MANUFACTURING DEFECTDETECTION-CNN

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CASE STUDY

PROBLEM

A manufacturing plant has trouble quickly finding defects because its manual inspection process is slow and prone to errors. Missed defects lower product quality and increase costs for replacements or repairs.

GOAL

Create a highly accurate CNN model and Comparing Optimizers for Enhanced Defect Detection to decrease undetected defects, improving product quality and cutting replacement/repair costs.

DATASET

This dataset consists of images of casting manufacturing products. All these photos depict the top view of a submersible pump impeller.

Source	Kaggle (URL: <u>Real-Life Industrial Dataset of Casting Product</u>)
Format	Images (JPEG format)
Total Data	7348 image data
Categories	Def and Ok
Image Size	512x512 grayscale

DATA PREPROCESSING

Preprocessing	Deskripsi
Resizing	300x300 piksel.
Color Mode	grayscale
Normalisasi	1/ 255
Label Kelas	'ok' = 0 dan 'def' = 1
Batch Size	*32*
Pengaturan *Seed*	0
Class Mode	*Binary*

ARCHITECTURE CNN

Layer	Output Shape	Parameter
Conv2D (16)	(None, 150, 150, 16)	160
MaxPooling2D	(None, 75, 75, 16)	0
Conv2D (32)	(None, 75, 75, 32)	4640
MaxPooling2D	(None, 37, 37, 32)	0
Conv2D (64)	(None, 37, 37, 64)	18496
MaxPooling2D	(None, 18, 18, 64)	0
Conv2D (128)	(None, 18, 18, 128)	73856
MaxPooling2D	(None, 9, 9, 128)	0
Flatten	(None, 10368)	0
Dense (128)	(None, 128)	1327232
Dense (1)	(None, 1)	129
	Total Parameter	1424513
	Trainable Parameter	1424513

This architecture enables deep feature extraction through the convolutional and pooling layers, with the dense layers at the end of the architecture used to make the final decision regarding the presence of defects in casting industrial products.

OPTIMIZER COMPARISON: TRAINING RESULTS

Optimizer	Epoch	Train		Validasi	
		Accuracy	Loss	Accuracy	Loss
Adam	25	0.9908	0.0247	0.9908	0.0984
	50	**0.9992**	**0.0009**	**0.9940**	**0.0331**
SGD	25	0.9597	0.1006	0.9646	0.1044
	50	0.9977	0.0067	0.9894	0.0446
RMSprop	25	0.9974	0.0067	0.9925	0.0321
	50	0.9992	0.0030	0.9910	0.0745

Research confirms that utilizing the Adam optimizer at epoch 50 achieves outstanding accuracy, reaching 99.92% in training and 99.4% in validation. Additionally, achieved loss values are remarkably low, with 0.0009 during training and 0.0331 during validation.

FOUR IDEAS

MARS

Despite being red, Mars is actually a cold place. It's full of iron oxide dust, which gives the planet its reddish cast, and it's made of basalt

VENUS

Venus has a beautiful name and is the second planet from the Sun. It's terribly hot and its atmosphere is extremely poisonous

JUPITER

Jupiter is a gas giant and the biggest planet in the Solar System. It's the fourth-brightest object in the night sky. It was named after a Roman god

SATURN

Saturn is a gas giant and has several rings. It's composed mostly of hydrogen and helium. It's the sixth planet from the Sun

SIX IDEAS

Earth is the third planet from the Sun and the only one that harbors life in the Solar System. We all live on this planet

Saturn is a gas giant and has several rings. It's composed of hydrogen and helium. It's the sixth planet from the Sun

Jupiter is a gas giant and the biggest planet in the Solar System. It's the fourth-brightest object in the night sky

CONFUSION MATRIX RESULTS

- For "Ok" class: Precision, Recall, and F1-score are 0.9962, indicating accurate classification with good balance.

- Total data for "Ok" class: 262.

- For "Defect" class: Precision, Recall, and F1-score are all 0.9978, indicating highly accurate classification.

- Total data for "Defect" class: 453.

These metrics illustrate the model's performance in classifying both classes, demonstrating its high capability in distinguishing and classifying data in both categories.

MISSCLASSIFIED

Misclassified Test Images

Actual: OK | Actual: OK | Actual: OK

Predicted: Defective (92.21%) | Predicted: Defective (97.42%) | Predicted: Defective (55.72%)

Results from Figure 5.6 show that the model using Adam optimizer for 50 epochs struggled with predictions. It misclassified 3 out of 715 test data instances, all of which were labeled 'Ok' but predicted as 'Defective'

SUMMARY

- Convolutional Neural Network (CNN) model successfully detects defects in casting industrial products.
- After comparing SGD and RMSProp, the Adam optimizer was selected to maximize defect detection performance and accuracy during training.
- With Adam optimization, the CNN model achieves 99.34% accuracy in detecting "Ok" and 95.8% accuracy in detecting "Defect".
- The model demonstrates high success rates in accurately classifying both categories of defects.