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A BIBLIOMETRIC ANALYSIS OF COMPUTER VISION APPLICATIONS IN CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT

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ABSTRACT

With approximately 10 billion tonnes of construction and demolition waste produced yearly, the construction sector is the biggest producer of solid waste, which accounts for 40% of urban solid waste that contributes to serious environmental issues, including soil degradation, resource depletion, and an excessive dependence on landfilling. Introduction of new avenues towards addressing these issues has been facilitated by recent advancements in computer vision that have yielded efficient, self-sustaining, and prudent construction and demolition waste management. The objective of this study is to conduct a rigorous bibliometric analysis to examine the role of computer vision towards improved construction and demolition waste management. This study will identify the growth of the research area, top contributing sources, and collaboration patterns. A bibliometric approach was employed to evaluate 29 peer-reviewed journal articles and conference proceedings between 2015 and 2025. Organized keyword searching to obtain information from Scopus and Web of Science was employed. Manual analysis was done for identifying publication patterns, top sources, and country output. Keyword co-occurrence and collaboration network analysis were done using VOS viewer software. Although computer vision techniques, including semantic segmentation, object detection, and deep learning, have been promising in recycling and waste sorting automation, existing literature is fragmented. Most studies are focused on a single application, without the extraction of broader trends or collaborative dynamics. The paper provides an integrated corpus of knowledge for researchers, practitioners, and policymakers by presenting an exhaustive bibliometric analysis that documents the historical patterns of computer vision in construction and demolition waste research.

Keywords: *Bibliometric Analysis; Construction and Demolition Waste; Computer Vision; VOS viewer; Waste Management.*

1. INTRODUCTION

The construction industry is a significant contributor to global CO_2 emissions and the world's largest producer of waste (Driouache et al., 2024). Due to the accelerated global urbanisation, the annual production of construction and demolition waste (CDW) surpasses 10 billion tonnes, accounting for up to 40% of total solid waste (Prasad &

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Arashpour, 2025), rendering it the most common type of urban solid waste (Wu et al., 2024). Moreover, CDW is one of the most significant energy consumers during the construction process (Gong et al., 2024). Inadequate management and disposal of CDW may result in significant environmental deterioration, including soil pollution, resource depletion, excessive landfill usage, and increased greenhouse gas emissions (Prasad & Arashpour, 2024b). Therefore, the efficient and sustainable handling of CDW has become a significant concern for stakeholders and regulators.

Over the past years, Computer Vision (CV) has been an emerging technology, proving itself capable of resolving challenging issues related to the management of CDW. CV is a field that focuses on enabling machines to interpret and understand visual information from the world, primarily through the analysis of images and videos (Sirimewan et al., 2024). CV revolutionises the administration of CDW by automating, precisely, and efficiently, the processes of identifying, classifying, and separating waste (Sun & Gu, 2022). Advanced techniques such as semantic segmentation (Lu et al., 2022), object detection (Zhou et al., 2023), and image recognition (Dong et al., 2022) enable computer vision systems to interpret complex and mixed detritus structures in real time. This process of automation not only significantly improves the efficacy and accuracy of material recovery processes, but it also reduces the need for human labour, thereby preventing health and safety issues (Ji et al., 2024). Further to the authors, in conjunction with automation solutions and deep learning platforms, CV enables intelligent decision-making along waste sorting lines, resulting in optimal recycling rates, reduced processing costs, and sustainable construction practices.

Despite this technological enthusiasm, the literature illustrates a non-linear and fragmented progression in the development of research in CV applications for CDW. Several studies have examined single-use cases, including the classification of recyclable images (Dong et al., 2022), the detection of objects for robotic categorisation (Wang et al., 2024), and the use of semantic segmentation (Lu et al., 2022) in waste management. However, these contributions frequently continue in their isolation, lacking a comprehensive synthesis of research trends, development paths, and collaboration networks. Therefore, this paper conducts a thorough bibliometric analysis of scholarly research on CV applications in CDW management to address this critical gap. The objective of this study is to conduct a comprehensive review of the current literature on CV in CDW to establish a comprehensive foundation for the further development and dissemination of knowledge. As a result, the objectives of this study are the following: (i) to identify the evolutionary progression of the research field in CV in the CDW and (ii) to reveal the primary research themes in the field. The paper structure begins with an introduction to the study and followed by the research methodology and findings. The final section of the paper presents the conclusion of this research.

2. METHODOLOGY

This study employs a comprehensive methodological approach, applying bibliometric analysis to identify the sophisticated literature which is in relation to the CV in CDW management. According to (De-Oliveira et al., 2019) bibliometric analysis is a statistical instrument that is employed to represent the current state of scientific knowledge. It identifies research opportunities, trends, and voids by analysing citations, authors, institutions, countries, and journals, thereby facilitating the development of scientific projects. For the bibliometric analysis of this study, Scopus and Web of Science were employed due to their extensive coverage of subjects and adequate quality. Additionally, they possess the largest abstract and citation database of peer-reviewed articles in comparison to the other databases (Wijewickrama, 2025). Following key terms were used as the search string with the intention of extracting as many relevant, high-quality papers as possible. ("computer vision" OR "machine vision" OR "AI vision" OR "artificial vision") AND ("construction waste" OR "demolition waste" OR "C&D waste" OR "construction and demolition waste" OR "construction debris"). These keywords were selected for their relevance to the context of this study, with the objective of presenting a comprehensive overview of the trends and patterns in the expanding research on CV in CDW. This syntax was subsequently employed to search for articles in the selected databases using the search query "Article title, Abstract, Keywords."

A total of 52 records were retrieved from Scopus (42), and Web of Science (10) during the initial search of databases. The data was screened thoroughly, and 9 duplicate entries were removed to preserve the originality of the data for future analysis. Journal articles and conference papers were included in the literature search while books, book chapters and similar were excluded. Further publication years were limited to 2015-2025. Figure 1 illustrates the systematic review process.

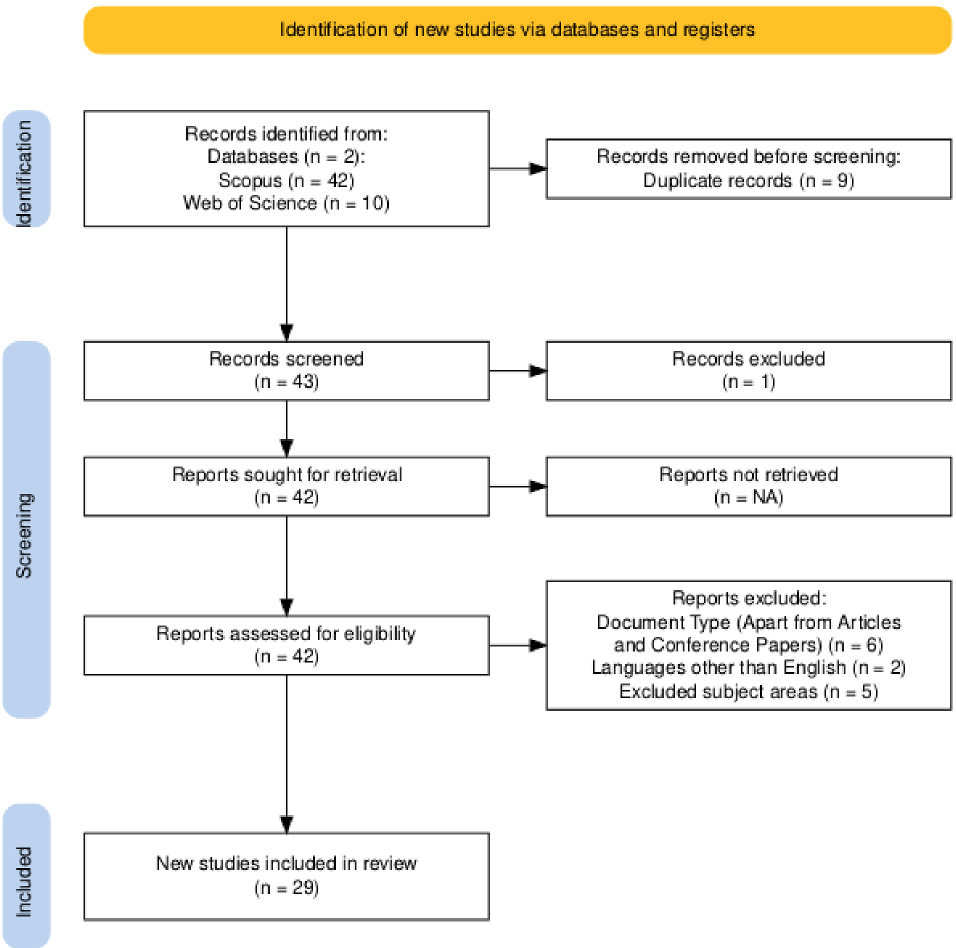


Figure 1: Systematic review process

Table 1: Inclusion and exclusion criteria

Criteria	Inclusion criteria	Exclusion criteria
Year	Publication years from 2015-2025	Publications before 2015
Document Type	Articles and Conference Papers	Books, Book chapters, reviews, notes, and editorial
Language	English language	Languages other than English
Subject Areas	Engineering, computer science, decision science, environmental science, energy, multidisciplinary	All the other subject areas

After applying the inclusion and exclusion criteria mentioned in Table 1, 29 papers from the search via databases were chosen for the analysis. This study conducted a variety of bibliometric studies using both manual techniques and VOS viewer software (version 1.6.20). The manual study concentrated on examining yearly publishing patterns and identifying the most impactful journals and conferences in the sector. Additionally, keyword co-occurrence analysis was conducted using VOS viewer to reveal significant research topics and emerging areas of interest. It also enabled the identification of prominent countries contributing to the field, as well as their patterns of international collaboration. These analyses jointly facilitated a qualitative interpretation of the bibliometric data, providing significant insights into the developing research landscape of CV in the context of CDW management.

3. RESULTS AND DISCUSSION

This section presents the results of the bibliometric analysis with relevant interpretations while addressing the objective of the study.

3.1 EVOLUTION OF PUBLICATIONS AND TOP CONTRIBUTING SOURCES

Figure 2 represents the yearly publication with related to the CV in CDW management from 2015-2025.

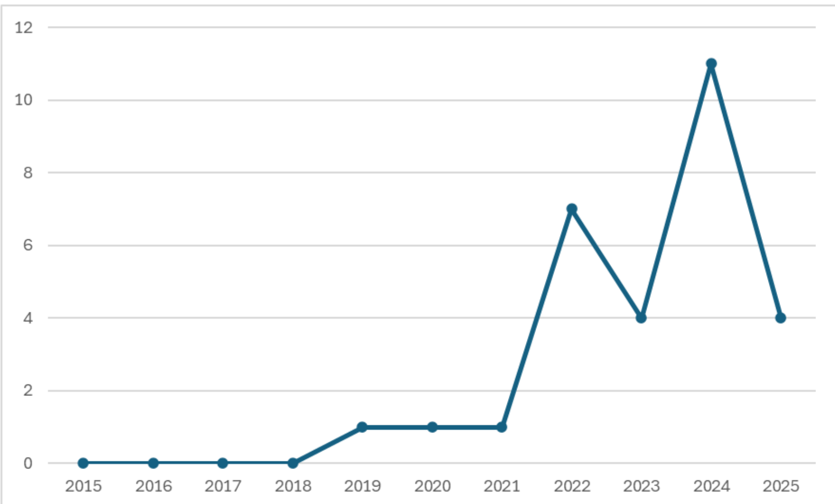


Figure 2: Publication distribution through 2015-2025

An analysis of research development patterns over the last 11 years was conducted based on the reviewed literature. According to Figure 2, there were no relevant publications concerning the chosen issue for the first four years of the specified time frame, 2015-2018. During 2019-2021 the publications remained constantly low. However, it is noticeable that there has been a gradual increase in research on computer vision in C&DW management over the past four years. This subject has attracted the attention of researchers, particularly in the years 2021–2022 increasing the publications from one to six, when it experienced a 600% rapid growth. In 2024, output reached a peak of 11 publications, exceeding the significant increase seen in 2022 by more than double. This indicates that computer vision has offered a practical solution to practical challenges in the administration of C&DW, including the generation, collection, transportation, and disposal stages. According to Wu et al. (2025), the rise in publications after 2021 is attributed to increased urbanisation, progress in intelligent technologies such as AI and computer vision, and an increasing focus on sustainable practices in the management of building and demolition waste, tackling complex difficulties within the industry. Given that merely four months have elapsed in 2025, and four publications have already been documented, it is reasonable to predict that the overall number of publications by year-end may near 12, contingent upon a steady publishing pace for the remaining months.

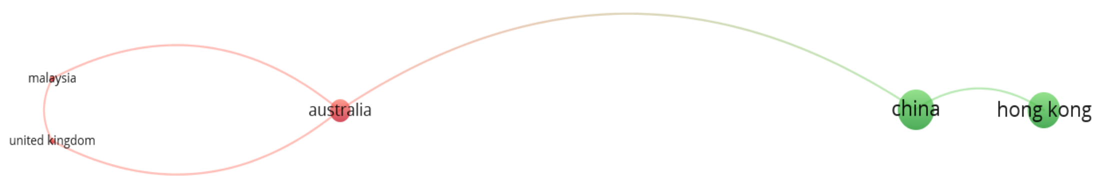
Table 2: Top contributing sources

Source Name	No of Articles
Journal of Environmental Management (Q1)	5
Resources, Conservation and Recycling (Q1)	5
Waste Management (Q1)	4
Sustainability (Switzerland) (Q2)	2
Buildings (Q2)	1

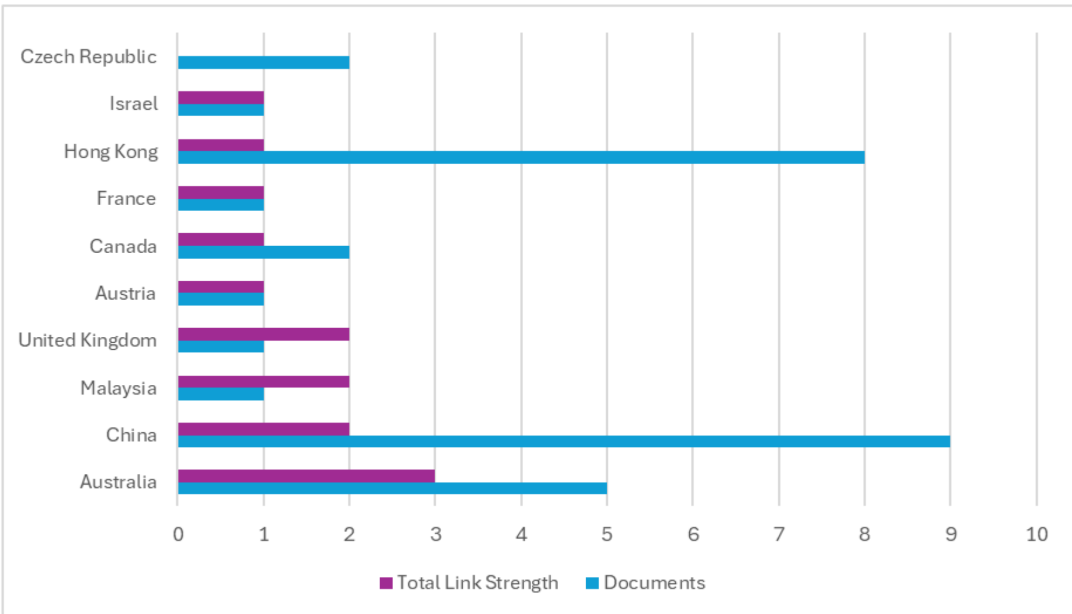
Table 2 shows the top five contributing sources of publication that have substantially contributed to advancing the area of study, publishing nearly 58% of the articles. The highest number of articles has been published by the Journal of Environmental Management (5) and Resources, Conservation and Recycling (5) followed by Waste Management (4). Even though most articles are published in journals related to waste management discipline, sources related to computer science and technology provide a substantial contribution to the knowledge in this area, providing a multidisciplinary nature to the concept.

3.2 LEADING COUNTRIES UNDERTAKING RESEARCH ON CV IN CDW MANAGEMENT

Figure 3 indicates the top countries and their collaborative networks in advancing research on CV in CDW management. In Figure 3(a), circle sizes in the image likely indicate the quantity of publications, and lines between circles indicate the strength of collaborative ties. The analysis reveals Hong Kong and China as top contributors with 8 and 9 documents respectively, proving their high level of scholarly contribution. Australia also contributes at a high level with 5 documents and a link strength total of 3, proving an active contribution. Even so, countries like Austria, Canada, and France, though contributing fewer documents, prove the diversity of global interest in CV in CDW research. This difference indicates varying degrees of interaction and collaboration between countries to advance CV research in the CDW management in the examination of collaborative activity across countries in the CV within the CDW research for the construction sector, Australia (total link strength of 3) and China (total link strength of 2) demonstrate the most significant level of collaborative linkages. The United Kingdom and Malaysia also demonstrate strong participation, with a link strength of 2, to signify their active engagement in international collaborative research efforts. While Hong Kong has a high document output of 8, a comparatively low link strength of 1 would suggest a more solo approach to research among its collaborative partners. Notably, developing nations such as Malaysia and China are well represented in collaborative research efforts. The presence of these countries along with developed nations such as Australia and the UK indicates an even contribution based on economic status. However, some countries with high scholarly contribution, such as the United States and Japan, indicate minimal cooperation (link strength of 0), indicating an independent research approach. This contrast highlights divergent strategies in CV in CDW research participation, with some nations focusing on partnerships while others focus on individual initiatives. The active co-operation of rising nations such as China and Malaysia, despite challenges, reflects their growing influence and role towards the advancement of CV research in the construction sector.



(a)



(b)

Figure 3: Representations of prominent countries and their collaborative networks in advancing research on CV in CDW management.

3.3 KEY WORD CO-OCCURRENCE

Figure 4 illustrates the results of the analysis conducted using VOS viewer software, with a minimum threshold of two occurrences for keywords. In the network, the diameter of each circle represents the frequency of the term, while the thickness of the connecting lines denotes the strength of the association between the keywords. Furthermore, the closeness of nodes demonstrates the extent of linkage, with nearer nodes indicating more closely connected phrases. Keyword co-occurrence analysis is essential in academic research as it illustrates linkages between study subjects, uncovers temporal patterns, and assists researchers in comprehending the development of knowledge domains, hence informing future research paths (Zhao, 2024). Due to the associated search string, construction and demolition waste and computer vision appear as the most occurred keywords.

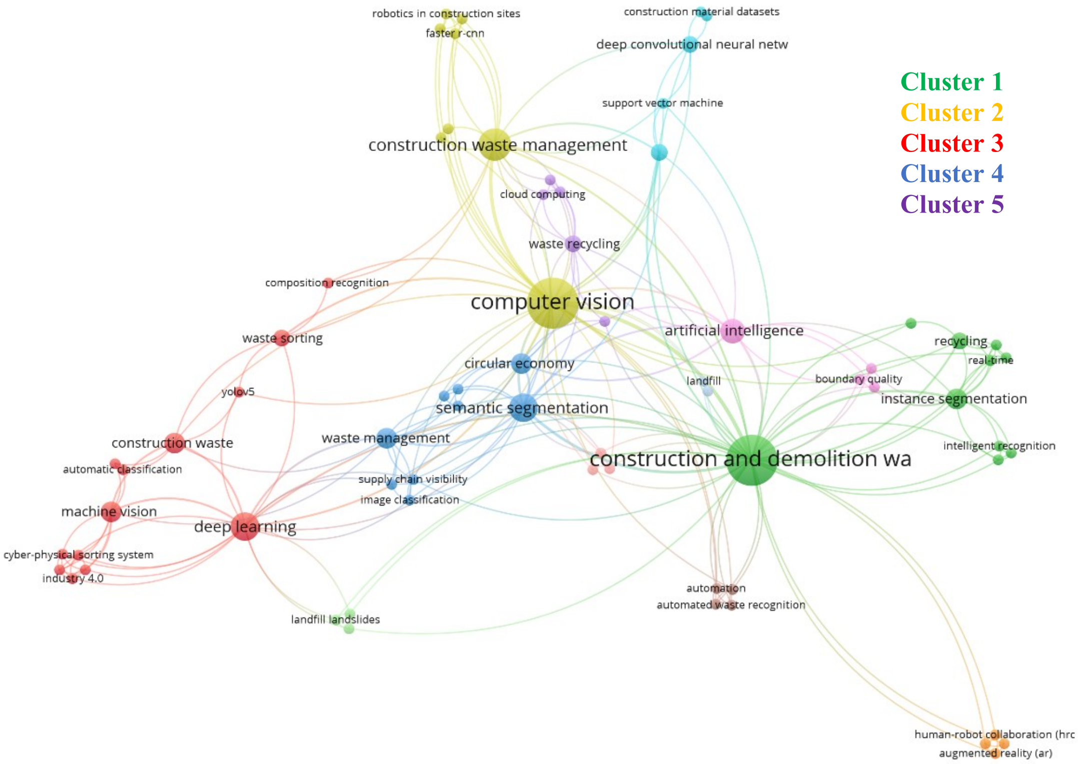


Figure 4: Key words co-occurrence analysis

The network visualisation identifies five separate research clusters in computer vision applications for construction waste management. Cluster 1 focuses on practical applications such as recycling, instance segmentation, and intelligent detection, establishing a domain-specific basis. Cluster 2 functions as a technology nexus, integrating visual analytic capabilities with waste management methodologies using technologies such as Faster R-CNN and computer vision. Cluster 3 includes sophisticated computational techniques such as YOLOv5, deep learning, automated classification, machine vision, Industry 4.0 and cyber-physical sorting systems designed for construction waste issues. Cluster 4 highlights image usage for accurate material identification across supply chains and a focus was gained in circular economy concept, whereas cluster 5 encompasses specialised neural architectures and machine learning methodologies that facilitate these applications such as cloud computing and AI. Cross-cluster interaction is most intense at the intersections of technological advancement and practical application. The strong connections between deep learning and construction waste clusters illustrate the targeted optimisation of AI algorithms for waste material detection, while the linkages between computer vision and semantic segmentation indicate the integration of methodologies across AI fields. The integration of circular economy principles across several sectors emphasises the role of sustainability frameworks in encouraging technological innovation. Emerging domains such as human-robot cooperation and augmented reality at the network perimeter indicate new multidisciplinary frontiers where physical and digital technology intersect. The collaborative patterns illustrate a research ecosystem in which computer researchers, environmental engineers, and construction management specialists collaborate to create advanced waste management solutions that integrate visual intelligence with domain knowledge.

3.4 APPLICATION OF CV IN CDW MANAGEMENT

The CDW management faces several challenges due to waste volume and environmental impact (Sirimewan et al., 2024) such as illegal disposal, costly recycling, transportation challenges, and inadequate treatment facilities (Mager et al., 2025). Further to the author, the enforcement of policy directives such as the European Union's Waste Framework Directive is obstructed by inadequate resources and inappropriate attitudes towards products derived from recycled materials. The workers' health is also at risk when manually segregating, which is why there is an inclination to automate the process. Additionally, manual sorting methods are labour-intensive and inefficient (Chen et al., 2023) and these complexities highlight the importance of automating waste recognition and handling processes and technological advancements like CV and AI.

Recent advancements in deep learning and CV have revolutionized waste management, particularly in the identification, classification, and segregation of CDW (Wang et al., 2020; Yong et al., 2023). Advanced architectures like convolutional neural networks (CNNs), Mask R-CNN, U-Net, and DeepLabv3+ enable highly accurate waste detection and segmentation, significantly improving sorting and recycling processes (Sirimewan et al., 2024). These technologies have been successfully applied in various specialized applications, including semantic segmentation models like DeepLabv3+ and PromSeg-Waste (Sirimewan et al., 2024; Wang et al., 2020) that provide pixel-level accuracy for material identification, hybrid optical-physical systems (Chen et al., 2021) that enhance composition analysis in material recovery facilities, and real-time detection systems using YOLOv5 and vision transformers (Chen et al., 2022; Yong et al., 2023) that facilitate instant trash classification. Further innovations such as instance segmentation combined with Simultaneous Localization and Mapping (SLAM) technologies (Dong et al., 2025; Wang et al., 2020) improve trash detection in complex environments, while RGB-D data integration enhances object boundary detection for robotic sorting systems (Prasad & Arashpour, 2025). Together, these technological advancements reduce reliance on manual sorting, gradually improve recycling efficiency, and support more sustainable waste management practices. When integrated with Industry 4.0 principles, the integration of automated sorting systems, enhanced by artificial intelligence and machine vision, allows for efficient classification and recycling of materials, thereby reducing waste and promoting resource recovery (Konstantinidis et al., 2023; Prasad & Arashpour, 2024a). These systems, such as Cyber-Physical Sorting Systems (CPSS), utilize multispectral imaging and deep learning to improve the accuracy of material identification, which is crucial for effective recycling (Konstantinidis et al., 2023). Furthermore, the application of Industry 4.0 principles facilitates the development of intelligent waste management solutions that can adapt to various waste types, ultimately supporting sustainable practices and reducing the environmental impact of CDW activities (Driouache et al., 2024; Nežerka et al., 2024). Table 3 demonstrates a summary of the selected articles for the study.

Table 3: Summary of the literature findings

Author	Type of model used	Usage	Dataset Size	Accuracy	Waste Type
Sirimewan et al., 2024	PromSeg-Waste model	Waste segmentation	5277 image-mask pairs corresponding to ten distinct waste classes	9% increase compared to the existing SOTA model	Concrete, Fill dirt, Wood, Hard plastic, Soft plastic, Steel, Fabric, Cardboard, Plasterboard, Glass
Konstantinidis et al., 2023	Cyber-Physical Sorting System (CPSS)	use of multi-sensor systems for real-time material classification and sorting	171 images, with 41.5% being plastic and 27.5% metal of urban-based samples from commercially available materials	80% detection accuracy	Glass, Metal, Paper, Plastic
Nežerka et al., 2024	Gradient boosting, multi-layer perception, Convolutional neural network	Waste recognition and sorting	2664 nos. of 1920 × 1280 px images of ~30–250 mm fragments distance of about 70 cm	GB-92.3%; MLP-91.3%; CNN-85.9%	Light-coloured Aerated Autoclaved Concrete (AAC), Asphalt conglomerates, Ceramics (Roof Tiles and Bricks), Concrete
Dong et al., 2025	17 models including BEiT; DeepLab V3; OCRNet; FastFCN etc	Waste sorting	4396 common local construction waste images	Highest accuracy BEiT model with 58.31% accuracy	Rock, Gravel, Earth, Packaging; Wood, Non-inter; Mixed
Zhou et al., 2023	YOLOv5	Object detection and waste sorting	3046 construction waste images	0.9480 precision on the test dataset	Brick, Wood, Stone, Plastic

Author	Type of model used	Usage	Dataset Size	Accuracy	Waste Type
Lu et al., 2022	DeepLabv3+	Semantic segmentation approach for CW composition recognition	5,366 images	mean Intersection over Union (mIoU) of 0.56 for segmenting construction waste materials	Inert and non-inert waste
Mager et al., 2025	Segment Anything Model (SAM) and ResNet-50	Aerial image analysis for illegal construction waste	46,000+ manually labelled masks	86% (area classification), 67% (mask classification)	Mixed waste
Chen et al., 2022	Monocular vision-based volume estimation algorithm	Automatic quantification of material volumes	2,914 waste truckloads analyzed	Relative error: 0.065 (bucket size), 0.169 (material-level volume); Processing time: 3.3s/image	Rock, Gravel, Earth, Packaging, Wood, Non-inter, Mixed
Dong et al., 2022	Boundary-aware Transformer (BAT) with cascade decoder and edge refinement	Semantic segmentation of different waste materials in cluttered mixtures	5366 photos of highly cluttered construction waste mixtures	69.19% Mean Accuracy	Rock, Gravel, Earth, Packaging, Wood, Non-inter, Mixed
Prasad & Arashpour, 2025	ShARP-WasteSeg: Shape-Aware Real-Time Precise Waste Segmentation (multi-modal with RGB + depth)	Real-time instance segmentation using boundary and shape info for cluttered CDW objects	3568 high-definition colour and depth images	ShARP-WasteSeg improved Mask Average Precision (AP) by 7.91%, and the boundary-sensitive Boundary Average Precision by a significant 11.44%	Aggregate, Cardboard, Hard plastic (HDPE), Metal, Soft plastic (LDPE), Timber
Yong et al., 2023	DeepLabV3+	Semantic segmentation of remote sensing	Case study in Shenzhen (52 landfills identified)	96.30% accuracy	Landfills

Author	Type of model used	Usage	Dataset Size	Accuracy	Waste Type
		imagery to detect CDW landfills			
Wang et al., 2024	Pixel-level recognition model with edge (YOLO-Tiny) & cloud computing integration (YOLACT)	Real-time automated recognition and instance segmentation for robotic waste sorting	Not specified	90.81% accuracy (edge), 93.2% instance segmentation accuracy (cloud)	Not specified
Prasad & Arashpour, 2024a	RGB-DL architecture with efficient depth fusion strategy	Intelligent segmentation of valuable recyclables from cluttered CDW streams	3,500+ RGB & depth images; 160,000+ labeled object instances	+13% segmentation accuracy	Aggregate, Cardboard, Hard plastic (HDPE), Metal, Soft plastic (LDPE), Timber
Prasad & Arashpour, 2024b	9 models including YOLACT++; CenterMask; CondInst; SOLOv2; RTMDet-Ins etc	Accurate, fast localization and segmentation of CDW recyclables	Not specified	+12.9% segmentation performance; +68% correct mask predictions	Aggregate, Cardboard, Hard plastic (HDPE), Metal, Soft plastic (LDPE), Timber
Driouache et al., 2024	Semantic segmentation DeepLabv3+	Identify and classify CDW materials in dump trucks before landfill entry	From the month of February 2022 to May 2022, 806 images were collected	accuracy: 99.0%; Homogeneity: 94.8%	Block, Gravel, Soil, Metal

4. CONCLUSION

Sustainable CDW management is crucial due to the fact that CDW accounts for up to 40% of the total solid waste produced worldwide and poses over 10 billion tonnes of waste annually. Even though the integration of computer vision (CV) in CDW processing in the form of automation of waste identification, classification, and categorisation offers potential solutions that can lead to increased recycling efficiency and a reduced environmental burden. The growth of co-related studies was prompted by global sustainability objectives and artificial intelligence in 2021, as evidenced by bibliometric metrics. China, Hong Kong, and Australia are among the countries that have been at the forefront of academic production and collaboration on an international scale. Cluster and keyword analysis reveal five critical research areas, including semantic segmentation, circular economy convergence, cyber-physical systems, and deep learning. The

YOLOv5, Mask R-CNN, and DeepLabv3+ models were used to demonstrate real-world applications of high-precision material classification and identification. In the meanwhile, the implementation of Industry 4.0 technologies, including cyber-physical systems, has enabled the development of scalable and intelligent waste management facilities. Future research should further investigate human-CV collaboration systems and adaptable models based on transfer learning. Further, the incorporation of CV with life cycle assessment methods may improve its environmental benefits, and research on its economic feasibility will enable it to be applied to a broader range of applications. In order to ensure the equitable and effective integration of CV in CDW management, it is also necessary to develop ethical artificial intelligence and smart policy-supporting tools. In conclusion, computer vision has the potential to transform CDW management by enhancing its sustainability, intelligence, and efficiency, which is consistent with the objectives of the circular economy and the global environmental community.

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