Building surface damage recognition based on synthetic data

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Problem

The problem of visual inspection lies in the fact that this type of inspection is largely based on manual data collection with the naked eye, and some approaches require inspectors to access various hard-to-reach infrastructure components [1]. The unmanned system, which reduces the role of the inspector, provides a safer and more efficient control [2].

The use of neural network algorithms makes it possible to automate the process of processing video data, reducing the workload on personnel and increasing the efficiency of damage monitoring. Due to the complexity of obtaining a data set for training neural networks, it is possible to use synthetic data modeling technology [3]. We use development tools such as Unreal Engine [4] to automatically create and collect data for training neural networks in applied problems of object detection and classification.

Simulation setup

- **The Res-UNet as a neural network classifier;**
- **Image 256x256 pixels;**
- **Training and validation sets were formed in a ratio of 9 to 1;**
- **Training was carried out until an accuracy of 95-98%;**

! - Training samples were formed using simulated synthetic data in the Unreal Engine environment (fig.1). Thus, a sample of the wall and roof was formed with customized materials with the imposition of procedural textures of defects on them for the final rendering (fig.2).

a b c d e

Fig. 1. Examples of Photorealistic Fracture Materials Used to Generate the Synthetic Training Dataset (a).
Different rendering maps of the digital human fall registration: diffuse(b), normal (c), opacity (d), roughnes (e).

Fig. 2. Synthetic data modeled in Unreal Engine

The implemented data generation pipeline allows to automatically create defect masks for training neural network (fig. 3).

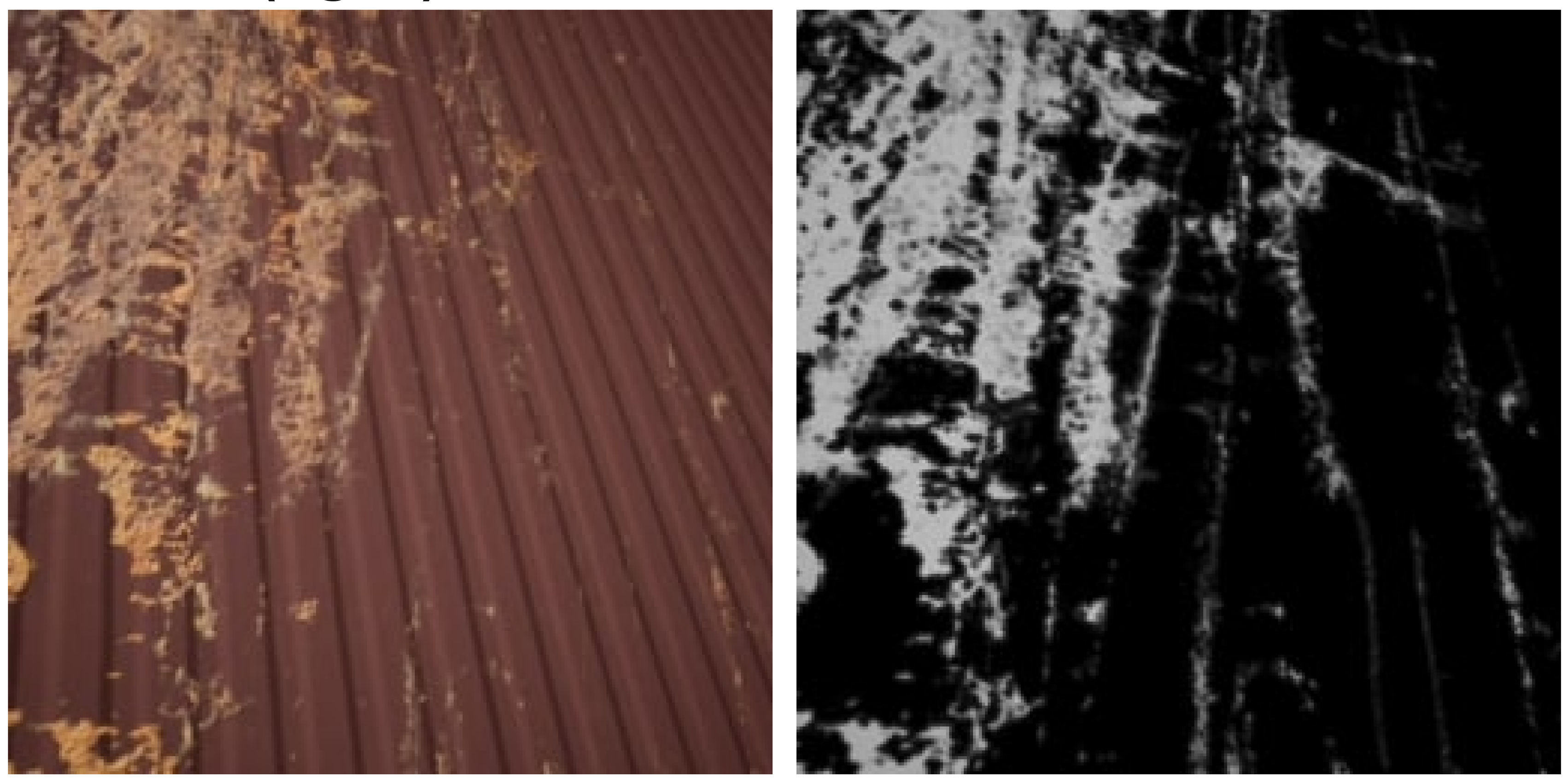

Fig. 3. An instance from an automatically generated synthetic dataset (rgb image of a rusted roof top (left) and defect mask (right))

Conclusion

The neural network algorithm was trained on the obtained synthetic data and showed high accuracy in detecting building surface integrity violations (fig. 4).

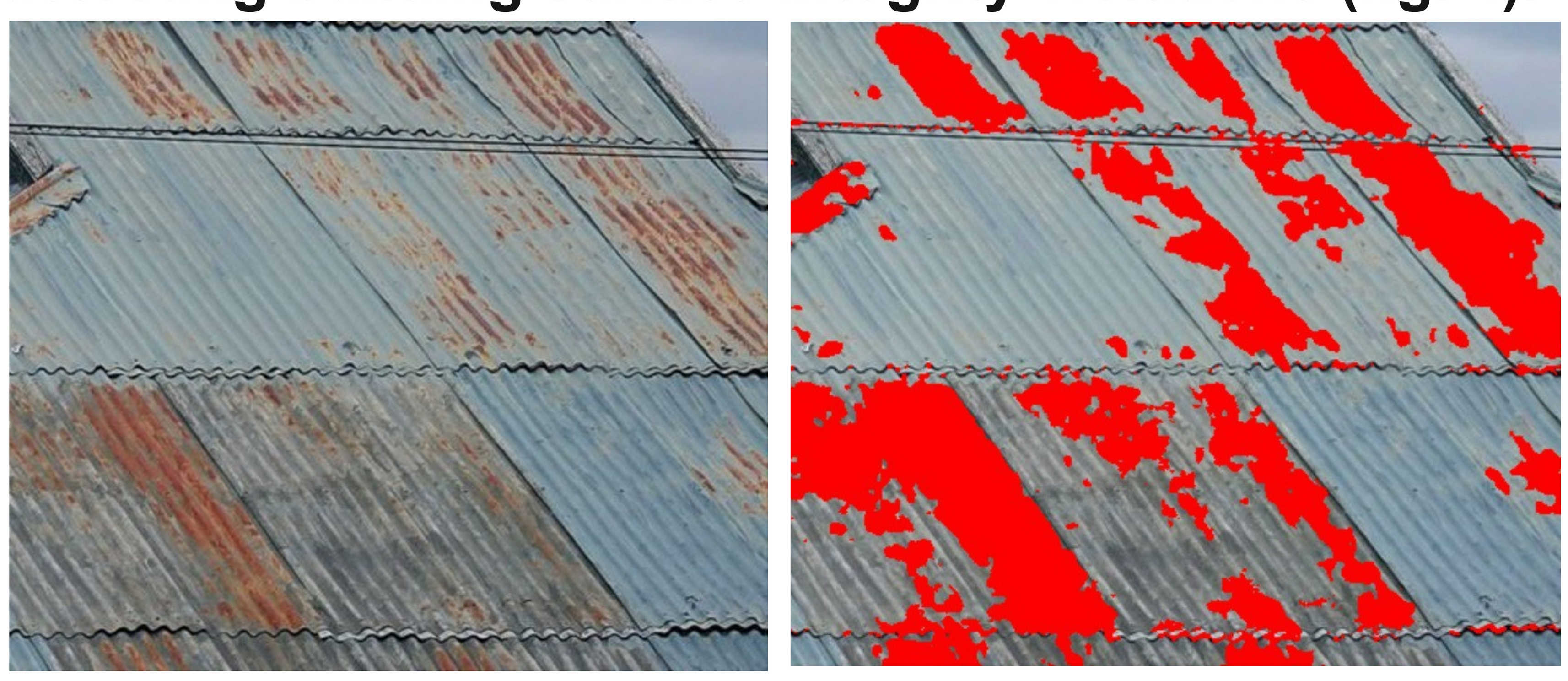

Fig. 4. Control photo for rust detection (up) and results of segmentation by a neural network algorithm (down)

TABLE I. PRECISION, RECALL AND F1 VALUES FOR RUST AND CRACK DETECTION IN THE CONTROL GROUP OF OBJECTS.

	Rust	Cracks
Precision	78%	91.3%
Recall	91.2%	87.1%
F1-score	84.1%	89.2%

Thus, the use of the approach for generating synthetic data of surface defects based on photorealistic rendering made it possible to ensure the accuracy of detecting the localization of cracks and rust on infrastructure facilities by 91.3 and 78%, respectively.

References

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