Technical University of Lodz
Institute of Electronics

Computer Analysis of Food Images
Case Studies

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Workshop on Computer Image Analysis in Bio-sciences, Olsztyn 2014

Visual Inspection and Computer Vision

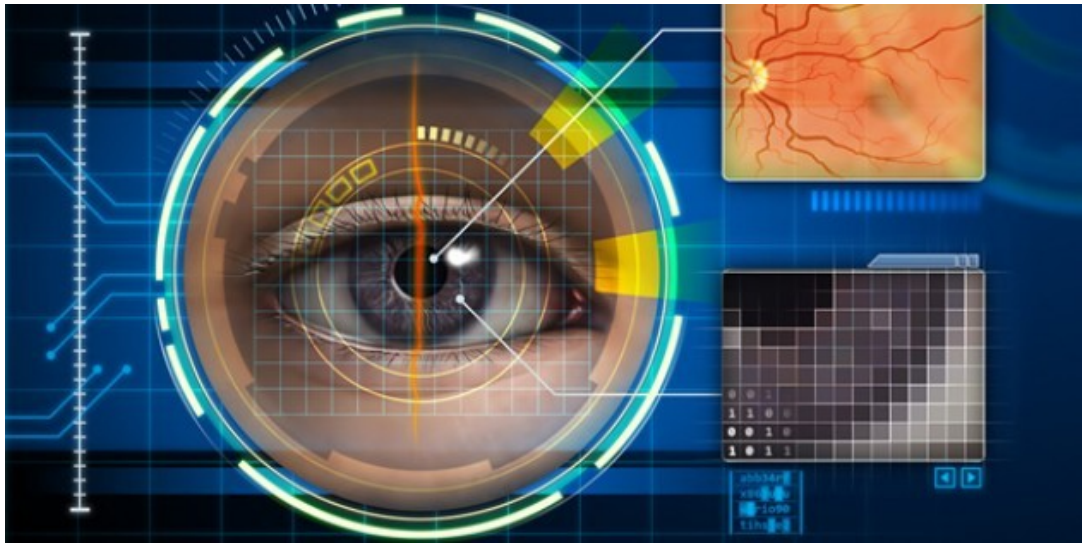
1) Visual inspection is one of the oldest and reliable food quality assessment methods. However, in industrial environment it is labor-expensive.

2) With the development of video and image analysis algorithms the human-expert can be replaced by an automatic expert systems.

3) Consistent methodology for developing such systems is not yet established. Nevertheless each case can be solved individually using unique, tailored algorithms.

blog.fieldid.com

Expectations



www.gunnars.com

- Computer vision can imitate human sense of vision
- Consistent computer vision methodology exists
- Results are objective, reproducible and quantitative
- Results are relyable

Scope of the Presentation

Introduction of image analysis goals in evaluation of agricultural products.

The case studies on:

- assessment of wheat kernel germination ability,
- barley kernel recognition,
- potatoes variety determination,
- analysis of meat product composition.

The methods:

- image segmentation,
- color and texture attributes computation,
- shape characterization,
- machine learning,
- data classification.

www.directindustry.com

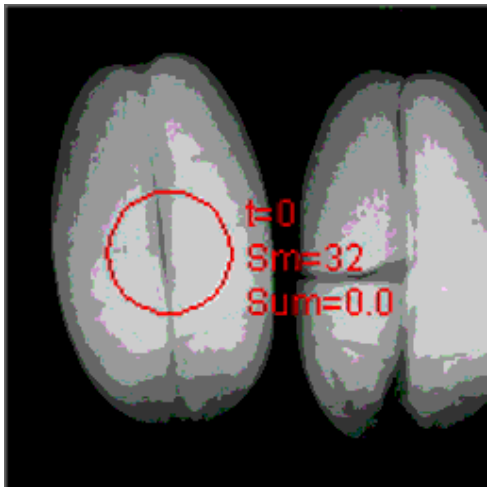
Wheat kernel cracks
Problem and Motivation

- Drying causes internal cracks
- The cracks may influence germination ability
- Location of cracs with respect to the germ is vital
- Assessment of germination ability is economically viable
- Goal to automatically determine germination ability from X-Ray image

Wheat kernel cracks
Region and orientation

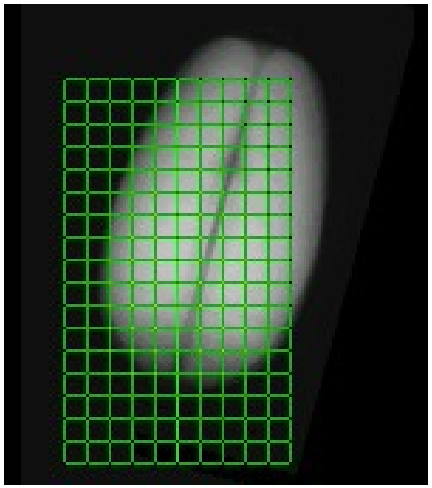
Active contour for region of interest identification

- combines image analysis with a-priori knowledge on the shape of object



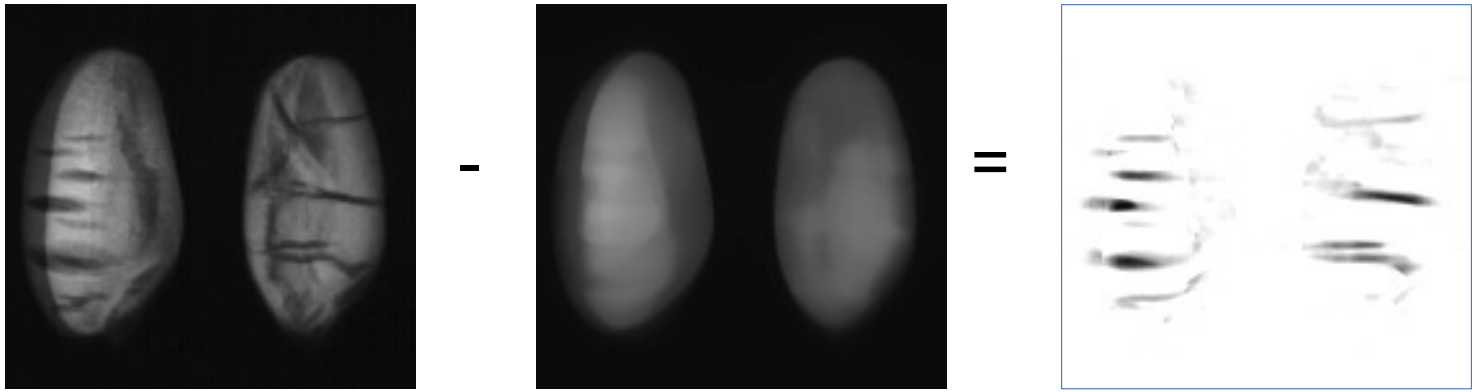
Deformable grid for recognition and orientation determination

- flexible template of model kernel to match image under study
- deformation degree determines similarity between the grid and the image



Wheat kernel cracks
Detection and coefficient

- Top-hat-like transform to expose cracs



original image | median filtered | map of cracks

- Demage coefficient includes:
  - Number and size of cracks
  - Crack distance form the germ

Wheat kernel cracks
Results

- Computer program for automatic assessment of germination ability
- Proven correlation between crack location and germination ability

P. Strumiłło, J. Niewczas, P. Szczypiński, P. Makowski, W. Woźniak, *Computer System for Analysis of X-Ray Images of Wheat Grains*, Int. Agrophysics, 1999, 13, pp. 133-140

Barley kernel quality assessment
Problem and Motivation

- Malting requires barley of uniform size, varietal purity and technological quality
- Quick quality assessment based on visual images from inexpensive flat-bed scanner

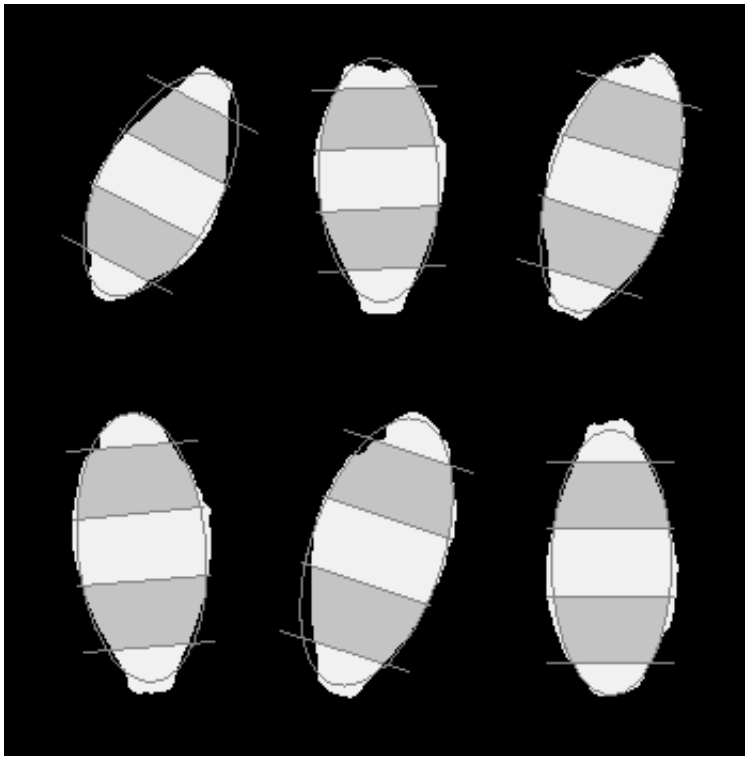
Barley kernel quality assessment
Region identification

- Conversion to monochromatic image – reduces 3D color space problem to 1D
- Gray-scale thresholding segmentation (binarization) to estimate kernel regions
- Morphological opening to remove dust and peninsulas
- Morphological closing to remove cavities

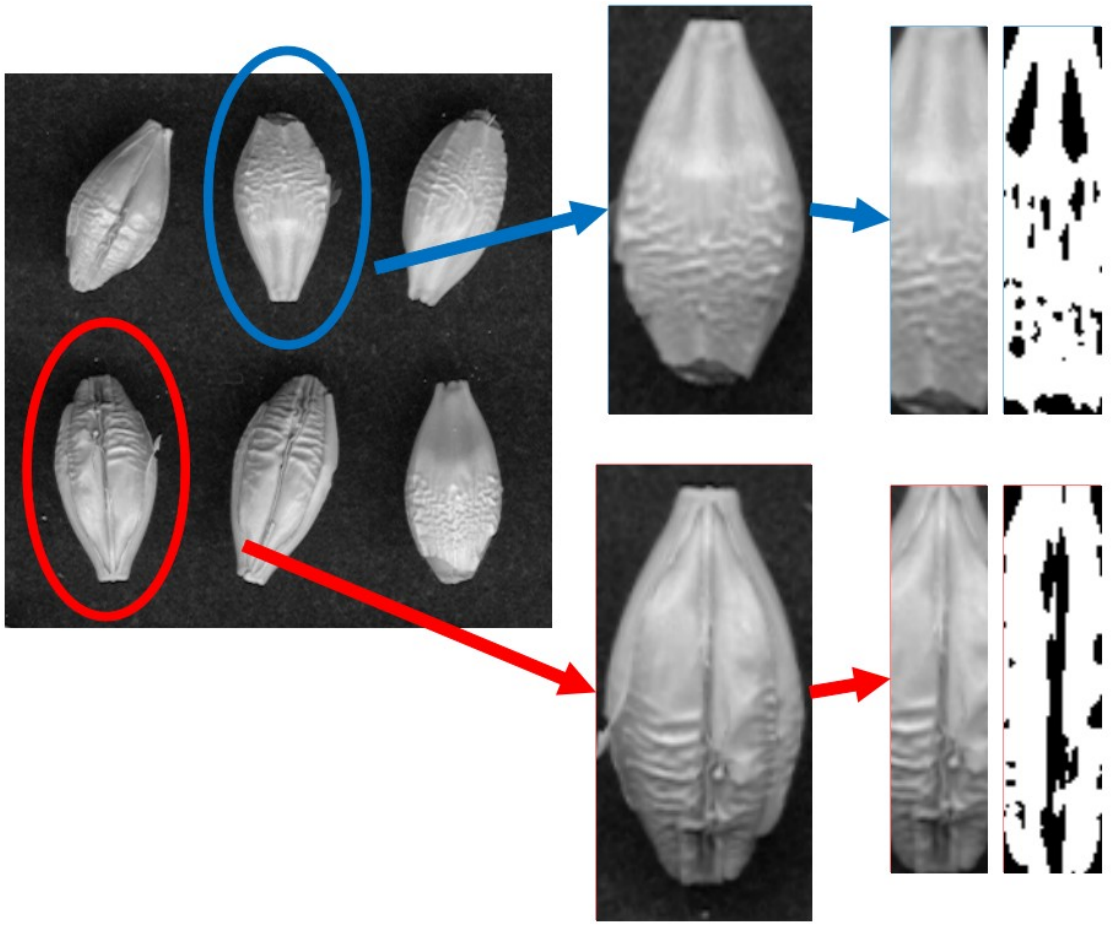
Barley kernel quality assessment
Orientation analysis

- Fitting an ellipse to roughly estimate the region and the symmetry axis of the kernel

- Germ-brush direction is determined – kernel is wider on the germ side



Barley kernel quality assessment
Orientation analysis



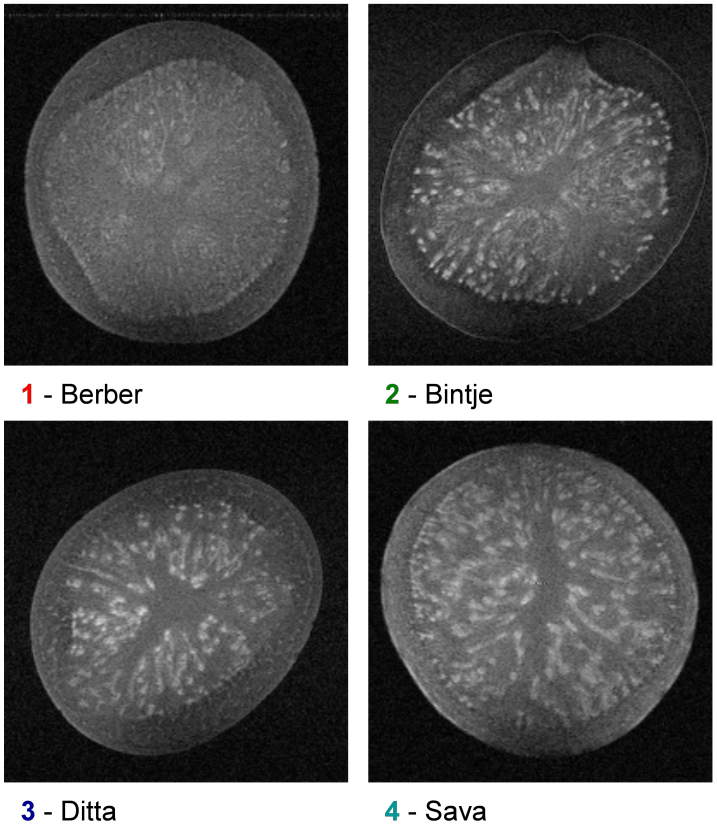
- Image segmentation is applied again to find a crease, and thus dorso-ventral orientation

Barley kernel quality assessment
Results

- Germ-brush orientation correctly determined in 98% of cases
- Dorso-ventral orientation (correct detection of crease): 96.7%.
- Finding individual kernel regions: 99%

Piotr M. Szczypiński, Piotr Zapotoczny,
Computer vision algorithm for barley kernel identification, orientation estimation and surface structure assessment,
Computers and Electronics in Agriculture 87 (2012): 32-38

Potato variety identification
Problem and Motivation



1 - Berber

2 - Bintje

3 - Ditta

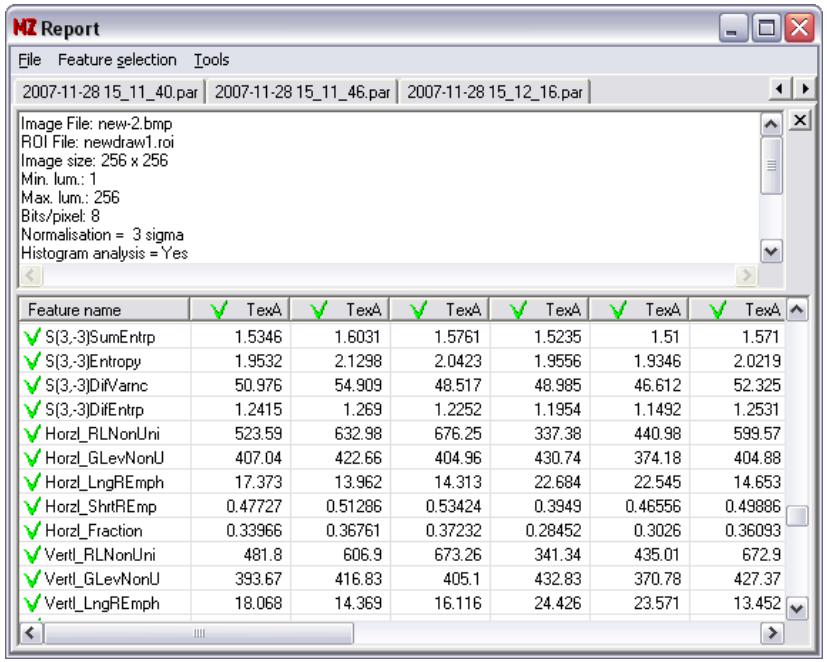
4 - Sava

- Variety classification economically vital
- Magnetic Resonance Imaging expose starch in potato core
- Strch texture differs between potato varieties
- Computer analysis of texture to di-scriminate varieties

Potato variety identification
Texture and texture attributes

A texture perceived by humans is a visualization of complex patterns composed of spatially organized, repeated subpatterns, which have a characteristic, somewhat uniform appearance.

Humans assess texture qualitatively. Quantitative texture analysis requires computation of mathematically defined texture properties (attributes).

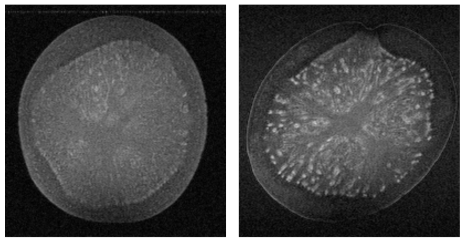


Feature name	TexA	TexA	TexA	TexA	TexA	TexA
S(3,-3)SumEntrp	1.5346	1.6031	1.5761	1.5235	1.51	1.571
S(3,-3)Entropy	1.9532	2.1298	2.0423	1.9556	1.9346	2.0219
S(3,-3)DifVarnc	50.976	54.909	48.517	48.985	46.612	52.325
S(3,-3)DifEntrp	1.2415	1.269	1.2252	1.1954	1.1492	1.2531
Horzl_RLNonUni	523.59	632.98	676.25	337.38	440.98	599.57
Horzl_GLevNonU	407.04	422.66	404.96	430.74	374.18	404.88
Horzl_LngREmph	17.373	13.962	14.313	22.684	22.545	14.653
Horzl_ShrtREmp	0.47727	0.51286	0.53424	0.3949	0.46556	0.49886
Horzl_Fraction	0.33966	0.36761	0.37232	0.28452	0.3026	0.36093
Vertl_RLNonUni	481.8	606.9	673.26	341.34	435.01	672.9
Vertl_GLevNonU	393.67	416.83	405.1	432.83	370.78	427.37
Vertl_LngREmph	18.068	14.369	16.116	24.426	23.571	13.452

Piotr M. Szczypiński, et al.
MaZda—A software package for image texture analysis,
Computer methods and programs in biomedicine 94.1 (2009): 66-76

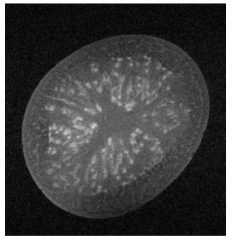
Potato variety identification
Machine Learning

- Searching for attribute vector spaces in which vectors associated with different varieties form separate clusters
- Supervised machine learning finds decision boundaries between vectors of different classes
- Classification use decision boundaries to discriminate attribute vectors computed for new potato images of unknown variety

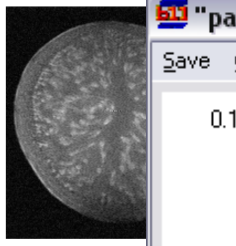


1 - Berber

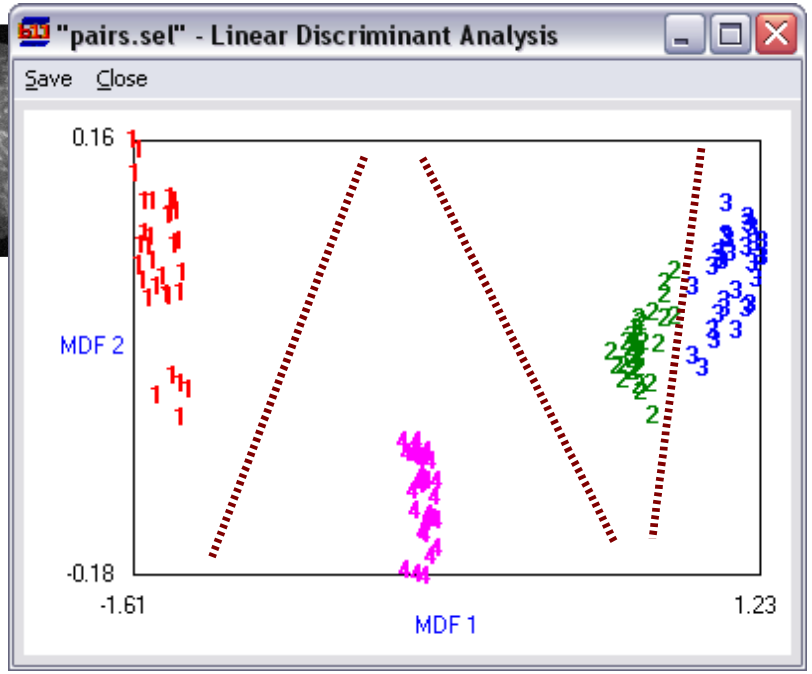
2 - Bintje



3 - Ditta



4 - Sava



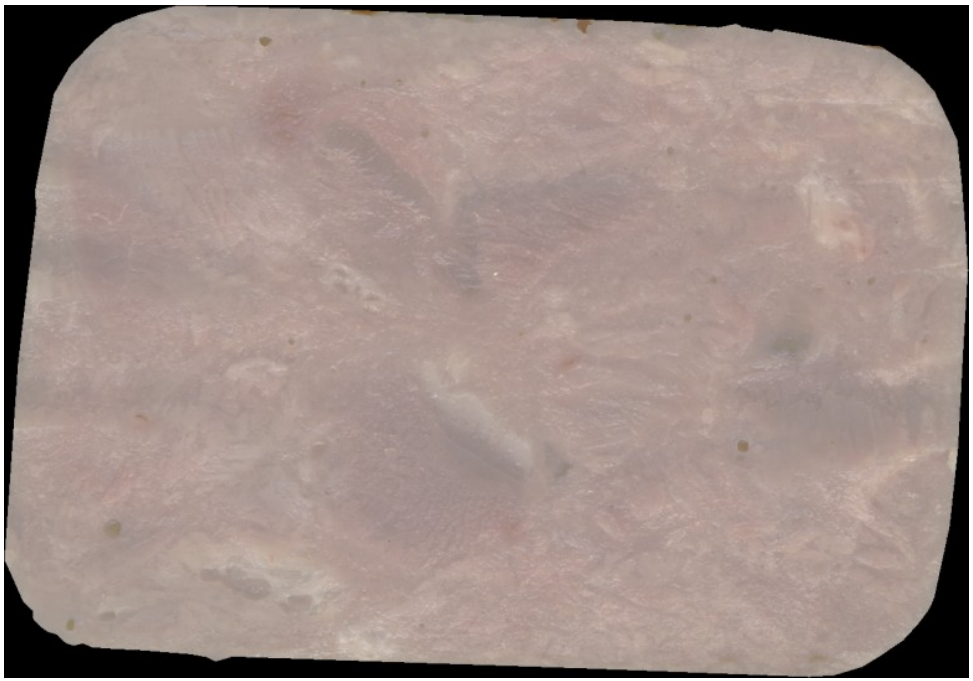
Potato variety identification
Results

- Features extracted using image texture analysis are applicable for determination of potato vairety (four varieties – 92% accuracy)
- Classification of sensory variations is feasible
- MR-imaging gives information about anatomic structures in potatoes

Anette K. Thybo, Piotr M. Szczypinski, Anders H. Karlsson, Sune Donstrup, Hans S. Stodkilde-Jorgensen, Henrik J. Andersen, *Prediction of sensory texture quality attributes of cooked potatoes by NMR-imaging (MRI) of raw potatoes in combination with different image analysis methods*, Journal of Food Engineering, Elsevier 2004, pp. 91-100

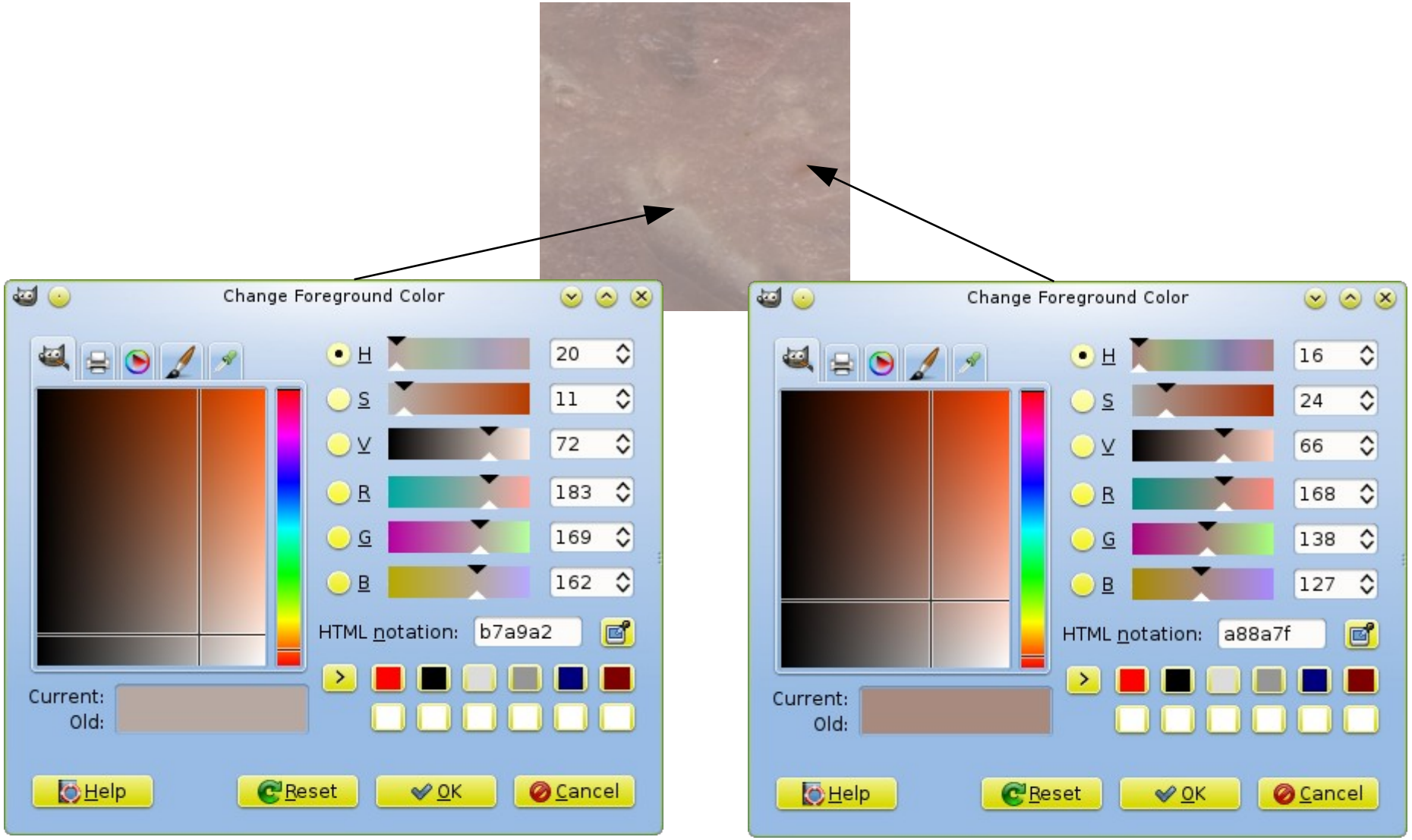
Spam Composition Analysis
Problem and Motivation

- Spam quality control: amount of the components and degree of grinding
- Visual images are easy to acquire
- Regions (segments) related with particualr components are too small to be outlined manualy



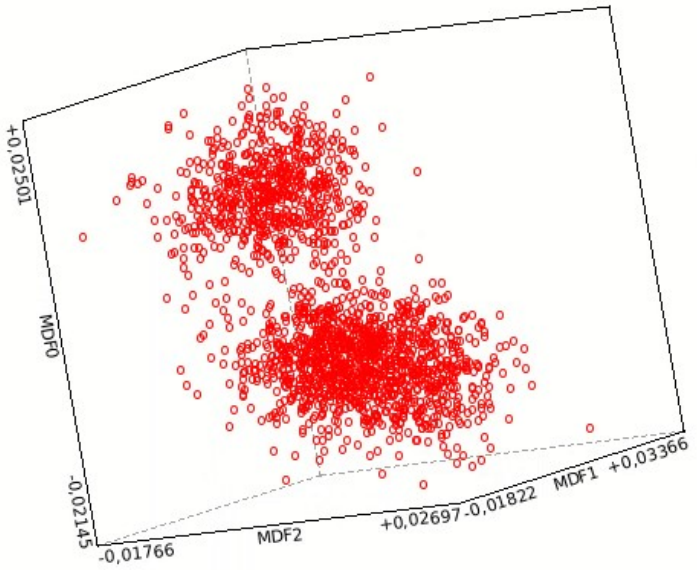
Spam Composition Analysis

Color based segmentation

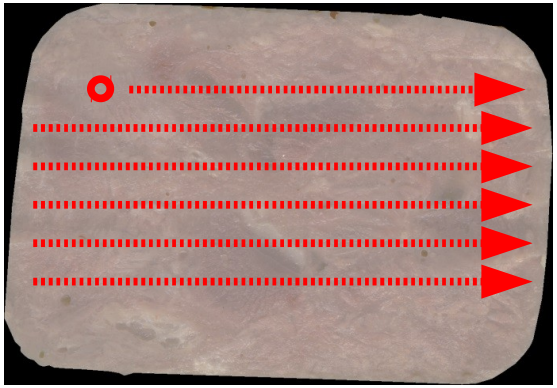


Spam Composition Analysis
Unsupervised learning

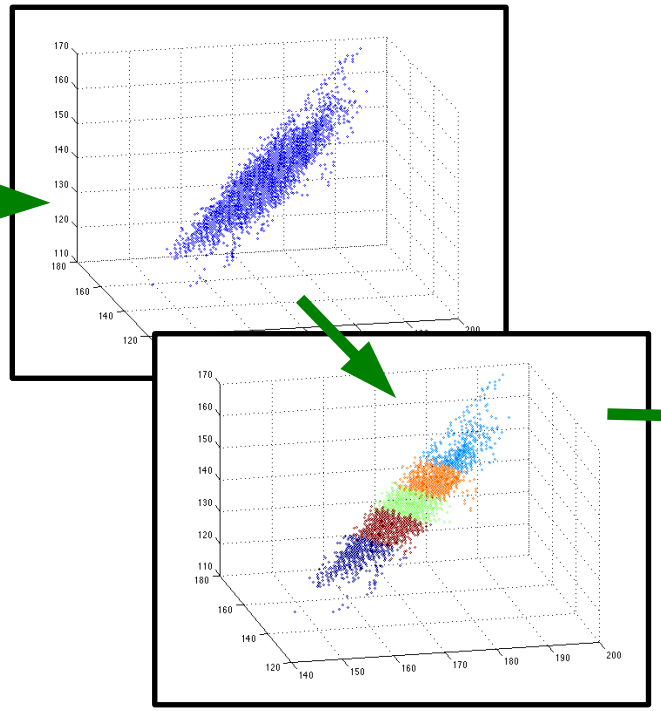
- Searches for possibly separable vector clusters and defines decision boundaries between them.



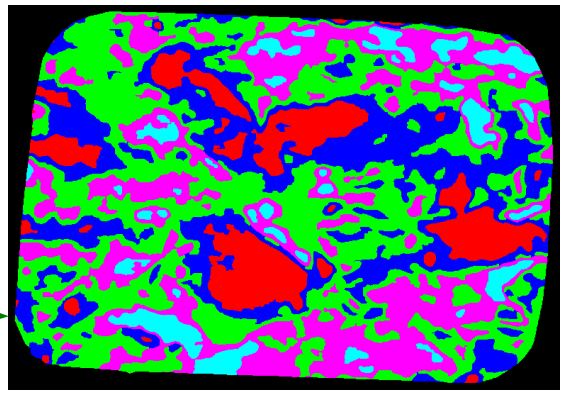
Spam Composition Analysis
Unsupervised learning



Every pixel is assigned color attributes R, G, B, H, S and V components

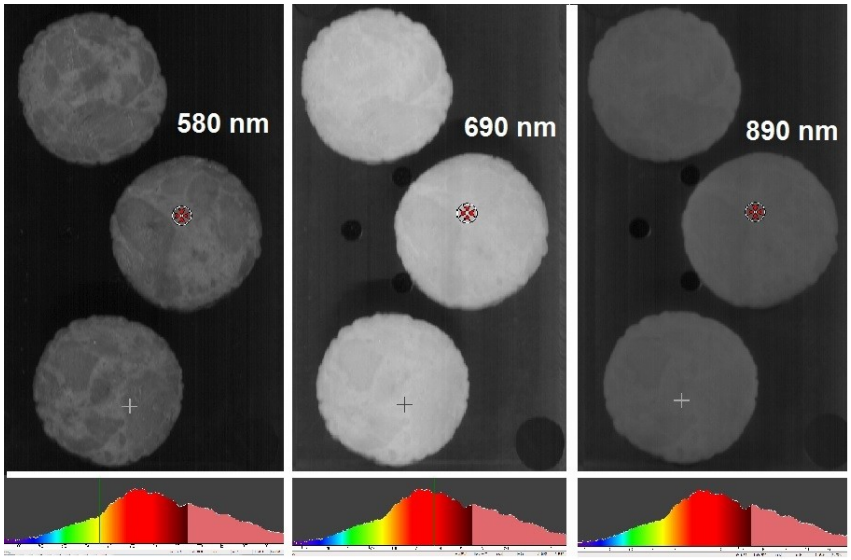


Attribute vectors are clasterized in 6-dimensional space of attributes (for simplicity the plot shows only 3 dimensions)



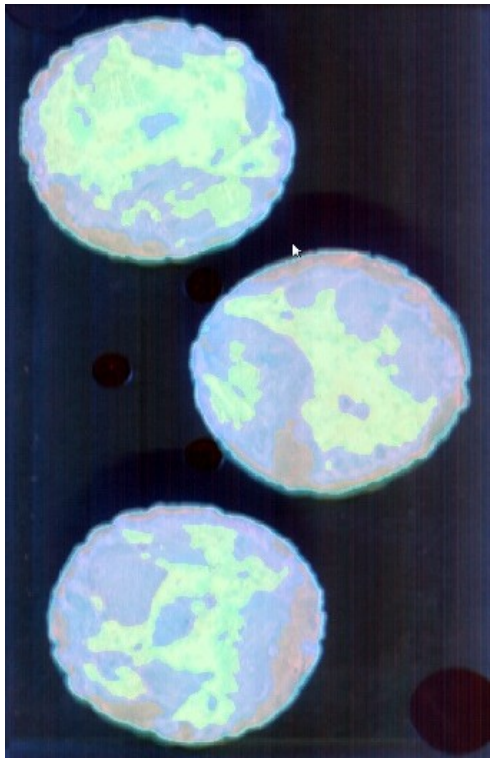
Every pixel is marked accordingly with the cluster it belongs

Spam Composition Analysis
Pseudo RGB



Future studies with hyperspectral imaging

Pseudo RGB image



Segmentation preliminary results are encouraging

Spam Composition Analysis
Results

- Quantitative assessment of the components
- Evaluation of grinding degree based on the size and shape of the segments

Conclusions

- Computer vision can imitate human sense of vision to some extent. Understanding of image content is beond capabilities of such methods.
- Consistent computer vision methodology does not exist. Every problem is solved individually with different problem-tilored algorithms.
- Results are objective, reproducible and quantitative. However relayability is not guarateed.