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16 Publication

Fei Hu, Iftikhar Rasheed. "Deep Learning and Its Applications for Vehicle Network... <1%

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Student Project Approval Form

KF7029 MSc Computer Science and Digital Technologies Project

You should use this document in all cases. If your project approval form is deemed high risk your supervisor will need to undertake additional ethics approval work. Please complete this document and discuss your study with your supervisor before you collect any data. ***Failure to complete this document and have all aspects signed off and approved by the module team risks a notable deduction in your grade and may risk a case of Academic Misconduct.***

Please ensure that your project meets the conditions of the existing module level ethics application (available on Blackboard). If it does not, then you will need to submit a full ethics application instead via the main university ethics system.

Student name:	Kalivemula Vignesh Goud
Student ID:	W24035700
Programme name (e.g., MSc Computer Science, BSc Data Science):	MSc Advanced Computer Science With Advanved Practice.
Project Title:	IR Reasoner: Real-Time Infrared Object Detection by Visual Reasoning (CVPRW 2023)
Supervisor Name:	Jiguang Li
What type of Data Collection are you using, if any (check all that apply):	☐ Questionnaire or Survey ☐ Interviews ☐ User Studies ☐ Data Generated by Systems ✓ ☒ Secondary Data Analysis ✓ ☒ No data collected from humans
Does your project involve the development of Machine Learning algorithms and/or creation of novel AI systems or tools?	☐ No ✓ ☒ Yes

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Please answer the following questions and complete all information in full:

1. Human Participants: does your study involve human participants YES/NO

If ***YES***, please answer the following questions and **ensure that you include your participant information sheet, participant consent sheet and any participant recruitment materials/permission letters for participants in Appendix B**:

1a) Who are your participants and what is the inclusion criteria you will be using?	NA
1b) How many participants will you recruit and from where?	NA
1c) Are there any exclusion criteria (reasons why people should not participate)?	NA

2. Data Collection: Will your study collect any primary data or use any secondary data not in the public domain? YES/NO

Please complete the following questions, noting that somebody should be able to read this and replicate your approach:

2a) What type of data are you going to use? (Identify main types of information/data)	This research will work with secondary thermal infrared image data, that is available publicly and per the available open datasets, the FLIR ADAS thermal data 1. This data is available in the form of infrared images that have been taken in actual driving scenarios and they contain annotated items like pedestrians, vehicles and bikes. Image-level annotations are recorded in the form of bounding boxes and the class label, which are essential in supervised object detection, in the dataset. No personal or identifiable or sensitive human information will be gathered or analysed.
2b) What procedures will you use to collect data (include all equipment/methods you plan to use)	The dataset will be downloaded via web browser or dataset hosting sites to get publicly available sources. Procedural preparation of data would be done under Python. The pictures and comments will be sorted into systematic folders suitable to YOLO trainers. Preprocessing

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	will involve image resizing, image normalisation, label verification, and train, validation, and test splitting. The development and testing of the models will be carried out using a standard personal computer and a GPU may be used to speed up training (optionally).
2c) What methods will you use to analyse this data?	Deep learning-based object detection will be used to analyse the data. Thermal object detection will be carried out by implementing an equivalent of a baseline YOLO detector (e.g. YOLOv4 or YOLOv7). An efficient lightweight self-attention Reasoner module will then get incorporated into the stage of feature extraction to increase the spatial as well as semantic thinking at image regions. The standard object detection measures of mean Average Precision (mAP), precision, recall, inference speed (FPS), and false detection rate will be used to measure model performance. The baseline YOLO model and the improved IR Reasoner architecture will be compared in terms of their performance.

3. Data Management

Standard phrases have been added to the information sheet (available on Blackboard). In rare instances, these may not be appropriate for your study. If not, please describe any additional data

This project utilises publicly available secondary thermal infrared image data that are useful in research including the FLIR ADAS dataset. The information in the form of infrared images and related objects annotations does not contain personal, sensitive, or personally identifying data.

All the data sets and trained models will be stored in a password-protected personal computer and will be utilised in the scope of academic research. No redistribution of data will be performed and no commercial use will be seen. All resulting derived data, experimental results, and trained models files will only be stored as long as the project lasts and handled by the university data management policies. This study will not need any extra data management processes other than the standard requirements of the module level ethics.

Dataset Link: https://www.kaggle.com/datasets/rthwkk/ir-object-detection-dataset

management procedures below:

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4. Risk Assessment, Health and Safety

All research activity carried out by Northumbria University is subject to risk assessment and health and safety issues. Depending on the nature of your research work, you may need to use one of the risk assessments below and/or complete a Project Risk Assessment in discussion with your supervisor. Once you have identified risks and associated health and safety issues, you may need to consult relevant technical and other staff for further advice and guidance. Further information including a blank risk assessment form for research can be found here: Risk Assessment (northumbria.ac.uk).

Please check this box after you have read and understood ethics and health and safety information

☐ I confirm I have read the University's health and safety policy and ethics policy. I have read and understood the requirement for the mandatory completion of risk assessments and that my study does not deviate from the module level approval ethics information on Blackboard**:** *Relevant risk assessments are listed in the ethics application. If your project needs additional risk assessments, then you will need to submit a new ethics application. Please identify the elements of the listed risk assessment that are relevant for your study and the risk assessment(s) you are working with. Note that these are only relevant if you are collecting data face-to-face.*

Please check the relevant boxes:

☐ No physical risks

☐ HL_RISK_173 Testing in an external environment

☐ HL_RISK_722 Face-to-face interview

☐ HL_RISK_727 Group interview

Your Supervisor and Second Supervisor (where appropriate) will approve this ethical submission using the following checklist. Please check the Blackboard ethics submission area for the module ***BEFORE*** starting your practical research to make sure you have ethical approval in place. It is your responsibility to complete this ethics application and check it has been approved before starting your main research project.

- ✓ Ethics Form Complete
- ✓ Ethical Concerns Acknowledged
- ✓ Research Tools Checked
- ✓ All relevant forms included (consent, etc)
- ✓ Ethics is not high risk

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Appendix A: Proposal Outline

You must include an outline of your main proposal here that you are seeking ethical approval for. You should already have done significant literature review to ground your understanding of the proposed work in the current state-of-the-art. Please complete this section to include a minimum of the following elements, noting that it should be able to be read by any other researcher to allow them to replicate your approach:

Introduction to the project:

Treat like an introduction to the study. Why is your proposed study important? What has already been done on the topic? How does your proposed study 'fit' with the current literature and what does it add? Make reference to appropriate (published) studies here.

IR object detection is a very essential task in features like autonomous driving, surveillance, and night time surveillance because in most cases the camera based on visible light does not work well because of low light or poor weather. Thermal infrared images give resilience in such conditions though object recognition in infrared images is impeding due to low texture details, low contrast, and blurred edges of the objects. Conventional computer vision methods together with standard deep learning detectors usually do not learn significant spatial and semantic associations of thermal cases (Zhang *et al*. 2023).

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Recent pinnacle developments in deep learning have transferred object detectors based on the convolutional neural network, in specific, the YOLO-family structures, to infrared images with evident outcomes. Research has revealed that by fine-tuning YOLO models to thermal data like FLIR ADAS, a real-time performance with limited accuracy of the detection can be performed due to lack of contextual thoughts. The IR Reasoner framework overcomes this shortcoming with a lightweight self-attention-based reasoning module which reinforces both spatial and semantic associations among image sections without decreasing the pace of real-time inferences (Redmon and Farhadi 2022).

The proposed project aligns with the existing sources as it extends the existing literature on YOLO detectors and incorporates a visual reasoning system to support the infrared data. The paper will be valuable as it applies and tests the IR Reasoner architecture on a reproducible experimental system and the comparison of baseline and improved models and trade-off between detection precision and real-time speed in thermal object detection.

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Aim of the project:

What is the aim and main objectives of the proposed study?

Aim

The proposed project will be dedicated to the implementation and testing of the real-time infrared object detection system that will be based on the IR Reasoner structure and will expand to a YOLO-based detector using visual reasoning to enhance the detection scheme in thermal images.

Objectives

- To perform a literature review of the existing literature on infrared object detection and thermal image analysis with YOLO.
- To develop a baseline YOLO object detector of thermal infrared images.
- To add the visual reasoning module of IR Reasoner into the YOLO extraction feature.
- To optimise and estimate the proposed model on a publicly available thermal dataset.
- To assess and compare the model at the baseline and with improvements on conventional object detection metrics.
- To examine the tradeoff between the accuracy in detection and real time inferences.

4

Method:

Please outline your main research design here (e.g., experimental, design based, exploratory, etc.) and detail the proposed procedures and any resources and equipment you will use.

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Finally, a methodology section acceptable by the 24 specification of the IR Reasoner: Real-Time Infrared Object Detection by Visual Reasoning, (CVPRW 2023) project is provided as plain unformatted text, very precisely formatted to the allotment and structure required by submissions to the KF7029 Project Approval.

This can be directly piped on the form.

Method

2 Research Design

The research is a quantitative, experimental, and design-based study. The project will be aimed at implementing, extending, and testing a deep learning-based infrared object detectors model by introducing a visual reasoning module to an existing YOLO architecture. Assessment will be conducted by using controlled experiments and comparison (Bochkovskiy et al. 2020).

Procedures

The research will commence by choosing a publicly accessible thermal infrared dataset, including annotated objects against which to do supervised learning, like the FLIR ADAS dataset. Preprocesses in the dataset will include image resizing, normalising of the pixel values, checking the quality of annotations, and dividing the data into a training, validation, and test set.

To begin with, a basic YOLO object detector model (e.g. YOLOv4 or YOLOv7) will be deployed and taught on the thermal dataset. The feature extraction part of the YOLO network will be then incorporated with the IR Reasoner self-attention module to facilitate spatial and semantic reasoning. The improved model will be then trained or fine-tuned on the same experimental conditions (Teutsch *et al.* 2024).

8 Standard object detection metrics will be employed to compare the model performance in terms of mean Average Precision (mAP), accuracy, recall, and the speed of inference expressed in the number of frames per second (FPS). The findings will be evaluated to determine the increment of detection accuracy and real time performance.

Resources and Equipment

Software: Python

Python Frameworks/Libraries: PyTorch, OpenCV, NumPy, Matplotlib

Hardware: Personal computer; add-on GPU which supports faster training.

Novelty

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According to the paper reviewed Infrared Maritime Object Detection Network With Feature Enhancement and Adjacent Fusion, an evident and justifiable innovation to this paper would be to adapt the fixed feature-enhancement and fusion model to adjustable, condition-sensitive, and general-relevant detection. In particular, whereas the current paper is concerned with handcrafted attention improvements (ICA, Dilated CBAM), and a fixed adjacent feature fusion as an activity, specific to the maritime environment, the paper by you can bring a dynamic context-adaptable mechanism that can increase or reduce the strength of feature improvement and fusion course depending on the environment of the scene (sea state, clutters density, target scale distribution or thermal contrasts). This may be done by lightweight scene-adaptive gating, transformer-based global reasoning or uncertainty-aware attention that explicitly represents background ambiguity. Moreover, a domain-resilient learning approach (such as cross-domain training, self-supervised pretraining, or physics-informed loss functions) can be suggested to enhance the viability of performance coping with maritime and generic infrared tasks, unlike the checked paper, which admits inability to do so due to limited generalisation to non-maritime data. This puts the work as not only enhancing the accuracy of the detection of low and small targets, but it is also concerned with flexibility and dependence on deployability, which is still an open restriction in literature. Scene-Adaptive Context-Aware Infrared Object Detection Network (SACA-IODNet) model will be implemented.

Redmon, J. and Farhadi, A., 2022. *YOLOv3: An Incremental Improvement*. arXiv preprint arXiv:1804.02767. Available at: https://arxiv.org/abs/1804.02767

Bochkovskiy, A., Wang, C.Y. and Liao, H.Y.M., 2020. *YOLOv4: Optimal Speed and Accuracy of Object Detection*. arXiv preprint arXiv:2004.10934. Available at: https://arxiv.org/abs/2004.10934

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Appendix B: Participant Information

Note: this section *MUST* be completed if you are including *human participants* in your study

Please include here your participant information sheet, participant consent form plus any participant recruitment materials and permission letters.