

## **A Review of Computational Vision applied to Materials Selection**

**Pedro Henrique D'Oliveira<sup>1,\*</sup>, Joyce Baptista Azevedo<sup>1,2,3</sup>, Thiago Barros Murari<sup>1,2</sup>**

<sup>1</sup> *CIMATEC University, PP-GETEC, Salvador, Bahia, Brazil,*

<sup>2</sup> *INCITE Industry 4.0, Salvador, Bahia, Brazil,*

<sup>3</sup> *Federal University of Bahia, ICTI, Camaçari, Bahia, Brazil,*

*\*Corresponding author: CIMATEC University: Salvador-BA; institution; phd19994@gmail.com*

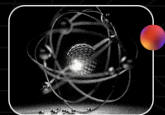
**Abstract:** This bibliographic review shows the crescent works in the field of computational vision applied to materials selection within the framework yolo. The results obtained with the search present studies from the years of 2021 to 2025, published in the patforms Dimensions, Google Scholar and WebofScience. It was observed that studies in that field are crescent, have increased from 2023. Researches in that field indicate that solutions for defects, classification and material properties are the most common fields of study. Architectures of Deep Learning and Convolutional Neural Networks are the most common used techniques, together with framework Yolo for integration in already built-in solutions

**Keywords:** material selection, material identification, artificial intelligence, computer vision, yolo

### **1.Introduction**

Currently the development of intelligent systems tends to use the generation of images and Artificial Intelligence (AI) elements of machine vision and computer vision [1] to raise the relevance in the field, since the task uses à lot of computer resources and needs a lot of data. That technology has been applied in material selection field, for example, recycling, for classification and sorting waste [2]. Other solutions consist of analyzing materials properties, using scanning electron microscopy (SEM) analysis, to identify microstructure degratation [3], but most of the solutions used currently are related to materials sortage, another related area is the solid waste identification, with Machine Learning ( ML ) algorithms that can identify metals, non-metals and plastic [5]. A tool identified in that bibliographic research for

materials selection using AI is the YOLO framework, for it's practicality and an already built-in interface for system integration and easily usage [8, 12, 14]. It has à CNN architecture build in it's structure, and make easier for defining and changing hyperparameters, besides it has à wide benchmark of increased performance and resource usage. YOLO is an open source tool which enables its use and improvement by the community, It has an advantage of using pre-trained models and databases for an existing weight-model creation, which improves the accuracy of new models[15]. Models are influenced by the environment of the scene, when light is stronger or darker, some characteristics may be affected, dropping accuracy[4, 16], depending on the model architecture and tools used to create it, for that



frameworks like YOLO within built in models are used for a wide range of applications strengthening their accuracy [ 21].

Yolo framework uses, Deep Learning (DL) architectures, that are suitable and used for crack detection in roads, as an example of applicable solution in traffic policies outperforming traditional techniques[6], and Convolutional Neural Networks (CNN) architectures that are derived from DL. CNNs are used for segmentation tasks and more detailed information from images. Another field of study and application are the automotive industry, being enhanced by YOLO's, techniques like data augmentation, and the use of CNN layer architectures are capable of identifying car damage better[7]. Another classification solution with the current methods are identifying variances in the same

## 2. Methodology

This literature review has the objective to summarize the fields of Computer Vision applied to the materials selection, with the most recent and discussed techniques and approaches. Therefore the research was done using scientific platforms like “ Google Scholar “, “Dimensions” and “ Web of Science” in the period of 2021 - 2025.

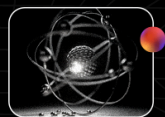
The research was made in the month of July of 2025, it involved a carefully key-word

material, as plastic for example, it has transparent plastic, which is a hard task for humans, together with some systems it can complete those tasks[8]

Computational Vision can be integrated with robot systems, either for helping human tasks, or to improve them. Waste collection is a delicate activity, with challenges within sorting objects, not only from inorganic but from organic source [5, 19]. Health and Industry activities in that field may affect people constantly, for that solutions using AI with object detection and segmentation are applied, together with frameworks like YOLO[9]

In that context this work has the objective of searching studies in the field of AI and materials selection.

search to cover the main interest areas, they words were combined using boolean operators ( AND, OR ) to maximize the scope and the results relevance. The specific key-words combination was (**“Material selection” OR “Material identification”**) AND (**“Artificial intelligence” OR “Computer vision”**) AND **“yolo”** .

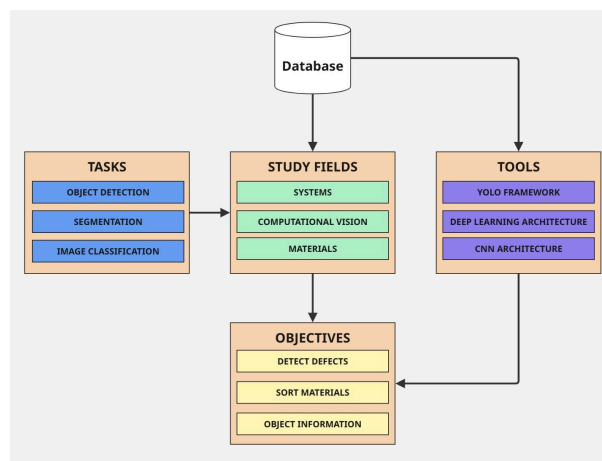


### 3. Results and Discussion

The results observed in the search appoint that there are many useful cases for applying object detection in current solutions, the most common cases are referred to identify materials patterns in 2D images[10], within the help of Deep Learning and Convolutional Neural Network techniques. There are many researches in quality control of materials, as defects are subject of many studies and are hard to detect [11].

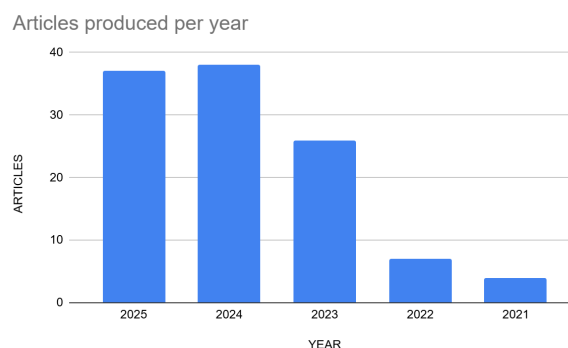
The works and solutions available follow a pattern shown in Figure 1, most common tasks are Object Detection, Segmentation and Image Classification [2, 5, 11, 12]. Many of the works in the field have a challenge of using specific database for their needs, also there are ways of maximizing the efficiency of already existing tools[13], for instance in inspection systems, with the aid of CNN techniques

**Figure 1.** Standard workflow of Computational Vision solutions and the tools used.



The search using keywords and their combinations resulted in a total of 146 publications. The quantitative of the studies is presented in figure 2, showing an increase from 2023 indicating an interest of the subject and it's use.

**Figure 2.** Summary of the articles found researching through platforms, Dimensions, Google Academic, WebofScience



The papers have results for the current “ state of the art “ reference, using CNN techniques together with YOLO and



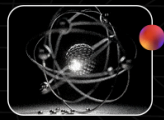
integration with other systems as robots, the accuracy in models generated by that architecture have higher results, even when under light different conditions [2]. Another approach used by the papers, is the improvement of exiting models and architectures, in recent studies using data from câmeras and milimeter wave radar to have an intersection between the layers of information and bounding boxes, had great results, showing that it is possible to generate solutions based on image conditions difficulties, since it affects deeply the results[4].

Object detection is a common task in industry and services, there was a proposal of solutions where a specific type of material shall be identified and sorted in waste management. A great result was classifying materials in metals, non-metals and plastic, in the paper, with that the algorithm scope is reduced, further increasing its accuracy with CNN architectures in the model [5], besides that using pre-trained models with labeled images from the materials type that should be identified, proved to be very useful.

In real case-scenarios like waste management, materials and objects can be in the same layer, and probably will not be separated without being covered by other objects. Training techniques for grouping more than one object with same characteristics in a layer and then detecting its label proved

efficient, as well as training multi label detection in images with objects separated [5].

Identifying materials properties have also been subject of current studies, in Review of Pavement Defect Detection Methods[11], some techniques were stated, and most of them are currently being used in general solutions. Crack Detection Based on Binary Classification, where an image is divided into sub-images and then the probability of a property ( crack, defect ), can be measured on the number of labeled “defect blocks” [11], and Crack Detection Based on Multi-Class Classification, for deciding which type of “ defect “ the image has, in a multi label problem, in that case the image is classified if it has cracks or not, if it has then a grid label is created using principal component analysis vector to decide the direction type [11]. Crack Detection Based on Pixel Segmentation is another approach where pixels are labeled or scored due to its properties. Crack Detection Based on Object Detection is the technique in which a bounding box is used to determine the object edges, in three steps, first extracting image features, second propose candidate regions for objects and finally classification the objects bounding boxes regions. Most of the results and comparisons in the study between the datasets using the techniques showed a result above 85%, they use architecture models of CNN [11].



## 4. Conclusion

The works from the search show that solutions used in the materials field are related to object segmentation, object detection and image classification, most of them are related to sortage of materials and identifying materials property, either for defects or quality control quantification.

Deep Learning and Convolutional Neural Networks are the architecture

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approaches used for modeling Computational Vision Solutions. They have better accuracy and response to modeling creation than other techniques.

YOLO is a well known and solution integrated framework used in most cases. It enables the creation of faster and resource optimized models that can be used in many different cases and scenarios.

Post Graduation Program of Management and Industrial Technology ) with all the available resources.

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