Neuromorphic Computing and Vision for Interactive Robotics

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Neuromorphic computing and event-based vision seek to replicate the brain's sparse, spike-driven information processing, offering a pathway to robots that perceive and react with the speed and parsimony of biological systems. This work pursues that goal through a single narrative arc that begins with computation, advances through perception, and culminates in adaptive interaction. It starts by converting frame-based deep networks into spiking models and deploying them on the SpiNNaker neuromorphic platform. Systematic comparisons of conversion algorithms reveal how timing precision, power consumption and accuracy interplay, yielding practical guidelines for real-time deployment. With spiking computation established, the work next addresses perception. A dynamic-attention mechanism, realised as a recurrent spiking neural network, tracks multiple moving objects in asynchronous event streams, enabling a robot to prioritise salient targets while ignoring distractors. An accompanying data pipeline exploits the microsecond resolution of event cameras, supporting both hand-gesture recognition and vibration-based machinery monitoring. In evaluation, these perception modules maintain high accuracy under challenging lighting and rapid motion, confirming the advantages of event-level sensing. The final stage connects machine perception to human intent. Event-based vision is fused with physiological and behavioural indicators to infer the cognitive load of a human partner, enabling the robot to adjust its actions to the user's real-time mental state. This multimodal loop closes the gap between low-level spikes and high-level collaboration, demonstrating how neuromorphic methods can underpin more intuitive human–robot teamwork. Taken together, the work charts a coherent path from energy-efficient spiking computation, through event-driven attention and sensing, to cognitively aware interaction, illustrating how each layer supports the next in building responsive, robust and scalable neuromorphic robotic systems.

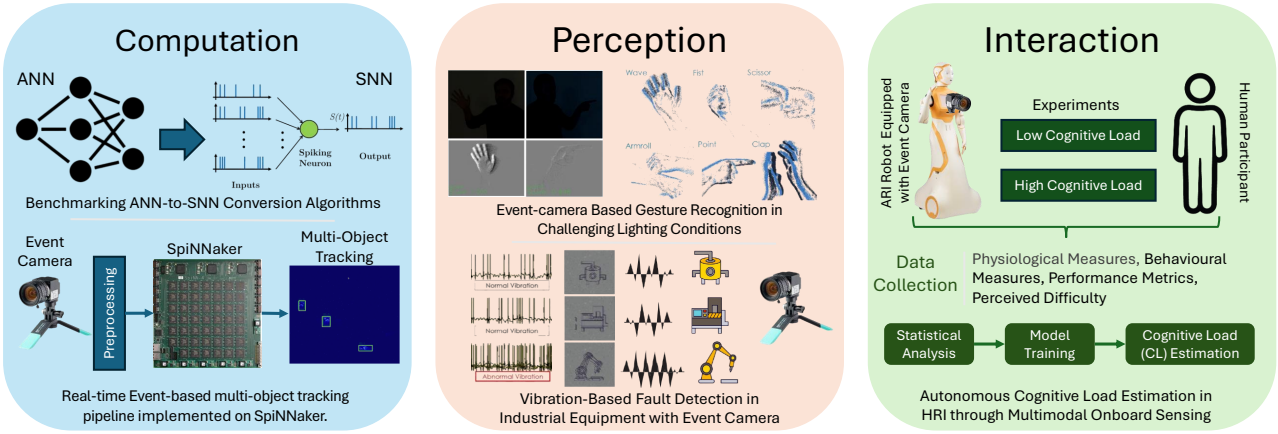

Figure 1: Overview of the proposed neuromorphic pipeline spanning computation, perception and interaction.

[1] M. Aitsam et al., IEEE Access, 10, 122261–122279, 2022.

[2] M. Aitsam et al., Proc. CVPR Workshops, 5055–5062, 2025.

[3] M. Aitsam et al., Eng. Res. Express, 6(4), 045238, 2024.

[4] M. Aitsam et al., Proc. ECCV Workshops, 293–306, 2025.