and is often used in conjunction with other libraries such as Pandas, Seaborn, and Scikit-learn.
8. **Scikit-learn:** This is a library for machine learning in Python, and can be used for tasks such as data preprocessing, feature extraction, and model evaluation.
9. **Pandas:** This is a library for data analysis in Python and can be used to manipulate and analyze data in various formats, such as CSV files.
10. **Flask:** This is a web framework for Python and can be used to create web applications that interact with the garbage dumping detection system.
11. **PyMongo:** This is a library for working with MongoDB databases in Python and can be used to store and retrieve data related to garbage dumping incidents.

V. FUTURE ENHANCEMENT

Multi-camera support: The system could be enhanced to support multiple cameras, allowing it to monitor a larger area and improve accuracy. Real-time notification: The system could be enhanced to provide real-time notifications to relevant authorities, such as a waste management team or local law enforcement, when garbage dumping is detected.
Improved accuracy: The machine learning models used for garbage dumping detection could be further optimized to improve accuracy and reduce false positives. Integration with smart waste management systems: The system could be integrated with smart waste management systems that can automatically dispatch cleaning crews to the location of garbage dumping. Differentiate types of garbage: The system could be enhanced to differentiate between different types of garbage, such as recyclable and non-recyclable, allowing for more targeted and efficient waste management.
Localization and tracking: The system could be enhanced to localize and track the individuals who are dumping the garbage, providing additional information to authorities for follow-up action.
Environmental monitoring: The system could be expanded to include other environmental monitoring features, such as detecting air pollution or water contamination.
These enhancements could improve the overall effectiveness and efficiency of the system, making it a more valuable tool for waste management and environmental monitoring in public spaces.

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VI. CONCLUSION

The "Smart Surveillance system for illegal garbage dumping" project aims to develop a system that uses computer vision to detect when people dump garbage in public places and notify the relevant authorities for prompt action. The system uses video surveillance footage and machine learning algorithms to recognize the actions of dumping garbage.
Through the use of various libraries, such as OpenCV, TensorFlow, Keras, NumPy, SciPy, Matplotlib, Pandas, Scikit-learn, YOLO, and PyTorch, machine learning models can be developed and trained on large datasets of annotated video footage for real-world surveillance scenarios.
Potential future enhancements to the system could include multi-camera support, real-time notifications to authorities, improved accuracy of garbage dumping detection, integration with smart waste management systems, differentiation of types of garbage, localization and tracking of individuals, and environmental monitoring.
In conclusion, the "Smart Surveillance system for illegal garbage dumping" project has the potential to improve waste management and environmental monitoring in public spaces. By using computer vision and machine learning algorithms, this system can detect garbage dumping actions, provide real-time notifications to authorities, and help prevent environmental damage caused by illegal dumping of waste.

VII. ACKNOWLEDGEMENT

In the "Smart Surveillance system for illegal garbage dumping" project, the following acknowledgments can be made:

1. The developers of the open-source libraries, including OpenCV, TensorFlow, Keras, NumPy, SciPy, Matplotlib, Pandas, Scikit-learn, YOLO, and PyTorch, for providing the tools and resources necessary to develop and train the machine learning models used in the project.
2. The organizations and individuals who provided the annotated video footage used to train the machine learning models, as this data is critical to the success of the project.
3. The waste management teams and local authorities who provided feedback and support throughout the development process, as their input helped shape the direction and goals of the project.
4. The researchers and developers who have contributed to the field of computer vision and machine learning, as their work has laid the foundation for this project.
5. The funding agencies or organizations that supported the project financially, as without their support, the project may not have been possible.

Overall, the success of the "Smart Surveillance system for illegal garbage dumping" project relies on the contributions and support of many individuals and organizations, and it is important to acknowledge their efforts and assistance.

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