

Simultaneous Estimation of Food Categories and Calories with Multi-task CNN

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Introduction (1)

Spread of meal management applications.

Recording **food calorie**.



e.g. Foodlog <http://www.foodlog.jp/introduction/log.ja>

Introduction (2)

Example of applications to record food calorie.

Foodlog

2016年04月09日 18:41

1/4 人前	205
1/3 人前	279
1/2 人前	411
2/3 人前	551
3/4 人前	617
1 人前	823
1.5 人前	1234
2 人前	

Volume selection required

Crop a dish
Food category recognition
Select volume **manually**, etc...

CaloNavi

食事写真を撮るだけで
カロリーがわかります

栄養士が実際にあなたの食事写真を
見てカロリーをチェックします

傾向が分かりやすい
体重グラフもあります

2015/3/1 Sun
1300 kcal

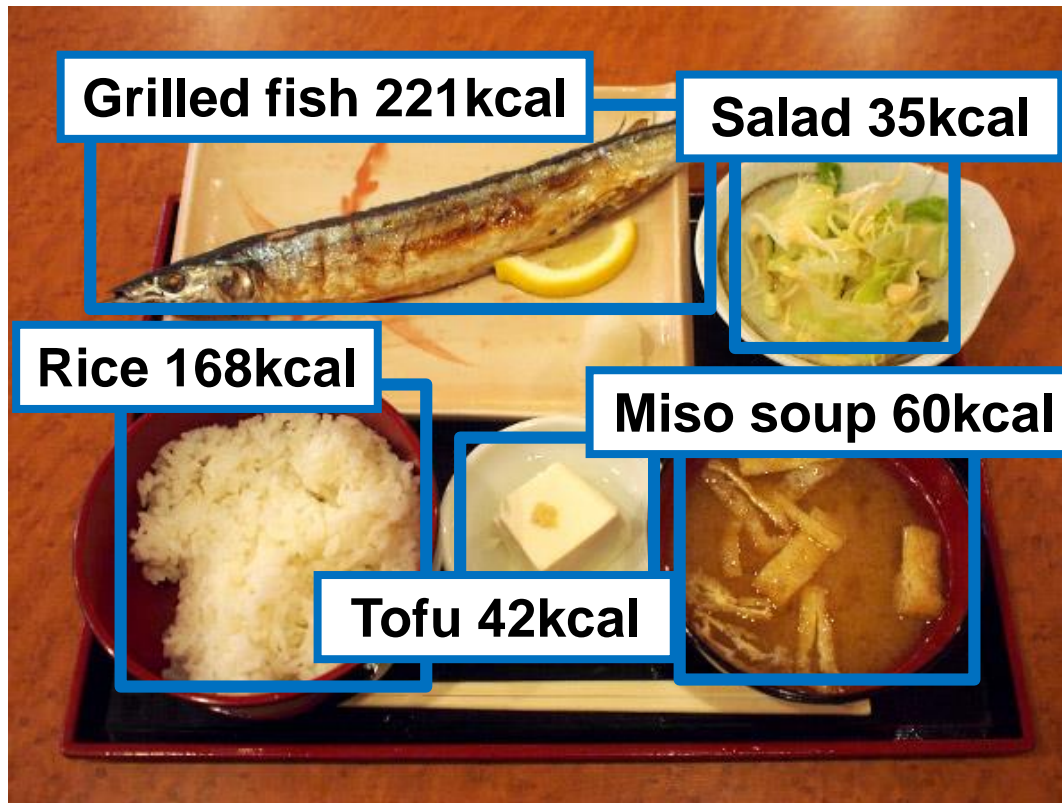
2014/10/8
54.0 kg

1ヶ月 3ヶ月 12ヶ月

Dietary advices by
nutrition professional.
Human cost ➡ **Pay service**

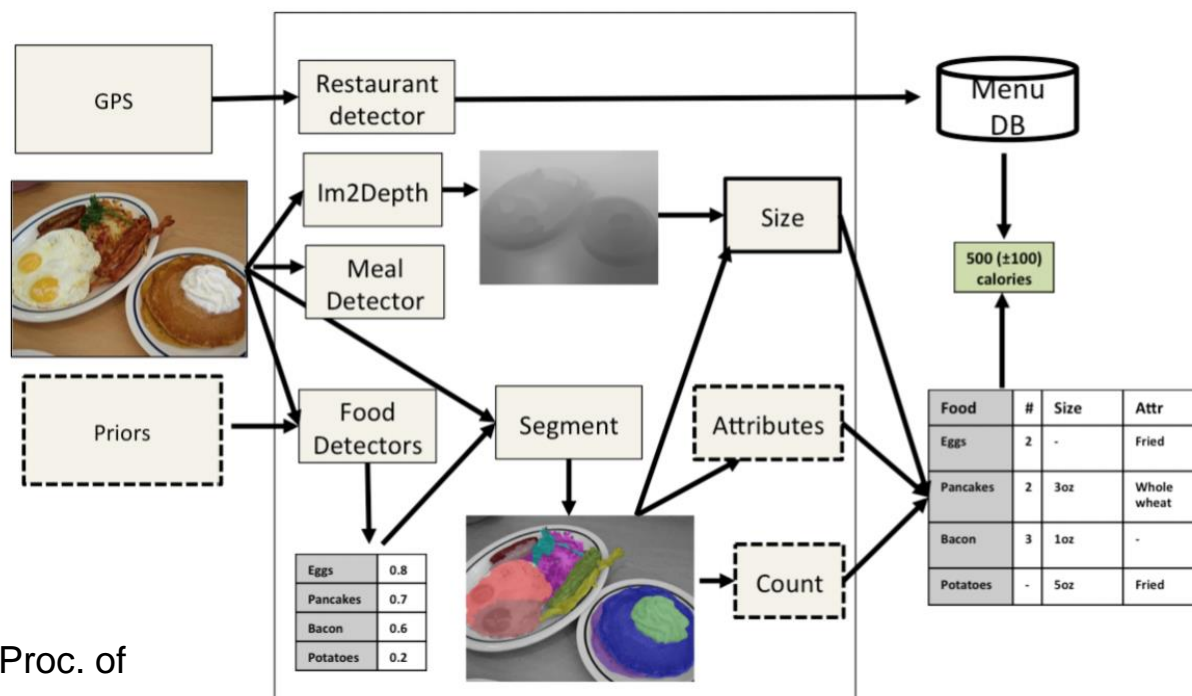
Objective

Image-based food calorie estimation



Related works (1)

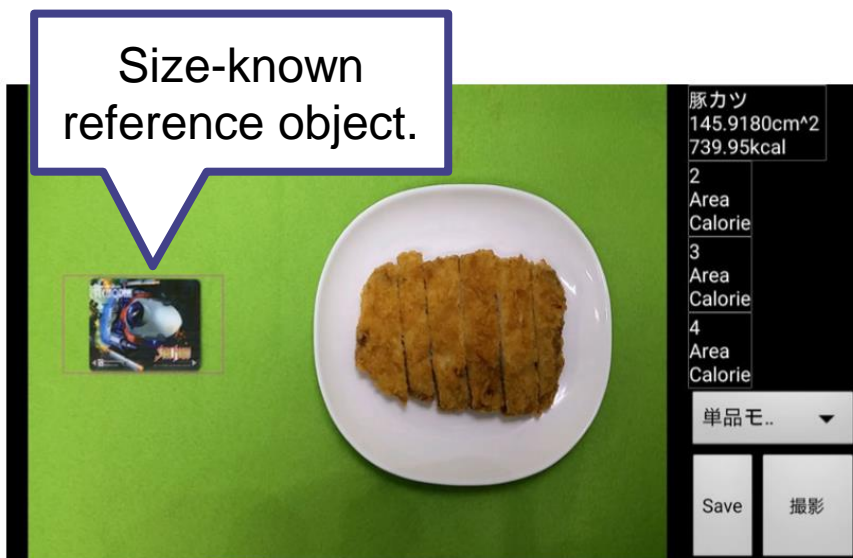
- Im2Calories [Myers et al. 2015]
 - CNN-based categorization
 - CNN-based 3D sized estimation etc...



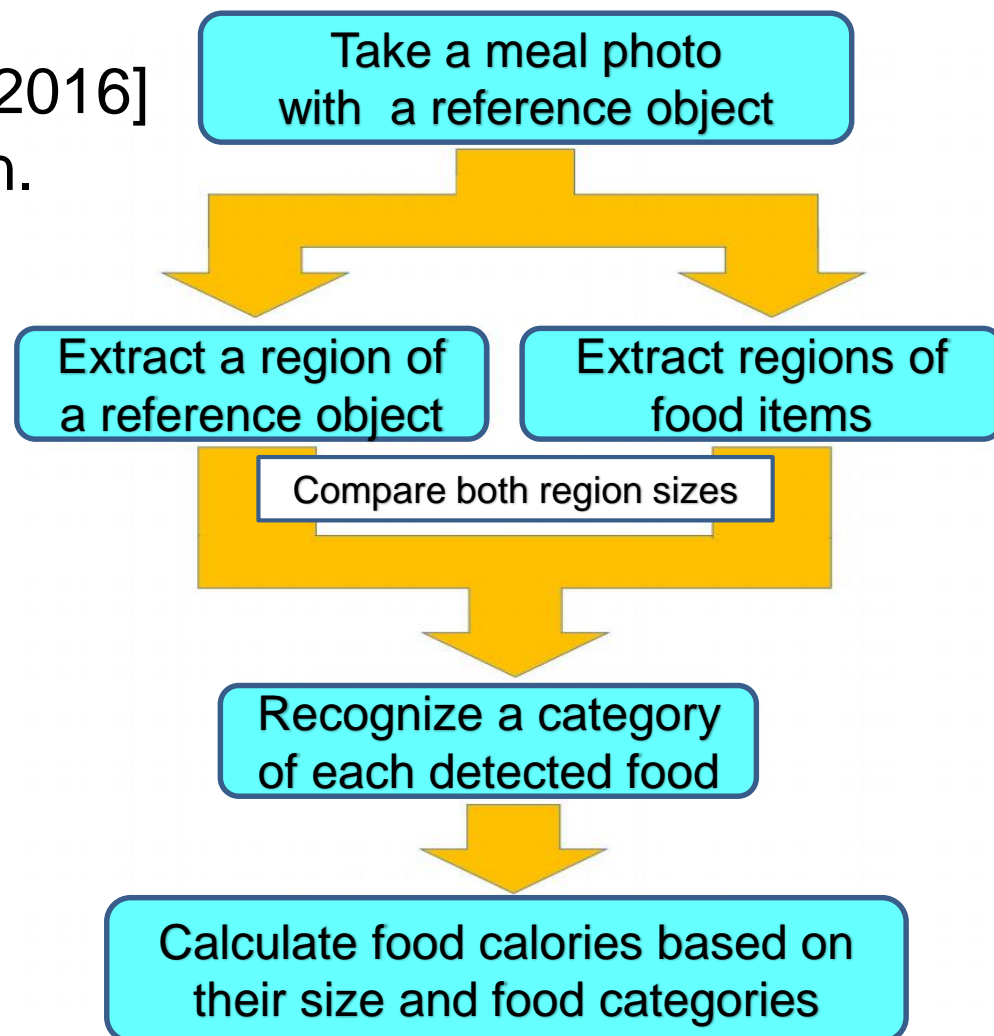
Myers et al. Im2calories, In Proc. of IEEE International Conference on Computer Vision, 2015.

Related works (2)

- CalorieCam [Okamoto et al. 2016]
 - CNN-based categorization.
 - 2D sized estimation.

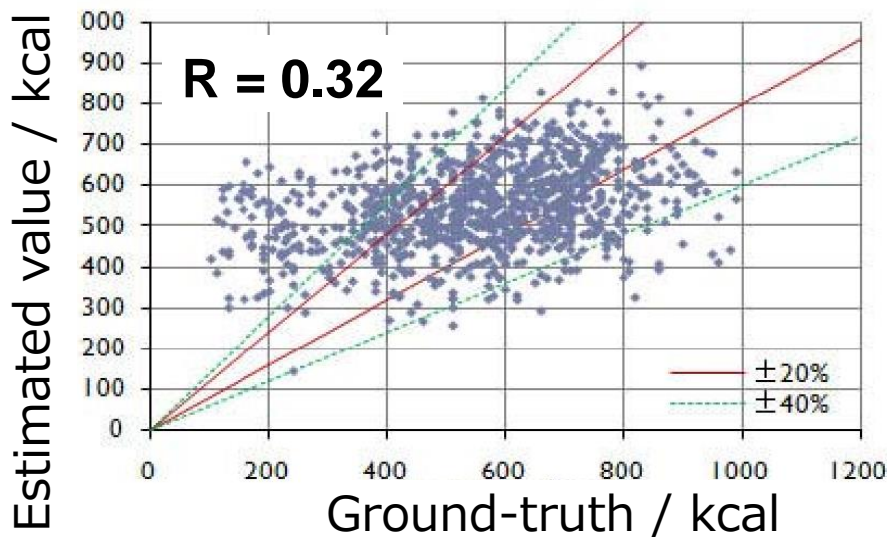


Okamoto et al. An Automatic Calorie Estimation System of Food Images on a Smartphone, MADiMa, 2016.

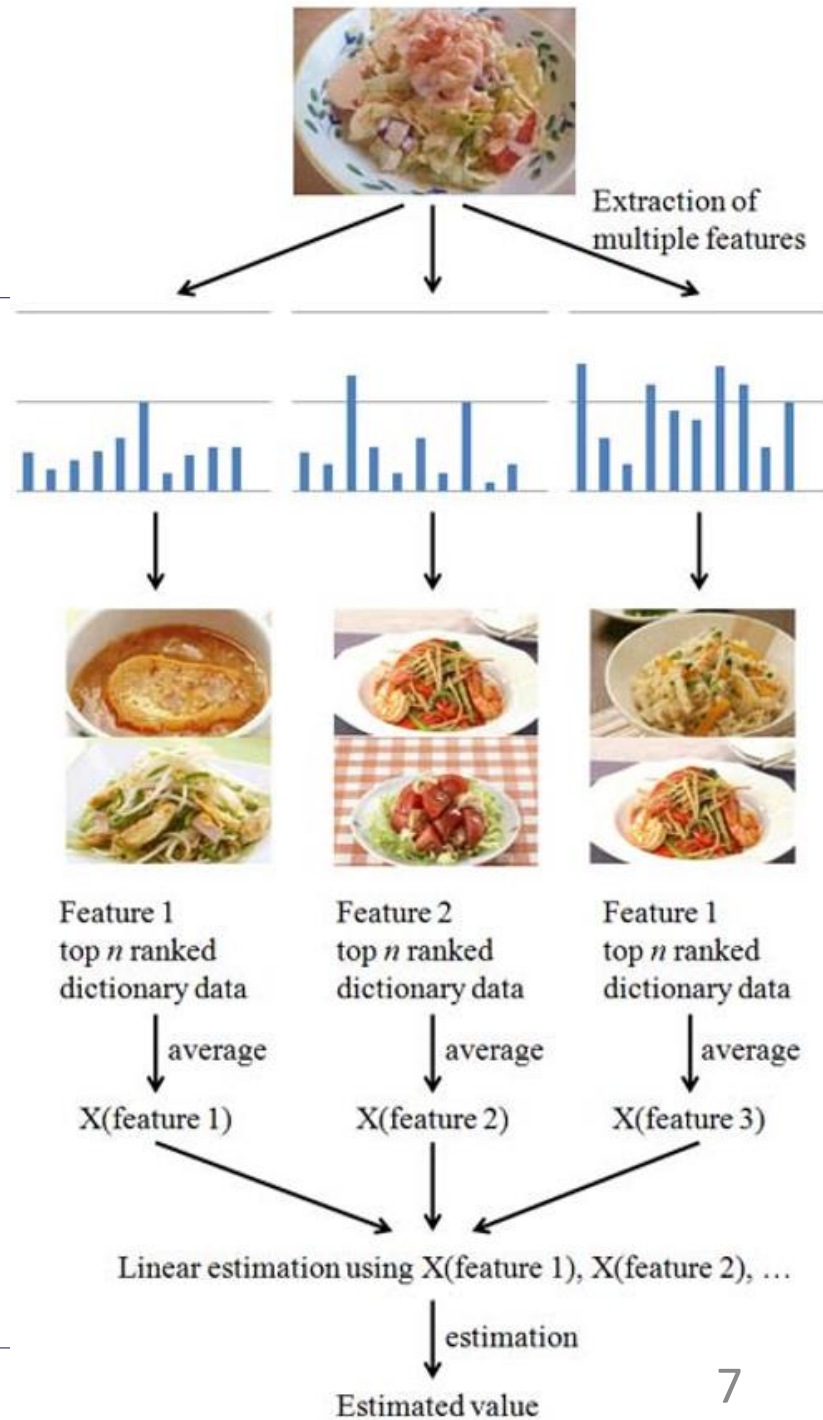


Related works (3)

- Direct calorie estimation by regression based. [Miyazaki et al. 2011]
- Without estimating food categories and volumes.



Miyazaki et al. Image-based Calorie Content Estimation for Dietary Assessment, CEA, 2011



Our approach

- Image-based direct calorie estimation.
- CNN-based method.
- Multi-task estimation of food categories and calories.

Single-task estimation

- Direct calorie estimation by regression based.
- CNN-based method.
- Single-task estimation of food calories.



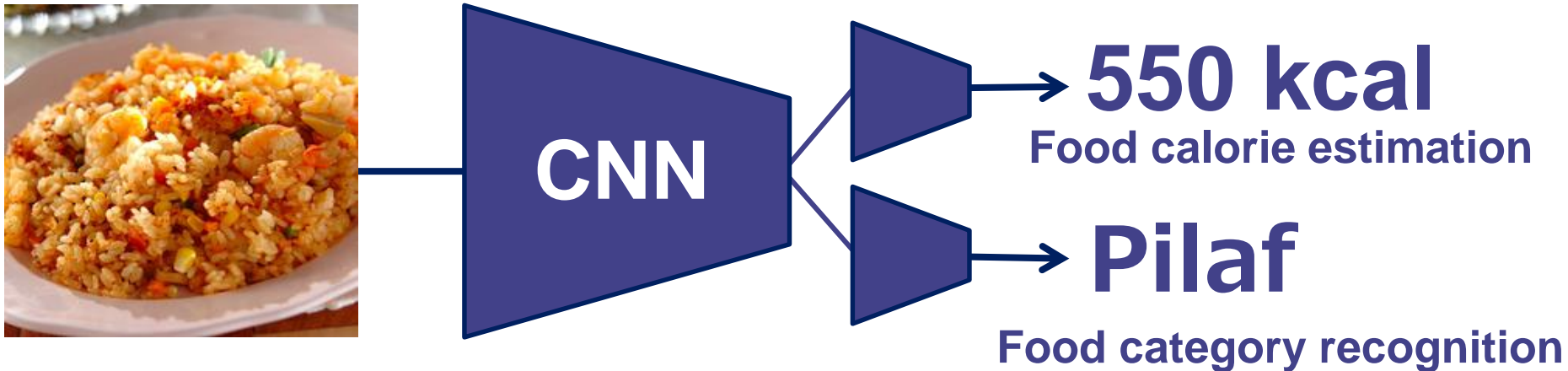
CNN

550 kcal

Food calorie estimation

Multi-task estimation (proposal method)

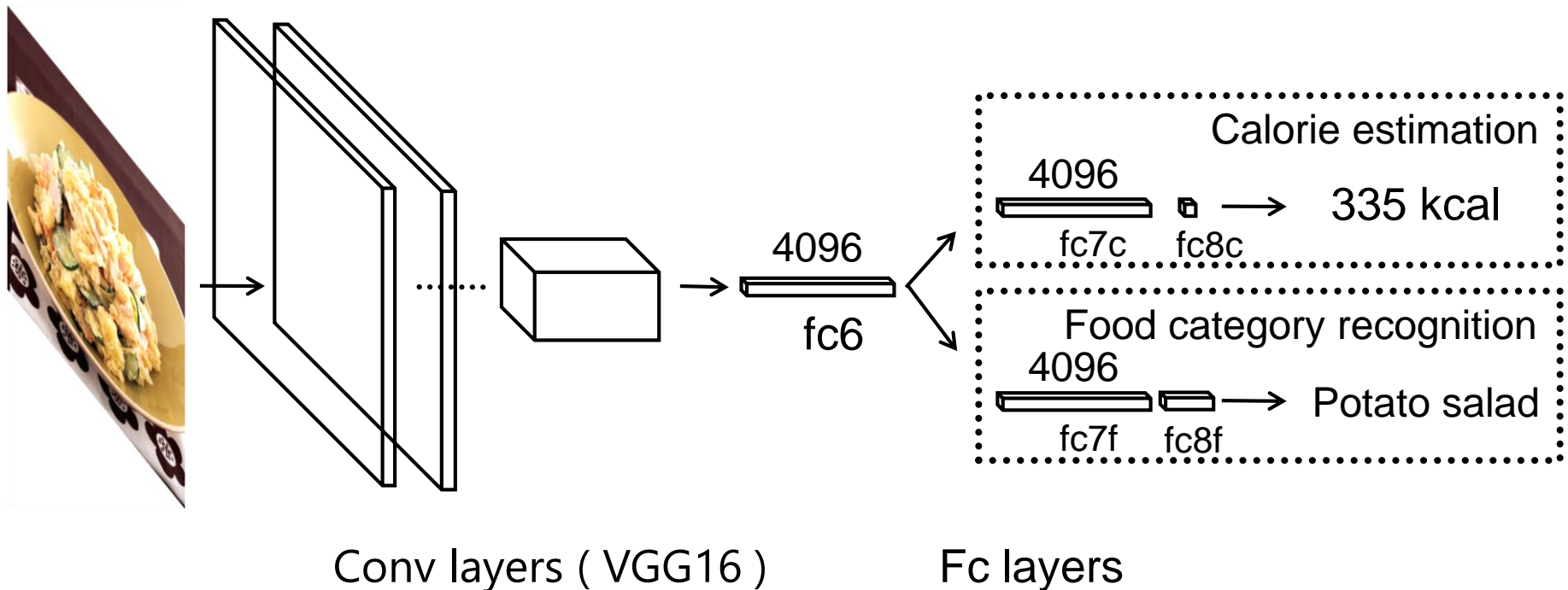
- Direct calorie estimation by regression based.
- CNN-based method.
- Simultaneous estimation of food categories and calories.



Improve accuracy of each task

Network architecture of Multi-task CNN

- VGG16 are extended.
- Simultaneous estimation of food categories and calories.



Construction of calorie-annotated food photo dataset

Cooking recipe sites

AJINOMOTO.Park

E・レシピ

kikkoman

おいしい記憶をつくりたい。

レタスクラブニュース

みんなの
きょうの料理
NHKエデュケーショナル

今日のレシピが必ず決まる!

オレンジページnet



A food photo

調理時間 30分 エネルギー 310kcal
塩分 1.1g 野菜摂取量 7g
※エネルギー・塩分・野菜摂取量

310kcal
調理時間5分

Food Calorie

(1)さけは「コンソメ」をふって両面にびじませ、小麦粉をまぶす。

(2)フライパンにAを熱し、(1)のさけの両面を中火で色よく焼き、弱火にしてフタをし、約3分蒸し焼きにする。

(3)じゃがいもは皮をむいて3等分にし、水に10分ほどさらして水気をきる。鍋に入れ、ヒタヒタの水を加えて火にかけ、煮立ったら弱火にし、フタをしてやわらかくなるまで約10分ゆで、ザルに上げる。

(4)空鍋を火にかけ、(3)のじゃがいもを戻し入れ、鍋を揺すりながら粉をふかせて塩をふる。

(5)ブロッコリーは小房に分け、塩ゆでにし、ザルに上げ

About **83,000** recipes were collected.

Construction of calorie-annotated food photo dataset

Labeling on 100 meals of UEC food-100 [1].

Noise removal.

Remove categories with fewer than 100 samples.

Food **15** categories.
A total of **4877** images.



Pilaf



Curry



Fried rice



Fried noodle



Spaghetti



Gratin



Miso soup



Stew



Simmered meat and potatoes



Hamburg steak



Cold tofu



Sushi bowl



Omelet with fried rice



Potato salad

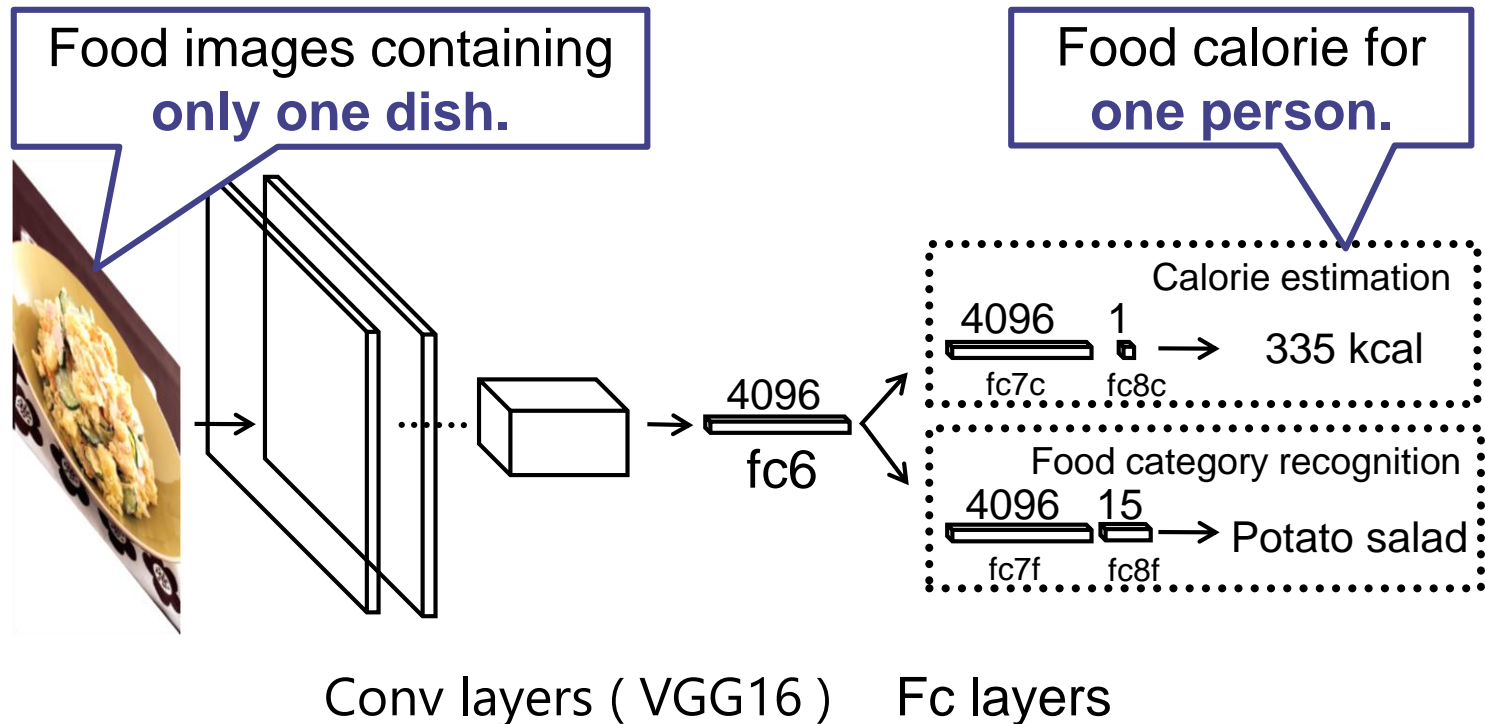


Mixed rice

[1] Matsuda et al. Recognition of multiple-food images by detecting candidate regions. In Proc. of IEEE International Conference on Multimedia and Expo, 2012.

Training of our network

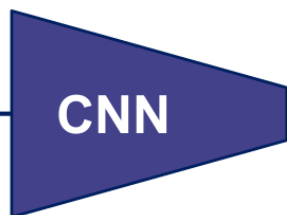
- Training: 70%, Validation during training: 10%, Testing: 20%
- Frame work : Chainer [1].



[1] Tokui et al. Chainer: a nextgeneration open source framework for deep learning. NIPS, 2015.

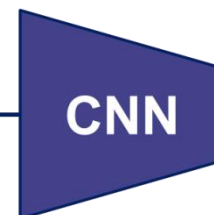
Experiments

Train and compare both networks.



550 kcal

**Single-task CNN
(baseline)**

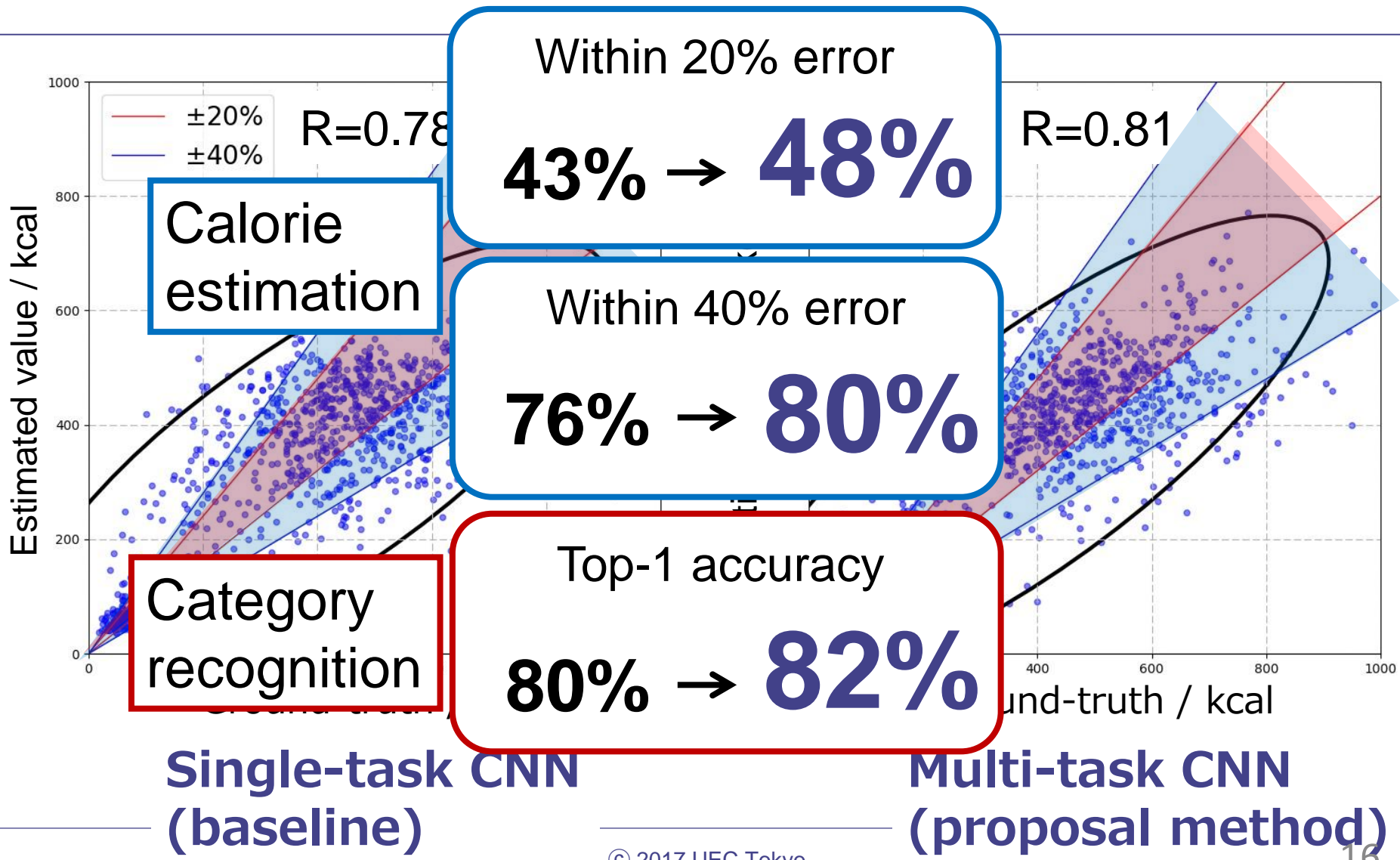


550 kcal

Pilaf

**Multi-task CNN
(proposal method)**

Comparison of single and multi-task



Good results

Miso soup



Estimated
value

400 kcal
Spaghetti

771 kcal
Curry

33 kcal
Miso soup

199 kcal
Miso soup

Ground-
truth

402 kcal
Spaghetti

768 kcal
Curry

32 kcal
Miso soup

214 kcal
Miso soup

Error

-2 kcal

+3 kcal

+1 kcal

-15 kcal

Bad results

Categorization failure



Estimated
value

338 kcal
Miso soup

523 kcal
Spaghetti

244 kcal
Miso soup

372 kcal
Curry

Ground-
truth

575 kcal
Stew

228 kcal
Potato salad

58 kcal
Miso soup

706 kcal
Curry

Error

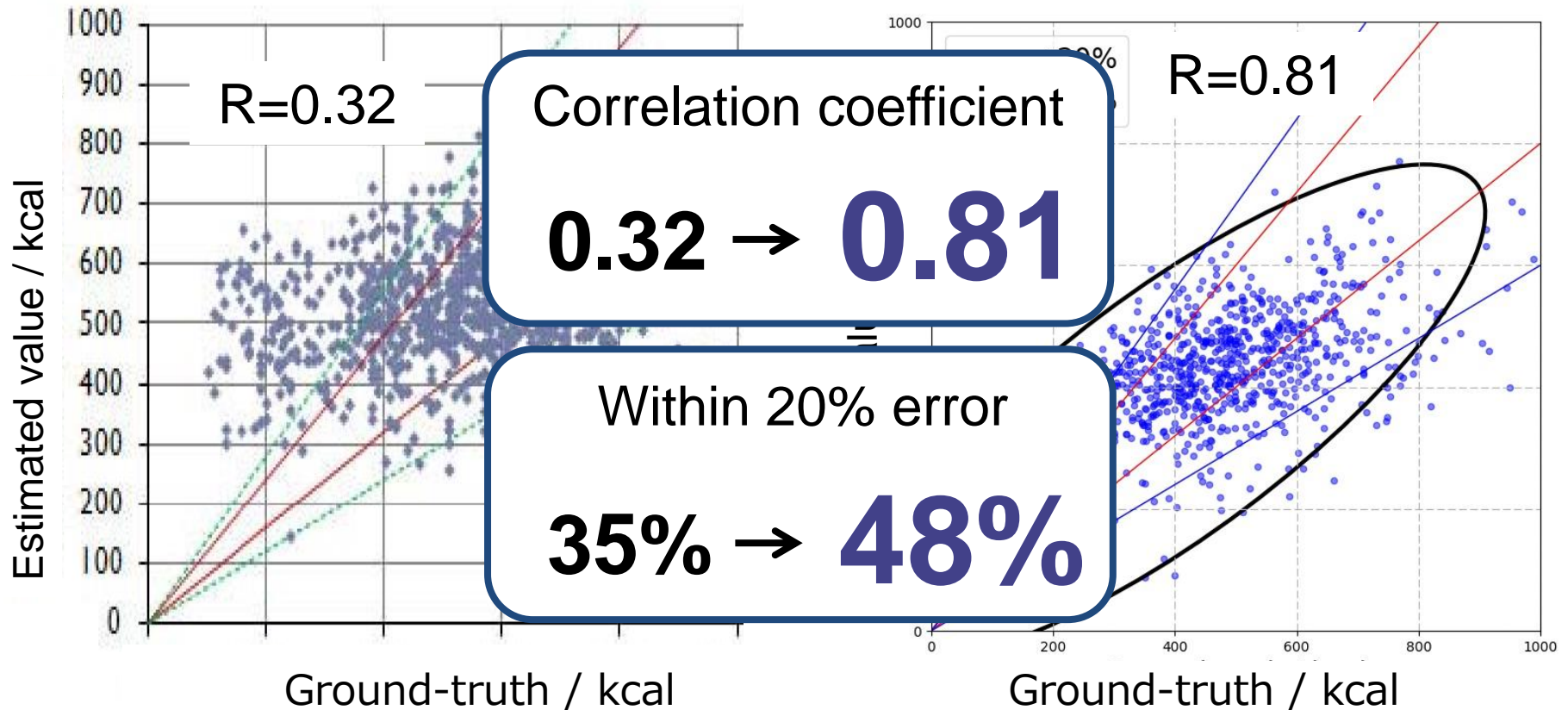
-237 kcal

+295 kcal

+186 kcal

-334 kcal

Comparison to a existing work [Miyazaki et al. 2011] (No CNN)



**Direct estimation with
conventional hand-crafted
features** [Miyazaki et al. 2011]

Multi-task CNN [Ours]

Conclusions

- We proposed simultaneous estimation of food categories and calories for food photos.
- We achieved great improvement with multi-task CNN.
- We constructed Calorie-annotated food photo dataset.

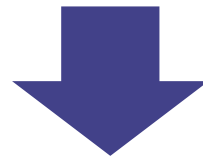
Future work

- Use of ingredients and cooking directions.
- CNN-based region segmentation (+3D volume estimation) for complicated background.



Construction of calorie-annotated food photo dataset

- The data collected from the recipe sites has ...
 - food images containing **only one dish**.
 - food calories for **one person**.

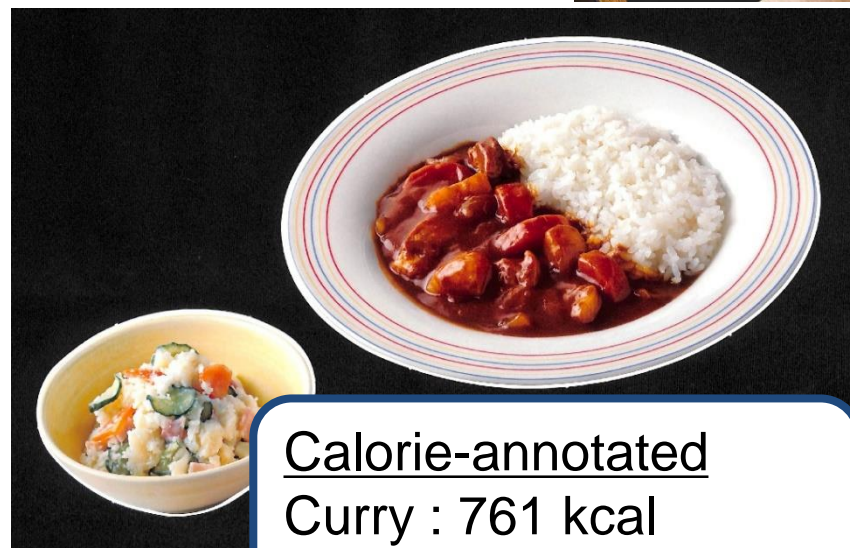
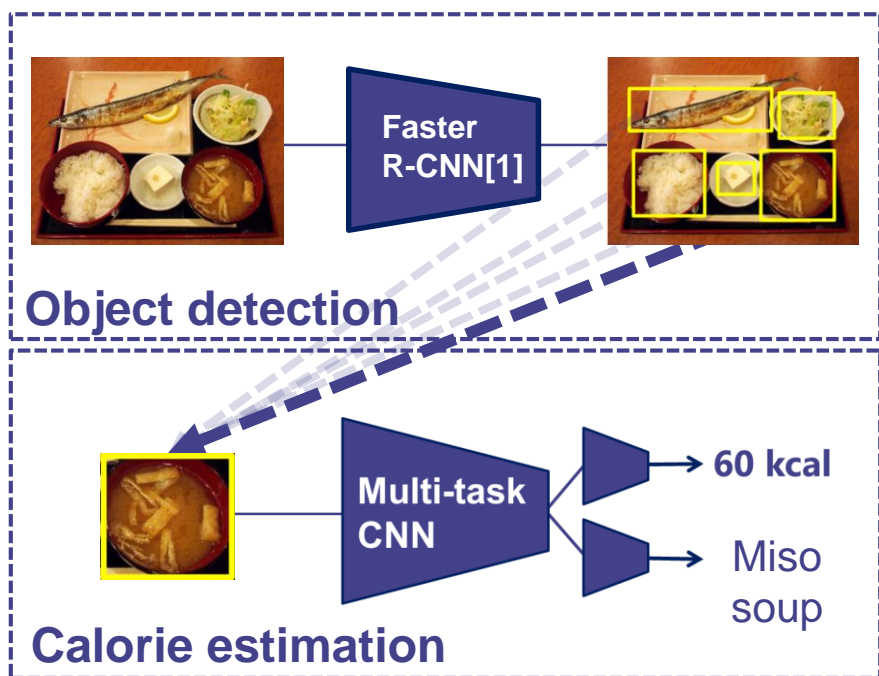


- We assume to ...
 - input a food image containing **only one dish**.
 - estimate food calorie for **one person**.
(without considering volumes.)

Multiple dishes estimation

Combine food dish detection.

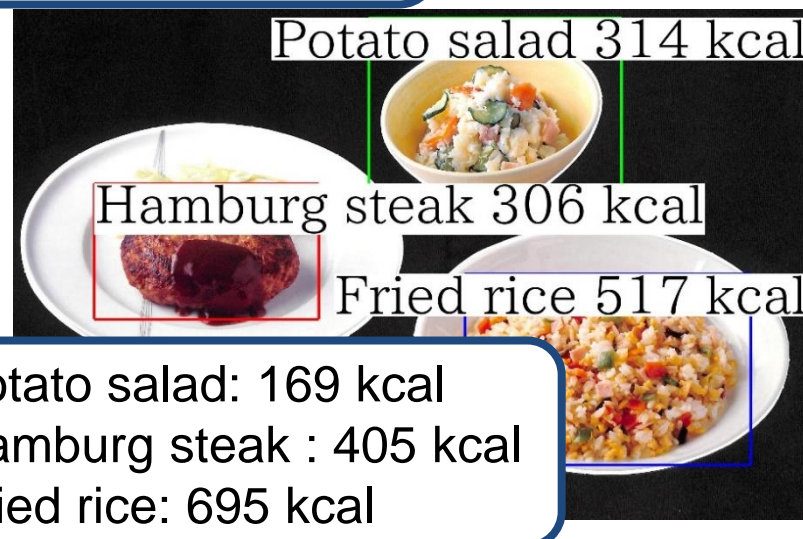
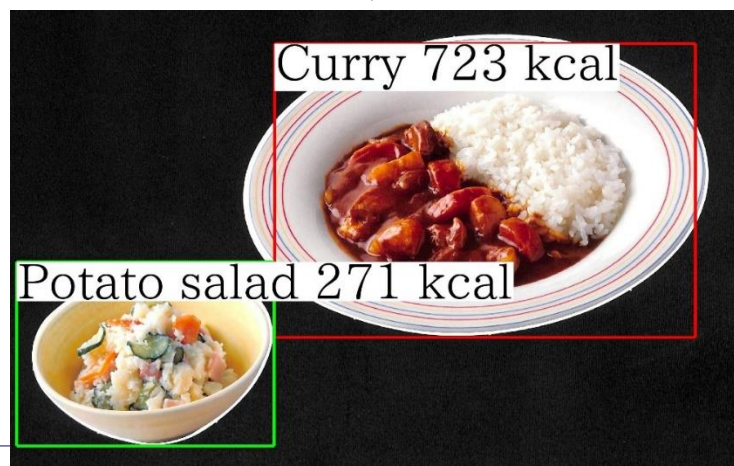
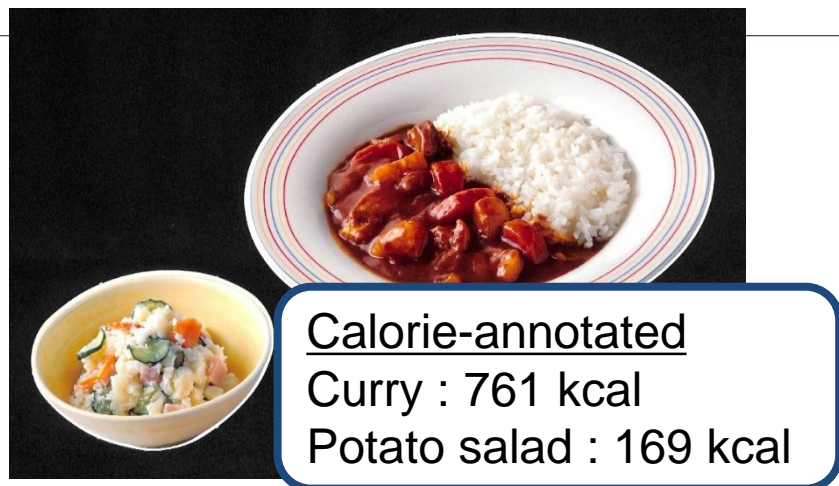
Use food photos of calorie-annotated dish cards.



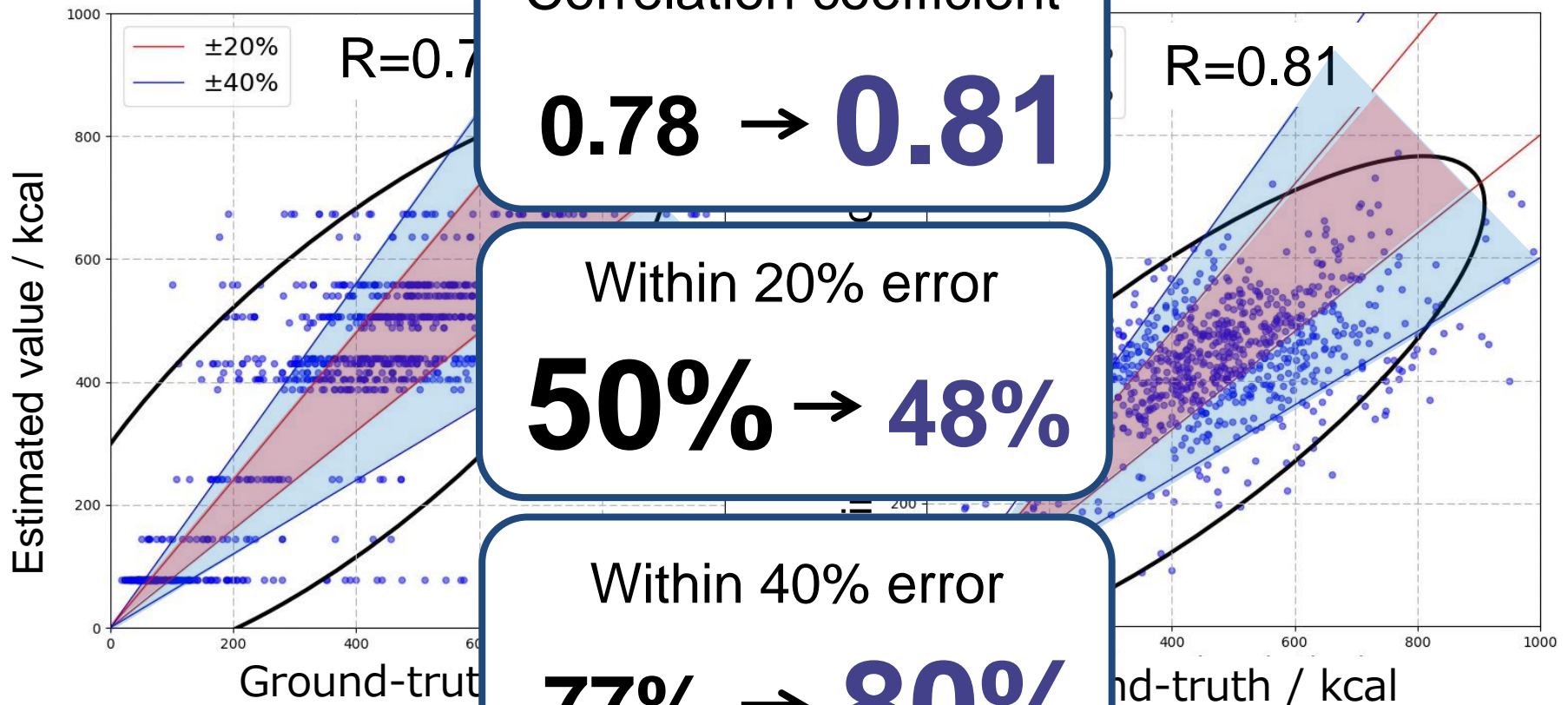
Calorie-annotated
Curry : 761 kcal
Potato salad : 169 kcal

[1] S. Ren et al. Faster R-CNN: Towards realtime object detection with region proposal networks. In Advances in Neural Information Processing Systems, 2015.

Results of multiple dishes estimation



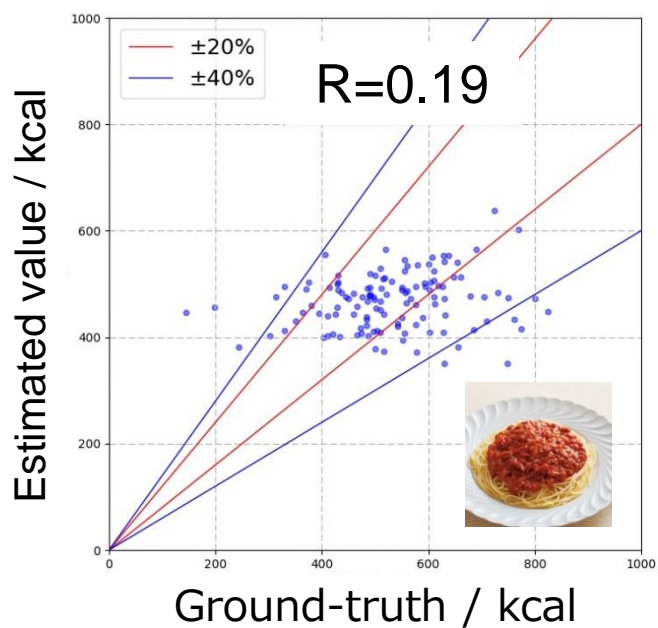
Comparison to a simple baseline



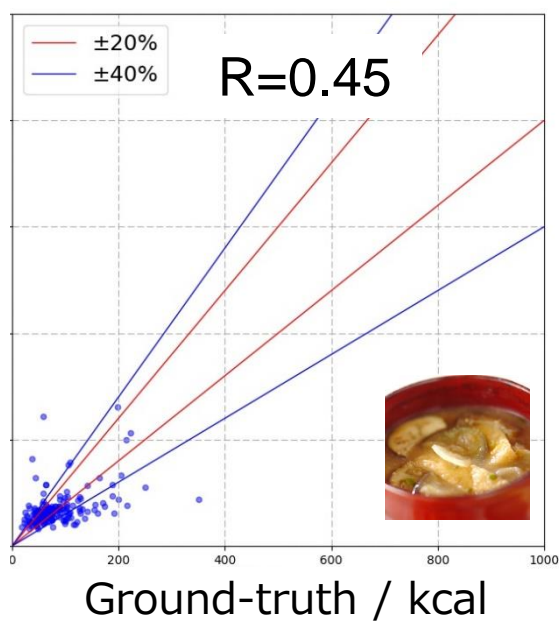
The calorie estimation on food category recognition.
[Simple baseline]

Multi-task CNN. [Ours]

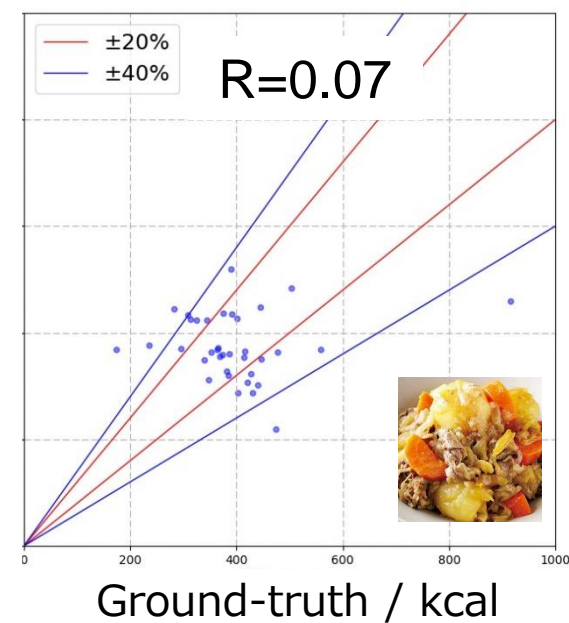
Representative 3 categories



Spaghetti



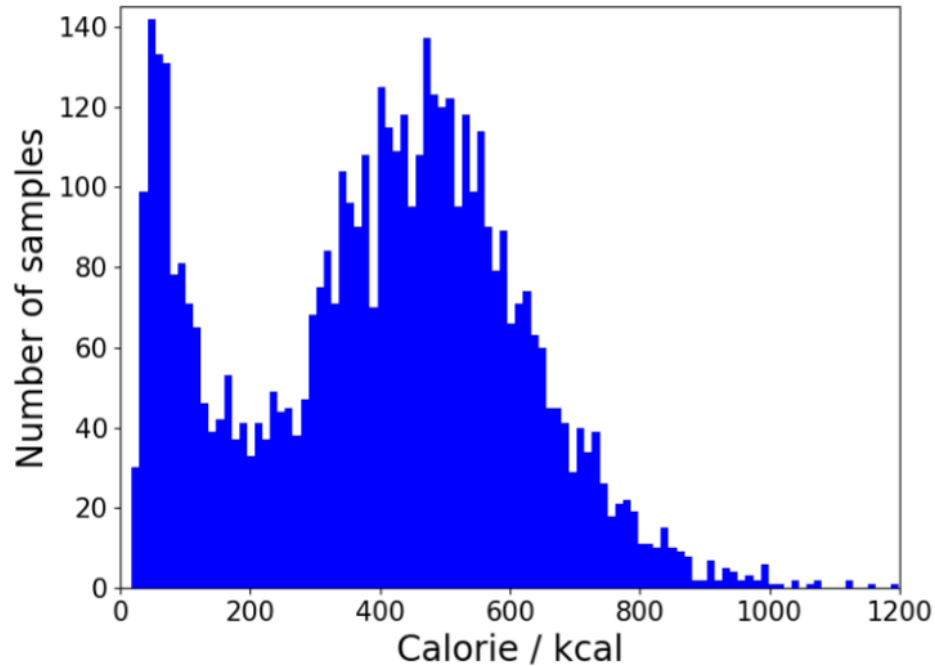
Miso soup



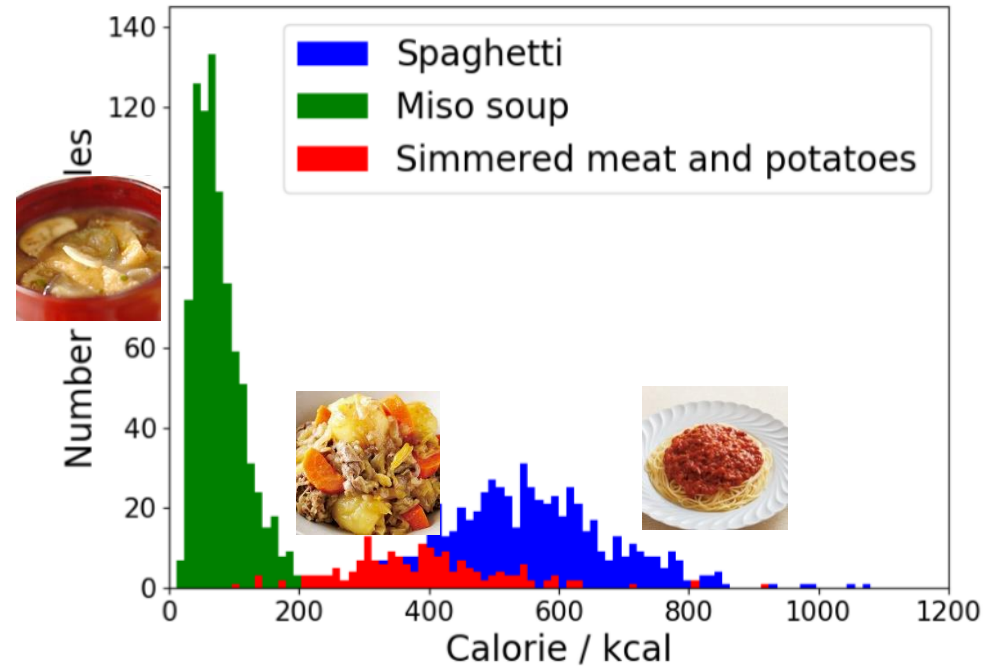
Simmered meat and potatoes

Construction of calorie-annotated food photo dataset

The distributions of the food calories of the collected recipes.



All the 15 foods.



“Spaghetti”, “Miso soup”,
“Simmered meat and potatoes”.