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Defect Detection Based on Synthetic Dataset

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ABSTRACT The goal of this exercise is to use machine learning (ML) to perform segmentation on a dataset of synthetically generated gear and spring images. An ensemble of neural networks was designed. In the first step, a classification neural network model was used to determine if the image was of a gear or spring. In the second step, two separate segmentation models were use for gear and spring images respectively, in order to detect regions of defects in the input images. To design the classification model, transfer learning was applied to the VGG16 convolutional neural network (CNN). For segmentation, transfer learning was applied on the DeepLabv3 neural network, which is an existing deep neural network model which has been designed for segmentation. The results are discussed, and suggestions for improvements are made.

INDEX TERMS Machine learning, deep neural networks, transfer learning, computer vision

1. INTRODUCTION

An introduction is already written in the abstract. This exercise is a little small for a full introduction with literature review.

1. PART 1: DEFECT DETECTION IN SYTHETHIC IMAGES

Two separate models were trained for springs and gears, because the shapes of the source objects and the manner in which light reflects off them creates very different images. The DeepLabv3 deep neural network with a ResNet101 backbone is a pretrained model which was chosen as a starting point. It is a popular ML model that is used to identify and segment regions in images. It uses atrous convolution for multiscale segmentation, and is effective with input images of any size. [1]

Transfer learning was applied to the last layer, in order to train the model to recognize the defects in gear and spring images. The DeepLabv3FineTune package [2] was used to apply the transfer learning. Transfer learning allows for fast and effective training when there is a limited dataset.

1. GEARS

An 8:2:1 training:validation:test split was used. This was achieved by leaving 1 folder aside for testing and applying a random 80:20 split on the rest of the 10 synthetic image folders. 5 epochs were used for training, with a total training time of 13 hours on a CPU. (No Cuda-enabled GPU was available for faster and more numerous model generation.) The loss metric used was the mean squared error (MSE).

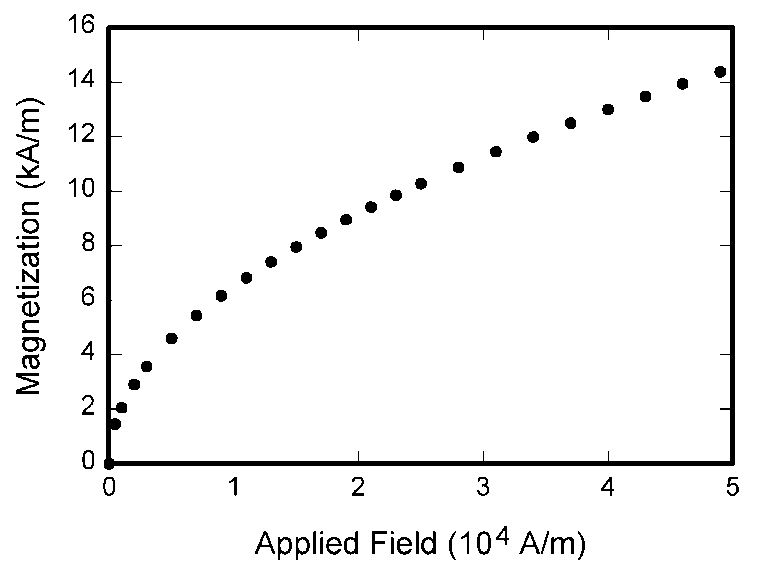
TABLE I

Performance measurements for gear defect detection

|  |  |  |  |
| --- | --- | --- | --- |
|  | Loss | F1 score | AUROC |
| *Train* | 0.00226 | 0.070 | 0.965 |
| *Validation* | 0.00299 | 0.395 | 0.906 |
| *Test* |  | 0.031 | 0.564 |

Using the standard threshold at

1. Recommendations for Improvement



1. Magnetization as a function of applied field. Note that “Fig.” is abbreviated. There is a period after the figure number, followed by two spaces. It is good practice to explain the significance of the figure in the caption.

TABLE I

Units for Magnetic Properties

|  |  |  |
| --- | --- | --- |
| Symbol | Quantity | Conversion from Gaussian and  CGS EMU to SI a |
| Φ | magnetic flux | 1 Mx → 10−8 Wb = 10−8 V·s |
| *B* | magnetic flux density,  magnetic induction | 1 G → 10−4 T = 10−4 Wb/m2 |
| *H* | magnetic field strength | 1 Oe → 103/(4π) A/m |
| *m* | magnetic moment | 1 erg/G = 1 emu  → 10−3 A·m2 = 10−3 J/T |
| *M* | magnetization | 1 erg/(G·cm3) = 1 emu/cm3  → 103 A/m |
| 4π*M* | magnetization | 1 G → 103/(4π) A/m |
| σ | specific magnetization | 1 erg/(G·g) = 1 emu/g → 1 A·m2/kg |
| *j* | magnetic dipole  moment | 1 erg/G = 1 emu  → 4π × 10−10 Wb·m |
| *J* | magnetic polarization | 1 erg/(G·cm3) = 1 emu/cm3  → 4π × 10−4 T |
| χ*,* κ | susceptibility | 1 → 4π |
| χρ | mass susceptibility | 1 cm3/g → 4π × 10−3 m3/kg |
| μ | permeability | 1 → 4π × 10−7 H/m  = 4π × 10−7 Wb/(A·m) |
| μr | relative permeability | μ → μr |
| *w, W* | energy density | 1 erg/cm3 → 10−1 J/m3 |
| *N, D* | demagnetizing factor | 1 → 1/(4π) |

CONCLUSION

A conclusion section is not required. Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions.

APPENDIX

Appendixes, if needed, appear before the acknowledgment.

ACKNOWLEDGMENT

The preferred spelling of the word “acknowledgment” in American English is without an “e” after the “g.” Use the singular heading even if you have many acknowledgments. Avoid expressions such as “One of us (S.B.A.) would like to thank ... .” Instead, write “F. A. Author thanks ... .” In most cases, sponsor and financial support acknowledgments are placed in the unnumbered footnote on the first page, not here.

REFERENCES AND FOOTNOTES

1. REFERENCES

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REFERENCES

# References

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