Monitoring of Perception Systems: Deterministic, Probabilistic, and Learning-Based Fault Detection and Identification (Abstract Reprint)

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Abstract

This paper investigates runtime monitoring of perception systems. Perception is a critical component of high-integrity applications of robotics and autonomous systems, such as self-driving cars. In these applications, failure of perception systems may put human life at risk, and a broad adoption of these technologies requires the development of methodologies to guarantee and monitor safe operation. Despite the paramount importance of perception, currently there is no formal approach for system-level perception monitoring. In this paper, we formalize the problem of runtime fault detection and identification in perception systems and present a framework to model diagnostic information using a diagnostic graph. We then provide a set of deterministic, probabilistic, and learning-based algorithms that use diagnostic graphs to perform fault detection and identification. Moreover, we investigate fundamental limits and provide deterministic and probabilistic guarantees on the fault detection and identification results. We conclude the paper with an extensive experimental evaluation, which recreates several realistic failure modes in the LGSVL open-source autonomous driving simulator, and applies the proposed system monitors to a state-of-the-art autonomous driving software stack (Baidu's Apollo Auto). The results show that the proposed system monitors outperform baselines, have the potential of preventing accidents in realistic autonomous driving scenarios, and incur a negligible computational overhead.

References

Antonante, P.; Nilsen, H.; and Carlone, L. 2023. Monitoring of perception systems: Deterministic, probabilistic, and learning-based fault detection and identification. *Artificial Intelligence*, 325: 103998.