ARCHITECTURE FRAMEWORK

VEDLIoT
Very Efficient Deep Learning in IoT

A COMPOSITIONAL APPROACH TO CO-DESIGN OF VEDLIoT

INTRODUCTION

Designing a complex and distributed system is a hierarchical process. Highly specialized views allow for the decomposition of the design task. The requirements and architecture often co-evolve, known as the twin-peak model. Developing complex system is also a highly collaborative act between many stakeholders. New stakeholders, such as data scientists and ethical experts must be involved in the deep learning model development for VEDLIoT. The design of the system is therefore also a collaborative act.

For VEDLIoT, the architectural framework needs to account for both aspects of co-design: Integrated design and collaborative design.
Furthermore, the framework must support explicitly aspects of distributed systems (IoT) and AI system development. The framework must also be flexible enough to cover all current and future use cases. A special focus lies on the support of non-functional requirements / quality views, and the traceability of design decisions to allow for safety cases.

APPLYING THE FRAMEWORK

The compositional architectural framework is applied iteratively. First, clusters of concerns are determined based on the desired use case. Then, the necessary levels of abstraction (detail levels) and existing architectural decisions are added. The missing architectural views are filled, and relations are created between the architectural views. Iteratively, additional clusters of concern can be added during the system development. The approach is scalable to any necessary number of clusters of concerns and levels of abstractions.

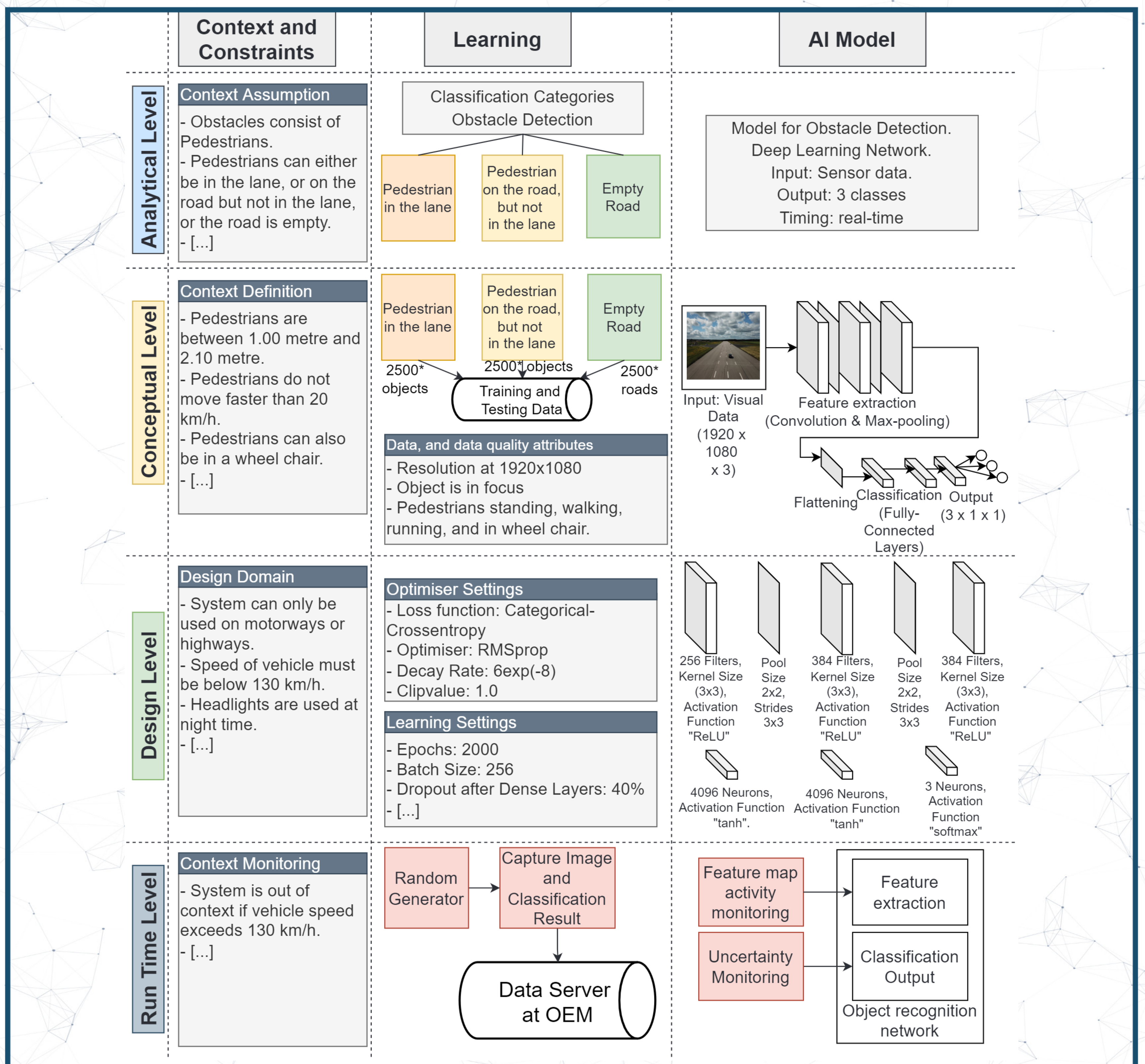
The following rules guide the design of the architecture:

Rule 1 — **Clusters of concern shall contain architectural views with different levels of details of a certain aspect of the VEDLIoT system.**

Rule 2 — **Architectural views shall be sorted into levels of abstractions, according to their level of details about the VEDLIoT system.**

Rule 3 — **Correspondence rules allow for arriving at different architectural views of the VEDLIoT system without encountering inconsistencies.**

Rule 4 — **Architectural views, and relations between them, shall be mapped to the next lower level of abstraction.**



EXAMPLE

The example shows three clusters of concerns: Context and Constraints, Learning Environment, and AI Model Design. The analytical level contains high level information about the use case (e.g., the model is aiming at obstacle detection, outputting three classes: pedestrian in the lane, pedestrian on road but not in lane, empty road). The conceptual level contains first design decisions, such as specifications of the obstacle to be detected, data specifications, and the setup of the deep learning model. The design level contains the final design decisions on a low level. The run time level contains information about necessary runtime monitoring.

CONCLUSION

The proposed architectural framework is scalable in the number of clusters of concerns to fit all use cases of **VEDLIoT**. The framework contains a set of clusters of concern related quality concerns, which can support any non-functional requirements. This includes ethical aspects, such as explainability, security, safety, and data privacy concerns.

The architectural framework supports middle-out design, i.e., existing design decisions can be integrated into the architectural framework. For example, **VEDLIoT** provides a set of specific hardware for accelerated deep learning in the IoT, such as **u.RECS** and **t.RECS**, which can be chosen as hardware platforms in the system hardware architecture viewpoint from the start.

Traceability can be ensured by following the outline rules of applying the architectural framework. This allows the support of safety standards, which require strict traceability of design decisions.

Problem Space
Solution Space

Business Goals and Use Cases

	Behaviour and Context			Means and Resources			Communication		Quality Concerns				
	Logical Behaviour	Process Behaviour	Context & Constraints	Learning	AI Model	Hardware	Information	Con-nectivity	Ethics	Security	Safety	Energy Efficiency	Privacy
Analytical Level	Function com-ponents	Interaction	Context assum-ptions	Learning objectives	High level AI model	High level hardware archi-tecture	Com-pilation	Interfaces	Ethic principles	Threat analysis (TARA)	Hazard analysis (HARA)	High level energy & power concept	Privacy impact analysis
Conceptual Level	Logical com-ponents	Logical se-quences	Context definition	Learning concept / data selection	AI model concept	System hardware archi-tecture	Infor-mation model	Node con-nectivity	Ethic concept	Cyber-security concept	Functional safety concept	System level energy & power concept	Privacy concept
Design Level	Com-puting ressource allocation	Resource se-quences	Con-straints / Design Domain	Learning settings	AI model con-figuration	Com-ponent hardware archi-tecture	Data model	Resource con-nectivity	Ethic technical realisation	Technical cyber-security concept	Technical safety concept	Solutions for energy and power	Technical solutions for privacy
Run Time Level	Be-haviour monitoring	Adaptive behaviour	Context monitoring	Runtime data collection & continous learning	AI models per-formance monitoring	Hardware per-formance monitoring	Data monitoring	Con-nectivity monitoring	Assess-ment / auditing of AI decisions	Security monitoring / threat response	Safety monitoring / safety de-gradition	Energy and power monitoring	Assess-ment of privacy com-pliance

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