The Nineteenth International Conference on Digital Society
ICDS 2025 May 18, 2025 to May 22, 2025 - Nice, France

Image Processing Technique to Detect Adulteration of Food with Foreign Materials: A Systematic Review

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INTRODUCTION

- Image processing represents a subset of Artificial Intelligence (AI) that focuses on the examination of image data at the pixel level.
- Food adulteration is introducing inferior materials into food, which compromises public safety and health.
- The visual identification of food adulteration poses significant challenges due to the inherent complexities involved.
- Food adulteration detection represents a significant application of image data analysis, facilitating the assessment of the purity of food products.
- Different algorithms are used to develop food adulteration classification models.

- Food adulteration is one of the causes of different diseases such as cancer, autism, paralysis, internal organ dysfunction, heart attacks, infertility (testicular degeneration in males), brain damage, liver disorder, skin disorder, epidemic dropsy, nerve and vital organ damage, paralysis, tetanus, blurred vision, foot drop [1][2].
- This systematic review aims to identify the image processing techniques and the algorithms used to detect adulteration of different food items.
- The review is organized into six sections: Introduction, Methodology, Results, Discussion, Conclusion, and Future Work.

Key questions:

1. What are the health impacts of food adulteration?
2. What are image preprocessing techniques?
3. Which deep learning algorithm is best? and
4. How does image processing help to detect food adulteration?

METHODOLOGY

- Keywords of the title were used to retrieve publications “Image Processing for Food Adulteration”; “Deep Learning to Detect Bad Substances in Food”; “Image Processing AND food Adulteration AND Algorithm "Image Processing"-Chemical”; “Image Processing AND Detecting Foreign Materials in Food AND Foreign Materials.”
- Emerald, Science Direct, Google Scholar, IEEE Xplore, and Springer Link databases were accessed.
- Boolean operators, AND, OR, and NOT were used
- PRISMA (Preferred Reporting Items for Systematic Reviews and Meta Analysis) checklist was used to write the present work.
- EndNote V. 20.2 reference manager was used to cite and reference articles.
- 59 articles published between 2017 and 2021 were found relevant for the systematic review.

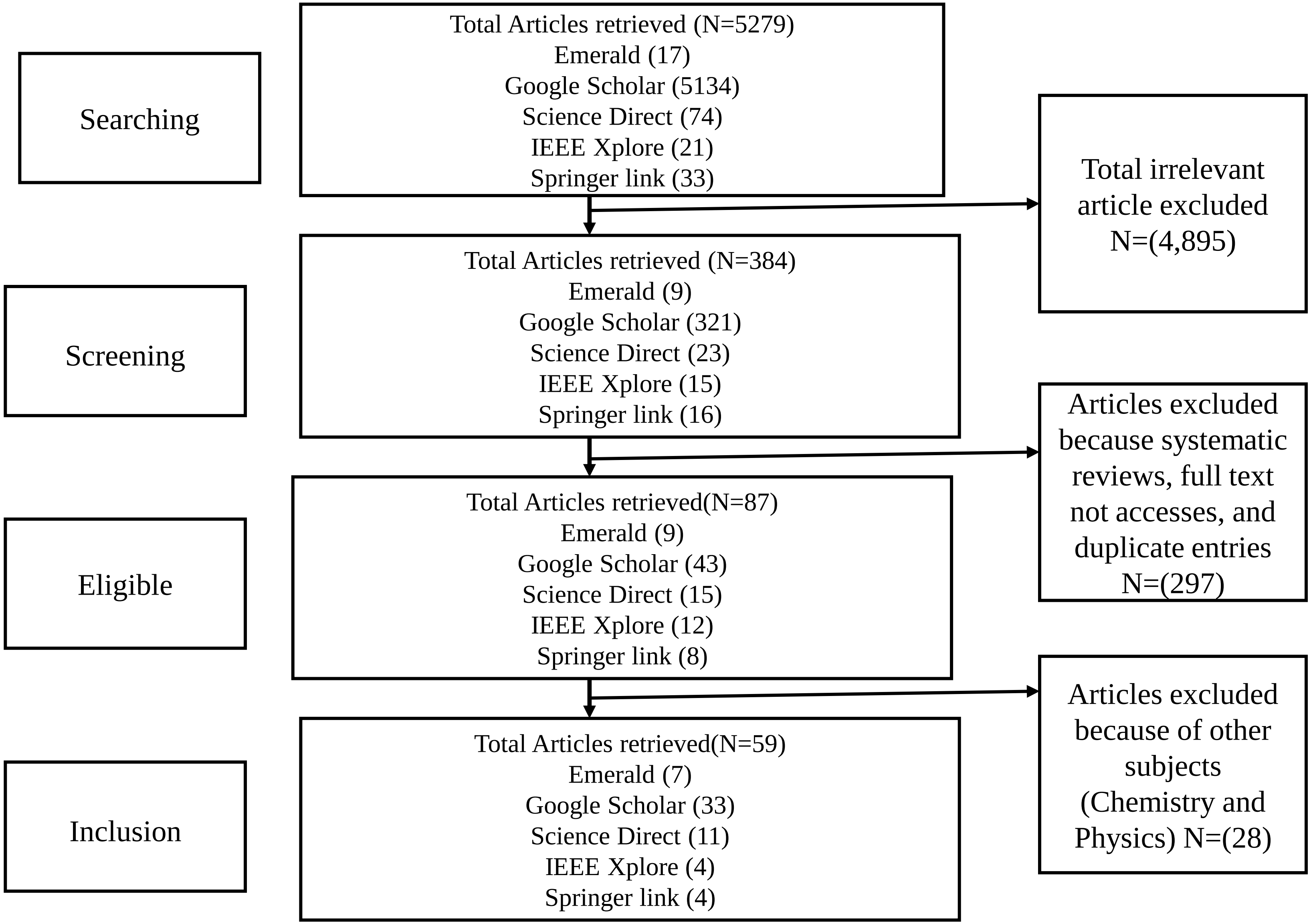

Figure 1. Steps followed to select relevant articles for the present work.

Article	Algorithm (Method)	Foreign material detected in food	Finding
[3]	Discriminant linear function	Vegetable fat in butter	92.2% accuracy
[4]	Water shade algorithm with hyperspectral image	Other grains in sorghum	96% of accuracy
[5]	CNN algorithm and FT-NIR (Fourier-transform infrared spectra)	Commercial 'espresso" adulterated by chicory, barley, and maize	98% accuracy
[6]	Siamese network	Papaya seed in black peppercorns	92% accuracy of the model
[7]	R-CNN algorithm, CNN models (AlexNet, VGG16 and VGG19)	Atlantic salmon bone residues in honey	The three models registered accuracy of 84%, 87%, and 83%
[8]	CNN	Pork and fat in red meat	94% accuracy
[9]	Hyperspectral imaging with SVM (Support Vector Machine)	Wheat bran, rice bran, and sawdust were detected in red chili powder	99% classification accuracy
[10]	Terahertz spectral imaging and CNN	Wheat husk, wheat straw, wheat leaf, wheat grain, weed, and ladybugs in wheat	ResNet-V2_50 registered 98.58%
[11]	CNN with infrared spectroscopy	Milk adulteration with Bicarbonate, formaldehyde, peroxide, starch, and sucrose	98.7% accuracy

RESULTS

- The adulteration of food products can lead to various health issues and may ultimately result in death [12].
- Image preprocessing methods encompass image correction and enhancement techniques to improve models’ accuracy.
- We found that the Convolutional Neural Network (CNN) algorithm is a widely used deep learning algorithm for image processing.
- Different food items are susceptible to food adulteration.

DISCUSSION

- Food adulteration, introducing foreign elements in food items, makes digestion difficult, leading to different health impacts.
- Image preprocessing techniques help the performance of the model’s accuracy and save computational power.
- Hyper-spectral imaging can also improve the accuracy of image analysis models.
- The Convolutional Neural Network (CNN) algorithm is currently the most used in image analysis because it handles complex convolutions and big data.

CONCLUSION AND FUTURE WORK

- Food adulteration is a key issue on the globe, impacting human health.
- Image processing can aid in the detection of food adulteration.
- Image preprocessing helps image classifier models to learn the required features.
- The CNN algorithm is the best algorithm for image data analysis.
- Hyperspectral images can improve the accuracy of the model.
- Real-time image classifier models and sensor machines are identified for future research.

ACKNOWLEDGMENT

- We would like to express our gratitude to Jimma University and the University of South-Eastern Norway for their assistance in conducting the systematic review and sharing the findings.

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