First Principle Solution

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Consistency Analysis of Application Scenarios

Phase 1 - formalization of the discrete behavior

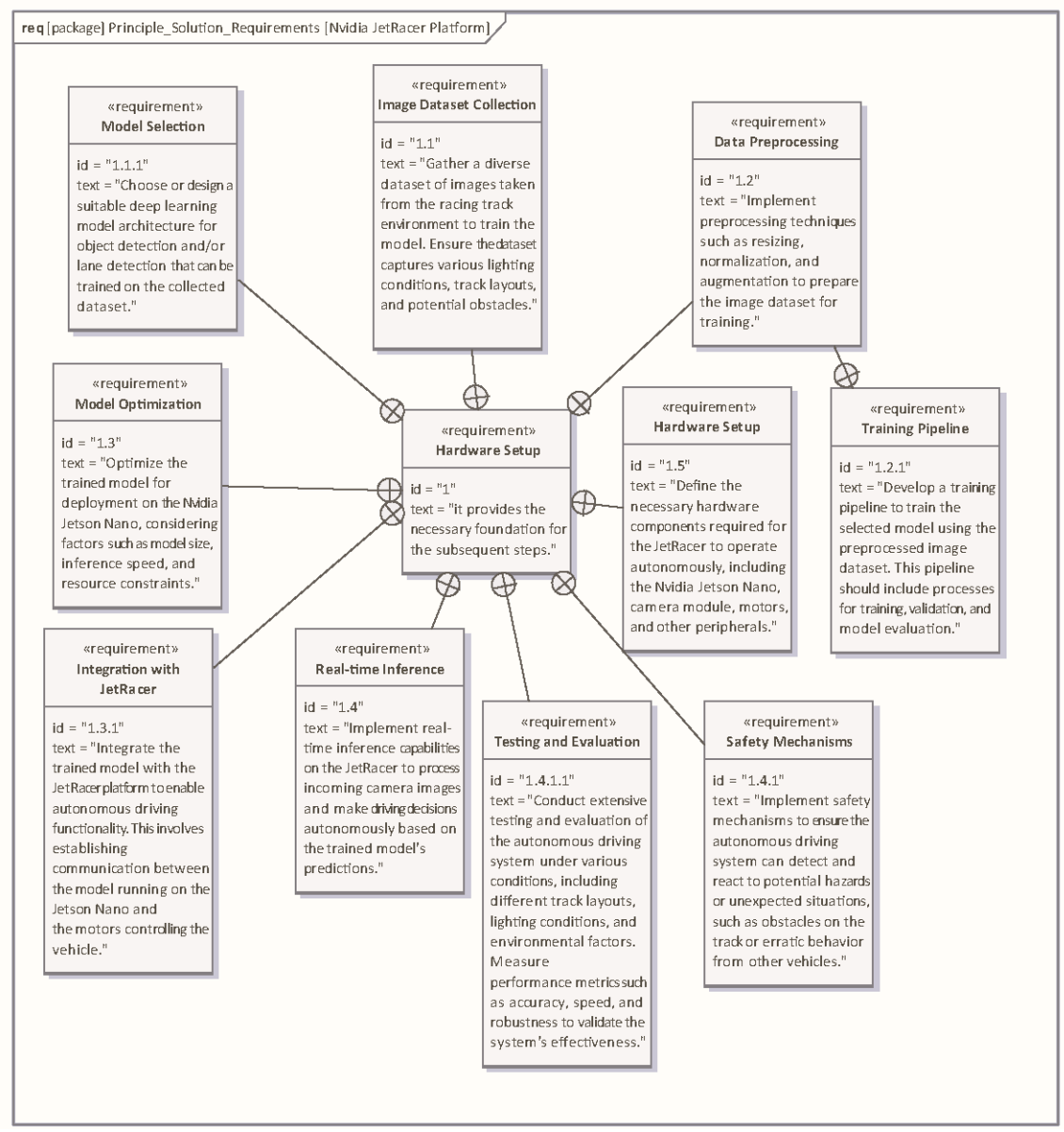

Figure 1 JetRacer System Requirement diagram

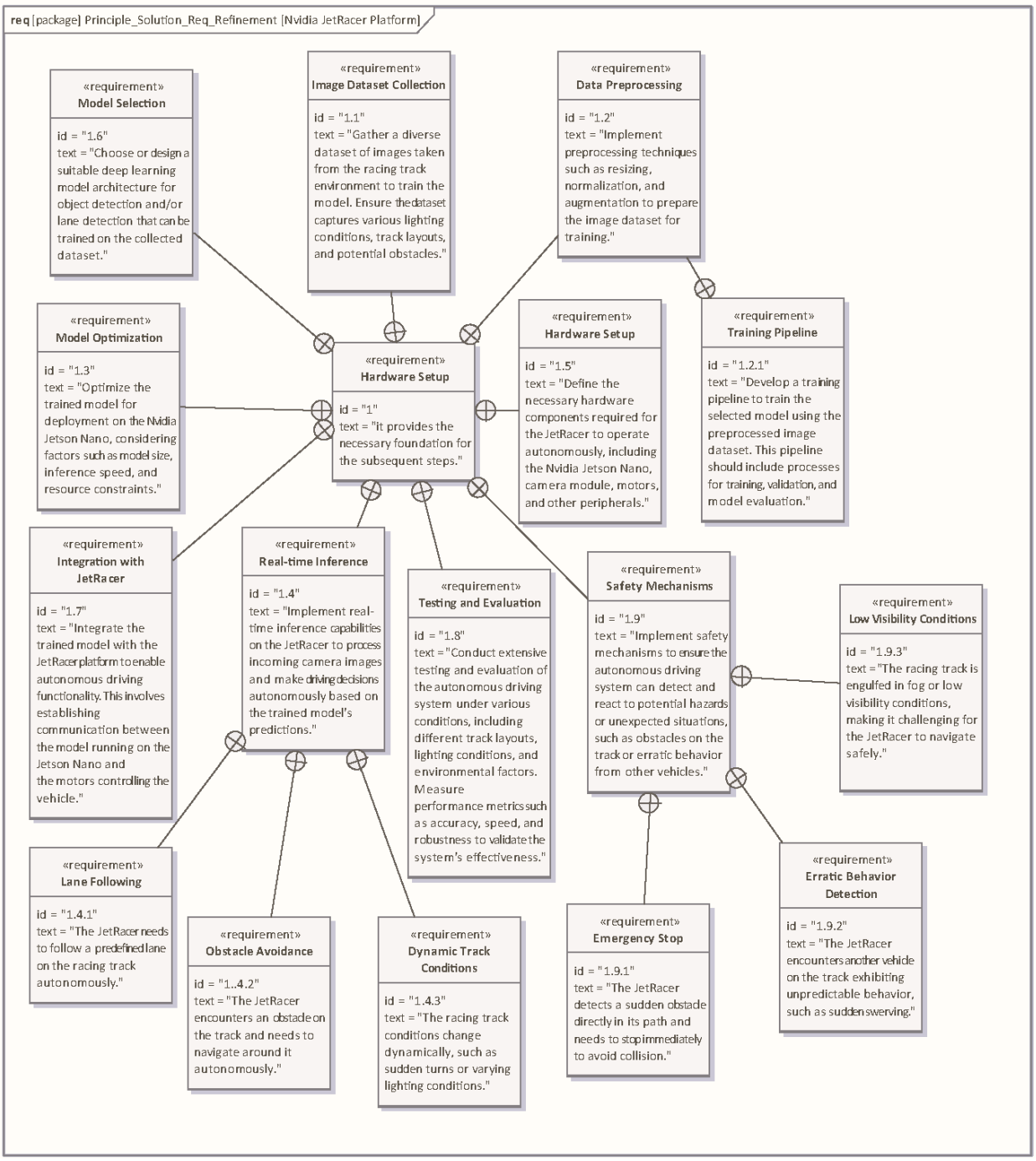

Figure 2 JetRacer Refined System Requirements Diagram

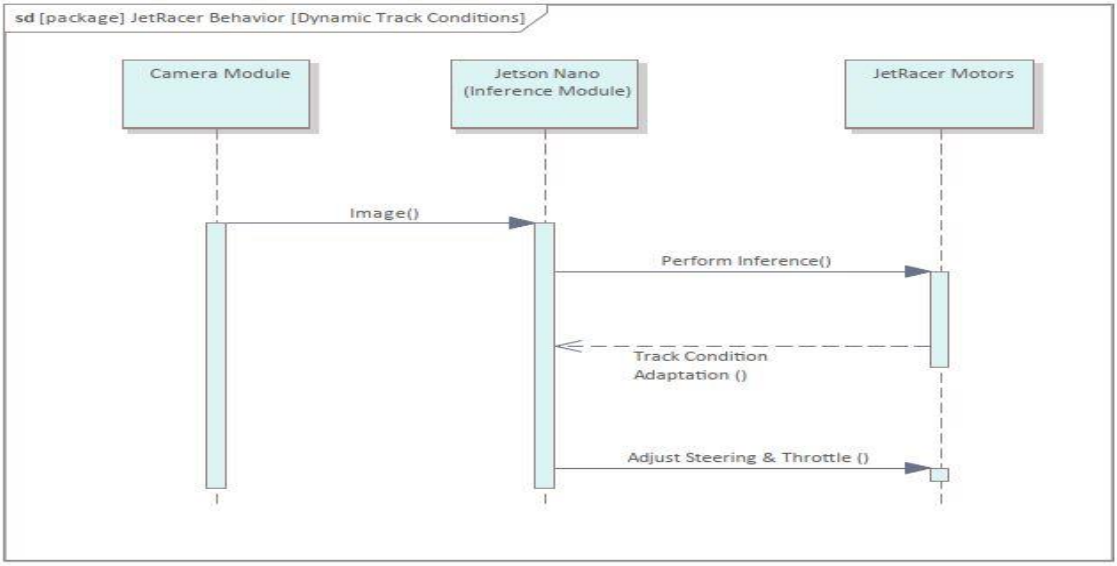

Figure 3 JetRacer behavior in Dynamic Track Conditions

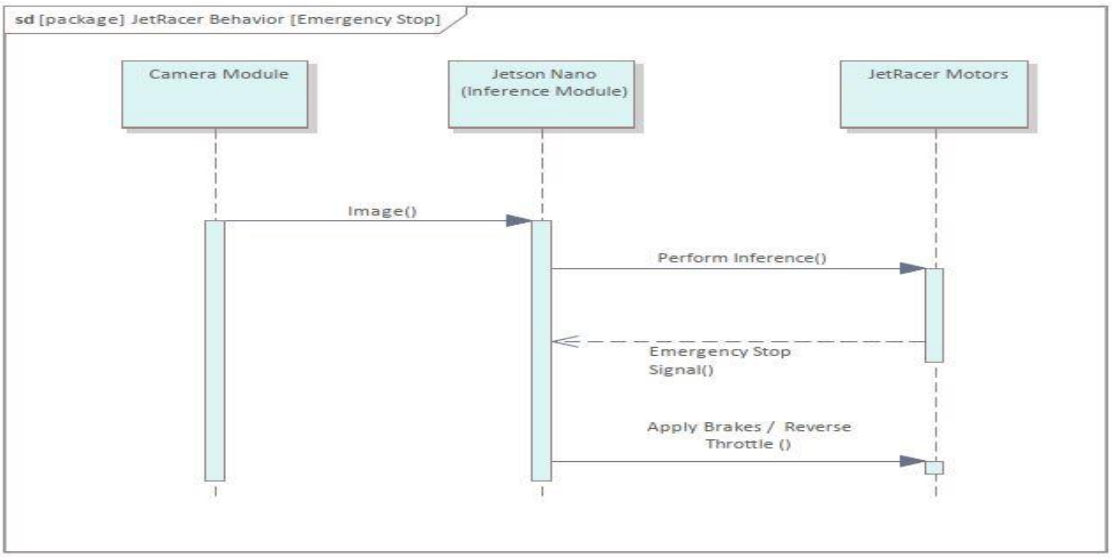

Figure 4 JetRacer Emergency Stop Behavior

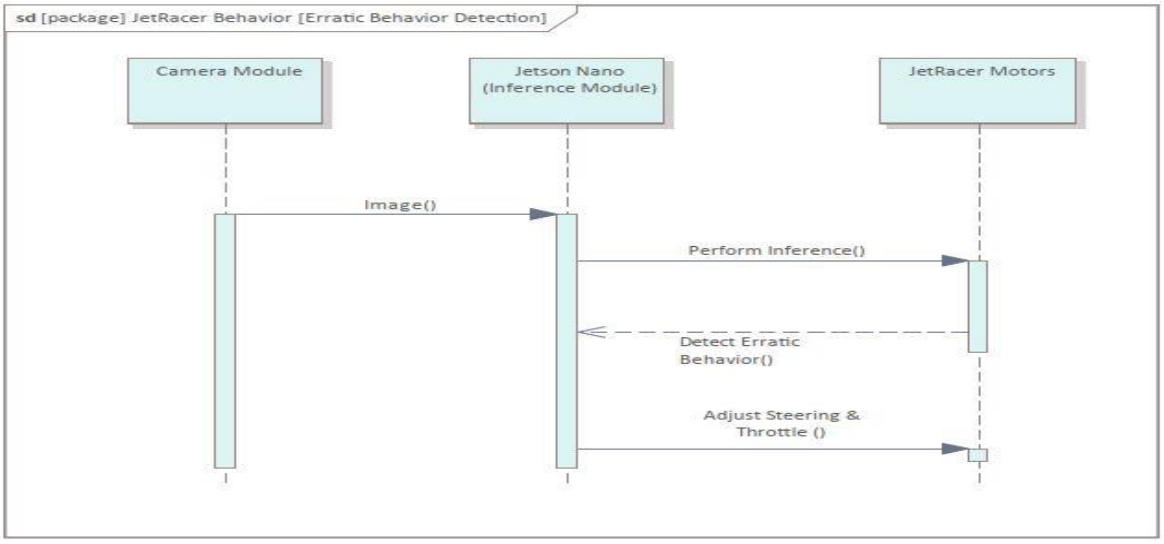

Figure 5 JetRacer Erratic Behavior Detection

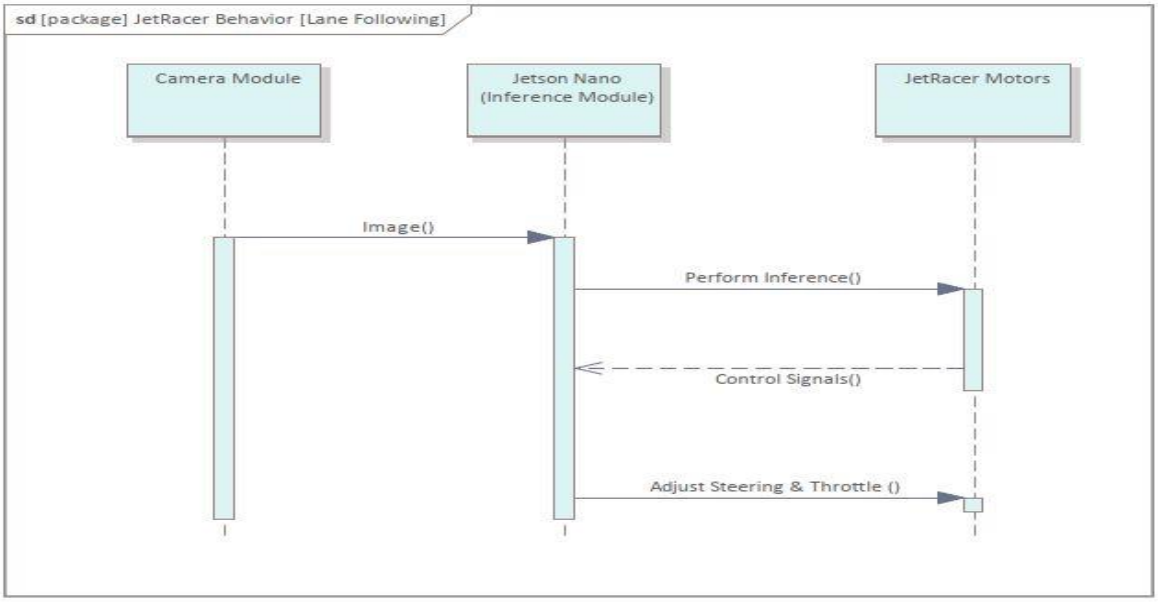

Figure 6 JetRacer Lane Following Behavior

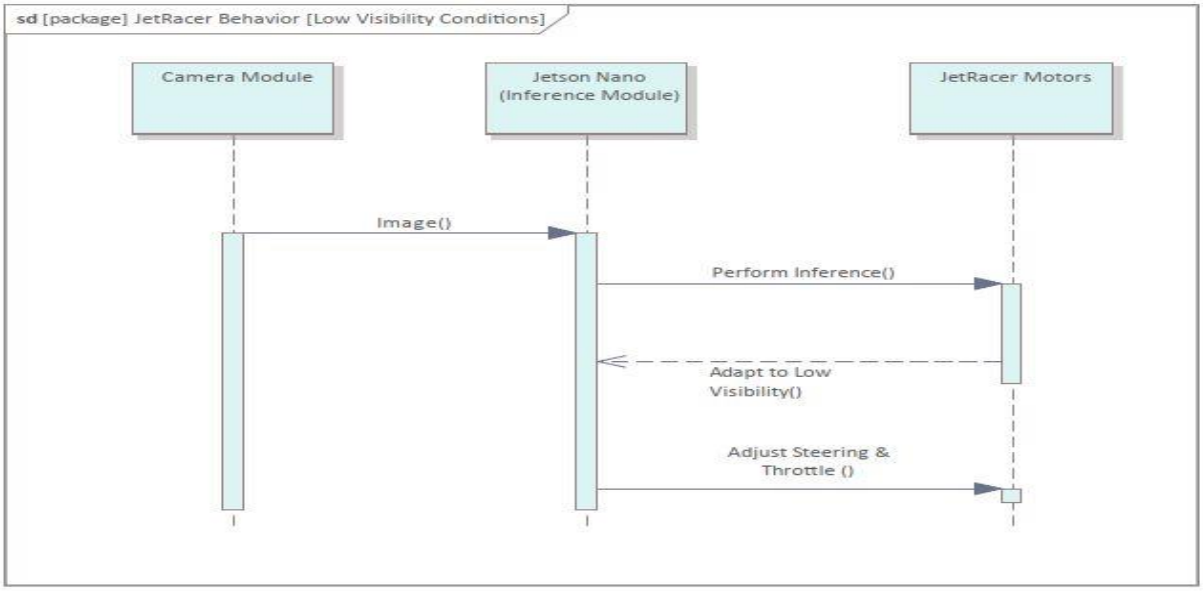

Figure 7 JetRacer Behavior in Low Visibility Conditions

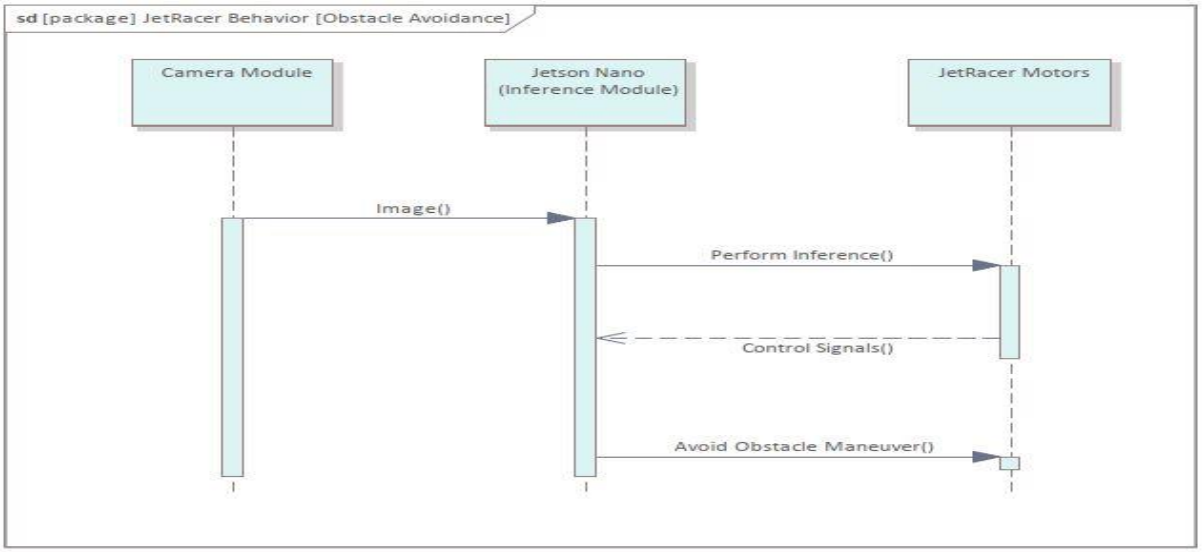

Figure 8 JetRacer Obstacle avoidance Behavior

Design of the System of Objectives

Phase 1 - development of the hierarchy of objectives

Hierarchical list of the objectives

Objective 1: Optimize model size and inference speed to fit within Jetson Nano's memory constraints while ensuring real-time processing for continuous lane detection.

Objective 1.1: Minimize model size

Objective 1.2: Minimize model inference time

Objective 1.3: Ensure continuous lane position detection

Objective 1.4: Ensure model optimization by minimizing model size and inference time, facilitating real-time lane detection.

Objective 1.4.1: Minimize model size

Objective 2: Enhance the JetRacer's ability to detect and avoid obstacles autonomously by ensuring rapid image processing, real-time inference, and safe maneuver execution.

Objective 2.1: Optimize obstacle detection speed

Objective 2.2: Implement real-time inference

Objective 2.3: Adjust steering mechanism to avoid obstacles

Objective 2.4: Enhance obstacle avoidance capabilities by optimizing image processing, real-time inference, and steering control mechanisms.

Objective 2.4.1: Optimize obstacle detection speed

Objective 3: Maintain optimal lane alignment by accurately determining lane position, calculating steering angles, and dynamically adjusting the steering based on real-time environmental feedback.

Objective 3.1: Determine lane position

Objective 3.2: Calculate optimal steering angle

Objective 3.3: Adjust steering mechanism dynamically

Objective 3.4: Maintain optimal lane alignment through accurate lane position determination, steering angle calculation, and dynamic steering adjustment.

Objective 3.4.1: Determine lane position

Objective 4: Ensure safe autonomous driving in low visibility conditions by implementing robust real-time inference, adaptive control signals, and emergency response protocols.

Objective 4.1: Implement real-time inference for low visibility conditions

Objective 4.2: Adapt control signals dynamically

Objective 4.3: Implement rapid emergency stop response

Objective 4.4: Ensure safe navigation in low visibility conditions through robust real-time inference, adaptive control, and emergency response.

Objective 4.4.1: Implement real-time inference for low visibility conditions

Objective 5: Achieve efficient and safe autonomous navigation by minimizing inference latency, optimizing model performance, and integrating robust safety mechanisms for dynamic track conditions.

Objective 5.1: Minimize inference latency

Objective 5.2: Optimize model performance for deployment

Objective 5.3: Integrate safety mechanisms for dynamic conditions

Objective 5.4: Facilitate efficient and safe autonomous navigation through latency minimization, model performance optimization, and dynamic safety integration for changing track conditions.

Objective 5.4.1: Minimize inference latency

Phase 2 - deductive analysis of disturbing influences

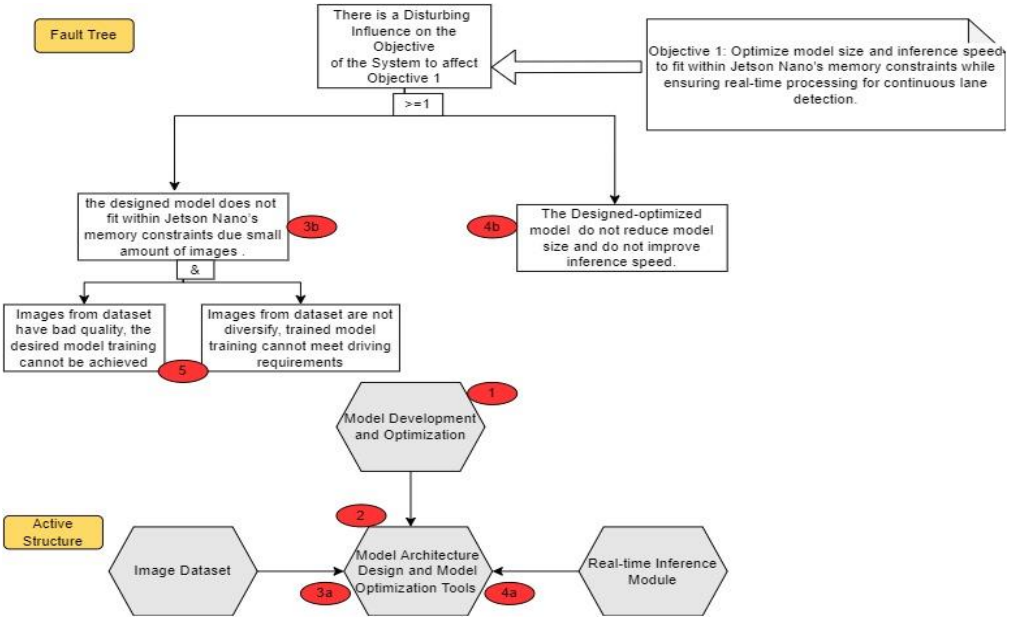

Figure 9 Deductive analysis of disturbing influences of JetRacer considering Objective 1

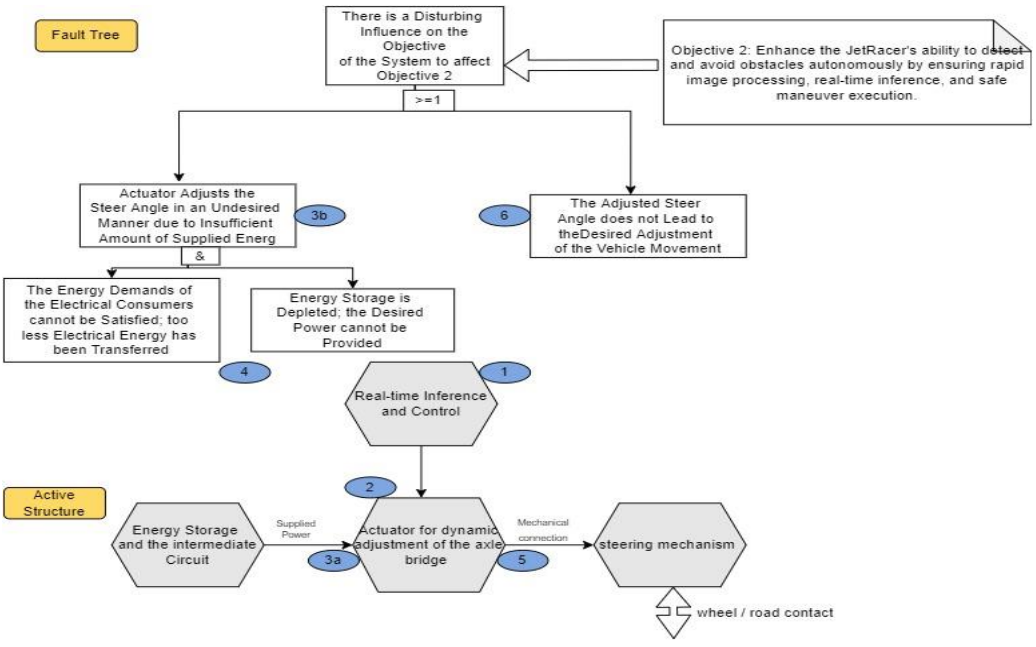

Figure 10 Deductive analysis of disturbing influences of JetRacer Considering Objective 2

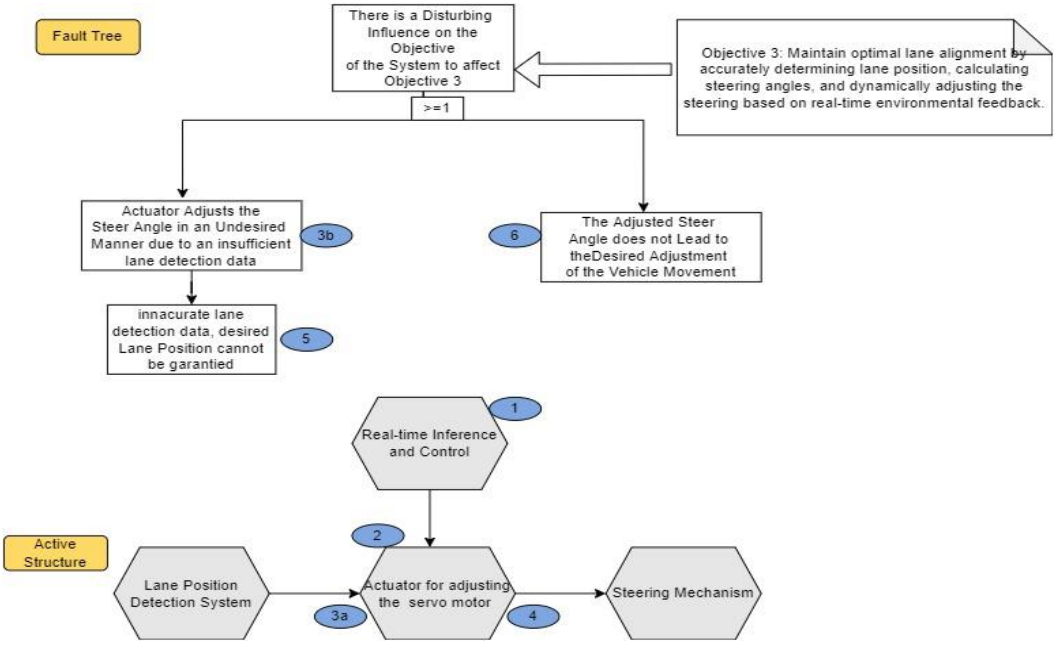

Figure 11 Deductive analysis of disturbing influences of JetRacer considering Objective 3

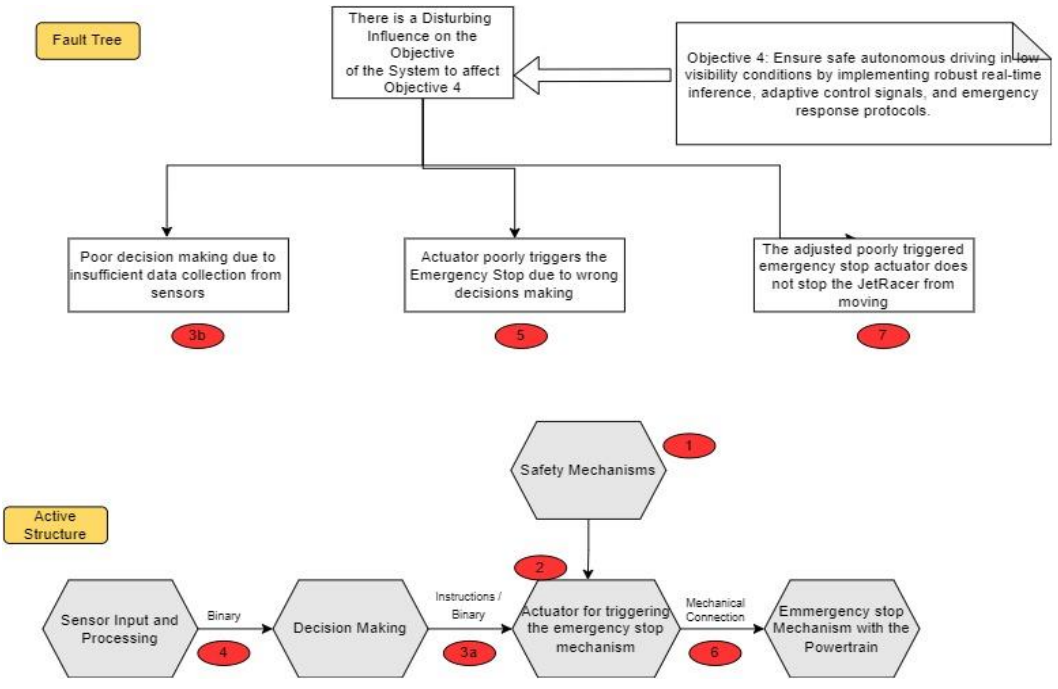

Figure 12 Deductive analysis of disturbing influences of JetRacer considering Objective 4

Phase 4 - refinement of the principle solution

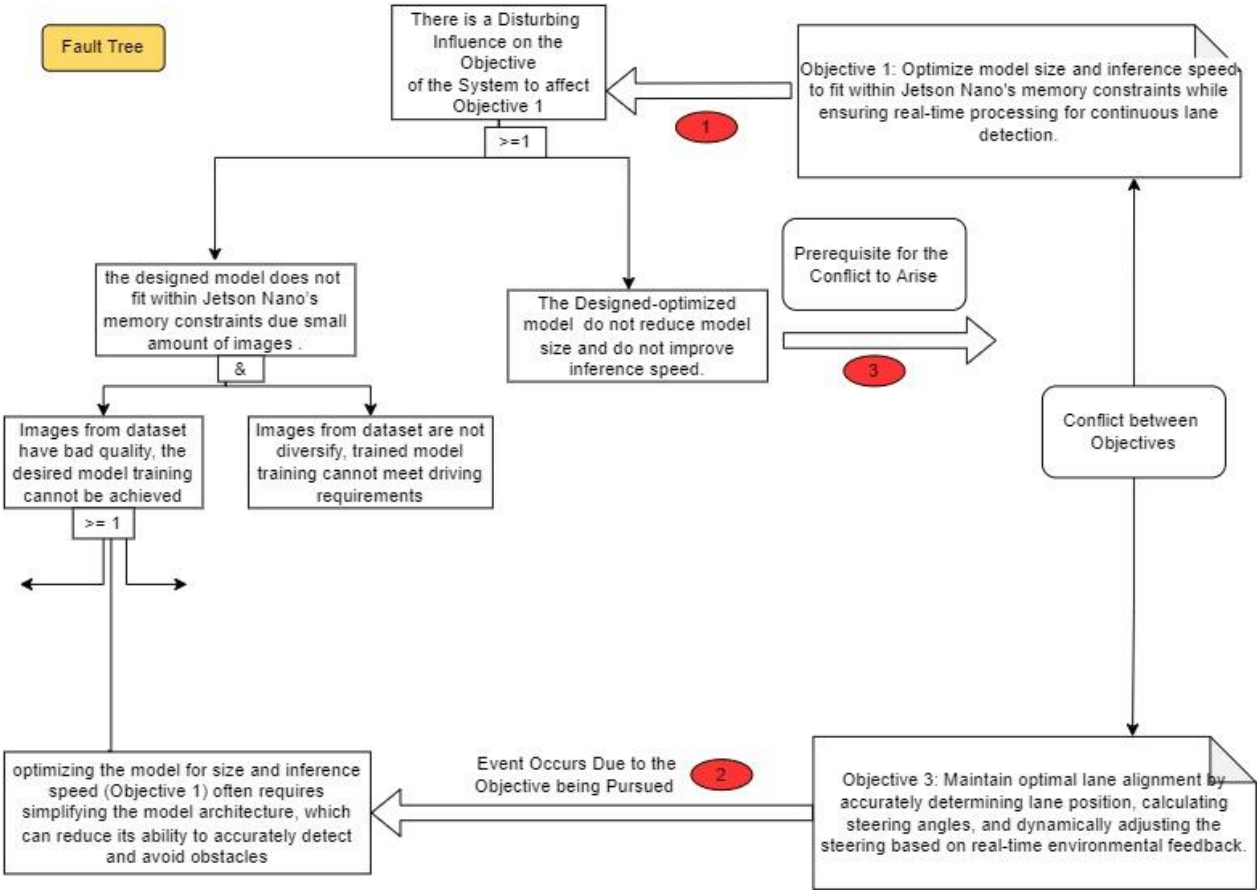

Figure 13 Identification of conflicts between objectives 1 and 3 based on the Fault Tree

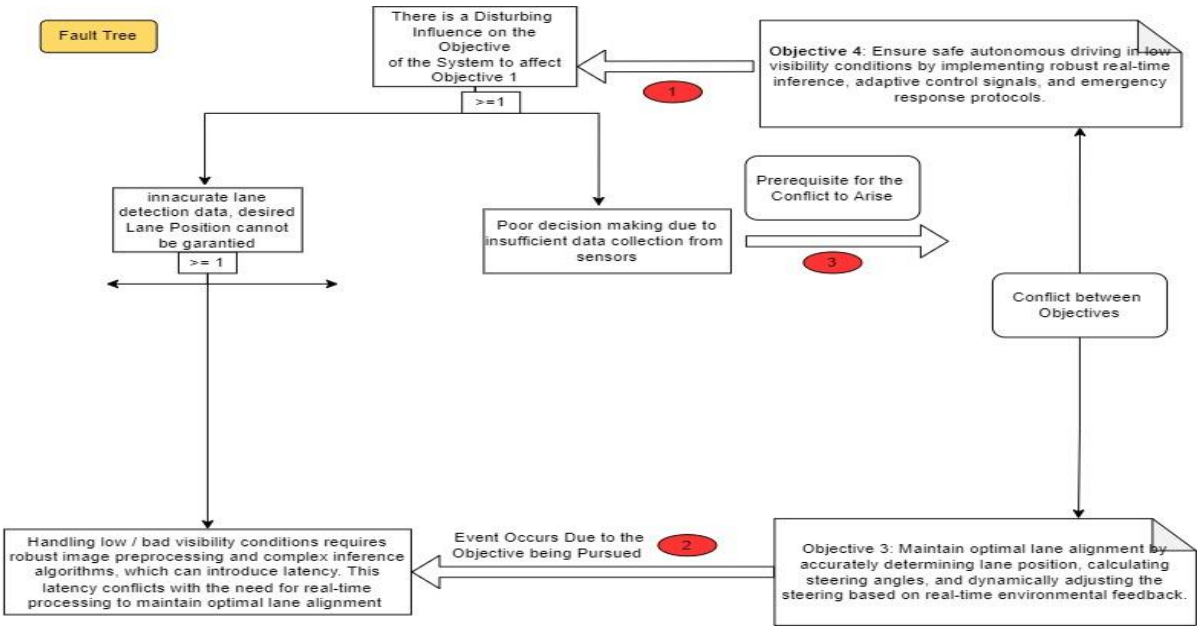

Figure 14 Identification of conflicts between objectives 4 and 3 based on the Fault Tree

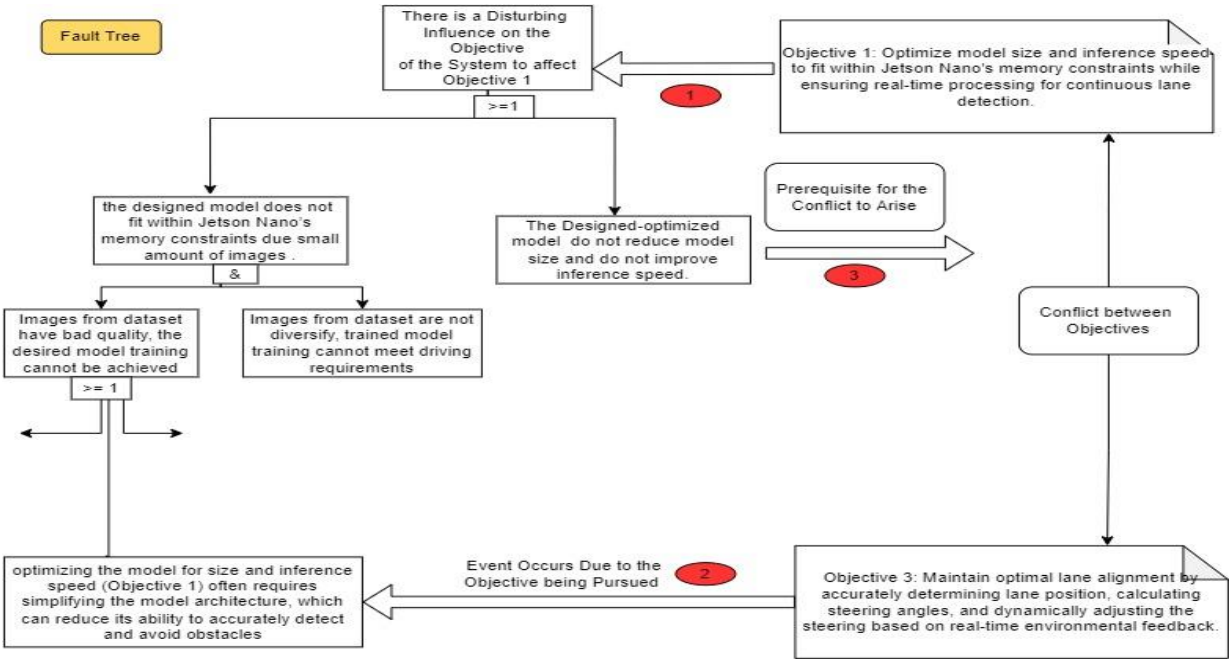

Figure 15 Identification of conflicts between objectives 1 and 3 based on the Fault Tree

References

[1] Gausemeier, J., Rammig, F.J. and Schäfer, W., 2014. Design methodology for intelligent technical systems. Lecture Notes in Mechanical Engineering. Springer, 1(2), p.3.