

**RANCANG BANGUN SISTEM IDENTIFIKASI PRODUK CACAT PADA
FOLDING BOX BERBASIS YOLOv8m YANG TERINTEGRASI DENGAN
*REJECTION AREA***



SKRIPSI

diajukan untuk memenuhi sebagian syarat untuk memperoleh gelar Sarjana
Teknik Program Studi Mekatronika dan Kecerdasan Buatan

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UNIVERSITAS PENDIDIKAN INDONESIA
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Sebuah skripsi yang diajukan untuk memenuhi salah satu syarat memperoleh gelar
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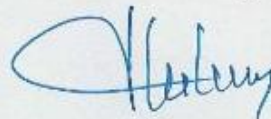
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Rancang Bangun Sistem Identifikasi Produk Cacat pada *Folding Box* berbasis
YOLOv8m yang Terintegrasi dengan *Rejection Area*

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ABSTRAK

Industri manufaktur kemasan memerlukan sistem *quality control* yang cepat, akurat, dan efektif untuk menjaga kualitas produk. Penelitian ini merancang dan mengintegrasikan prototipe sistem produksi dengan algoritma deteksi cacat berbasis YOLOv8m. Sistem terdiri dari enam area: *folding box placement*, *image acquisition*, *rejection*, *good folding box*, *computerization*, dan *air compression*. Dataset tiga kategori (normal, robek, terlipat) diperoleh dari pengambilan gambar pada variasi ketinggian kamera, dianotasi menggunakan *instance segmentation*, dan diperluas dengan *data augmentation*. Model dilatih 50 *epoch* di Google Colab dan dievaluasi dengan akurasi, presisi, *recall*, mAP, dan *F1-score*. Metode dengan *augmentation* mencapai akurasi 0,906, presisi 0,964, *recall* 0,962, dan mAP 0,977, melampaui metode tanpa *augmentation*. Integrasi dengan sistem *rejection* memungkinkan deteksi dan pemisahan *folding box* cacat secara *real-time* tanpa intervensi manual, dengan FAR dan FRR rendah. Sistem stabil pada ketinggian kamera 30 cm maupun 40 cm dengan jarak antar *folding box* 20–35 cm. Penelitian ini menyimpulkan bahwa kombinasi *hardware* terintegrasi dan YOLOv8m menjadi solusi efektif untuk otomasi identifikasi produk cacat pada *folding box* di industri kemasan.

Kata kunci: YOLOv8m, *quality control*, deteksi cacat, *folding box*, *instance segmentation*.

Design and Development of a Defective Product Identification System for Folding Box Based on YOLOv8m Integrated with a Rejection Area

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ABSTRACT

The packaging manufacturing industry requires a fast, accurate, and effective quality control system to maintain product standards. This study designed and integrated a production system prototype with a defect detection algorithm based on YOLOv8m. The system comprises six areas: folding box placement, image acquisition, rejection, good folding box, computerization, and air compression. A three-category dataset (normal, torn, folded) was obtained through image capture at varying camera heights, annotated using instance segmentation, and expanded via data augmentation. The model was trained for 50 epochs in Google Colab and evaluated using accuracy, precision, recall, mAP, and F1-score. The augmented method achieved 0.906 accuracy, 0.964 precision, 0.962 recall, and 0.977 mAP, outperforming the non-augmented method. Integration with the rejection system enabled real-time detection and removal of defective folding boxes without manual intervention, with low FAR and FRR. The system was stable at camera heights of 30 cm and 40 cm with box spacing of 20–35 cm. This study concludes that the combination of integrated hardware and YOLOv8m provides an effective solution for automating defect identification of folding boxes in the packaging industry.

Keywords: *YOLOv8m, quality control, defect detection, folding box, instance segmentation.*

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DAFTAR PUSTAKA

- Abukhait, J. (2024). Automated Machine Vision Inspection System for Applying Plastic Lids on Wet Wipes Packs. *International Journal of Electrical and Electronic Engineering and Telecommunications*, 13(4), 309–316. <https://doi.org/10.18178/ijeetc.13.4.309-316>
- Achmad, H., Pramudwiatmoko, A., Satrio Gumilang, M., Al Karim, B., & Wiyono, H. (2025). Analisis Kinerja Model Deteksi Objek Yolo, Ssd, dan Faster R-Cnn pada Citra Penglihatan Malam untuk Pengenalan Tindak Kejahatan. *Jurnal Teknologi Informasi dan Ilmu Komputer*, 12(1), 145–152. <https://doi.org/10.25126/jtiik.2025128409>
- Agnew, C., Scanlan, A., Denny, P., Grua, E. M., Van De Ven, P., & Eising, C. (2024). Annotation Quality Versus Quantity for Object Detection and Instance Segmentation. *IEEE Access*, 12, 140958–140977. <https://doi.org/10.1109/ACCESS.2024.3467008>
- Alhassan, M. A. M., & Yilmaz, E. (2025). Evaluating YOLOv4 and YOLOv5 for Enhanced Object Detection in UAV-Based Surveillance. *Processes*, 13(1). <https://doi.org/10.3390/pr13010254>
- Alkentar, S. M., Alsahwa, B., Assalem, A., & Karakolla, D. (2021). Practical comparison of the accuracy and speed of YOLO, SSD and Faster RCNN for drone detection. *Journal of Engineering*, 27(8), 19–31. <https://doi.org/10.31026/j.eng.2021.08.02>
- Alshahrani, A., Balubaid, R. H., Alowaybidi, R. I., & Alnasiri, H. A. (2025). A Comparative Study of Deep Learning Techniques for Ocular Diseases. *International Journal of Computer Science and Network Security*, 25(5), 21–30.
- Alzubaidi, L., Zhang, J., Humaidi, A. J., Al-Dujaili, A., Duan, Y., Al-Shamma, O., Santamaria, J., Fadhel, M. A., Al-Amidie, M., & Farhan, L. (2021). Review of deep learning: concepts, CNN architectures, challenges, applications, future directions. In *Journal of Big Data* (Vol. 8, Nomor 1). Springer International Publishing. <https://doi.org/10.1186/s40537-021-00444-8>
- Anita, Marpaung, F., Aulia, F., & Nabila, R. C. (2022). *Computer Vision Dan Pengolahan Citra Digital*. www.pustakaaksara.co.id
- Ardhiansyah, A., Tavita Eva, G., & Iskandar. (2019). Identifikasi Jenis Cacat Kayu Bulat Jati Pada Areal Pemanenan Di KPH Jember. *Jurnal Hutan Lestari*, 7, 525–531.
- Ardyan, E., Tanus, E. D., Sani, F. A., & Marselinus, S. C. (2023). Customer Satisfaction During The Post Covid-19 Pandemic: Testing The Effect of Food Quality, Packaging, and Customer Trust. *Review of Management and Entrepreneurship*, 7(2), 271–292. <https://doi.org/10.37715/rme.v7i2.4130>

- Aveo. (2021). *Reject System*. Nikodan. <https://nikodan.eu/reject-system/>
- Bagas Prakosa, B. V., & Rochmoeljati, R. (2021). Analisa Pencegahan Reject Pada Produksi Roll Karet dengan Fault Tree Analysis (FTA) dengan Rekomendasi Perbaikan Failure Mode and Effects Analysis (FMEA) di PT. Ustegra (Usaha Teknik Grafika). *Juminten*, 2(5), 25–37. <https://doi.org/10.33005/juminten.v2i5.297>
- Bakita, J., & Anderson, J. H. (2023). Hardware Compute Partitioning on NVIDIA GPUs. *Proceedings of the IEEE Real-Time and Embedded Technology and Applications Symposium, RTAS, 2023-May*, 54–66. <https://doi.org/10.1109/RTAS58335.2023.00012>
- Basuki, A., & Chusnayaini, I. (2021). Identifikasi Resiko Kegagalan Proses Penyebab Terjadinya Cacat Produk dengan Metode FMEA-SAW. *Matrik*, 22(1), 37. <https://doi.org/10.30587/matrik.v22i1.1967>
- Bhargava, M., & Gaur, S. (2021). Process Improvement Using Six-Sigma (DMAIC Process) in Bearing Manufacturing Industry: A Case Study. *IOP Conference Series: Materials Science and Engineering*, 1017(1). <https://doi.org/10.1088/1757-899X/1017/1/012034>
- Bochkovski, A., Wang, C.-Y., & Liao, H.-Y. M. (2020). YOLOv4: Optimal Speed and Accuracy of Object Detection. *IEEE transactions on neural networks and learning systems*. <http://arxiv.org/abs/2004.10934>
- Cai, S. (2024). *ALW-YOLOV8n : A Lightweight underwater detector Enhanced by Attention mechanism , ADown Block and Wise-WIoU on YOLOv8n*
- Chai, J., Zeng, H., Li, A., & Ngai, E. W. T. (2021). Deep learning in computer vision: A critical review of emerging techniques and application scenarios. *Machine Learning with Applications*, 6(March), 100134. <https://doi.org/10.1016/j.mlwa.2021.100134>
- Chan, A., Gujarati, A., Pattabiraman, K., & Gopalakrishnan, S. (2023). Evaluating the Effect of Common Annotation Faults on Object Detection Techniques. *Proceedings - International Symposium on Software Reliability Engineering, ISSRE*, 474–485. <https://doi.org/10.1109/ISSRE59848.2023.00072>
- Chang, C. M., Liou, Y. D., Huang, Y. C., Shen, S. E., Yu, P. J., Chuang, T. H., & Chiou, S. J. (2022). YOLO based deep learning on needle-type dashboard recognition for autopilot maneuvering system. *Measurement and Control (United Kingdom)*, 55(7–8), 567–582. <https://doi.org/10.1177/00202940221115199>
- Chebotareva, E., Toshev, A., & Magid, E. (2024). Comparative analysis of neural network models performance on low-power devices for a real-time object detection task. *Computer Optics*, 48(2), 242–252.

<https://doi.org/10.18287/2412-6179-CO-1343>

- Cheng, Y. (2024). YOLO V8 Network Lightweight Method Based on Pruning and Quantization. *Mathematical Modeling and Algorithm Application*, 3(2), 1–8.
- Chlap, P., Min, H., Vandenberg, N., Dowling, J., Holloway, L., & Haworth, A. (2021). A review of medical image data augmentation techniques for deep learning applications. *Journal of Medical Imaging and Radiation Oncology*, 65(5), 545–563. <https://doi.org/10.1111/1754-9485.13261>
- Ciaglia, F., Zuppichini, F. S., Guerrie, P., McQuade, M., & Solawetz, J. (2022). Roboflow 100: A Rich, Multi-Domain Object Detection Benchmark. *IEEE Xplore*. <http://arxiv.org/abs/2211.13523>
- De Mel, V. L. B., & Mel, D. (2023). Survey of Evaluation Metrics in Facial Recognition Systems. *IEEE Xplore*, July. <https://doi.org/10.13140/RG.2.2.10974.20805>
- Dwyer, B. (2020). *Roboflow*. Roboflow.
- ElMaraghy, H., Monostori, L., Schuh, G., & ElMaraghy, W. (2021). Evolution and future of manufacturing systems. *CIRP Annals*, 70(2), 635–658. <https://doi.org/10.1016/j.cirp.2021.05.008>
- Elngar, A. A., Arafa, M., Fathy, A., Moustafa, B., Mahmoud, O., Shaban, M., & Fawzy, N. (2021). Image Classification Based On CNN: A Survey. *Journal of Cybersecurity and Information Management*, 6(1), PP. 18-50. <https://doi.org/10.54216/jcim.060102>
- Esmacilian, B., Behdad, S., & Wang, B. (2016). The evolution and future of manufacturing: A review. *Journal of Manufacturing Systems*, 39, 79–100. <https://doi.org/10.1016/j.jmsy.2016.03.001>
- Essel, E., Lacy, F., Belu, R., Areed, N. F. F., & Ismail, Y. (2025). Performance Optimization of FPGA-Accelerated YOLOv8 for Driver Drowsiness Detection Using Vivado HLS. *International Journal of Computing and Digital Systems*, 18(1). <https://doi.org/10.12785/ijcds/1571130888>
- Fahriza rizky maulana, F., Yusfrizal, & Syari, M. A. (2023). Design and Development of Swimming Pool Water pH Level Monitoring System and Automatic Solenoid Valve Control Based on the Internet of Things. *Journal of Artificial Intelligence and Engineering Applications (JAIEA)*, 3(1), 269–273. <https://doi.org/10.59934/jaiea.v3i1.305>
- Fan, Y. L., Hsu, C. H., Hsu, F. R., & Liao, L. De. (2024). Exploring the use of deep learning models for accurate tracking of 3D zebrafish trajectories. *Frontiers in Bioengineering and Biotechnology*, 12(September), 1–15. <https://doi.org/10.3389/fbioe.2024.1461264>
- Fazekas, S., Budaiorcid, B. K., Stollmayerorcid, R., Kaposiorcid, P. N., & Bérczi, V. (2022). Artificial intelligence and neural networks in radiology – Basics

- that all radiology residents should know. *Imaging*, 14(2), 73–81. <https://doi.org/10.1556/1647.2022.00104>
- Fertansyah, A. A., & Islami, M. C. (2025). Quality Control To Reduce Defect In Packaging Using Six Sigma And FMEA Methods At T XYZ. *Jurnal Aplikasi Teknik dan Pengabdian Masyarakat*, 9(1), 55–62.
- Gamani, A.-R. A., Arhin, I., & Asamoah, A. K. (2024). *Performance Evaluation of YOLOv8 Model Configurations, for Instance Segmentation of Strawberry Fruit Development Stages in an Open Field Environment*. 1–15. <http://arxiv.org/abs/2408.05661>
- Garbowski, T. (2024). Evaluating safety factors in corrugated packaging for extreme environmental conditions. *Packaging Review*, 2(4), 6–15. <https://doi.org/10.15199/42.2023.4.1>
- Guarnido-Lopez, P., Pi, Y., Tao, J., Mendes, E. D. M., & Tedeschi, L. O. (2024). Computer vision algorithms to help decision-making in cattle production. *Animal Frontiers*, 14(6), 11–22. <https://doi.org/10.1093/af/vfae028>
- Gupta, A., Sharma, P., Jain, A., Xue, H., Malik, S. C., & Jha, P. C. (2023). An integrated DEMATEL Six Sigma hybrid framework for manufacturing process improvement. *Annals of Operations Research*, 322(2), 713–753. <https://doi.org/10.1007/s10479-019-03341-9>
- Hesti Puspitasari, Joko Susetyo, & Rahayu Khasanah. (2022). Usulan Pengendalian Kualitas Untuk Mengurangi Produk Cacat Kemasan Minyak Telon. *Jurnal Rekavasi*, 10(1), 35–44. <https://doi.org/10.34151/rekavasi.v10i1.3878>
- Hikmawati, F. (2020). Metodologi Penelitian. In *Proceedings of the National Academy of Sciences* (Vol. 3, Nomor 1). <http://dx.doi.org/10.1016/j.bpj.2015.06.056%0Ahttps://academic.oup.com/bioinformatics/article-abstract/34/13/2201/4852827%0Ainternal-pdf://semisupervised-3254828305/semisupervised.ppt%0Ahttp://dx.doi.org/10.1016/j.str.2013.02.005%0Ahttp://dx.doi.org/10.10>
- hussain, zahid. (2019). Optimizing productivity by eliminating and managing rejection frequency using 5s and kaizens practices: case study. *Independent Journal of Management & production*, 10(6), 1952–1970. <https://doi.org/10.14807/ijmp.v10i6.943>
- Hussain, M. (2023). YOLO-v1 to YOLO-v8, the Rise of YOLO and Its Complementary Nature toward Digital Manufacturing and Industrial Defect Detection. *Machines*, 11(7). <https://doi.org/10.3390/machines11070677>
- Hussain, M. (2024). YOLOv1 to v8: Unveiling Each Variant-A Comprehensive Review of YOLO. *IEEE Access*, 12(March), 42816–42833. <https://doi.org/10.1109/ACCESS.2024.3378568>
- Jamal, M., Faisal, S., Kusumaningrum, D. S., & Rohana, T. (2024). Application Of

- Yolo V8 For Product Defect Detection In Manufacturing Companies. *Jurnal Sistem Informasi dan Ilmu Komputer Prima*, 8(1), 1–11.
- Janiesch, C., Zschech, P., & Kai, H. (2023). Machine learning and deep learning. *Quantum Computing and Artificial Intelligence: Training Machine and Deep Learning Algorithms on Quantum Computers*, 71–84. <https://doi.org/10.1515/9783110791402-004>
- Kadam, P., Fang, G., & Zou, J. J. (2024). Object Tracking Using Computer Vision: A Review. *Computers*, 13(6). <https://doi.org/10.3390/computers13060136>
- Kaltsas, P. I., Koustoumpardis, P. N., & Nikolakopoulos, P. G. (2022). A Review of Sensors Used on Fabric-Handling Robots. *Machines*, 10(2). <https://doi.org/10.3390/machines10020101>
- Kandel, I., Castelli, M., & Manzoni, L. (2022). Brightness as an Augmentation Technique for Image Classification. *Emerging Science Journal*, 6(4), 881–892. <https://doi.org/10.28991/ESJ-2022-06-04-015>
- Kesav, N., & Jibukumar, M. G. (2022). Efficient and low complex architecture for detection and classification of Brain Tumor using RCNN with Two Channel CNN. *Journal of King Saud University - Computer and Information Sciences*, 34(8), 6229–6242. <https://doi.org/10.1016/j.jksuci.2021.05.008>
- Khairunisa, N., . C., & Jamaludin, A. (2024). Analisis Perbandingan Algoritma Cnn Dan Yolo Dalam Mengidentifikasi Kerusakan Jalan. *Jurnal Informatika dan Teknik Elektro Terapan*, 12(3). <https://doi.org/10.23960/jitet.v12i3.4434>
- Korkmaz, A., Agdas, M. T., Kosunalp, S., Iliev, T., & Stoyanov, I. (2024). Detection of Threats to Farm Animals Using Deep Learning Models: A Comparative Study. *Applied Sciences (Switzerland)*, 14(14). <https://doi.org/10.3390/app14146098>
- Krichen, M. (2023). Convolutional Neural Networks: A Survey. *Computers*, 12(8), 1–41. <https://doi.org/10.3390/computers12080151>
- Kumar, A., & Zhang, Zuopeng Justin Lyu, H. (2020). Object detection in real time based on improved single shot multi-box detector algorithm. *ACM International Conference Proceeding Series*. <https://doi.org/10.1145/3446132.3446170>
- Kumar, S., Asiamah, P., Jolaoso, O., & Esiowu, U. (2025). Enhancing Image Classification with Augmentation: Data Augmentation Techniques for Improved Image Classification. *IEEE*. <http://arxiv.org/abs/2502.18691>
- Lauriola, I., Lavelli, A., & Aioli, F. (2022). An introduction to Deep Learning in Natural Language Processing: Models, techniques, and tools. *Neurocomputing*, 470(xxxx), 443–456. <https://doi.org/10.1016/j.neucom.2021.05.103>
- Lee, Y. K., Lee, S., & Kim, S. H. (2024). Real-Time Defect Monitoring of Laser

- Micro-drilling Using Reflective Light and Machine Learning Models. *International Journal of Precision Engineering and Manufacturing*, 25(1), 155–164. <https://doi.org/10.1007/s12541-023-00849-w>
- Liu, J., Zhu, X., Zhou, X., Qian, S., & Yu, J. (2022). Defect Detection for Metal Base of TO-Can Packaged Laser Diode Based on Improved YOLO Algorithm. *Electronics (Switzerland)*, 11(10), 1–14. <https://doi.org/10.3390/electronics11101561>
- Lou, Y. (2024). *RT-DETR-Based Multimodal Detection with Modality Attention and Feature Alignment*. 3(5).
- Luo, Y., Du, Y., Wang, Z., Mo, J., Yu, W., & Dou, S. (2025). DScanNet: Packaging Defect Detection Algorithm Based on Selective State Space Models. *Algorithms*, 18(6), 370. <https://doi.org/10.3390/a18060370>
- Ma, J., Ushiku, Y., & Sagara, M. (2022). The Effect of Improving Annotation Quality on Object Detection Datasets: A Preliminary Study. *IEEE Computer Society Conference on Computer Vision and Pattern Recognition Workshops, 2022-June*, 4849–4858. <https://doi.org/10.1109/CVPRW56347.2022.00532>
- Magar, V. M., & Shinde, V. B. (2014). Application of 7 Quality Control (7 QC) Tools for Continuous Improvement of Manufacturing Processes. *international Journal of Engineering Research and General Science*, 2(4), 364–371.
- Mahfoud, S., Derouich, A., El Ouanjli, N., Taoussi, M., & Mahfoud, M. El. (2021). A New Strategy-Based PID Controller Optimized by Genetic Algorithm for DTC of the Doubly Fed Induction Motor. *Lecture Notes in Networks and Systems, 211 LNNS*, 1687–1698. https://doi.org/10.1007/978-3-030-73882-2_153
- Majhi, R. K., & Waoo, A. A. (2024). Advances in Computer Vision: New Horizons and Ongoing Challenges. *ShodhKosh: Journal of Visual and Performing Arts*, 5(5), 431–438. <https://doi.org/10.29121/shodhkosh.v5.i5.2024.1893>
- Manoj, G., & Nireesh, J. (2020). an Empirical Study on the Conrol of Rejection Rate in Instrument Cluster Assembly Line By Using Quality Control Tools and Kaizen. *International Journal of Engineering Technologies and Management Research*, 7(9), 14–23. <https://doi.org/10.29121/ijetmr.v7.i9.2020.774>
- Olorunshola, O. E., Irhebhude, M. E., & Ewwiekpaefe, A. E. (2023). A Comparative Study of YOLOv5 and YOLOv7 Object Detection Algorithms. *Journal of Computing and Social Informatics*, 2(1), 1–12. <https://doi.org/10.33736/jcsi.5070.2023>
- Park, G., & Lee, Y. (2024). Wildfire Smoke Detection Enhanced by Image Augmentation with StyleGAN2-ADA for YOLOv8 and RT-DETR Models. *Fire*, 7(10). <https://doi.org/10.3390/fire7100369>
- Penati, A. (2025). *In-home medication : integrating multidisciplinary perspectives in design-driven pharma practices*.

- Powell, D., Magnanini, M. C., Colledani, M., & Myklebust, O. (2022). Advancing zero defect manufacturing: A state-of-the-art perspective and future research directions. *Computers in Industry*, 136, 103596. <https://doi.org/10.1016/j.compind.2021.103596>
- Psarommatis, F., Prouvost, S., May, G., & Kiritsis, D. (2020). Product Quality Improvement Policies in Industry 4.0: Characteristics, Enabling Factors, Barriers, and Evolution Toward Zero Defect Manufacturing. *Frontiers in Computer Science*, 2(August), 1–15. <https://doi.org/10.3389/fcomp.2020.00026>
- Psarommatis, F., Sousa, J., Mendonça, J. P., & Kiritsis, D. (2022). Zero-defect manufacturing the approach for higher manufacturing sustainability in the era of industry 4.0: a position paper. *International Journal of Production Research*, 60(1), 73–91. <https://doi.org/10.1080/00207543.2021.1987551>
- Purwono, Ma'arif, A., Rahmانيar, W., Fathurrahman, H. I. K., Frisky, A. Z. K., & Haq, Q. M. U. (2022). Understanding of Convolutional Neural Network (CNN): A Review. *International Journal of Robotics and Control Systems*, 2(4), 739–748. <https://doi.org/10.31763/ijrcs.v2i4.888>
- Radke, K. L., Kors, M., Müller-Lutz, A., Frenken, M., Wilms, L. M., Baraliakos, X., Wittsack, H. J., Distler, J. H. W., Abrar, D. B., Antoch, G., & Sewerin, P. (2023). Adaptive IoU Thresholding for Improving Small Object Detection: A Proof-of-Concept Study of Hand Erosions Classification of Patients with Rheumatic Arthritis on X-ray Images. *Diagnostics*, 13(1). <https://doi.org/10.3390/diagnostics13010104>
- Rahman, A., & Perdana, S. (2021). Analisis Perbaikan Kualitas Produk Carton Box di PT XYZ Dengan Metode DMAIC dan FMEA. *Jurnal Optimasi Teknik Industri (JOTI)*, 3(1), 33–37. <https://doi.org/10.30998/joti.v3i1.9287>
- Read, R. L., Bechard, N., Suturen, V., Zuiderwijk, A., & Mellenthin, M. (2025). The PolyVent educational platform: An open mechanical ventilation platform for research and education. *HardwareX*, 21(January), e00615. <https://doi.org/10.1016/j.ohx.2024.e00615>
- Reddy, S. S., Janarthanan, M., & Khan, I. U. (2025). *RT-DETR with Attention-Free Mechanism: A Step towards Scalable and Generalizable Traffic Sign Recognition. I.*
- Redmon, J., Divvala, S., Girshick, R., & Farhadi, A. (2016). You Only Look Once: Unified, Real-Time Object Detection Joseph. *Proceedings of the IEEE conference on computer vision and pattern recognition*. <https://doi.org/10.1145/3243394.3243692>
- Redmon, J., & Farhadi, A. (2017). YOLOv2 | YOLO9000 : Better, Faster, Stronger Joseph. *IEEE Xplore*, April, 187–213. http://www.worldscientific.com/doi/abs/10.1142/9789812771728_0012

- Redmon, J., & Farhadi, A. (2018). YOLOv3: An Incremental Improvement. *IEEE transactions on neural networks and learning systems*. <http://arxiv.org/abs/1804.02767>
- Richo, Adhitya, R. Y., Hasin, M. K., Syai'in, M., & Setiawan, E. (2023). Analisis Pengaruh Optimizer pada Model CNN untuk Identifikasi Cacat pada Perekat Kemasan Optimizer Analysis on the CNN Model for Identification Packaging Defects. *Jurnal SISFOTENIKA*, 13(2), 217–229. <http://sisfotenika.stmikpontianak.ac.id/index.php/ST>
- Rinjani, I., Wahyudin, W., & Nugraha, B. (2021). Analisis Pengendalian Kualitas Produk Cacat pada Lensa Tipe X Menggunakan Lean Six Sigma dengan Konsep DMAIC. *Unistek*, 8(1), 18–29. <https://doi.org/10.33592/unistek.v8i1.878>
- Rohimudin, R., Dwiputra, G. A., & Supriyadi, S. (2016). Analisis Defect pada Hasil Pengelasan Plate Konstruksi Baja dengan Metode Six Sigma. *Jurnal INTECH Teknik Industri Universitas Serang Raya*, 2(1), 1–10. <https://ejurnal.lppmunsera.org/index.php/INTECH/article/view/857>
- Roth, L., & Wybenga, G. (1967). The Packaging Designer's Book Of Patterns. In *Angewandte Chemie International Edition*, 6(11), 951–952.
- Safitri, V. A., Sari, L., & Gamayuni, R. R. (2019). Research and Development, Environmental Investments, to Eco-Efficiency, and Firm Value. *The Indonesian Journal of Accounting Research*, 22(03), 377–396. <https://doi.org/10.33312/ijar.446>
- Sager, C., Janiesch, C., & Zschech, P. (2021). A survey of image labelling for computer vision applications. *Journal of Business Analytics*, 4(2), 91–110. <https://doi.org/10.1080/2573234X.2021.1908861>
- Sahin, M. E., Ulutas, H., Yuce, E., & Erkok, M. F. (2023). Detection and classification of COVID-19 by using faster R-CNN and mask R-CNN on CT images. *Neural Computing and Applications*, 35(18), 13597–13611. <https://doi.org/10.1007/s00521-023-08450-y>
- Salehi, A. W., Khan, S., Gupta, G., Alabdullah, B. I., & Almjally, A. (2023). A Study of CNN and Transfer Learning in Medical Imaging: Advantages, Challenges, Future Scope. *Multidisciplinary Digital Publishing Institute*.
- Salvador, A., Gir, X., & Marqu, F. (2013). Faster R-CNN Features for Instance Search es. *IEEE Xplore*.
- Samad, A., Natsir, A. D. S. R., & Mustika Kadir, D. (2022). Identifikasi Kemasan Cacat Produk Rajungan Dengan Metode Six Sigma Pada PT. Kencana Bintang Terang Makassar. *Journal of Agro-industry Engineering Research*, 1(2), 24–31. <https://doi.org/10.61844/jaier.v1i2.354>
- Sapkota, R., Ahmed, D., & Karkee, M. (2024). Comparing YOLOv8 and Mask R-CNN for instance segmentation in complex orchard environments. *Artificial*

Intelligence in Agriculture, 13, 84–99.
<https://doi.org/10.1016/j.aiia.2024.07.001>

Shanghai DE. (2025). *DePrintedBox*.

Sholahuddin, M. R., Harika, M., Awaludin, I., Dewi, Y. C., Fauzan, F. D., Sudimulya, B. P., & Widarta, V. P. (2023). Optimizing YOLOv8 for Real-Time CCTV Surveillance: A Trade-off Between Speed and Accuracy. *Jurnal Online Informatika*, 8(2), 261–270. <https://doi.org/10.15575/join.v8i2.1196>

Shorten, C., & Khoshgoftaar, T. M. (2019). A survey on Image Data Augmentation for Deep Learning. *Journal of Big Data*, 6(1). <https://doi.org/10.1186/s40537-019-0197-0>

Sumit, Shrishti Bisht, Sunita Joshi, & Urvi Rana. (2024). Comprehensive Review of R-CNN and its Variant Architectures. *International Research Journal on Advanced Engineering Hub (IRJAEH)*, 2(04), 959–966. <https://doi.org/10.47392/irjaeh.2024.0134>

Suprijono, H., Hakim, E. A., Nugroho, D. S., & Islahudin, N. (2022). Identifikasi Jenis Cacat Pada Produk Industri Logam Komponen Kapal Menggunakan Pengolahan Citra dan Jaringan Syaraf Tiruan. *Seminar Keinsinyuran Program Studi Program Profesi Insinyur*, 2(1), 1–8. <https://doi.org/10.22219/skpsppi.v3i1.4992>

Suseno, & Kalid, S. I. (2022). Pengendalian Kualitas Cacat Produk Tas Kulit Dengan Metode Failure Mode and Effect Analysis (Fmea) Dan Fault Tree Analysis (Fta) Di Pt Mandiri Jogja Internasional. *Jurnal Cakrawala Ilmiah*, 1(6), 1307–1320. <https://doi.org/10.53625/jcijurnalcakrawalailmiah.v1i6.1131>

Suwarno, S., & Kevin, K. (2020). Analysis of Face Recognition Algorithm: Dlib and OpenCV. *Journal of Informatics and Telecommunication Engineering*, 4(1), 173–184. <https://doi.org/10.31289/jite.v4i1.3865>

Szeliski, R. (2011). Computer vision: algorithms and applications. *Choice Reviews Online*, 48(09), 48-5140-48–5140. <https://doi.org/10.5860/choice.48-5140>

Terven, J., Córdova-Esparza, D. M., & Romero-González, J. A. (2023). A Comprehensive Review of YOLO Architectures in Computer Vision: From YOLOv1 to YOLOv8 and YOLO-NAS. *Machine Learning and Knowledge Extraction*, 5(4), 1680–1716. <https://doi.org/10.3390/make5040083>

Thanh, B. D., Anh, M. T., Khanh, G. D., Dong, T. C., & Huong, N. T. (2025). *SGDR-YOLOv8: Training Method for Rice Diseases Detection Using YOLOv8 BT - Advances in Computing and Data Sciences* (M. Singh, V. Tyagi, P. K. Gupta, J. Flusser, T. Ören, A. R. Cherif, & R. Tomar (ed.); hal. 170–180). Springer Nature Switzerland.

Tian, Z., Shen, C., Wang, X., & Chen, H. (2021). BoxInst: High-Performance Instance Segmentation with Box Annotations. *Proceedings of the IEEE*

- Computer Society Conference on Computer Vision and Pattern Recognition*, 5439–5448. <https://doi.org/10.1109/CVPR46437.2021.00540>
- Trianingsih, A., Amalia, N. R., Naila, A. M., & Anggraeny, F. T. (2024). Deteksi Dan Klasifikasi Cacat Pada Produk Kain Dengan Metode Pengolahan Citra Digital. *Jurnal Ilmiah Teknologi Informasi dan Robotika*, 6(2), 107–117. <https://doi.org/10.33005/jifti.v6i2.164>
- Twede, D., Selke, S. E. M., Kamdem, D.-P., & Pira, S. (2015). Second Edition Cartons, Crates and Corrugated Board Handbook of Paper and Wood Packaging Technology David Shires, BA (Hons). *DEStech Publications*.
- Vijayakumar, A., Vairavasundaram, S., Koilraj, J. A. S., Rajappa, M., Kotecha, K., & Kulkarni, A. (2024). Real-time visual intelligence for defect detection in pharmaceutical packaging. *Scientific Reports*, 14(1), 1–23. <https://doi.org/10.1038/s41598-024-69701-z>
- Viswanatha, R, C., & A., R. (2022). Real Time Object Detection System with YOLO and CNN Models: A Review. *Journal of Xi'an University of Architecture & Technology*, XIV(7), 144–151. <http://arxiv.org/abs/2208.00773>
- Voulodimos, A., Doulamis, N., Doulamis, A., & Protopapadakis, E. (2018). Deep Learning for Computer Vision: A Brief Review. *Computational Intelligence and Neuroscience*, 2018. <https://doi.org/10.1155/2018/7068349>
- Vu, T. T. H., Pham, D. L., & Chang, T. W. (2022). A YOLO-based Real-time Packaging Defect Detection System. *Procedia Computer Science*, 217(2022), 886–894. <https://doi.org/10.1016/j.procs.2022.12.285>
- Wang, D., Zhu, H., Zhao, Y., & Shi, J. (2025). A Method for Constructing a Loss Function for Multi-Scale Object Detection Networks. *Sensors*, 25(6). <https://doi.org/10.3390/s25061738>
- Wang, G., Chen, Y., An, P., Hong, H., Hu, J., & Huang, T. (2023). UAV-YOLOv8: A Small-Object-Detection Model Based on Improved YOLOv8 for UAV Aerial Photography Scenarios. *Sensors*, 23(16). <https://doi.org/10.3390/s23167190>
- Wang, J., Dai, H., Chen, T., Liu, H., Zhang, X., Zhong, Q., & Lu, R. (2023). Toward surface defect detection in electronics manufacturing by an accurate and lightweight YOLO-style object detector. *Scientific Reports*, 13(1), 1–12. <https://doi.org/10.1038/s41598-023-33804-w>
- Wang, S. (2024). Evaluation of impact of image augmentation techniques on two tasks: Window detection and window states detection. *Results in Engineering*, 24(November). <https://doi.org/10.1016/j.rineng.2024.103571>
- Wang, Y., & Stone, R. B. (2021). Box Folding Machine Design by Using Product Design Method Functional Based Model. *Journal of Physics: Conference Series*, 1852(4), 0–9. <https://doi.org/10.1088/1742-6596/1852/4/042017>

- Wang, Y., Zhang, K., Wang, L., & Wu, L. (2024). An Improved YOLOv8 Algorithm for Rail Surface Defect Detection. *IEEE Access*, 12(March), 44984–44997. <https://doi.org/10.1109/ACCESS.2024.3380009>
- Waruwu, M. (2024). Metode Penelitian dan Pengembangan (R&D): Konsep, Jenis, Tahapan dan Kelebihan. *Jurnal Ilmiah Profesi Pendidikan*, 9(2), 1220–1230. <https://doi.org/10.29303/jipp.v9i2.2141>
- Widiastuti, H., Surbakti, S. E., Restu, F., Albana, M. H., & Saputra, I. (2019). Identifikasi Cacat Produk Dan Kerusakan Mold Pada Proses Plastic Injection Molding. *Jurnal Teknologi dan Riset Terapan (JATRA)*, 1(2), 76–80. <https://doi.org/10.30871/jatra.v1i2.1805>
- Xiao, L., Wu, B., & Hu, Y. (2020). Surface Defect Detection Using Image Pyramid. *IEEE Sensors Journal*, 20(13), 7181–7188. <https://doi.org/10.1109/JSEN.2020.2977366>
- Yang, J., Zeng, A., Li, F., Liu, S., Zhang, R., & Zhang, L. (2023). Neural Interactive Keypoint Detection. *Proceedings of the IEEE International Conference on Computer Vision*, 15076–15086. <https://doi.org/10.1109/ICCV51070.2023.01388>
- Yang, X., Han, M., Tang, H., Li, Q., & Luo, X. (2020). Detecting Defects with Support Vector Machine in Logistics Packaging Boxes for Edge Computing. *IEEE Access*, 8, 64002–64010. <https://doi.org/10.1109/ACCESS.2020.2984539>
- Yash Goyal. (2024). Comparative Study of Microcontoller : ARDUINO. *International Journal for Research in Applied Science & Engineering Technology (IJRASET)*, July.
- Yue, X., Qi, K., Na, X., Zhang, Y., Liu, Y., & Liu, C. (2023). Improved YOLOv8-Seg Network for Instance Segmentation of Healthy and Diseased Tomato Plants in the Growth Stage. *Agriculture (Switzerland)*, 13(8). <https://doi.org/10.3390/agriculture13081643>
- Yuliza, Y., Muwardi, R., Rhozaly, M., Lenni, L., Yunita, M., & Yehezkiel, G. E. (2023). Fast Human Recognition System on Real-Time Camera. *Jurnal Ilmiah Teknik Elektro Komputer dan Informatika*, 9(4), 895–903. <https://doi.org/10.26555/jiteki.v9i4.27009>
- Zaman, K., Zhaoyun, S., Shah, S. M., Shoaib, M., Lili, P., & Hussain, A. (2022). Driver Emotions Recognition Based on Improved Faster R-CNN and Neural Architectural Search Network. *Symmetry*, 14(4). <https://doi.org/10.3390/sym14040687>
- Zewen, L., Fan, L., Wenjie, Y., Shouheng, P., & Jun, Z. (2021). A survey of convolutional neural networks: analysis, applications, and prospects. *IEEE transactions on neural networks and learning systems*, 33(12), 6999–7019.
- Zhao, Y., Fang, Y., Yang, J., Zhang, W., Ge, X., Cao, S., & Xia, X. (2020). An

implementation method for an inductive proximity sensor with an attenuation coefficient of 1. *Energies*, 13(24), 1–15. <https://doi.org/10.3390/en13246482>

Zheng, Z., Wang, P., Liu, W., Li, J., Ye, R., & Ren, D. (2020). Distance-IoU loss: Faster and better learning for bounding box regression. *AAAI 2020 - 34th AAAI Conference on Artificial Intelligence*, 2, 12993–13000. <https://doi.org/10.1609/aaai.v34i07.6999>