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Master Thesis Proposal

Federated Learning for Object Detection Using 3D Depth Images

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1 Introduction

1.1 Topic of This Thesis

- Provide reasonably detailed description of what you intent to do in your R&D project.
- You may also discuss the challenges that you have to address.
- Reflect on the profile of the reader and PLEAAAAASE, tell a story here and refrain from bombarding the readers with details which they may not be able to appreciate.
- TODO: Put a story or a very basic scenario here to make the reader understand the problem.
- Keep it in industrial context
- Start with privacy issue with the centralized training especially in the consumer AI context
- Issue with scaling DL models
- Then how FL solves that problem, put a FL workflow diagram
- FL settings, what is our focus in that
- Industrial context
- Applicable to broader fields, medical, finance, surveillance
- Laws enforcing FL, put those papers

1.2 Relevance of This R&D Project

- Who will benefit from the results of this R&D project?
- What are the benefits? Quantify the benefits with concrete numbers.

2 Related Work

2.1 Survey of Related Work

- What have other people done to solve the problem?
- You should reference and briefly discuss at least the “top twelve” related works
- Rising research trend for FL, put that fig with papers over years
- But mostly theoretical aspect on benefits of FL and its comparison with some toy datasets
- FL+CV, only classification is covered in most of the papers, show that paper published graphs
- A very few FL+OD papers, that to even in practical and application oriented are close to none

2.2 Limitation and Deficits in the State of the Art

- List the deficits that you have discovered in the related work and explain them such that a person who is not deep into the technical details can still understand them. For each deficit, provide at least two references
- You should reference and briefly discuss at least the “top twelve” related works
- None in the 3D depth image domain or intensity images
- Here, input data itself prioritize privacy especially when it comes to person recognition

3 Problem Statement

- Which of the deficits are you going to solve?

- What is your intended approach?
- How will you compare your approach with existing approaches?
- FL+OD working pipeline, on a real world dataset
- A non-RGB based dataset
- Implementation on edge-devices
- Compare FL frameworks and choose 1 or 2
- Check FL aggregation methods
- Analyze compute resource constrained OD models

4 Project Plan

4.1 Work Packages

WP1 Literature Study

- WP1.1 Conduct a comprehensive literature review of state-of-the-art methods for object detection under adverse weather conditions using multiple modalities
- WP1.2 Analyze and compare various fusion strategies for exploiting the complementary characteristics of different sensors
- WP1.3 Search for suitable public datasets with adverse weather conditions and multimodal sensors data

WP2 Data Collection and Preparation

- WP2.1 Acquire the necessary datasets for multimodal object detection under adverse weather conditions, such as K-radar, DENSE, and aiMotive
- WP2.2 Develop tools for pre-processing and augmenting the datasets to enhance the performance of the models

- WP2.3 Perform statistical analysis to identify the main characteristics and challenges of the datasets, including data imbalance and class imbalance

WP3 Model Design and Implementation

- WP3.1 Design and implement an existing multimodal object detection architectures that integrates camera, LiDAR, and radar data
- WP3.2 Investigate various fusion strategies, such as concatenation, mixture of experts, attention-based fusion etc, to determine the most effective approach
- WP3.3 Explore deep learning architectures, such as CNNs, RNNs, and Transformers, to improve the performance of the multimodal model
- WP3.4 Optimize the model's hyperparameters and train the model on the acquired datasets

WP4 Model Evaluation and Validation

- WP4.1 Evaluate the performance of the developed multimodal object detection model on the acquired datasets under adverse weather conditions
- WP4.3 Compare the proposed model's results to existing state-of-the-art or baseline methods and analyze the strengths and weaknesses of each approach
- WP4.4 Identify the limitations of the proposed model and suggest possible future improvements

WP5 Project Report

- WP5.1 Write a detailed report that includes the research problem, objectives, methodology, results, and conclusion
- WP5.2 Present the research findings in a clear and concise manner, highlighting the contributions and limitations of the proposed multimodal object detection model
- WP5.3 Discuss possible future research directions based on the outcomes of the study

4.2 Milestones

- M1 Literature review completed and best practice identified
- M2 Data collection and preprocessing completed, including cleaning and augmentation
- M3 Initial model development and testing completed
- M4 Evaluation and optimization of the model completed
- M5 Final model development and testing completed, including comparison with existing state-of-the-art methods and analysis of strengths and weaknesses of each approach.
- M6 Project report completed

4.3 Project Schedule

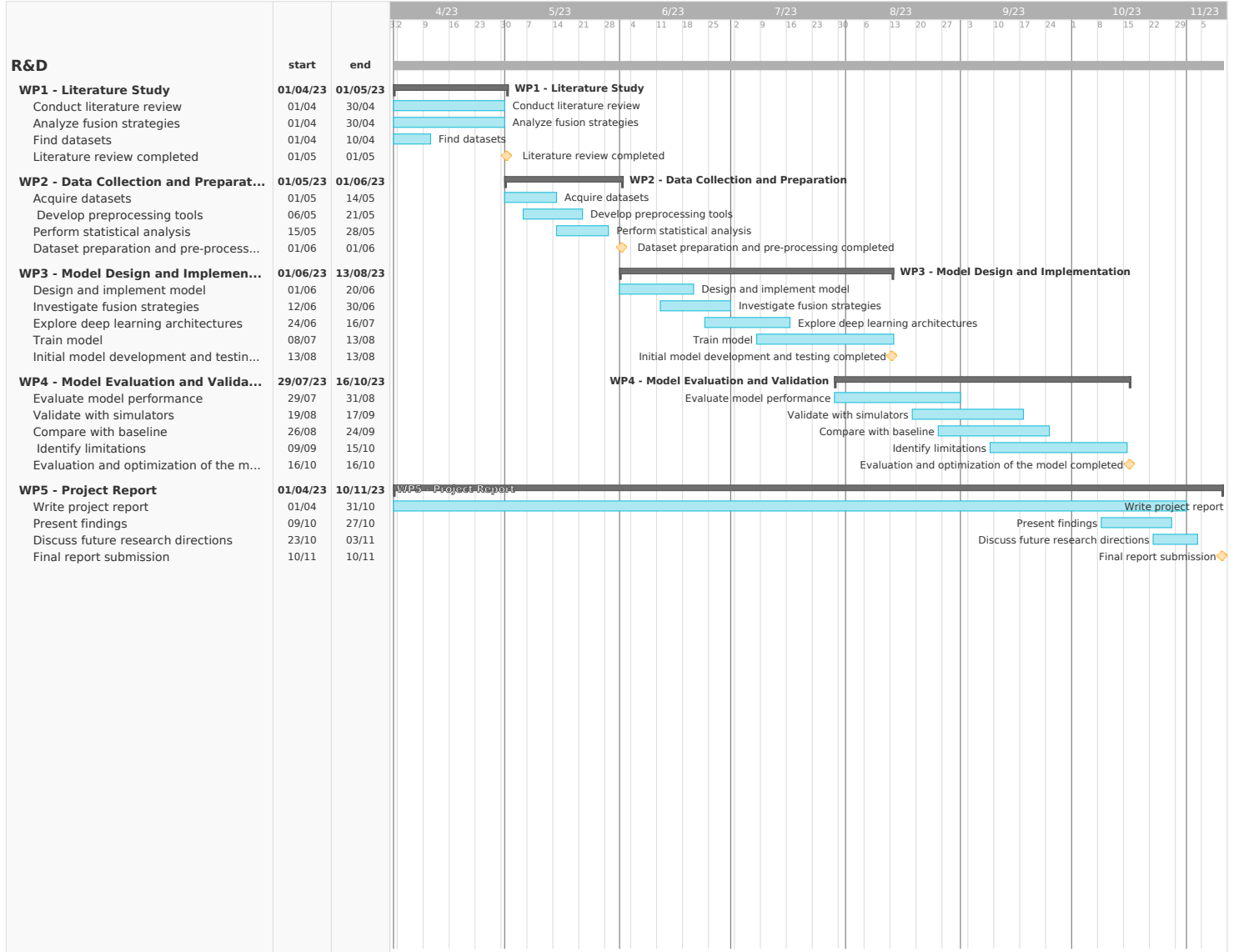


Figure 1: Gantt chart of the project schedule

4.4 Deliverables

Minimum Viable

- Conduct a comprehensive literature review on state-of-the-art Federated Learning (FL)-based object detection methods
- Develop and test existing models to reproduce results from relevant literature
- Perform a comparative analysis of at least two methods on a custom dataset
- Produce a detailed project report that summarizes the work done and the obtained results

Expected

- Fulfill all minimum viable deliverables
- Perform a comparison of centralized versus FL-based object detection, focusing on performance analysis
- Complete the final development and testing of the model, and a detailed analysis of the strengths and weaknesses of each approach
- Develop a working pipeline for FL-based object detection on 3D depth images (simulated)
- Produce a more extensive project report detailing the methodology, experimental setup, results, and in-depth analysis

Desired

- Fulfill all expected deliverables
- Implement FL-based object detection on edge devices
- Develop a containerized workflow for easy deployment
- Additional objectives (if time permits):

- Integrate object tracking with FL-based object detection
- Implement FL-based object detection with uncertainty estimation

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