Real-Time Mobile Recipe Recommendation System Using Food Ingredient Recognition

ACM Multimedia 2012 Workshop
Interactive Multimedia on Mobile and Portable Devices (IMMPD'12)

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[Demo] Recipe search by object recognition at a grocery store

Point a camera to carrots

Object recognition

Recipe lists

Select one from the list

Get to know how to cook

mobile × recipe search × object recognition

Background

OpenCV

×

Smart phone

⬇

Easy to implement an object recognition system on smartphones

Proposed System

mobile × Recipe search × Object Recognition

Impossible to use both hands for operation of mobile devices while shopping at a grocery stores

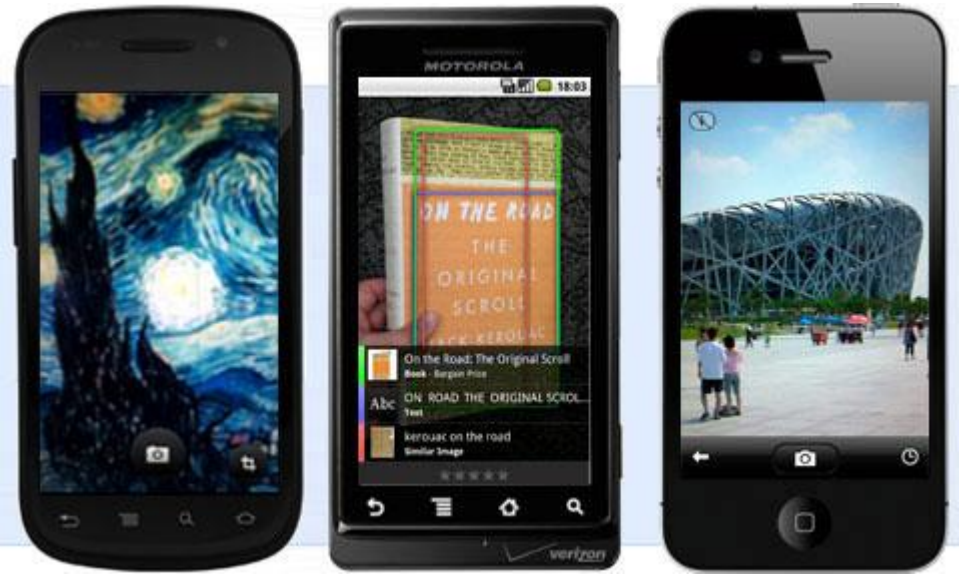
Easy recipe search while shopping

Recognition performed on a smartphone

The first system for recipe search with object recognition on smartphones

Related work —mobile image recognition—

Google Goggles



- Sudoku

- ***Specific object recognition***
- ***Similar image search***
- ***OCR***

Object recognition for generic object is impossible

Implement useful app with generic object recognition

The flow of the proposed system

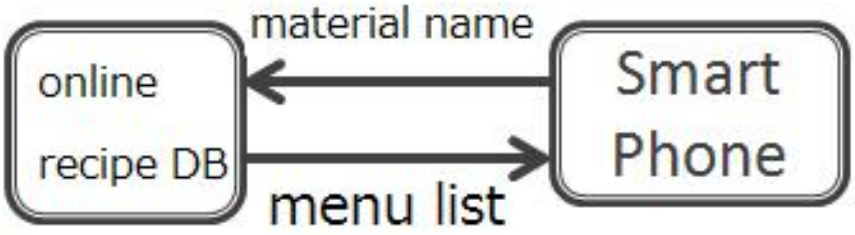
1. Point a camera to food ingredients

The system recognizes photo stream repeatedly and continuously

2. Recognize food ingredients

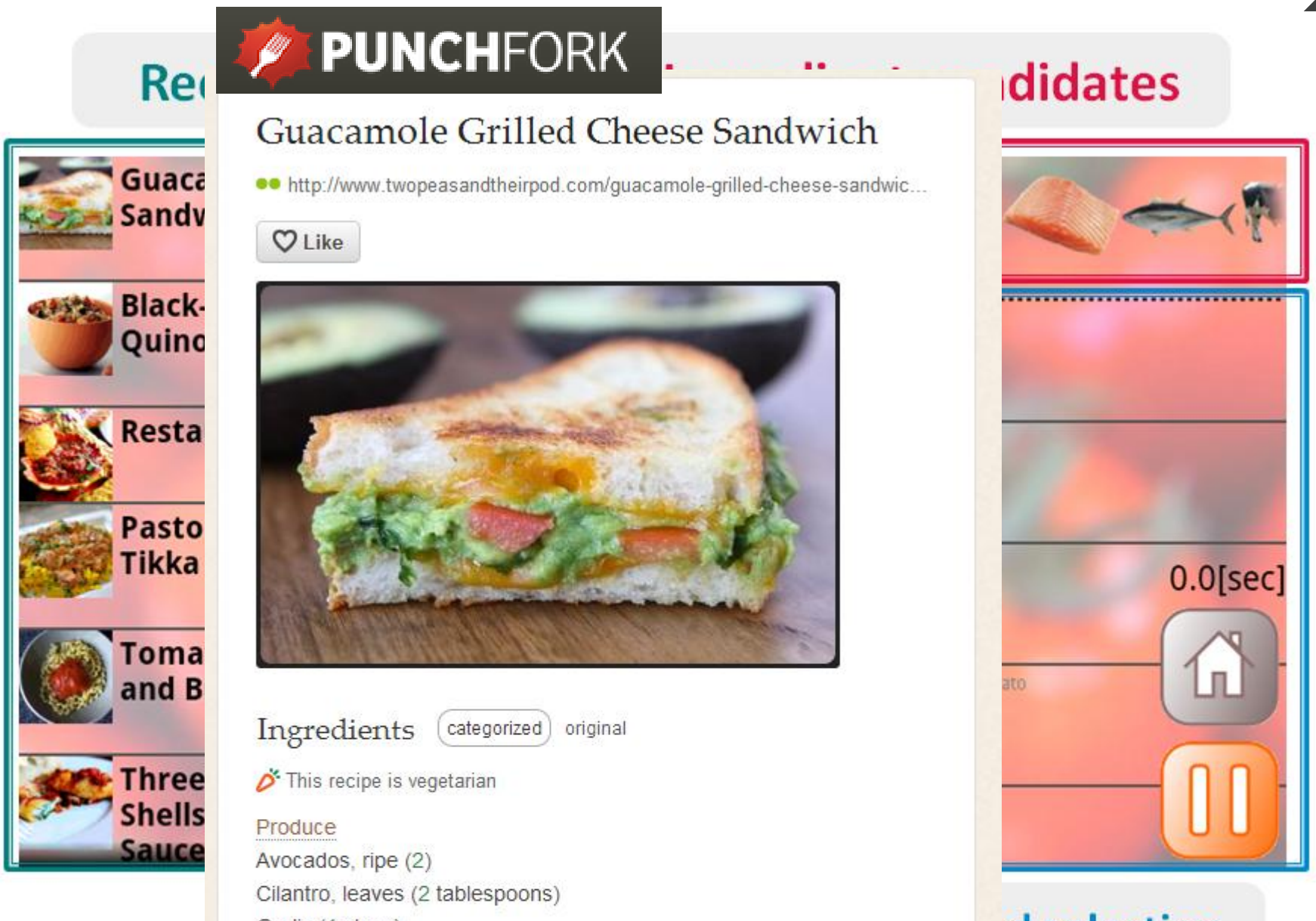
Rank 1 → Rank 6

3. Search an online recipe database

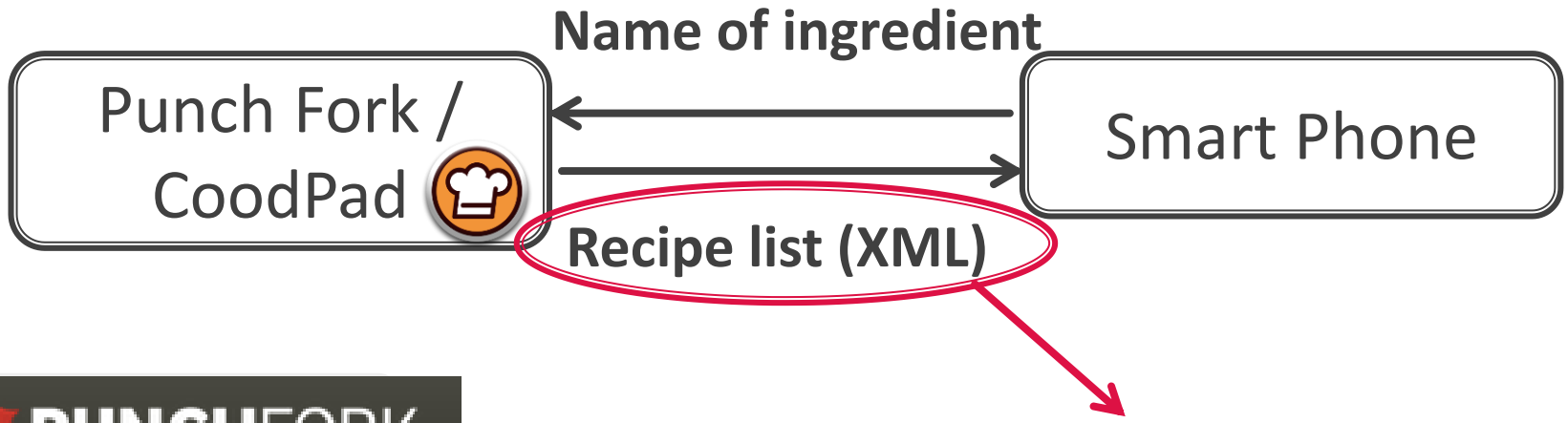


4. Display a menu list

Screen of the System



Obtain recipe list from WebAPI



PUNCHFORK

- User-generated recipe site
- Services in USA
- WebAPI is provided

Currently, the order of the recipe on the sreen is the same as the results from WebAPI.

Need to be improved

Method for Object Recognition

Image Features

Bag-of-Local Color Histogram, Bag-of-SURF
(with KD-tree, 1000 dim codebook)

Multi-frame recognition

Classification method

Linear SVM for saving memory and speed-up

Can recognize a food ingredient in 0.17 second

Time for recognition

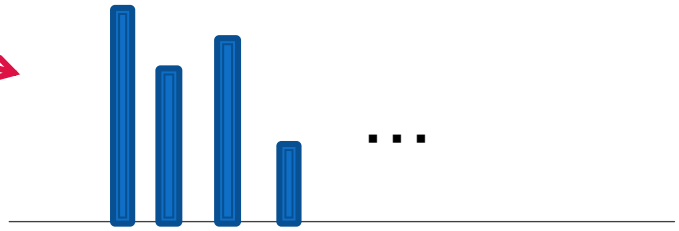
Galaxy S2
- June 3, 2011
- 1GHz Dual Core
- 1GB RAM

HTC Desire HD
- Nov. 12, 2010
- 1GHz
- 756MB RAM

Phone	Avg. (msec.)
GAXALY S2	167.8
HTC DesireHD	394.0

単位はmsec

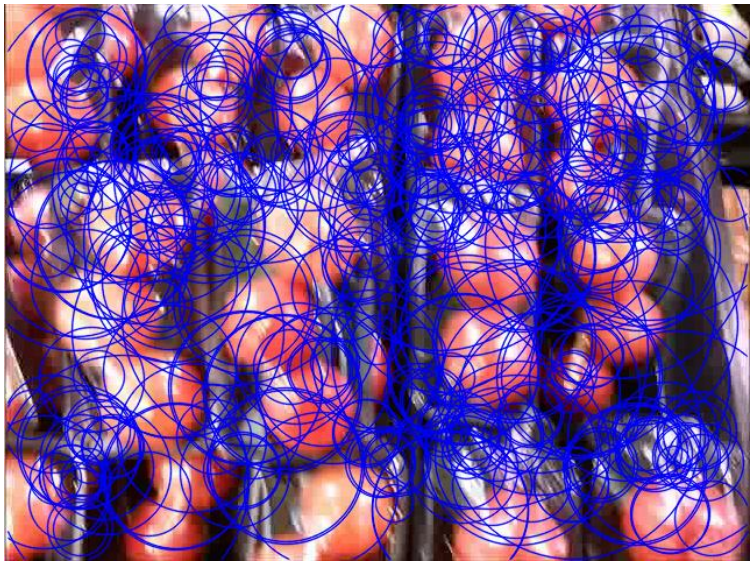
Feature(1): Local Color Histogram



Divide color space
Into 64 bins (4x4x4)

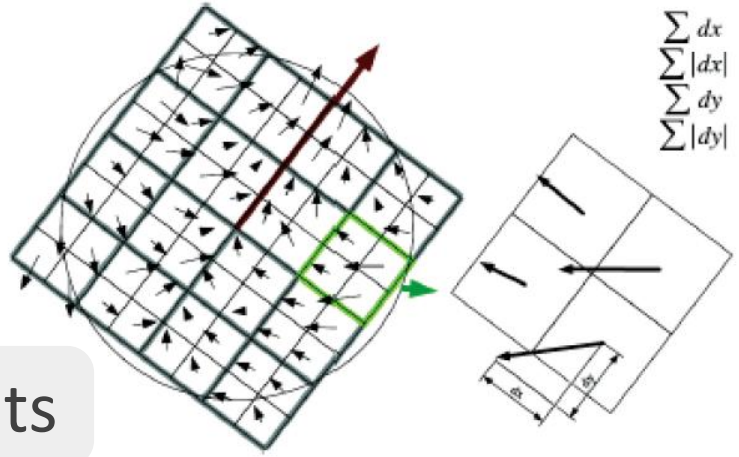
12 x 12 grids ➡ 144 local color histogram

Feature(2): SURF



4dim * 4x4 grids = 64 dims.

$$\sum dx, \sum dy, \sum |dx|, \sum |dy|$$



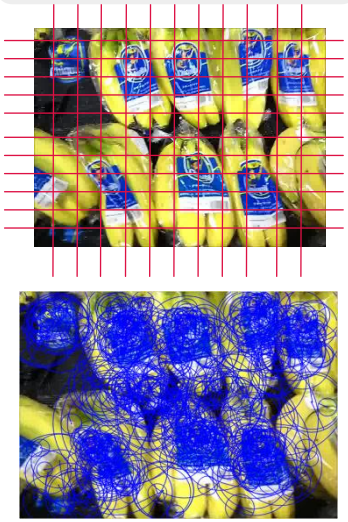
Tested in two ways of keypoints

- Default way (Hessian-based)
- 12x12, 24x24,48x48,96x96 multi-scale grid

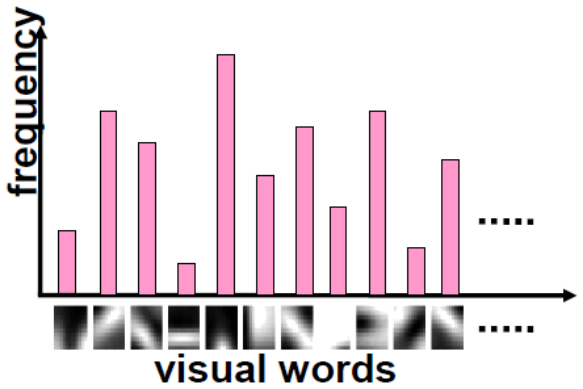
Bag-of-Features

Input image

Local features



BoF vectors



Vote each local feature to corresponding visual word

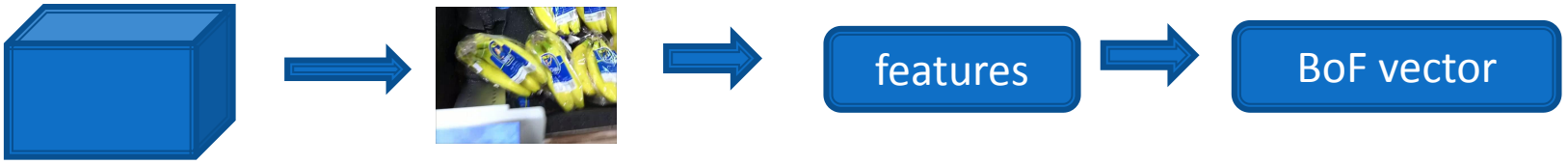
Codebook size: N=1000 (for both local color hist. and SURF)

Use KD-tree to search for visual words: O(logN)

Multi-frame

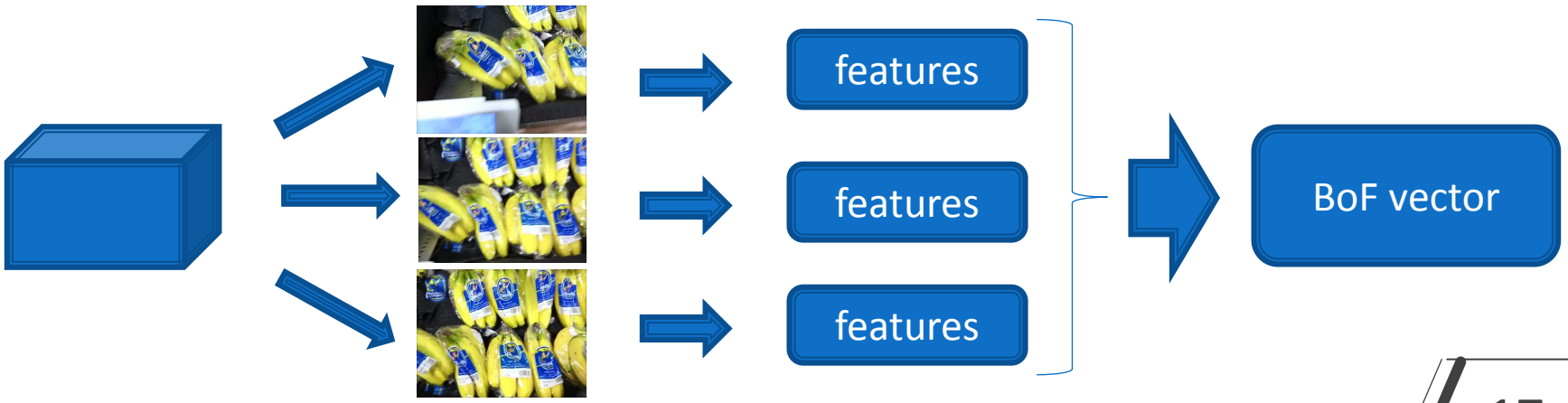
Aggregate local features extracted
from multi frames and build a BoF

- Single Frame



- Multi Frame

in experiments n=1, 2, 3, 4, 5



Linear SVM for speed-up and saving memory

Linear SVM classifer

$$y(x) = \sum_{i=1}^{N} w_i x_i^T x + b$$

Inner product

$O(DN)$

$$= x \boxed{\sum_{i=1}^{N} w_i x_i} + b$$

Can be computed off-line

$$= x^T w + b$$

$O(D)$

y : output

x : input

xi : support vector

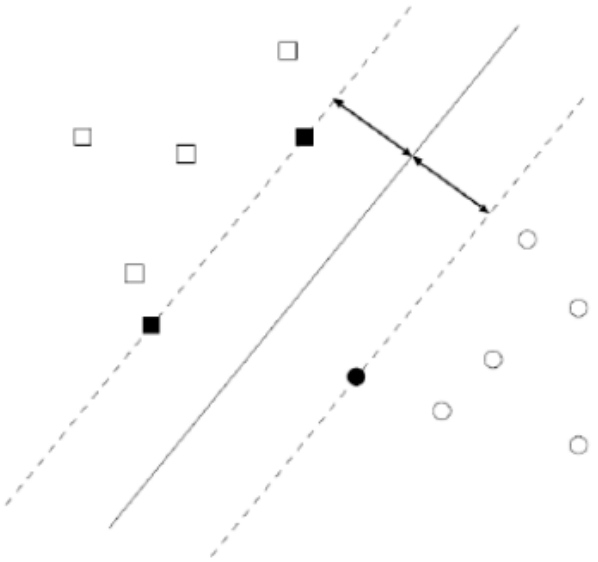
wi : support vec. weight

N : # support vectors

D : dimension of Bof (1000)

Training: offline (on PC), Classifying: on-line (on smartphone)

Linear SVM for speed-up



Estimation of required memory

Codebook (1000-dim)

$$1000 \times 64 \times 4byte \cong 256Kbyte$$

Weight W (for 30 class)

$$1000 \times 30 \times 4byte \cong 30Kbyte$$

Fast & small memory

Limitation: Android app -> 16MByte

Experiments

Dataset

30 kinds of food ingredient: 10 5-sec videos for each

Recorded at 10 grocery stores in Tokyo

Evaluation

Classification rate (features, food, top k)

Evaluate by 10-cross validation

User study

食材3種類を対象に目的のレシピを検索、時間

システムの評価、ユーザのコメント

30 kinds of food ingredient

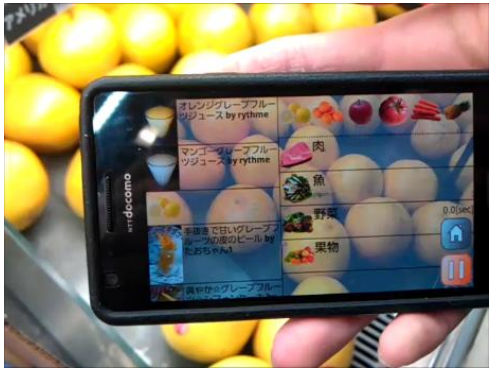
meat	chicken	beef	pork	ham	sausage
	minced meat				
fish	tuna	squid	octopus	shrimp	salmon
vegetable	potato	mushroom	carrot	eggplant	lettuce
	radish	tomato	cucumber	Chinese cabbage	
	Shitake	onion	Green onion	cabbage	
fruit	apple	banana	pineapple	orange	
	strawberry	grapefruit			

Examples

Recorded at 10 grocery stores

Grapefruit

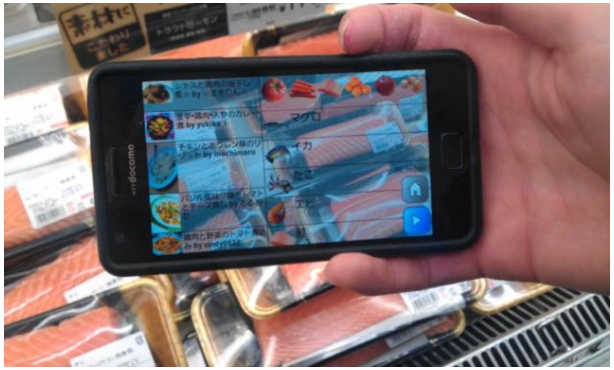
Recognized correctly



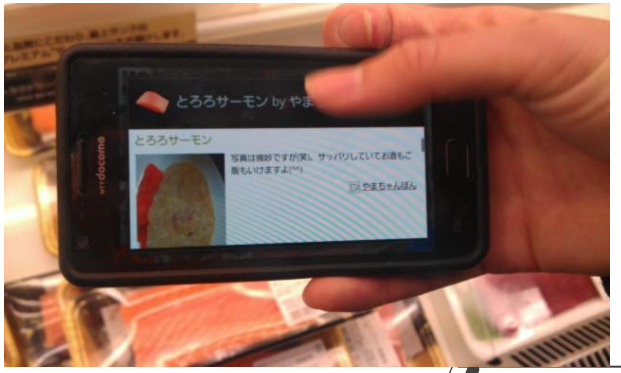
recipe

Salmon

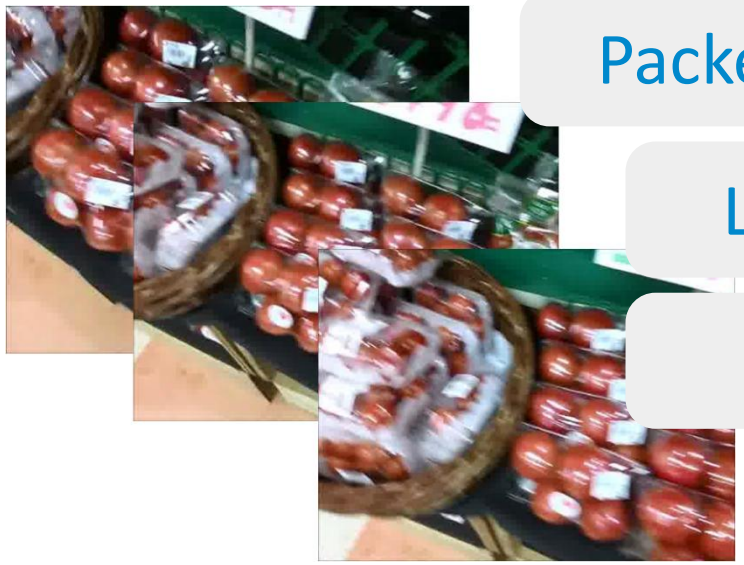
Touch 3rd candidates



recipe



Difficulty in the Dataset

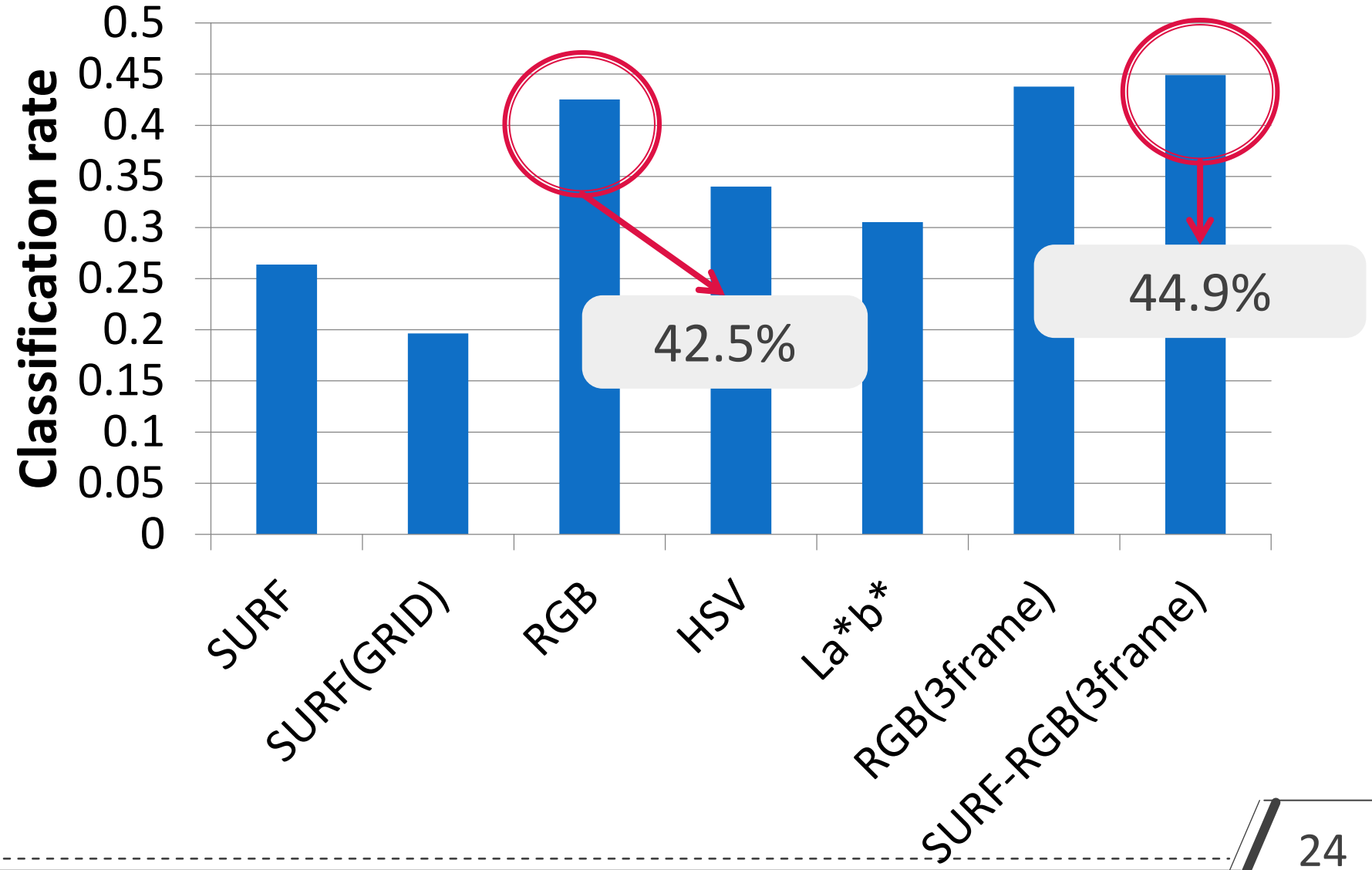


Packed or wrapped

Light reflected

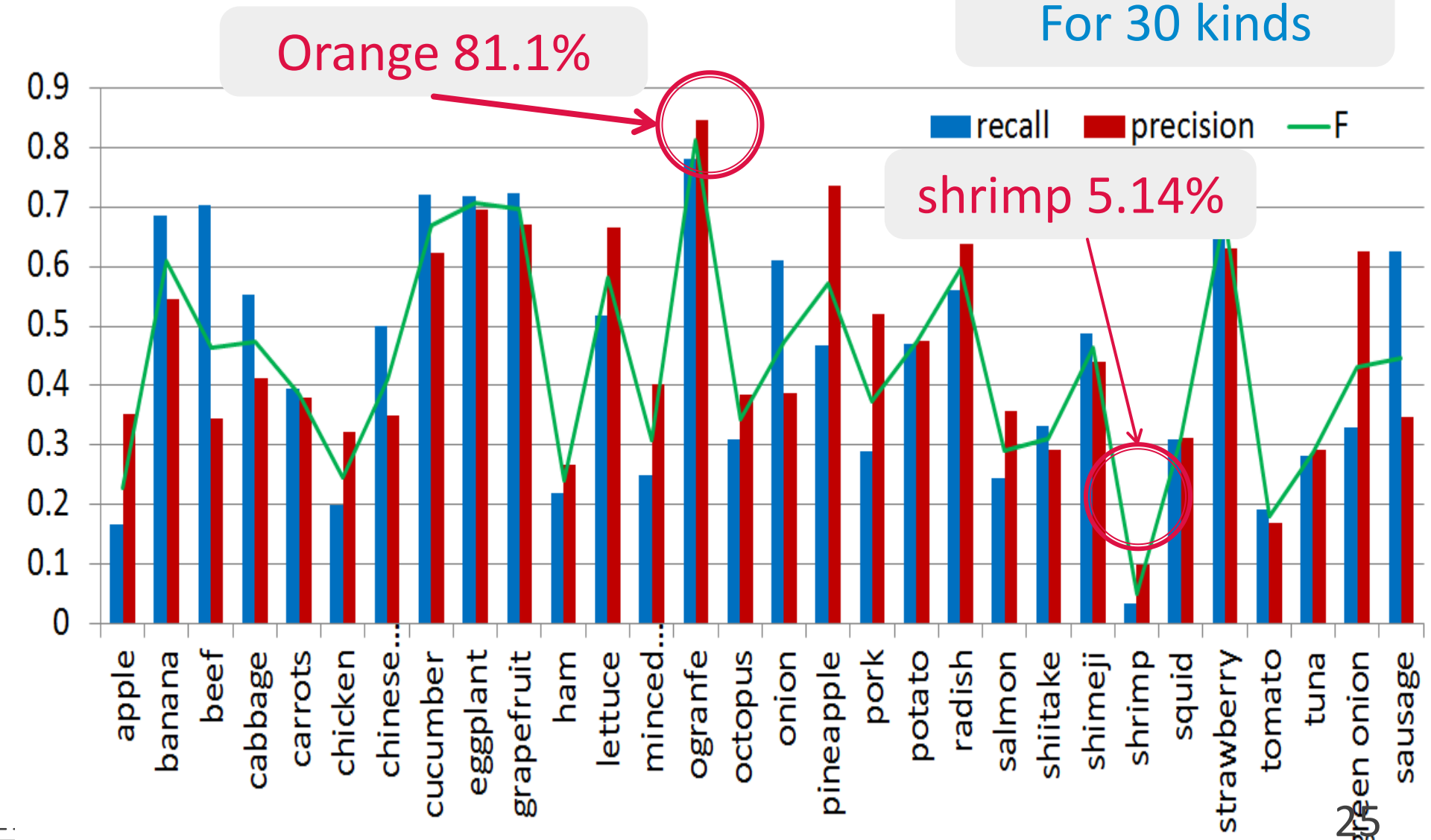
Looks similar

Classification rate for features



Classification rate for each

For 30 kinds



成功した食材、失敗した食材

[best] orange：Orange color is specific to oranges.



[worst] shrimp：color is too various. Freezed, boiled, raw




Confusing food ingredient

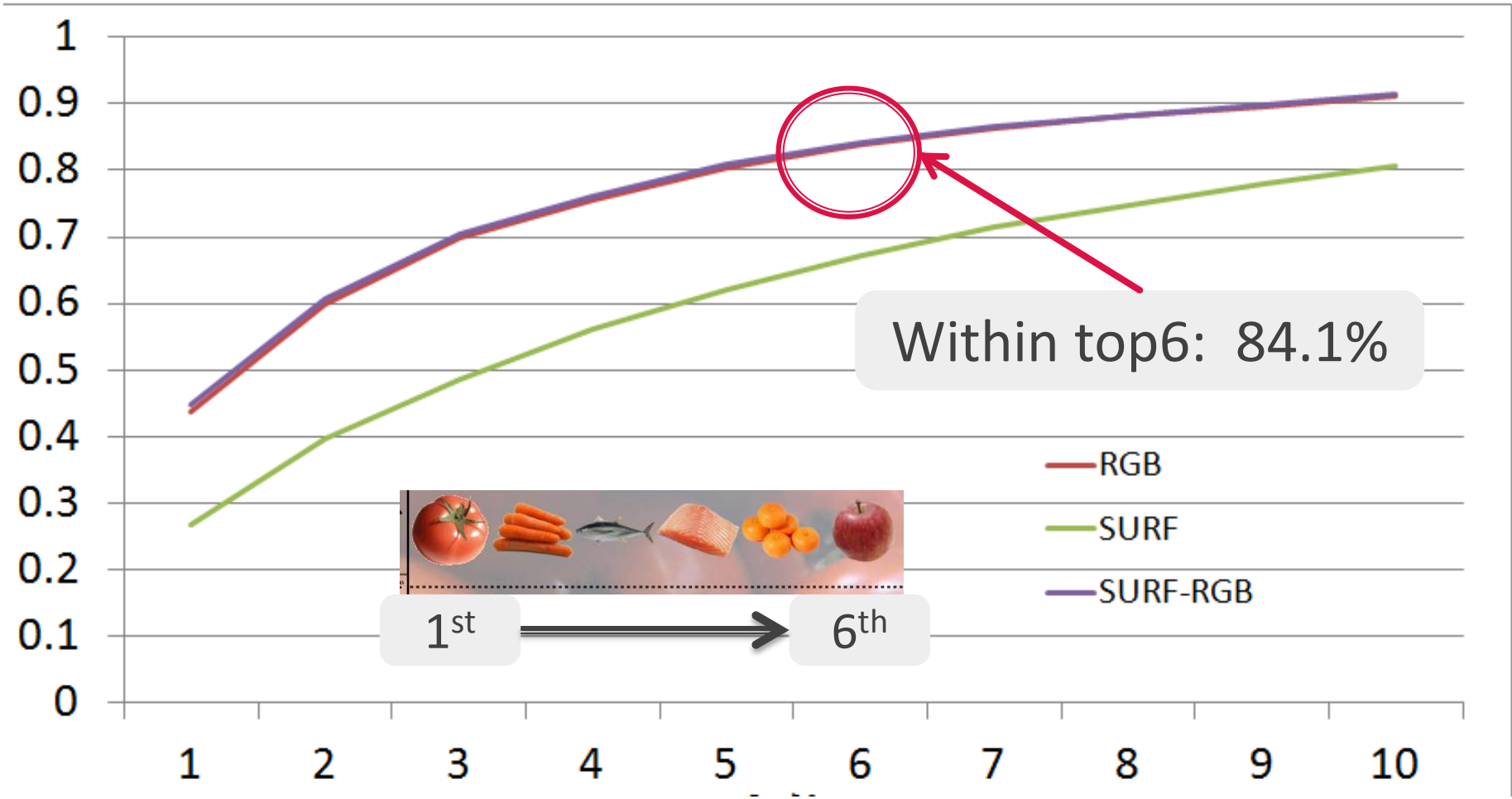
Apple: 2types (green and red)




Tomato, grapefruit




Classification rate within top k



User study

Method

3 ingredient x 3recipes = 9 patterns

Measure times when using obj. rec. and manually

- **Recognition accuracy (5 step)**
- **Usablity (5 step)**
- **Which is better, obj. rec. or manually ? (5 step)**

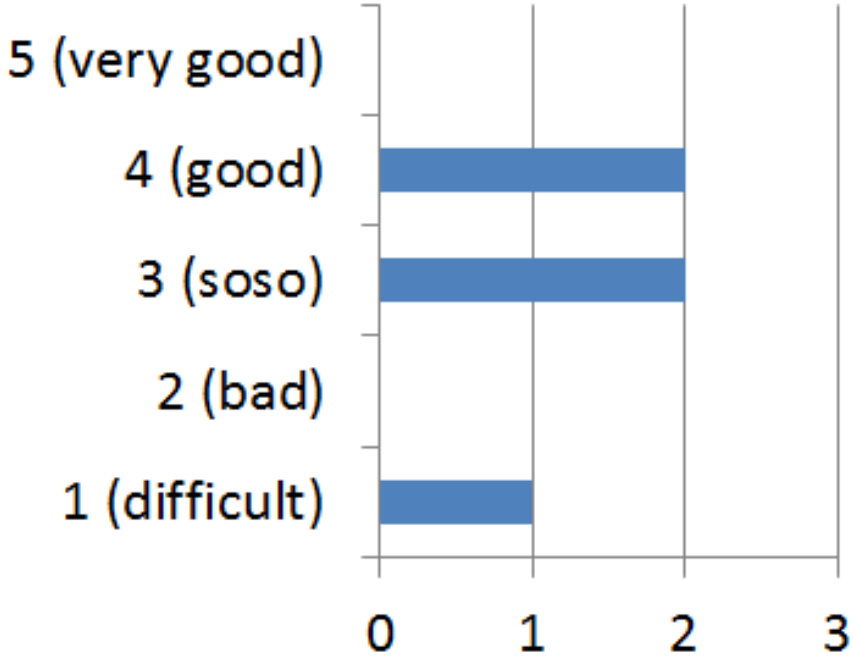
coments

Subjects

5 students

User evaluation (1)

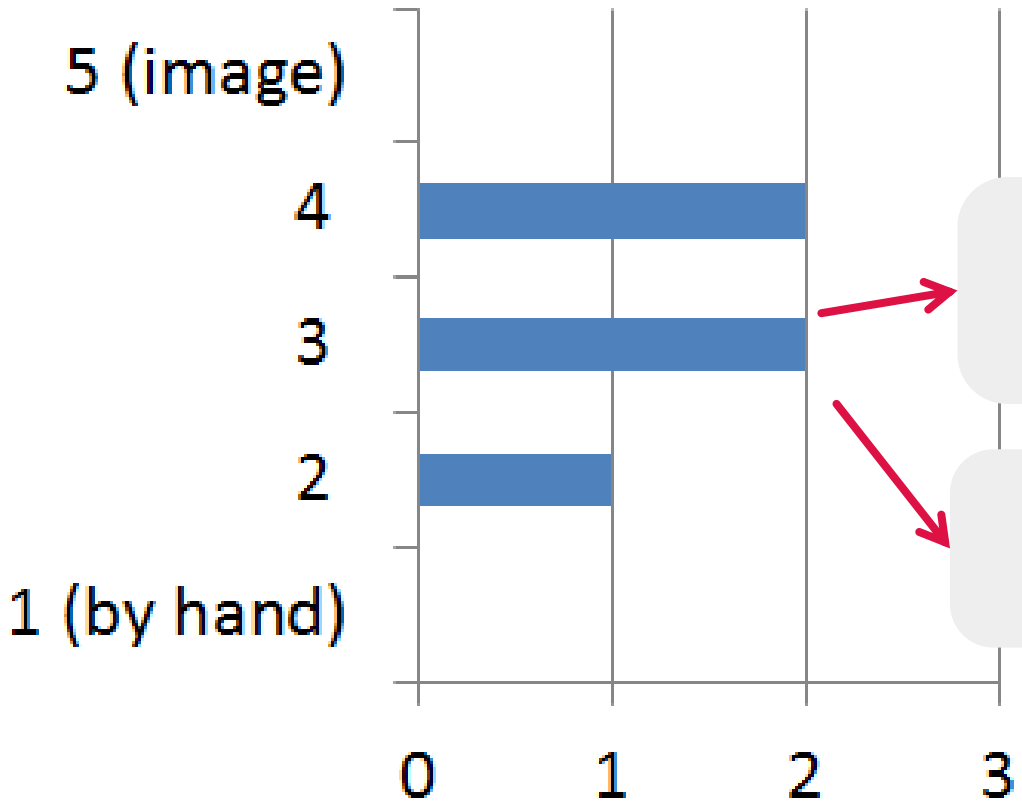
Usability



Recognition Accuracy

User evaluation (2)

Which is better to use,
by object recognition or manually？



Comments

When items was recognized correctly, obj. rec.-based was better.

If accuracy is improved, it must be more practical.

Comments from subjects

comment

It is convenient, because easy to search for recipe at a grocery.

If acuracy is improved, I’d like to use it regularly.

Accuracy seems to depend on kinds of ingredient greatly.

Taking account of the prices would be more helpful.

Conclusions

Propose system

- ✓ By only pointing food ingredient, we can search for the cooking recipe at a grocery store.
- ✓ It takes 0.17[sec] for one-time recognition of 30 kinds of food ingredient.

User study

The users pointed out improvement on recognition accuracy is needed.

Evaluation

Classification rate: 44.9% (1^{st})
84.1% (～6^{th})

Future work

System

Toward being more practical

Search recipe DB by combination of several ingredients (AND-search)

Taking account of budget and price for low-cost cooking

Taking account of ingredient left in the fridge

Recognition

Improve rate and increase kinds

Find better features and make DB bigger

You can try it !

The Android app can be downloaded !
(We do not provide iOS version.)

Download site

http://mm.cs.uec.ac.jp/mobile_recipe/