

Motion-Aware Perception via IMU-Guided Spatial Attention for Autonomous Vehicles

Emin Bayramov^a, Zoltán Istenes^b

^aAcademic-Industrial Cooperation Center, Faculty of Informatics, Eötvös Loránd
University, Budapest, Hungary
[ORCID: 0000-0002-0428-8908](#)

^bAcademic-Industrial Cooperation Center, Faculty of Informatics, Eötvös Loránd
University, Budapest, Hungary
[ORCID: 0000-0002-0169-4791](#)

Abstract. Object detection systems in autonomous vehicles suffer from reduced accuracy during rapid motion, where acceleration and sharp turns create significant visual distortions like blur and edge smearing. This paper presents a novel approach that enhances detection robustness by leveraging vehicle Inertial Measurement Unit data to guide internal spatial attention. IMU readings are encoded into a learnable motion embedding, which conditions a small convolutional network to generate attention maps, dynamically modulating the feature maps of a YOLO-based detection model. Unlike traditional approaches that apply motion-aware corrections during pre- or post-processing, the proposed method refactors the detection network itself, enabling real-time, motion-informed feature adjustment within the model. Evaluation on the Zenseact Open Dataset, which provides synchronized IMU and high-resolution image data, demonstrates up to a 3% improvement in detection accuracy under high-motion conditions. The method remains modular and computationally efficient, offering a practical enhancement for perception reliability in Advanced Driver Assistance Systems.

Keywords: Advanced driver assistance system, Perception degradation, Object detection, Motion-Aware Perception, Inertial Measurement Unit, Spatial Attention

1. Introduction

Research indicates that motion blur is a significant factor causing localization inaccuracies in object detectors, particularly during nighttime when increased shutter durations exacerbate the effect. To address these challenges, we propose a novel motion-aware object detection framework that integrates vehicle dynamics directly into the model’s internal processing pipeline.

2. Background and related work

Pre-processing methods aim to mitigate motion blur by enhancing images before they are fed into object detection models. Gong et al. proposed a deep learning model that directly estimates motion flow from blurred images using a fully convolutional network[2]. A novel real-time motion blur compensation system has been developed to address blur caused by high-speed one-dimensional motion between a camera and a target [3].

3. Impact of Vehicle Motion on Perception

Human vision is adept at processing complex scenes; however, it is susceptible to motion-induced perceptual anomalies. One notable phenomenon is motion-induced blindness (MIB) [1], where stationary objects in the peripheral vision can disappear from awareness when overlaid on a moving background. **Camera sensors** integral to ADAS, are also vulnerable to motion-related distortions, notably motion blur [5] and the rolling shutter effect [4].

4. Methodology

In this work, motion-informed object detection framework is proposed that enhances spatial perception in dynamic driving conditions by leveraging real-time vehicle motion data. The core idea is to utilize IMU readings to generate a motion-aware spatial attention map, which modulates intermediate feature maps [6] within a YOLO-based object detection model.

The architecture comprises three main components:

- an IMU encoder that transforms raw 6D motion vectors into a compact, learnable motion embedding
- a spatial attention generator, which uses this embedding to produce a 2D attention map
- a feature map adjustment block, where the attention map reweights the backbone’s spatial features before detection

Figure 1 illustrates the high-level structure of the proposed architecture.

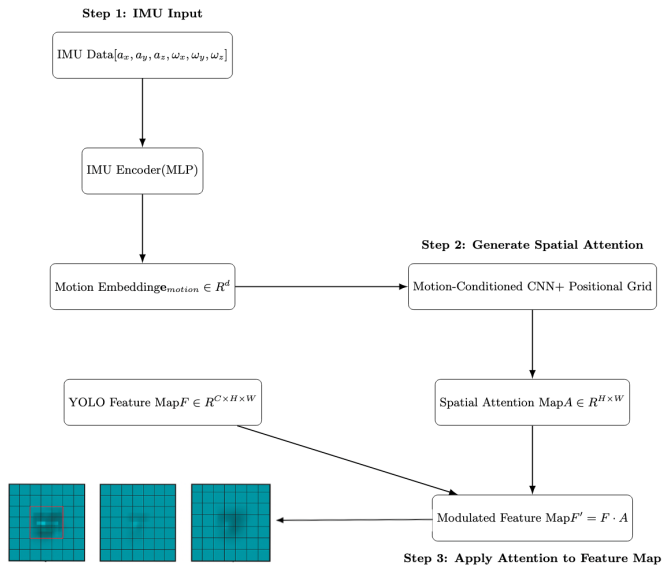


Figure 1. Architecture of the proposed motion-aware spatial attention module

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