Case Study

Edge Processing Camera based on NVIDIA® Jetson Nano™

Introduction

Artificial Intelligence and Edge Computing are two key modern-day technologies that are revolutionising cameras and imaging solutions, be it home, industrial or enterprise applications. Cameras powered by AI, also known as Smart Cameras or Edge Cameras, are finding its way to a wide range of applications, such as Robotics, Industrial, Healthcare, ADAS and Autonomous Vehicles among others. Powered by advanced AI-enabled system on chips (SoCs), Smart Cameras are designed to run compute-intensive workloads at the edge of network. In addition, superior IoT capabilities providing high-speed data exchange enable fast and real-time communication between the camera and Cloud.

Smart Cameras / Edge Cameras with Vision Analytics come with superior image processing, machine learning, and security features, in addition to integrated AI Algorithms that help make intelligent decisions at the edge. This case study outlines Mistral's expertise in designing an Edge Camera for Vision Analytics and AI/DL Applications with 4K@30 video capturing and integrated AI-Video analytics algorithms.

> "This case study showcases Mistral's expertise in designing an Edge Camera for Vision Analytics and AI/DL Applications."

PREFERRED PARTNER

The Customer

The customer is a technology company offering smart windows for automatic in-house climate control and energy saving.

The Requirement

The customer had been exploring AI technologies to provide intelligence to the products they offer. The idea was to automatically control the climate inside a building, by regulating the natural light entering the room through the window glasses. The customer approached Mistral to develop an Edge Camera that comprises of essential sensors and AI Vision Analytics to accurately detect, cognize and interpret the environmental conditions of the room (including temperature and light) and automatically trigger commands that enable their product to ensure optimum climatic conditions in the room.

Solution Provided

Requirement Analysis: Mistral conducted a comprehensive requirement study to capture functional aspects of the camera. Based on the requirement analysis, Mistral proposed a design and development activity with the following scope.

- Hardware Design using NVIDIA Jetson Nano SoM as the processing core
- Drivers and BSP development with Linux as High-level OS
- OpenCV for Vision Analytics
- Integration of various sensors
- Camera and sensor integration
- Proto build and supply

Hardware Design: The camera was designed around NVIDIA Jetson Nano, one of the smallest Artificial Intelligence (AI) platforms available in market, powered by Quad-core ARM A57 @ 1.43 GHz CPU and the 128-core Maxwell GPU. The Jetson Nano SoM comes with 4GB LPDDR4 memory, 16GB eMMC Flash and plenty on I/O options, including a MIPI CSI connector, 4 USB ports (1x USB 3.0 and 3 x USB 2.0), gigabit ethernet port, and 40 GPIO pins, which makes it a perfect platform for the edge camera.

Mistral custom designed a carrier board for Jetson Nano, which exercises all the features of the SoM. The carrier board provides I/O accessibility and power to the Jetson Nano. The carrier card is integrated with a 4K Camera Module, IR Thermal Sensor, UWB + Bluetooth + Accelerometer combo chip, Digital MIC and SD Card Slot, in addition to PoE and several interfaces.

The 4K Camera Module is interfaced with the Jetson Nano over 2-Lane CSI. The camera captures 4K@30 video for Vision Analytics. The IR Thermal Sensor is connected over I2C for real-time thermal measurements. The UWB + Bluetooth + Accelerometer chip is connected to the SoM over SPI (can be connected over UART as well) and configured as a real-time location system (RTLS) to aid real-time people tracking.

The platform is provided with an 802.3af Power over Ethernet (PoE) for data streaming and constant power supply and USB Ports for system programming & configuration. Mistral provided an SD Card slot for additional storage and to run edge AI - ML applications. The design also includes a USB to UART converter for Host communication.

Software Design: Mistral ported Linux Kernel 4.9 on the platform. The Linux Kernel was enabled with support for UWB + Bluetooth + Accelerometer chip, digital MIC, 4K camera sensor and a provision for camera temperature measurement. Mistral developed Python codes for IR-sensor and 4K camera streaming using OpenCV and GStreamer. Mistral also developed and ported Linux kernel driver for IR sensor on the carrier card.

Booting of the platform was enabled over an SD-CARD based filesystem [Bootloaders & Kernel loaded from internal EMMC]. Mistral also developed a GPIO Kernel driver to control the reset of all the peripherals such as UWB transceiver IC with, IR-sensor & MIC.

Implementation of OpenCV: Mistral implemented OpenCV for advanced image processing and vision analytics within the Camera. OpenCV was tested for face detection using jetson-inference engine on the platform. OpenCV based Edge-ML Application for face mask detection and social distancing; and Occupancy Detection Application for object detection and people counting were provided by the customer. Mistral ported these applications to custom designed carrier card and additionally modified the Occupancy Detection Application by adding filters for noise reduction and better performance.

Test Applications: Mistral created test utilities to,

(i) Monitor long run tests to observe current consumption & temperature throttling points

(ii) To set different power modes, observe total power consumption & performance

(iii) To perform all peripheral interface tests.

The Challenges

- **Temperature and Power Management:** The design team noticed that the standard PoE power source was not able to meet the power requirements of the Jetson Nano due to the heavy computational load it handles. To increase the PoE efficiency, Mistral added additional load capacitors, which provided a stable voltage and power to the system. By implementing this, Mistral could achieve a PoE efficiency of above 85% for the design. In addition, the PoE power insufficiency and the extremely high computational load resulted in high temperature of the Jetson platform, beyond the defined limit, causing automatic shutdown of the platform. This issue was addressed by designing and integrating a custom heat sink for the Jetson platform.

- **Camera Temperature Measurement:** Another challenge was the implementation of a constant temperature measurement mechanism for 4K camera sensor. The camera sensor driver does not provide an API to measure temperature. Mistral found the register for temperature measurement from the sensor datasheet and implemented sysfs APIs to get the updated temperature value from the 4k sensor.

Achievements

(I) Mistral successfully integrated both thermal imaging and optical imaging sensors in this design and used the combined data for making decisions at the edge

(ii) Achieved high power efficiency by implementing custom-designed heat sinks and adding load capacitors in the design.

Customer Benefits

- **Small form-factor Design:** The customer is benefitted by the low-power small form-factor design offered by Mistral, which enabled them to aesthetically package the product.

- **Faster time to market:** Mistral's expertise in Jetson platform, Sensor Integration, Embedded Linux and OpenCV reduced the overall development lifecycle of the camera solution.

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Engineering the Intelligent Edge

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