

Semi-Supervised Grocery Image Classification

A Machine Learning Mini-Project



Meet Our Visionary Project Team



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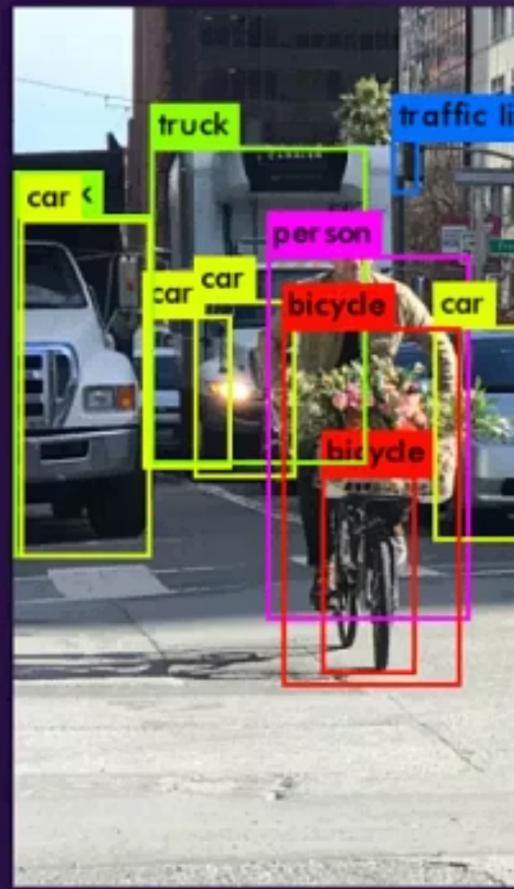


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Together, our diverse expertise and collaborative spirit drive innovation, ensuring every aspect of this project achieves excellence and delivers outstanding results.

Labeling Vision



The High Cost of Labeling: A Real-World Problem



Expensive Manual Labeling

Manually labeling vast datasets of product images is a labor-intensive and costly process, especially for large e-commerce platforms.



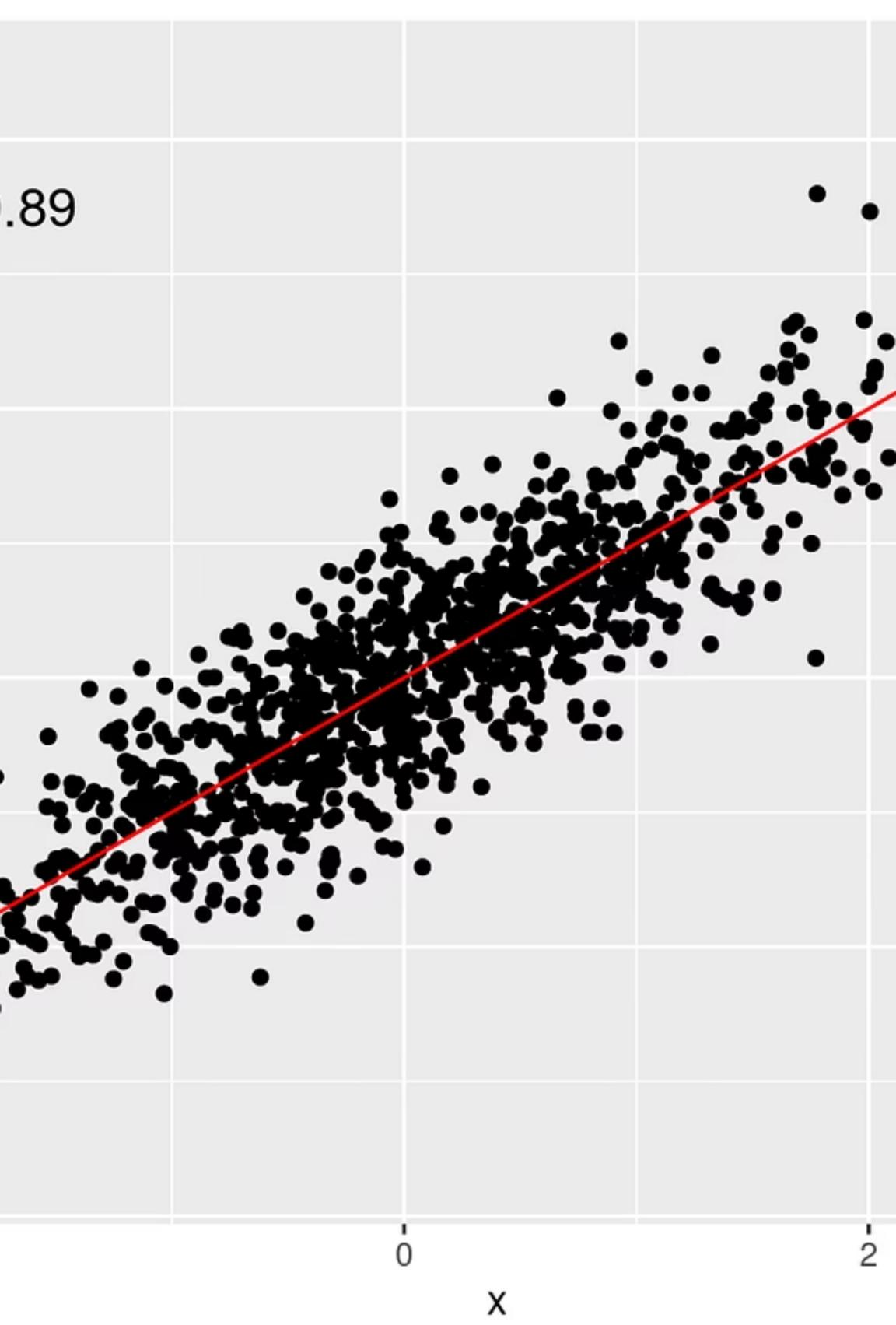
E-commerce Scale

Platforms like Amazon deal with millions of diverse products, requiring efficient, scalable classification solutions that minimize human effort.



Need for Efficiency

Automated or semi-automated labeling is crucial to maintain competitive pricing and rapid product onboarding.



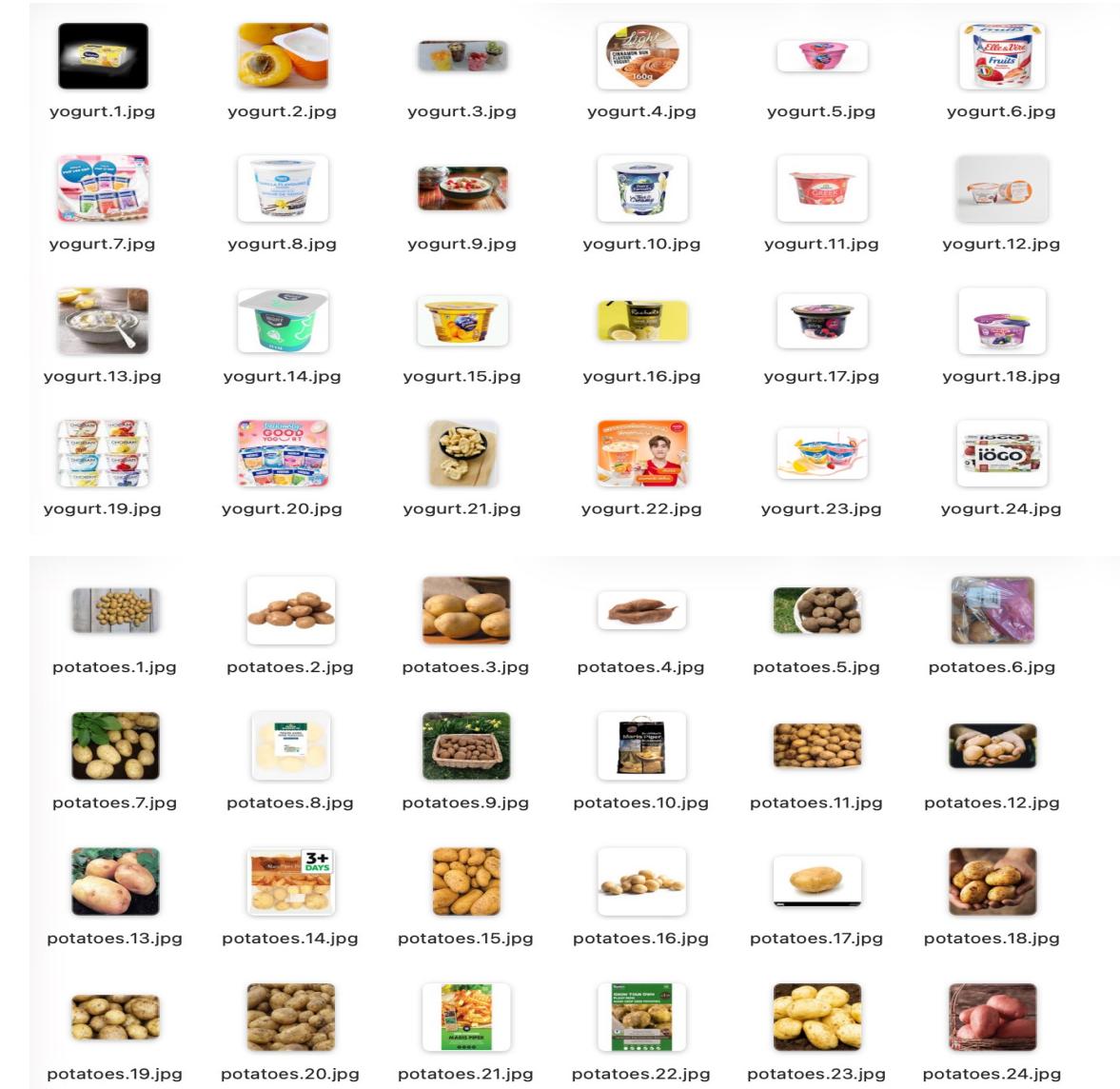
The Classification Challenge: Limited Labeled Data

- Large grocery image datasets are mostly **unlabeled**
- Manual image labeling is **expensive and time-consuming**
- Supervised learning requires **fully labeled data**
- Image classification alone does not provide **direct user value**
- Need to convert predictions into **useful recommendations**

Dataset Overview

We utilized a specialized dataset tailored for grocery product classification, reflecting the diversity found in typical retail environments.

						
bacon 408 files	banana 385 files	bread 407 files	broccoli 412 files	butter 423 files	carrots 497 files	cheese 410 files
						
chicken 408 files	cucumber 393 files	eggs 441 files	fish 403 files	lettuce 412 files	milk 259 files	onions 444 files
						
peppers 404 files	potatoes 453 files	sausages 410 files	spinach 403 files	tomato 405 files	yogurt 406 files	





Key Challenges

Classifying grocery images at large scale presents several technical challenges related to data size, labeling, and model scalability.

High-dimensional images

Raw pixels are too large for ML

Limited labeled data

Few annotated samples available

Compact representation needed

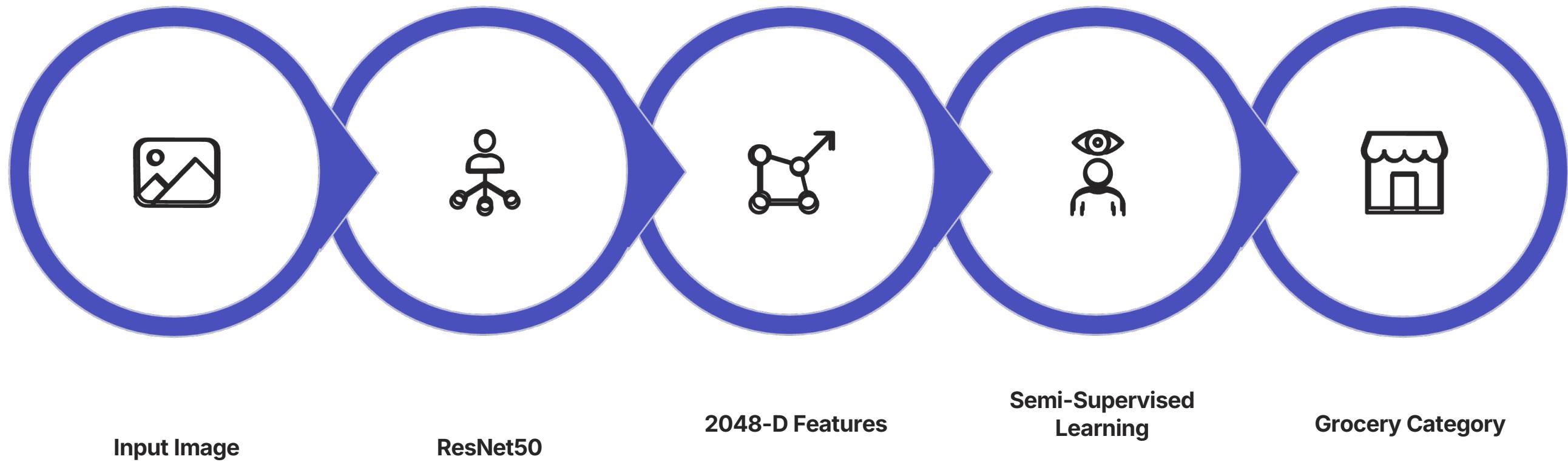
Images must be converted into vectors

Scalability

Method must handle large datasets efficiently

Our Proposed Classification Pipeline

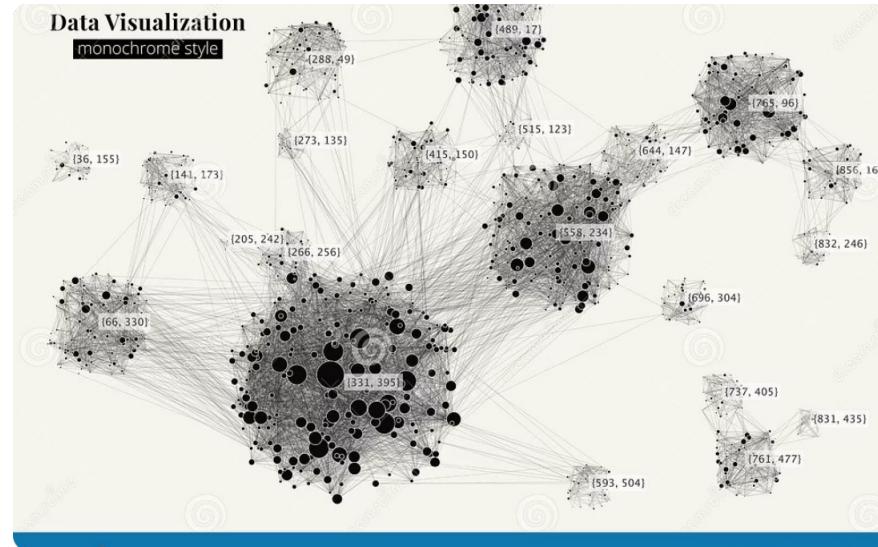
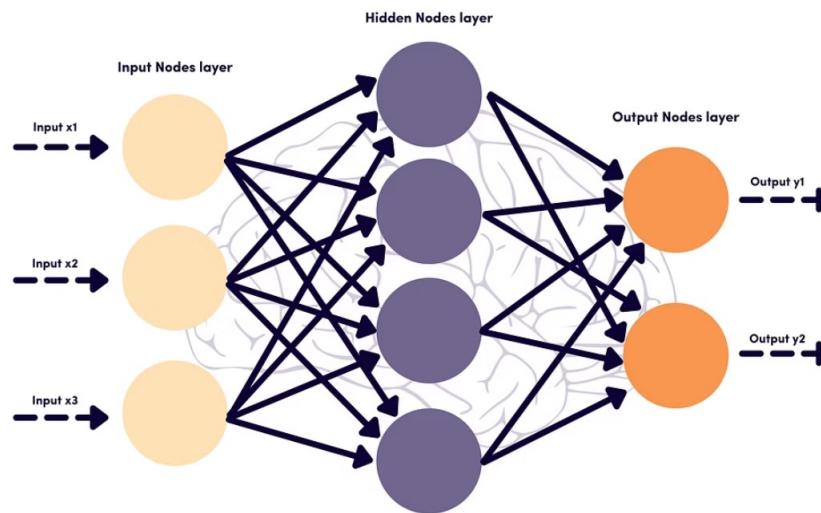
This simplified diagram illustrates the flow from a raw grocery image to its final classified category using our semi-supervised approach.



Each stage plays a crucial role in transforming complex visual data into an understandable classification.

CNN Embeddings: Transforming Pixels into Insight

Convolutional Neural Networks (CNNs) serve as powerful feature extractors, converting complex raw images into compact, meaningful numerical representations known as embeddings.



Feature Extraction

CNNs learn hierarchical features, from edges and textures to complex object parts, effectively capturing visual essence.

Dimensionality Reduction

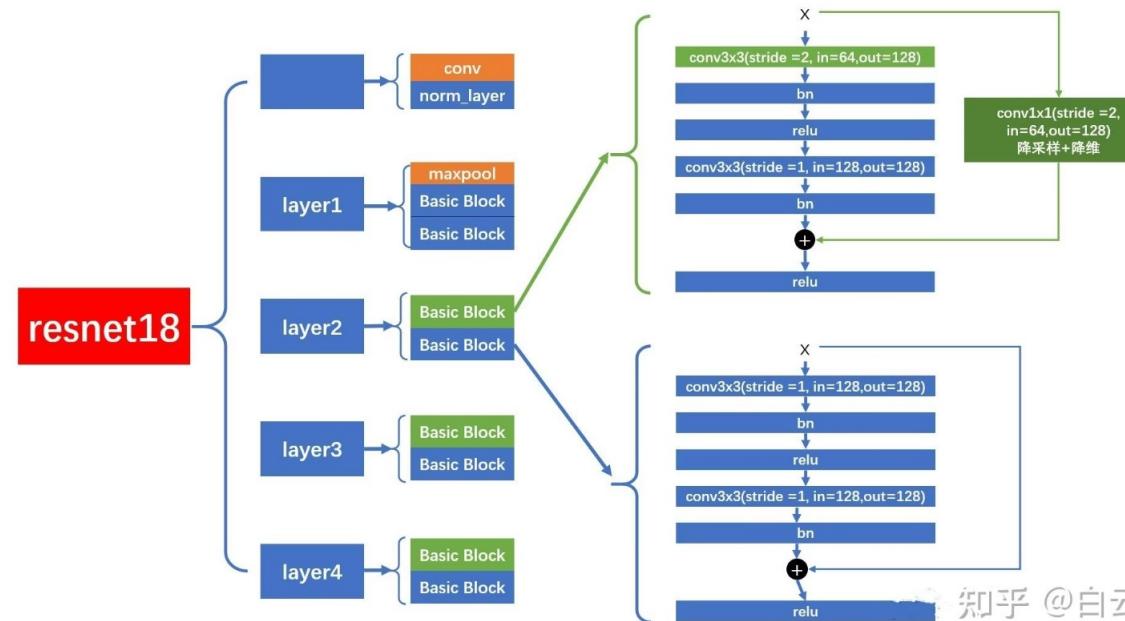
This process significantly reduces the data's dimensionality while preserving crucial information, making it tractable for subsequent ML tasks.

Compact Numerical Vectors

Each image is transformed into a fixed-size vector, representing its semantic content in a lower-dimensional space.

ResNet50: Our Chosen Feature Extractor

For our project, we selected ResNet50, a well-established convolutional neural network architecture, due to its strong balance between representational depth and computational efficiency.



- **Architecture:** ResNet50 is a deeper variant of the Residual Network architecture, utilizing *skip connections* to mitigate the vanishing gradient problem and enable effective training of deep networks.
- **Pre-trained Advantage:** We leverage a ResNet50 model pre-trained on ImageNet, allowing it to capture rich and diverse visual features learned from large-scale image data.
- **Output:** The final convolutional layer of ResNet50 produces a **2048-dimensional feature vector** for each input image.
- **Purpose:** These **2048-D feature vectors** serve as robust CNN embeddings, capturing essential visual information while remaining suitable for downstream semi-supervised learning algorithms.



The Semi-Supervised Learning

Semi-supervised learning is a paradigm that bridges the gap between supervised and unsupervised methods, making it ideal for scenarios with limited labeled data.

Label Propagation

Graph-based method that propagates labels from labeled samples to unlabeled ones based on similarity

Label Spreading

An improved version of label propagation that uses soft labeling and regularization for better stability.

Self-Training (Pseudo-Labeling)

Iterative approach where a model trained on labeled data generates high-confidence labels for unlabeled samples and retrains itself.

Output :

Image Prediction

Upload Image

Choose a grocery image

Drag and drop file here
Limit 200MB per file • JPG, JPEG, PNG

peppers.14.jpg 7.4KB



Uploaded Image

Prediction Results

Peppers

Confidence: 100.0%

Top Predictions

- sausages
- tomato
- spinach
- yogurt
- peppers

Confidence (%)

Upload Image

Choose a grocery image

Drag and drop file here
Limit 200MB per file • JPG, JPEG, PNG

eggs.3.jpg 3.8KB



Prediction Results

Eggs

Confidence: 100.0%

Top Predictions

- banana
- peppers
- carrots
- potatoes
- eggs

Confidence (%)

Output :

Deploy

Upload Image

Choose a grocery image

Drag and drop file here
Limit 200MB per file • JPG, JPEG, PNG

Browse files

?

Prediction Results

👉 Upload an image to get started

My Grocery List

Clear List



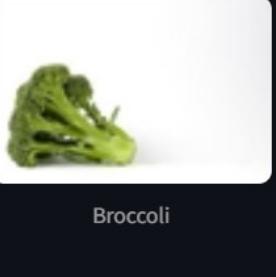
Chicken



Cheese



Tomato



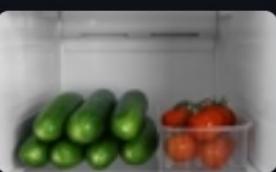
Broccoli



Bread



Carrots



Cucumber

Output :

Roasted Broccoli with Asiago (Match: 67%)



Instructions

Preheat oven to 450°F. Cut each crown of broccoli lengthwise into 4 spears. Place broccoli in large bowl; toss with olive oil and sprinkle with salt and pepper. Transfer broccoli to large rimmed baking sheet. Add grated Asiago cheese to same bowl. Roast broccoli until crisp-tender and stalks begin to brown, about 25 minutes. Return broccoli to bowl with cheese. Using tongs, toss to coat.

Matching Ingredients

1 1/2 pounds (about 1 large bunch) broccoli, stalks trimmed to 2 inches below crowns 1 cup grated Asiago cheese

Missing Ingredients (1)

3 tablespoons olive oil

67%
Match Score

Benedictine Sandwiches (Match: 60%)

Chicken Breasts with Sun-Dried Tomato and Garlic Crust (Match: 60%)



Instructions

Combine breadcrumbs, sun-dried tomatoes, 2 tablespoons oil reserved from tomatoes and garlic in processor. Using on/off turns, process until tomatoes are coarsely chopped. Season to taste with salt and pepper. (Can be made 8 hours ahead. Cover and chill.) Preheat oven to 375°F. Sprinkle chicken with salt and pepper. Heat 1 1/2 tablespoons oil reserved from tomatoes in heavy large skillet over medium-high heat. Add chicken, skin side down, and cook until skin is crisp and golden, about 5 minutes. Transfer chicken, skin side up, to heavy rimmed baking sheet. Spoon breadcrumb mixture atop chicken, dividing equally and pressing to adhere. Bake until chicken is cooked through, about 30 minutes. Place chicken on plates and serve.

Deploy

Recommended Recipes

Parmesan-Crusted Chicken (Match: 100%)



Instructions

Preheat oven to 425°F. Combine Hellmann's® or Best Foods® Real Mayonnaise with cheese in medium bowl. Arrange chicken on baking sheet. Evenly top with Mayonnaise mixture, then sprinkle with bread crumbs. Bake until chicken is thoroughly cooked, about 20 minutes. This recipe is made available as a courtesy by Hellmann's®.

Matching Ingredients

"1/2 cup Hellmann's® or Best Foods® Real Mayonnaise", 1/4 cup grated Parmesan cheese

4 boneless, skinless chicken breast halves (about 1 1/4 lbs.) 4 tsp. Italian seasoned dry bread crumbs

100%
Match Score

Blue Cheese Crusted Tomatoes (Match: 75%)



Instructions

Prepare barbecue (high heat), leaving opposite side unlit if gas grill or without coals if charcoal grill. Mix breadcrumbs and olive oil in small bowl, mashing to coat. Cut top 1/4 from each tomato. Sprinkle tomatoes with salt and pepper. Top each with 1 tablespoon blue cheese. Sprinkle with breadcrumb mixture. Arrange tomatoes (topping side up) on unlit side of grill. Cover grill and cook tomatoes until slightly soft and cheese melts, about 13 minutes. Serve immediately.

Matching Ingredients

1/2 cup fine dry breadcrumbs 12 medium tomatoes 3/4 cup crumbled blue cheese (about 3 ounces)

75%
Match Score

Measuring Success: Evaluation Metrics

For our project, we selected ResNet18, a renowned Convolutional Neural Network architecture, for its balance of depth and computational efficiency.

	Label Propagation	Label Spreading	Self-Training (Pseudo-Labeling)
Train accuracy	95.04%	96.54%	100%
Test accuracy	77.36%	77.53%	77.94%
F1 Score	0.77	0.77	0.78
Recall	0.77	0.78	0.78
Precision	0.78	0.78	0.78

Results and Observations

The experimental results show that **Self-Training** is the most effective semi-supervised method for this task.

- **Best overall performance** – Self-Training outperforms Label Propagation and Label Spreading
- **Scalability** – Handles large unlabeled datasets efficiently
- **Stable learning** – High-confidence pseudo-labels improve accuracy
- **Practical suitability** – Well adapted to real-world grocery image classification



Thank You !

We appreciate your attention and welcome any questions.