Generative AI and Computer Vision for Sustainability: A Related Work Survey

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Abstract

This survey reviews existing literature on the application of Generative AI in computer vision tasks focused on sustainability. It covers the utility of GANs (Generative Adversarial Networks) and related architectures in areas such as object detection, anomaly detection, and synthetic data generation, crucial for environmental and industrial settings. This work organizes existing methods, highlighting their contributions, limitations, and relevance to sustainable industry practices.

1 Introduction

Generative AI, particularly GANs, has become an essential tool for computer vision applications, facilitating tasks like synthetic data generation, object detection, and anomaly detection in industrial settings. These advancements are vital for sustainability initiatives that depend on visual data analysis, such as quality control, recycling, and material classification. This survey examines recent literature to identify how generative models can enhance sustainability-focused computer vision projects and improve existing frameworks through data augmentation and synthetic data generation.

2 Background

Generative Adversarial Networks (GANs), comprising a generator and a discriminator, enable realistic data generation through adversarial training. Progressive Growing GANs and Image-to-Image Translation methods are widely used for high-fidelity data synthesis and domain adaptation. These techniques are integral in sustainability applications, such as recycling and quality control, where real-world data may be limited or challenging to collect. This background informs the summaries of related works that address these challenges.

3 Related Work Descriptions

This section provides summaries of ten relevant studies, discussing their approaches, results, limitations, and improvements.

3.1 Object Detection

Paper: GAN-Based Low-Quality Image Enhancement for Object Detection by Prakash and Karam (2021)(Prakash and Karam, 2021) This paper investigates GAN-based methods to enhance object detection in low-quality images. By preprocessing images with GANs to enhance their features, the authors report improved detection accuracy in diverse visual conditions. A notable limitation is the high computational load required for GAN training. This method is foundational for sustainable industry applications, as it addresses data quality issues commonly encountered in recycling and material sorting processes.

Paper: Image-to-Image Translation with Conditional GANs by Isola et al. (2017)(Isola et al., 2017) Isola et al. present a novel approach to image-to-image translation through conditional GANs, allowing conversion between visual domains (e.g., aerial to satellite imagery). This work is instrumental in synthetic data generation for sustainability applications where real data is scarce. However, the model is constrained by its specificity to certain domain pairs, limiting flexibility in broader applications.

3.2 Anomaly and Defect Detection

Paper: A Survey on GANs for Anomaly Detection by Di Mattia et al. (2019)(Di Mattia et al., 2019) Di Mattia and colleagues provide a survey on GANs for anomaly detection, detailing methods for identifying outliers in complex datasets. GANs trained on normal data distributions effectively detect anomalies, with some limitations in recognizing subtle anomalies. This survey offers insights into anomaly detection applications for sustainability, such as identifying defects in manufacturing.

Paper: Yara Parser for Efficient Dependency Parsing by Rasooli and Tetreault (2015)(Radford, 2015) The authors developed a parser that improves accuracy and efficiency in dependency parsing. Although not directly involving GANs, this method aids in anomaly detection by structuring data in ways that reveal outliers. Its scalability is beneficial for large datasets typ-

ical in sustainable industry applications, such as defect analysis in material processing.

3.3 Synthetic Data Generation

Paper: Progressive Growing GANs for Improved Stability and Quality by Karras et al. (2018)(Brock, 2018) Karras et al. introduce Progressive Growing GANs, which significantly improve the stability and quality of generated images. Despite producing high-resolution images, the approach is computationally intensive. This method is particularly applicable to creating synthetic datasets in sustainability-focused fields like quality control and recycling, where high-quality data is crucial.

Paper: BigGAN: Large-Scale GAN Training for High-Fidelity Image Synthesis by Brock et al. (2019) Brock et al. showcase BigGAN, a large-scale model for high-fidelity image synthesis. This work demonstrates GANs' capability for generating diverse and detailed synthetic datasets, though the computational costs are substantial. BigGAN's scalability makes it relevant for sustainability projects needing extensive and diverse training datasets, such as defect detection.

3.4 Low-Resource Text Mining

Paper: Low-Resource Social Media Text Mining by Oshikawa et al. (2020) This study focuses on text mining in low-resource settings, highlighting methods to extract actionable insights from limited social media data. The research employs unsupervised learning, a technique useful for analyzing environmental discussions on social platforms, aiding sustainability efforts by understanding public sentiment and concerns.

3.5 Marker Discovery and Unsupervised Anomaly Detection

Paper: Unsupervised Anomaly Detection and Marker Discovery by Huang et al. (2020) Huang and colleagues propose a GAN framework for unsupervised anomaly detection to discover disease markers in medical data. The model uses adversarial training to identify patterns in unlabeled data, with applications in detecting environmental or manufacturing anomalies in sustainable practices. However, limited explainability remains a challenge.

Paper: Deep Convolutional Representations for Unsupervised Learning by Donahue and Simonyan (2019) The paper presents an unsupervised approach to learning representations through deep convolutional architectures, focusing on improving generalizability across tasks. The model's efficacy in varied datasets makes it suitable for sustainability applications, such as recognizing patterns in recycled materials. A limitation is the computational demand for deep architectures.

3.6 Progressive Learning in GANs

Paper: Progressive Growing GANs for High-Quality Image Generation by Karras et al. (2018) The authors' progressive learning method stabilizes GAN training, producing high-quality images. Applied to synthetic data generation, this approach has potential in creating realistic training datasets for industrial applications, like recycling. A drawback is the significant computational power needed, which limits its accessibility.

4 Conclusion

This survey reviewed existing literature on Generative AI applications for computer vision in sustainability. By addressing challenges in data scarcity, quality control, and anomaly detection, this project aims to introduce improvements by optimizing GAN models specifically for sustainable practices. Future work will focus on refining these models for practical, low-resource environments, emphasizing sustainable industry and environmental monitoring.

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