

ICMR

Region-Based Food Calorie Estimation for Multiple-Dish Meals

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足立 賢人

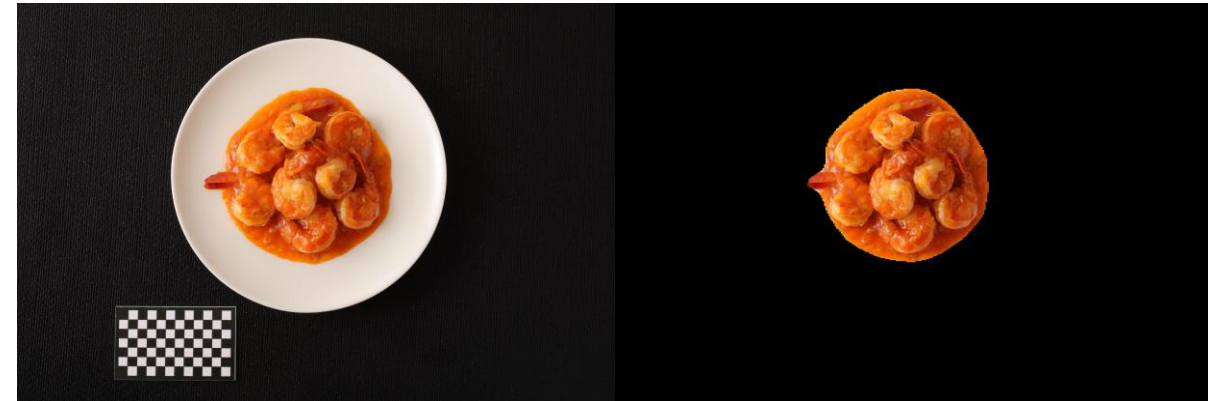
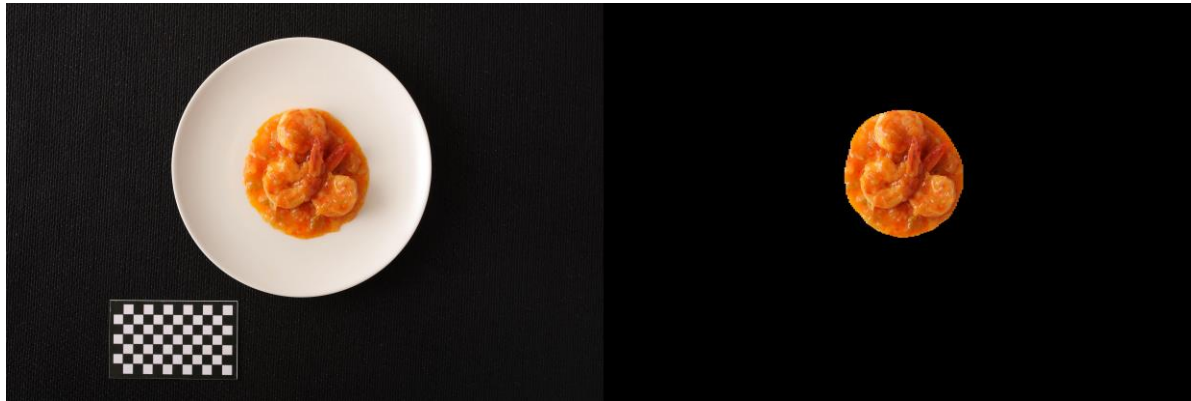
<adachi-k@mm.inf.uec.ac.jp>

柳井 啓司

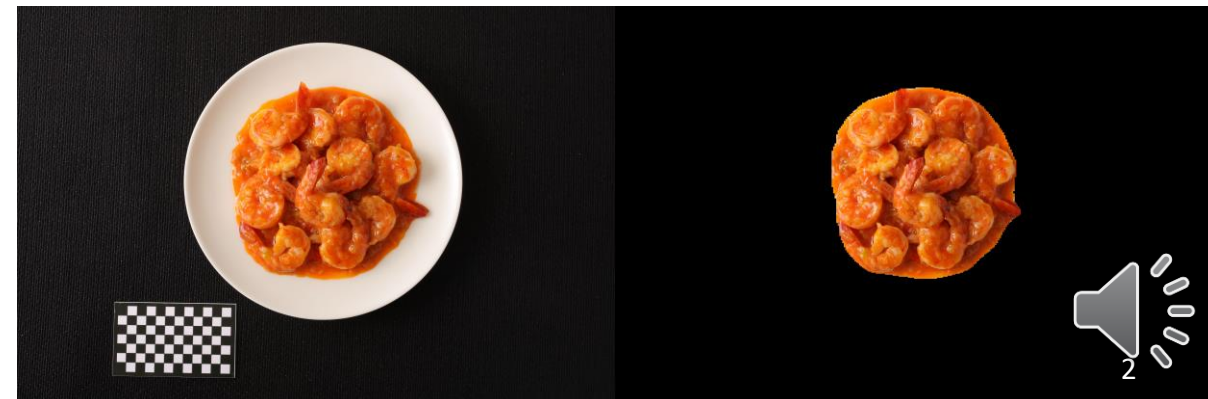
<yanai@cs.uec.ac.jp>

1. Background : Relationship between food area estimation and calorie

There is a big relationship between food area and calories.

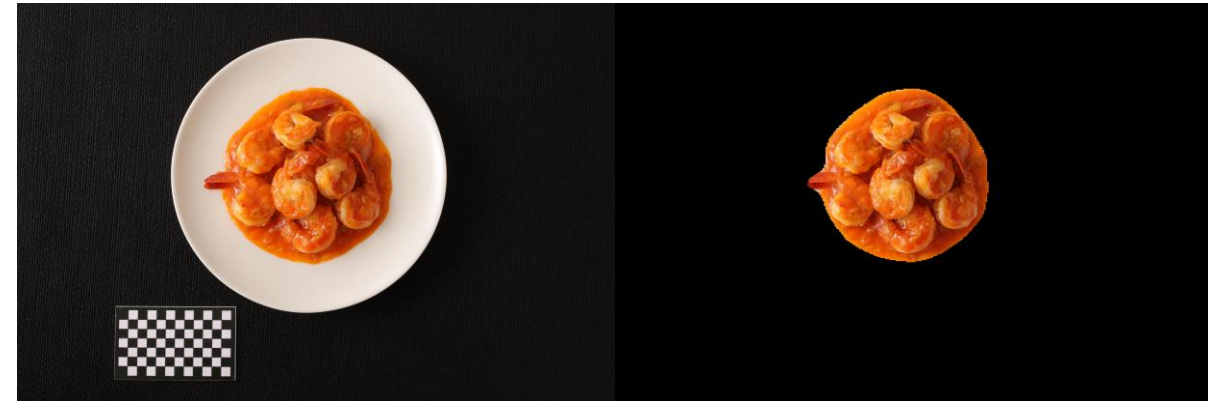
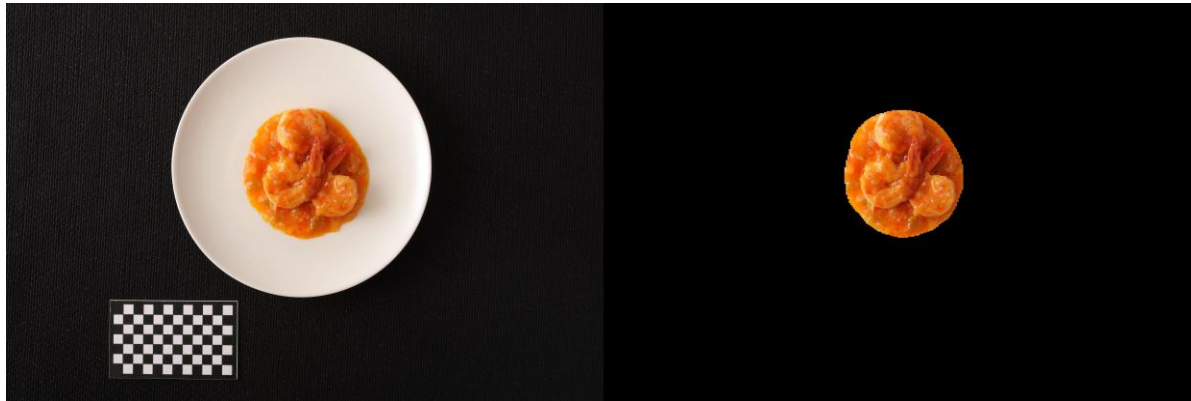


Food area	Calorie
59.4cm ²	89kcal
115.1cm ²	177kcal
160.0cm ²	354kcal



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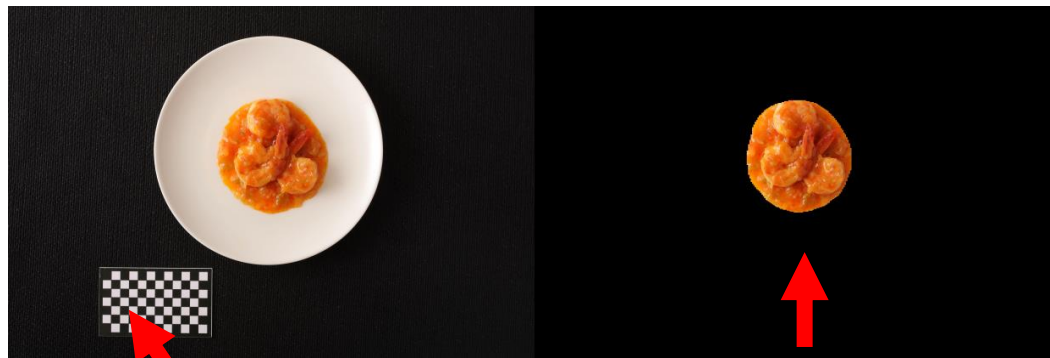
Food area	Calorie
59.4cm ²	89kcal
115.1cm ²	177kcal
160.0cm ²	354kcal

Segmentation is essential for calorie estimation

1. Background : Relationship between food area estimation and calorie

To estimate calorie:

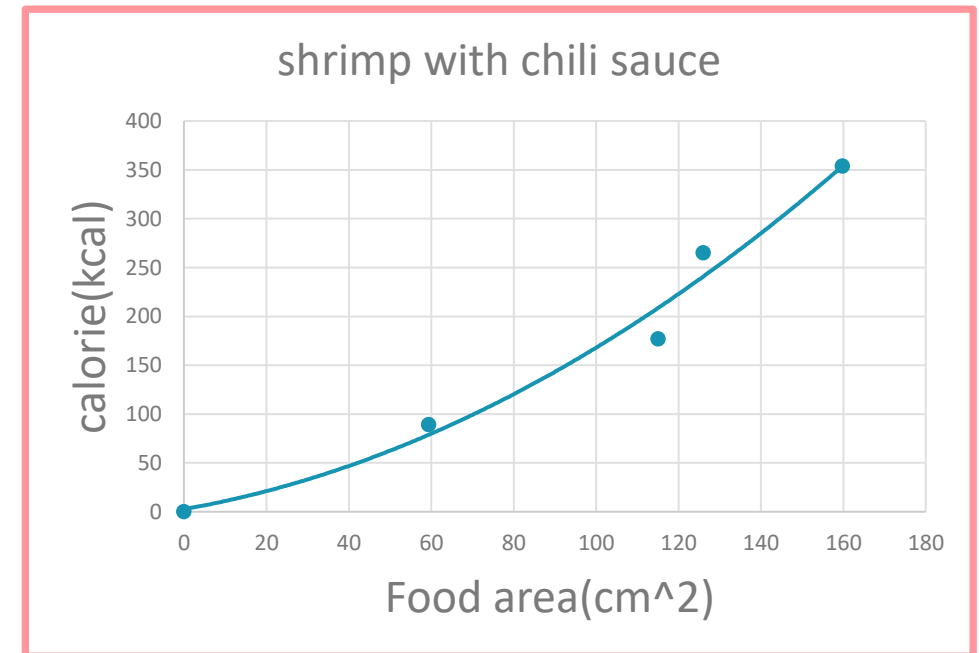
⇒ **actual size** and **calorie value** are needed



ref-object

food area

Calorie-Size relation



Food category

Food area

Calorie

shrimp with chili sauce

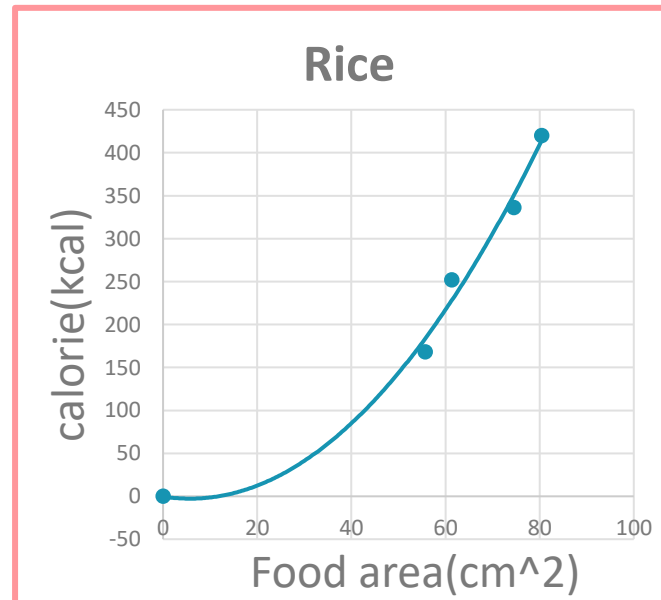
115cm²

177kcal



1. Background : Relationship between food area estimation and calorie

In the case of meals containing multiple item, each category need a relationship of food area and calorie content.



1. Background : Relationship between food area estimation and calorie

In the real situation, nutrition labeling shows only total calorie content

ハンバーグ弁当

消費期限：03. 12.24 午前2時 **1** レンジ加熱目安
1.22 午後8時製造 1500W 120秒

ラップシート 450円

1食当り熱量853kcal 蛋白質30.0g
脂質28.5g 炭水化物120.5g Na1.4g

名称：弁当

原材料名：ご飯 ハンバーグ ポテトサラダ チーズ
煮物（蓮根 人参 椎茸 その他）きんぴら 付合せ **2**

調味料（アミノ酸） pH調整剤 グリシン 酸化防止剤
（V.E） 増粘多糖類 セルロース 香辛料 カラメル

色素 カロチノイド色素 香料（原材料の一部に卵 小
麦 落花生 牛肉 大豆 豚肉を含む）

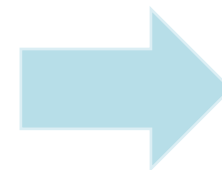
製造者： 祇園花子 京都府〇〇市〇〇町89



● 栄養成分表示

● 食品添加物の表示

● アレルギー物質の表示



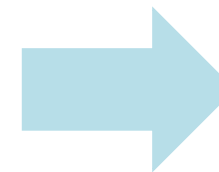
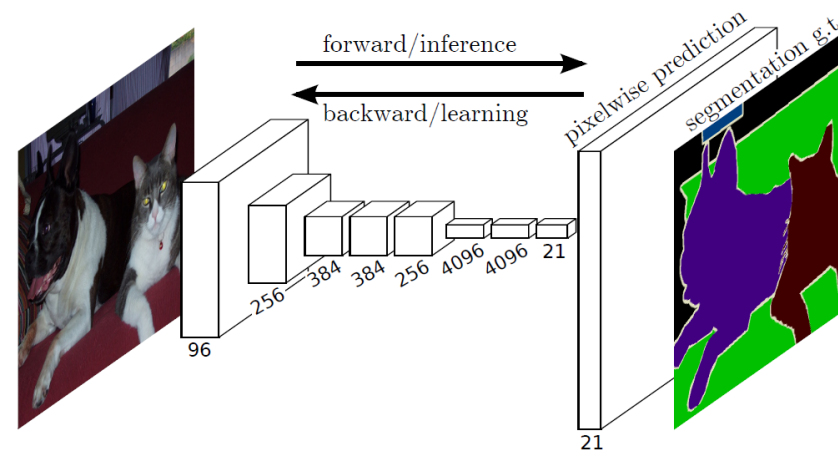
**Calorie for each food item
is not provided**



2. Purpose for research

Purpose for fesearch

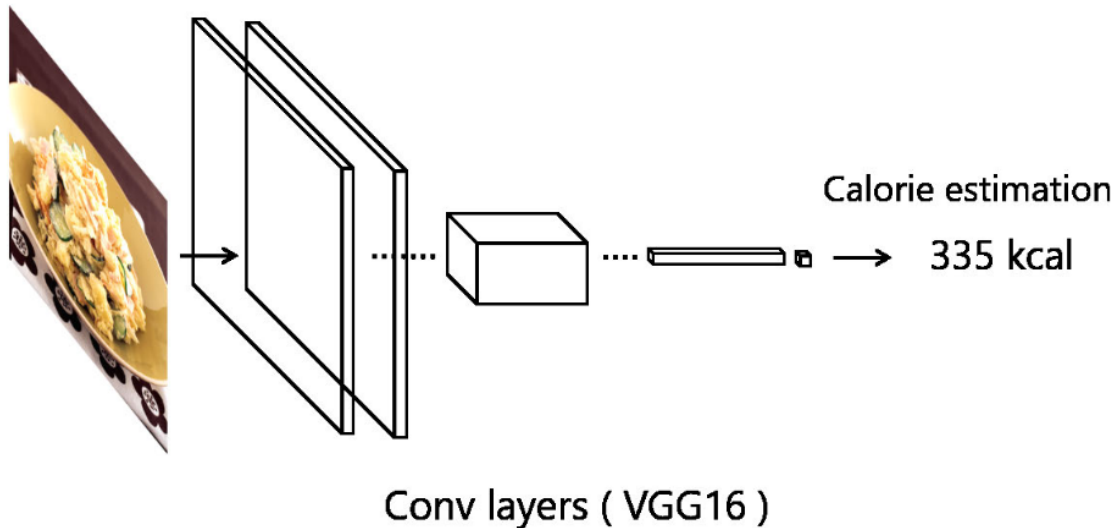
Estimate the calorie contents of each food category from single image training with known total calories.



3.Literature review : Estimating calorie content of multiple items

Ege et al.[1]

⇒ estimate calorie from each food item using detection model.



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Ege et al[1]

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4.Methodology

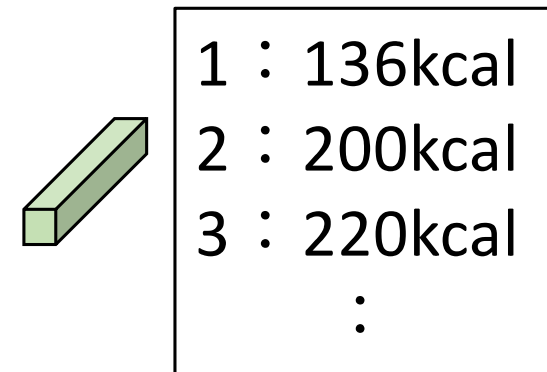
1.Dataset

2.Model

- Segmentation part
- Calorie estimation part



Multi calorie vector



5. Methodology : Dataset

Requires total calorie content dataset with mask image

⇒ Collect data from the Inzai city's Lunch Center website.

- ・学校給食費について
- ・各給食調理施設の概要
- ・各給食調理施設の問い合わせ先
- ▶お知らせ (給食の停止希望について)
- ▼中央給食センター第一調理場
- ▶献立表
- ▶中央給食センター第二調理場
- ▶牧の原給食センター
- ▶印旛給食センター
- ▶放射性物質検査結果 (結果速報)
- ・食材検査結果
- ・給食まるごと検査結果
- ▶農産物の放射性物質検査結果

COUNTER 922124

印西市教育センター

2021/02/12 NEW 2月12日の給食

by:hana03

☆献立☆

クリームパンネ カレーコロッケ ブロッコリーとハムのサラダ ミニエクレア 牛乳



【バレンタイン給食】

今日の主食はパンネです。パンネは小麦粉を練って作ります。マカロニは筒状の形をしています。パンネは先がとがった筒状をしています。今日は、ほうれんそうやマッシュルームが入ったクリームパンネにしました。

デザートのエクレアの語源はフランス語の「エクレール」で、いなづまや電光という意味があります。クリームがこぼれないように素早く食べる様子からきているそうです。

エネルギー649kcal たんぱく質21.6g 脂質エネルギー比42.7% 食塩相当量2.4g (中学年)

5. Methodology : Dataset

Create a dataset by adding a mask image using the annotation tool

- 474 learning images and 119 evaluation images
- 60 different meal categories



5. Methodology : Dataset

Number of images for each category in the dataset

Top 5 categories

Food category	Images
Milk	593
Miso-soup	321
Japanese salad	273
Rice	265
Green salad	225

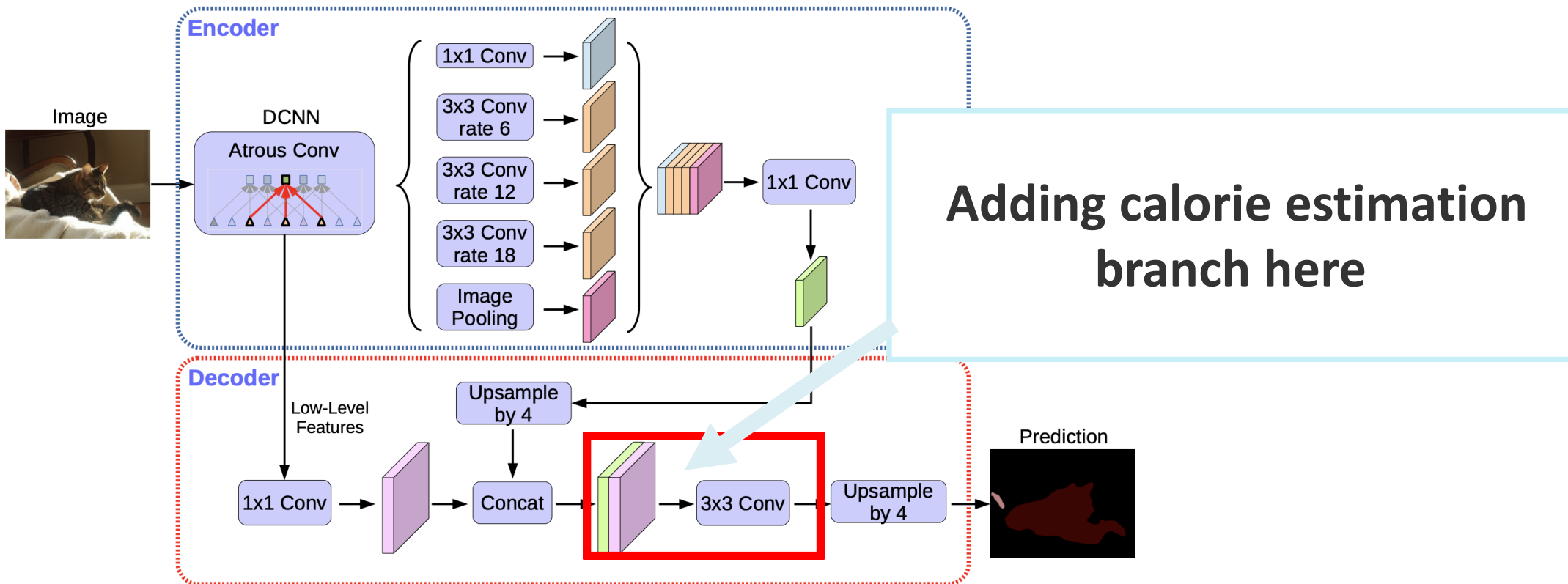
Bottom 5 categories

Food category	Images
Spring roll	5
Fried noodles	5
Fried smelt fish	5
Oden	4
Sausage	2

5. Methodology : Model

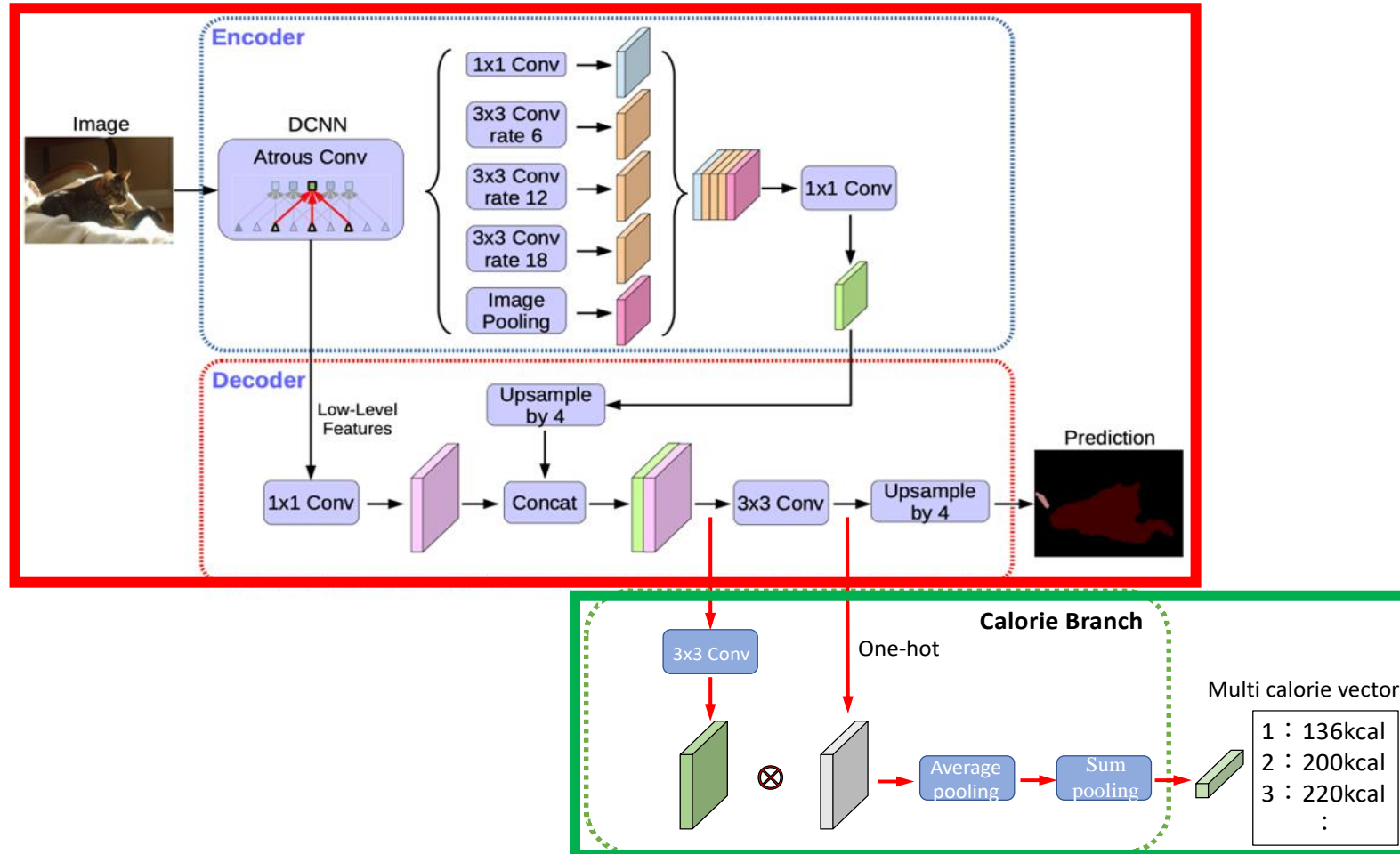
DeepLab V3+ as calorie estimation model

⇒ Adding calorie estimation branch



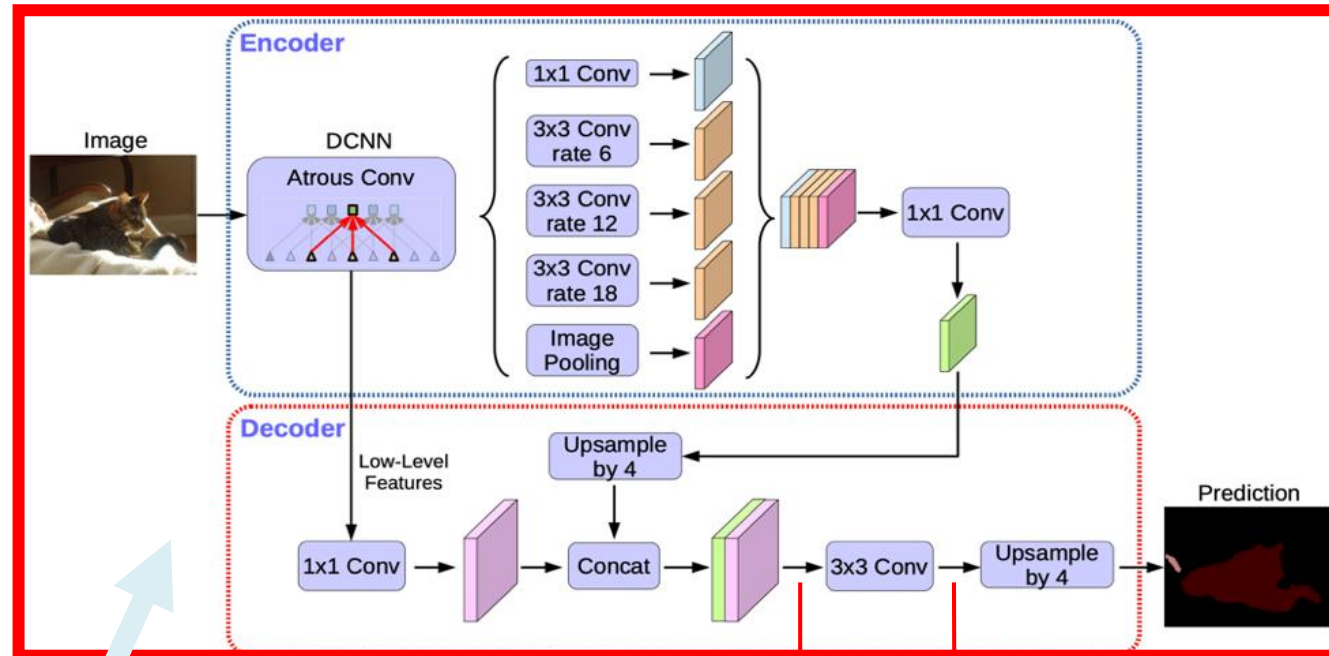
5. Methodology : Model

Consists of **Segmentation part** and **Calorie estimation part**

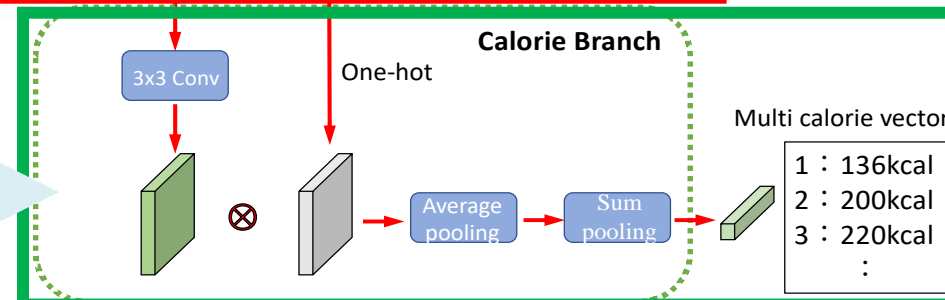


5. Methodology : Model Overview

Consists of **Segmentation part** and **Calorie estimation part**



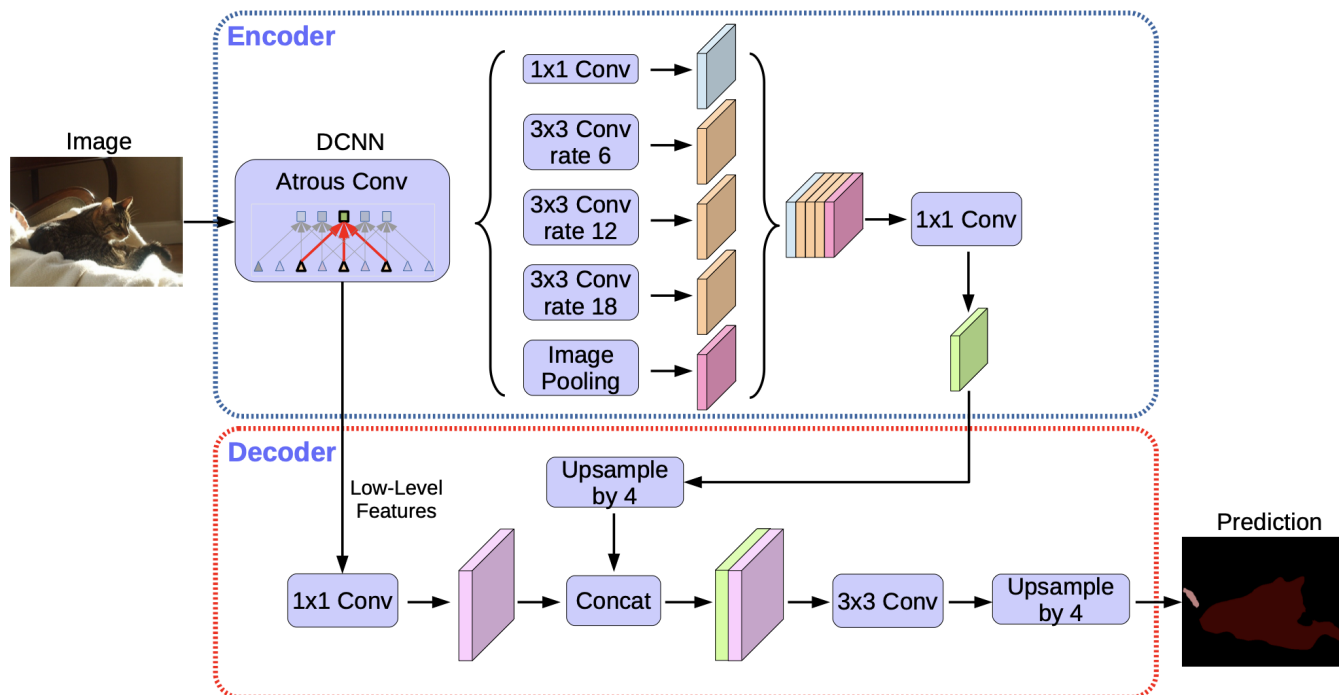
Two parts are trained separately



5. Methodology : Segmentation part

Train Deeplab v3+ using our dataset

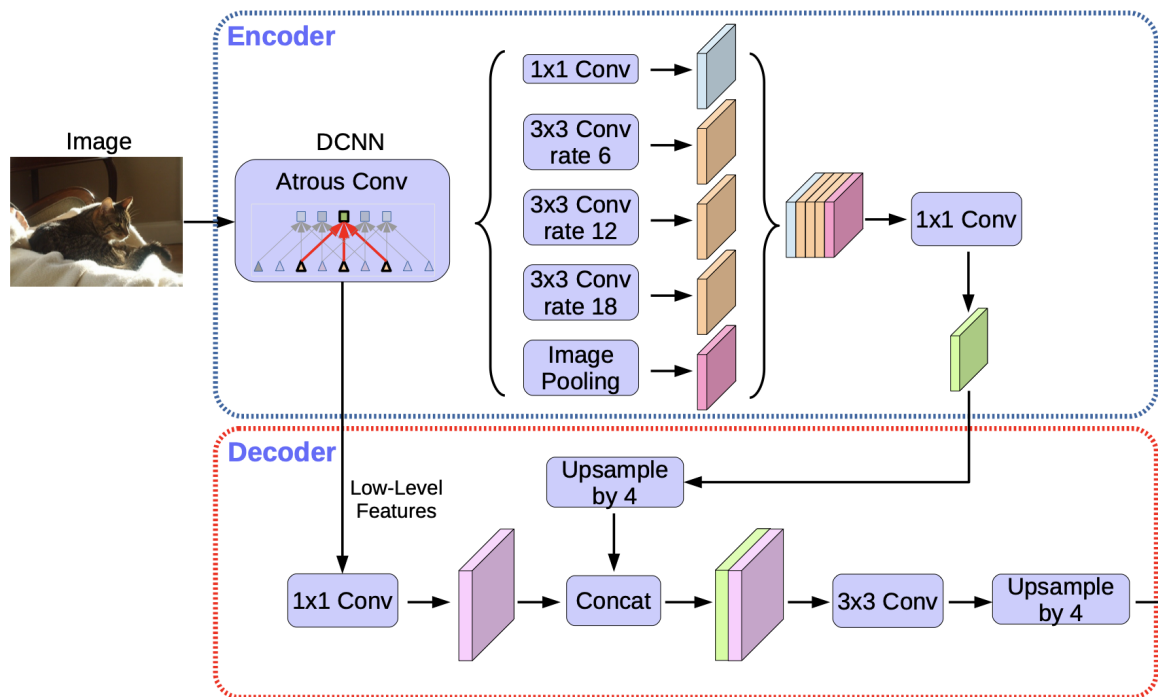
⇒ mIoU 0.48 Acc 0.61



5. Methodology : Segmentation part

Train Deeplab v3+ using our dataset

⇒ mIoU 0.48 Acc 0.61

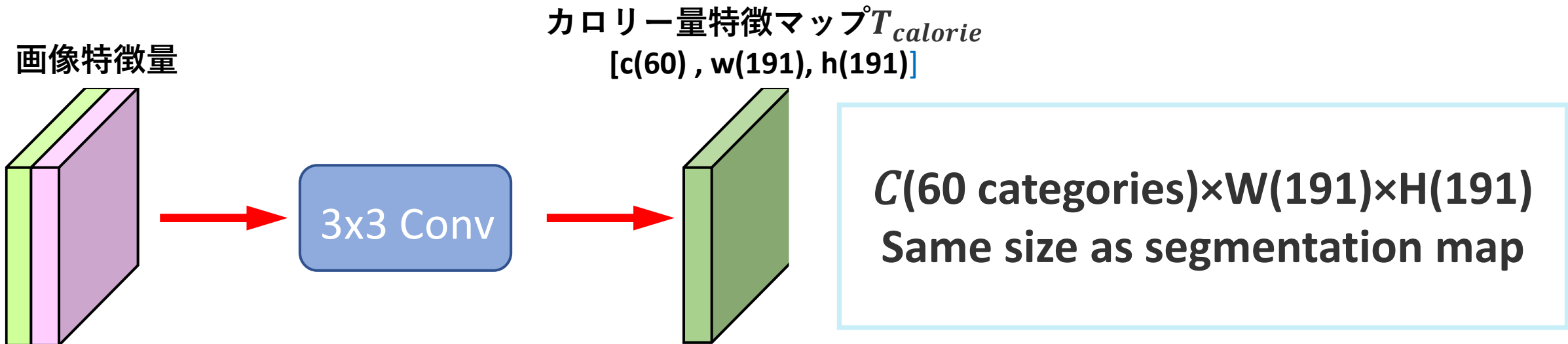


Freeze params in order to train calorie estimation part

5. Methodology : Calorie estimation part

Apply conv. to convert image feature into calorie feature map $T_{calorie}$

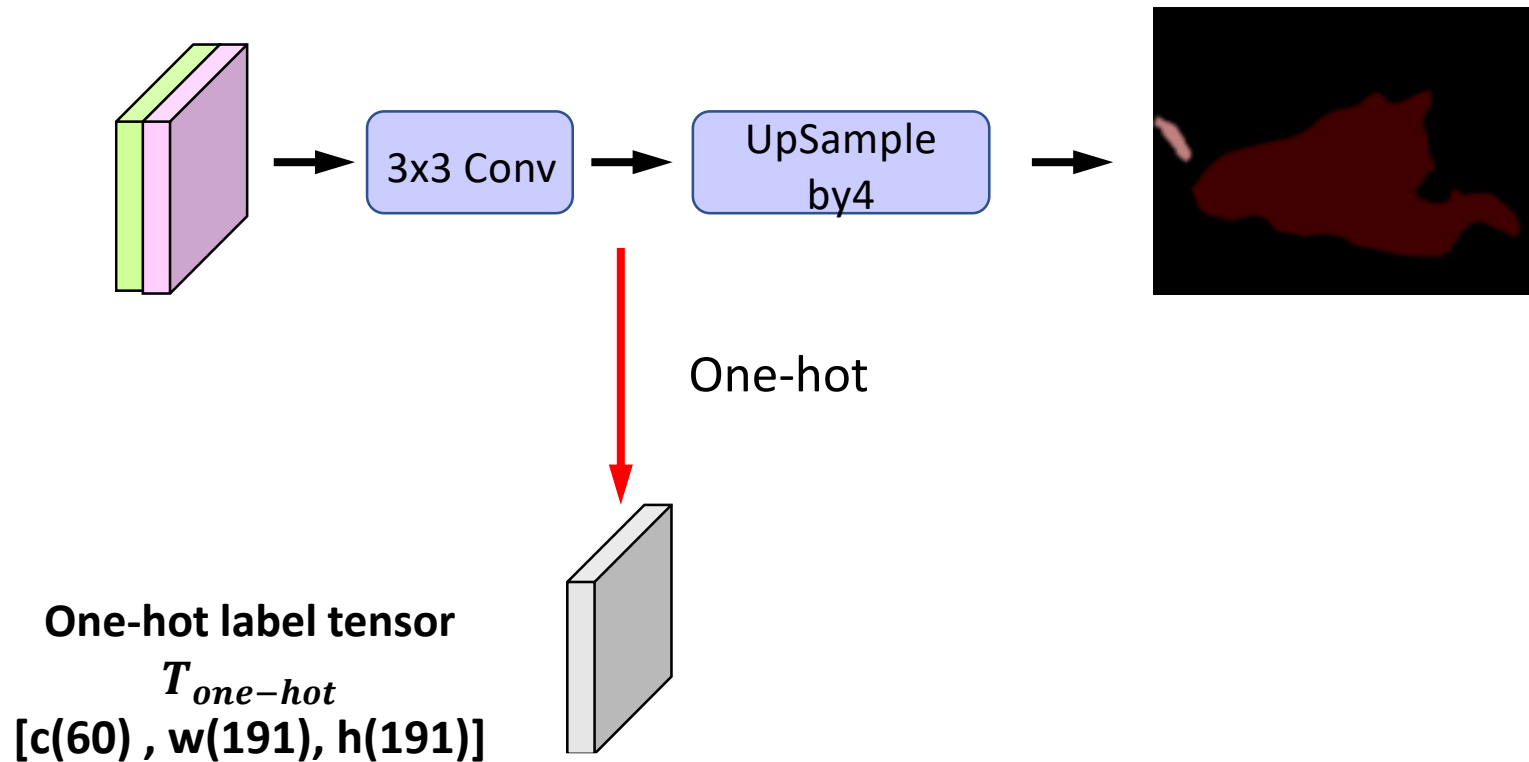
⇒ corresponding to calorie amount on each pixel



5. Methodology : Calorie estimation part

Convert segmentation map into one-hot tensor $T_{one-hot}$

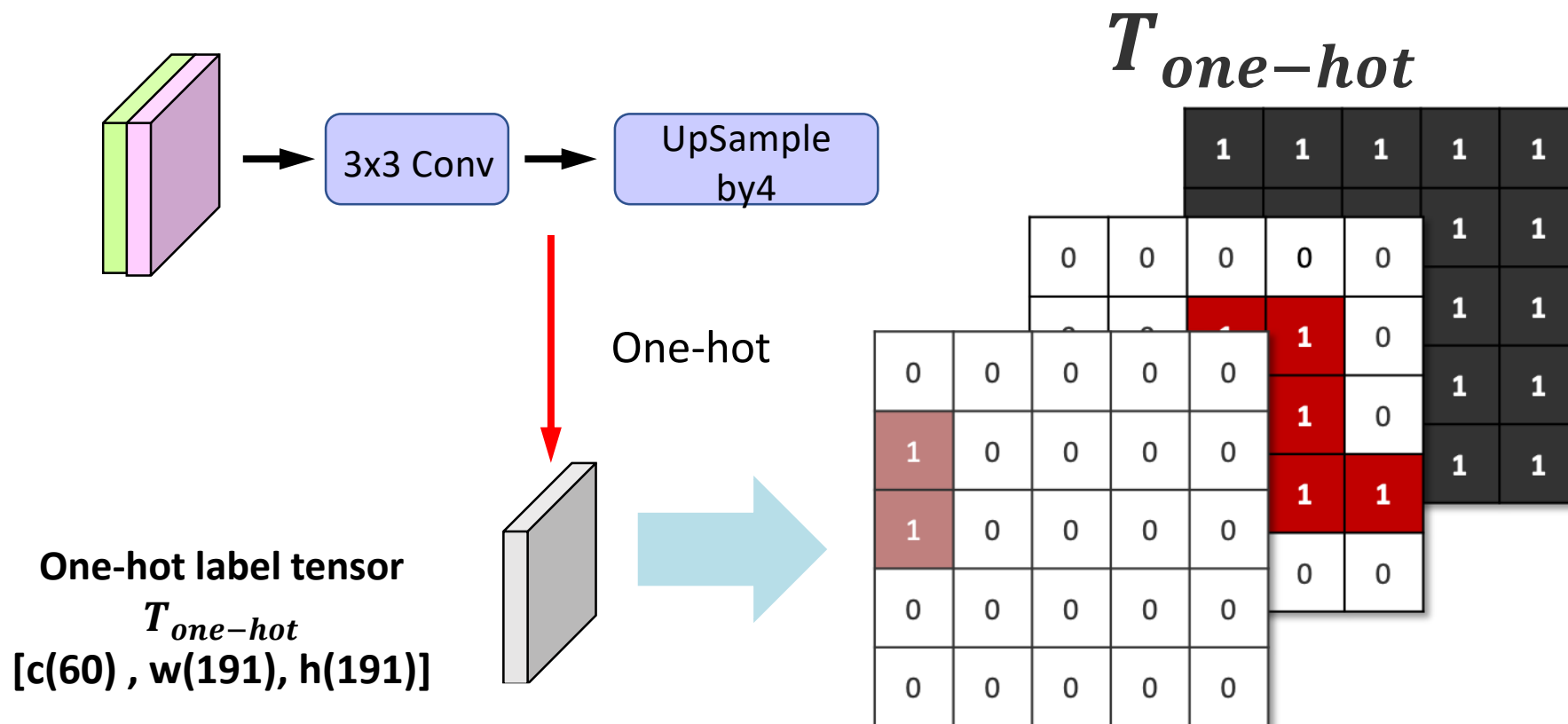
⇒ corresponding class : 1 , other : 0



5. Methodology : Calorie estimation part

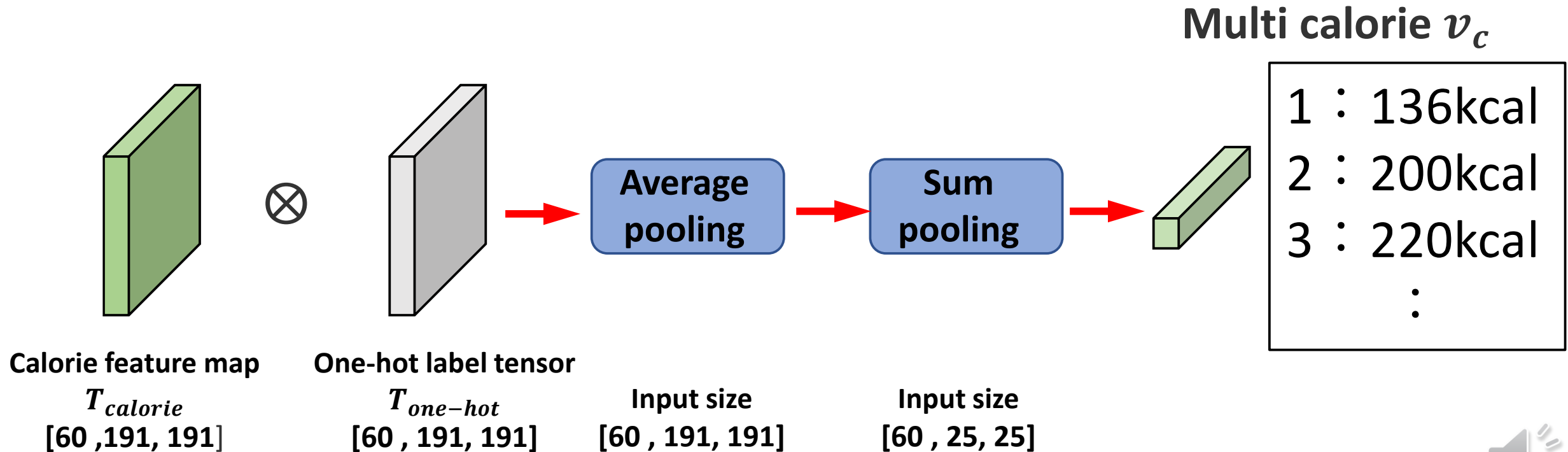
Convert segmentation map into one-hot tensor $T_{one-hot}$

⇒ corresponding class : 1 , other : 0



5. Methodology : Calorie estimation part

Hadamard product $T_{calorie}$ and $T_{one-hot} \Rightarrow$ Average pooling \Rightarrow Sum pooling
 \Rightarrow Calculate calorie vector v_c corresponding to calorie for each category



5. Methodology : Loss function

Weighted absolute error and relative error

$$L_{ab} = \lambda |v - g| \begin{cases} \lambda = 1.0 (v - g \geq 0) \\ \lambda = 1.2 (otherwise) \end{cases} \quad L_{re} = \frac{|v - g|}{g}$$

Total loss function

$$L_{cal} = \lambda_{ab} L_{ab} + \lambda_{re} L_{re}$$

- v is the estimated total calorie of each food category
- g is ground truth total calorie
- $\lambda_{ab}(=0.01)$ $\lambda_{re}(=0.1)$ are hyper parameter weighting each loss.

6. experiment

Estimate ...

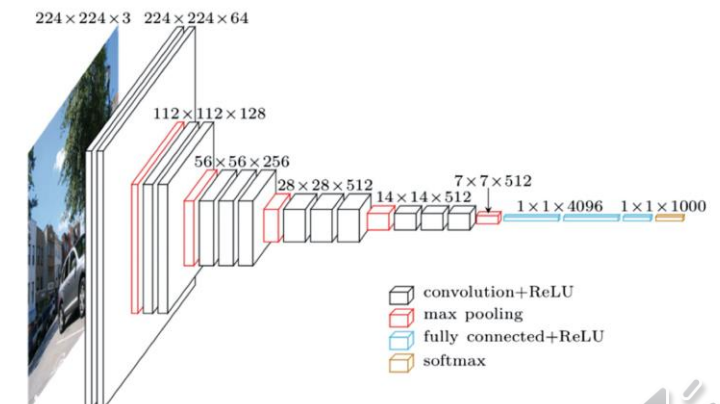
- total amount of calories
- calories of each food items in school lunch photos.



6. experiment

Comparative experiments in three models

- **Model A** : directly estimate total calorie
- **Model B** : Model A + category label
 - Train multi-label classification model (VGG16) \Rightarrow add calorie estimate branch (FC) after conv.
- **Model C (ours)** : segmentation + calorie estimation
- **Ege et al[1]** : detection \Rightarrow calorie regression for each food item



6. experiment

Absolute error on total calorie amounts (kcal)

model	school lunch (22)	school lunch (60)
model A (direct regression)	-	45.0
model B (multi-label)	-	44.2
model C (Ours)	74.5	74.8
baseline (Ege <i>et al.</i> [11])	136.8	-

**Error in each category
has been accumulated**

6. experiment

Average estimated calorie amounts of common 13 category food items in 60 categories (kcal).

Category	Model A	Model B	Model C	Ref. Calorie
Milk	11.5	457.6	123.3	130
Rice	12.1	50.9	209.4	250
Mixed rice	10.6	21.7	220.2	250
Bread	10.8	7.5	190.3	220
Japanese salad	11.9	33.1	60.2	50
Green salad	11.9	33.0	68.9	50
Grilled pork loin	12.2	2.5	74.4	240
Grilled chicken teriyaki	11.6	2.0	35.8	300
Miso soup	10.3	59.9	147.6	159
Minestrone	11.1	15.5	141.4	159
Fruit punch	11.1	5.2	68.1	50
Jelly	11.3	3.1	55.4	89
Oranges	9.6	0.5	45.5	50

6. experiment

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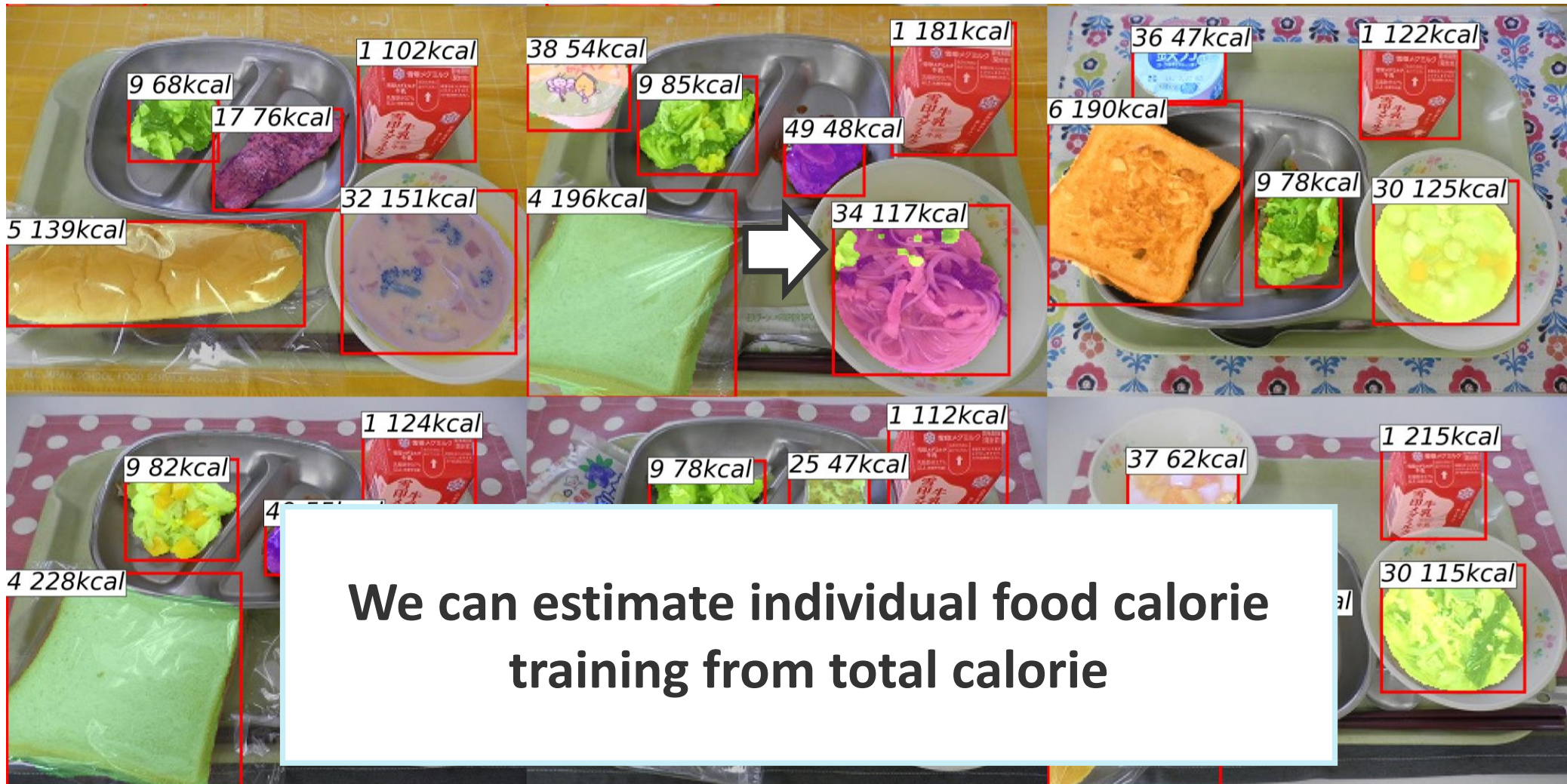
Grille

Our Model C is the most reasonable for estimating calorie in each food category training from total calorie.

6.実験結果：モデルCを用いた推定結果画像



6.実験結果：モデルCを用いた推定結果画像



We can estimate individual food calorie training from total calorie

7.Future works

Experiment is still small scale, not generic.

- Dataset expansion
- Cost reduction for annotating segmentation dataset



8.Conclusion

Conclusion

- Proposed method that estimate calorie for each food category training from total calorie.
- Adding a calorie estimation branch to semantic segmentation model.
- In experiment, proposed method can estimate the calories of multiple-dish school lunch dataset in high accuracy.