A Novel Spike Vision Approach for Robust Multi-Object Detection Using SNNs

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Abstract
In this paper, we propose a novel system that combines computer vision techniques with SNNs to detect spike vision-based multi-object and tracking. Our system integrates computer vision techniques for robust and accurate detection and tracking, extracts regions of interest (ROIs) for focused analysis, and simulates spiking neurons for biologically inspired representation. Our approach advances the understanding of visual processing and empowers the development of efficient SNN models. In addition, our approach has achieved state-of-the-art results in visual processing tasks, showcasing the effectiveness and superiority of our approach. Extensive experiments and evaluations have been conducted to demonstrate the effectiveness and superiority of our proposed architecture and algorithm. The results obtained from our system are provided in this paper, showcasing the revolutionary performance that validates the efficacy of our approach and establishes it as a promising solution in the field of SNNs.

Keywords
Spiking neural network, multi-object detection/tracking, Neural model, event-based approach

1. Introduction

Neural networks (called SNN) have emerged as a powerful paradigm for modeling neuronal dynamics and enabling brain-inspired computation. One of the challenges in utilizing SNNs effectively is the generation of large-scale spike-train for training and evaluating these models. Existing motion detection systems often fall short of capturing the spatiotemporal patterns of neuron firing that are critical for understanding visual processing in biological systems [1]. This limitation poses obstacles to developing and advancing SNN models across various applications. To address this challenge, this paper proposes a novel system that combines computer vision techniques with an SNN model to detect multi-object tracking using spike vision-based applications. By integrating computer vision techniques such as frame differencing and contour detection, the proposed architecture achieves a robust and accurate detection

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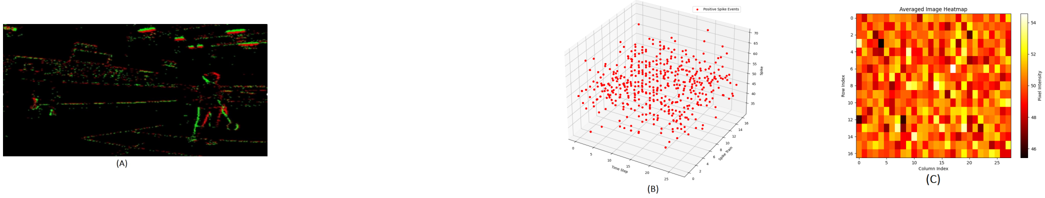

Figure 1: (A): High-performance SNN-based multi-object detection in real-time for reliable and robust results. (B): Visualizing dynamic spike events in a 3D space-time representation from real-time data. And (C): Heatmap visualization demonstrates the average image data extracted from real-time observations.

system, surpassing the limitations of traditional approaches [2]. These techniques enable the identification and detection of moving objects, capturing the dynamics of visual stimuli and enhancing the fidelity of the generated spike train. In addition, the extraction of ROIs from the visual input allows for focused analysis of specific moving objects or areas, thereby enhancing the interpretability and efficiency of the dataset [3]. This targeted approach enables a deeper understanding of the visual processing mechanisms employed by biological systems and provides valuable insights for developing more effective SNN models. To capture the temporal dynamics of neuron firing, the proposed SNN model simulates the behavior of spiking neurons. This biologically inspired representation of visual information improves the ability of SNNs to process and interpret visual stimuli [4]. The SNN model's capacity to capture temporal dynamics, the proposed approach is able and enable extensive spike train creation, facilitating comprehensive training and evaluation of SNN models for a wide range of visual processing tasks [5, 6, 7] and empowers the development of more efficient and accurate SNN models for diverse applications [8, 9].

The SNNs neural model allows the proposed methodology to capture the temporal dynamics and intricate patterns of objects in the visual scene [10]. This biologically inspired approach enables the proposed application to help in difficult scenarios to rapidly detect and track moving objects, which are challenging for traditional methods. Figure 1, demonstrates the capabilities of the proposed SNN-based architecture. Figure 1 (A), shows the real-time multi-object detection using SNN-based architecture. Figure 1(B), represents a 3D space-time plot illustrating the positive spike events captured by the SNN during the detection process, where the x-axis represents the time step, the y-axis represents the spike train index, and the z-axis represents the spike value. Each point in the plot corresponds to a positive spike event captured by the LIF model. Additionally, for further analysis of the spike trains captured by the SNN-based architecture, another informative visualization is presented in Figure 1(C). This plot represents the averaged image data in the heatmap plot derived from the spike trains obtained during the multi-object detection process, which provides insights into the regions of interest and the overall patterns captured by the proposed application. Each pixel in Figure 1(C), represents the average intensity of spikes recorded at that specific spatial location. These visualizations validate the ability of the proposed SNN-based architecture and demonstrate the extracted useful information from the spike trains generated data. The combination of real-time multi-object detection, the 3D space-time plot, and the averaged image heatmap demonstrates the effectiveness of the SNN-based architecture in capturing and processing visual information in complex and dynamic scenes.

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