Automated Classification of Building Defects Using Machine Learning Techniques

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Introduction

- Housing corporations must maintain houses in good condition, including intact window casings and roofs for the houses to be habitable.
- Current full inspections conducted by professionals are costly and time-intensive
- Drones can be used to collect data about building and help automation.
- Using Deep Learning, the drone images can be classified good or defected which can help reduce the manual labor and provide accurate and consistent results.

Materials and Methods

- In this research 2 datasets are used: Window casings and Tiled roofs.
- The data is extracted based on the expert's annotations and preprocessed by cropping the desired annotation and removing everything in the crop that is not part of the classes of interest.
- Manual data cleaning is applied to increase the quality of the datasets.
- Augmentation is applied to deal with class imbalance for the window casing dataset

Abstract

We propose an automated classification approach using CNNs to detect and classify building components. Aerial images are analyzed, focusing on window casings and roof tiles. Models like VGG11 and ResNet50 demonstrate outstanding performance, showcasing the potential of deep learning in defect identification. This research contributes to automating building inspections, providing an efficient solution for real-world scenarios.

Materials and Methods

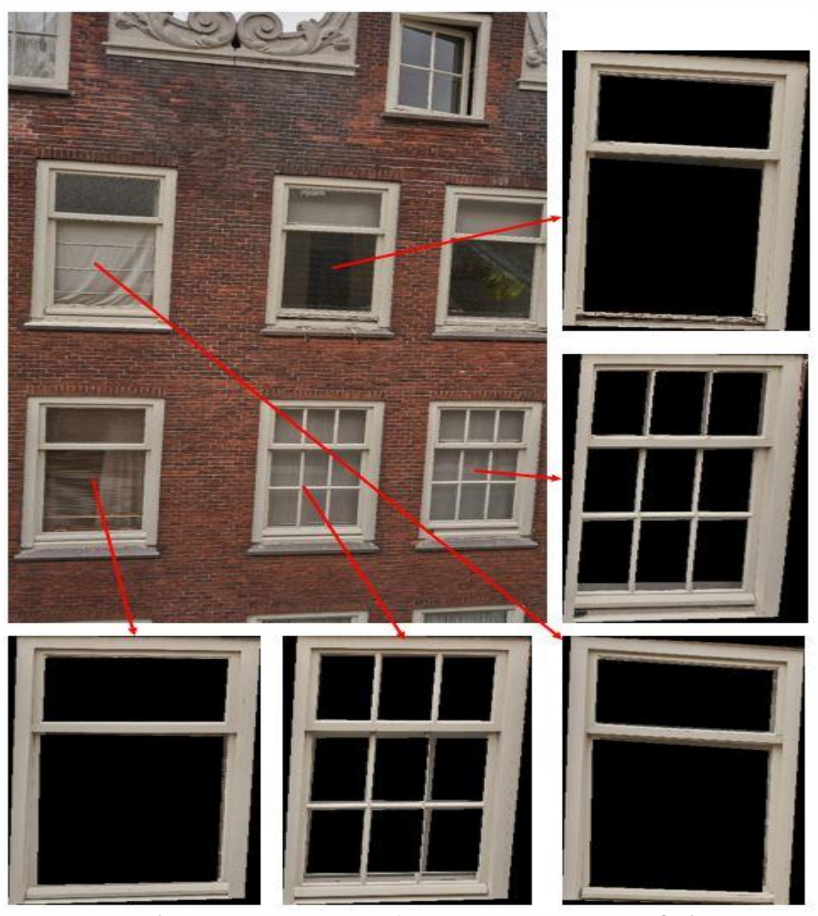

Figure 1. The cropping and preprocessing of the data visualized.

Figure 2. Example of good and defected data in the datasets.

Models:
In order to achieve optimal classification outcomes, we examined a diverse range of deep learning models. In our research, we investigated various model architectures, including VGG(fig.3) and Swin Transformer.

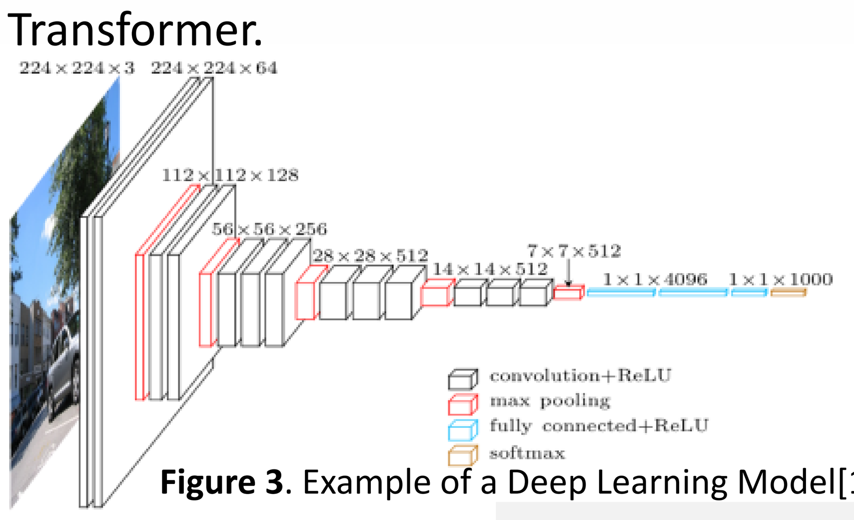

Figure 3. Example of a Deep Learning Model[1]

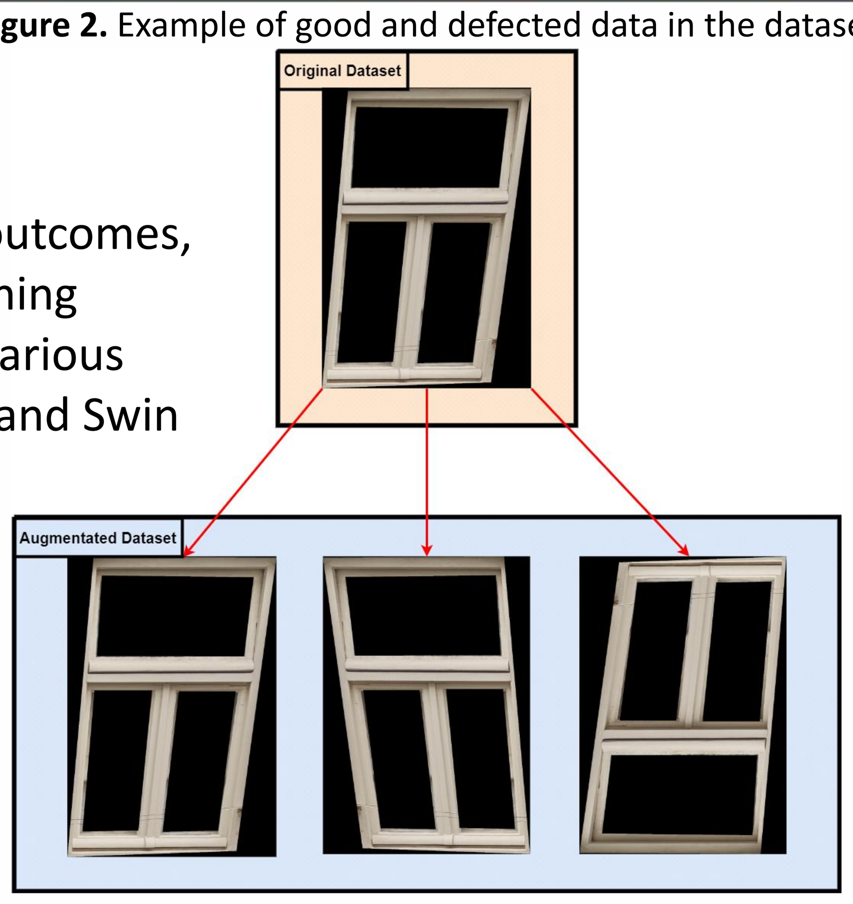

Figure 4. Data augmentation visualized.

Acknowledgements

- This project is a collaboration between the Computer Vision & Data Science professorship and AeroScan B.V.

Experiments and Results

- **Experiment 1:** Window casing dataset. VGG19 performs the best. Using Grad Cam, we unveiled the image features VGG19 relied on for accurate predictions (Fig.5). This visualization confirms the model's ability to properly use relevant elements in the images.

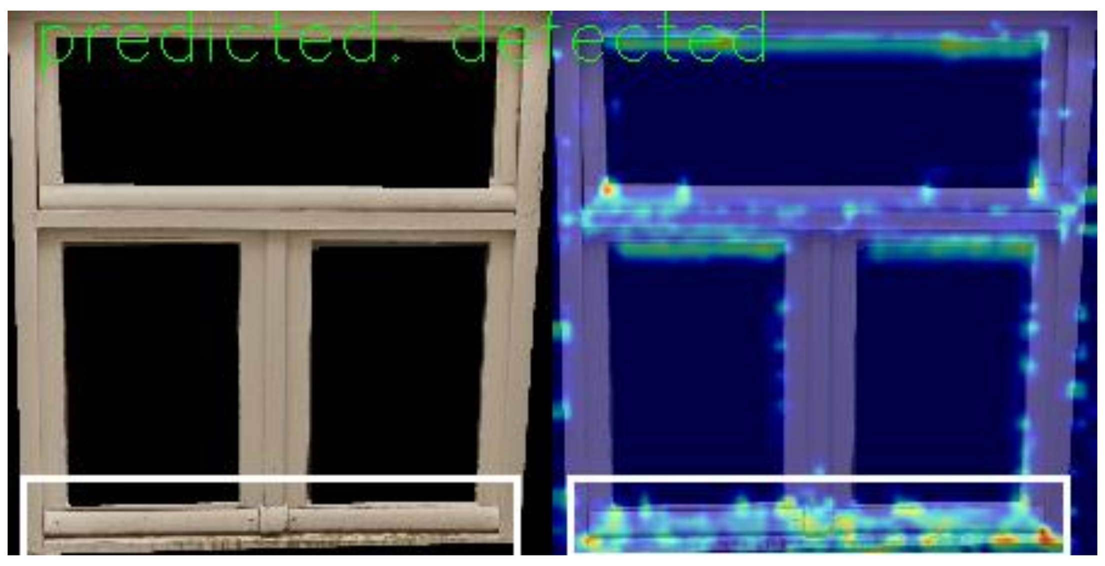

Figure 5. Grad Cam visualization of the features used by the model.

Model	Precision	Recall	F1-Score
VGG11	0.85	0.71	0.77
VGG19	**0.86**	**0.82**	**0.84**
ResNet50	0.85	0.72	0.78
EfficientNetV2s	0.79	0.71	0.75
GoogleNet	0.78	0.72	0.75
ResNext50	0.79	0.69	0.74
Swin Transformer	0.79	0.71	0.75

- **Experiment 1.2:** Tiled roof dataset.
  - We trained the same models on the tiled roof dataset, Swin Transformer turned out to have the best performance.
  - Grad Cam confirms that the Swin Transformer model is making predictions based on the relevant features (Fig.6).

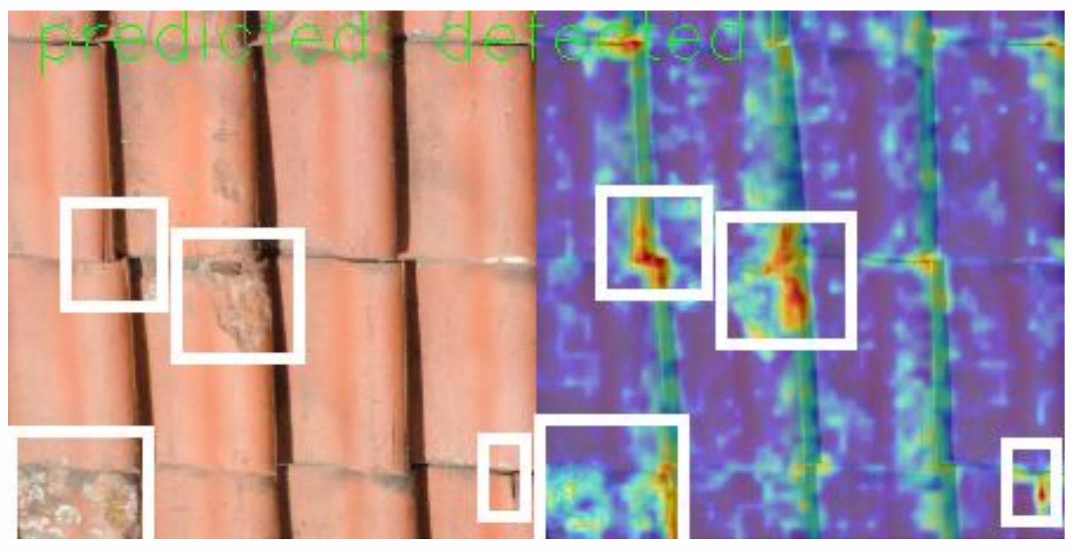

Figure 6. Grad Cam visualization of the features used by the model.

Model	Precision	Recall	F1-Score
VGG11	0.73	0.90	0.81
VGG19	0.78	0.78	0.78
ResNet50	**0.94**	0.89	0.90
EfficientNetV2s	0.81	0.89	0.85
GoogleNet	0.71	0.82	0.76
ResNext50	0.81	0.89	0.85
Swin Transformer	0.92	**0.97**	**0.94**

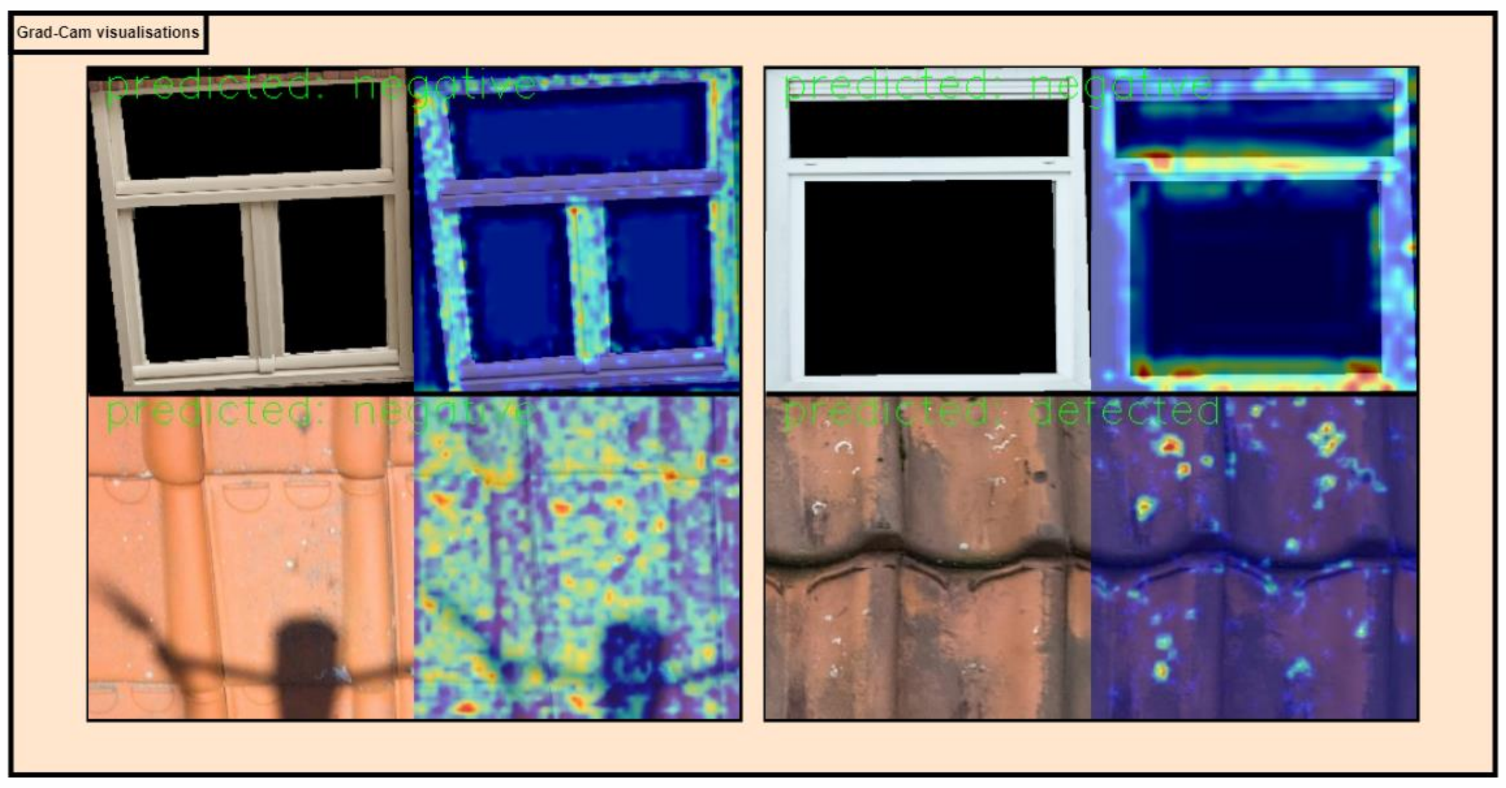

Figure 7. Results classification model visualized with Grad-Cam.

Conclusions

- VGG19 produces the best results for the window casing dataset.
- Swin Transformer benefits the most from a larger dataset which leads to having the best results for the tiled roof dataset.
- Visual analysis shows that the models use the relevant features of an image to make its prediction

References

- [1] Andrew Zisserman KAren Simonyan. paperswithcode. https://paperswithcode.com/method/vgg, 2015.

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