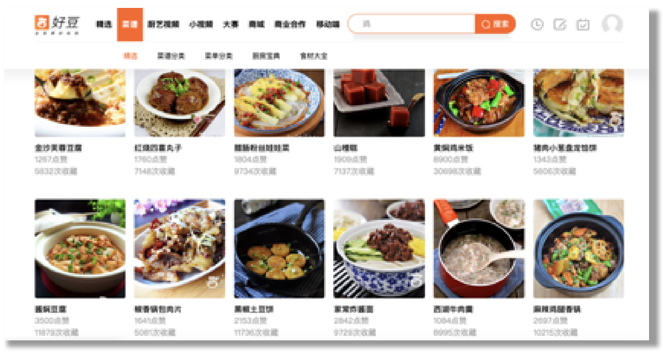
Categorization of Cooking Actions Based on Textual/Visual Similarity

Yixin Zhang[1], Yoko Yamakata[2] and Keishi Tajima[1]
[1]Kyoto University and [2]The University of Tokyo, Japan

KYOTO UNIVERSITY
THE UNIVERSITY OF TOKYO

RESEARCH BACKGROUND



- 5,482,309 recipes in Chinese
- (source: https://www.haodou.com/recipe/1190778)
- Every procedural step is associated with an image.
- The pairs of text and image in procedural steps are used in this research.
- 57,361,678 steps in total

RESEARCH PURPOSE

Word embedding of action verbs in recipes.

- To calculate similarities and differences between action verbs.
  - "Cut" and "Cut into" have similar meanings but the later one indicates the shape of ingredients after being cut.
- To be used for recipe retrieval or recipe automatic translation in the future.

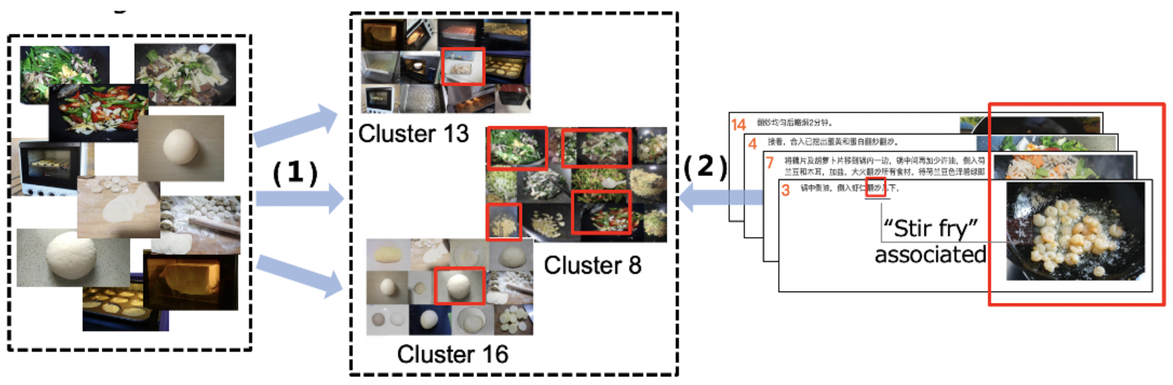
- Existing method: Word2vec
  - Train word-embedding model by recipe text data and transform each verb into multi-dimensional vector.
  - Given word embedding vectors of verbs, the similarity between two verbs is computed by the cosine similarity of their embedded vectors.

PROPOSED METHOD

- Word embedding by associated images.

(1) Clustering images into groups which consist of images of similar style.

(2) For each verb, calculating the probability distribution of the associated images over clusters.



- Probability distribution of associated images indicates the meaning of the verb.

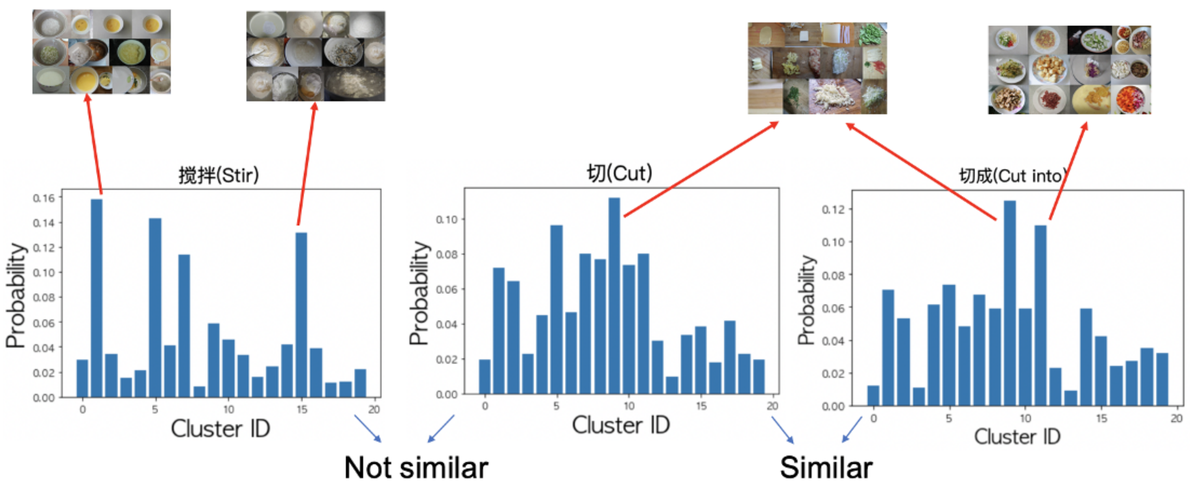
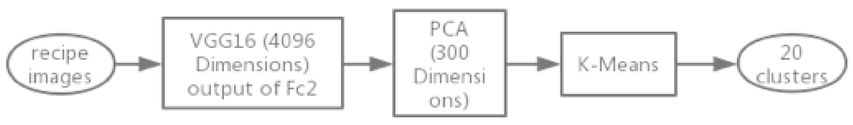


IMAGE CLUSTERING METHOD



- Image clustering
  - Cluster all 48164 images in our dataset into 20 clusters by using k-means clustering method

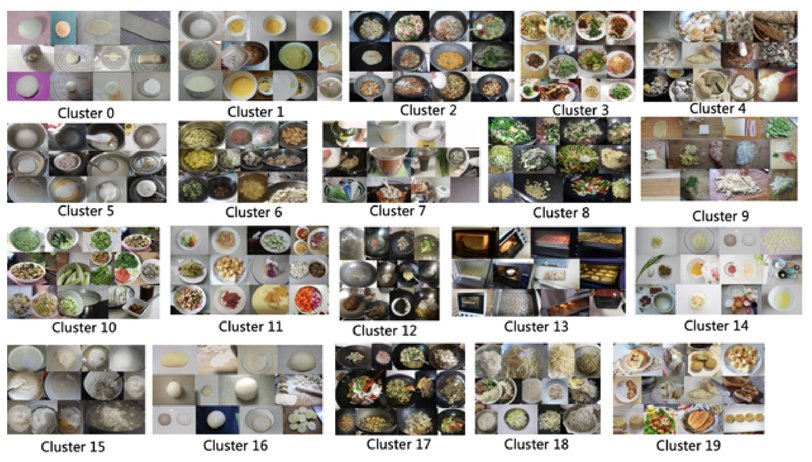


Table 1: The Number of Images in Each Cluster

cluster	#img	cluster	#img	cluster	#img	cluster	#img
00	775	05	3107	10	3468	15	2387
01	3244	06	2574	11	2530	16	1882
02	2561	07	3919	12	1436	17	1685
03	2696	08	2258	13	1123	18	1175
04	2664	09	3529	14	2544	19	2607

EXPERIMENT

- Dataset
  - #Recipe: 12,548
  - #Image: 48,164
  - Word segmentation and POS tagging by Jieba [1]

- Total Verbs: 26,9993
- Distinct Verbs: 3,175
  - 341 verbs (10.7%) of which appeared 100 times or more.
  - 1262 verbs (39.7%) appeared 2 to 9 times.
  - 695 verbs (21.9%) appeared only once.

[1] https://github.com/fxsjy/jieba

Table 1: Top 20 Most Frequent Verbs

rank	verb		frequency
1	put in	放入	16958
2	add in	加入	12187
3	pour in	倒入	7150
4	stir fry	翻炒	5413
5	prepare	准备	4792
6	boil	煮	4625
7	stir	搅拌	4613
8	set aside	备用	4590
9	moderate amount	适量	4341
10	wash	洗净	4291
11	add	加	3716
12	put	放	3096
13	out	出	2918
14	cut into	切成	2763
15	cut	切	2733
16	be	是	2550
17	clean	清洗	2202
18	mix well	拌匀	2171
19	ferment	发酵	2119
20	cover	盖	2089

- Computing top-10 similar verbs by using our three vectorization methods.
- Calculating how many of the top-n results given by our image-based method are also included in the top-10 results given by the word2vec method for n = 1, . . . , 10.
- Image-clustring based probability distortion holds word semantics even under hard dimension compression.
- Dimensional compression from 4096 to 20 using image clustering did not cause performance deterioration.

COMPARISON OF METHODS

- Ground truth: Word2vec
  - To evaluate whether the proposed method achieves word embedding which represents word semantics as word2vec does.
- We compared **three ways** to vectorize verbs.
  - Method 1 and 2 use the image vectors calculated from VGG16 and PCA .
  - Method 3 uses the clusters of recipe images (proposed method).

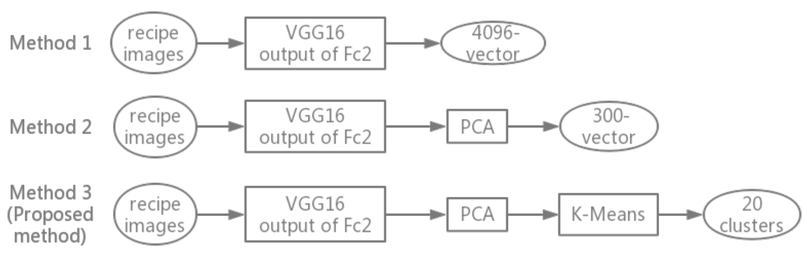
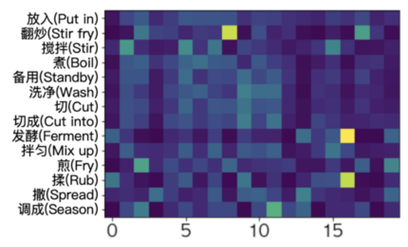


Table 5: Degree of Agreement with Text-Based Method

n	1	2	3	4	5	6	7	8	9	10
4096-vector	10	13	16	21	23	27	29	31	33	35
300-vector	10	13	17	21	24	27	29	31	35	39
20-vector	8	12	18	22	24	26	30	31	32	34

- The top-10 results of the Word2vec method and the method using the 20-dimensional vectors for the 14 example verbs.
- Text-based similarity and image-based similarity of verbs are complementary to each other.



boil 煮

	text		image	
1	boil	煮开	put in	放入
2	boil	煮沸	boil	煮沸
3	make soup	煲	boiling water	开水
4	cooked	煮熟	fish out	捞出
5	stew	焖	pour	倒入
6	boil	烧开	add in	加入
7	stew	炖煮	cook	煮熟
8	stew	炖	cooking wine	料酒
9	make soup	熬	stew	焖
10	turn	转	chop	切碎

cut into 切成

	text		image	
1	cut	切	cut	切
2	tear into	撕成	go	去
3	chop	剁成	standby	备用
4	grow	成长	wash	洗净
5	rub	擦	pickle	腌制
6	cut	切好	drain	控干
7	smash	拍	prepare	准备
8	crush	剁碎	soak	浸泡
9	chop	切碎	soak	泡
10	remove	去掉	remove	去掉

CONCLUSION

- Word embedding of action verbs using pairs of text and images in recipes.
- Image-based word embedding achieves as good performance as Word2vec.
  - Dimensional compression from 4096 to 20 using image clustering did not cause performance deterioration.
  - Text-based similarity and image-based similarity of verbs are complementary to each other.
- Future work
  - To evaluate our proposed method by manulally generated ground truth.
  - To further research on the relevance between textual and visual data.
    - Not only verbs, but also extend the method to other POS (e.g. adj).
  - To deploy our method for recipe auto-translation or recipe multi-lingual retrieval.