Project Notes:

Project Title: Utilizing Machine Learning to Create an Effective Tool for Managing Food Waste

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Contents:

Knowledge Gaps:

This list provides a brief overview of the major knowledge gaps for this project, how they were resolved and where to find the information.

Knowledge Gap	Resolved By	Information is located	Date resolved
Lack of knowledge about the differences between different deep learning models	Researching article 5 which told me how to create my own. This led to me to start researching all types of articles in relation to this topic.	Article 5 Notes Formal Presentation Slideshow	09/20/25
How Deep Learning Models are created	Seeing how different models used the same process and had the same characteristics	Article 2-7	10/05/25
How to form better data for my model	Analyzing the overfitting in all articles. Noticing how many of them used data augmentation	Article 5 analysis for formal meeting	10/05/2025
The best item for pre-	Reading the articles	Article 5 and Article 6	9/30/25

liminary models	and seeing that most training data was fruit. Apples had the greatest frequency of usage for models.		

Literature Search Parameters:

These searches were performed between (Start Date of reading) and 12/20/2025.

List of keywords and databases used during this project.

Database/search engine	Keywords	Summary of search
Live Science	AI	Information new AI models and how they are being applied to current inventions
IEEE	Deep Learning, AI, Food spoilage, OpenCV, CNN, Machine Learning, Refrigerators, Food Recognition, Calorie Prediction, Food Waste, Spot Spoilage, spoil types,	Multiple conference systems focusing on food recognition, calorie estimation, effect of deep learning, and spoilage detection
Academia	Food Recognition, Object Detection, Food Waste	Mostly focused on calorie estimation and detecting food objects
PNAS	Food Waste, Deep Learning, Artificial Intelligence	Theoretical use of deep learning and how it came to be
Nature.com	Food Waste	How food waste impacts society as a whole and how companies cause it
Google Patents	Food Spoilage Models	Information was available

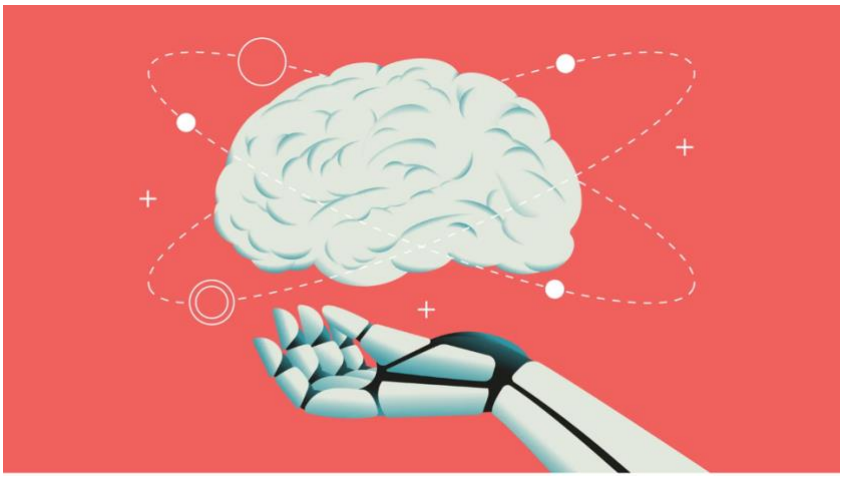
		about either patents involving calorie tracking or involving spoilage.

Tags:

Tag Name	
#objectDetectionModel	#DeepLearning
#food	#ArtificialIntelligence

Article #1 Notes: New AI system can 'predict human behavior in any situation' with unprecedented degree of accuracy, scientists say

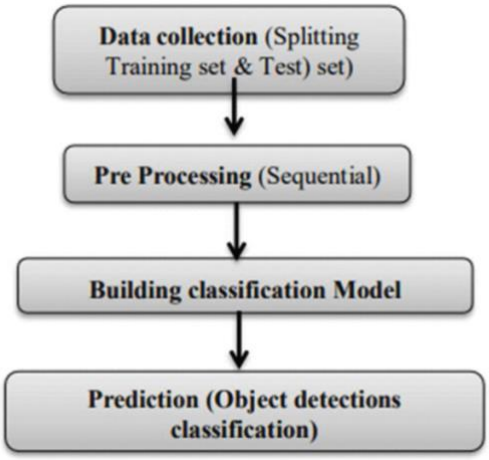
Source Title	New AI system can 'predict human behavior in any situation' with unprecedented degree of accuracy, scientists say
Source citation (APA Format)	Thaler, P. (2025, July 9). New AI system can 'predict human behavior in any situation' with unprecedented degree of accuracy, scientists… *Live Science*. https://www.livescience.com/technology/artificial-intelligence/new-ai-system-can-predict-human-behavior-in-any-situation-with-unprecedented-degree-of-accuracy-scientists-say
Original URL	https://www.livescience.com/technology/artificial-intelligence/new-ai-system-can-predict-human-behavior-in-any-situation-with-unprecedented-degree-of-accuracy-scientists-say
Source type	News Article
Keywords	Artificial Intelligence, cognitive modeling, psychology
#Tags	#ArtficialIntelligence
Summary of key points + notes (include methodology)	Centaur is a new AI language model that can anticipate and mimic human behavior through training from a dataset named Psych-101. This dataset includes over 100 million choices made by 60,000 people, including what the individuals have told, seen, and done. To enable the model to predict behavior

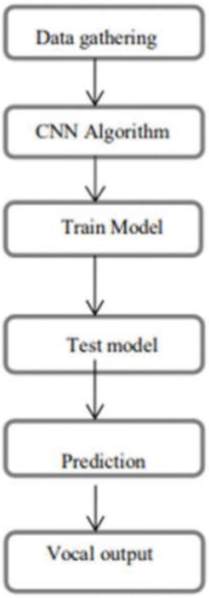
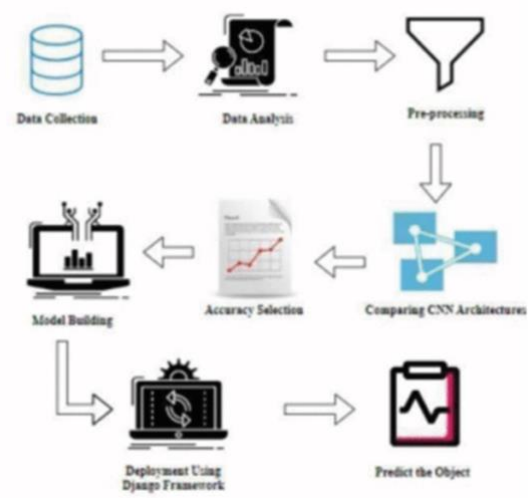
	based on an individual's characteristics, researchers aim to expand the dataset to include demographic and psychological data. These advancements will allow for answers to questions relating to how humans process information, learn through problems, and make decisions while experiencing mental health conditions. This relates to my idea of using audio and visual patterns to predict and flag individuals at public transportation stations. Training an AI model requires a dataset and possibly a model that can be tuned for the purpose of the project. This new model may be useful in predicting the choices of certain people and building connections between the behavior and the level of danger. For example, screaming (identified using YAM Net) in a passenger car signifies danger and alerts security personnel. I will need to deploy a similar process to create my own neural network (or modify another one) to predict behavior and create connections.
Research Question/Problem/ Need	Can Centaur, an AI model of human cognition predict human behavior in any situation with an unprecedented degree of accuracy?
Important Figures	 Describes the similarities between human processing and artificial intelligence predictions.
VOCAB: (w/definition)	Human Cognition- The mental process of acquiring, processing, and using information to understand and interact with the world.

	Virtual Laboratory- An online simulation of a physical lab environment Psych-101 dataset- A dataset which includes data from 60,000 people who made more than 10 million individual choices over 160 psychology experiments.
Cited references to follow up on	N/A
Follow up Questions	How would the Centaur model adjust for the accepted behavior for many cultures and demographics of people? How could teachers use this model to edit lesson plans for student preferences? How would mental disabilities impact the results of the Centaur model?

Article #2 Notes: AI Based Voice Assisted Recognition for Visually Impaired Society

Source Title	AI Based Voice Assisted Object Recognition for Visually Impaired Society
Source citation (APA Format)	Hemavathy, J., Sabarika Shree, A., Priyanka, S., & Subhashree, K. (2023). AI Based Voice Assisted Object Recognition for Visually Impaired Society. *2023 International Conference on Data Science, Agents & Artificial Intelligence (ICDSAAI)*, 1–7. https://doi.org/10.1109/ICDSAAI59313.2023.10452456
Original URL	https://ieeexplore.ieee.org/document/10452456
Source type	Conference Paper
Keywords	OpenCV, Object recognition, Text-to-speech, Environmental Response
#Tags	#ObjectDetectionModel #ArtificialIntelligence #DeepLearning
Summary of key points + notes (include methodology)	This system assists those who are visually impaired in identifying common objects around them due to alerts from their phone. It starts by using a CNN model along with OpenCV technology to identify the objects and their distance from the subject. After labeling the objects, the system converts the text to speech and provides the visually impaired person with an accurate description of their surroundings. To allow more people to access the product, it can also translate the description into other languages. This product relates to one of my ideas of creating a camera system in fridges that can use the traits of certain foods to identify when they will spoil. I can use

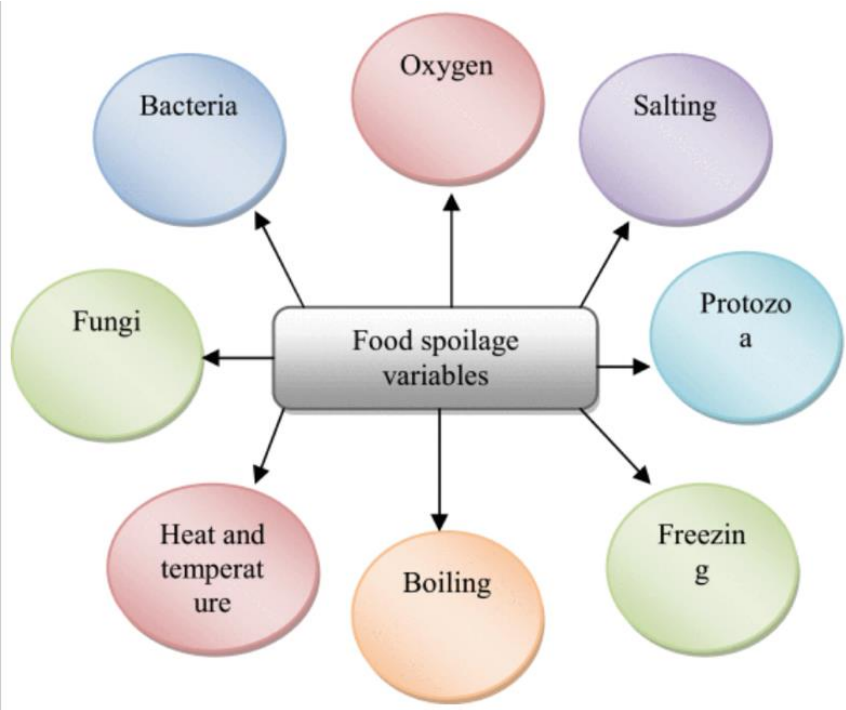
	neural networks to create connections between the images of a spoiled item and that item in the fridge. Labeling the item will allow me to track the contents of the fridge through the application. Both projects will utilize similar technologies and procedures to enhance the daily lives of individuals.
Research Question/Problem/ Need	Blind individuals need a voice-assisted application that provides technical support and assistance through their smartphones to allow them to independently navigate through the obstacles in the world around them.
Important Figures	 Describes the process of how a machine learning model learns and eventually predicts an outcome.

	 Describes the human process of creating a deep learning model.  Describes the human process of creating a deep learning model using images for visualization.
VOCAB: (w/definition)	Backpropagation- An algorithm used to train neural networks which determines how to adjust parameters to enable the model to learn from its data. Bounding boxes- A rectangle that defines the special limits of the target item

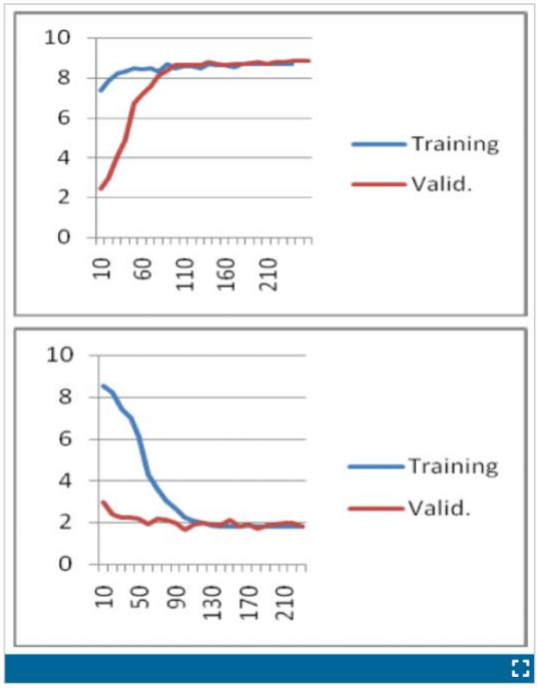
	Generalization Capabilities- The capacity of a deep learning model to perform well on unseen datasets Speech Synthesis- Another word for text-to-speech which creates artificial human speech from text.
Cited references to follow up on	N/A
Follow up Questions	How much more effective would it be to combine visual feedback with ultrasonic sensors? Could this system identify signs and other texts to provide the blind individual essential information about their surroundings? Coul vibrations be used to alert the user of their distance from objects to prevent collision. How?

Article #3 Notes: Development of CNN Model to Avoid the Food Spoiling Level

Source Title	Development of CNN Model to Avoid the Food Spoiling Level
Source citation (APA Format)	Usha, R., Selvan, R. S., Basi Reddy, A., & Chandrakanth, P. (2023). Development of CNN Model to Avoid the Food Spoiling Level. *2023 International Conference on New Frontiers in Communication, Automation, Management and Security (ICCAMS)*, *1*, 1–7. https://doi.org/10.1109/ICCAMS60113.2023.10525936
Original URL	https://ieeexplore.ieee.org/document/10525936
Source type	Conference Paper
Keywords	Sensor, Food Spoilage, CNN networks, Food storage, Gas sensors
#Tags	#objectDetectionModel #food #DeepLearning #ArtificalIntelligence
Summary of key points + notes (include methodology)	This project attempts to reduce food waste by monitoring the freshness of food by detecting changes in gas levels, humidity levels, and temperatures. When the food is no longer consumable, the system alerts the user. The final goal of the project is to use convolutional neural networks to identify the state of a food and eventually identify the ideal state to store it. The camera sensor, trained using various images, works with the humidity and gas sensors to track food deterioration. For my fridge, which detects when food is spoiling, I hope to use a similar Arduino system that uses neural networks to identify

	patterns. Furthermore, this article helped me realize that I may need a second type of sensor to get an accurate prediction.
Research Question/Problem/ Need	All urban and rural households need a monitoring system which can detect food spoilage levels to extend shelf life and reduce food waste.
Important Figures	 Describes the possible reasons for spoilage. This helps identify with the CNN model.

Names	*Minimum Temp.*	*Maximum Temp*	*Average shelf life*	*Maximum ideal storage life*	*Minimum ideal storage life*
Apple	31	31	12	15	17
Banana	31	30	40	41	43
Beetroot	32	33	15	170	172
Cherries	30	32	16	130	132
Cauliflower	33	35	18	160	162

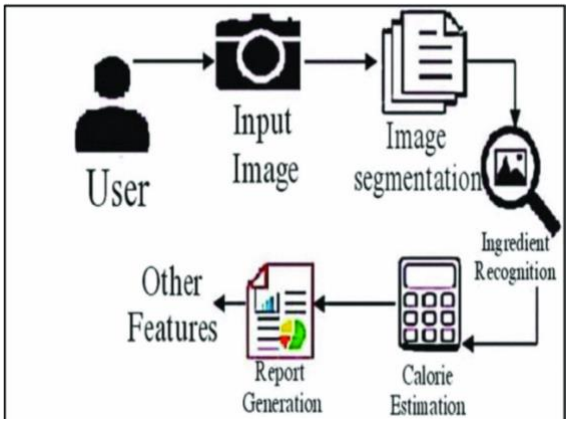
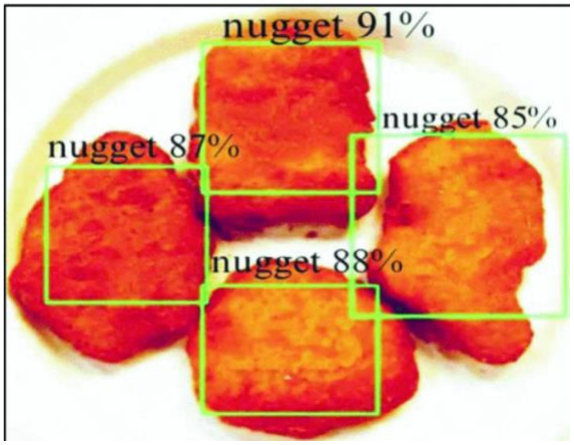
	Provides the ideal storage conditions for each item derived from the project.  **Fig. 5.** Comparison between Training Data Vs Validation Data Loss Compares validation and training data to consider overfitting. Since the lines are close together, the data is not overfitted.
VOCAB: (w/definition)	Shelf life- The amount of time food remains consumable under reasonable storage conditions Overfitting- When the model over memorizes the training set and is unable to generalize Microbiological Spoiling- Spoiling caused by bacteria and other microorganisms Epochs- The number of passes through the training dataset
Cited references to follow up on	

Follow up Questions	How would one be able to use the current method for the smaller dataset to automatically train new products from images from the user? How does the previous preservation technique impact the prediction for the new preservation technique? Could the model identify the type of microorganism causing the spoiling?

Article #4 Notes: A Multi-Purpose Food Recognition System Using Convolutional Neural Network

Source Title	A Multi-Purpose Food Recognition System Using Convolutional Neural Network
Source citation (APA Format)	Baby Shamini, P., Nivetha, R., Rituja Yadav, R., & Hemala, R. (2023). A Multi-Purpose Food Recognition System Using Convolutional Neural Network. *2023 International Conference on Research Methodologies in Knowledge Management, Artificial Intelligence and Telecommunication Engineering (RMKMATE)*, 1–5. https://doi.org/10.1109/RMKMATE59243.2023.10368631
Original URL	https://ieeexplore.ieee.org/document/10368631
Source type	Research Paper
Keywords	Food Recognition Image Segmentation Algorithm Machine Learning
#Tags	#objectDetectionModel #food #DeepLearning
Summary of key points + notes (include methodology)	This study aims to solve the issue of imbalanced food choices and unhealthy eating trends using a more cost-effective, efficient, and advanced food logging service. The system identifies the meals by analyzing an image using Convolutional Neural Network algorithms trained on an extensive dataset,

	enhanced with image augmentation techniques, and then identifies the number of calories in the food consumed. Moreover, by tracking the calories and dietary choices of the user, the application creates a personalized diet consultant as well as recommends appropriate restaurant choices. Notes: System consists of -User Profile (BMI, Calorie Consumption) -Ingredient Detection -Diet Planner -Restaurant Recommendation (Based on food images by user) -Food History -Smart assistant to have conversations about diet To get more data use data augmentation. This includes -Zoom -Angle changes Allows for data to be trained on same images. Good Source for a variety of images -Google Images -Social Media Platforms -Ingredients from restaurant, food courts, street vendors' carts
Research Question/Problem/ Need	How can a multi-purpose food recognition system track the calories one consumes and provide an accurate representation of the user's eating habits?

Important Figures	 Examines the procedure for the creation of the device. This also organizes the process through the importance of each task.  Shows an example of how bounding boxes and segmentation works to identify the object.
VOCAB: (w/definition)	Data Augmentation: A technique used to artificially increase the size and diversity of a training dataset by creating modified copies of existing data. Latency: The delay or time it takes for data to travel from one point to another. Segmentation: Dividing an image into parts to identify specific objects Dataset: A collection of data used to train AI models

	Convolutional Neural Network(CNN): A type of deep learning neural network specifically designed for processing image data, mimicking the human visual context.
Cited references to follow up on	Ganesh Gaurav, D., G, P., Dhananja, Yc, C., & KomalBharti. (2021). Survey on Food Recognition System Using Machine Learning. In *Smart Intelligent Computing and Communication Technology* (pp. 134–138). IOS Press. https://doi.org/10.3233/APC210025 Liu, C., Cao, Y., Luo, Y., Chen, G., Vokkarane, V., & Ma, Y. (2016). DeepFood: Deep Learning-Based Food Image Recognition for Computer-Aided Dietary Assessment. In C. K. Chang, L. Chiari, Y. Cao, H. Jin, M. Mokhtari, & H. Aloulou (Eds.), *Inclusive Smart Cities and Digital Health* (pp. 37–48). Springer International Publishing. https://doi.org/10.1007/978-3-319-39601-9_4 Wasif, S. M., Thakery, S., Nagauri, A., & Pereira, S. I. (2019). Food calorie estimation using machine learning and image processing. *International Journal of Advance Research, Ideas, and Innovations in Technology, 5*(2), 1627-1630. https://www.ijariit.com/manuscripts/v5i2/V5I2-1935.pdf
Follow up Questions	Although the paper states that the system can identify a collection of foods, how will it adapt to new dishes, different from the ones it is trained for? The article states that larger datasets will be collected to enhance the product. Will you use the images of users and how can that be a privacy concern?

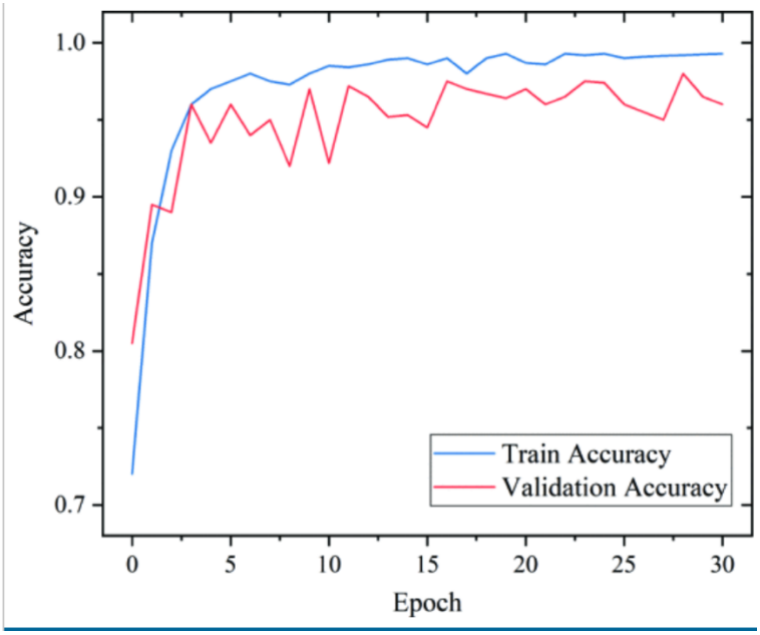
	Are you looking into increasing the number of layers in the CNN model as the diversity of foods increases or will you use other methods to keep the accuracy and speed of the system consistent?

Article #5 Notes: Automated Food Spoilage Detection Using Deep Learning: A CNN-Based Approach

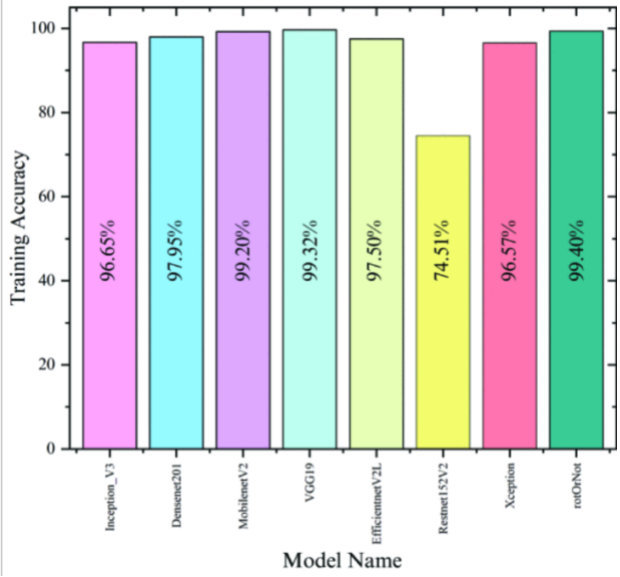
Source Title	Automated Food Spoilage Detection Using Deep Learning: A CNN-Based Approach
Source citation (APA Format)	Chowdhury, R., Rahman, Md. T., Nur, F. N., Sultana, S., & Saiful Islam, A. H. M. (2025). Automated Food Spoilage Detection Using Deep Learning: A CNN-Based Approach. *2025 2nd International Conference on Next-Generation Computing, IoT and Machine Learning (NCIM)*, 1–6. https://doi.org/10.1109/NCIM65934.2025.11160190
Original URL	https://ieeexplore.ieee.org/document/11160190
Source type	Conference Paper
Keywords	Food Spoilage Detection, Deep Learning, Food Quality Control, Freshness Detection
#Tags	#objectDetectionModel #DeepLearning #food #ArtificialIntelligence
Summary of key points + notes (include methodology)	This study attempts to solve the problem of food waste and improve food safety. Rahman et. al. introduces a convolution neural network which can detect food spoilage through the analysis of images. It uses a dataset of over 15,000 images of fruits in all stages, split 7:2:1 for training, testing, and validation, to create the model. This model, called rotOrNot was extremely accurate, with a 99.4% training accuracy and 97.52% test accuracy. Its

	accuracy was higher than many previous models and the ones it used to create the more advanced model. Since the model was trained faster than common models, it is shown to be a possible solution for reducing food waste if tested in the real world. Notes: Problem -200 diseases from consumption of spoiled food, affecting 4 billion individuals per year -1.6 million fatalities attributed to food contamination Limitations -Lack of physical hardware (difficult to apply to real world situations) -Specific dataset, little variation (prone to overfitting) Model Architecture Input Layer-1 -Confirms images are consistent -Formatted correctly -255*255 Convolutional Layers- 4 -Use filters to look for details -Earlier layers look for simple details (colors, edges) -Later Layers look for complex patterns (Identify spots of spoilage) -Use ReLU activation to hide background “noise” -Stride 2→Looks at every other pixel Pooling Layers-4

	-Summarizes most important findings from each area -2x2 pooling Flattening + Dense Layers-1 -Flattening layers format to make easier to analyze for final decision -Dense Layers make final decision Bias -Parameters different for comparing models -Different ideal usage than other models -Lack of validation loss to show the lack of overfitting.
Research Question/Problem/ Need	How can a deep learning system which aims to reduce food waste and improve food safety be developed and perform better than manual labor or sensors?
Important Figures	 Examples of the dataset



Compares the training and validation accuracy to show the lack of overfitting(Lines are fairly similar by the end, signifying no overfitting).



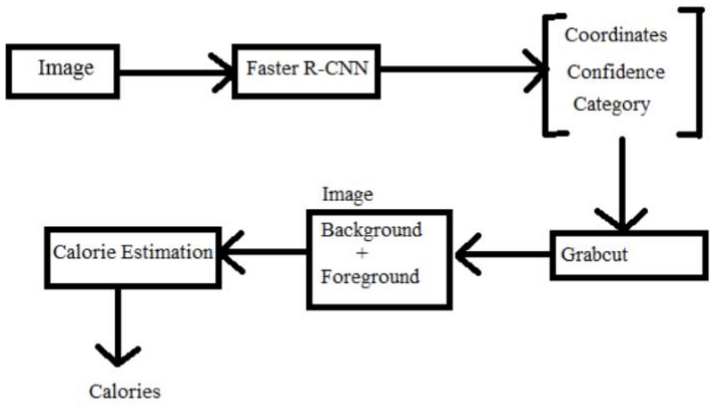
Compares the rotOrNot model with other common models for food spoilage detection.

VOCAB: (w/definition)	ROC-AUC- Receiver Operating Characteristic – Area Under Curve→measures the ability of a model to distinguish between positive and

	negative cases. In this case, it would be to distinguish between spoiled and suitable foods Validation Loss- Error on validation data, the data using for initial testing during the training phase to identify overfitting. Hashing- A method to generate a compact representation of an image Pooling Layers- Layers in a CNN model which make the network more efficient, control overfitting, and introduces small distortions in the image.
Cited references to follow up on	Masuk Shopnil, M. M., Husna, A., Sultana, S., & Islam, M. N. (2023). An Ensemble ML Model to Predict the Wastage of Food: Towards Achieving the Food Sustainability. *2023 International Conference on Next-Generation Computing, IoT and Machine Learning (NCIM)*, 1–6. https://doi.org/10.1109/NCIM59001.2023.10212669 Hebbar, N. (2020). Freshness of Food Detection using IoT and Machine Learning. *2020 International Conference on Emerging Trends in Information Technology and Engineering (Ic-ETITE)*, 1–3. https://doi.org/10.1109/ic-ETITE47903.2020.80
Follow up Questions	How does this model react to non-fruit produce, including vegetables, meats, and cooked foods)? How would the addition of odor or gas sensors affect the accuracy of this model? Would it just enhance the model or cause confusion between the systems? What would need to be done to implement this product for real-time detection in fridges?

Article #6 Notes: Food calorie estimation using machine learning and image processing

Source Title	Food calorie estimation using machine learning and image processing
Source citation (APA Format)	Wasif, S. M., Thakery, S., Nagauri, A., & Pereira, S. I. (2019). Food calorie estimation using machine learning and image processing. *International Journal of Advance Research, Ideas, and Innovations in Technology, 5*(2), 1627-1630. https://www.ijariit.com/manuscripts/v5i2/V5I2-1935.pdf
Original URL	https://www.academia.edu/39051292/Food_calorie_estimation_using_machine_learning_and_image_processing
Source type	Journal Article
Keywords	Machine Learning, Image Processing, Food Recognition, Calorie Estimation
#Tags	#objectDetectionModel #DeepLearning #food
Summary of key points + notes (include methodology)	This study attempts to assist individuals to live a healthy lifestyle by making it easier for them to track their calories. To do this, they used the top and side view of foods and image segmentation through the Grab Cut algorithm to detect the product. Then, the used volume estimation and the identity of the product to predict the calories. This product had less than 10% error in calorie estimation for some common items and fresh produce. However, it is unable to detect many cooked items.

	Notes: -Faster R-CNN-Does not rely on selective search -Uses probe object of 1-rupee coin -Probe objects are used for a scale factor to measure amount and size of food -Volume is detected using mathematical equations, each different for shape of container/food -Calories are estimated using relationship between volume, density, and calories per gram of food.
Research Question/Problem/ Need	Those attempting live a healthier lifestyle need a system to estimate the calories of food items using only images to make it easier to track calories compared to manual methods.
Important Figures	 **Fig. 1: System architecture** Shows the faster CNN system architecture.

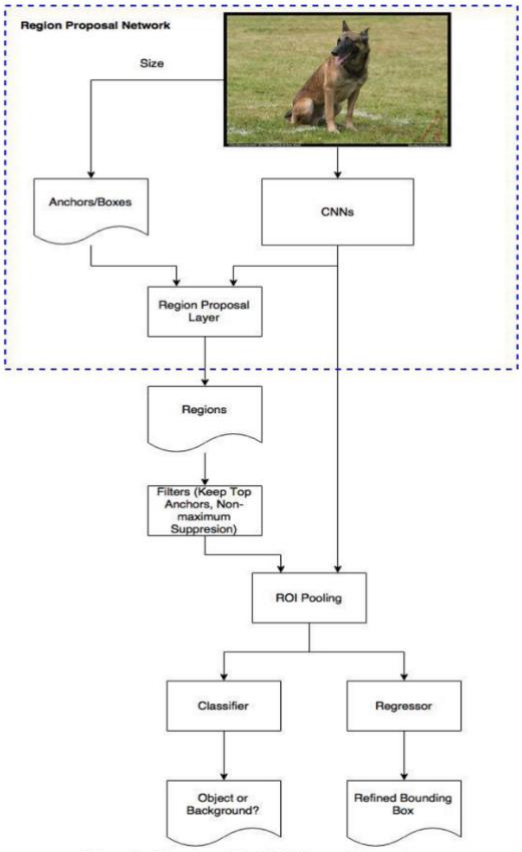


Fig. 2: Faster R-CNN architecture

Food Item	Actual Calories	Obtained Calories	Error in %
Apple	95	92	3.1
Banana	105	99	5.7
Bread	53	57	7.5
Donut	195	203	4.1
Mango	201	210	4.4
Lichi	6	7	16
Lemon	17	18	5.8
Kiwi	42	46	9.5
Orange	87	91	4.5
Egg	78	83	6.4

VOCAB: (w/definition)

Grab Cut Algorithm- A technique to sperate foreground from background with limited user input.

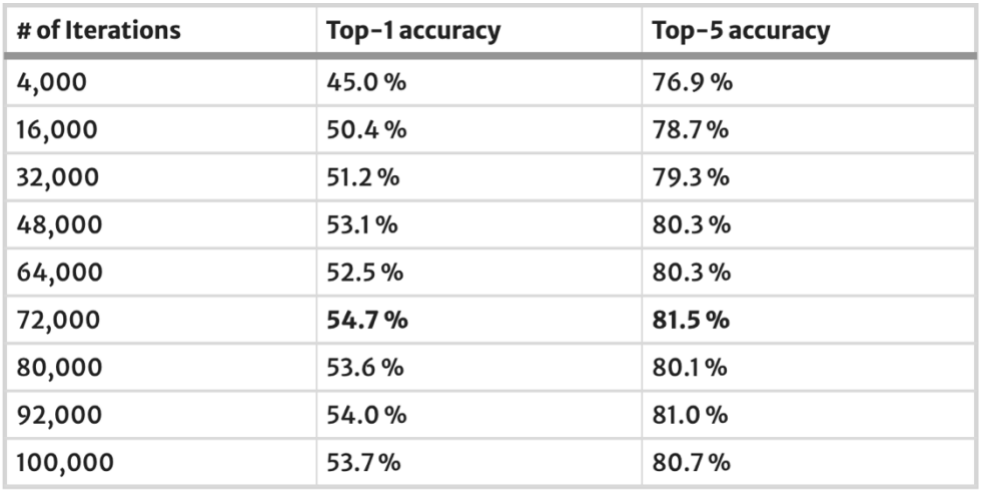
Foreground Extraction- Separating the object of focus from the rest of the image

Probe Object- A reference object with a known size, used to calculate the

	scale and volume of other objects
Cited references to follow up on	N/A
Follow up Questions	How could this model be extended to cooked foods by detecting and predicting the ingredients of the product? Would it be possible to accurately detect the item through only one image? Since this product was made in 2019, how would newer object detection techniques impact the accuracy?

Article #7 Notes: DeepFood: Deep Learning-Based Food Image Recognition for Computer-Aided Dietary Assessment

Source Title	DeepFood: Deep Learning-Based Food Image Recognition for Computer-Aided Dietary Assessment
Source citation (APA Format)	Liu, C., Cao, Y., Luo, Y., Chen, G., Vokkarane, V., & Ma, Y. (2016). DeepFood: Deep Learning-Based Food Image Recognition for Computer-Aided Dietary Assessment. In C. K. Chang, L. Chiari, Y. Cao, H. Jin, M. Mokhtari, & H. Aloulou (Eds.), *Inclusive Smart Cities and Digital Health* (pp. 37–48). Springer International Publishing. https://doi.org/10.1007/978-3-319-39601-9_4
Original URL	https://link.springer.com/chapter/10.1007/978-3-319-39601-9_4
Source type	Conference Paper
Keywords	Calorie Intake, Food Analysis, Computer Vision, Automated Pattern Recognition, Food Nanotechnology
#Tags	#objectDetectionModel #DeepLearning #food
Summary of key points + notes (include methodology)	This study attempts to accurately predict the food type, portion size, and the calories through images from mobile devices. It uses pre-trained models, UEC-100/UEC-256 and Food-101 from large-scale datasets to eventually tune their model to recognize the specific foods. Due to the large dataset, it takes 2 to 3 days for an external server to train the model.

	By the end of the training, it was able to receive high recognition accuracy, confirming that transfer learning and Inception-based architectures significantly improve food recognition. They hope to integrate this device into real-world mobile devices using a cloud-computing system. Notes: Dietary Assessments cause bias and underestimation of calorie intake Use mobile cloud computing systems-phone captures image and cloud servers analyze them Supervised learning with dataset of ImageNet Uses pre-trained models and fine-tunes them Images use bounding boxes to make items easier to recognize
Research Question/Problem/ Need	Those attempting to keep track of their diet need a product to make recording their calories simpler and more convenient to improve the accuracy of their dietary estimations.
Important Figures	

# of Iterations	Top-1 accuracy	Top-5 accuracy
4,000	45.0 %	76.9 %
16,000	50.4 %	78.7 %
32,000	51.2 %	79.3 %
48,000	53.1 %	80.3 %
64,000	52.5 %	80.3 %
72,000	**54.7 %**	**81.5 %**
80,000	53.6 %	80.1 %
92,000	54.0 %	81.0 %
100,000	53.7 %	80.7 %

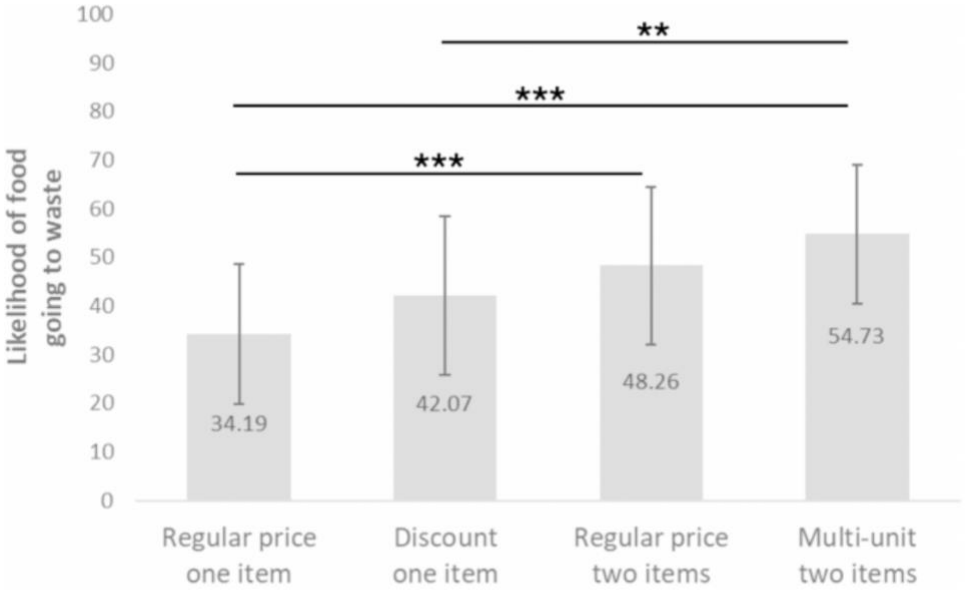
	<table><tr><th># of Iterations</th><th>Top-1 accuracy</th><th>Top-5 accuracy</th></tr><tr><td>10,000</td><td>70.2 %</td><td>91.0 %</td></tr><tr><td>30,000</td><td>74.7 %</td><td>93.0 %</td></tr><tr><td>50,000</td><td>75.1 %</td><td>93.0 %</td></tr><tr><td>70,000</td><td>74.0 %</td><td>92.1 %</td></tr><tr><td>90,000</td><td>76.3 %</td><td>93.4 %</td></tr><tr><td>160,000</td><td>76.6 %</td><td>93.4 %</td></tr><tr><td>180,000</td><td>77.2 %</td><td>93.3 %</td></tr><tr><td>200,000</td><td>76.9 %</td><td>93.4 %</td></tr><tr><td>250,000</td><td>77.4 %</td><td>93.7 %</td></tr><tr><td>300,000</td><td>76.4 %</td><td>93.0 %</td></tr></table>
VOCAB: (w/definition)	Top 1 accuracy – When the predicted outcome with the highest confidence is the correct label Cloud Integration- The process of connecting various applications and systems Transfer Learning- When a pre-trained model is reused as the starting point of a new one to reduce the time of training
Cited references to follow up on	Krizhevsky, A., Sutskever, I., & Hinton, G. E. (2012). ImageNet Classification with Deep Convolutional Neural Networks. *Advances in Neural Information Processing Systems*, *25*. https://proceedings.neurips.cc/paper/2012/hash/c399862d3b9d6b76c8436e924a68c45b-Abstract.html *MyNetDiary—Free Calorie Counter and Diet Assistant*. (n.d.). MyNetDiary. Retrieved September 20, 2025, from https://www.mynetdiary.com/
Follow up Questions	How would further training with more obscure databases help or harm the model?

	Is there a cultural bias in the datasets which may cause the model to function worse in certain locations? How can the use of systems such as OpenCV make it easier for the model to be trained and used?

Article #8 Notes: In-store promotions increase sales as well as household food waste

Source Title	In-store promotions increase sales as well as household food waste
Source citation (APA Format)	Gravert, C., & Mormann, M. (2025). In-store food promotions increase sales as well as household food waste. *Scientific Reports*, *15*(1), 18035. https://doi.org/10.1038/s41598-025-01800-x
Original URL	https://www.nature.com/articles/s41598-025-01800-x
Source type	Scientific Article
Keywords	Food Waste Over-Purchasing Promotional Offers Multi-Unit Offers
#Tags	#food
Summary of key points + notes (include methodology)	Food waste is a serious problem affecting both global food security and climate change. This large-scale field experiment uses 43,246 perishable vegetables to attempt to prove that in-store offers lead to over-purchasing of food items which results in food waste for households. To prove that multi-unit offers are often chosen, they had two offers with the same percentage of discount, one single-unit product and one double-unit product. The purchasing of double-unit products was more common. However, people were more likely to use a single-unit product when they randomly encountered the product. This shows the how humans tend to sense value from more products.

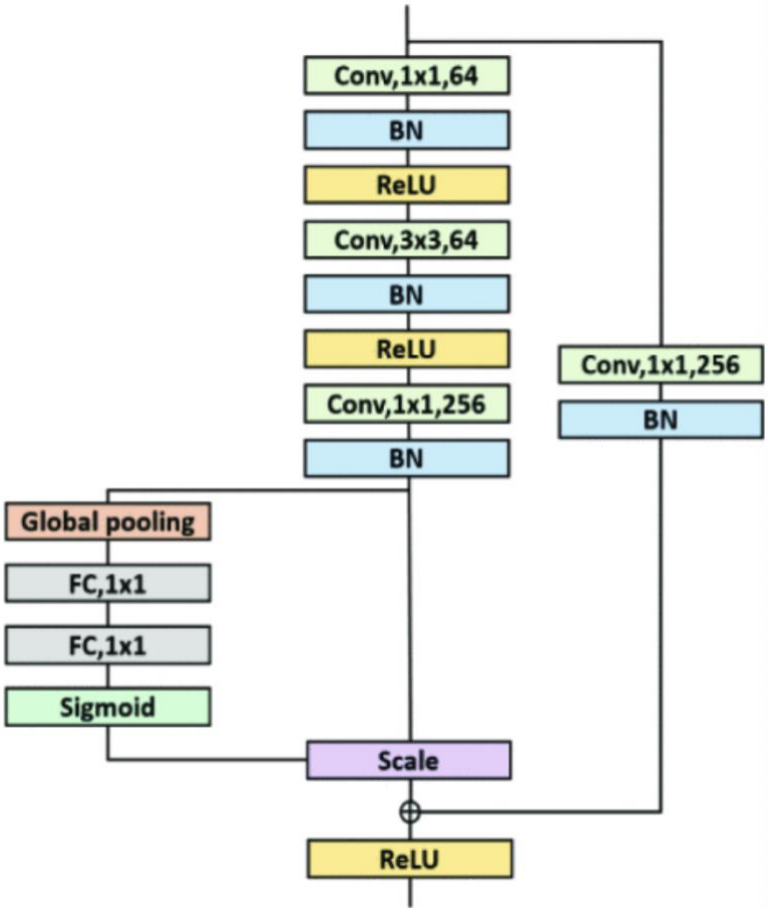
	Notes: -Over $1 trillion worth of food go to waste each year -782 million people worldwide struggle with hunger -13% of food fails to reach the retail stage -60% of food are wasted from and after the retail stage -Food was less likely to go to waste when shoppers were exposed to how much money they were actually saving with multi-unit offers -Then, single-unit products were more common, reducing food waste
Research Question/Problem/ Need	Does the availability of multi-unit offer of the same value as the single unit offer lead to increased rates of purchase and then of eventual household waste?
Important Figures	 **(A)**  **(B)**  **(C)**  **(D)**

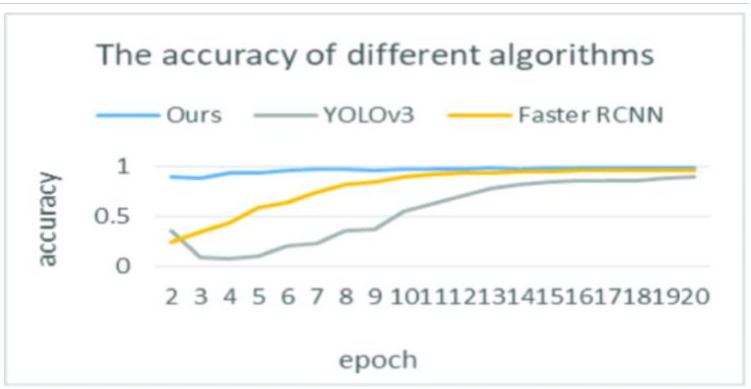
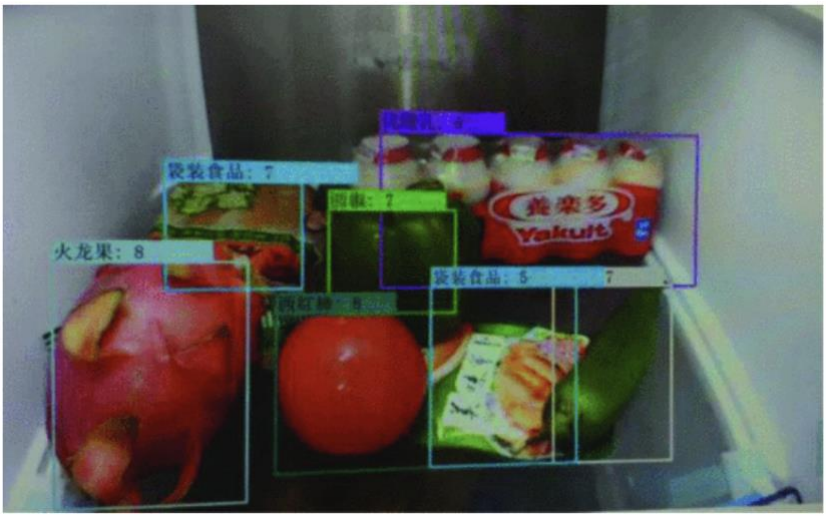
	Fig. 2  The effects of multi-unit offers on household food waste. Bars show SD. $p <$ 0.10; $^{**}p < 0.05$; $^{***}p < 0.01$ No other differences were significant.
VOCAB: (w/definition)	Perishable- Likely to decay or spoil quickly Heuristic-A mental shortcut which helps people make quick decisions without deep analysis Salient- Easily noticeable
Cited references to follow up on	Graham-Rowe, E., Jessop, D. C., & Sparks, P. (2014). Identifying motivations and barriers to minimising household food waste. *Resources, Conservation and Recycling*, *84*, 15–23. https://doi.org/10.1016/j.resconrec.2013.12.005 Williams, H., Wikström, F., Otterbring, T., Löfgren, M., & Gustafsson, A. (2012). Reasons for household food waste with special attention to packaging. *Journal of Cleaner Production*, *24*, 141–148. https://doi.org/10.1016/j.jclepro.2011.11.044

Follow up Questions	At what point (family size) does such multi-product offers become worth it, compared to the loss from single-unit products? What products are most susceptible to such spoilage, indicating a requirement of surveillance? What advertisements make one most likely to buy a product and how much of that food is wasted?

Article #9 Notes: High Precision Food Detection Method based on Deep Object Detection Network

Source Title	High Precision Food Detection Method based on Deep Object Detection Network
Source citation (APA Format)	Wang, J., Ding, X., & Guo, B. (2021). High Precision Food Detection Method based on Deep Object Detection Network. *2021 IEEE 5th Information Technology,Networking,Electronic and Automation Control Conference (ITNEC)*, *5*, 646–650. https://doi.org/10.1109/ITNEC52019.2021.9587189
Original URL	https://ieeexplore.ieee.org/document/9587189
Source type	Conference Papers
Keywords	Data Preprocessing Transfer Learning Feature Extraction
#Tags	#objectDetectionModel #DeepLearning #food
Summary of key points + notes (include methodology)	Many current technologies rely on food recognition, including smart fridges, healthy diet tracking, and food spoilage systems. This system attempts to use an advanced and improved YOLOv3 algorithm to detect the actual foods. The process starts by augmenting the data to create hybrid training images. Then, it uses anchor box clustering to create bounding boxes to help the algorithm easily identify the object. Then, after creating

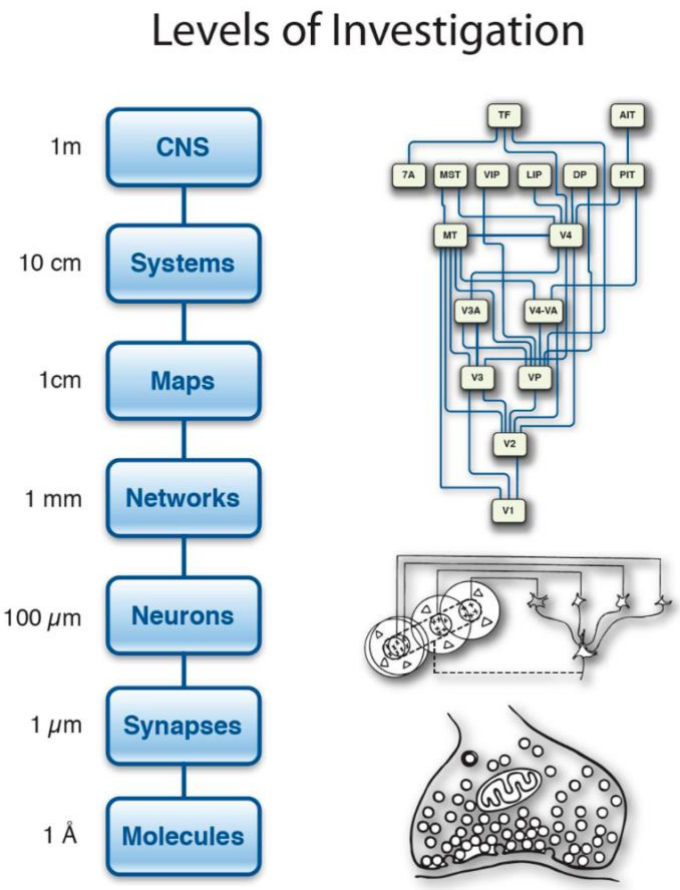
	the model, training does not commence. Instead, it uses transfer learning, which takes the knowledge from one task, and applies it to a different, but related task. This accelerates the learning so that the of 21,671 data pictures, split by a ratio of 7:2:1 for training, validation, and testing, can better form the model. Since the images were all taken naturally by cameras, the model is better trained for the testing phase.
Research Question/Problem/ Need	How can a system accurately and efficiently recognize food inside a refrigerator, even in less-than-ideal situations?
Important Figures	

	 
VOCAB: (w/definition)	YOLOv3- “You Only Look Once”, which detects multiple objects Transfer Learning- Using pre-trained models from another dataset which was used for a different, yet similar, situation to improve performance Feature Fusion- Technique to integrate multiple cues to improve recognition activity.
Cited references to follow up on	He, K., Zhang, X., Ren, S., & Sun, J. (2016). *Deep Residual Learning for Image Recognition*. 770–778. https://openaccess.thecvf.com/content_cvpr_2016/html/He_Deep_Residual_Learning_CVPR_2016_paper.html

Follow up Questions	How does the system perform for systems with unseen food types or different fridge layout types? What is the trade-off for using such a large model size for real world scenarios? How could one edit the model to work with specific filters to identify food spoilage?

Article #10 Notes: The unreasonable effectiveness of deep learning in artificial intelligence

Source Title	The unreasonable effectiveness of deep learning in artificial intelligence
Source citation (APA Format)	Sejnowski, T. J. (2020). The unreasonable effectiveness of deep learning in artificial intelligence. *Proceedings of the National Academy of Sciences*, *117*(48), 30033–30038. https://doi.org/10.1073/pnas.1907373117
Original URL	https://www.pnas.org/doi/10.1073/pnas.1907373117
Source type	Research Article
Keywords	Deep Learning Neural Networks Generative Models
#Tags	#DeepLearning #ArtificalIntelligence
Summary of key points + notes (include methodology)	Deep learning models are essential for so many tasks, yet it is uncommon to fully understand why. They attempt to replicate the human brain processes by using the neuron models and structure. To get a full understanding, the methods that must be used are analysis of deep learning networks in real-world tasks and outliers when training. This provides information about how such networks can learn and scale with more training and layers. The first model, Perceptron, from the 1950s, trained one neuron to identify a pattern. In later models, unsupervised models and multiple layers were created.

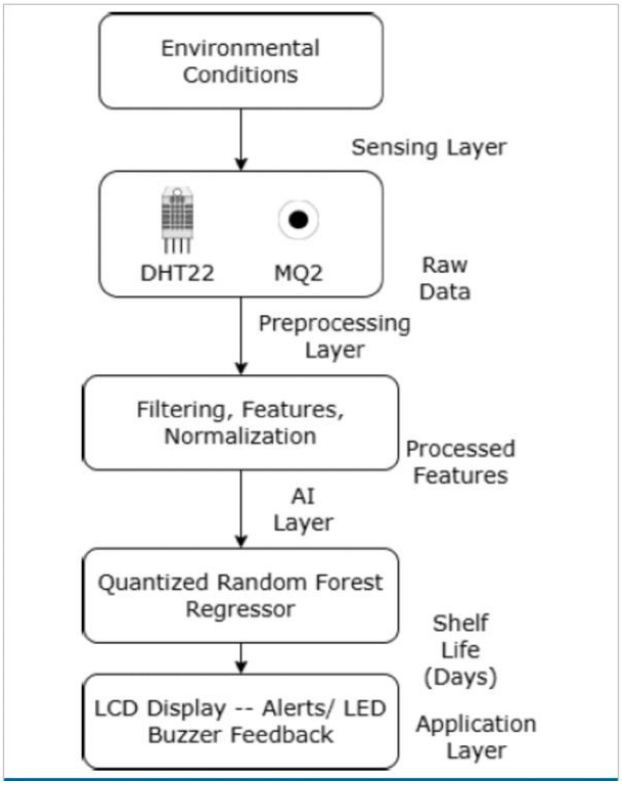
	Notes: -More layers often improve performance, scalable -Studying brains can inspire ways to advance AI -Surprisingly, deep learning networks can work well with more parameters than training examples
Research Question/Problem/ Need	How are deep learning models a replication of human activities and how are they made?
Important Figures	
VOCAB: (w/definition)	Perceptron- The earliest deep learning model which had a single layer and

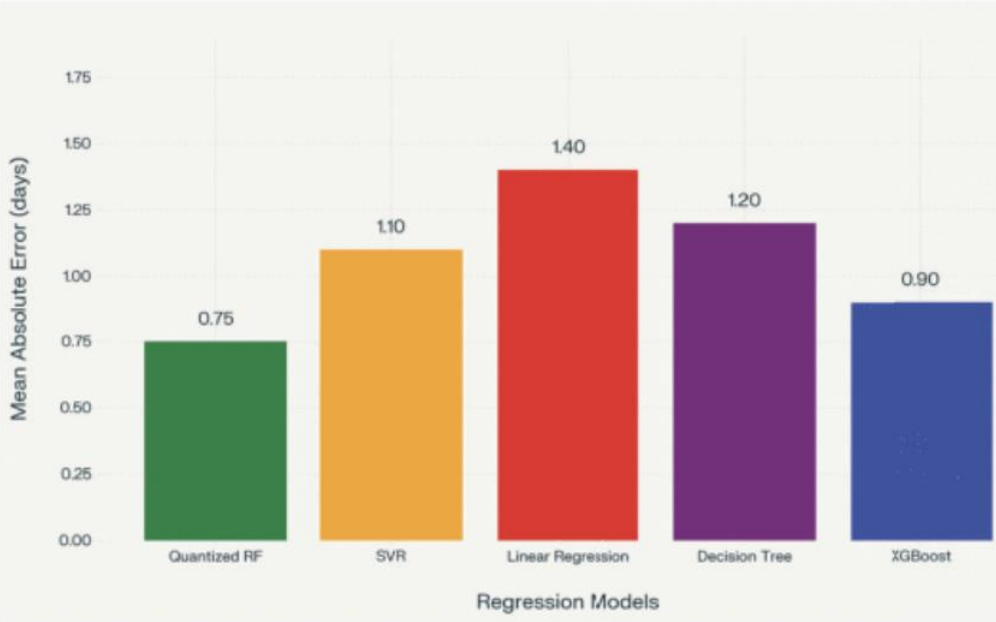
	was capable of extremely simple pattern recognition Boltzmann Machine- Neural network model which could use multiple layers Overparameterization- When the neural network has parameters than training dataset examples
Cited references to follow up on	Sejnowski, T. J. (2018). *The Deep Learning Revolution*. MIT Press. Ackley, D. H., Hinton, G. E., & Sejnowski, T. J. (1985). A learning algorithm for boltzmann machines. *Cognitive Science*, *9*(1), 147–169. https://doi.org/10.1016/S0364-0213(85)80012-4
Follow up Questions	How can the prediction of emotions be modeled by neural networks? Do deep learning models benefit from rest to retain information? How can multiple specialized networks increase or decrease the effectiveness of a generalized model?

Article #11 Notes: AI Based Food Freshness Tracking System with Shelf-Life Prediction

Source Title	AI Based Food Freshness Tracking System with Shelf-Life Prediction
Source citation (APA Format)	Reddy, E. K., Balaji, T. S. P., & Manivannan, K. K. (2025). AI Based Food Freshness Tracking System with Shelf-Life Prediction. *2025 5th International Conference on Intelligent Technologies (CONIT)*, 1–6. https://doi.org/10.1109/CONIT65521.2025.11166784
Original URL	https://ieeexplore.ieee.org/document/11166784
Source type	Conference Paper
Keywords	Internet of Things technologies Shelf Life Gas Sensors
#Tags	#objectDetectionModel #food #DeepLearning #ArtificalIntelligence
Summary of key points + notes (include methodology)	Main Problem: -1.3 billion tons (1/3 of world's food production) wasted each year due to spoiling + incorrect handling -Methane released→greenhouse gases -Hunger + resource inefficiency Due to static expiration dates that do not represent actual state

	Visual examination or predetermined expiration dates do not account for storage containers + diverse food types + chemical around + humidity + temperature Objective -Design architecture with real-time monitoring with AI models. -Use machine learning models -Cross validate across different categories under different conditions -Quantify real-world impacts Methodology P1: -MQ2 gas sensor to detect ammonia and ethylene -DHT22 to detect temperature and humidity -3o-day interval of controlled temp at 90% humidity to get samples of 1,500 examples +visual observation of mold or coloring P2: -Sensor measurements for 6 key features: temp, humidity %, gas emission avg, interaction (ex. Temp * humidity), rate of change in gas concentration, normal value -Uses Random Forest Regressor since can fight overfitting and model non-linear relationships P3 -Run CNN model through TensorFlow Lite→low-resource hardware -Kept 92% accuracy

	-Each prediction taking 2.1 seconds on average P4 -Tests products and cross validates between temp and food Results -Accuracy of 92% -Trend→Protein-based foods with the lowest mean of absolute error.
Research Question/Problem/ Need	The world which requires food needs new technologies that can offer accurate and real-time measurements of food quality to prevent waste and ensure maximum safety.
Important Figures	 This figure displays the CNN model and the processes it went through to evnetually predict the outcome. One must notice that this figure does not

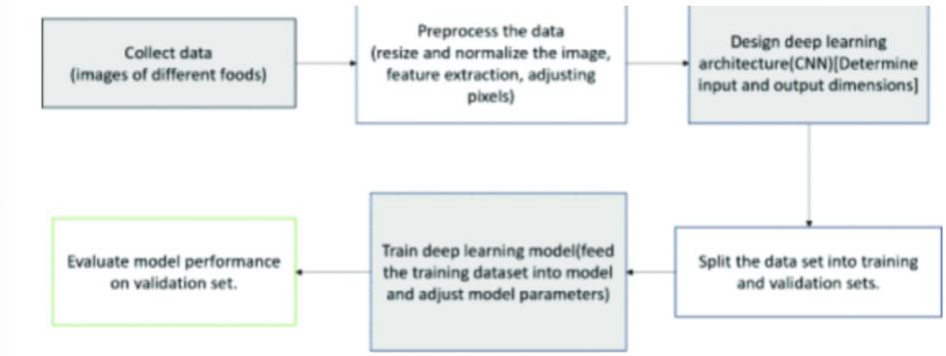
	just adress the CNN model, but also the additional steps needed before and after the model is used.  This figure compares the mean of absolute error helps to identify the best method to predict shelf-life.
VOCAB: (w/definition)	Regression models-Predict numeric value based on input Decision Trees-Splits data based on features→prone to overfitting Random Forests-Multiple decision trees Cross-Validation – A type of testing method to check whether a sitatuion works similarly in all scenarios
Cited references to follow up on	*Monitoring and Shelf Life Extension of Food Products Based on Machine Learning and Deep Learning: Progress and Potential Applications: Food Reviews International: Vol 0, No 0*. (n.d.). Retrieved October 15, 2025, from https://www.tandfonline.com/doi/abs/10.1080/87559129.2025.2541856
Follow up Questions	1.Could you integrate both visual and gas sensors to synergize at the same

	time to reduce computing time? 2. How would this impact the number of food-borne illnesses? 3. What other factors like the previous storage condition could impact the cross-inspection?

Article #12 Notes: Deep Spoil: A Deep Learning-Based model for Accurate Food Spoilage Detection

Source Title	Deep Spoil: A Deep Learning-Based model for Accurate Food Spoilage Detection
Source citation (APA Format)	Chigurupati, M., Gopavarapu, A., & Sammeta, N. (2025). Deep Spoil: A Deep Learning-Based model for Accurate Food Spoilage Detection. *2025 2nd International Conference on Research Methodologies in Knowledge Management, Artificial Intelligence and Telecommunication Engineering (RMKMATE)*, 1–7. https://doi.org/10.1109/RMKMATE64874.2025.11042472
Original URL	https://ieeexplore.ieee.org/document/11042472
Source type	Conference Paper
Keywords	VGG model Real-time detection CNN Architecture Image preprocessing
#Tags	#objectDetectionModel #food #DeepLearning #ArtificalIntelligence
Summary of key points + notes (include methodology)	Problem -Food Spoilage affects global economy + human health + environmental elements -Current human dependence to detect foods requires high costs while being unreliable (human error)

	Objective -Develop deep learning model that can classify whether food is spoiled or not using image datasets -Stack based model -Compare with different models -Improved accuracies Methodology Data Description Dataset-Kaggle which has 9147 pictures 416 x 416 pixels Contains fresh and rotten apples, bananas, and oranges (6 classes) Preprocessing Creation -CNN model -Using YOLO for bounding boxes Training -64 batch size -Binary cross-entropy function (common for CNN models) -Includes Convolutional layers and pooling layers -0.001 learning rate→slow but good knowledge retention -10 epochs only (too little) Also uses VGG model which has the same processes but a different retention strategy Uses RNN Algorithm as well

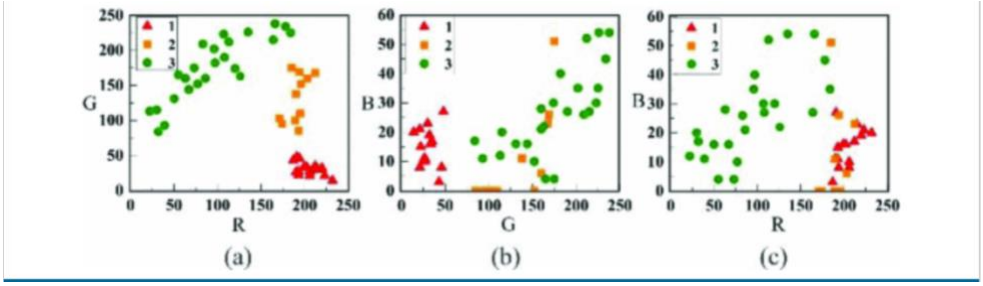
	Uses LeNet to make predictions about object locations and class at the same time as another method Highest accuracy was through the CNN model, VGG model, then LeNet, and lastly the RNN algorithm giving the conclusion that it should be used.
Research Question/Problem/ Need	What type of deep learning model can best identify the visual difference between spoiled and fresh foods?
Important Figures	 The training process which is standard for all models is shown in the figure above. *SNO* | *Model* | *Accuracy* | *loss* 1 | CNN | 0.9336 | 0.1814 2 | VGG | 0.9367 | 0.2114 3 | RNN | 0.2425 | 1.7526 4 | LeNet | 0.8938 | 0.2952 This shows that the CNN model was the most accurate with the least loss.
VOCAB: (w/definition)	Binary Cross-Entropy Function- A loss function for binary tasks when there are only two possible outputs Backpropagation-Algorithm used to neural networks by minimizing loss

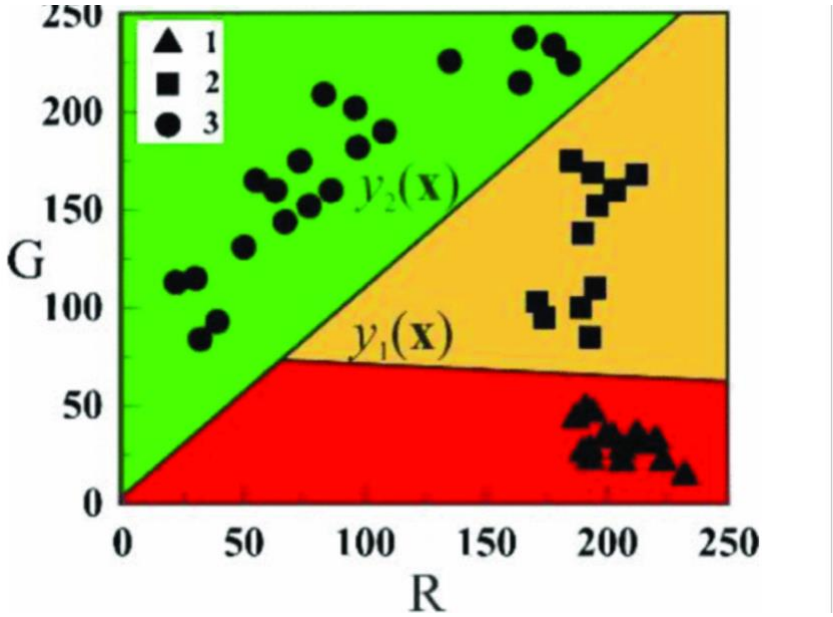
	Multi-class classification-Problems where there is more than two possible class (types of objects)
Cited references to follow up on	Megalingam, R. K., Sree, G. S., Reddy, G. M., Sri Krishna, I. R., & Suriya, L. U. (2019). Food Spoilage Detection Using Convolutional Neural Networks and K Means Clustering. *2019 3rd International Conference on Recent Developments in Control, Automation & Power Engineering (RDCAPE)*, 488–493. https://doi.org/10.1109/RDCAPE47089.2019.8979114
Follow up Questions	1. Would the VGG model and LeNet model perform better with more epochs of training? 2. What does the higher loss for the VGG model mean for its usage? 3. What type of structure would be the most useful for lower processing power systems in real life scenarios?

Article #13 Notes: Construction of a Linear Food Quality Classifier Based on their Color Analysis

Source Title	Construction of a Linear Food Quality Classifier Based on their Color Analysis
Source citation (APA Format)	Savchenko, A., Galuza, A., Protsay, N., Kolenov, I., Tevyasheva, O., & Tonitsa, O. (2021). Construction of a Linear Food Quality Classifier Based on Their Color Analysis. *2021 11th International Conference on Advanced Computer Information Technologies (ACIT)*, 5–8. https://doi.org/10.1109/ACIT52158.2021.9548333
Original URL	https://ieeexplore.ieee.org/document/9548333
Source type	Conference Paper
Keywords	Multi-class classification problem Real-time diagnostics Color Analysis Food Product Quality Color Ripeness RGB
#Tags	#objectDetectionModel #food #DeepLearning #ArtificalIntelligence
Summary of key points +	Problem

notes (include methodology)	-Difficult to identify food product quality in real time without physically contacting the product -Traditional methods(manual) are slow and require significant labor -Often, dynamic changes in quality including meat spoilage in varying conditions can make classification difficult -Color perception requires multi-dimensional analysis, making the mathematical analysis complex Objective -Develop automated systems to identify food products based on real-time, color analysis -The model must be able to handle both static samples (like apples which don't change color rapidly) and dynamic samples (tuna which changes colors rapidly in varying conditions) -Identify the minimum dimension of the sample that allows class identification Methodology Data Collection -200 Gala apples photos taken under controlled lighting for uniform lighting -6 tuna samples cut into smaller pieces and stored under a variety of conditions (due to dynamic states), including different temperatures, humidity, oxygen, and light for 100 hours. -Each sample was photographed 17 times Format -Objects represented by (R, G, B) vectors for both products -For tuna (dynamic sample), the color states were tracked across multiple time points -Apples assigned 3 classes for ripeness: 1-Ripe, 2- Medium, 3-Unripe -Tuna assigned 2 classes: 1-Edible, 2-Inedible

	-For tuna, there were points identified which would show what transitioned between the classes Construction -Apple colors only used R(red) and G(green) when plotted -Three classes compared with each other pairwise (One versus one) -Decision made directly with range of colors -Tuna did not just RGB values -Data was converted to Lab color space, which better matches how humans see color -Use critical points to focus on difference from edible and inedible meat -Use the change in time with Lab space colors to predict spoilage Results -Successful to identify three ripeness classes for static in apples -No numerical percentages reported apart from conclusion for apples -8% classification error for training set -False positive: 7%, False Negative: 0.9% -Missing spoiled meat percentage is less than 1%
Research Question/Problem/ Need	How can the quality of food be assessed based on the color of the product in real-time using optical color analysis?
Important Figures	 The training sample for Gala Apples in pairs of coordinates comparing the classes

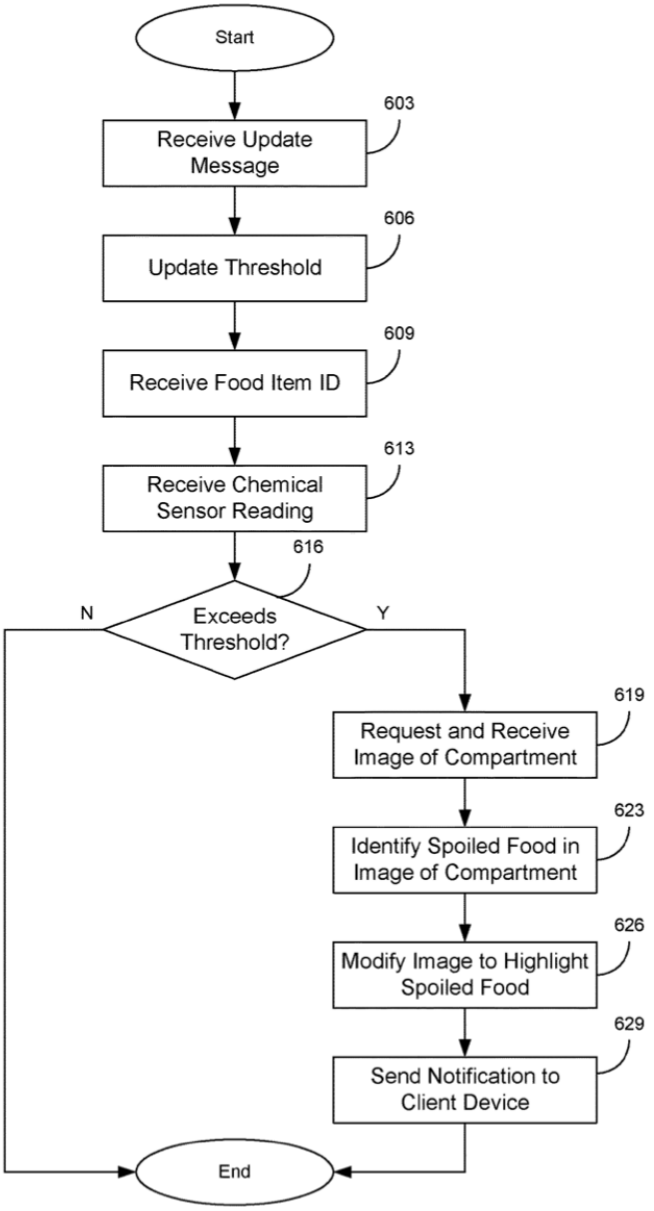
	 Linear classifier for Gala Apple recognition in the RG feature space
VOCAB: (w/definition)	Lab Color Space- Color space to identify small differences in color Static Sample- Dataset of one-time measurements of objects Dynamic Sample-Dataset capturing repeated measurements of the same objects over time Discriminant Surface- A mathematical surface that separates classes Critical points- Points where dramatic change is observed
Cited references to follow up on	C. Bishop *Pattern Recognition and Machine Learning*, New York : Springer-Verlag, 2006. D. Kernell and R. Groningen, *Colours and Colour Vision: An Introductory Survey*, Cambridge : Cambridge University Press, 2016.
Follow up Questions	Can this approach be applied to mixed-color foods like the inside of watermelon? How did each variable, especially lighting variations affect the performance of the classifier?

	How would analyzing the texture of the product with images improve classification accuracy?

Patent #1 Notes: Scent-based spoilage sensing refrigerator

Source Title	Scent-based spoilage sensing refrigerator
Source citation (APA Format)	Johnston, S. K. (2021, November 23). Scent-based spoilage sensing refrigerator.
Original URL	https://patentimages.storage.googleapis.com/b5/57/60/7172daa4800cf1/US11181515.pdf
Source type	Patent
Keywords	Perishable goods monitoring Food Quality Control Reusable Sensing Device
#Tags	#objectDetectionModel #food #DeepLearning #ArtificalIntelligence
Summary of key points + notes (include methodology)	Problem -Perishable foods need controlled environments to last with special care for temperature -In a commercial setting, manual inspection and logging are time-consuming, prone to errors, and only get worse the larger the project is. -Current sensors are not ideal as the battery drains too fast in cold environments and are often not food-grade -Time checking sensors may miss events occurring during short periods -Many regulatory standards in commerce require accurate, numerical tracking

	Objective -Design a motion activated sensing device for monitoring conditions around perishable food items in the fridge -The device must be wireless and use low-energy communication Methodology -A sealed sensing device is constructed with materials suited for directed contact with food -This device has a temperature sensor, processor and memory, low-energy wireless communicator, battery, motion sensor. -Motion sensor is used to signify when to activate processer when movement is detected -Once activated, the device will detect environmental conditions, store data, and transfer data to the receiver. Results -Enables real-time monitoring of food conditions -Allows extended battery life due to the device only starting with motion -Eliminates the need for precise temperature logs by hand -Improves food safety and resource efficiency -Offers a scalable solution for food storage commercially
Research Question/Problem/ Need	There is a need for a low power, yet reliable, food safe sensing device that can monitor the environmental conditions of perishable food items, due to existing methods being too labor-intensive and inconsistent

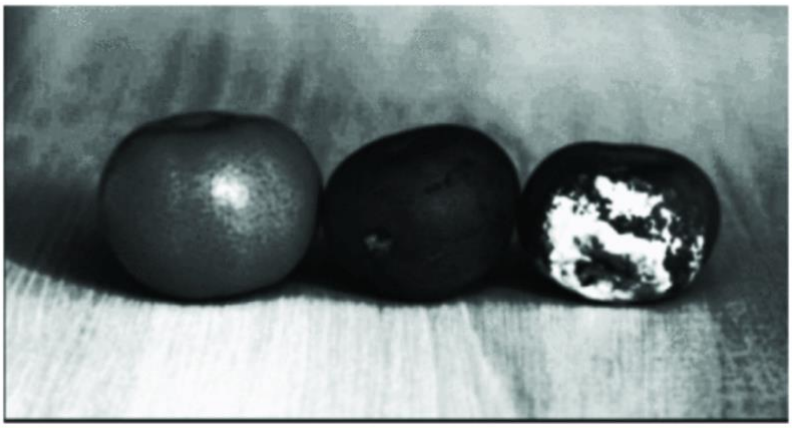
Important Figures	 The figure above walks through the process of identifying whether the product in the refrigerator is spoiled or not using benchmark values. If the values are over the threshold, the item causing spoilage is identified and the user is informed.
VOCAB: (w/definition)	Condition Sensor- A sensor that measures environmental parameters like the temperature

	Supply chain monitoring- Tracking conditions of goods from their birth to their delivery. Food-grade material- Safe to contact with other foods without hazard
Cited references to follow up on	N/A
Follow up Questions	How can the battery be further optimized for the cold environment? How can additional sensors improve spoilage detection? How do AI models predict spoilage risk based on the sensor data?

Article #14 Notes: Food Spoilage Detection using Advanced Image Processing Techniques: A Multicategory Approach

Source Title	Food Spoilage Detection using Advanced Image Processing Techniques: A Multicategory Approach
Source citation (APA Format)	R, R., S, P., R, Y., & Devie, P. M. (2025). Food Spoilage Detection using Advanced Image Processing Techniques: A Multicategory Approach. *2025 7th International Conference on Intelligent Sustainable Systems (ICISS)*, 1150–1156. https://doi.org/10.1109/ICISS63372.2025.11076223
Original URL	https://ieeexplore.ieee.org/document/11076223
Source type	Conference Paper
Keywords	Food Safety Food Spoilage Detection Edge Detection Feature Extraction Color Segmentation
#Tags	#objectDetectionModel #food #DeepLearning #ArtificalIntelligence
Summary of key points +	Problem -Food spoilage causes major economic and health risks worldwide

notes (include methodology)	-Traditional methods including thorough chemical analysis are expensive, slow, and require specialized equipment -Products cannot detect across multiple food categories Objective -Develop an automated food spoilage detection system using image processing techniques -Detect different spoilage indictors including mold, texture changes, deformation, and discoloration -Apply this approach to multiple different food categories including raw meat and produce Methodology Image Preprocessing -Images from 5 categories-dairy products, raw meat, vegetables, fruits, and fermented foods -Conversion to greyscale to reduce complexity -Gaussian blurring to reduce noise and enhance features Creation/Methods -Color Segmentation with RGB images converted to color space -Gray-Level Co-occurrence Matrix to identify degradation in surface -Detects edges and wrinkles along with irregular boundaries -Detects shape deformation using aspect ratio analysis Results -No quantitative data provided -Color segmentation identified discoloration and mold growth in fruits, vegetables, meat, and dairy products specifically -CNN-based classification showed high accuracy across all categories -Image pre-processing lead to an effective non-invasive alternative

Research Question/Problem/ Need	How can visual features found through image processing techniques be used to automatically detect food spoilage reliably across different food categories?
Important Figures	 Above is a HSV(decolored) Image of spoiled orange
VOCAB: (w/definition)	HSV Color model- Color space separating hue, saturation, saturation, and color value for improved, simpler color analysis Gray-Level Co-occurrence Matrix (GLCM)- Method used to analyze texture by calculating how often pairs of pixels with specific grayscale values occur to identify special relationship Color segmentation- Image preprocessing technique to isolate regions based on color
Cited references to follow up on	S. Fang, "Design of intelligent detection system for food spoilage," in 11th International Conference on Intelligent Computation Technology and Automation (ICICTA), Changsha, 2018, pp. 190 194, doi: 10.1109/ICICTA.2018.00050.

	G. C. Green, A. D. C. Chan, and R. A. Goubran, "Monitoring of food spoilage with electronic nose: Potential applications for smart homes," in 3rd International Conference on Pervasive Computing Technologies for Healthcare, London, 2009, pp. 1–7, doi: 10.1109/PCTHEALTH.2009.5291419.
Follow up Questions	Can the method distinguish natural aging (apple insides slightly changing color) from spoilage? How would the model adapt for spoilage which depends on colors to show signs? How well would the system perform in real-time environments without bounding boxes?

Article #15 Notes: Food Insecurity and the Global Environment: The Role of Food Loss and Waste

Source Title	Food Insecurity and the Global Environment: The Role of Food Loss and Waste
Source citation (APA Format)	Ayeni, O., Ogunmefun, O., Afolabil, O., Adeniyi, F., & Akpor, O. (2024). Food Insecurity and the Global Environment: The Role of Food Loss and Waste. *2024 IEEE 5th International Conference on Electro-Computing Technologies for Humanity (NIGERCON)*, 1–8. https://doi.org/10.1109/NIGERCON62786.2024.10927238
Original URL	https://ieeexplore.ieee.org/document/10927238
Source type	Conference Paper
Keywords	Food Security Food Waste Microbial Spoilage Food Insecurity Food Loss Preservation
#Tags	#food
Summary of key points + notes (include methodology)	Problem -Large portion of food produced globally is lost or wasted due to spoilage -Food waste and loss worsen food insecurity, hunger, public health risks, and environmental damage -Developing countries face worser insecurity -Microbial spoilage is a major cause of the food state deterioration

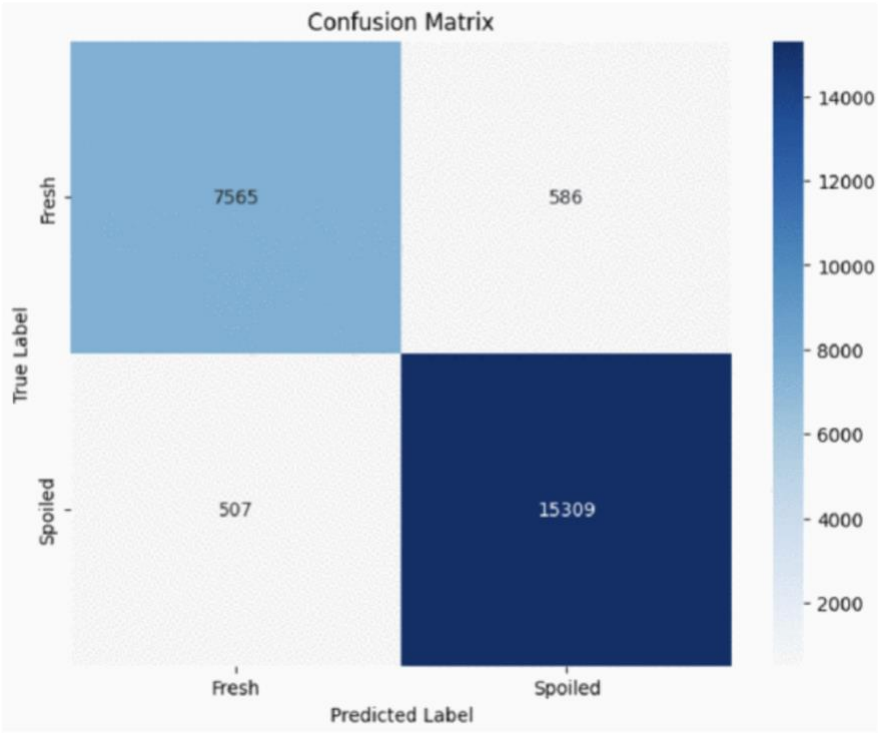
	Objective -Explain the concept of food insecurity and how food waste effects it -Identify causes of food spoilage and how microbial factors affect spoilage -Identify how reducing food spoilage can reduce food security Methodology -Examination factors include -Intrinsic factors (biological factors, nutrients, water, pH) -Extrinsic factors (temperature, humidity, surrounding gasses) -Competition with other organisms -Storage factors (How was it stored?) Results -One-third of global food production is lost or wasted annually -40% of food produced is wasted along the supply chain -Microbial spoilage accounts for ~25% of global food loss -In 2022, 29.6% of the global population experienced moderate or extreme food insecurity -Africa recorded the highest percentage of food insecurity at 60.9% -Effective food preservation can reduce spoilage, food loss, and health risks
Research Question/Problem/ Need	How does food spoilage contribute to food insecurity globally and in developing countries?
Important Figures	None
VOCAB: (w/definition)	Food Insecurity: The lack of regular access to safe food Intrinsic Factors: Internal properties including making pH and water height Extrinsic Factors: The nature of someone coming from outside Microbial Spoilage-Deterioration of the food's quality due to the growth of microorganisms.

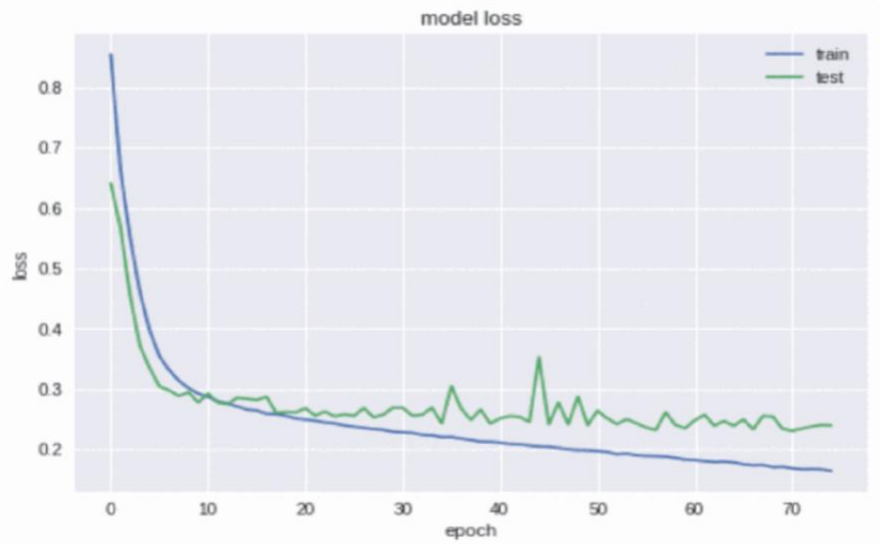
Cited references to follow up on	K. Norris, S. Pitts, H. Reis and L. Haynes-Maslow, “A systematic literature. review of nutrition interventions implemented to address food insecurity as a social determinant of health”, *Nutrients*, vol. 15 no. 15, pp. 1 - 19, 2023. B.A. Piperata, S.A. Scaggs, D.L. Dufour and I.K. Adams, “Measuring food. insecurity: An introduction to tools for human biologists and ecologists ”, *Am. J. Hum. Biol*. vol. 25 no. 2, pp. 1 - 21, 2023.
Follow up Questions	How can low-cost preservation technologies be scaled in developing countries which need efficiency? How can technology and AI affect the process of food preservation? How can food waste be reduced at the urban level compared to rural areas?

Article #16 Notes: An Efficient Deep Learning for Food Quality Detection

Source Title	An Efficient Deep Learning for Food Quality Detection
Source citation (APA Format)	Sekar, K., Yuvarajan, T., Tejashwini, J. S., & Dheepa, T. (2025). An Efficient Deep Learning Approach for Food Quality Detection. *2025 3rd IEEE International Conference on Industrial Electronics: Developments & Applications (ICIDeA)*, 1–5. https://doi.org/10.1109/ICIDeA64800.2025.10962944
Original URL	https://ieeexplore.ieee.org/document/10962944
Source type	Conference Paper
Keywords	Food Waste Deep Learning Real-time classification Image Preprocessing Food spoilage detection
#Tags	#objectDetectionModel #food #DeepLearning #ArtificalIntelligence
Summary of key points + notes (include methodology)	Problem -Global food waste and illnesses from spoiled food are major challenges -Existing systems that use deep learning models struggle with generalization across diverse food types, lighting conditions, and subtle spoilage indicators (ex. wrinkles)

	-Traditional machine learning methods have limited real world usability due to high false positives and false negatives (Type 1 and Type 2 errors). Objective -Develop a deep-learning system that decides whether food items are edible from photos uploaded by user -Classify food as fresh or spoiled using visual cues -Reduce food waste and improve safety with real-time classification Methodology -System uses YOLOv8 object detection and classification model -Training on Food-101 dataset which contains 101,000 images across 101 categories -These images are captured under various lights, angles, and environments -User uploads an image that goes through image validation to make sure there is sufficient lighting, clarity, minimal obstruction and other small details. Image Preprocessing -Images resized to match input dimension -Normalization to give value between 0-1 for training stability -Data Augmentation (slight changes) simulate real-life scenarios - Background distractions removed for focus on object Model -Processes the image in a single pass and divides it into a grid to predict class probabilities in bounding boxes -Fine-tuned to detect specific patterns -Final output is sent with confidence score Results -95% accuracy on Food-101 dataset Training-7565 fresh items and 15,309 spoiled items correctly classified -507 False Negatives and 586 False Positives

	-Validation showed precision of 0.94 for fresh foods and 0.96 for spoiled foods -Recall: 0.93 for fresh and 0.97 for spoiled -F1-score: 0.93 for fresh and 0.97 for spoiled -Shows strong generalization ability across a wide variety of foods in a variety of conditions.
Research Question/Problem/ Need	How can a deep learning-based system use YOLOv8 asses a variety of food edibility from images from users in diverse environments?
Important Figures	 Above is a confusion matrix of the training dataset. The stark contrast proves that the model is good at generalization.

	 Above is the loss curve of the model, showing that the model a couple of spikes in the middle. This could be due to a lack of shuffling in the data or purely by chance.
VOCAB: (w/definition)	YOLOv8- A real-time object detection and classification deep learning model Data Augmentation-Artificially expanding datasets using slight edits and transformations Precision-Accuracy of positive predictions Recall-Ability to correctly identify all relevant instances F1-Score- Balance between precision and recall
Cited references to follow up on	V. Aravinth, A. G. Aakash, S. Kumar, and T. Preethiya, "*DeepAllergy: A Deep Learning Approach for Accurate and Rapid Food Allergen Detection*," 2024.

	Yudong Zhang, Lijia Deng, Hengde Zhu, Wei Wang, Zeyu Ren, Qinghua Zhou, Siyuan Lu, Shiting Sun, Ziquan Zhu, Juan Manuel Gorriz, Shuihua Wang, Deep learning in food category recognition, *Information Fusion*, Volume 98, 2023, 101859, ISSN 1566–2535, https://doi.org/10.1016/j.inffus.2023.101859.
Follow up Questions	How does the system perform on real-world user images not sourced from a dataset? Has there been any testing with real user images conducted? How would training data from other user's labels be implemented and would it help?

Article #17 Notes: DeepAllergy: A Deep Learning Approach for Accurate and Rapid Food Allergen Detection

Source Title	DeepAllergy: A Deep Learning Approach for Accurate and Rapid Food Allergen Detection
Source citation (APA Format)	A, V. Aravinth., G, Aakash., S, S. Kumar., & T, Preethiya. (2024). DeepAllergy: A Deep Learning Approach for Accurate and Rapid Food Allergen Detection. *2024 10th International Conference on Advanced Computing and Communication Systems (ICACCS)*, *1*, 2225–2230. https://doi.org/10.1109/ICACCS60874.2024.10717042
Original URL	https://ieeexplore.ieee.org/document/10717042
Source type	Conference Paper
Keywords	Food Allergies Deep Learning Allergen Detection Image Classification
#Tags	#objectDetectionModel #food #DeepLearning #ArtificalIntelligence
Summary of key points + notes (include methodology)	Problem -Modern recipes and unique ingredients have increased the risk of food allergies

	-Seemingly safe dishes can hide allergens, putting sensitive individuals at serious health risk -Existing systems struggle with accuracy, expansion, and generalization, especially when relying on images -Misidentification can lead to severe outcomes and allergic reactions Objective -Evaluate and compare three pre-trained deep learning models, YOLOv8, ViT, and EfficientNet for food image classification and allergen detection -Identify the model with the highest accuracy with minimal tuning -To determine what architecture of a model is most effect for real-world food allergy applications Methodology -2 Kaggle datasets containing 6,271 images across 20 Indian good classes -CSV dataset with food ingredients and allergens associated -Split into 80% training, 10% validation, 10% testing -All three models trained under same conditions YOLOv8 -Used primarily for object detection, but can be used for food classification -Predicts bounding boxes and class probabilities and uses regions of interest for classification ViT (Vision Transformer) -Images are divided into patches -Uses self-attention mechanism to learn relationships -Effective at capturing information in context -More layers and dropout due to complex model EfficientNet B4 -Balances images -Designed for maximum accuracy with limited computation

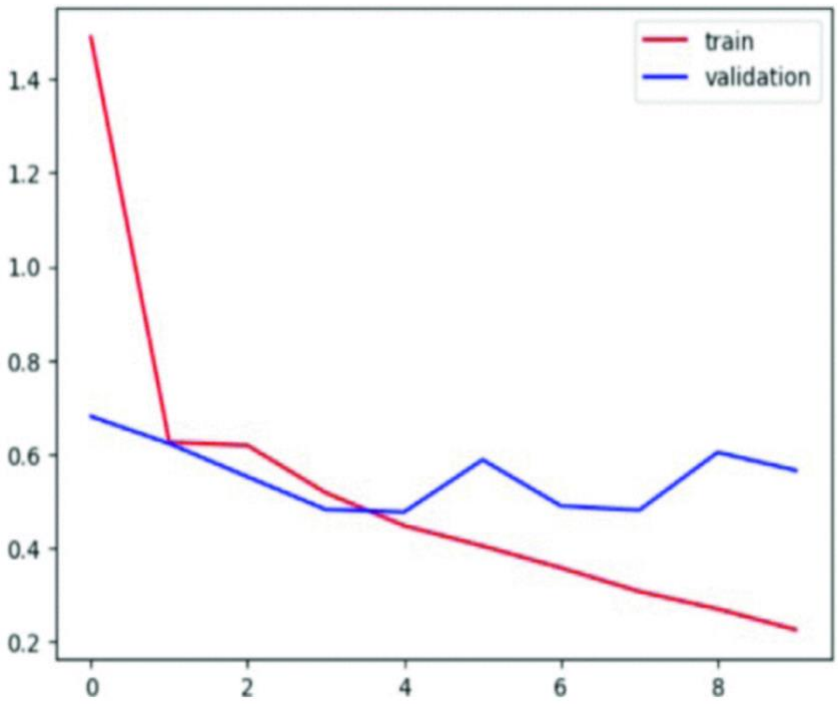
	Results -EfficientNet had the highest accuracy at 92.29% -Training loss = 2.2, validation loss = 2.2 -YOLOv8 had accuracy of 92.05% - Training loss = 0.3, validation loss = 2.79 -ViT was almost random 52.04% accuracy -Training loss = 2.84, validation loss = 2.79 -Low loss and greater attention to detail shows that EfficientNet provides the most accurate and efficient solution
Research Question/Problem/ Need	Which pretrained deep learning mode between YOLOv8, Vision Transformer, or EfficientNet provides the most accurate and efficient solution for food classification and allergen detection.
Important Figures	<table><tr><th></th><th>Accuracy</th><th>Val accuracy</th><th>Loss</th><th>Val loss</th></tr><tr><td>YOLOv8</td><td>92.05%</td><td rowspan="2">-</td><td>0.3</td><td>2.2</td></tr><tr><td>Vision Transformer (ViT)</td><td>52.04%</td><td>47.06%</td><td>2.84</td><td>2.79</td></tr><tr><td>EfficientNet</td><td>92.28</td><td>85.16%</td><td>2.2</td><td>2.2</td></tr></table> This figure shows the difference in accuracy between the models and the loss. Using these values, one can compare the losses and then the accuracy to decide that EfficientNet is the best model.
VOCAB: (w/definition)	Yolov8- A real-time object detection deep learning model Fine-tuning- Adjusting a pre-trained model for a specific task
Cited references to follow up on	

	N. Darapaneni, V. Singh, Y. S. Tarkar, S. Kataria, N. Bansal, A. Kharade, and A. R. Paduri, “Food image recognition and calorie prediction,” in *2021 IEEE International IOT, Electronics and Mechatronics Conference (IEMTRONICS), IEEE*, 2021.
Follow up Questions	How would the model perform with a more diverse dataset? Would it be able to accurately identify cooked foods without relying on context? How will the allergens be revealed in cooked foods? How well would these models generalize from user uploaded data?

Article #18 Notes: Food Image Recognition and Calorie Prediction System using CNN

Source Title	Food Image Recognition and Calorie Prediction System using CNN
Source citation (APA Format)	Anusha, M., Nandan, T. P. K., Shivani, M., Kaif, M., Mithra, P. S., & Kumar, K. C. (2025). Food Image Recognition and Calorie Prediction System using CNN. *2025 5th International Conference on Soft Computing for Security Applications (ICSCSA)*, 1130–1134. https://doi.org/10.1109/ICSCSA66339.2025.11170907
Original URL	https://ieeexplore.ieee.org/document/11170907
Source type	Conference Paper
Keywords	Calorie Intake Obesity Deep Learning Food Image Recognition Convolutional Neural Network
#Tags	#objectDetectionModel #food #DeepLearning #ArtificalIntelligence
Summary of key points + notes (include methodology)	Problem -Obesity and related health issues are a major global concern, causing millions of deaths annually

	-The main problem is not the food availability, but the lack of awareness of nutritional and calorie content -Manuel tracking is outdated, inconvenient, and inaccurate, leading to poor diets -Existing systems which automatically complete such tasks struggle with portion estimation Objective -Develop an automated food image recognition and calorie prediction system using deep learning -Help the user monitor daily calorie intake make better dietary decisions -Promote a healthier lifestyle Methodology -Uses a CNN model to extract visual features such as shape, texture, and color for food images -Uses Mask R-CNN for image segmentation -With image segmentation, the system can detect food items, generate pixel-wide masks, and accurately isolate regions with food in them. -All images are resized to 128*128 pixels -Then, the area is calculated for the food area -Calorie content is estimated through a calorie per mask mapping -To improve generalization, the system was trained on a large food dataset containing multiple cuisines and ingredients Results -CNN Model: 95% training accuracy and 93% validation accuracy -Training and validation accuracy curves match closely, indicating strong ability to generalize -Loss decreases slowly with increasing epochs, signifying lack of overfitting -Calorie prediction was accurately mapped after the recognition, demonstrating higher efficiency than existing models
Research Question/Problem/ Need	How can a CNN-based food image recognition system accurately estimate calorie intake from images to support healthier dietary habits?

Important Figures	 The figure above shows the loss curve for the CNN model used to identify the item in the refrigerator. It clearly needs more epochs of training as loss is still extremely high and the loss significantly varies between training and validation.
VOCAB: (w/definition)	Mask R-CNN- Deep learning model for image segmentation into parts for analysis Image Processing- Techniques to analyze and modify images to be in the right format for models Instance Segmentation- Pixel-level identification of objects
Cited references to follow up on	S. Dash, K. Murali Gopal, R. Kumar Mahanta and S. Babu Punuri, "CNN Driven Nutritional Analysis: Predicting Food Composition Via Image Processing Techniques," 2024 International Conference on Integrated Intelligence and Communication Systems (ICIICS), Kalaburagi, India, 2024. H. Hu, Z. Zhang and Y. Song, "Image Based Food Calories Estimation Using

	Various Models of Machine Learning," 2020 5th International Conference on Mechanical, Control and Computer Engineering (ICMCCE), Harbin, China, 2020.
Follow up Questions	How well does the system generalize for global cuisines that the model is not trained upon? How can portion size be included for meals and how does that affect the outcome? Is the model able to add the calories in one plate by handling multiple food items at once?

Article #19 Notes: IoT Based Food Spoilage Detection using Machine Learning Techniques

Source Title	IoT Based Food Spoilage Detection using Machine Learning Techniques
Source citation (APA Format)	Anusha, K., Uma, K., Jayasri, K., Kambham, S., & Dandamudi, S. D. (2024). IoT Based Food Spoilage Detection using Machine Learning Techniques. *2024 International Conference on Advances in Computing, Communication and Applied Informatics (ACCAI)*, 1–7. https://doi.org/10.1109/ACCAI61061.2024.10602355
Original URL	https://ieeexplore.ieee.org/document/10602355
Source type	Conference Paper
Keywords	Food Waste Sensors Real-Time Monitoring Sustainability Predictive Analysis
#Tags	#objectDetectionModel #food #DeepLearning #ArtificalIntelligence
Summary of key points + notes (include methodology)	Problem -Food spoilage causes significant food waste and economic losses worldwide. -Traditional food quality monitoring(manual) is time-consuming, vulnerable to errors,

	ineffective for early detection, economically taxing -With a growing population and limited resources, food waste is a problem -Existing automatic systems lack consistent monitoring and capabilities to predict future outcomes Objective -Develop a food spoilage detection system that uses both machine learning algorithms and sensors -Provide real-time monitoring and prediction of food quality within a certain period -Evaluate system performance and demonstrate improvements over the current, existing systems Methodology Sensors -3 sensors: DHT11 sensor for temperature and humidity, MQ135 sensor for gas detection, level sensor for food quantity -Continuously collect environmental data and transfer to cloud-based platform for analysis Data Preprocessing -Remove noise -Remove outliers -Normalize features -Reduce bias by equalizing dataset Machine Learning Model -Uses Support Vector Machine (SVM) due to its ability to handle large groups of data with variation and accuracy, -Input: Temperature, humidity, gas levels, food levels -Output: Classification (fresh or spoiled) Real Time Monitoring -Alerts sent from text or email

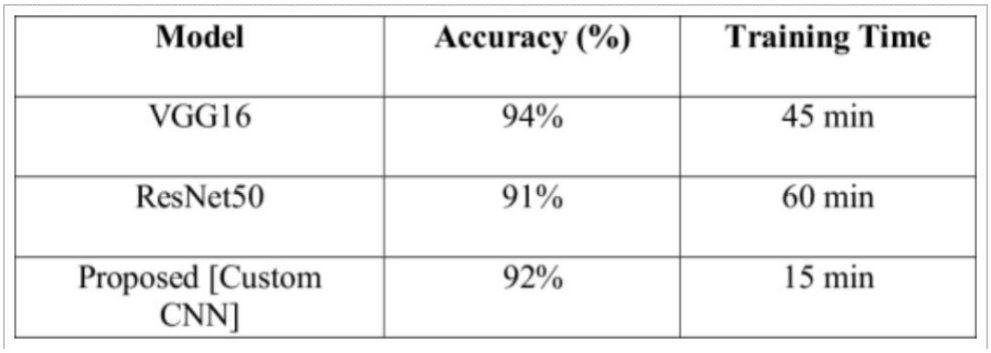
	-The sensor data is continuously analyzed and updated -Tested in real-world environments like food storage facilities and transport vehicles Results New System vs Existing System performance Accuracy: 92% vs 85% Precision: 90% vs 87% Recall: 89% vs 83% F1-Score: 91% vs 85% 96% of fresh food correctly detected 94% of spoiled food correctly detected In all cases, the new system is much more accurate in all aspects when compared the existing system. The model is better at detecting whether food is fresh compared to when food is spoiled.
Research Question/Problem/ Need	How can a sensor-based system using machine learning algorithms detect and predict food spoilage in real time to reduce food waste?
Important Figures	<table><tr><th>Temperature (°C)</th><th>Humidity (%)</th><th>Gas Levels (ppm)</th><th>Food Level (%)</th><th>Spoilage Status</th></tr><tr><td>5</td><td>65</td><td>300</td><td>90</td><td>Fresh</td></tr><tr><td>6</td><td>70</td><td>320</td><td>85</td><td>Fresh</td></tr><tr><td>7</td><td>68</td><td>350</td><td>80</td><td>Fresh</td></tr><tr><td>8</td><td>72</td><td>400</td><td>75</td><td>Spoiled</td></tr><tr><td>10</td><td>75</td><td>420</td><td>70</td><td>Spoiled</td></tr><tr><td>12</td><td>78</td><td>450</td><td>65</td><td>Spoiled</td></tr><tr><td>15</td><td>70</td><td>350</td><td>60</td><td>Fresh</td></tr><tr><td>16</td><td>68</td><td>330</td><td>55</td><td>Fresh</td></tr><tr><td>18</td><td>65</td><td>310</td><td>50</td><td>Fresh</td></tr></table> Sample data set for food spoilage detection, which shows the importance of humidity in the spoilage status.

VOCAB: (w/definition)	Predictive Analysis- Using data to forecast possible future outcomes Support Vector machine (SVM) – A supervised machine learning algorithm to classify objects into multiple classes Sensor deployment- Strategically placing sensors to collect environmental data Sustainability- Efficient use of resources to reduce the environmental impact from them
Cited references to follow up on	B. V. S. Nithin, K. S. Nithin, B. Sneha, and V.V. Kumar, NonDestructive Approach for Detection of Food Freshness using IoT, *2023 International Conference on Inventive Computation Technologies (ICICT)*, Apr. 2023, doi: 10.1109/icict57646.2023.10134232.
Follow up Questions	What types of food produces the least predictable reactions and why? How does sensor calibration play a role in the accuracy of the system? How well can the product scale across large chains and predict the future outcomes of the product in changing facilities?

Article #20 Notes: Ai-Powered Food Spoilage Detection Using Image Analysis

Source Title	Ai-Powered Food Spoilage Detection Using Image Analysis
Source citation (APA Format)	Tambe, P., Shinde, S., Pawar, K., Shimpi, S., & Nankar, D. (2025). Ai-Powered Food Spoilage Detection Using Image Analysis. *2025 Third International Conference on Networks, Multimedia and Information Technology (NMITCON)*, 1–7. https://doi.org/10.1109/NMITCON65824.2025.11188244
Original URL	https://ieeexplore.ieee.org/document/11188244
Source type	Conference Paper
Keywords	Food Spoilage Food Classification Food Quality Assessment Computer Vision Supply chain management
#Tags	#objectDetectionModel #food #DeepLearning #ArtificalIntelligence
Summary of key points + notes (include methodology)	Problem -Food spoilage causes countless economic losses and health risks in the food industry -30-40% of food is wasted globally due to spoilage and poor-quality control

	-Manual inspection, especially for fruits, is laborious, time-consuming, and inconsistent -When expanding to the global scale, the system needs to be automated and scalable Objective -Develop an AI system for fruit freshness classification -Use CNN deep learning techniques to improve accuracy -Compare the CNN model with traditional machine learning and pre-trained models -Evaluate real-time progress for industrial use Methodology -CNN Based Learning model -Database from Kaggle: Fresh and Stale Classification dataset -It has 7,000 labeled images with 2 classes, fresh and rotten with a variety of visual variables -Preprocessing includes resizing images to 150*150 and using data augmentation to slightly alter images to artificially expand dataset -CNN architecture includes layers with 3*3 filters, ReLU activation, 2*2 max pooling, 0.5 dropout, sigmoid output layer for binary classification. -Training setup includes Adam optimizer, binary cross-entropy loss, 20 epochs of training, batch size of 32, 8:2 split -Compare with VGG16 and ResNet50 models Results -92% accuracy for classification -Training accuracy went from 83% to 92% -Validation accuracy exceeded 83% -Competitive with VGG16 and ResNet50 Models -Fast, scalable, and suitable for amateur real-time deployment
Research Question/Problem/ Need	How effectively can a CNN deep learning model classify fruits as fresh or rotten using image data instead of traditional methods to eliminate food

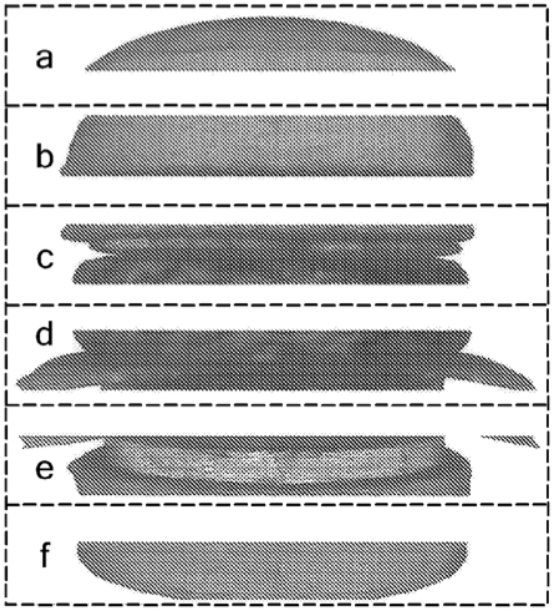
	waste?
Important Figures	 The figure above displays the accuracy of the proposed CNN model compared to existing models. Although its accuracy is average compared to the other models, its training time is far better.
VOCAB: (w/definition)	Binary Classification- Classifying an image or other data into two categories (in this case, fresh or rotten) Overfitting- When a model performs well on training data but not on validation data, showing its inability to generalize. Adam Optimizer- A optimization algorithm used to adapt the learning rate during training for a better eventual model
Cited references to follow up on	Khan, M., et al., "Machine Learning-Based Fruit Classification: A Comparative Study," *IEEE Access*, vol. 10, pp. 12345–12355, 2022. Sharma, P., et al., "CNN- Based Image Recognition for Food Classification," *International Journal of Computer Vision*, vol. 98, no. 2, pp. 210–225, 2021.
Follow up Questions	Can transfer learning (further training another model) reduce training time and costs of computation? How does the CNN model compare with the others in real-world lighting and backgrounds?

	How would the implementation of YOLO for bounding boxes assist the process in the real life?

Patent #2 Notes: Food and nutrient estimation, dietary assessment, evaluation, prediction and management

Source Title	Food and nutrient estimation, dietary assessment, evaluation, prediction and management
Source citation (APA Format)	Panetta, K. A., Rao, S. P., Kalasa Mohandas, S. K., Rajendran, R., Rajeev, S., Hennessy, E., Economos, C., Shonkoff, E. T., & Agaian, S. S. (2024, February 15). Food and nutrient estimation, dietary assessment, evaluation, prediction and management.
Original URL	https://patentimages.storage.googleapis.com/6e/3b/2a/ef6d5571236034/CN108332504A.pdf
Source type	Patent
Keywords	Computer Vision Personalized Nutrition Nutrient Estimation Deep Learning Food Volume Estimation
#Tags	#objectDetectionModel #food #DeepLearning #ArtificalIntelligence
Summary of key points + notes (include methodology)	Problem -Obesity and other diet related diseases are widespread and increasing -Traditional method to track consumption require manual logging, are labor intensive, and suffer from errors -Existing food recognition devices fail with mixed, complex meals

	Objective -Develop an AI-based automated system for dietary assessments, calorie and nutrient estimation, nutrition planning, and food waste estimation. -Use computer vision to identify food from images and measure the amount -Generate individualized meal plans Methodology -System takes data by capturing variety of images of foods of plates from positions -Multiple of these images are used to reconstruct a 3-D model of the food on the plate. -The 3-D item is cut and divided into equal slices to find the total volume -The volume relates to the weight and nutrient information -Uses this information to perform dietary assessments, estimate food waste, and generate personalized meal plans Results -Enables automated dietary assessment of the food volume, nutrients, calorie content, and waste -Supports personalized nutrition and medical treatment planning -Reduces food waste through better estimation of portions and meal planning -Functions in the real world without any clunky hardware
Research Question/Problem/ Need	There is a growing need for accurate, automated, dietary assessment and planning systems that reduces the reliance on manual entry for calorie tracking.

Important Figures	 The figure above describes the process of calculating volume using two-dimensional images. Splitting the image allows for the calculation of parts to arrive at the total volume.
VOCAB: (w/definition)	Segmentation-Separating items within an image 3-D reconstruction – Creating a three-dimensional model from two-dimensional images Dietary assessment- Evaluation of the nutritional value of food that one intakes.
Cited references to follow up on	N/A
Follow up Questions	How can the system improve performance in cluttered environments? What is the large-scale impact of this product on locations where diets are important, including hospitals and schools? Can the system be adapted for dynamic movement in foods including soups and jelly?

Estimated Volume (ml)	
a	28.6
b	36.4
c	24.2
d	22.3
e	28.9
f	26
Total	166.4