UEC-FoodPIX Complete: A Large-scale Food Image Segmentation Dataset

Kaimu Okamoto and Keiji Yanai

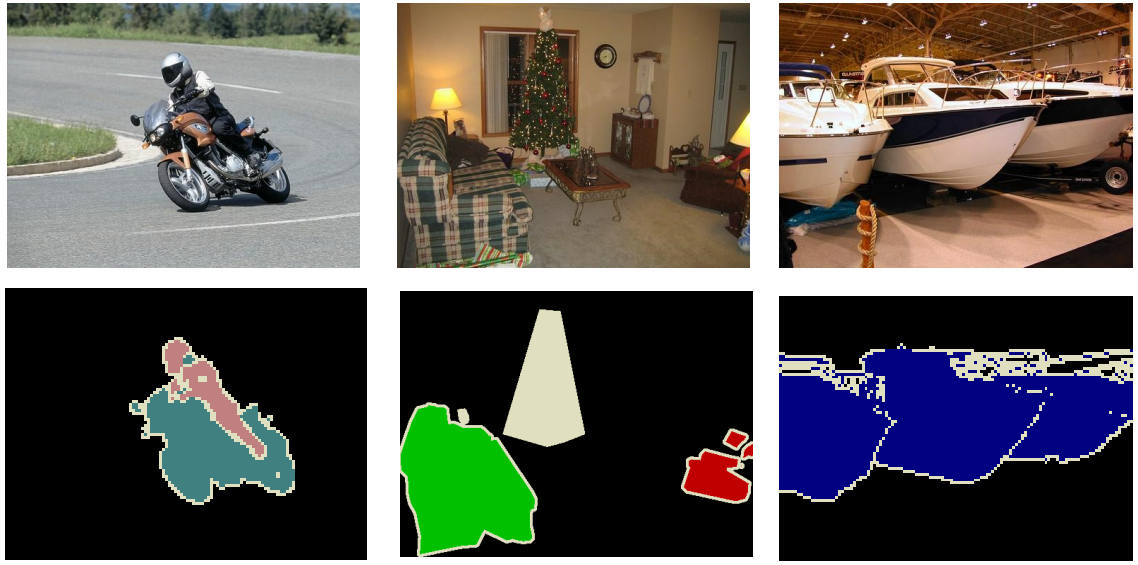
The University of Electro-Communications, Tokyo

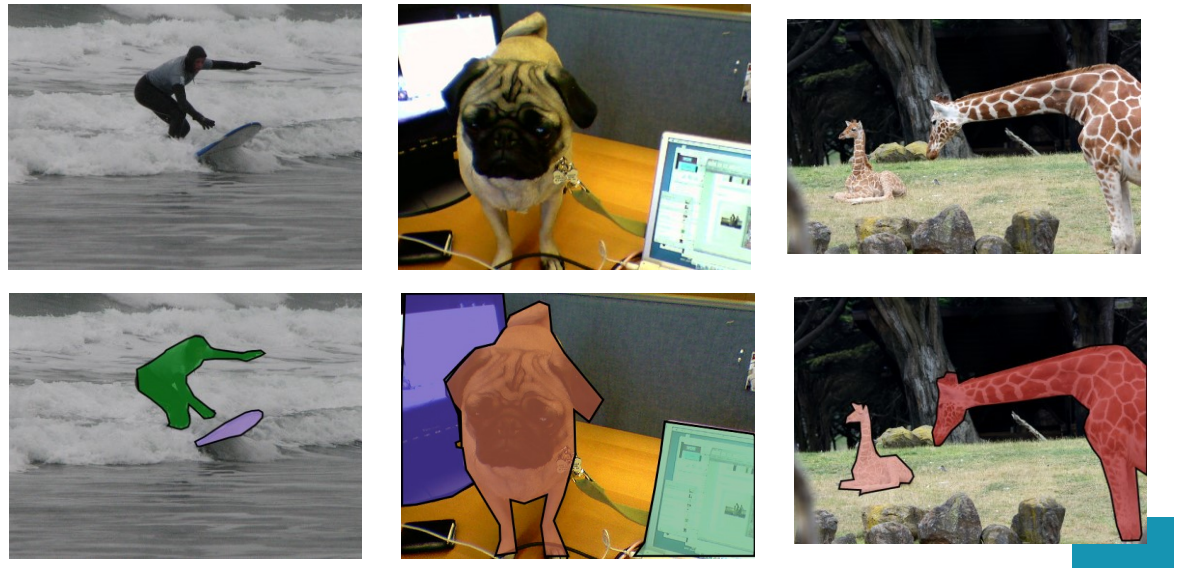
Introduction

Widely used as large-scale segmentation datasets [3][4]

22categories
About 10k images

80categories
About 330k images





Introduction

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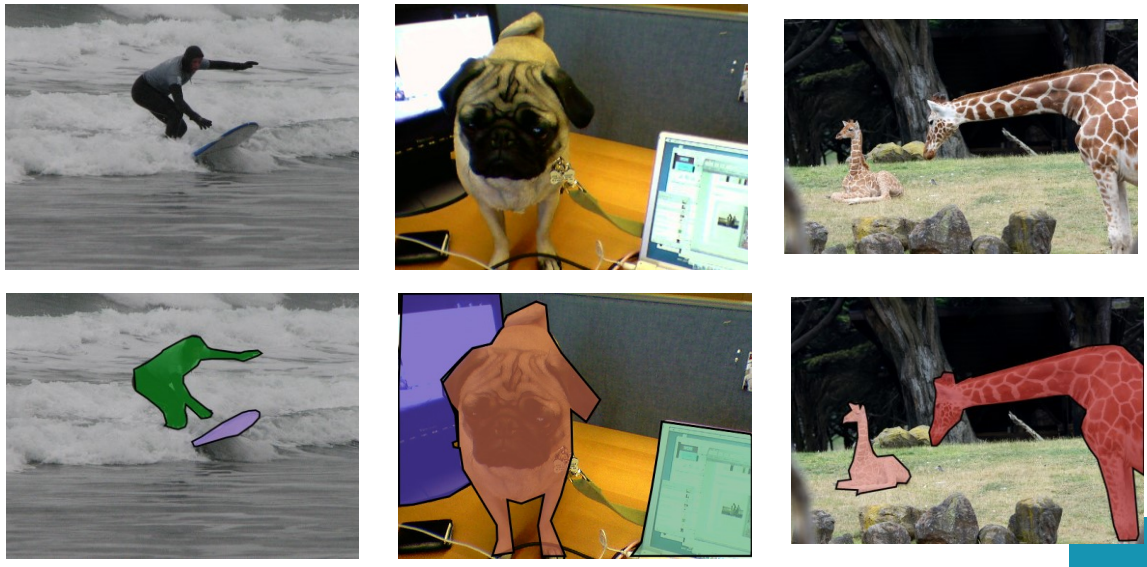
22categories
About 10k images

Microsoft Common Objects in Context

80categories
About 330k images

These includes only a limited number of food categories.
(Banana, Pizza, etc.)



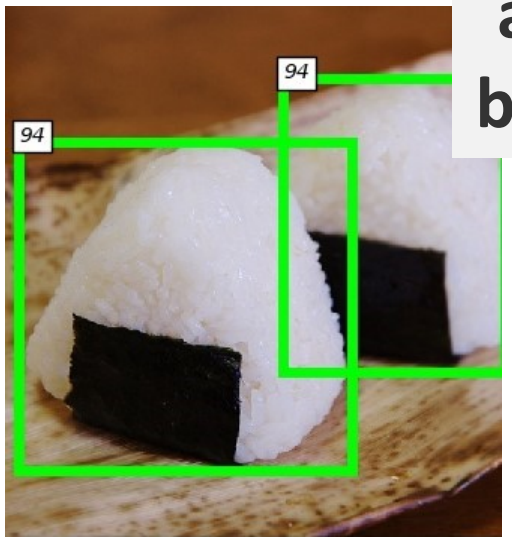
Introduction

Food segmentation dataset

- UEC-Food Pix by Ege et al.[2]

  ⇒Semi-automatically annotated by GrabCut [16] based on the bounding boxes annotated in the UECFood-100 dataset

BBox



annotated by Grab Cut

Mask

UEC-Food Pix dataset

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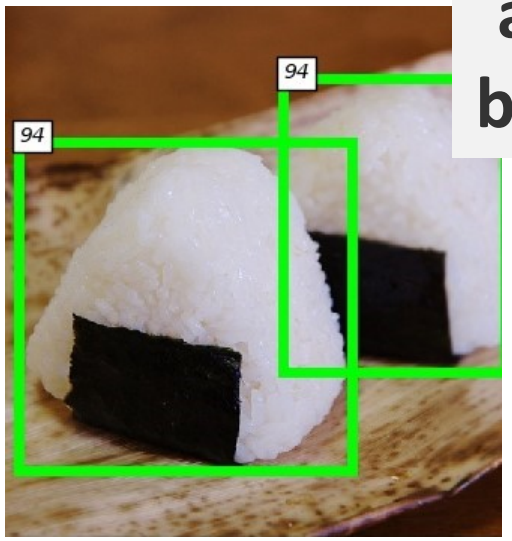

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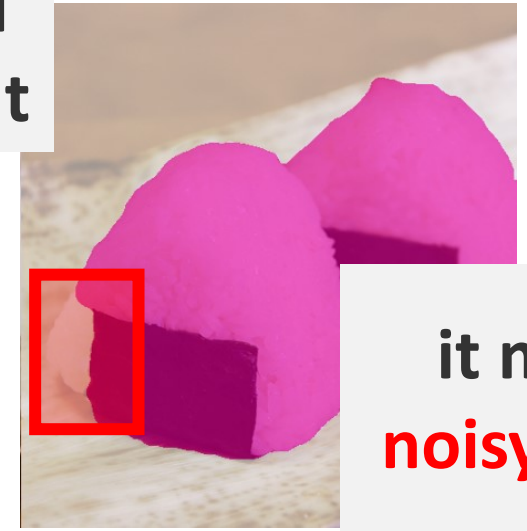
Mask



UEC-Food Pix dataset

it may contain noisy annotations

Objective

- **Updating UEC-Food Pix to make new food segmentation datasets**
- **Introducing application examples of this dataset**

UEC-Food Pix Complete

- **Food images synthesis**
- **Calorie estimation**

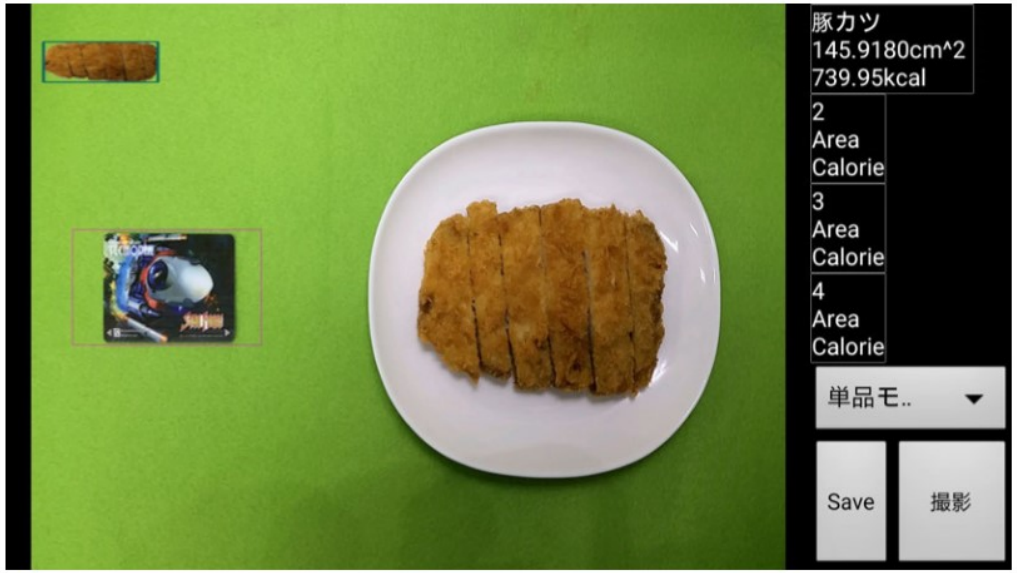
Related Work

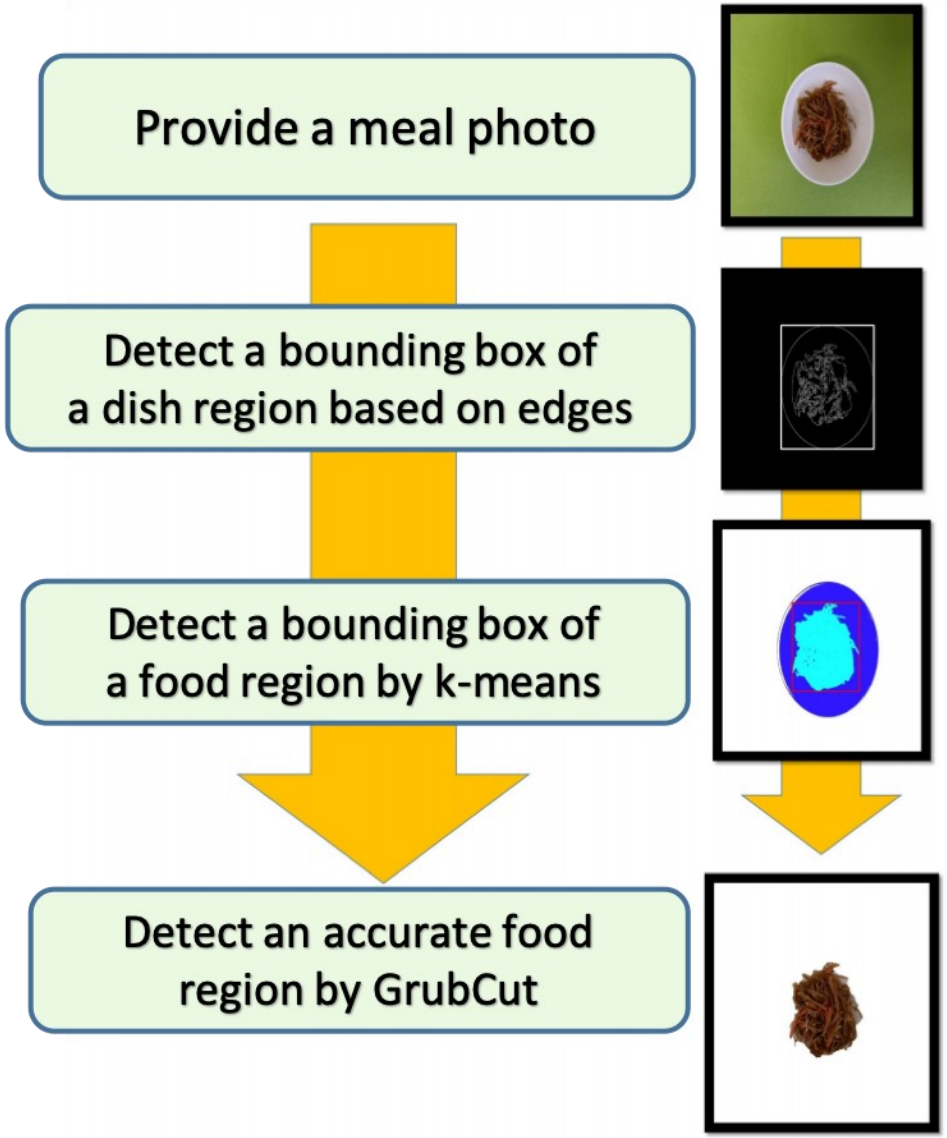
A region based food calorie estimation

- Calorie Cam [13]

  ⇒running on a mobile phone

  ⇒Using GrabCut[16] to detect food region





K. Okamoto and K. Yanai. An Automatic Calorie Estimation System of Food Images on a Smartphone, MADiMa, 2016

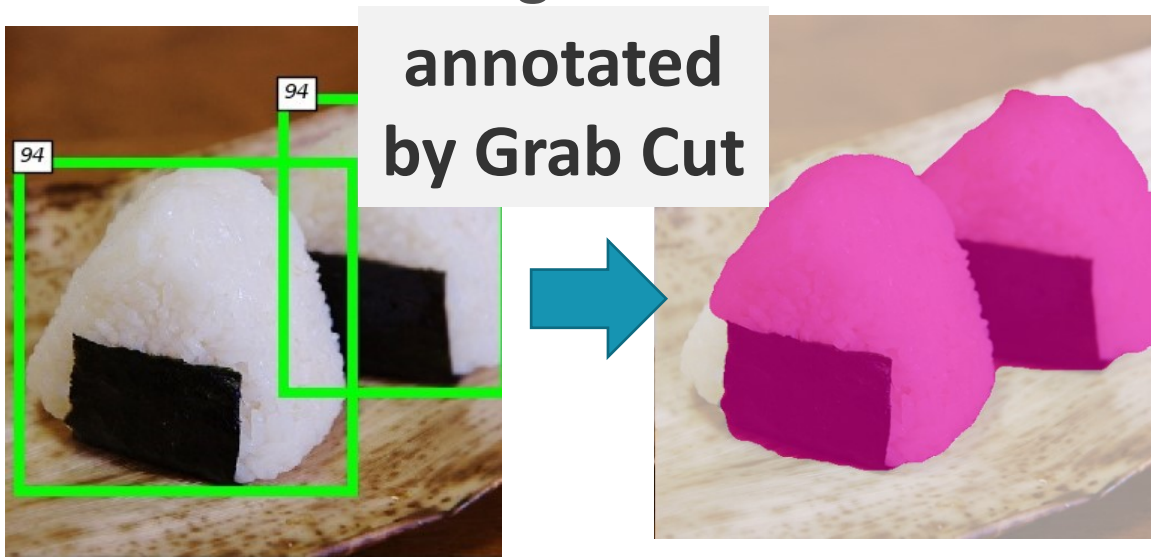
Related Work

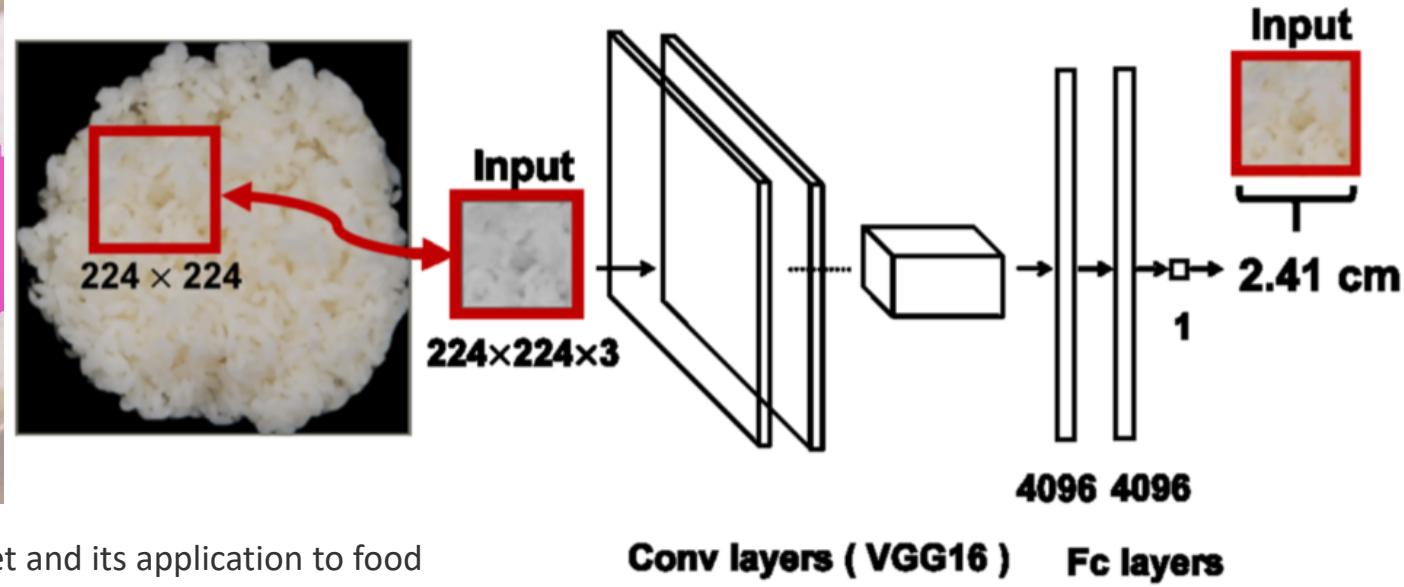
Estimating actual size of foods without a reference card

- Rice image actual size estimation system[6]

  ⇒Estimating actual size of foods by using the size of rice grains

  ⇒Creating the dataset for food segmentation applying calorie estimating





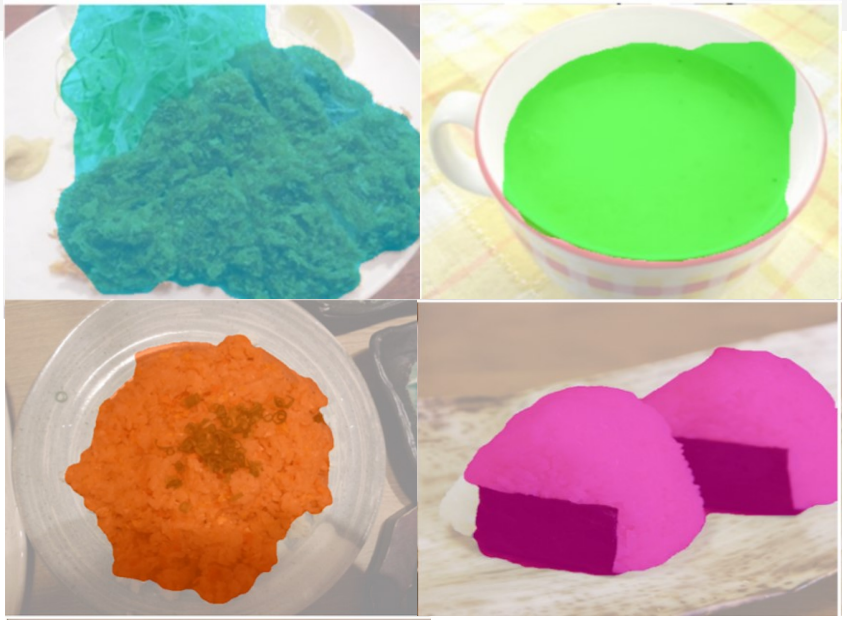
Ege, T., Yanai, K.: A new large-scale food image segmentation dataset and its application to food calorie estimation based on grains of rice. MADiMa, (2019)

Overview of the datasets

Introducing the datasets

UEC-Food Pix

102 food categories
9,000 train images(Automatically)
1,000 test images(hand annotation)



UEC-Food Pix Complete

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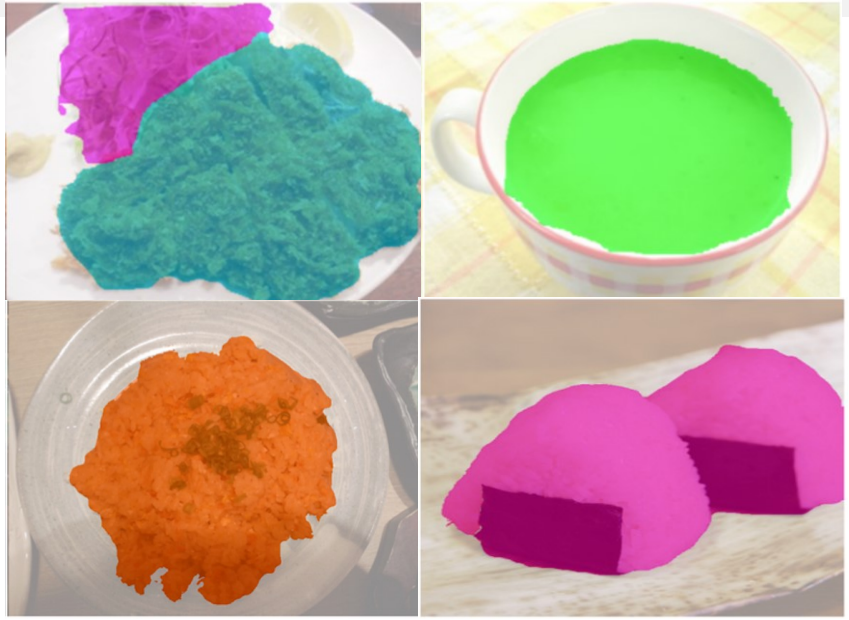
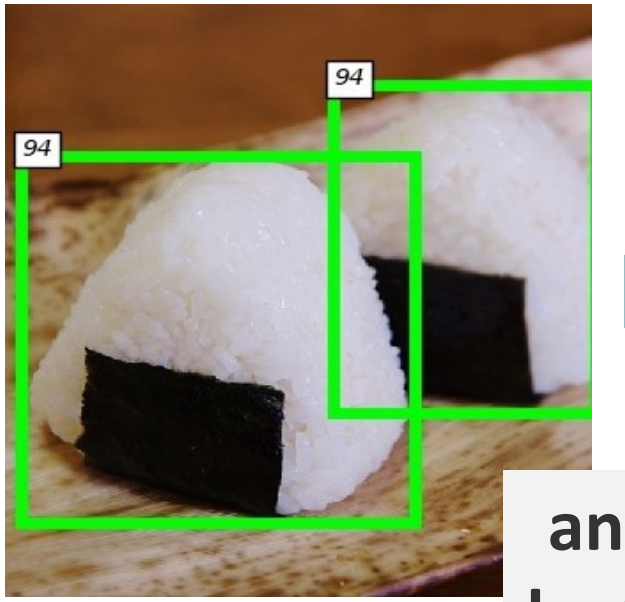


Dataset Construction

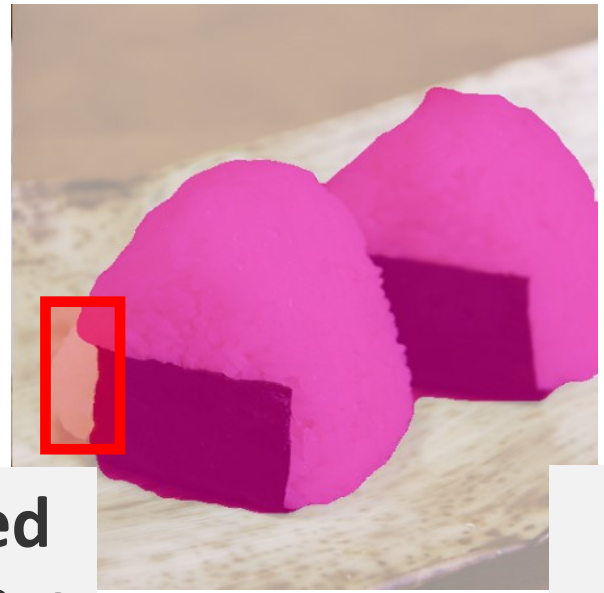
We created UEC-FoodPix Complete as a higher quality food image segmentation dataset by updating UEC-FoodPix manually.

UEC-FoodPIX

UECFoodPIX Complete



annotated by Grab Cut



Manually modifying

Dataset Construction

Using Web-based pixel-wise annotation tool for create this dataset

- Proposed web tool by Pongsate et al. [18].

  ⇒allows easy synthesis and separation of food regions with super-pixels

Tangseng, P., Wu, Z., Yamaguchi, K.: Looking at outfit to parse clothing. arXiv:1703.01386 (2017)

Dataset Construction

When done manually, the mask will differ depending on the person who works

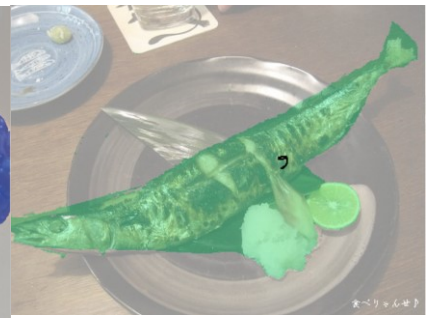
⇒set annotation some rules on how to create food region masks

ex.) ‘Yakitori’ skewers do not include, ‘Grated radish’ is set in the other food category

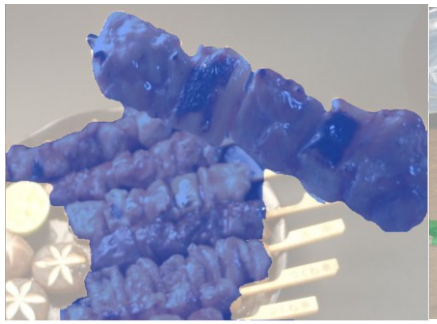
⇒10,000images, 4months creation period

Original a image

Different masks



Apply a rule to the mask



Evaluation

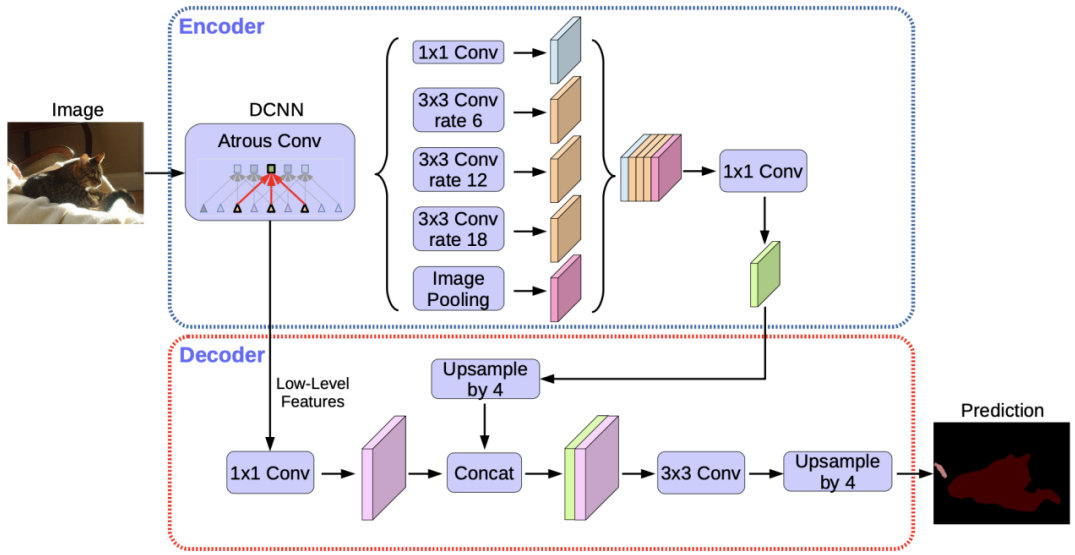
Accuracy and mIoU comparison between UEC-FoodPIX and Complete

⇒food region estimation by Deeplab V3+[1]

Training dataset	Acc	mIoU
UEC-Food Pix	0.560	0.416
partial UEC-Food Pix Complete (2000 hand annotation)	0.597	0.436
UEC-FoodPix Complete	0.668	0.555

9,000 training images　1,000 test images

Deeplab V3+

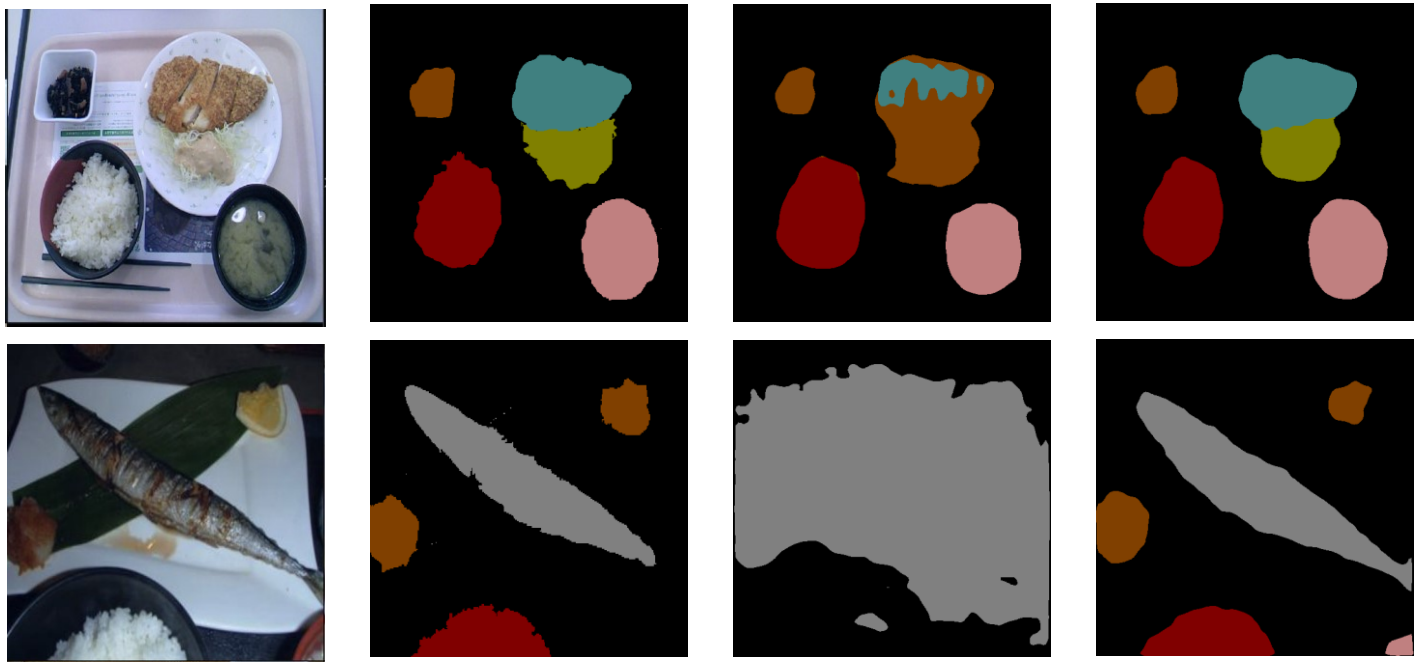


Deeplab V3+: Chen, L., Zhu, Y., Papandreou, G., Schroff, F. and Adam, H.: Encoder-Decoder with Atrous Separable Convolution for Semantic Image Segmentation, in Proc. of ECCV (2018).

Evaluation

Some segmentation results by both models

Input | Ground truth | UECFOODPIX | COMPLETE



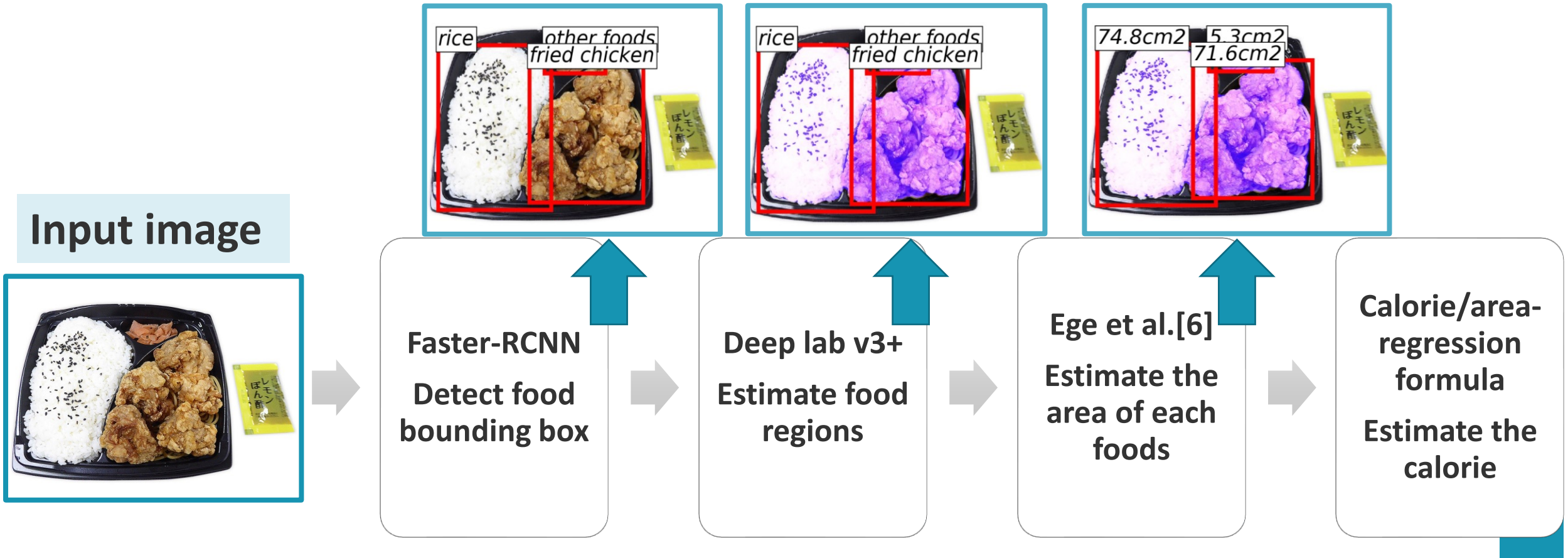
The results by the Complete model are similar to the groundtruth

Application 1: Region-based Food Calorie Estimation

Application 1: Region-based Food Calorie Estimation

Food region and Calorie estimation system

⇒Following Ege et al.[6]



Application 1: Region-based Food Calorie Estimation

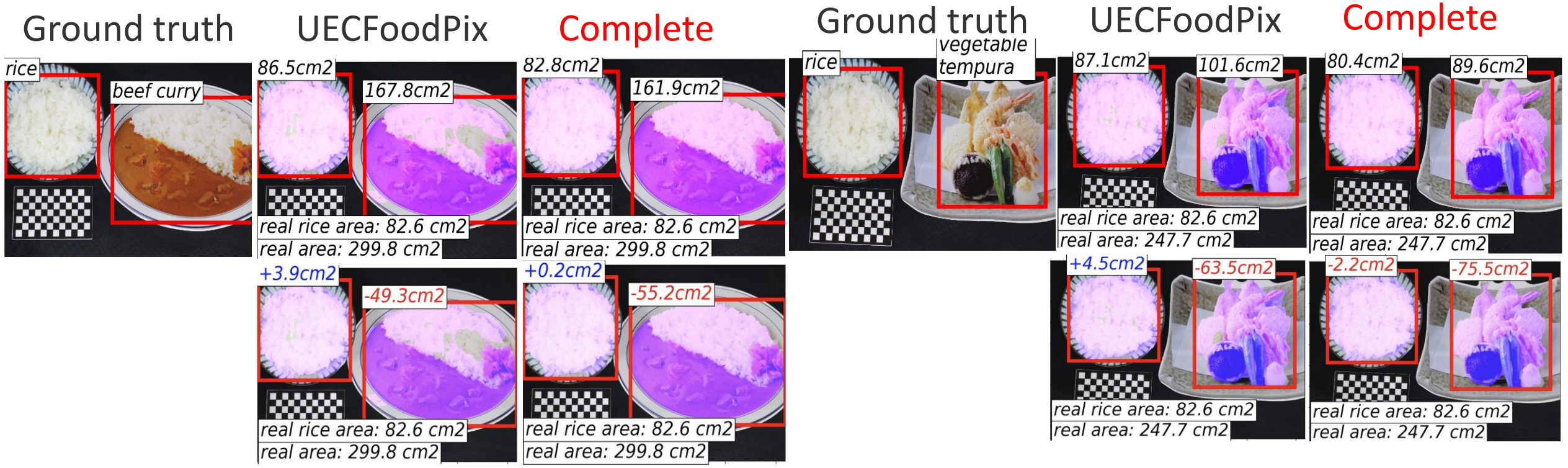
Food region estimation

	Area(rice)		Area(multiple food)		Calorie(multiple food)	
dataset	Abs.err(cm^2)	Rel.err(%)	Abs.err(cm^2)	Rel.err(%)	Abs.err(kcal)	Rel.err(%)
UECFoodPix[6]	7.21	8.73	30.0	14.2	240.8	29.8
Complete	3.03	3.67	44.7	20.7	268.5	33.4

- Only rice area estimation accuracy was improved
- Multiple dishes, both errors of the original UEC-Food Pix were lower.

Application 1: Region-based Food Calorie Estimation

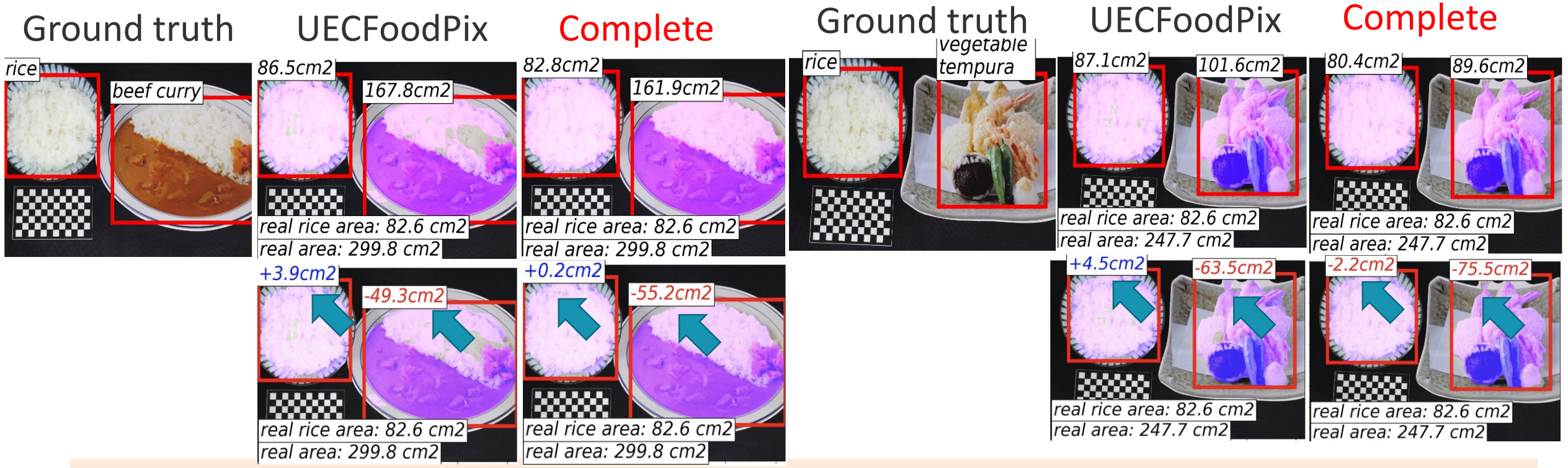
Estimation of Food region size



- **Higher-quality area estimation is possible using the model trained with "Complete".**

Application 1: Region-based Food Calorie Estimation

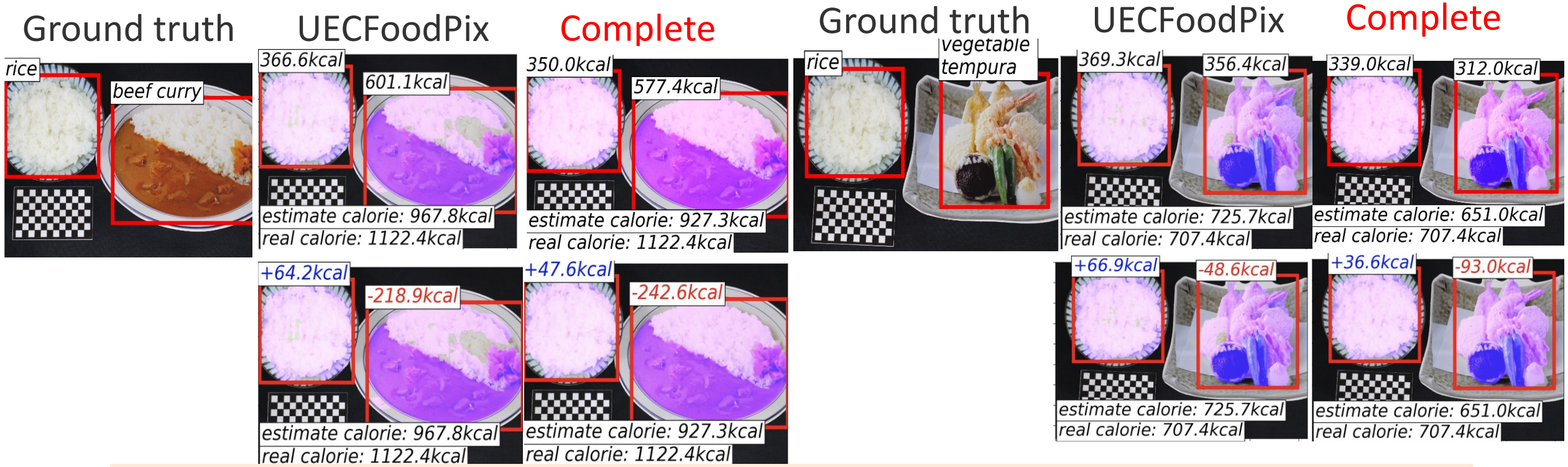
Estimation of Food region size



- **When training by 'Pix', the rice part calculates the large actual size**
- **So even if the mask is applied a little, the value close to the total correct value is calculated.**

Application 1: Region-based Food Calorie Estimation

Food Calorie estimation



- **The values close to the actual calories were calculated**
- **Since the calorie content is estimated based on the actual size, also this result is better with PIX.**

Application 2: Mask-based Image Synthesis

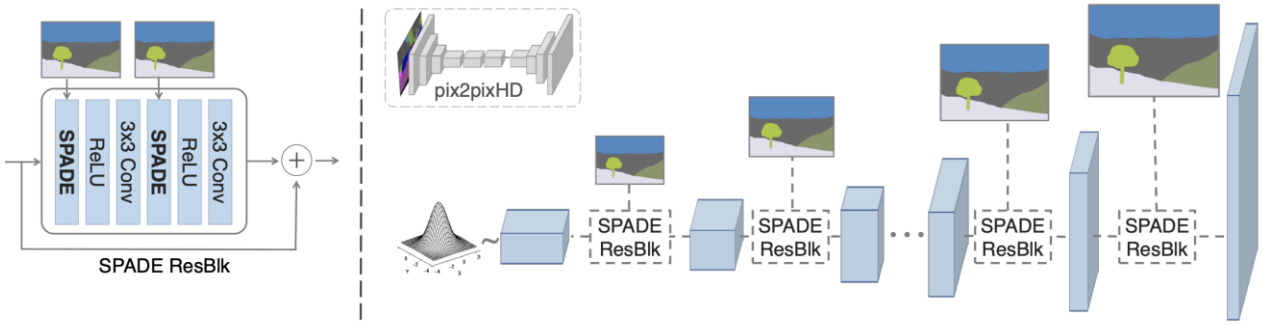
Application 2: Mask-based Image Synthesis

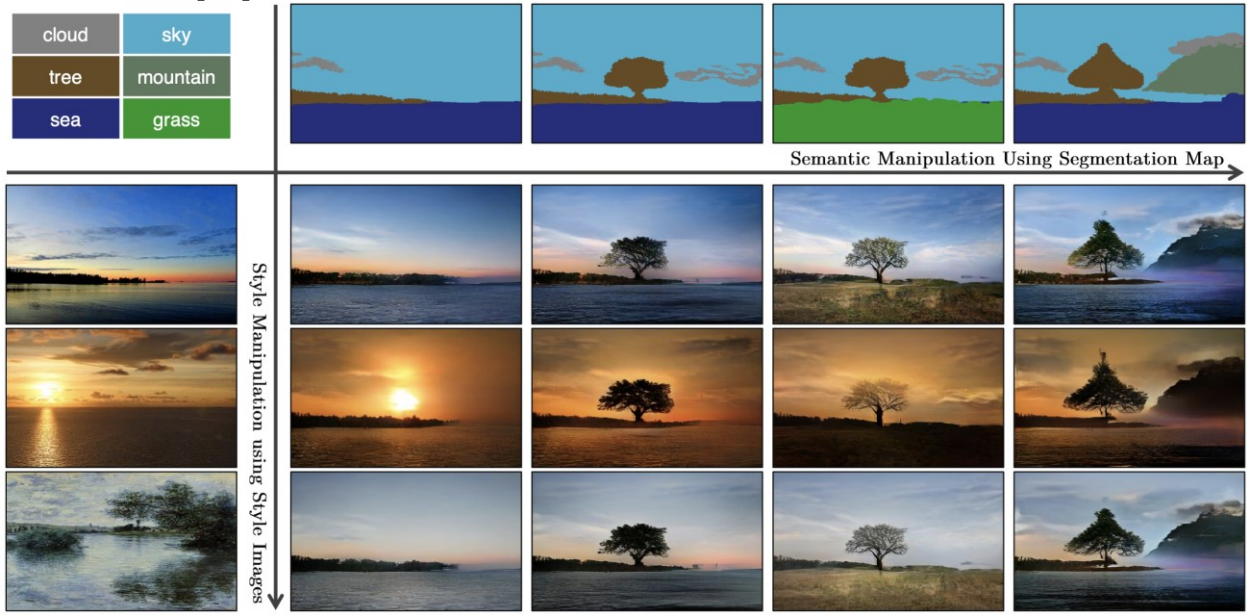
Mask-based Image synthesis method

- SPADE[14]

  ⇒the state-of-the-art mask-based image generation method

  ⇒spatially adaptive normalization applied

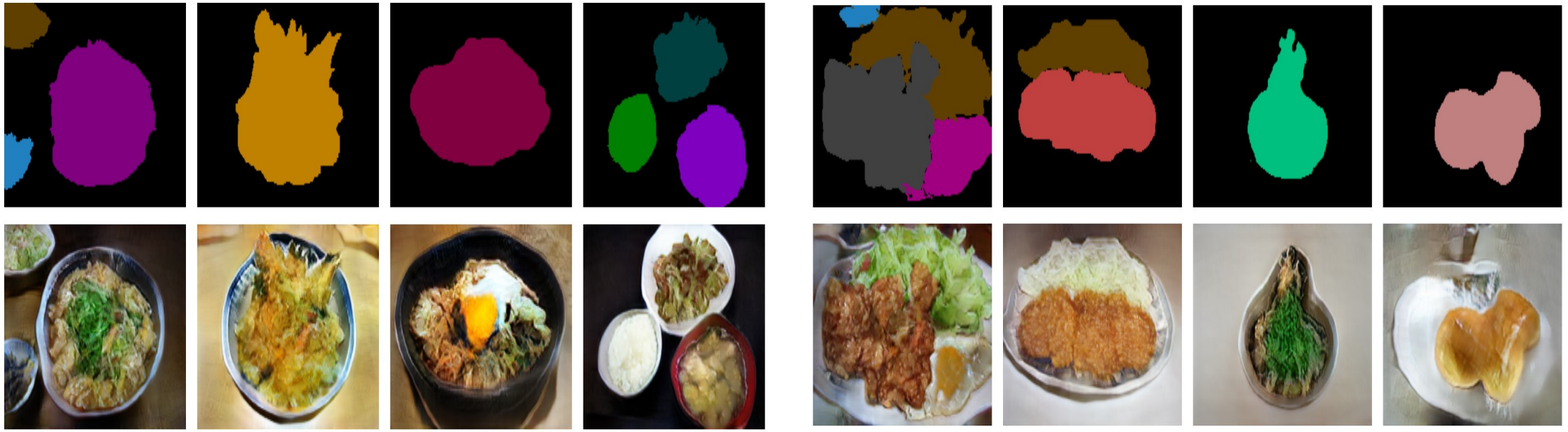




Park, T., Liu, M., Zhu, J.: Semantic image synthesis with spatially-adaptive normalization. CVPR (2019)

Application 2: Mask-based Image Synthesis

Food Images Synthesis by SPADE[14]



- **Rice bowls and Japanese combo meals were successfully generated.**
- **Deformed and concatenated images are generated**

Application 2: Mask-based Image Synthesis

Food Images Synthesis from the same mask images with different class labels

Multiple dish food images were synthesized well, although the shape of plates and bowls sometime were distorted and look unnatural.

Conclusions

Summary

- UEC-FoodPix Complete, by updating the existing the food image segmentation dataset UEC-FoodPix [6].
- This dataset was shown that it can be applied to calorie content estimation and image generation.

Future works

- Annotate this dataset with other information such as calorie.

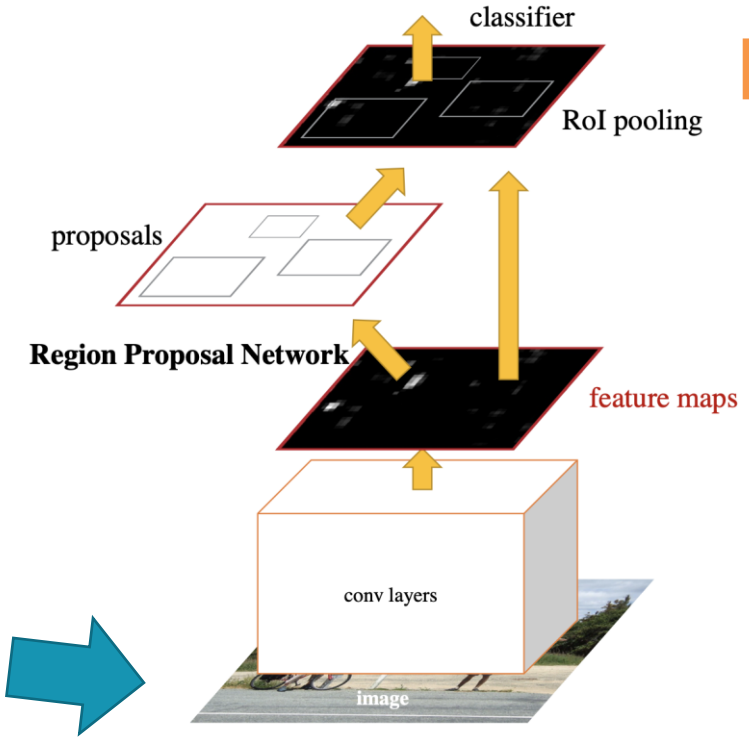
Question Slide

Application 1: Region-based Food Calorie Estimation

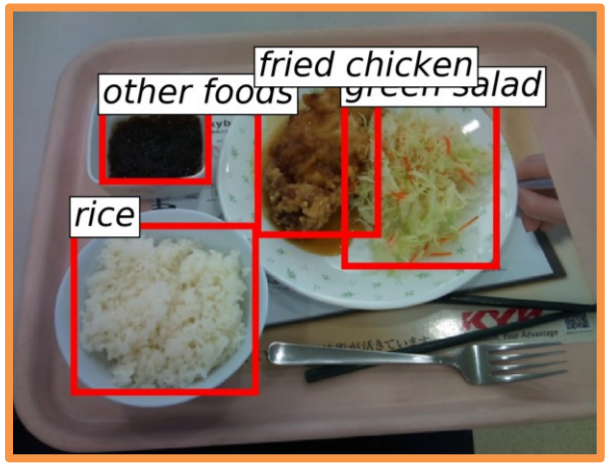
Detecting food bounding box using Faster R-CNN [6]

⇒Learning UECFood100 with bounding box

Input image



Detect BBox



	AP_{50}
UECFOOD100	0.58

Ren, K. He, R. Girshick, and J. Sun. Faster R-CNN: Towards real-time object detection with region proposal networks. IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 39, No. 6, pp. 1137–1149, 2017.

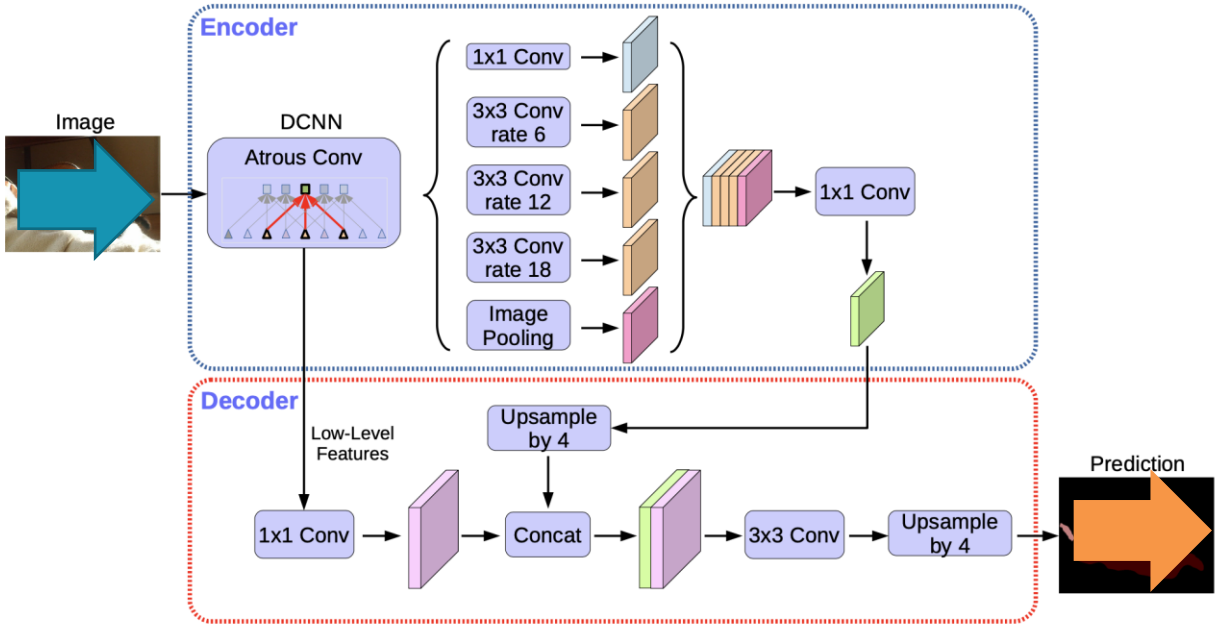
Application 1: Region-based Food Calorie Estimation

Estimate food regions with Deeplab V3+[1]

⇒ Estimate food/non food regions in areas of bounding box

bbox areas

Estimate with Deeplab V3+



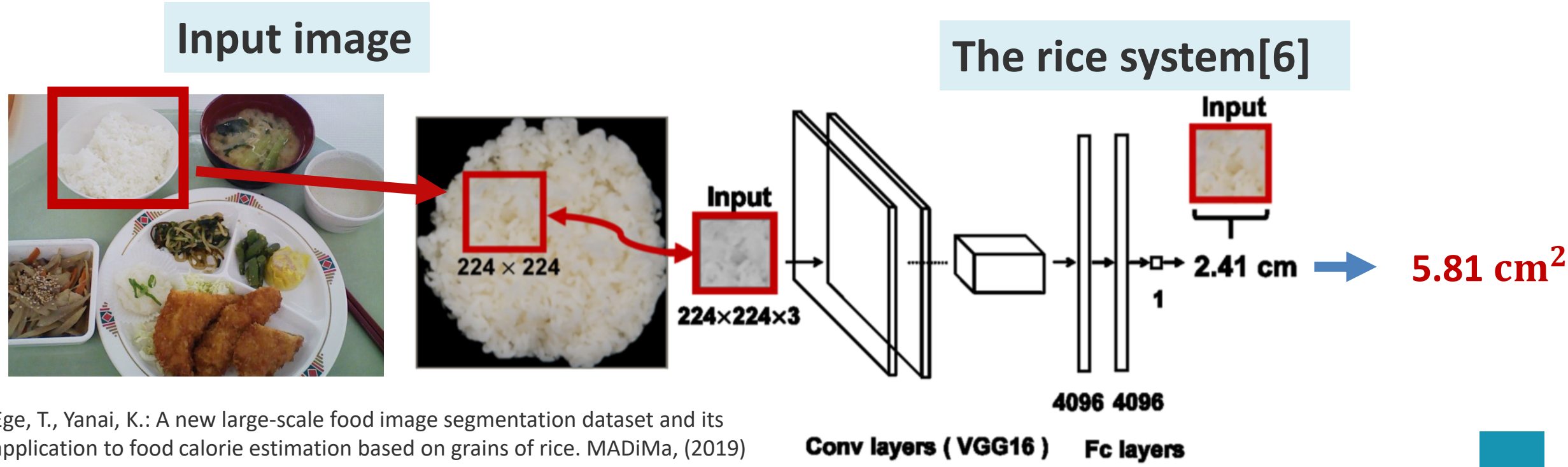
Food regions

Deeplab V3+: Chen, L., Zhu, Y., Papandreou, G., Schroff, F. and Adam, H.: Encoder-Decoder with Atrous Separable Convolution for Semantic Image Segmentation, in Proc. of ECCV (2018).

Application 1: Region-based Food Calorie Estimation

Estimating the actually area of each foods

⇒Estimating the cm/pixel from rice parts in images. Using squared cm^2/pixels



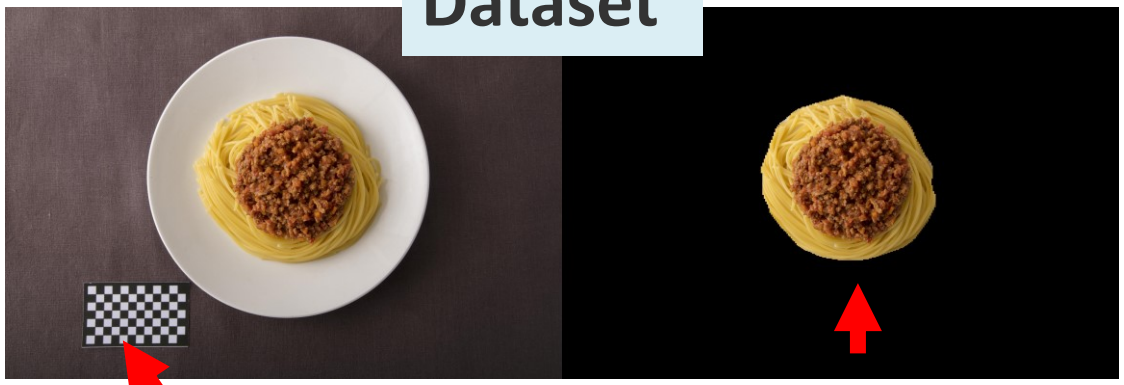
Ege, T., Yanai, K.: A new large-scale food image segmentation dataset and its application to food calorie estimation based on grains of rice. MADiMa, (2019)

Application 1: Region-based Food Calorie Estimation

Dataset with known reference object area and calorie(63 categories)

⇒Estimate food regions and create a regression equation for each category

Dataset



Example

Category	Food region	Calorie
Meat spaghetti	1.0	602kcal

Calorie / Area-regression formula