Literature Survey: Raspberry Pi AI Camera vs. Normal Cameras for Computer Vision Applications

1 Introduction

Computer vision applications heavily rely on camera hardware for capturing images and videos. The recent introduction of the Raspberry Pi AI Camera, which integrates onboard AI processing, offers an alternative to traditional cameras that rely entirely on external computing resources. This survey examines the differences, advantages, and limitations of the Raspberry Pi AI Camera compared to standard cameras used in computer vision.

2 Overview of Raspberry Pi AI Camera

The Raspberry Pi AI Camera features a **Sony IMX500** sensor, which includes an **embedded neural network accelerator** for AI-based image processing. Unlike traditional cameras, which capture raw image data and send it to an external processor, the Raspberry Pi AI Camera can process images locally using its **image signal processor (ISP)** and generate AI-based results (e.g., object detection, classification) before sending data to a Raspberry Pi board.

2.1 Key Specifications

- **12.3 MP sensor** with a **78.3° field of view**.
- **1.79 F-number (FAL) aperture**, offering manual focus but no autofocus.
- **Onboard AI accelerator** (ISP + Neural Processing Unit).
- Supports **classification, object detection, pose estimation, and segmentation**.
- **Supports TensorFlow and PyTorch** models (only feedforward networks).
- **Image tensor limitations**: 640×640 (color), 1024×1024 (grayscale).
- Can process AI models **independently** without relying on the Raspberry Pi's CPU/GPU.

3 Comparison with Normal Cameras

Feature	Raspberry Pi AI Camera	Normal Camera
Processing	AI processing on-camera	External processing required
AI Support	Built-in AI inference	Requires external AI inference
Autofocus	No autofocus	Some models support autofocus
Flexibility	Optimized for lightweight AI models	Can use any camera with external processing
Latency	Lower latency	Higher latency due to external processing
Power Consumption	Lower	Higher due to CPU/GPU use
Image Quality	Limited due to ISP constraints	High-quality raw image capture

Table 1: Comparison of Raspberry Pi AI Camera and Normal Cameras

4 Advantages of the Raspberry Pi AI Camera

- **Offloads AI computation from Raspberry Pi**: Normal cameras require the Raspberry Pi to handle AI processing, consuming CPU/GPU resources.
- **Faster AI inference**: AI models run directly on the camera, reducing processing time and latency.
- **Lower power consumption**: Unlike normal cameras that rely on the CPU for AI tasks, this camera performs AI inference internally.
- **Ideal for Edge AI applications**: Useful for real-time applications where Raspberry Pi resources are limited.

5 Limitations of the Raspberry Pi AI Camera

- **Limited AI model support**: Only supports **feedforward** models, no RNNs or recurrent architectures.
- **Fixed image tensor sizes**: 640×640 for color, 1024×1024 for grayscale (could limit high-resolution AI applications).
- **Manual focus only**: Lacks autofocus, which could affect applications requiring adaptive focusing.
- **Limited computational power**: Larger AI models (¿8–12 million parameters) require significant compression or are not feasible.
- **Not suitable for raw image processing**: Designed primarily for AI tasks, not for capturing raw images for external processing.

6 Use Cases

- **Smart surveillance**: Object/person detection with minimal CPU usage.
- **IoT & Edge AI applications**: AI processing without offloading data to cloud or external devices.
- **Robotics**: Real-time AI inference for navigation and object recognition.
- **Low-power AI tasks**: Battery-powered AI applications where normal cameras would drain resources.

7 Conclusion

The Raspberry Pi AI Camera introduces a new approach to embedded vision, enabling real-time AI inference directly within the camera. While it offers significant advantages in terms of **latency, power efficiency, and AI processing**, it has limitations such as **fixed model constraints, lack of autofocus, and limited raw image control**.

For applications requiring **basic AI processing with low CPU/GPU usage**, the Raspberry Pi AI Camera is an excellent choice. However, for **high-resolution image processing, complex AI models, or raw data manipulation**, traditional cameras with external processing remain more flexible.