Evaluation of Neural Object Detection Models for Human Detection in Infrared Images

PROJECT REPORT T1000

from the course of studies Computer Science - Artificial Intelligence

at the Cooperative State University Baden-Württemberg
Ravensburg Campus Friedrichshafen

by

Lukas Florian Richter

29.07.2025

Completion Time:	16 Wochen
Student ID, Course:	None, TIK24
Company:	Airbus Defence & Space, Taufkirchen
Supervisor in the Company:	René Loeneke

Declaration of Authorship

In accordance with clause 1.1.13 of Annex 1 to §§ 3, 4 and 5 of the Dual Hochschule Baden-Württemberg's Study and Examination Regulations for Bachelor's degree programs in the field of Technology, dated 29.09.2017. I hereby declare that I have written my thesis on the topic:

Evaluation of Neural Object Detection Models for Human Detection in Infrared Images

independently and have used no other sources or aids than those specified. I further declare that all submitted versions are identical.

Taufkirchen 29.07.2025

Lukas Florian Richter

Abstract

This project report evaluates the performance of neural object detection models for detecting humans in infrared images. The study focuses on comparing different variations of the SSD (Single Shot Mutlibox Detector) model, assessing their accuracy and inference speed, and identifying the most suitable model for the given task. Additionally

Table of Contents

List of Figures

List of Tables

Code Snippets

List of Acronyms

AI	Artificial Intelligence
AP	Average Precision
API	Application Programming Interface
CNN	Convolutional Neural Network
COCO	Common Objects in Context
CPU	Central Processing Unit
CUDA	Compute Unified Device Architecture
DL	Deep Learning
FC	Fully Connected
FN	False Negative
FP	False Positive
FP16	16-bit floating point
FP32	32-bit floating point
FPS	Frames per Second
GAN	Generative Adversarial Network
GPU	Graphics Processing Unit
HNM	Hard-Negative Mining
HTTP	Hypertext Transfer Protocol
HTTPS	Hypertext Transfer Protocol Secure
INT8	8-bit integer
IR	Infrared
IoU	Intersection over Union

ML	Machine Learning
MPS	Metal Performance Shaders
NMS	Non-Maximum Suppression
NN	Neural Network
OSI	Open Systems Interconnection
R-CNN	Region-based Convolutional Neural Network
RAM	Random Access Memory
REST	Representational State Transfer
RGB	Red, Green, Blue
RNN	Recurrent Neural Network
ROI	Region of Interest
RPN	Region Proposal Network
ReLU	Rectified Linear Unit
ResNet	Residual Network
SGD	Stochastic Gradient Descent
SSD	Single Shot MultiBox Detector
TCP	Transmission Control Protocol
TN	True Negative
TP	True Positive
TPU	Tensor Processing Unit
VGG	Visual Geometry Group
VOC	Visual Object Classes
YOLO	You Only Look Once
mAP	mean Average Precision

Glossary

Batch A batch is a group of data processed together as a unit.

Batch Gradient Descent Batch Gradient Descent is an optimization algorithm used to minimize the loss function in machine learning models by iteratively updating the model parameters based on their gradients with respect to the

Exploit An exploit is a method or piece of code that takes advantage of vulnerabilities in software, applications, networks, operating systems, or hardware, typically for malicious purposes.

Patch A patch is data that is intended to be used to modify an existing software resource such as a program or a file, often to fix bugs and security vulnerabilities.

Stochastic Gradient Descent Stochastic Gradient Descent (SGD) is an optimization algorithm used to minimize the loss function in machine learning models by iteratively updating the model parameters based on their partial derivatives with

Vulnerability A Vulnerability is a flaw in a computer system that weakens the overall security of the system.

1 Introduction

Introduces the problem of human detection in thermal images and the importance of infrared surveillance systems for security applications. Outlines the thesis objectives and structure.

2 Literature Review and Theoretical Background

Reviews existing object detection methods, focusing on SSD architectures, and examines previous work on thermal image processing and human detection in infrared imagery.

2.1 Object Detection Fundamentals

Covers basic principles of computer vision and object detection, including traditional methods and deep learning approaches.

2.2 Single Shot MultiBox Detector (SSD) Architecture

Detailed explanation of SSD model architecture, inclusing backbone networks (VGG, ResNet) and detection mechanisms.

2.3 Thermal Image Processing

Discusses characteristics of thermal images, preprocessing techniques (inversion, edge enhancement), and challenges specific to infrared imagery.

3 Methodology

Describes the experimental setup, datasets used, model configuraitons, and evaluation metrics employed in the study.

3.1 Dataset Description

Details the thermal image datasets (FLIR ADAS v2, AAU-PD-T, OSU-T, M3FD, KAIST-CVPR15) and their characteristics.

3.2 Model Implementation

Explains the implementation of SSD models with different backbones and preprocessing configurations.

3.3 Experimental Design

Outlines the systematic approach to comparing model variants and the evaluation framework.

4 Results and Analysis

Presents comprehensive results from model training and evaluation, including performance comparisons across different configurations.

4.1 Training Performance

Reports training loss curves, converegence behavior, and computational requirements for different mdoel variants.

4.2 Detection Accuracy Analysis

Provides detailed mAP scores and detection performance metrics for each model configuraiton and preprocessing technique.

4.3 Preprocessing Impact Evaluation

Analzyes the effects of image inversion and edge enhancement on detection performance.

5 Discussion

Interprets the results, discusses the practical implications for surveillance systems, adn addresses limitations of the current approach.

5.1 Model Performance Comparison

Compares SSD-VGG and SSD-ResNer performance and discusses trade-offs between accuracy and computational efficiency.

5.2 Practical Deployment Considerations

Discuesses real-world application scenarios and system requirements for thermal surveillance.

6 Conclusion and Future Work

Summarizes key findings, contributions to the field, and suggeststst directions for future research in thermal image human detection.

7 Examples

Just a couple of examples to demonstrate proper use of the typst template and its functions.

7.1 Acronyms

Use the `acr` function to insert acronyms, which looks like this Hypertext Transfer Protocol (HTTP).

Application Programming Interfaces are used to define the interaction between different software systems.

REST is an architectural style for networked applications.

7.2 Glossary

Use the `gls` function to insert glossary terms, which looks like this:

A Vulnerability is a weakness in a system that can be exploited.

7.3 Lists

Create bullet lists or numbered lists.

- This
- is a
- bullet list

1. It also
2. works with
3. numbered lists!

7.4 Figures and Tables

Create figures or tables like this:

7.4.1 Figures

Figure 1 — Image Example

7.4.2 Tables

	Area	Parameters
cylinder.svg	$\pi h \frac{D^2 - d^2}{4}$ (1)	h: height D: outer radius d: inner radius
tetrahedron.svg	$\frac{\sqrt{2}}{12} a^3$ (2)	a: edge length

Table 1 — Table Example

7.5 Code Snippets

Insert code snippets like this:

```
const ReactComponent = () => {
  return (
    <div>
      <h1>Hello World</h1>
    </div>
  );
};

export default ReactComponent;
```

Listing 1 — Codeblock Example

7.6 References

Cite like this K. R. Akshatha, A. K. Karunakar, S. B. Shenoy, A. K. Pai, N. H. Nagaraj, and S. S. Rohatgi [1]. Or like this [2].

You can also reference by adding `<ref>` with the desired name after figures or headings.

For example this Table 1 references the table on the previous page.

8 Conclusion

References

[1] K. R. Akshatha, A. K. Karunakar, S. B. Shenoy, A. K. Pai, N. H. Nagaraj, and S. S. Rohatgi, “Human Detection in Aerial Thermal Images Using Faster R-CNN and SSD Algorithms,” *Electronics*, vol. 11, no. 7, p. 1151, Jan. 2022, doi: 10.3390/electronics11071151.

[2] M. A. Farooq, P. Corcoran, C. Rotariu, and W. Shariff, “Object Detection in Thermal Spectrum for Advanced Driver-Assistance Systems (ADAS),” no. arXiv:2109.09854. arXiv, Oct. 2021. doi: 10.48550/arXiv.2109.09854.