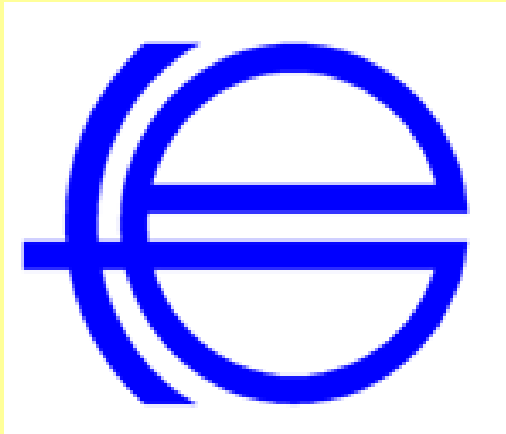


Colour and spectral image processing for measurement and recognition of complex objects

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- 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**

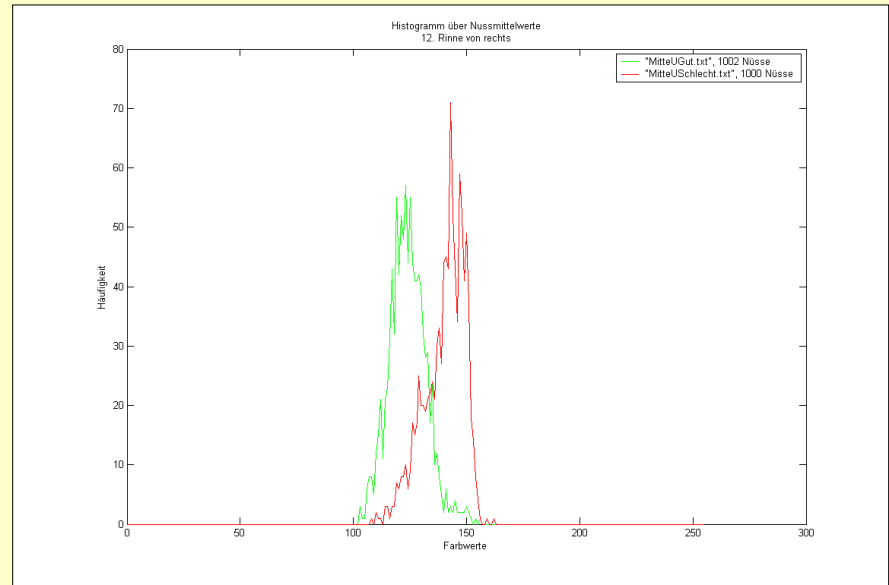


- complex objects with a high range of variation need many features for recognition
 - shape and intensity is often not sufficient
 - colour and texture need to be analyzed
 - specific chemical characteristics can be captured by spectral features
 - hyperspectral sensors, InGaAs-cameras and miniaturized 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-colourspace) as input features for an artificial neural network
- **Problem:** high speed of the conveyor belt (3 m/s) and slow feature extraction



Good

Poor

Advantages of the YUV-colour-space

- realtime compression by colour subsampling
- chrominance red and blue mapped intensity independent to U- and V-channel



**red
channel**



**green
channel**

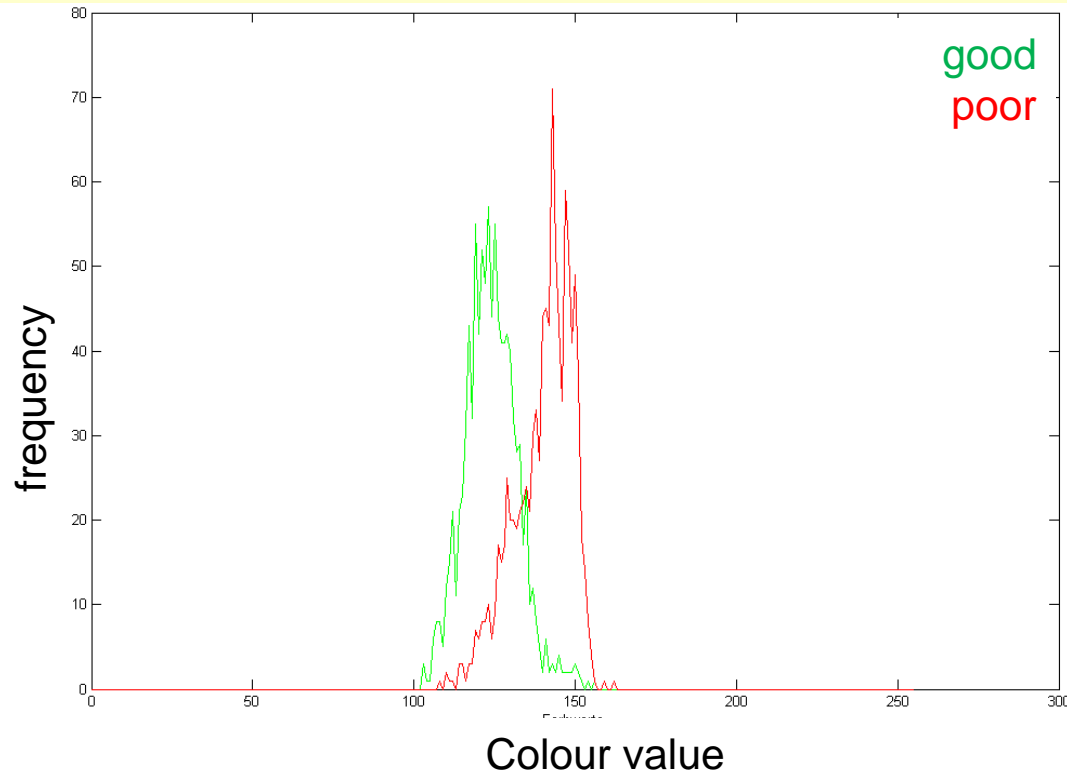


**blue
channel**

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

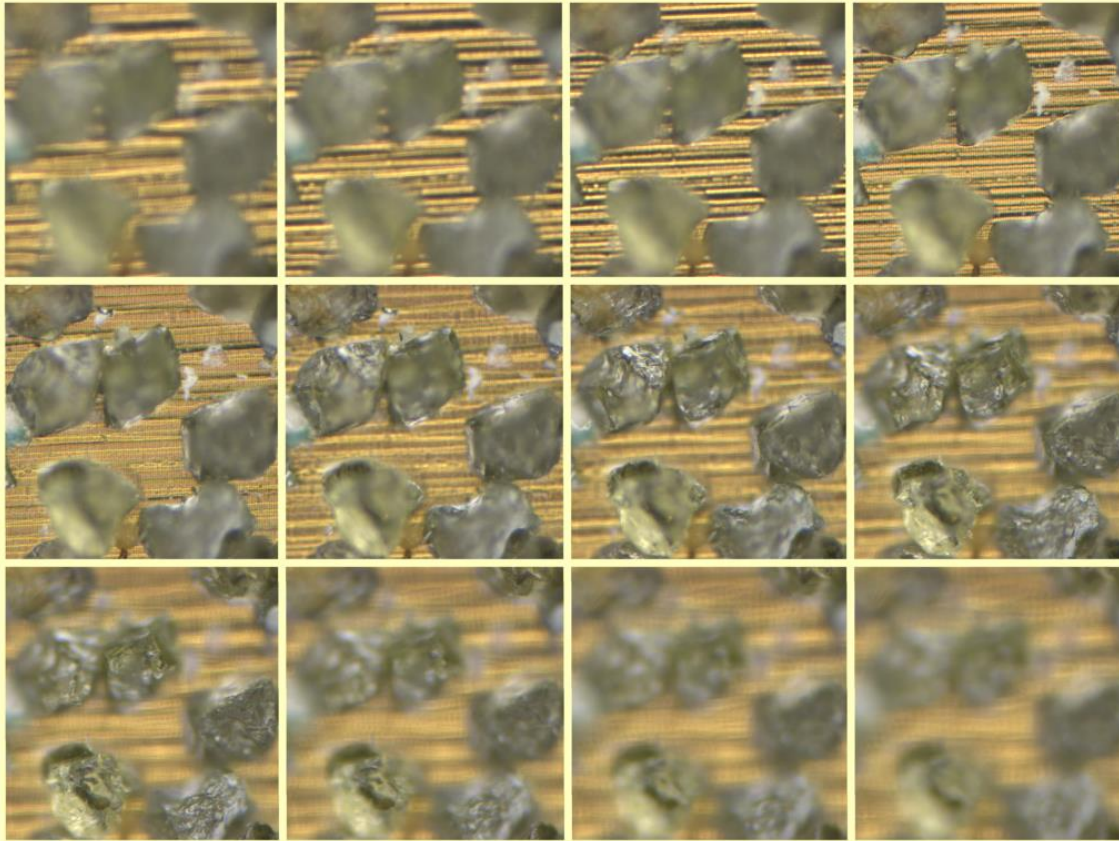


Thresholds on U- and V-channel estimated from nearly 1000 sample objects for good and poor nuts

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

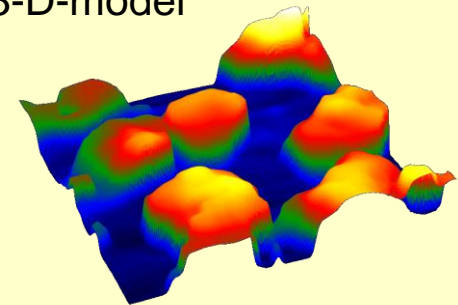
Shape-from-Focus with colour information for characterization of grinding tools



System OMG3

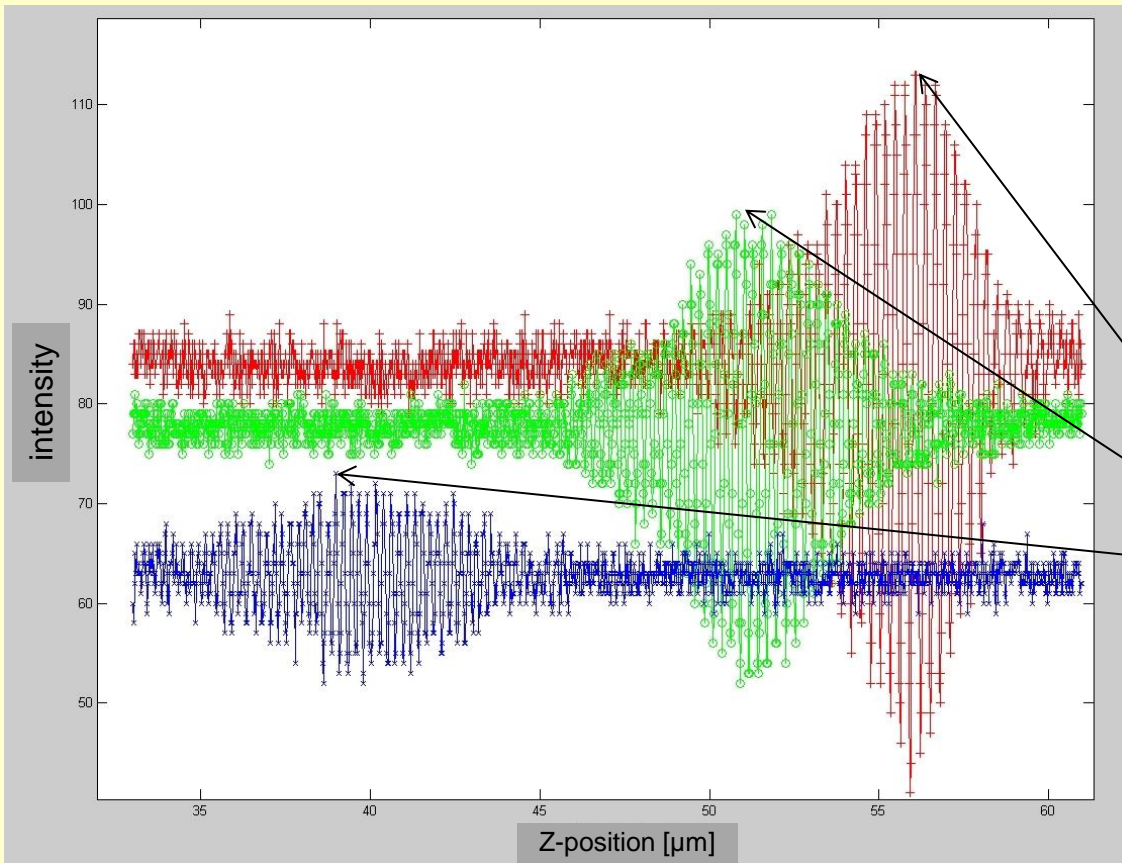


3-D-model



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

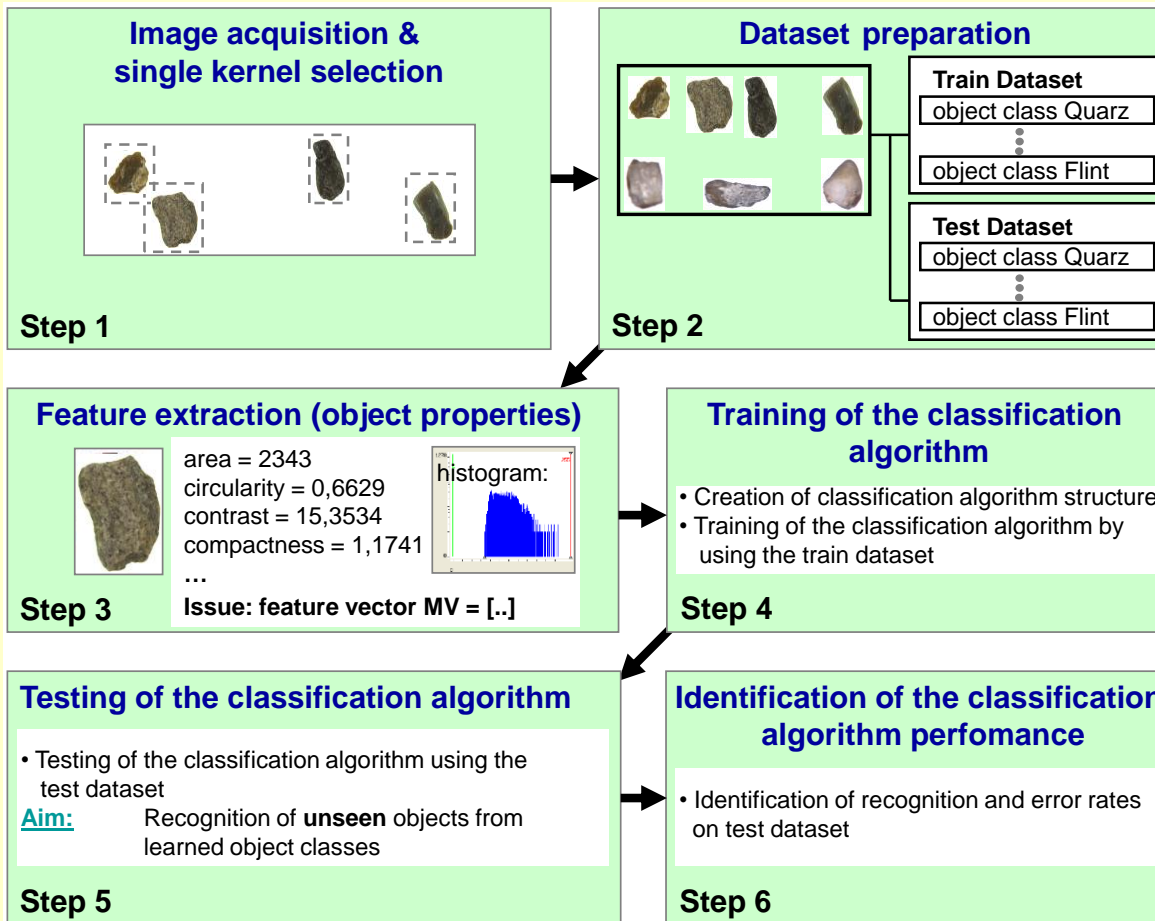
Phase shift depends only on MTF of the optical system and is equal for every pixel

Maxima of convex 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



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

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

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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