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Dish Detection and Segmentation for Dietary Assessment on Mobile Phones

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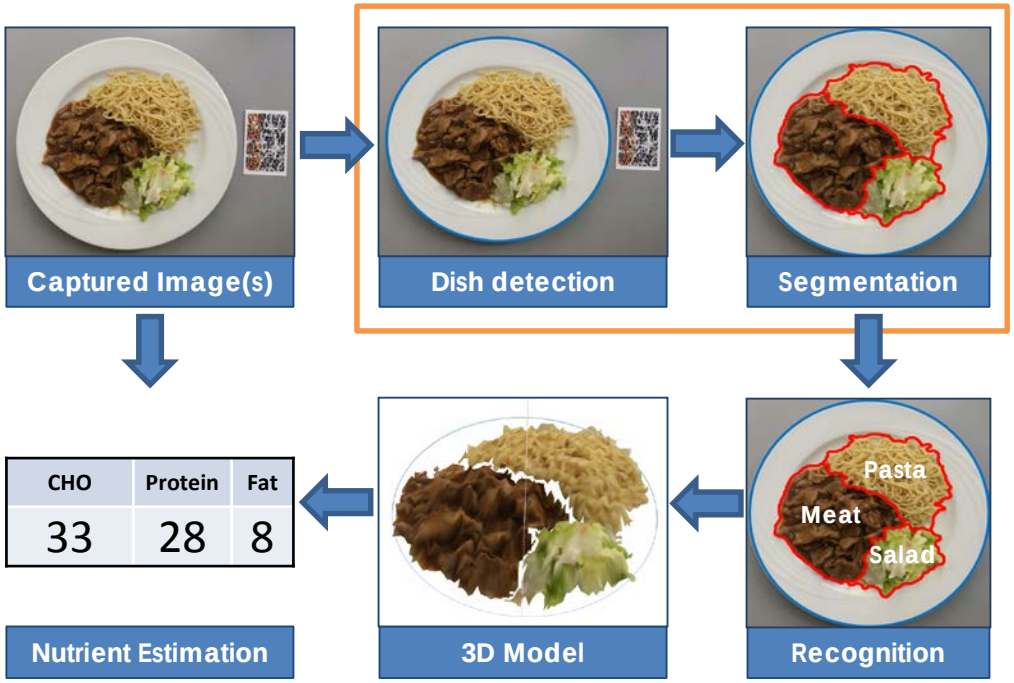

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Dish detection

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Input
An image of the meal inside an elliptic dish

Process
1. Preprocessing and Canny edge detection
2. Filtering of edge graph
3. Incremental RANSAC on edge segments

Output
A map with label codes for background and foreground
Ellipse equation

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Segmentation
Seeded region growing

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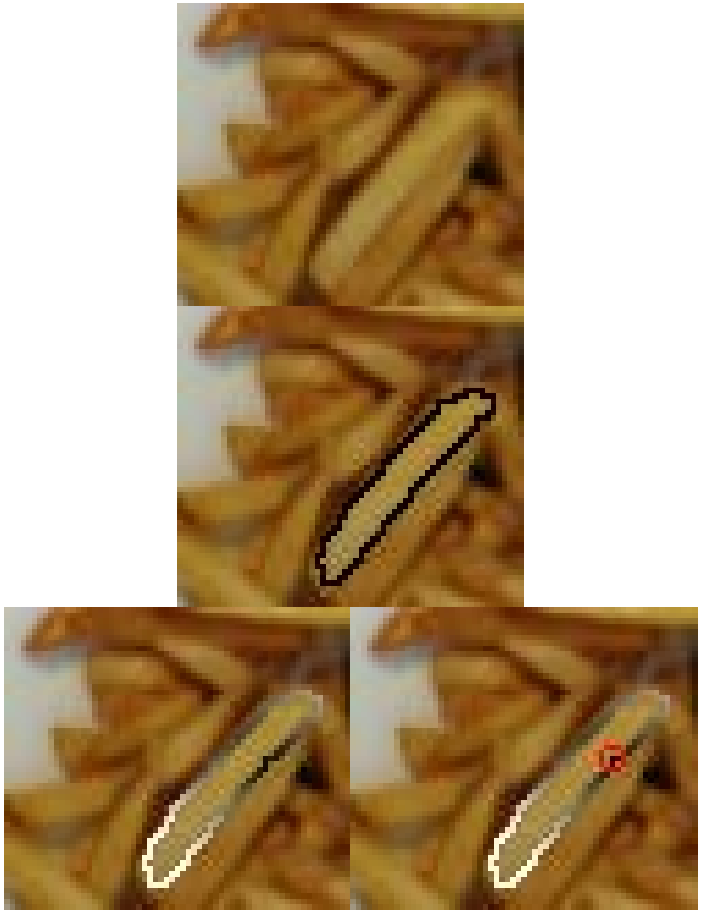
Input
"Seed regions": pixel sets

Process
1. Luminosity-dampened CIE94 colour distance
2. Iterative growth of the regions:
   Add the border pixel with the smallest distance to its region

Output
A map with label codes for background and food items



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Segmentation
Statistical region merging

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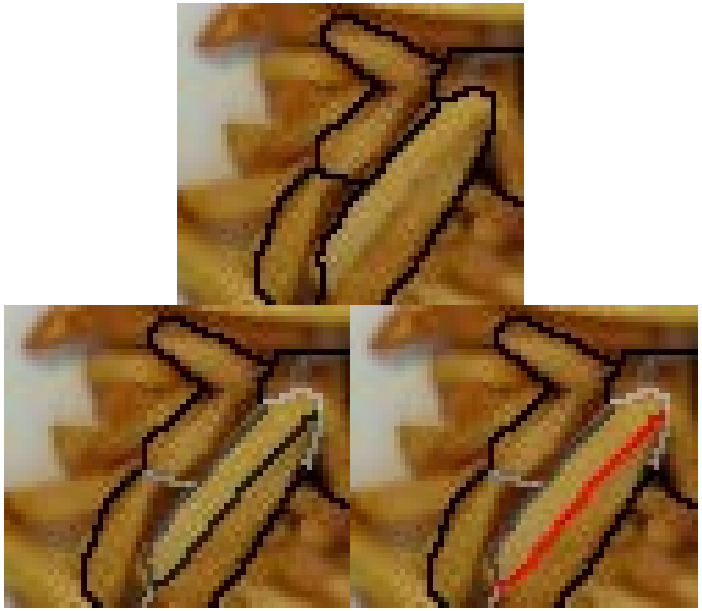
Input
Segmentation map
Process
1. Luminosity-dampened CIE94 colour distance
2. Iterative merging of the regions:
   Merge the two regions with the smallest distance between them

Output
A map with label codes for background and food items



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Segmentation

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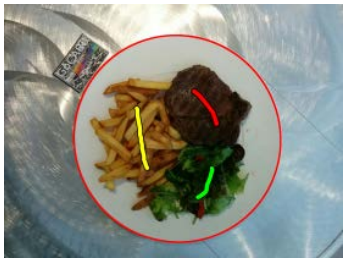
	Automatic	Semi-automatic
1. Seeds		
2. Region growing		
3. Region Merging		

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Evaluation - Procedure

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Dataset:

- 1600 Manually annotated images
- Single large round plate
- Food from the local hospital restaurant

Scoring:

- Average overlap between ground truth and result
- $NI_{sum}(G=>R) = \frac{\Sigma_i \, Max_j(|R \cap G_j|)}{\Sigma_i \, |R_i|}$
- $F_{sum} = 2 * NI_{sum}(G=>R) * NI_{sum}(R=>G) / (NI_{sum}(G=>R) + NI_{sum}(R=>G))$

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Evaluation

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Automatic	Average F_{sum} (%)	Time (s/image)
Proposed	88.2	0.45
Mean-shift [1]	87.5	2.1
Local Variation [2]	82.6	2.8
Ultrametric contours [3]	69.2	19
Semi-Automatic	**Average F_{sum} (%)**	**Time (s/image)**
Proposed	90.8	0.49
Flood fill	89.9	0.52

[1] Anthimopoulos, M.; Dehais, J.; Diem, P.; Mougiakakou, S., "Segmentation and recognition of multi-food meal images for carbohydrate counting," IEEE 13th International Conference on Bioinformatics and Bioengineering (BIBE), (2013)
[2] Felzenszwalb, P. F., Huttenlocher, D. P.: Image segmentation using local variation. In: IEEE Conference on Computer Vision and Pattern Recognition, pp. 98-104 (1998)
[3] Arbelaez P., Maire M., Fowlkes C., and Malik J.: Contour detection and hierarchical image segmentation. IEEE Trans. Pattern Anal. Mach. Intell., vol.33, no.5, pp.898–916 (2011.)

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Thank you for your attention.

(Photo credit: Kem Sypher)

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Dish detection
Incremental RANSAC

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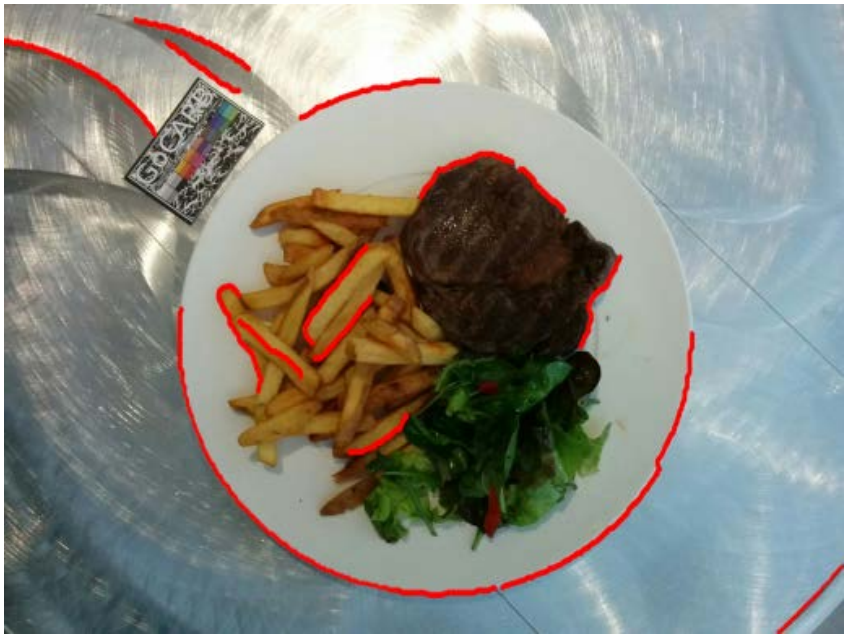
1. Each segment contains *s* edge points, *s* >>5
2. A conic can be generated from *k* <=5 segments

Incremental sampling:

1. Set k=1
2. Apply RANSAC
   Max consensus set size: n_k
3. If $n_k > n_{k-1}$ and $k<5$
   1. Set k=k+1
   2. Repeat 2-3

Average accuracy: 99.1%



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Segmentation
Colour Distance

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- $\mathrm{CIE94}\left(L,a,b,L',a',b'\right)=\sqrt{\Delta L_N^2+\Delta C_N^2+\Delta H_N^2}$, with
- $\Delta L_N=\left(L-L'\right)$,
- $\Delta C_N=\left(\sqrt{a^2+b^2}-\sqrt{a'^2+b'^2}\right)/\left(1+0.045\sqrt{a^2+b^2}\right)$,
- $\Delta H_N=\sqrt{\left(a-a'\right)^2+\left(b-b'\right)^2-\Delta C_N^2}/\left(1+0.015\sqrt{a^2+b^2}\right)$
- $\mathbf{dist}\left(L,a,b,L',a',b'\right)=\sqrt{|\Delta L_N|+\Delta C_N^2+\Delta H_N^2}$

Automatic	Av. F_{sum} (%)
RGB - Euclidian	61.1
CIE94	80.2
Proposed	88.2
Semi-Automatic	**Av. F_{sum} (%)**
RGB - Euclidian	72.3
CIE94	78.2
Proposed distance	90.8

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Segmentation
Merging Distance

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- $\mathrm{Dist}(R_i,R_j)=\frac{\mathrm{dist}(L_i,a_i,b_i,L_j,a_j,b_j)}{\sqrt{|edge_{i,j}|}}$, where
  - L_i: Median L_p, p in R_i
  - a_i, b_i: Average a_p, b_p, p in R_i

Merging Cost	Av. F_{sum} (%)
Color distance	85.8
Proposed	88.2

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