MISTRAL
... Partners in Real Time

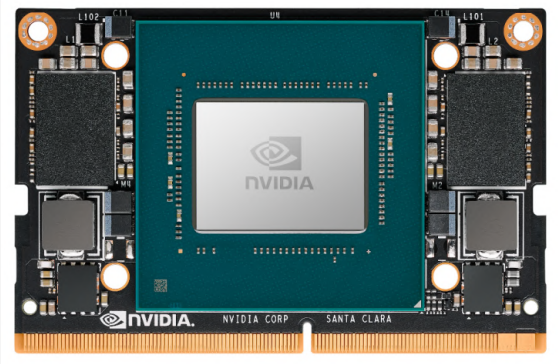
Designing a Video Analytics Engine for Smart Retail Cobots



Overview

The retail industry has always been an early adopter of advanced technologies, and the use of robots in the retail industry has been a game-changer. Robots are no longer science fiction. The combination of Machine Learning, Computer Vision, Face and Gesture Recognition technologies have enabled robots to accomplish a wider range of challenging and complex tasks than ever before. Retail Robots - right from big six-foot-tall autonomous machines to small, tiny free-moving vehicles - are used for inventory management tasks such as scanning and updating stocks, analyzing customer buying patterns, and assisting customers with personalized services.

NVIDIA is recognized as the world leader in GPU computing. In this application note, we will be using NVIDIA Jetson Xavier NX SOM and Mistral Neuron Base - Turbo (NB Turbo) for designing a Cobot, a collaborative robot, that will traverse the aisles to locate and identify products, scan the inventory, capture more granular data about the products on the shelves, update stocks and collaborate with the inventory management system. NVIDIA Jetson Xavier NX SOM brings supercomputer performance to the edge in a small form factor system-on-module (SOM). Mistral's NB Turbo brings out the required basic interfaces and connectivity features of the Jetson Xavier NX such as Ethernet, CSI, USB, HDMI, M.2 NVMe Slot, mmWave RADAR, etc. It is a more sophisticated platform with functional features and powerful multimedia interfaces and sensors such as Wi-Fi 802.11, Bluetooth, and 9-axis IMU Sensors.



This application note gives a technical perspective on how the Neuron Base can be adapted to meet the technical & functional requirements along with Jetson Xavier NX SOM for designing a Video Analytics Engine for Smart Retail Cobot.

Design Considerations

In this section, we will focus on some of the points that need to be taken into consideration while designing a Video Analytics Cobot. The cobot needs to qualify all AI, IoT, Machine Learning, Deep Learning, and Edge computing parameters.

The AI/DL process broadly involves two phases, training and runtime inferencing. The training process is a phase where thousands of images of

NVIDIA PREFERRED PARTNER

relevant objects are added and tagged into various AI/DL models based on TensorFlow, Caffe2, PyTorch, etc to generate metadata, which would be used during runtime inferencing. Runtime inferencing is a process where live images or videos processed (decoded, scaled, etc) are fed to the inferencing engine for object detection, classification and localization.

The Cobot, through the use of a camera, has to traverse through aisles to scan the racks, capture images of the medicine box, and process through the use of Computer Vision algorithms, recognizing exactly the object to be selected without knowing its position in advance. The cobot should inform or notify the inventory management system of what's out of stock. The cobot should be capable of live streaming the images to the cloud or store locally.

The NB Turbo powered with Jetson Xavier NX delivers up to 21 TOPS, making it an ideal platform for high-performance compute and AI in embedded and edge systems. It can decode four streams of 4K video, simultaneously, at 30 frames per second (fps) or 32 streams of full HD (1080p) video, simultaneously, at 30fps. With this platform you get the performance of 384 NVIDIA CUDA® Cores, 48 Tensor Cores, 6 Carmel ARM CPUs, and two NVIDIA Deep Learning Accelerators (NVDLA) engines. NB-Turbo comes with 4TB of SSD providing an option for cobot to store images locally. The data can also be mapped with the cloud storage over Wi-Fi interfaced with AWS Communication gateway.

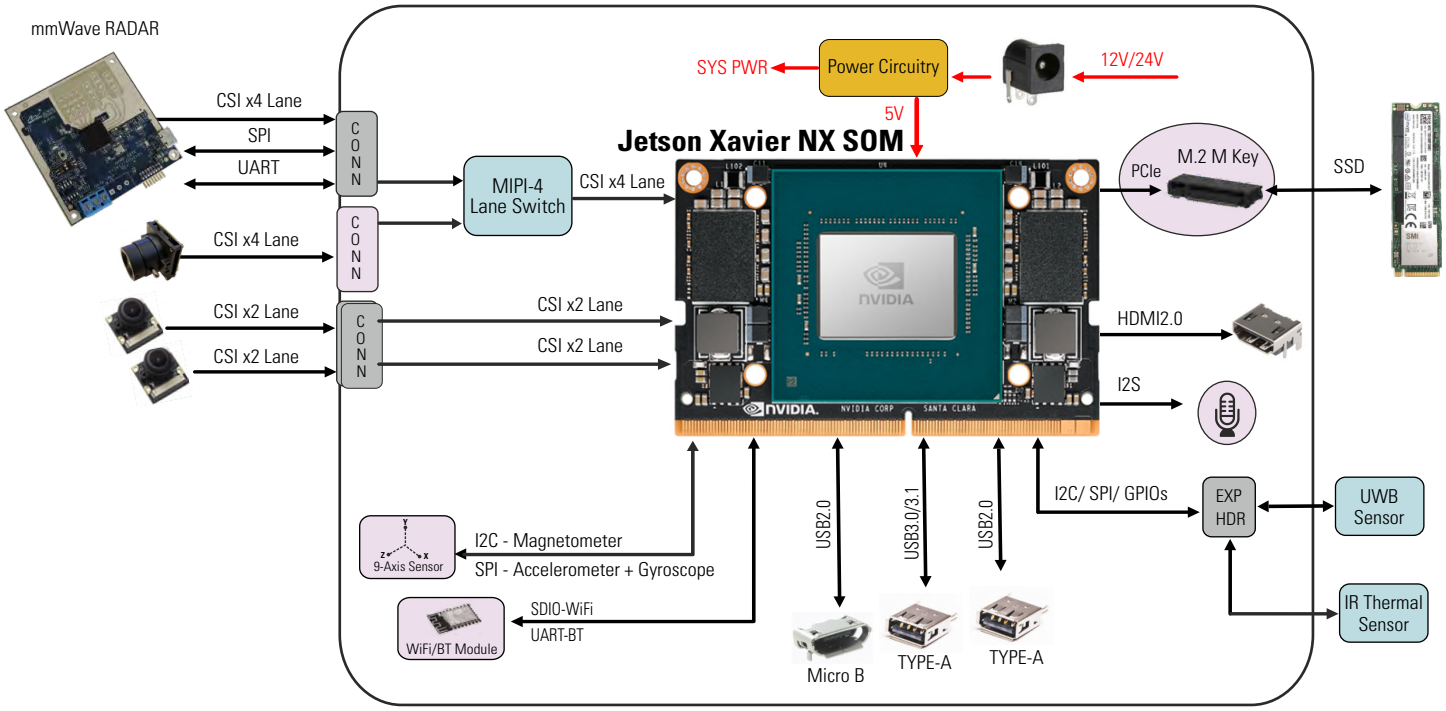
Most of the interfaces of the Jetson Xavier NX SOM are terminated onto the 40-pin Expansion Header/connector which can be used either as GPIO or special functions I/O (SFIO) such as HDMI, I2C, I2S, DMIC, SPI, CSI, Reset, Power, etc. These interfaces are integral components required for the cobot to be realized.

Product Implementation Approach

This section will focus on the implementation of a Video Analytics Engine for Smart Retail Cobot using the NB-Turbo from Mistral Solutions.

Below is the block diagram of Neuron Base - Turbo with Jetson Xavier NX SOM. As discussed earlier, the NB-Turbo already has most of the important blocks required for the cobot. In this example, we are looking at adapting the NB-Turbo to design a Video Analytics Engine for a cobot.

BLOCK DIAGRAM



Hardware Design & Integration

Here are some of the features of NB-Turbo that can be utilized for building a cobot that can capture, read, process, and store information.

The NB-Turbo platform supports multi-cameras which can be used for wider FOV (field-of-view) and depth analysis. A camera can also be used to detect the rack and scan the medicine information on the packaging. Optical camera(s) can be used to detect the objects on the trail the cobot navigates. In addition, a mmWave Radar Sensor can also be used as a complementing sensory unit for object detection, obstacle detection and navigation.

The NB-Turbo includes an onboard Wi-Fi/BT module interfaced on the SDIO port for the cobot to directly interact with the cloud system/local server based inventory management system via AWS Communication Gateway. The 9-axis IMU Sensors can be used to track the orientation and velocity of the cobot at any given time. It can also be used for magnetic field detection and the angular and linear movement of the robot. The data captured from the IMU Sensors can be transferred to the Jetson SOM via serial interfaces such as SPI/I2C.

The NB-Turbo includes a DMIC interface (I2S) which can be used for adding Audio Input for Natural Language Processing (NLP) to interact with the robotics system. Additional sensors such as UWB (Ultra-Wide Band) sensor for indoor navigation and tracking and IR Thermal sensors for temperature detection can be integrated with NB-Turbo through Expansion Header.

Developers can leverage the NB-Turbo to kick-start their projects and build the prototype in the shortest span of time. The platform can be customized further to enable only application-specific requirements, which will help in minimizing board form-factor.

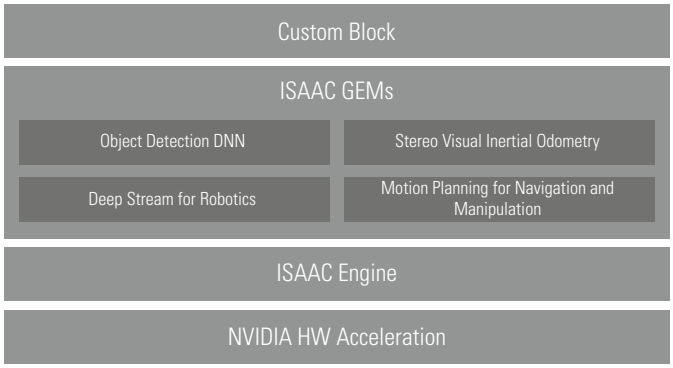
Software Design & Integration

The Neuron Base Board runs Ubuntu 18.04 Linux OS and supports VisionWorks, OpenCV, TensorRT, LibArgus, and CUDA for visual computing applications. The NB-Turbo is offered with the NVIDIA JetPack SDK, which enables quick development of AI applications utilizing libraries supporting major AI frameworks, computer vision, graphics, multimedia, and more. It is the most comprehensive solution for building a cobot. The Jetpack includes a reference file system derived from Ubuntu.

The objects of interest are fed to the model before the cobot hits the ground. The model is trained to recognize the objects of interest and their coordinates within the image using TensorFlow/PyTorch algorithms. TensorFlow is a library to develop and train machine learning models, in particular, it is used to create deep neural networks.

With the Linux-powered NB-Turbo serving as the main unit, the cobot could have multiple cameras to detect the medicine packages from a particular rack. Tensor RT, built on CUDA, acts as an inference engine to run the neural networks that process the captured images.

Developers can use the NVIDIA Isaac SDK which comes with a comprehensive set of tools, libraries, GPU-enabled algorithms, and tutorials to accelerate the development of robotics applications. Isaac SDK includes a depth estimation algorithm that could be used to analyze the distance of the medicine box from the cobot. The Object Detection algorithm and Motion Planning for Navigation algorithms are used for the cobot to plan its path, detect objects and avoid collisions – all at the same time.



Developers can also use ROS, an open-source project that carries out all the data processing and operation required to process the data captured from all the sensors and radar.

Similar Use Cases

The Neuron Base is ideal for realizing AI-based machine vision applications such as:

- Edge Camera with object detection and recognition
- Human Activity Recognition
- Autonomous Drones
- Autonomous Navigation Machine (Mining)

Benefits to the customer by using Neuron Base Board

- Comes with sufficient memory and power required for getting the OS and peripheral functionalities mapped
- Small form-factor & Light-weight module enables the customer design relatively small & user-friendly devices
- Capabilities of computer vision and distance measurement can help in operations at extreme environmental conditions.

Conclusion

The Autonomous Robot can be designed to suit various industrial and medical applications such as commercial robots, smart cameras, high-resolution sensors, automated optical inspection, smart factories, and other AIoT embedded systems. By integrating a camera module and mmWave Radars to Neuron Base Board, the platform can be used for AI based solutions such as:

- Range precision along with superior imaging capabilities for applications such as ADAS, autonomous vehicle, smart retail, industrial 4.0, robotics, smart building, and smart city, among others.
- The camera & mmWave RADAR complement each other for object detection, classification, range, velocity, and elevation parameters.

Mistral can supply the Neuron Base Boards in volume and also provide engineering services including hardware customization, OS customization, algorithm porting and integration to help take the product to market. Mistral can also provide customized AI enabled Sensor Fusion Kits that enable you to design and prototype your product quickly.

Mistral is an Embedded Product development company with over two decades of experience in the design and development of futuristic Industrial, Commercial, and Consumer products. Mistral can assist you through all or any stage of your product development life cycle – from concept to execution.

About Mistral

Mistral is a technology design and systems engineering company providing end-to-end solutions for product design and application deployment. Mistral is focused in three business domains: Product Engineering Services, Aerospace & Defense and Homeland Security. Mistral provides total solutions for a given requirement, which may include hardware design, embedded software development, systems integration and customized turnkey solutions. Mistral's strategic partnerships with leading technology companies help provide customers with a comprehensive package of end-to-end solutions.

Mistral's Product Engineering Services are delivered through a proven development process, designed for embedded product development. Mistral's hardware and software team works together in a seamless manner providing expert product designs covering board and FPGA Designs, BSP & Firmware developments, Embedded Application developments, integration of 3rd party solutions, Verification/Validation, Product prototyping, Production coordination and Product Sustenance services.

MISTRAL®
... Partners in Real Time

Mistral Solutions Pvt. Ltd.,
No.60, 'Adarsh Regent',
100 Feet Ring Road,
Domlur Extension, Bangalore - 560 071
Tel: +91-80-4562-1100
Fax: +91-80-2535-6444
E-mail: info@mistralsolutions.com

Mistral Solutions Inc.,
43092 Christy Street,
Fremont, CA 94538
USA
Tel: +1-408-705-2240
E-mail: usa@mistralsolutions.com

Branch Offices:
INDIA
- Hyderabad
- New Delhi

USA
- Dallas, Texas