STUDY OF OPTIMIZATION METHODS IN THE TASK OF SEGMENTATION AND DEFECT DETECTION IN STRUCTURAL MATERIALS

T. BAVSHIN, A. SUKHOV, E. KHITROV

National Research University ITMO

Technological Problem

Ensuring quality of construction materials is a critical aspect of modern construction and green building technologies which requires development of advanced quality control and monitoring methods.

Goals of the study

- Conducting foundational tests to support advanced experiments with artificial neural networks (ANN) in image processing.
- Expanding empirical knowledge on the performance and convergence of numerical optimization methods.
- Collecting data critical for the future development of a quality control system for wooden construction, leveraging computer vision tools.

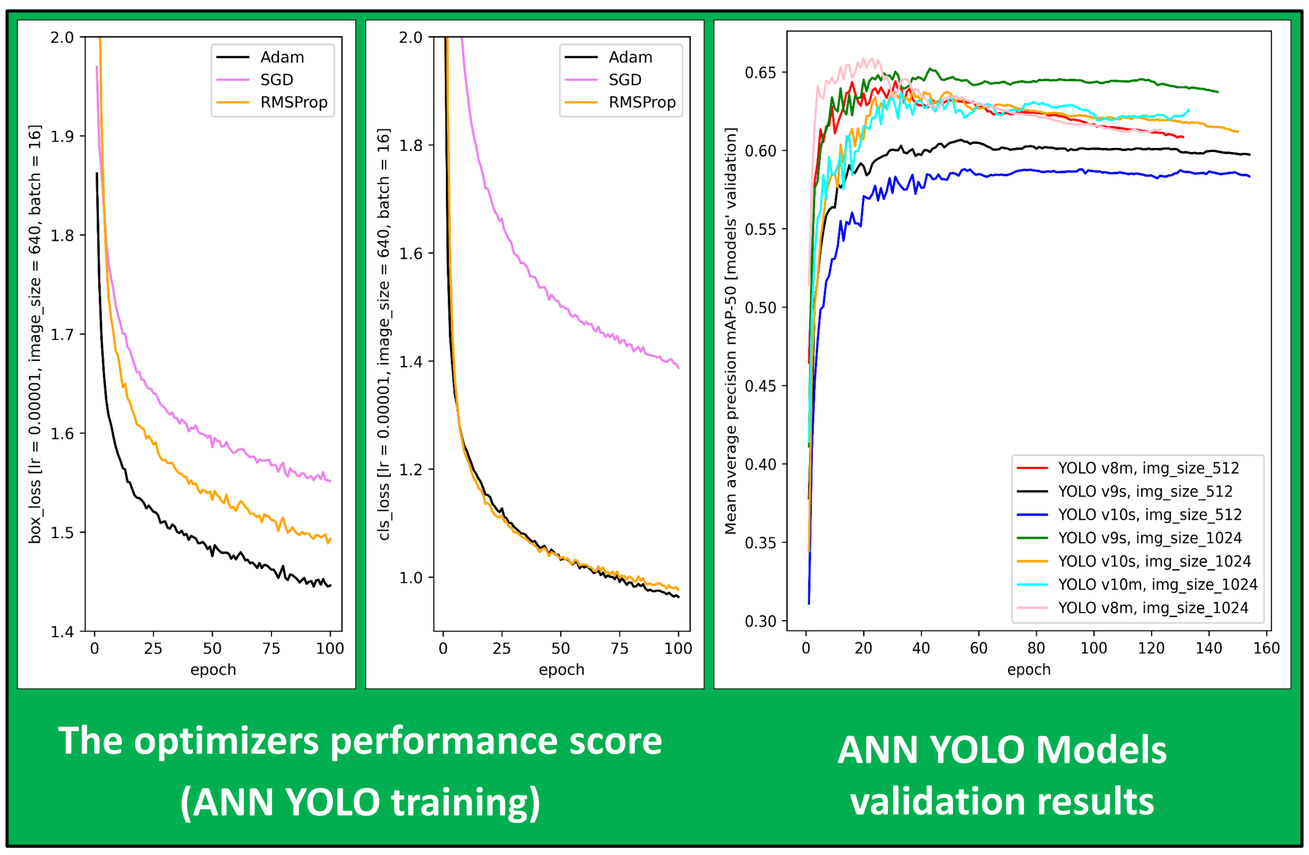
Experimental data and study design

The study uses an open-access dataset "A large-scale image dataset of wood surface defects for automated vision-based quality control processes" including over 20 000 high-scaled digital images of wood surface with 10 common types of defects, e.g. knots, cracks, marrow etc.

The experiments focus on training ANN YOLOv8-, v9-, v10-based models for the defects recognition.

The study scores SGD, RMSProp and Adam optimizers convergence and performance along loss-functions minimization. The optimizers' tuning include grid-search for the learning rate and batch size.

Pilot Research Results



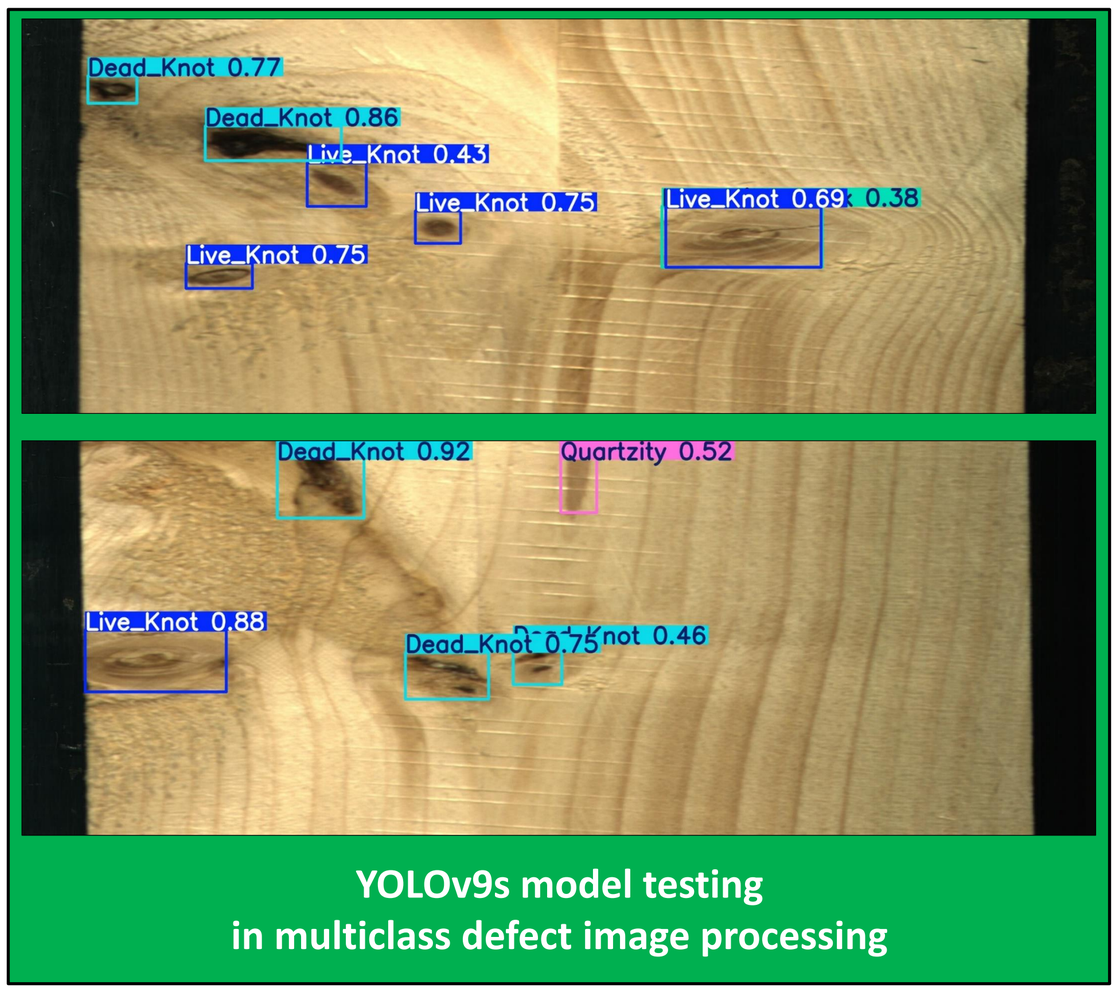
The optimizers performance score (ANN YOLO training)

ANN YOLO Models validation results

- Test performance in wood defect recognition reached with ANN YOLO models trained and scored on the big sets is sufficient and comparable to the results achieved with YOLO modifications when training on smaller single-defect datasets.
- Adam method demonstrates the best results for minimization of box_loss (segmentation quality metric) and cls_loss (defects classification accuracy metric) functions. RMSProp method shows decent results for the cls_loss function but appears less accurate in minimizing the box_loss function. In the experiment, the SGD method proved to be the least effective.

Future Perspectives

- Further wood surface data collection promises more detailed and precise results.
- Given the sensitivity of the minimization methods to hyperparameter tuning, further experiments should be conducted to tune these parameters, which is necessary for forming a more comprehensive and systematic understanding of the effectiveness of numerical minimization methods in solving deep learning tasks.
- One of the key steps should include studies which trend to describe the loss functions' mathematical specifics, which is supposed to be solved basing on a more detailed methods' convergence testing.
- Additionally, there are plans to develop a custom modification of ANN YOLO models and tuned optimization methods for integration into an automated wood quality inspection system.



YOLOv9s model testing in multiclass defect image processing

AI Autumn School