Moalty Foam Mattress Object Detection

Using YOLOv8 Deep Learning Architecture

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June 2025

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1. Project Overview

This project implements an automated mattress detection system using state-of-the-art computer vision techniques. The system can accurately detect foam mattresses in various settings, which can be used for quality control, inventory management, and production monitoring in mattress manufacturing environments.

The project utilizes the YOLOv8 (You Only Look Once) object detection architecture, which is known for its speed and accuracy in real-time detection tasks. The model was trained on a custom dataset of foam mattresses collected from various sources.

2. Deep Learning Architecture

2.1 YOLOv8 Architecture

The project employs the YOLOv8l (large) model, which consists of:

- **Backbone**: CSPDarknet with Cross-Stage Partial connections (375 layers)
- **Neck**: Path Aggregation Network (PAN) for feature fusion across different levels
- **Head**: Detection head that predicts bounding boxes, objectness scores, and class probabilities

2.2 Network Structure

- **Input Layer**: 960×960×3 image input (RGB)
- **Hidden Layers**: 375+ convolutional layers with skip connections and feature pyramid networks
- **Output Layers**: Multi-scale prediction heads at three different resolutions (80×80, 40×40, 20×20) for detecting objects of various sizes

> YOLOv8l contains approximately 43.7 million parameters, making it powerful enough for accurate detection while maintaining reasonable inference speed.

3. Training Configuration

3.1 Activation Functions

The network employs multiple activation functions:

- **SiLU (Swish)**: Primary activation function used throughout the network for non-linearity
- **Leaky ReLU**: Used in some parts of the backbone network
- **Sigmoid**: Used for objectness prediction and confidence scoring

3.2 Error Minimization

The model was trained using a combination of loss functions:

- **Box Loss**: Complete IoU (CIoU) loss for bounding box regression that considers overlap, distance, and aspect ratio
- **Classification Loss**: Binary Cross-Entropy (BCE) with logits for class prediction
- **Objectness Loss**: Binary Cross-Entropy for confidence score prediction

3.3 Training Parameters

Parameter	Value	Description
Epochs	200	Maximum number of training epochs
Batch Size	8	Number of images processed in each training batch
Input Size	960×960	Input image resolution for training
Learning Rate	0.01	Initial learning rate with cosine annealing scheduler
Optimizer	SGD	Stochastic Gradient Descent with momentum
Momentum	0.937	Momentum factor for SGD optimizer
Weight Decay	0.0005	L2 regularization to prevent overfitting
Early Stopping Patience	35	Number of epochs with no improvement before stopping

4. Dataset

The dataset was collected manually through multiple sources:

- On-site visits to the Moalty Foam Mattress factory
- Online sources including product images and stock photos
- Custom photoshoots of various mattress types and arrangements

The dataset was then augmented using various Python libraries to increase its size and variance:

- **Albumentations**: For geometric transformations and color adjustments
- **imgaug**: For complex image augmentation pipelines

Data augmentation techniques applied during training included:

- Horizontal flipping (probability: 0.5)
- Translation (up to 10% of image dimensions)
- Scale variations (up to 50%)
- Mosaic augmentation (combining 4 images)
- HSV color space augmentations

4.1 Factory Visit Documentation

Our team visited the Moalty Foam Mattress factory to gather first-hand data and understand the manufacturing process. This helped us create a more accurate detection model tailored to real-world production environments.

5. Model Performance

5.1 Evaluation Metrics

Metric	Value	Description
Precision	0.950	Proportion of correct positive predictions

Recall	0.898	Proportion of actual positives correctly identified
mAP50	0.932	Mean Average Precision at 50% IoU threshold
mAP50-95	0.784	Mean Average Precision across IoU thresholds from 50% to 95%

> These metrics indicate excellent performance, with the model achieving high precision and recall values. The mAP50 score of 0.932 shows that the model can accurately detect mattresses with good localization accuracy.

5.2 Performance Curves

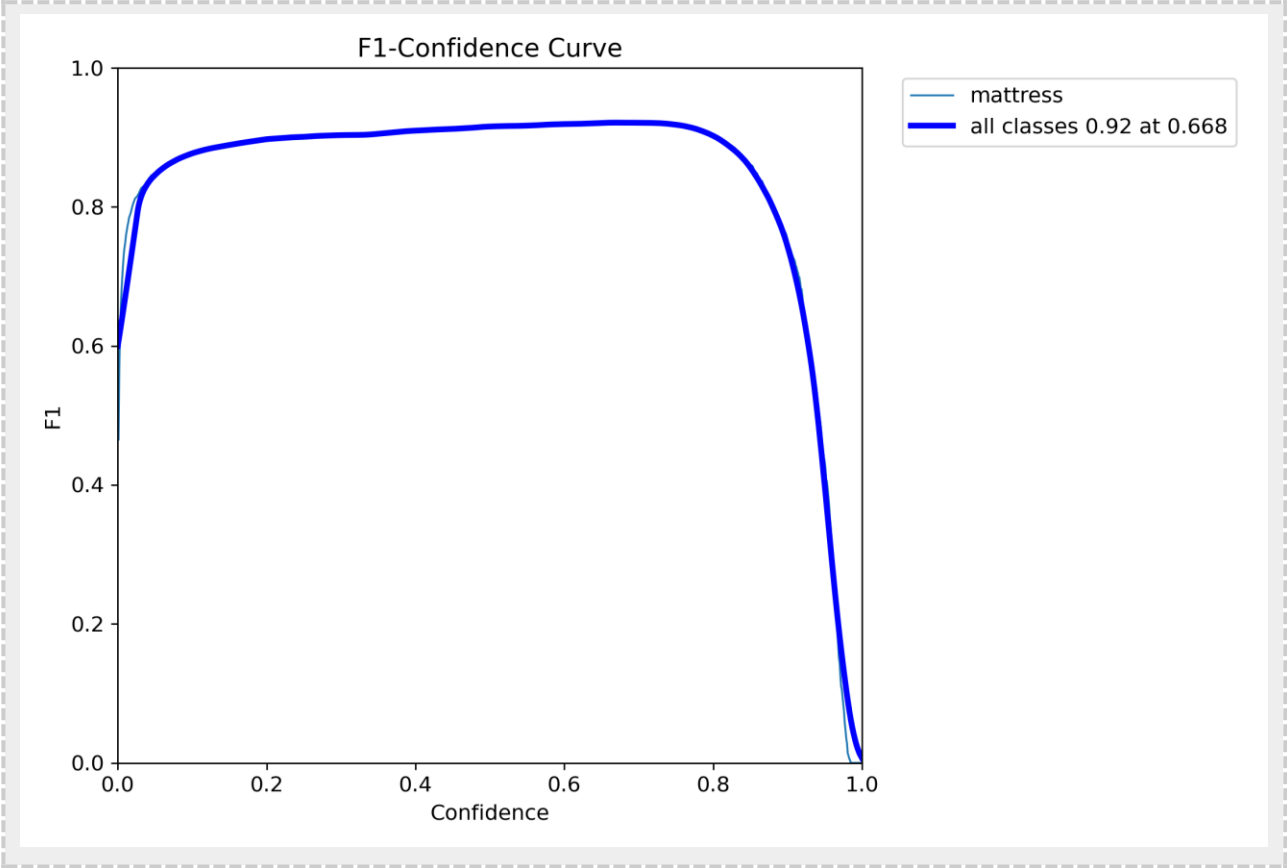

Figure 7: F1 score across different confidence thresholds

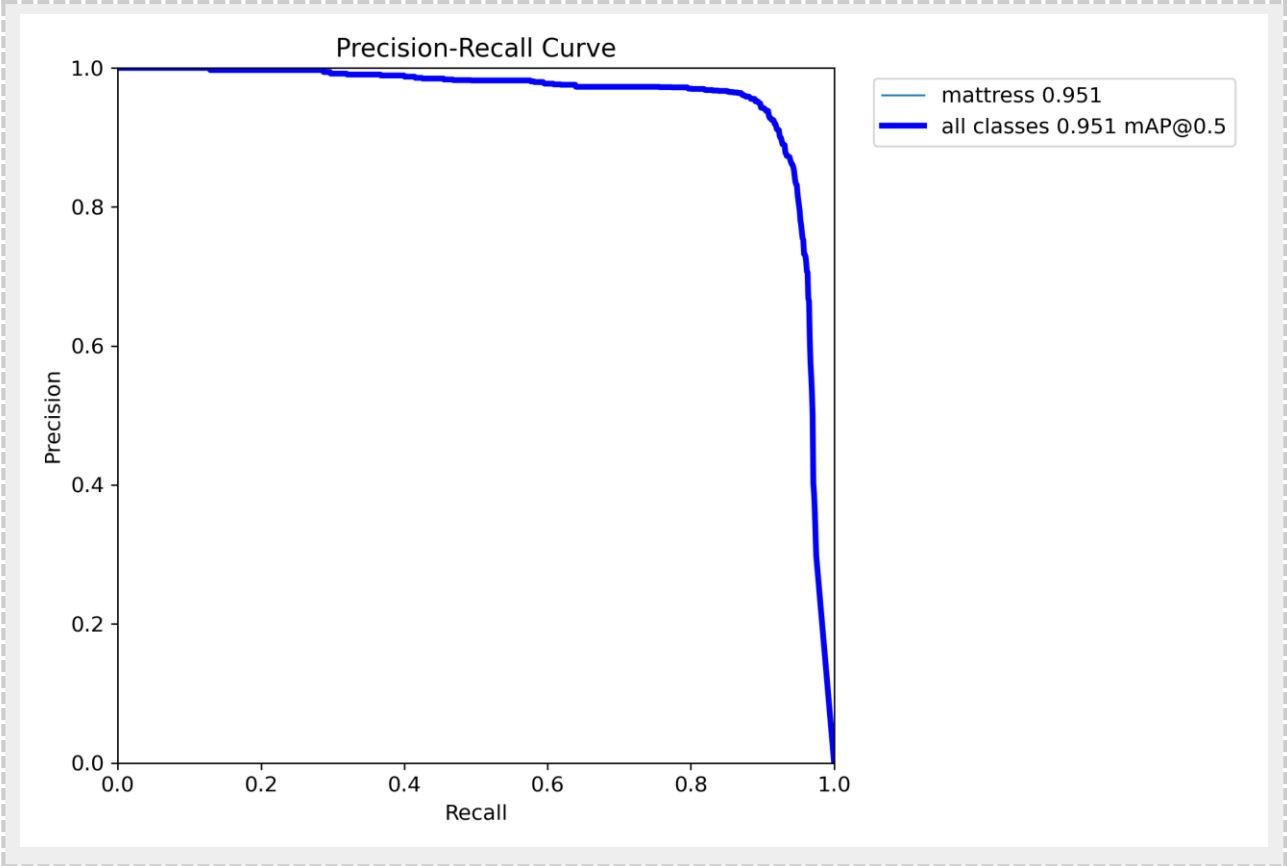

Figure 8: Precision-Recall curve showing trade-off between precision and recall

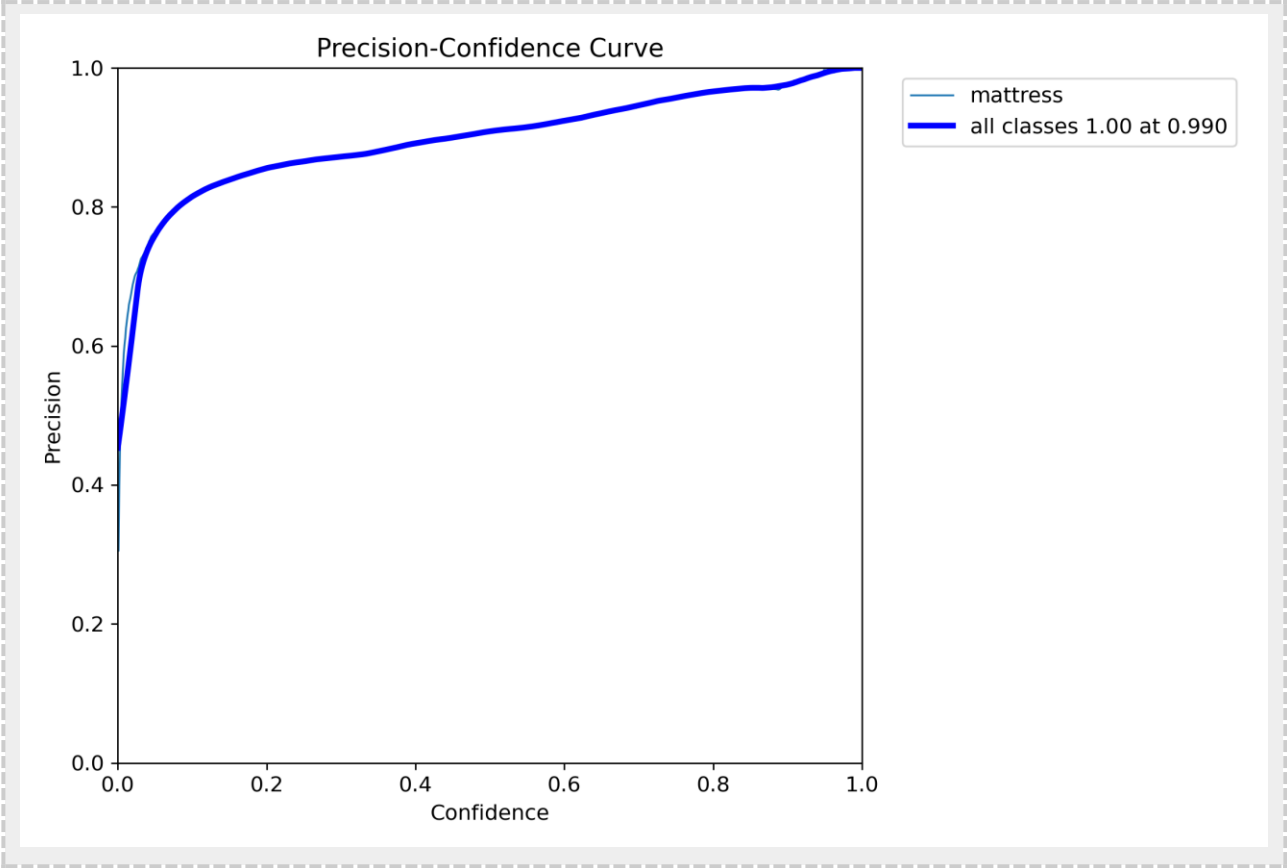

Figure 9: Precision across different confidence thresholds

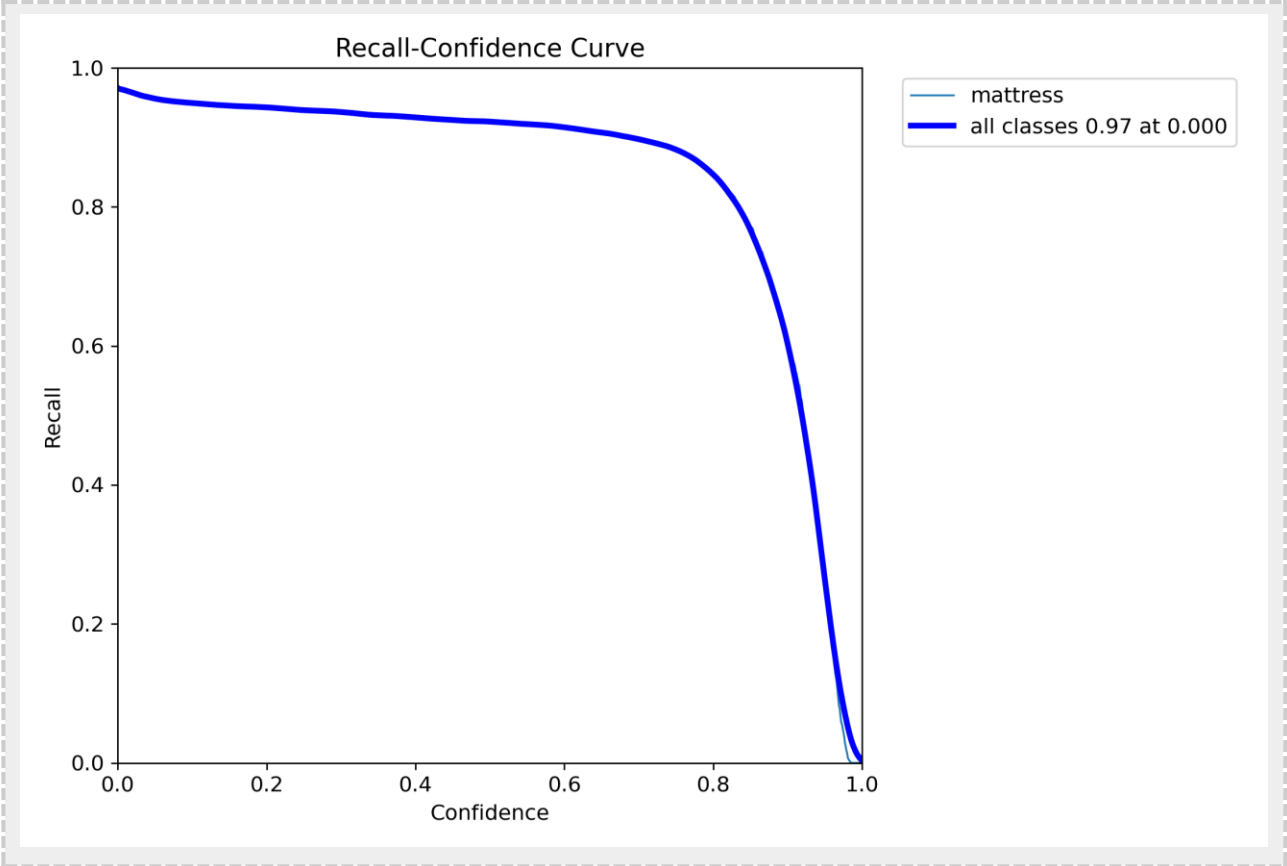

Figure 10: Recall across different confidence thresholds

5.3 Confusion Matrix

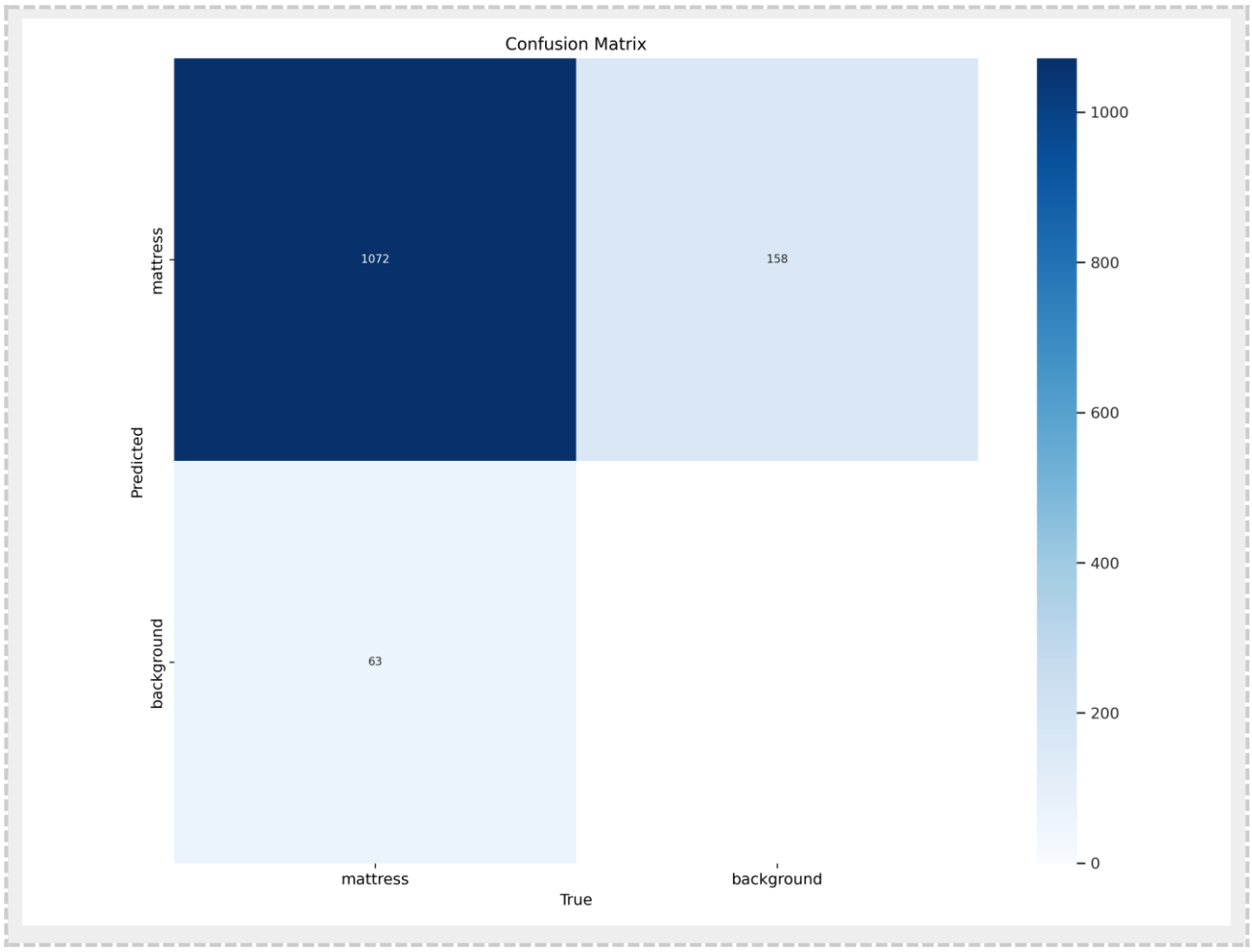

Figure 11: Confusion matrix showing model predictions vs ground truth

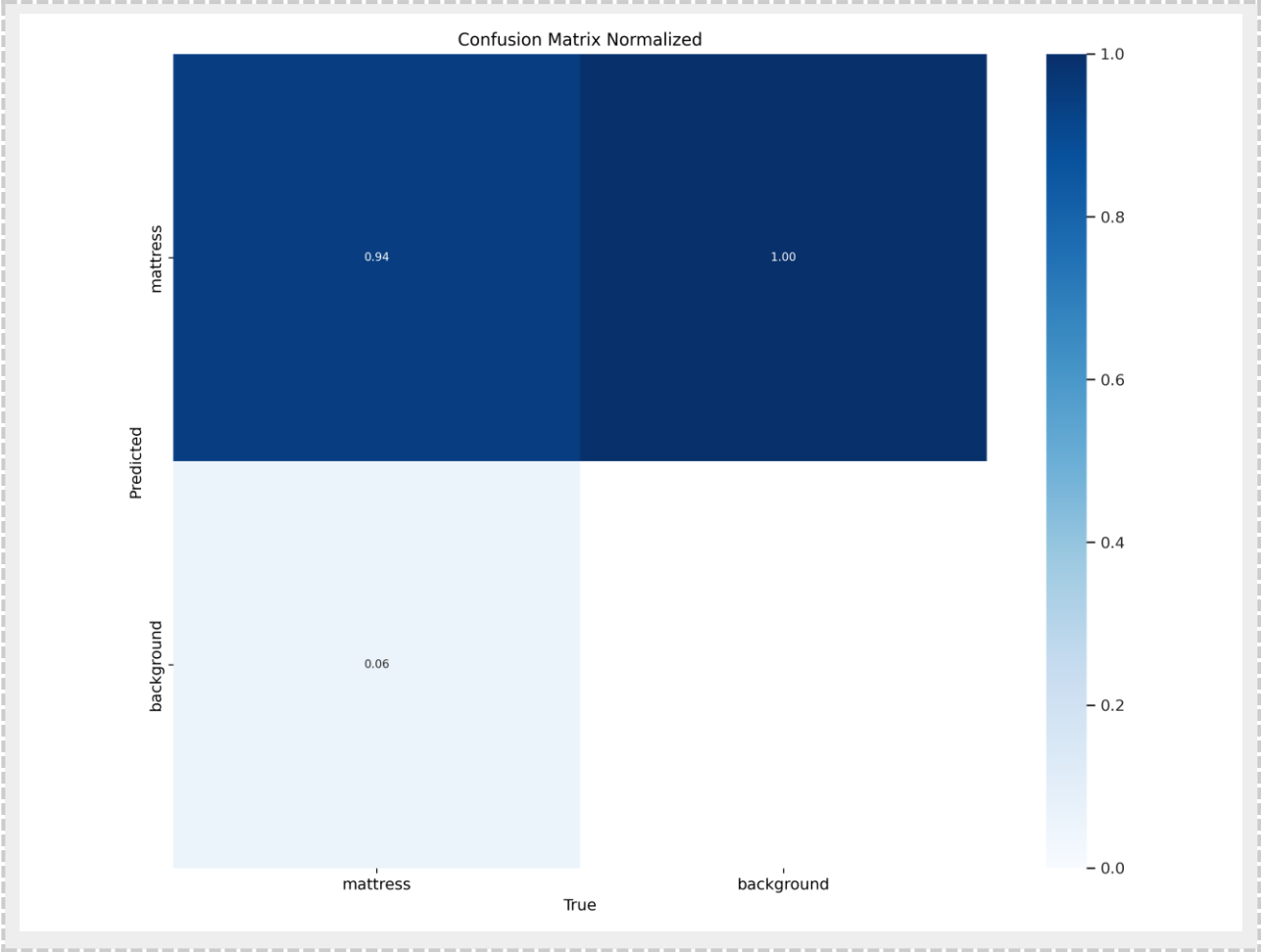

Figure 12: Normalized confusion matrix showing performance proportions

5.4 Validation Results

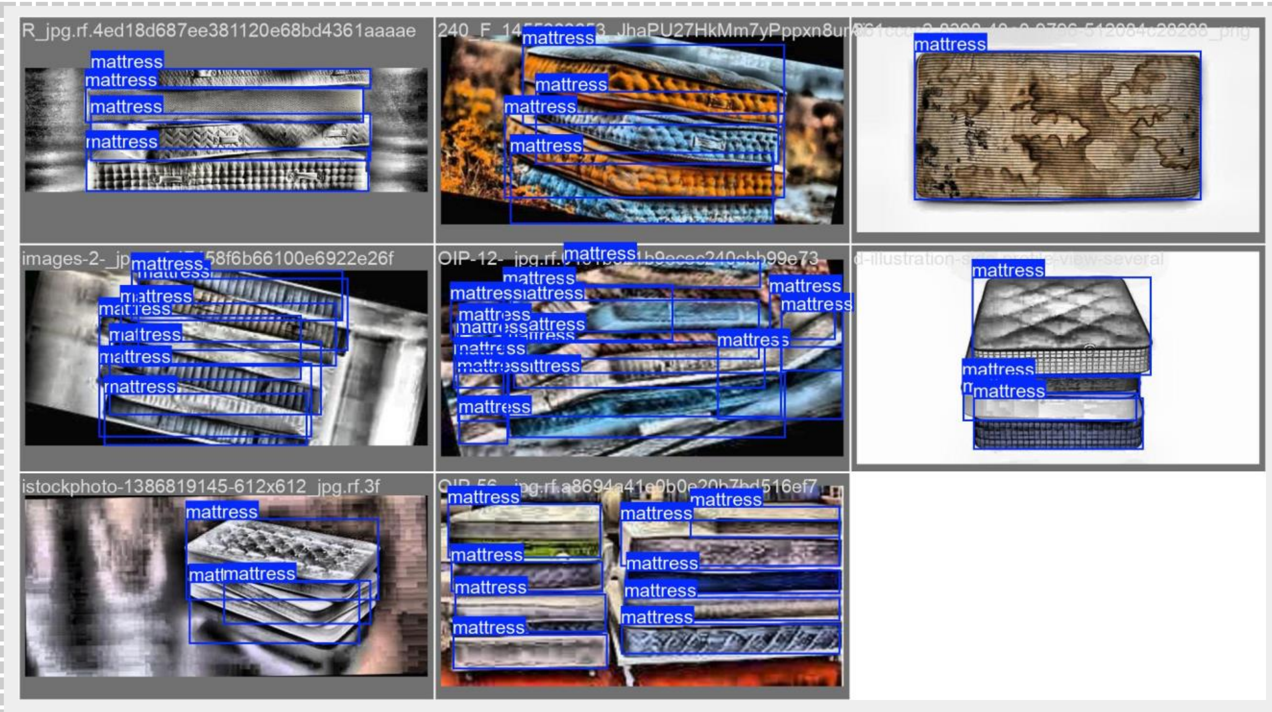

Figure 13: Validation batch with ground truth annotations

Figure 14: Validation batch with model predictions

6. Deployment and Application

The trained model can be deployed for various applications in the mattress manufacturing industry:

- Quality control during production
- Automated inventory management
- Real-time monitoring of mattress stacking and storage

The inference can be performed on both images and videos using the Analyze_Media.py script, which provides visualization of detections with bounding boxes and confidence scores.

7. Resources

The following resources are available for further exploration:

- **Dataset Link**: https://drive.google.com/drive/folders/1clGe-pQigSqK6Yd0Wyver-_UqEWV54VS?usp=sharing
- **Trained Model File**: https://drive.google.com/drive/folders/1mYYLTLmHr2IMzrRaiaPeqN4GwykRCsyg?usp=sharing