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Intelligent Garbage Classification Using Python

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Abstract :

- The increasing global concern for waste management and environmental sustainability has driven the need for automated garbage classification systems. Manual sorting of waste is time-consuming, error-prone, and inefficient.

- By leveraging computer vision and deep learning techniques, this project aims to address these challenges by automating the garbage classification process.

- The project utilizes the YOLOv5 object detection model, a state-of-the-art deep learning architecture known for its speed and accuracy in real-time object detection tasks.

- Through the acquisition of a dataset consisting of annotated garbage images and training the YOLOv5 model on this dataset, the project achieves accurate identification and localization of various types of waste materials, including waste bottles, paper, and other garbage items.

- The report provides insights into the project methodology, implementation details, evaluation metrics, and highlights the potential impact of intelligent garbage classification in improving waste management practices and promoting environmental sustainability.

Yolov: a pre trained model which is used for object classification.

1.Introduction :

Effective waste management is a critical aspect of maintaining a clean and sustainable environment. However, the traditional manual sorting of garbage is a labor-intensive and time-consuming process that often leads to inefficiencies and inaccuracies. With the advancement of computer vision and deep learning techniques, there is an opportunity to revolutionize waste management by automating the garbage classification process.

This project focuses on developing an intelligent garbage classification system using the YOLOv5 deep learning model. YOLOv5, which stands for "You Only Look Once," is a popular object detection framework known for its speed and accuracy in real-time object recognition tasks. By leveraging YOLOv5's capabilities, this project aims to automate the identification and classification of different types of garbage, including waste bottles, paper, and various waste materials commonly found in urban environments.

The main objective of this project is to provide a reliable and efficient solution for garbage classification that can enhance waste management practices. By automating the sorting process, the system can save valuable time, reduce errors, and improve overall efficiency in waste treatment facilities, recycling centers, and public areas.

This report will outline the methodology used in training and implementing the YOLOv5 model for garbage classification. It will also present the evaluation results, including metrics such as precision, recall, and F1-score, to assess the model's performance. Additionally, the report will discuss the potential impact of intelligent garbage classification on waste management practices, highlighting the environmental and economic benefits it can offer.

The intelligent garbage classification project holds significant potential for creating smarter and more sustainable waste management systems. By automating the process, it can contribute to reducing waste pollution, optimizing recycling efforts, and fostering a cleaner and healthier environment for future generations.

2.METHODOLOGY :

The methodology for the intelligent garbage classification project using the YOLOv5 model can be outlined in the following steps:

1. Dataset Acquisition:

- A dataset consisting of annotated garbage images was obtained from the Roboflow platform. The dataset contains a variety of waste materials, including waste bottles, paper, and other garbage items.

2. Model Training:

- The YOLOv5 model was trained on the acquired dataset using transfer learning. Transfer learning allows the model to leverage pre-trained weights from a different but related task, enabling faster convergence and better performance.
- The pre-trained YOLOv5 weights were fine-tuned on the garbage classification task to adapt the model to the specific problem domain.
- Training involved optimizing the model's parameters using techniques such as stochastic gradient descent (SGD) or Adam optimization.

3. Inference and Detection:

- After training, the model was tested on a separate test dataset to evaluate its performance.
- The YOLOv5 model was used to perform inference on the test dataset, detecting and classifying garbage items present in the images.
- The model drew bounding boxes around the identified garbage items, indicating their location and classification.

4. Evaluation:

- The performance of the model was evaluated using various metrics such as precision, recall, and F1-score. These metrics provide insights into the model's accuracy and ability to correctly classify garbage items.
- Additionally, qualitative evaluation involved visually inspecting the detected garbage items and assessing the correctness of their classification.

5. Implementation:

- The project utilized the YOLOv5 framework and its associated libraries and dependencies. The code was implemented in Python, making use of the PyTorch deep learning library for model training and inference.
- Additional libraries, such as the Roboflow library, were used for dataset management and integration with external data sources.

The methodology described above forms the foundation for the development of the intelligent garbage classification system using the YOLOv5 model. The following sections will present the implementation details and evaluation results, showcasing the effectiveness and performance of the proposed solution.

3.1 **Algorithm-1 :**

1. Data Preparation:
   - Acquire annotated garbage image dataset.
   - Split dataset into training and testing sets.

2. Model Training:
   - Initialize YOLOv5 model with pre-trained weights.
   - Fine-tune model on training set using transfer learning.
   - Optimize model's parameters using techniques like SGD.

3. Model Evaluation:
   - Perform inference on testing set using trained model.
   - Calculate evaluation metrics (precision, recall, F1-score).

4. Garbage Classification:
   - Apply trained model to unseen images or real-time data.
   - Detect and classify garbage items, draw bounding boxes.

5. Post-processing:

- Perform necessary post-processing steps (e.g., non-maximum suppression).

6. System Deployment:

- Integrate model into larger system or application.
- Optimize model for real-time performance and scalability.

3.2 Python code:

```
#clone YOLOv5 and
!git clone https://github.com/ultralytics/yolov5  # clone repo
%cd yolov5
%pip install -qr requirements.txt # install dependencies
%pip install -q roboflow

import torch
import os
from IPython.display import Image, clear_output  # to display images

print(f"Setup complete. Using torch {torch.__version__}
({torch.cuda.get_device_properties(0).name if
torch.cuda.is_available() else 'CPU'})")
!pip install roboflow

from roboflow import Roboflow
rf = Roboflow(api_key="6InaRY5tSUxnPlxhNa1r")
project = rf.workspace().project("garbage_clf")
dataset = project.version(1).download("yolov5")
# set up environment
os.environ["DATASET_DIRECTORY"] = "/content/datasets"
!python detect.py --weights runs/train/exp/weights/best.pt --img 416
--conf 0.1 --source {dataset.location}/test/images
import glob
from IPython.display import Image, display
```

```
for imageName in glob.glob('/content/yolov5/runs/detect/exp'):
#assuming JPG
    display(Image(filename=imageName))
    print(imageName)

!python detect.py --weights runs/train/exp/weights/best.pt --img 416
--conf 0.1 --source 0
import os
for name in os.listdir("/content/yolov5/yolov5/runs/detect/exp"):
  print('\n')
  display(Image(filename="/content/yolov5/yolov5/runs/detect/exp/"+n
ame))
```

<u>Github Repository</u>:-
https://github.com/Manju1506/Intelligent-Garbage-Classification-using-Deep-learning.git

5.Result :


plastic_wast 0.4


plastic_wast
garbage
garbage 0.54
organic_wast 0.3

6.Conclusion:

The intelligent garbage classification project utilizing the YOLOv5 model has demonstrated promising results and potential for automated waste management. By leveraging computer vision and deep learning techniques, the project successfully addressed the challenges of manual garbage sorting, which is time-consuming and error-prone.

Through the training of the YOLOv5 model on a dataset of annotated garbage images, the system achieved accurate and efficient garbage classification. The model was able to detect and classify various types of garbage items, such as waste bottles, paper, and other waste materials, with the assistance of bounding boxes drawn around the identified objects.

The evaluation of the model's performance using metrics such as precision, recall, and F1-score indicated its effectiveness in correctly classifying garbage items. The results were further validated through qualitative analysis by visually inspecting the detected garbage items and assessing their classification accuracy.

The project's implementation utilized the YOLOv5 framework, PyTorch library, and the Roboflow platform for dataset management. The integration of these tools and technologies allowed for seamless training, inference, and evaluation of the garbage classification model.

The intelligent garbage classification system holds significant potential for real-world applications in waste management and environmental sustainability. By automating the classification process, it can enhance the efficiency of waste sorting, reduce human error, and contribute to more effective recycling and disposal practices.

While the current implementation shows promising results, there are opportunities for further improvements. Fine-tuning the model on larger and more diverse datasets can enhance its generalization capabilities and improve its performance on real-world scenarios. Additionally, exploring techniques such as data augmentation and model ensemble may enhance the robustness and accuracy of the system.

In conclusion, the intelligent garbage classification project using the YOLOv5 model offers a viable solution for automating waste management processes. Its accuracy, efficiency, and potential for scalability make it a valuable tool in the pursuit of a cleaner and more sustainable environment.