

Ministry of education and science of Ukraine
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Real-Time Object Detection Algorithms for UAV Companion Computers

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Research Objective

- Develop real-time object detection system for UAV companion computers
- Create a retrainable pipeline for domain-specific datasets
- Evaluate performance in military and civilian target detection

Why UAV Object Detection Matters

- UAVs are versatile tools for various sectors
- Detection is the initial stage of decision-making in autonomous systems
- Autonomous systems can increase mission success rates
- Technology is easily scalable with domain-specific data for model training

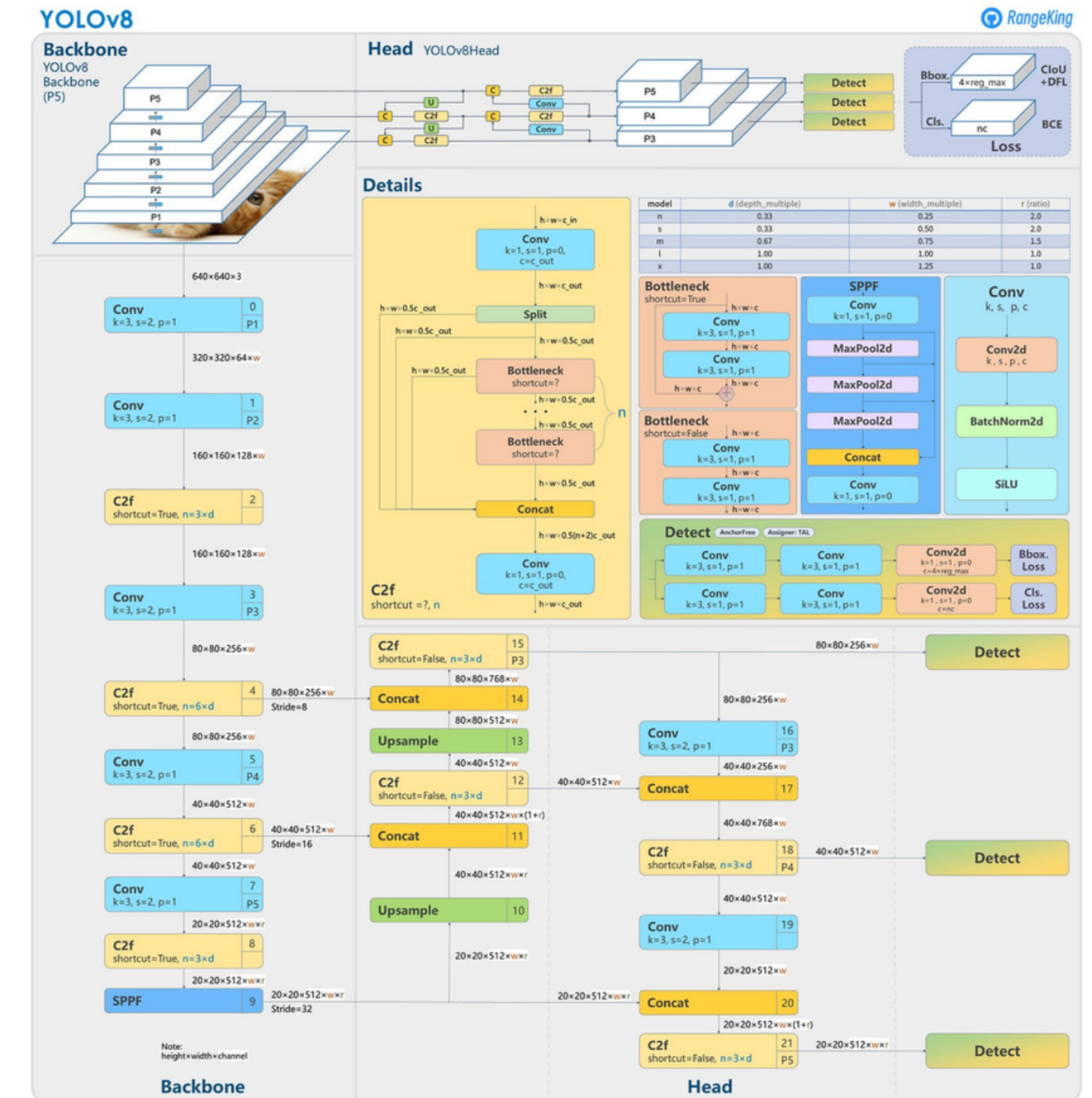


Scope of Experiments

- Initial Idea:
 - Train YOLOv8 model on domain-specific data
- Challenges:
 - Lack of data
 - Small object detection difficulties
 - Need for real-time inference
- Final Approach:
 - A pipeline with pre-processing of data for feeding it into the final network yolov8

Object Detection Algorithm Comparison

- Multi-stage detectors (R-CNN family)
 - High accuracy but computationally expensive
- One-stage detectors (YOLO family)
 - Better performance-efficiency tradeoff
- Transformer-based models (DETR)
 - Innovative but resource-intensive



Selected YOLOv8 for balanced performance and efficiency

Data Pipeline Architecture

- Dataset collection from multiple sources
- Duplicate removal using perceptual hashing
- Class remapping to reduce complexity (92 → 8 classes)
- Data filtering and normalization
- Custom augmentation pipeline
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Data augmentations

- Downscale: simulates lower quality cameras
- ImageCompression: applies realistic compression artifacts
- ShotNoise: adds random noise for sensor simulation
- GaussianBlur: simulates motion blur and focus issues
- Goal: Increase model robustness to real-world conditions



Implementation & Evaluation

- Model training on NVIDIA L4 Tensor Core GPU
- Performance metrics tracking using TensorBoard
- Comparison of baseline models:
 - Pre-trained COCO (mAP@0.50:0.95 = 37.3%)
 - Without augmentations (mAP@0.50:0.95 = 50.4%)
 - With augmentations (mAP@0.50:0.95 = 48.9%)



Challenges & Solutions

- Small Object Detection
 - Primary issue with civilian vehicles and people classes
 - Future work: specialized architecture modifications
- Augmentation Impact
 - Reduced performance with augmentations
 - Demonstrates tradeoff between lab metrics and real-world performance
- Successfully exported to Rockchip format

Future prospects

- Improve small object detection performance
- Try to implement different loss functions for class-specific optimization
- Deploy and test on actual UAV hardware
- Track real-world performance metrics