Colour and spectral image processing for measurement and recognition of complex objects

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Outline

1 Problem outline

2 Colour-based detection of defects on hazel nuts

3 Colour information for the optical characterization of galvanic grinding tools

4 Colour, texture and spectral information for recognition of mineral aggregates

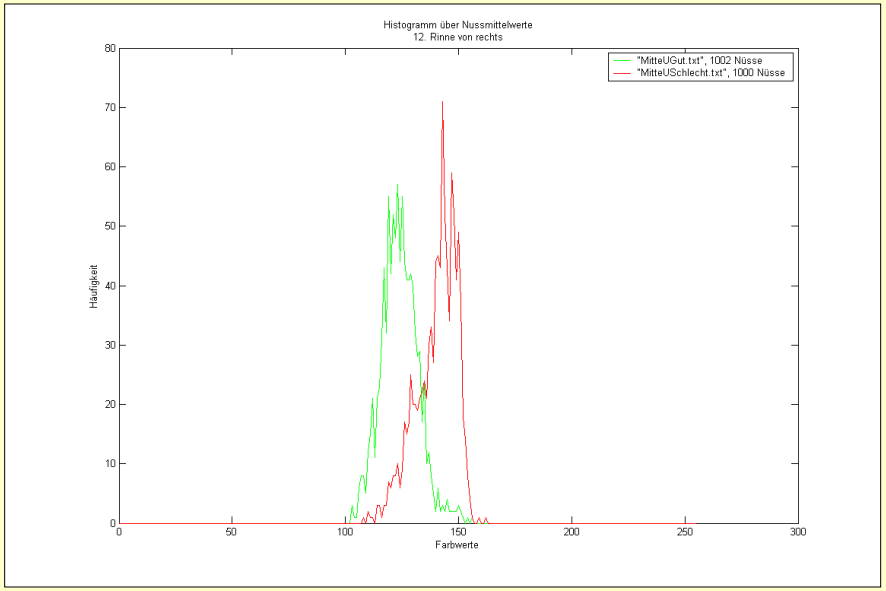
Problem outline

- complex objects with a high range of variation need many features for recognition
- shape and intensity is often not sufficient
- colour and texture need to be analyzed
- specific chemical characteristics can be captured by spectral features
- hyperspectral sensors, InGaAs-cameras and miniaturized spectrometers became available for many applications in research and industry
- support vector machines and artificial neural networks can solve complex recognition problems

=> **Colour and texture features from spectral images can enhance the results of complex recognition and measurement tasks or even make it possible to solve it.**

Colour-based detection of defects on hazel nuts

- Detection of putridity and insect damage on hazel nuts for optical realtime sorting
- colour features (histogram, colour statistics in the YUV-colorspace) as input features for an artificial neural network
- **Problem**: high speed of the conveyer belt (3 m/s)



Colour-based detection of defects on hazel nuts

- Detection of putridity and insect damages on hazel nuts for optical realtime sorting
- colour features (histogram, colour statistics in the YUV-colorspace) as input features for an artificlia neural network
- **Problem**: high speed of the conveyer belt (3 m/s) and slow feature extraction

Good **Poor**

red channel

green channel

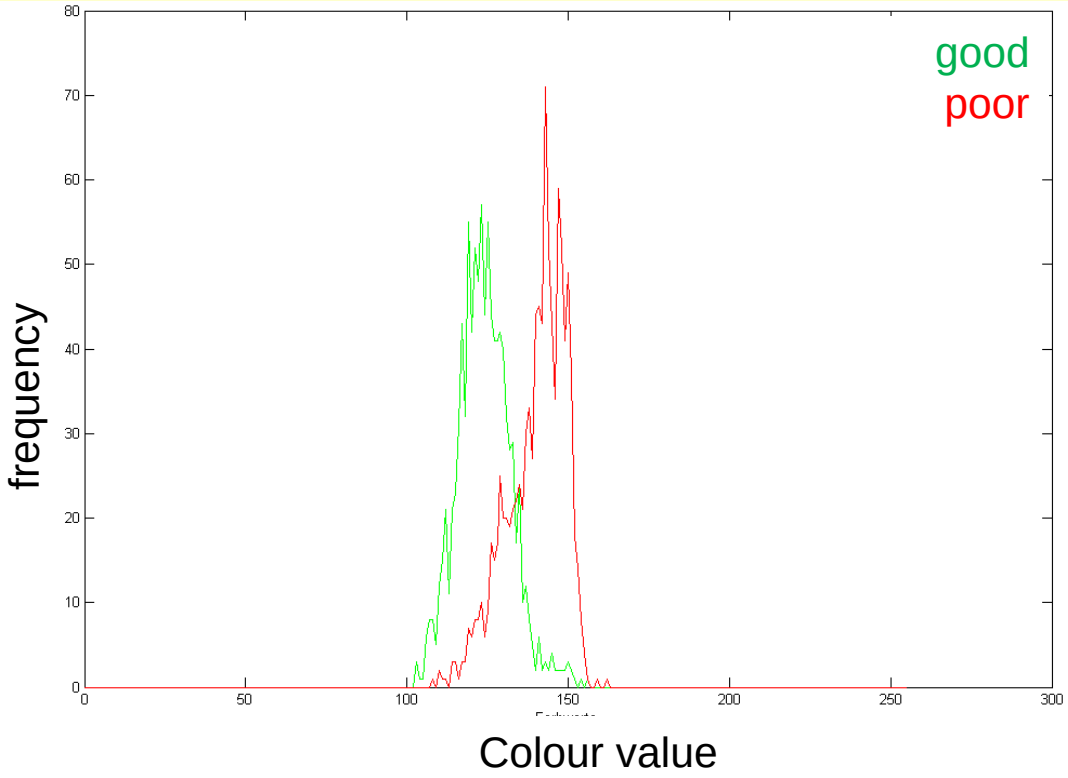
blue channel

Advantages of the YUV-colour-space
- realtime compression by colour subsampling
- chrominance red and blue mapped intensity independent to U- and V-channel

Source of images: Helms Technologie GmbH, Dr. Dirk Helms, info@helms-technologie.de

Colour-based detection of defects on hazel nuts

Histogram-based real-time detection by thresholding operation

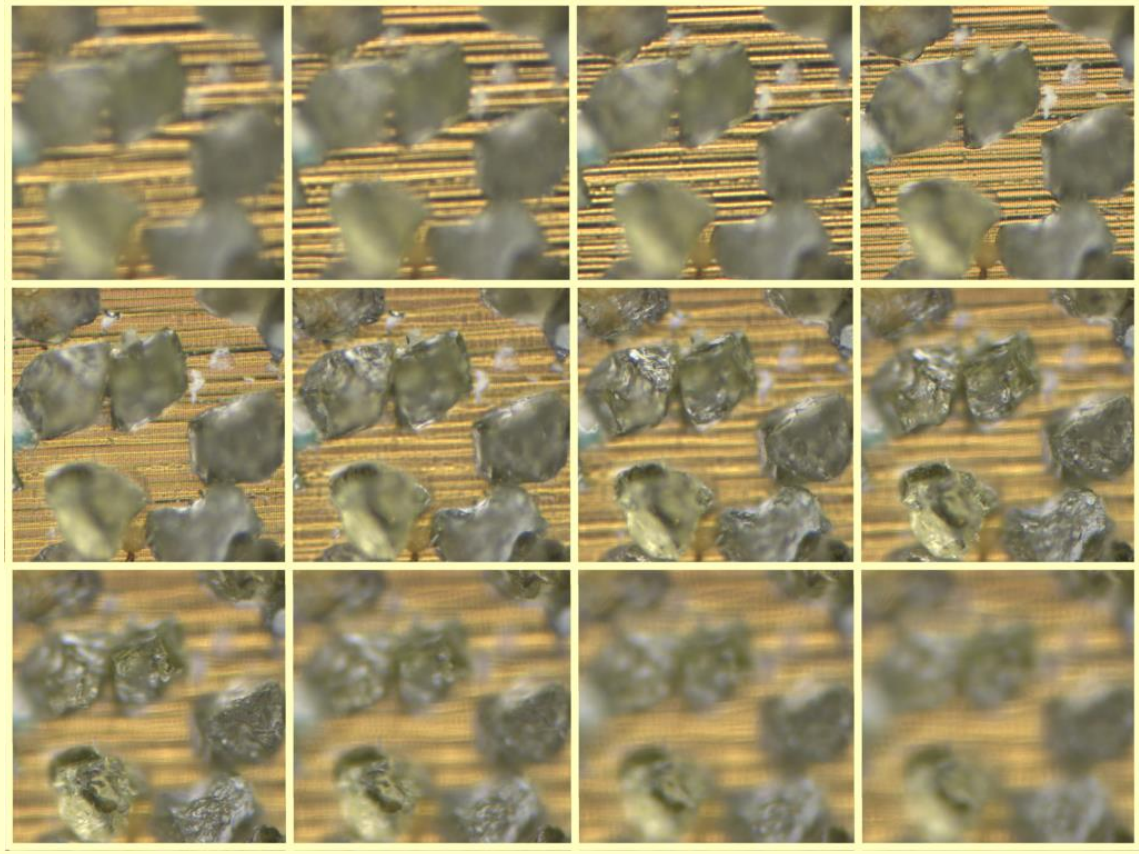


Thresholds on U- and V-channel estimated from nearly 1000 sample objects for good and poor nuts

Results: - nearly 100% true-positive rate and 2% false-positive rate
- real-time capability to enable online detection and pneumatic rejection of poor hazelnuts

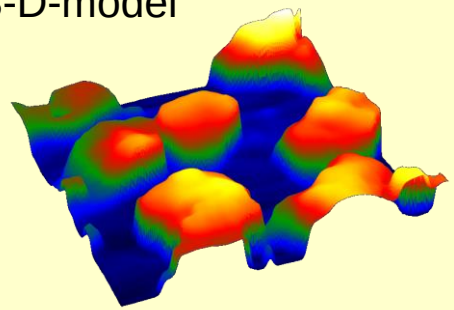
Colour information for the optical characterization of galvanic grinding tools

Shape-from-Focus with colour information for characterization of grinding tools



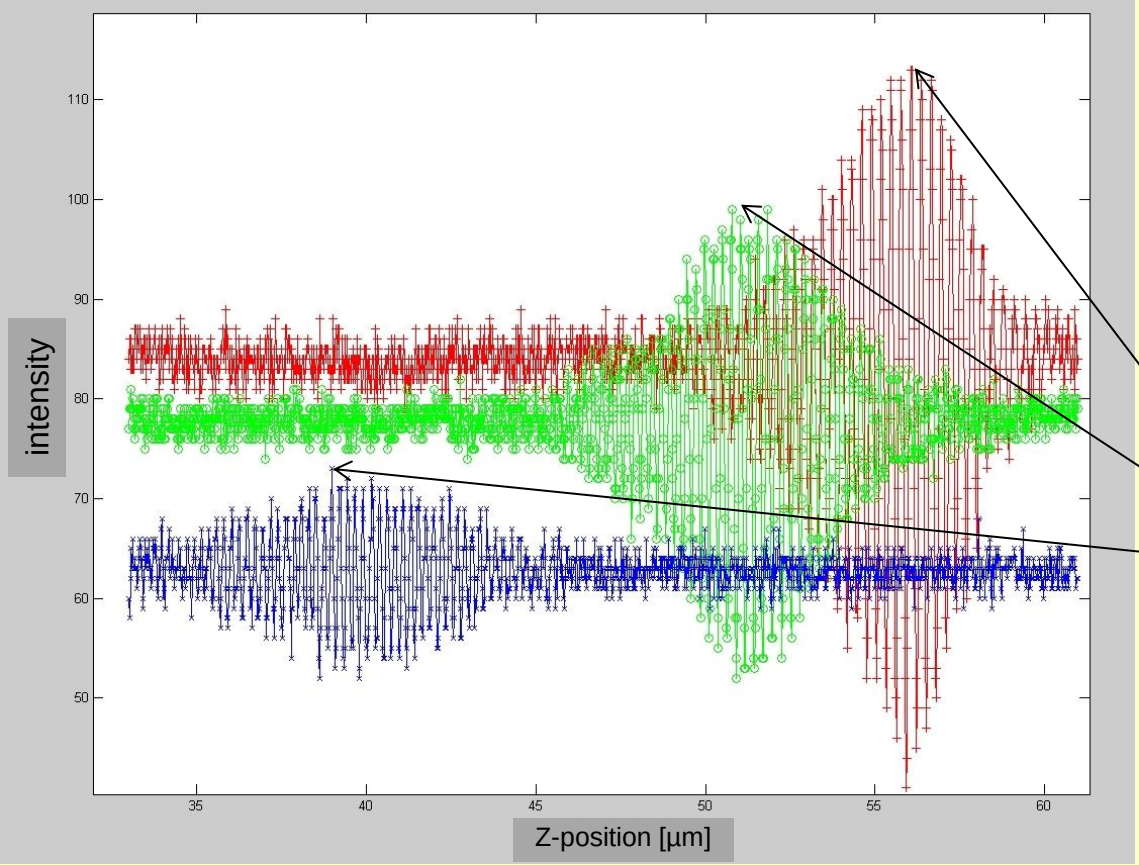
System OMG3

3-D-model



Colour information for the optical characterization of galvanic grinding tools

Enhancing the precision of white light interferometry by using colour information



Getting three interferograms instead of one

⇒ more stable results

⇒ less sensitive to noise

⇒ can handle a broad range of surfaces with different reflectance characteristics

Phase shift depends only on MTF of the optical system and is equal for every pixel

Maxima of convec hull determines Z-position

Quelle: J. Klemm, H.-W. Lahmann Verfahren zum Erfassen eines Oberflächenprofils, Patentschrift DE102007054734B4

Colour and texture for recognition of mineral aggregates

Recognition process overview

Image acquisition & single kernel selection

Step 1

Dataset preparation

Train Dataset
- object class Quarz
- ⋮
- object class Flint

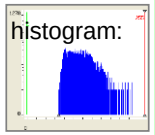
Test Dataset
- object class Quarz
- ⋮
- object class Flint

Step 2

Feature extraction (object properties)

area = 2343
circularity = 0,6629
contrast = 15,3534
compactness = 1,1741
…

histogram:



Issue: feature vector MV = [..]

Step 3

Training of the classification algorithm

- Creation of classification algorithm structure
- Training of the classification algorithm by using the train dataset

Step 4

Testing of the classification algorithm

- Testing of the classification algorithm using the test dataset

Aim: Recognition of **unseen** objects from learned object classes

Step 5

Identification of the classification algorithm perfomance

- Identification of recognition and error rates on test dataset

Step 6

Results with svm-classifier

	recognition rate per group[%]	total recognition rate [%]
Group 1	91,1	88,1
Group 2	71,3	
Group 3	83,0	
Group 4	86,2	

Results with nearly 200 colour and texture features are promising

What are the relevant spectral bands for further enhancement?

Quelle: Anding et al.: Automatic Petrographic Inspection by Using Image Processing and Machine Learning. XX IMEKO World Congress Metrology for Green Growth, Busan, Republic of Korea, September 9−14, 2012

Spectral Information for recognition of mineral aggregates

- capturing of very similar objects of different classes with a filter wheel camera with 11 different wavelength filters
- Investigation of colour and texture features on the different spectral bands with Fisher-Score* => Conclusion about the relevance of specific spectral bands

wavelength sorted by relevance (ascending)	
wavelength[nm]	mean F-Score
905	0.187
940	0.192
694	0.199
650	0.212
766	0.225
800	0.230
600	0.252
852	0.271
550	0.324
450	0.383
500	0.416

$$^{*}F = \frac{Intra - Class - Variance}{Inter - Class - Variance}$$

Sample objects

Conclusion

- Colour and texture information is essential for measurement and recognition tasks with highly variable objects
- spectral information can enhance the results gained with conventional colour images
- InGaAs-cameras without extra cooling make applications practical
- miniaturized spectrometers allow field applications in research and industry
- LEDs with specific spectral characteristics provide a stable illumination
- multivariate statistics, support-vector-machines and artificial neural networks make an evaluation of spectral data possible

Thank you for your attention!

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