

# Discovering Attributes for Food Description and Recognition

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# 50 Chinese Foods[3]



sandwich



goi cuon



rice tamale



sashimi



popcorn



lobster



omurice



fried noodles



donuts



sausage



shumai



braised pork



fried rice



dumplings



peking duck



arepas



bread



fried food



gongbao chicken



spaghetti



pizza



salad



steak



sushi



mapo tofu

# 50 Chinese Foods[3]



hamburger



curry rice



shrimp



subway



buns



chasiu



chocolate



corn



crab



croissants



curry chicken



ice cream



steamed sandwich



lasagne



potato chip



steamed bun



noodle soup



egg tart



turnip cake



hot&sour soup



stinky tofu



poutine



fish and chips

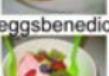
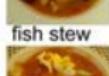
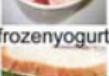


chicken rice



som tam

# ImageNet Foods[4]

								
alphabetsoup	appleturnover	baconeeggs	bbqwings	beefstew	bisque	bit	boiledegg	borsch
								
burrito	cannelloni	casserole	cheesefondue	chickenkiev	chickensalad	chickensw	chickensoup	chickenstew
								
chili	chocolatefondu	chowder	chowmein	cocoa	coffee	coleslaw	coquavin	couscous
								
cremebrulee	cremecaramel	curry	deviled egg	egg roll	eggsbenedict	enchilada	fish&chips	fishballs
								
fish stew	fish sticks	frenchtoast	friedrice	frittata	frozencyogurt	fruit custard	fruit drink	fruit salad
								
gazpacho	goulash	greenpeasoup	hamandeggs	hamburger	hamsandwich	hotdog	hotpot	icecream
								
kebab	lasagne	lentilsoup	lobster	macaronicheese	meatballs	meatloaf	milk	mousse

# ImageNet Foods[4]



# Baselines

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- ▶ Human Classification

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- ▶ Bag of Features (BoF)

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- ▶ PiCoDes [2]

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- ▶ Human Classification
- ▶ Bag of Features (BoF)
- ▶ PiCoDes [2]
- ▶ Meta-Class [1]

**Table.** Food Classification by Humans (scores are averaged over responses from 40 participants)

Class	F1 Score	Class	F1 Score
Roulade	1.00	Samosa	0.99
Spaghetti	1.00	Fried Rice	0.96
Kebab	1.00	Casserole	0.92
Deviled Egg	1.00	Curry	0.93
Pasta Salad	0.99	Paella	0.78

**Accuracy:** 95.6%

# Baseline Classification

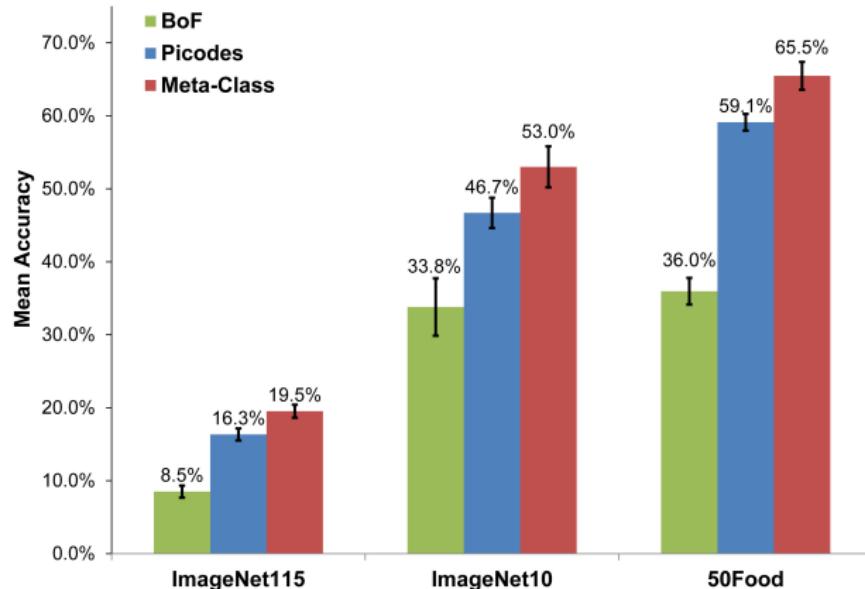
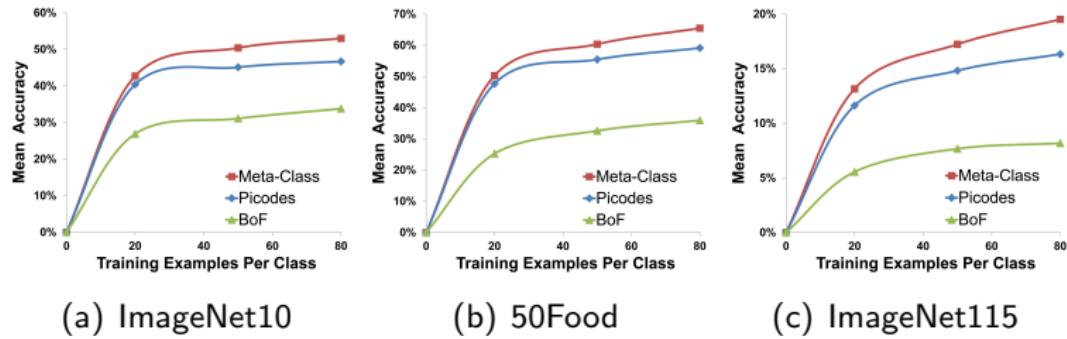


Figure. Baseline classification performance. Results are averaged over 5 random 80%/20% training/testing splits of the data.

# Baseline Learning Rate



**Figure.** Classification Performance vs. Number of Training Images.  
Results are averaged over 5 random training/testing splits of the data.  
The classifier is evaluated on a test set with 20 images per class.

# Confusing Foods

Table. 50Food Top 5 Most Confusing Foods: The first column has an instance of an image misclassified for the label of the second column and vice versa.

Food Class 1	Food Class 2	No.Mistakes/40
		8
Croissants	Donuts	
		6
Egg Tart	Donut	

Food Class 1



Sausage

Food Class 2



Fried Food

No.Mistakes/40

6



Braised Pork



Peking Duck



Ice Cream

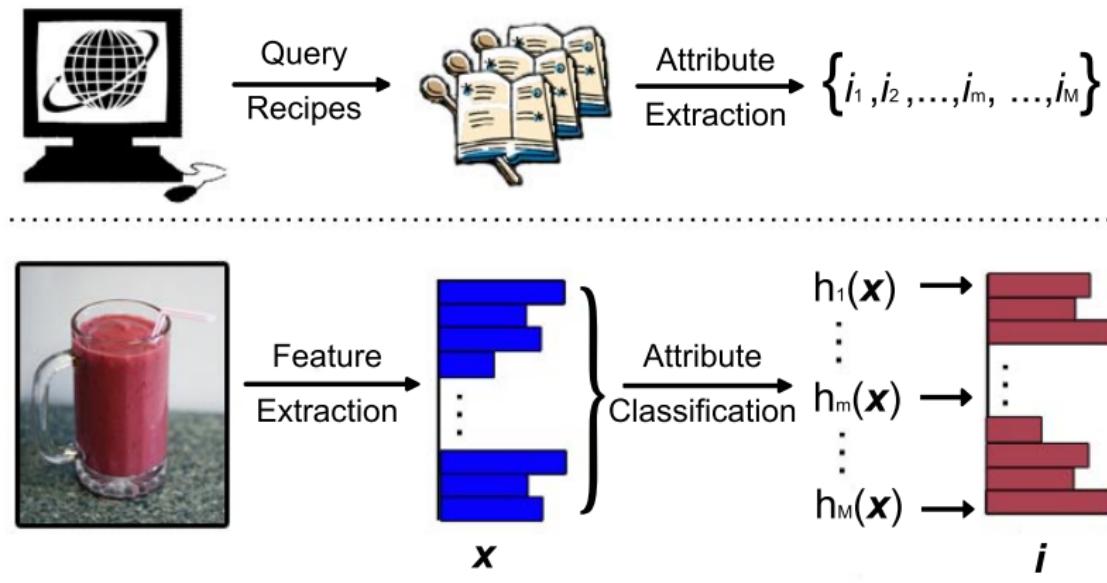


Buns

4

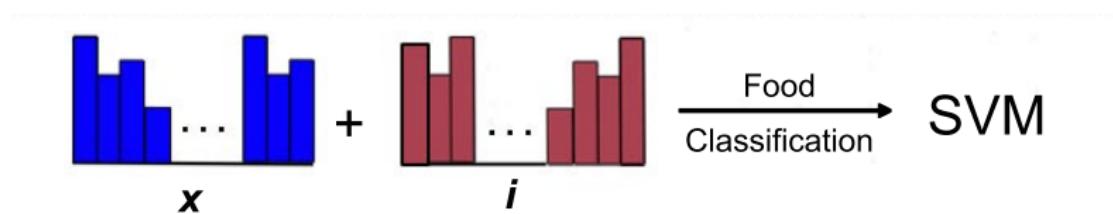
3

# Attribute Discovery and Classification Pipeline



**Figure.** **Top row:** Training labels are used to query the Internet for recipes. **Bottom row:** Visual descriptors are used as input for a set of trained attribute classifiers to compute recipe descriptor.

# Attribute Discovery and Classification Pipeline



**Figure.** The visual descriptor and the recipe descriptor are used together for classification.



Janine's Best Banana Bread

READY IN  
1 3/4 hr

29 Photos

4.5 stars (463 reviews)

Print

Every time there is a party or any type of gathering, I'm asked to bring a loaf of my homemade banana bread. It's always the first to go and I'm always jotting down the recipe afterwards for friends. It's simple, quick and delicious! — Janine Cunningham

Ingredients

Original recipe makes 2 - 8x4 inch loaf Change Servings

<input type="checkbox"/> 1/4 cup butter, softened	<input type="checkbox"/> 2 cups all-purpose flour
<input type="checkbox"/> 1 cup white sugar	<input type="checkbox"/> 1 teaspoon baking soda
<input type="checkbox"/> 2 eggs	<input type="checkbox"/> 1/2 teaspoon salt
<input type="checkbox"/> 3 ripe bananas, mashed	

Directions

- Preheat oven to 350 degrees F (175 degrees C). Lightly grease an 8x4 inch loaf pan.
- In a large bowl, cream together butter and sugar. Beat in the egg and mashed bananas. Mix in flour, baking soda and salt just until combined. Pour into prepared loaf pan.
- Bake in preheated oven for 1 hour. If top begins to brown too quickly, decrease heat slightly. Center should be soft and chewy, while the outside, crisp and crunchy.

Nutrition

Calories	248 kcal	12%
Cholesterol	23 mg	1%
Fiber	1.6 g	6%
Sodium	263 mg	11%
Carbohydrates	47.2 g	15%
Fat	5.5 g	8%
Protein	3.6 g	7%

\* Percent Daily Values are based on a 2,000 calorie diet.

# Enhanced Baseline Classification

**Table.** Classification Accuracy of Baseline vs. Enhanced Baseline Descriptors: Results are shown for classification with baseline descriptors (BL), enhanced baseline descriptors (+RBF), and enhanced baseline descriptors with ground-truth attributes (+GT). (Best results for each data set bolded.)

Data Set	BoF			PiCoDes			Meta-Class		
	BL	+RBF	+GT	BL	+RBF	+GT	BL	+RBF	+GT
ImageNet115	5.2	6.9	8.8	16.2	15.5	32.7	19.0	<b>19.5</b>	22.9
ImageNet10	36.5	36.0	36.5	47.0	48.5	66.0	51.0	<b>53.0</b>	57.0
50Food	33.0	33.9	33.8	58.6	53.9	70.1	64.3	<b>65.7</b>	67.6

## Enhanced Baseline Classification

**Table.** Comparison of Meta-Class and Enhanced Meta-Class Descriptors  
(Results averaged over five training/testing splits)

<b>Data Set</b>	<b>Accuracy (<math>\pm</math> SE)</b>	
	MC	+RBF
ImageNet115	$19.5 \pm 0.4$	<b><math>19.8 \pm 0.4</math></b>
ImageNet10	$53.0 \pm 1.2$	<b><math>53.9 \pm 0.6</math></b>
50Food	$65.5 \pm 0.8$	<b><math>66.5 \pm 0.6</math></b>

## Improvement by Attribute Type

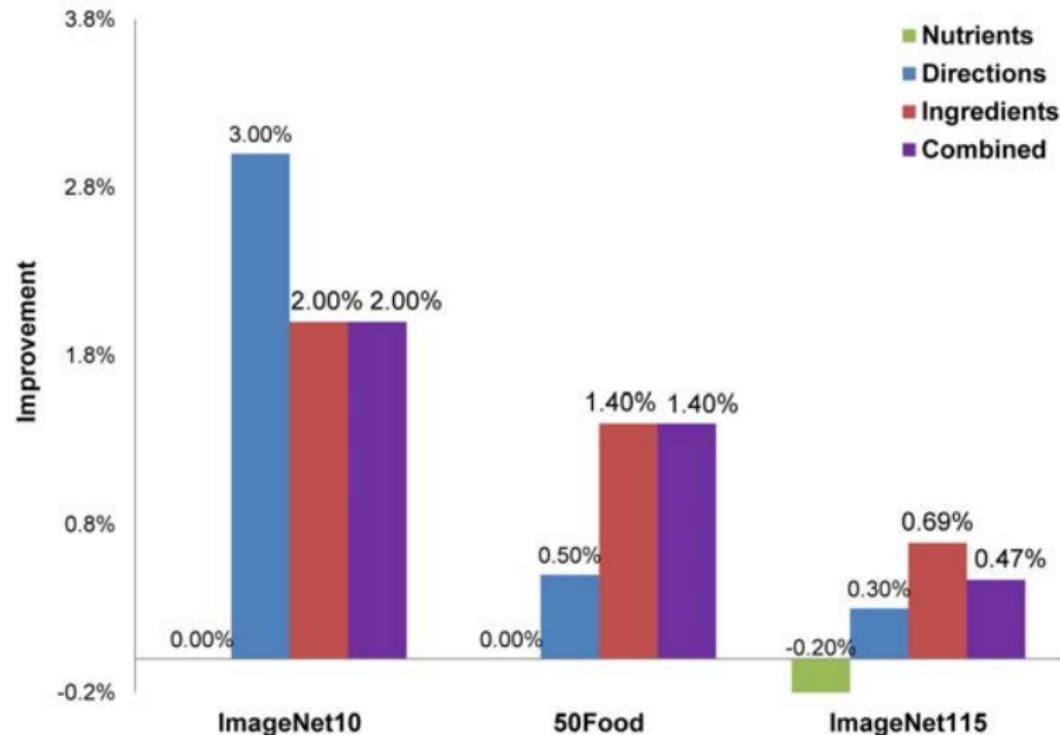
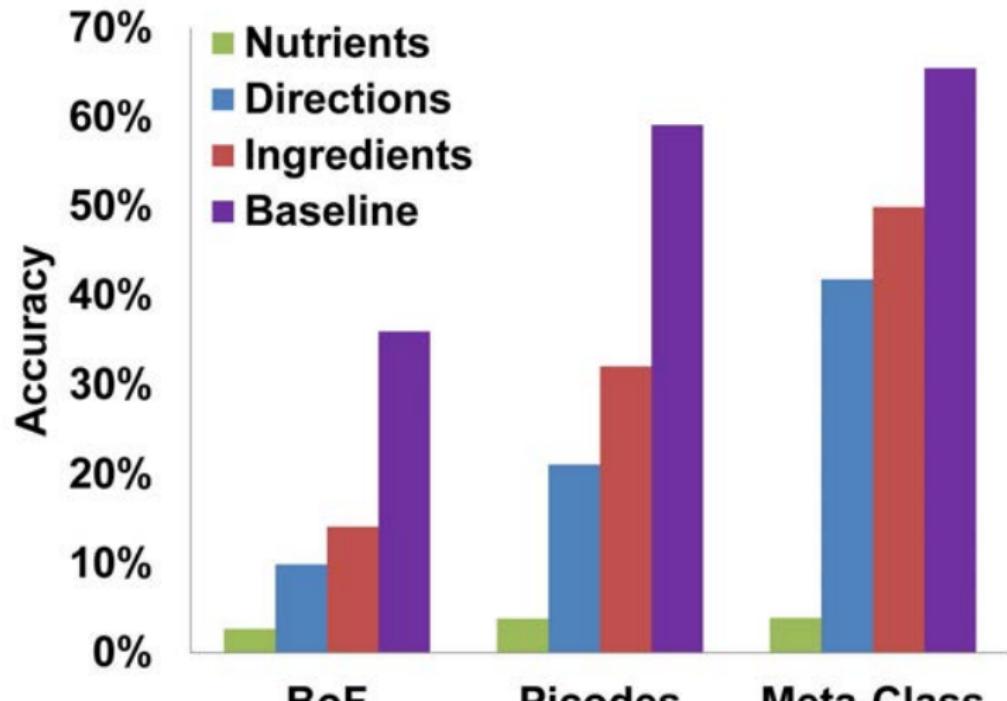


Figure. Improvement of Recipe Enhanced Meta-Class Over Basic Meta-Class by Attribute Type

## Classification with Attributes Only



(a) 50Food

Figure. Classification Accuracy with Attributes Only: Food classifiers are

## Classification with Attributes Only

Table. 50Food: Top 5 Most Confusing Foods by Ingredients

Food Class 1	Food Class 2	No.Mistakes/40
Mapo Tofu	Stinky Tofu	14
Arepas	Buns	7
Croissants	Buns	6
Curry Rice	Curry Chicken	6
Spaghetti	Lasagne	5

# Zero-Shot Learning: Pizza



(a) Novel Test Image

diced sweet **onion**  
**dried basil**  
butter, cubed  
**dried thyme**  
peeled and deveined shrimp  
**tomato puree**  
**dried oregano**  
garlic salt  
lemon, juiced  
andouille **sausage**

(b) Top Predicted Ingredients  
(search terms bolded)

# Zero-Shot Learning: Pizza



(c) Google Image Search Results (Hits highlighted in red)

# Zero-Shot Learning: Poutine



(a) Novel Test Image

processed cheese spread  
shredded Colby **cheese**  
margarine  
hash brown **potatoes**  
French fried onions  
condensed French onion soup  
quick-cooking grits  
cornflakes cereal  
rutabagas  
country **gravy** mix  
(b) Top Predicted Ingredients  
(search terms bolded)

# Zero-Shot Learning: Poutine



(c) Google Image Search Results (Hits highlighted in red)

# Zero-Shot Learning: Fish and Chips



(a) Novel Test Image

frozen **puff pastry**  
**apple juice**  
**oil for deep frying**  
beef broth  
ajwain seeds  
large wonton wrappers  
russet **potatoes**  
phyllo dough  
Kikkoman Thai Red Curry Sauce  
dry onion soup mix  
(b) Top Predicted Ingredients  
(search terms bolded)

# Zero-Shot Learning: Fish and Chips



(c) Google Image Search Results (Hits highlighted in red)

## References I

- [1] A. Bergamo and L. Torresani.  
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- [2] A. Bergamo, L. Torresani, and A. W. Fitzgibbon.  
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- [3] M.-Y. Chen, Y.-H. Yang, C.-J. Ho, S.-H. Wang, S.-M. Liu, E. Chang, C.-H. Yeh, and M. Ouhyoung.  
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## References II

- [4] J. Deng, W. Dong, R. Socher, L.-J. Li, K. Li, and L. Fei-Fei.  
Imagenet: A large-scale hierarchical image database.  
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