Automated Classification of Natural Aggregates

Using Hyperspectral Imaging in Concrete Production

Authors: Patrick Hunhold[1], Elske Linß[1], Katharina Anding[2], Galina Polte[2], Daniel Garten[3], Sandro Weisheit[1]

[1] Materialforschungs- und Prüfanstalt at the Bauhaus-University of Weimar – Research Team Sensor Technology for Products and Processes , Coudraystr. 9, 99423 Weimar, Germany
[2] Ilmenau University of Technology, Faculty of Mechanical Engineering, Group for Quality Assurance and Industrial Image Processing, Gustav-Kirchhoff-Platz 2, 98693 Ilmenau, Germany
[3] GFE Schmalkalden e.V., Näherstiller Straße 10, 98574 Schmalkalden, Germany

Motivation & Objectives

- Large number of structural damages are caused by the use of constituents in natural aggregates,
- Damage pattern of alkali-silica reaction (ASR) can caused by alkali-silica reactive aggregates [1],
- Other aggregate components can affect performance properties, durability and visual aspects negativly.

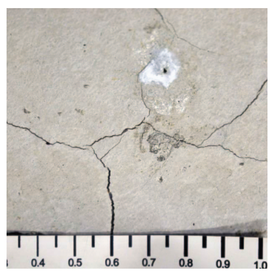

Fig. 1: Crack and gel formation after ASR [o. i.]

- Use spectral / chemical information as additional features,
- Improve recognition rate (RR) in classification by combining spatial and spectral features.

➡ Extend lifespan of products and use resources more efficiently.

Material

- Different aggregates for concrete production,
- Classified by designated geologist / mineralogist,
- Categorized in „non-critical", „critical 1" and „critical 2".

Fig. 2: Case containing some samples of different aggregates [o. i.]

Table 1: Categories and their critical properties.

Category	Critical Properties
Non-critical	None
Critical 1	Water-absorbent, swellable inorganic and alkali-reactive
Critical 2	Organic compounds, ferrous compounds, contains sulphur / sulphate, construction and demolition waste

Methods & Results

1. Data Acquisition & Preprocessing

- Categorized and labeled data,
- Captured images using a line scan camera,
- White balanced / baseline corrected images,
- Normalized images,
- Segmented objects.

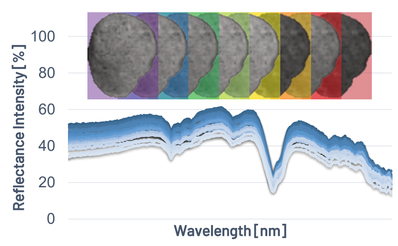

Fig. 3: Spatial and spectral characteristics [o. i.]

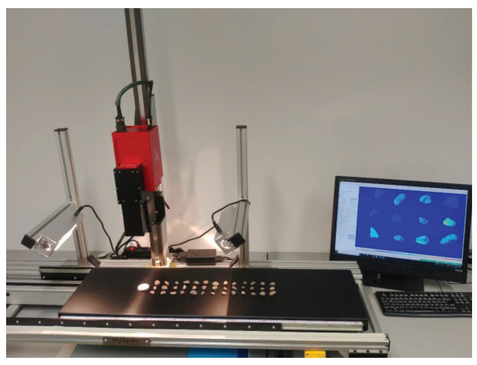

Fig. 4: Hyperspectral working bench [o. i.]

2. Feature Engineering

- Extracted / selected class specific features:
  - Color,
  - Texture,
  - Spectral information,
- Reduced high amount of data (dimensionality reduction) using:
  - Principal Component Analysis (PCA) and
  - Linear Discriminant Analysis (LDA),
- Generated false color representations of the samples.

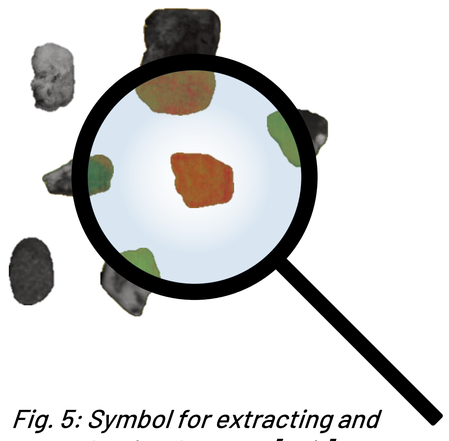

Fig. 5: Symbol for extracting and selecting features [o. i.]

3. Classifier Training and Validation

- Chose pretrained Deep Neural Networks (DNNs) like ResNet-50,
- Trained DNNs on own dataset,
- Adapted hyperparameters,
- Retrained last layers of the feature extractor of the DNNs (finetuning)

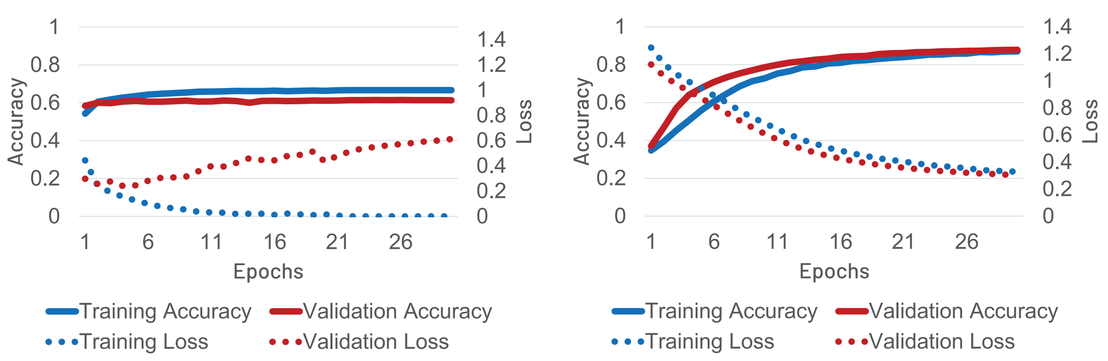

Fig. 6: Training and validation of a: left) pretrained and right) finetuned DNN, here ResNet-50 [o. i.]

4. Classifier Testing

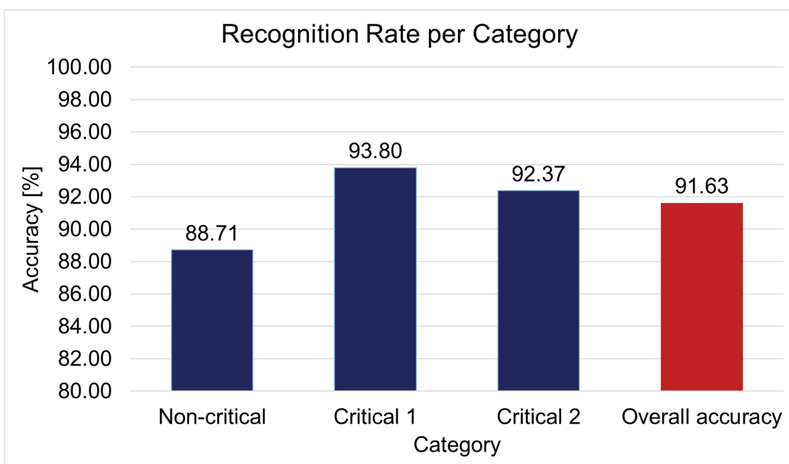

Fig. 7: Results classification on test dataset [o. i.]

Conclusion & Outlook

- Hyperspectral imaging is suitable for classify natural aggregates by means of their damage potential,
- Necessary to reduce the high amount of data to fewer significant features to increase the separability of each category,
- Accuracy of pretrained DNNs can be improved by retraining specific layers of the classifier (finetuning),

- Further improvement of RR in classification by improving every step in the image processing chain beginning from ilumination over object segmentation to calculation of additional features and using other classifiers.

Partners

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GFE – Gesellschaft für Fertigungstechnik und Entwicklung Schmalkalden e.V.

Steinbeis Qualitätssicherung und Bildverarbeitung GmbH

Mitteldeutsche Baustoffe GmbH

HABAU

References

[o. i.] Own illustration
[1] Ludwig, H.-M.: FUTURUM – Baustoff Straßenbeton. Forschungskolloquium „Betonstraßenbau", 2014
[2] Hunhold, P.: „Analyse der spektralen Charakteristik ausgewählter Gesteinsklassen für die effiziente automatisierte Klassifikation", Masterarbeit 2021

Materialforschungs- und -prüfanstalt
an der Bauhaus-Universität Weimar
Coudraystraße 9
99423 Weimar

Ansprechpartner:
M. Sc. Patrick Hunhold
Telefon: +49 (3643) 564-165
E-Mail: patrick.hunhold@mfpa.de

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Bundesministerium für Bildung und Forschung