Food recognition and leftover estimation for daily diet monitoring

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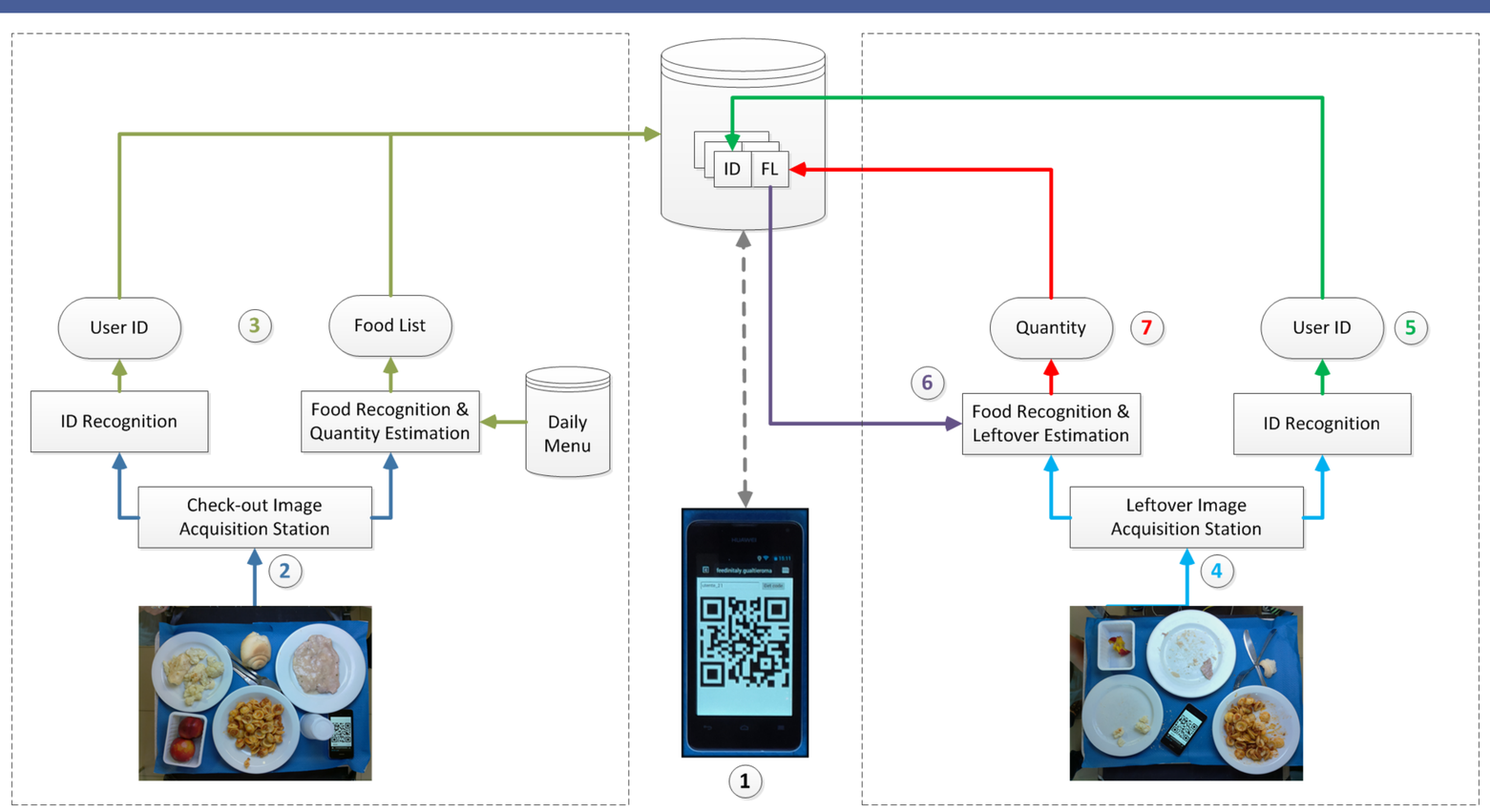
Abstract

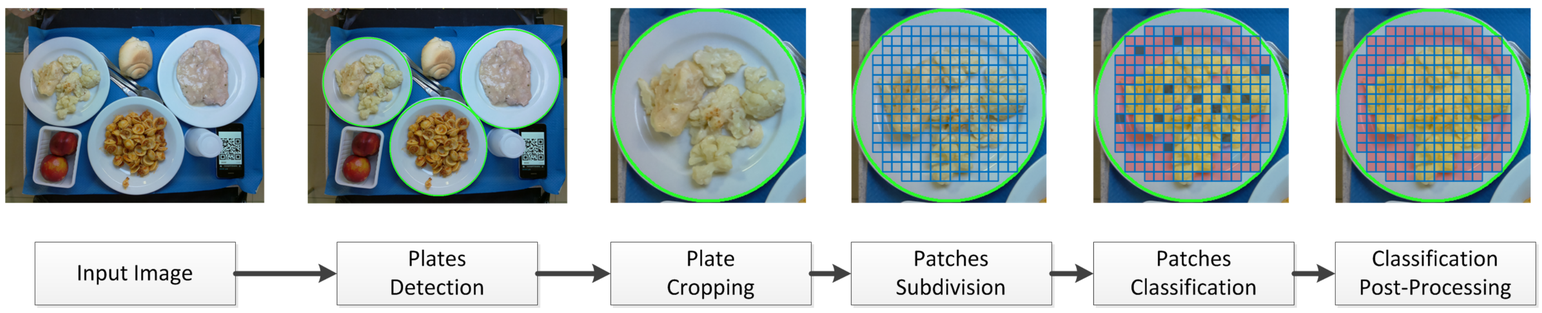
Automatic food recognition is an important task to support the users in their daily dietary monitoring and to keep tracks of their food consumption [1]. Here we propose a system for automatic dietary monitoring of canteen customers based on robust computer vision techniques. Our system, tested on 1000 customers of a real canteen images, is able to recognizes different foods and estimates food leftovers.

Proposed system workflow



1. The user ID is shown on its mobile application as QR-Code.
2. Check-Out: an image of the tray is acquired and sent to the server.
3. The user ID is decoded, the foods is recognized against the daily menu, and the food quantities are estimated. The collected information is stored into the user's dietary profile.
4. Leftover: an image of the tray is acquired and sent to the server.
5. The user ID is decoded.
6. The food list is retrieved as used in the recognition and estimation.
7. The leftovers are recognized and estimated. The information is logged back in the profile.

Approach & Results



		visual descriptors						
Classes (c)	w_c(%)	CEDD	OG	Gabor	LBP	LLC	CM	CWT
bistecca	(3.8%)	100.00	100.00	100.00	27.50	97.50	91.25	80.00
carote	(7.6%)	100.00	100.00	100.00	100.00	100.00	98.75	100.00
cavolfiore	(8.6%)	100.00	100.00	98.89	97.22	98.33	97.22	98.33
fagiolini	(7.6%)	100.00	100.00	100.00	99.38	100.00	100.00	96.25
frittata	(7.6%)	100.00	100.00	100.00	81.25	93.75	83.12	100.00
fusilli ragu	(8.6%)	100.00	100.00	100.00	85.56	100.00	97.22	100.00
insalata mista	(2.4%)	100.00	92.00	42.00	58.00	100.00	90.00	32.00
lenticchie	(7.1%)	98.67	99.33	96.67	68.00	94.67	28.67	57.33
minestra	(6.7%)	100.00	100.00	97.86	99.29	97.86	93.57	100.00
pasta cime rapa	(8.6%)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
pasta sugo	(2.4%)	100.00	100.00	100.00	28.00	76.00	100.00	98.00
piselli	(7.1%)	99.33	100.00	98.67	94.67	100.00	88.00	98.00
pollo ferri	(7.6%)	96.86	97.48	67.30	62.26	76.10	93.71	69.18
scaloppina	(8.6%)	98.90	99.45	99.45	13.81	98.34	97.79	98.90
tortino	(5.7%)	91.67	90.83	79.17	22.50	79.17	83.33	80.00
Standard Accuracy (SA)		**99.05**	99.00	94.33	74.14	95.05	89.57	90.38
Macro Average Accuracy (MAA)		**99.03**	98.61	92.00	69.16	94.11	89.51	87.20

Classification by a k-Nearest Neighbor classifier on patches of 40×40 pixels (best results). 1000 canteen customers acquired. 300 customers for training, 300 for test. Image dataset annotated using the IAT-image annotation tool [2]. Best results obtained with the Color and Edge Directivity Descriptor [3]

Classification accuracy measures:

$$SA = \frac{\sum_{c=1}^{C} TP_c}{\sum_{c=1}^{C} NP_c}; \qquad MAA = \frac{1}{C}\sum_{c=1}^{C} \frac{TP_c}{NP_c}.$$

Leftorver estimation error:

$$r_{ic}^{est} = \frac{\#Patches\ leftover}{\#Patches\ before}.$$

$$Error = \sum_{c=1}^{C} w_c \sum_{i=1}^{I} |r_{ic}^{gt} - r_{ic}^{est}|,$$

Average leftover estimation error: 15% (7% - 34%)

References

[1] Kawano, Y., Yanai, K.: Foodcam: A real-time food recognition system on a smartphone. Multimedia Tools and Applications pp. 1–25 (2014)

[2] Ciocca, G., Napoletano, P., Schettini, R.: Iat-image annotation tool: Manual. arXiv preprint arXiv:1502.05212 (2015)

[3] Chatzichristofis, S.A., Boutalis, Y.S.: Cedd: color and edge directivity descriptor: a compact descriptor for image indexing and retrieval. In: Computer Vision Systems, pp. 312–322. Springer (2008)

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