Current Applications of AI

White Paper

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IoT Solutions Alliance

Introduction

The first AI program, The Logic Theorist, was developed in 1955. The “father of AI,” John McCarthy coined the phrase Artificial Intelligence in 1956. Since then, AI has moved from its early days in realms of science fiction to the realization of some of those fantasies in real life.

The challenges at places like Carnegie Mellon University and the Massachusetts Institute of Technology (MIT) were creating systems that could solve limited problems and creating systems that can learn by themselves.

This white paper gives a broad overview of how AI works and some of the applications that can be seen today.

Definitions

There are a lot of domain-specific terms thrown around when talking about AI applications, but here are some of them along with brief descriptions.

Artificial Intelligence (AI)

The goal of AI is to make computers do tasks that are beyond the traditional scope of computers. This is achieved by making the computer "learn" to do something, quite often something a person would do already. The difference being that once the computer can do it, it can do it stronger and faster.

Machine Learning (ML)

Refers to how a computer learns. Who said computer geeks can't think of creative names? How it learns is by using mathematical algorithms. So the core of what the system does is to apply some math to scrape through data to get to a desired outcome. That "desired outcome" bit is something more advanced systems are looking to get past. There are three kinds of ML:

Supervised learning tries to teach the computer in much the way as a parent would teach a child. A dataset is provided and the machine must produce a result. Classification takes the input and identifies what is in the images, or what the images are. Regression tries to predict future results using the input data. The supervision is that the system must be manually trained to make sure the results are correct, and this requires human intervention.

Unsupervised learning takes an unlabelled dataset (i.e., hasn’t been classified as anything in particular), but it tries to make sense of the input and cluster it in a way that makes sense.

Reinforcement learning learns through feedback indicating success or failure of a tried formula.

Neural Networks (NN)

These emulate the way the human mind tackles tasks, like various neurons firing. NN consist of nodes which each take input data, process it, and produce output.

Deep Learning (DL)

Where machine learning and neural networks meet, there is deep learning. Large volumes of scattered data are processed to get a result. One example from the internet space is determining user intention, where certain actions might be interpreted as indicating they are ready to buy. In this case, there is often no single event that shows that a user intends to buy, but a combination of events that when combined indicate their intention.

x Processing Unit (xPU)

Graphics Processing Unit (GPU), Neural Processing Unit (NPU), and Vision Processing Unit (VPU) are powerful computer hardware that are critical AI functions. The CPU is designed as a general purpose device for running the computer, whereas these chips are much more specifically targeted at performing AI processes.

AI Model

This is an approach to solving a problem. The frameworks used to create these models aim to constantly make them faster and better.

> *John McCarthy, considered the fater of AI, coined the term "artificial intelligence" in 1956.*

Machine Automation to AI

At first glance, AI seems like a simple idea: machines performing tasks usually done by people.

Automation, achieved by machines, has been helping people for ages, with many manual jobs now being done by machines. The most ubiquitous replacement is on production lines where machines perform tasks originally done by a person, but now with the upside of higher production speeds, 24/7 operation, and the lower costs of mass production. The limitations on these machines are that they are designed by people to do highly specific tasks, they're not inherently "smart" in the traditional sense, they're just really fast and reliable for a specific task.

These machines are single-purpose and require predictable input to produce predictable output, both carefully controlled. Sometimes though, some "intelligence" is required, typically meaning actions that require a judgment to determine the next step or action. "Is the apple ripe?" is a rather trivial question for a person, but a machine must be taught, just as a person must be taught.

So AI for our purposes here, encompasses machines that can make these decisions. And like the humans they're replacing, they must be taught.

So how do machines learn?

Machine Learning

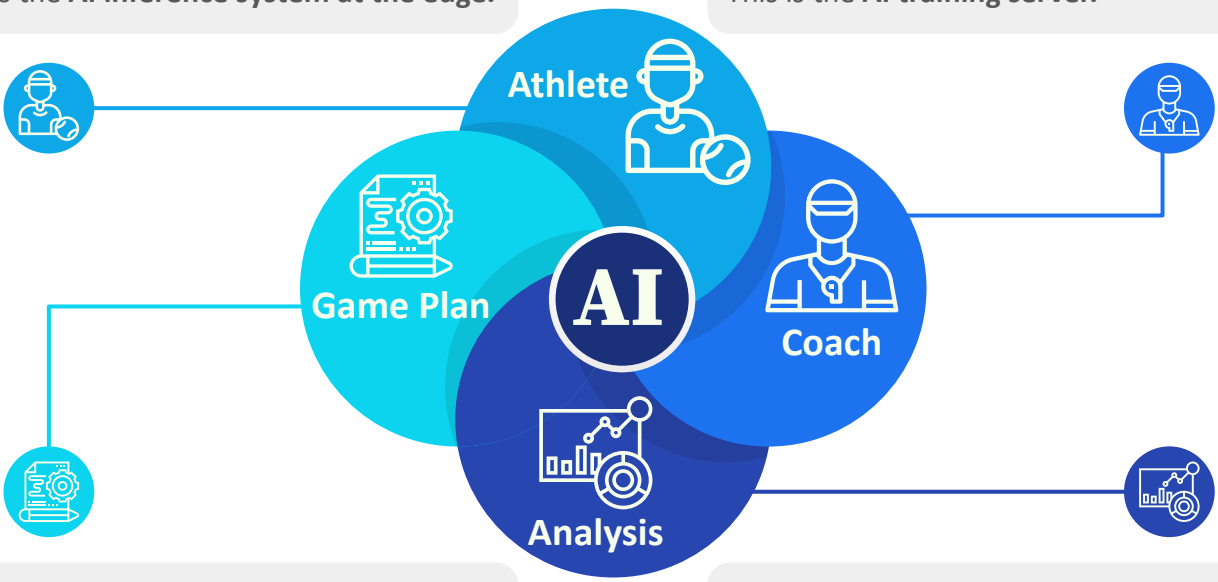
How do you teach a machine, and how do you make that knowledge useful for a specific purpose? The term AI brings about visions of robots from Sci-Fi movies like I, Robot, and much like that great movie portrays, there are multiple pieces to the AI system. And what better analogy to illustrate the AI process than the athlete and coach.

The Athlete

The professional sports player is a master in his chosen field. He knows where to be on the field. He keeps his eye on the ball. He analyzes the moves the opponent makes. He adjusts his moves to counter their offense. He observes their defense so he can make his move. His final score is the evaluation of his effectiveness in the game. This is the **AI inference system at the edge.**

The Coach

The all-knowing coach sees what the player cannot. While the player commits to the actions, the coach has his eye on the game as a whole. He sees the big picture. It is the coach who brings experience to the field and provides guidance to the player. To teach the player, the coach must analyze what happens, and formulate a game plan. This is the **AI training server.**



The Game Plan

When the coach relays the results of his analysis to the player, he can use that insight to adjust his play, how he responds to the other team, and make different moves the next time around. The player takes the increased knowledge of the coach and translates that into actual performance on the field. The game plan is the coach's analysis put into action by the player. This is the **optimized representative model** at the edge.

The Analysis

The coach keeps his eye on the game to monitor what happens. By absorbing and processing this information he can use his knowledge of the sport and accumulated experience to see where things have gone right or wrong, and why it happened that way. Why did that move fail to work as intended? How did the opposition manage to get the ball? Is there something we didn't anticipate? Asking questions is a key. This is the **deep learning framework** on a training server.

Artificial Intelligence streamliness manual work processes and brings 24/7 operation and increased reliability.

Applications

There are many applications in use today. The common thread between them is that they all aim to mimic, and improve on, the processes already performed by people using their five senses. It's these five senses that are recreated in an AI system, typically just one of them. With eyesight as the "primary" sense that governs much of human behavior and interaction, it should come as no surprise that vision applications have been a major focus of AI. They also provide an excellent opportunity to include cool stuff like robots in marketing materials. More seriously, other applications include the processing of sensor information (mimicking touch) that would suggest issues, for example, excessive vibration of a factory machine. Hearing also comes into play with voice analysis and again with the measurement of things that just "don't sound right." Taste and smell might come up short on this list, but it is only a matter of time before a machine designs perfume. So without further ado, let's dive into a few applications that are currently available.

Machine Vision for Sorting and Grading Agricultural Produce

Those magnificent red apples in the fruit basket on your living room table, the ones with the flawless skin and juicy meat, didn't get to that level of perfection by accident. Those apples were meticulously selected and separated from their siblings, who were sent to the food production facilities that emphasize quantity and value over appearance.

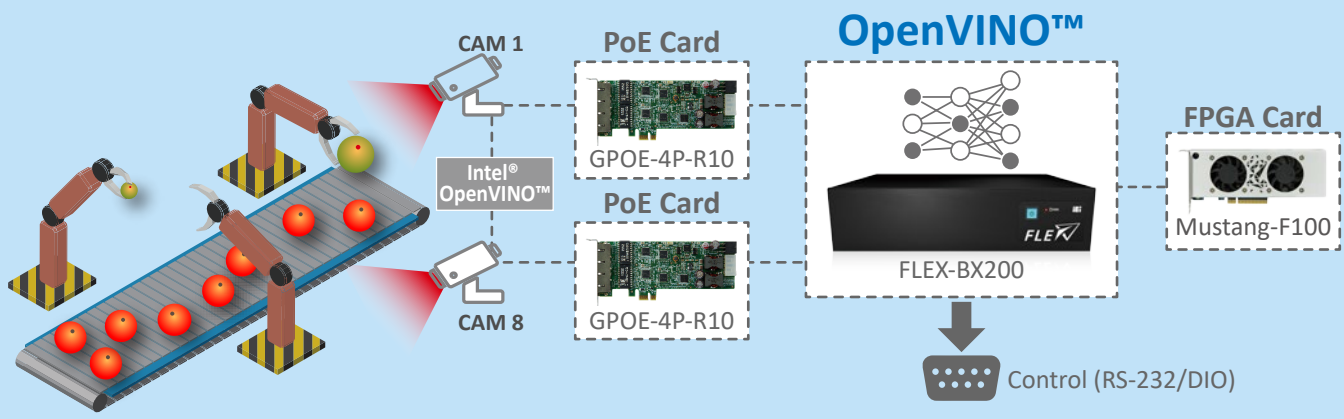
Agricultural produce goes through a lot of sorting and processing from the farm to the table. For demonstration purposes, we'll consider a juicier alternative to the apple, the mango. After being picked from the trees on the farm, the mango moves to the processing facility. This process finds the mangoes that have the best appearance, and those that don't and are likely to be used for other purposes.

The mangoes are placed into a large water tank, lifted out the water by an elevator, then cleaned and shined before visual inspection. The mangoes are shuttled along the sorting table for visual inspection (this is the part we'll get back to in a moment) where the "good fruit" is separated from the "bad fruit." The size and look of the outside of the mango determine whether it can be classified as export quality. Modern consumers in many countries have become accustomed to near-perfect looking fruit and vegetables, so export-quality produce must look the part. After separating out the sub-quality mangoes, they are sent along through a sorting machine that sorts the mangoes by size. Finally, these sorted mangoes are carried along conveyor belts for packing.

This entire process is automated, performed exclusively by machines, except for visual sorting. Well, that's where machine vision comes into play. The graders usually need to be taught to evaluate the quality of the mangoes, but they are susceptible to performance issues. They can get tired, fail to identify blemishes, and their determination of "good" and "bad" can be inconsistent. Machine vision eliminates these problems. With advanced sorting algorithms, the computer makes quality decisions from video data input, then uses a robotic arm to pick out the mangoes with blemishes for local distribution or otherwise.

The upsides to using this automated technique include more consistent identification of sub-standard fruit, but also identifying fruit that has been identified as sub-standard but is actually acceptable. Processing speed is at least the same as it was before, but with the extra bandwidth to expand and increase the speed with the addition of cameras and robotic arms.

For this machine vision application, the IEI FLEX, a powerful AI computer in a regular desktop computer case, is the best fit. Four PCIe 3.0 expansion slots support motion controller cards to control the robotic arms that will pull the fruit from the sorting. The IEI GbE PoE Ethernet card uses IEEE 802.3af for direct connection to CCTV cameras providing both data transfer and power over the same Ethernet cable. The "smarts" are provided by a selection of GPU/FPGA/VPU cards, depending on production needs.



AOI Defect Classification

Automatic Optical Inspection (AOI) is used for Printed Circuit Board (PCB) testing. It performs a visual inspection of the printed circuit boards. Faster and more accurate than manual visual inspection, this automated process allows for quick confirmation of correct placement and attachment of components.

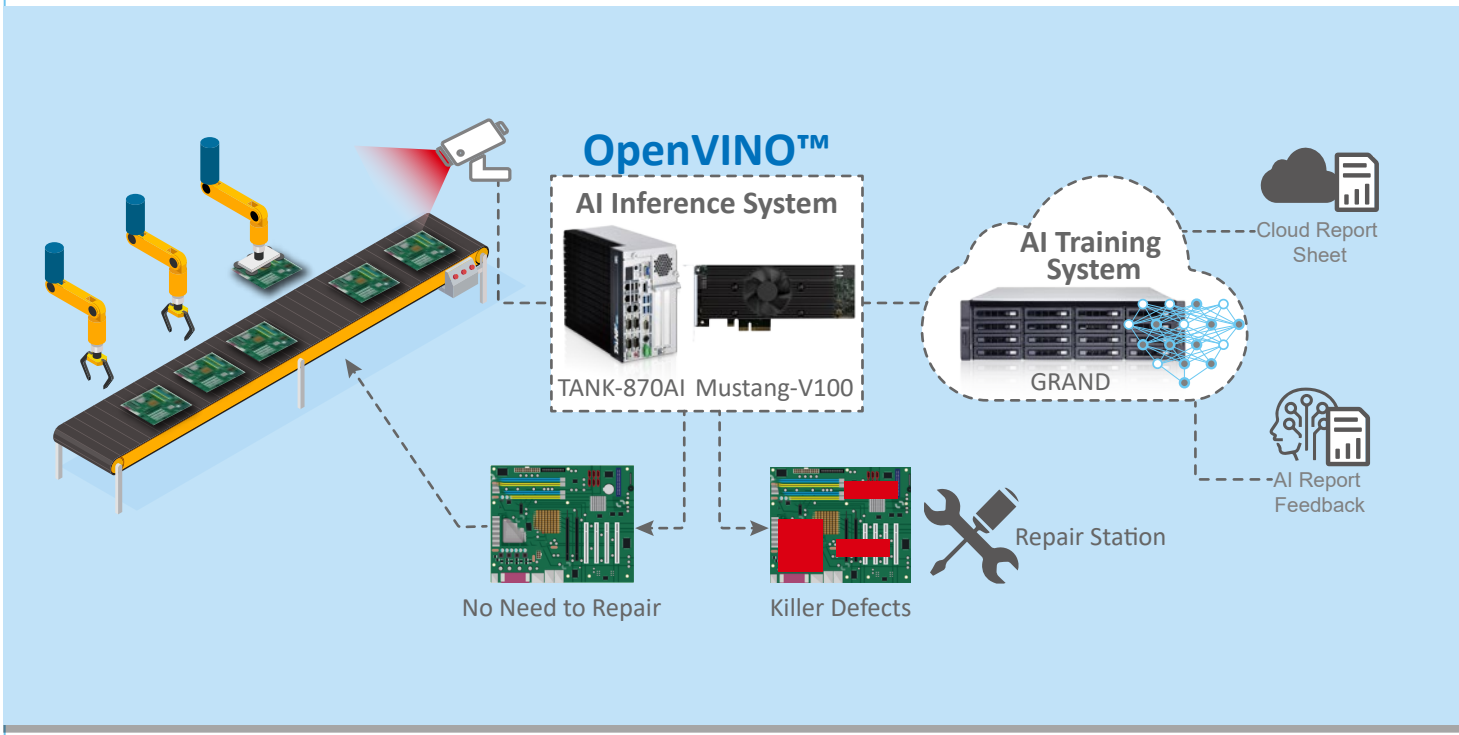
The small size and the large number of small parts on PCBs mean that it is no longer feasible for manual inspection. Combine that with over a thousand soldered joints, and manual inspection is simply not possible. Demand for PCBs has also increased rapidly, requiring faster production times to be competitive and to meet tight deadlines.

AOI processes mainly inspect the quality of soldering and are implemented after the soldering process on the production line so errors can be detected early. Fixing any of these errors further down the production line would incur greater costs.

Whatever the capture method, the AOI system looks for placement of components, size of components, the polarity of components, label pattern, and missing components. Soldering joints are also inspected. One difficulty is that the size of components can vary between boards, and other differences can occur that don't make a board "bad."

The accurate judgment of PCB quality requires a powerful AI system that can use advanced algorithms to process visual information quickly and accurately, allowing for even faster processing times and more accurate results.

For this application, the TANK AIoT Dev. Kit features pretty much every I/O you could hope for, and two PCIe x8 slots mainly designed for acceleration cards like the IEI Mustang-F100-A10 and Mustang-V100-MX8, or PoE video capture cards for industrial camera or video camera image capture.



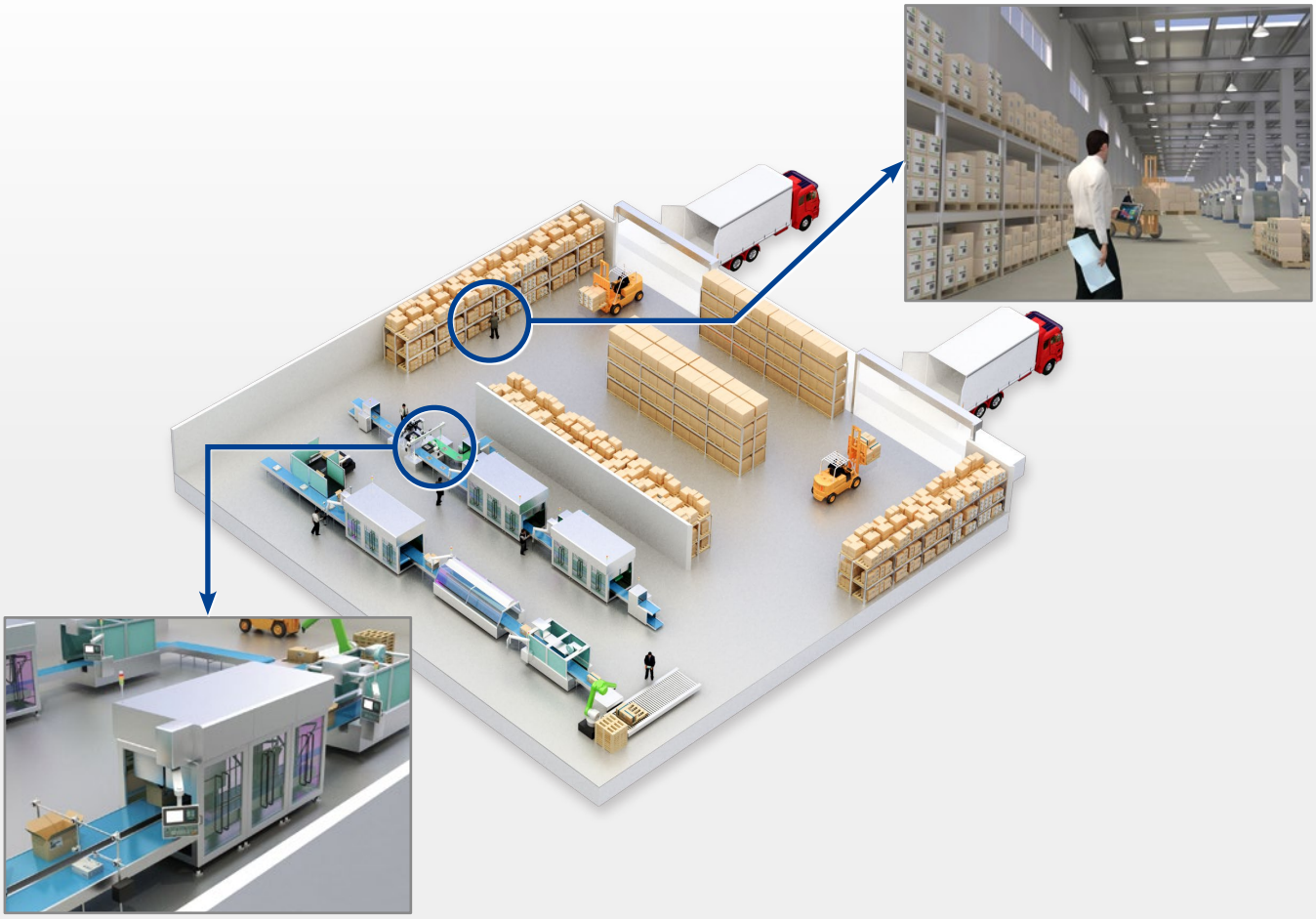
Industrial Automation

At the heart of all industries is a push to increase output, reduce costs, reduce time to market, and reduce bottlenecks to the production processes. Better, stronger, faster.

The AI shift is focused on the ability of machines to make decisions or choices based on input, mostly visual inputs. These inputs are often available through dedicated hardware, but still lack the processing power to make "smart" decisions or take various factors into account. Retrofitting these capabilities to current systems is taxing and expensive to upgrade to new hardware and get that new hardware setup. Offloading of processes to the cloud is making this easier, and with the advent of this new technology, many new options are available.

The main bottleneck is the processing power needed for AI technologies. These intensive image processing algorithms put a significant strain on the computer's CPU and simply cannot be accomplished with existing technologies. Retrofitting has been difficult because GPUs were not designed for these applications. Although they are powerful and help boost processing power, they are a brute force approach to solving this issue.

The Mustang series of addon cards are designed precisely with the needs of the smart factory in mind. Rather than being just super-powerful, they are powerful in precisely the way that is needed. This extra power allows the collection of even more detailed data on raw material storage, fabrication, completed products, and manufacturing process time and warehouse storage status, which can be used to streamline production processes.



Medical Applications

There is no doubt that AI is making massive headway in the medical field. The effects of computers have already been felt in the organizational aspects of hospitals and other medical facilities. Electronic Medical Records are quickly replacing paper-based systems because they can deliver information quicker and with fewer errors than ever before. Computer hardware can be the "extra set of eyes" on entries and can alert doctors and nurses to potential issues. The digitization has also led to automation that improves the functioning of traditionally manual processes, and in some cases, totally replaces the manual intervention required. It's these final cases for visual processing and the analysis of existing data, where AI technology currently has a major impact.

A slew of major AI software offerings have cropped up with the rise in these technologies, and a few big names are also leveraging their already massive processing resources for the same purpose.

Within the hospital space, the introduction of AI primarily aims at reducing the manual workload for physicians and hospital staff. Processes like checking X-Rays, EMI, and the like take an enormous amount of time, and AI can now be trained to eliminate this manual workload and reduce a full day of work to under a minute.

The following three cases are just a sampling of the potential uses of AI in the medical field. The common thread between these is that they take images that used to be manually processed by a trained professional, and are now done in almost no time by a powerful computer with a little AI.

> *AI supported image processing reduces manual image analysis from an entire day down to just a minute.*

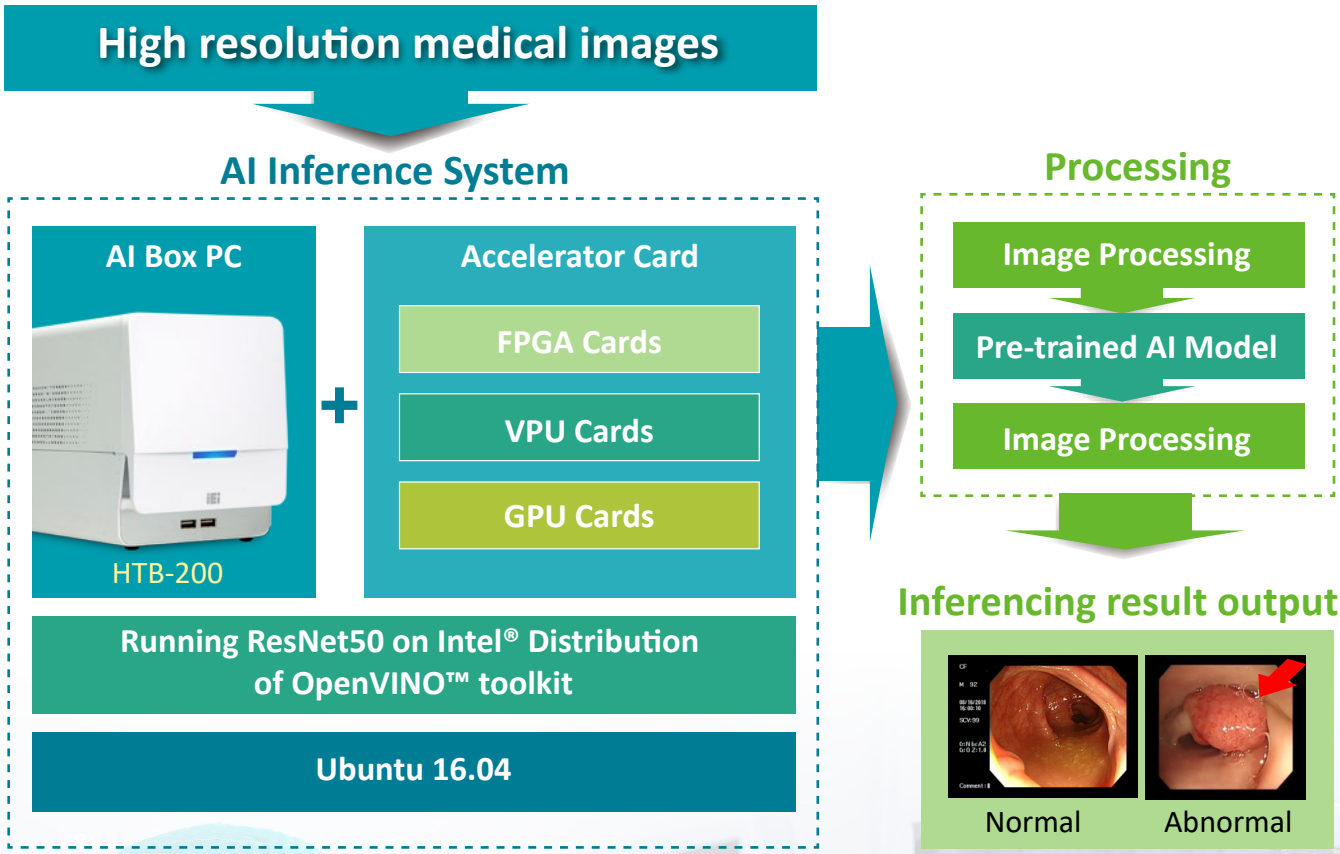
AI Inference in Colonoscopy

A colonoscopy is usually performed if there is bleeding from the anus, changes in bowel activity like diarrhea, pain in the abdomen, or unexplained weight loss. It is often used to screen for possible colon or rectal cancer.

Visual inspection of these images for irregularities is key to early intervention in the case of cancer treatment. However, the endoscopist's skill in identifying the early signs of problems takes years to build, and it's still difficult to identify them with regularity.

This is where the AI system comes into play. With algorithms available to identify common problems, the colonoscopy images can be processed almost instantaneously with AI, providing immediate and accurate results which can quickly be double-checked by the endoscopist.

This technology will not completely replace the trained eye, but it will improve the identification rates for experienced endoscopists and give much-needed support for less-experienced practitioners.

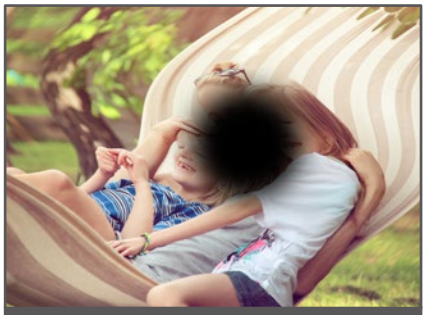


Age-related Macular Degeneration

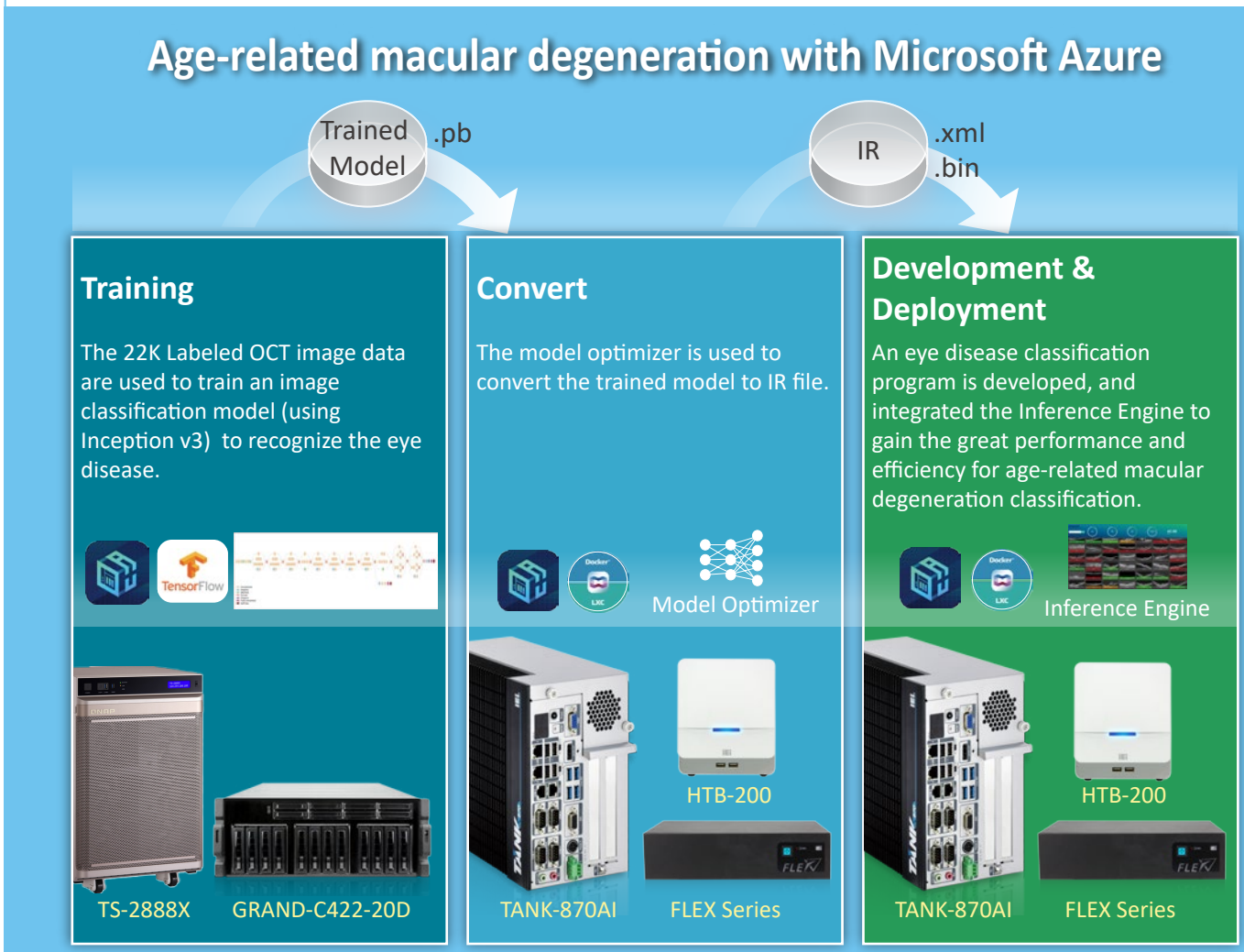
Age-related Macular Degeneration (AMD) is a medical condition that causes blurred or no vision in the center of the visual field. There are often no early symptoms, and vision slowly worsens until even daily activities become difficult, sometimes even bad enough to affect the recognition of people's faces. Over 6 million people are affected by AMD, and it is the fourth most common cause of blindness after cataracts, preterm birth, and glaucoma. It is an age-related disease, typically affecting people over the age of fifty, and becoming a more serious concern the older the person is.

Normal

Early identification of possible medical conditions can give medical practitioners a chance to provide intervention to slow, halt, or eliminate certain diseases. YangMing University in Taiwan used convolutional neural networks to develop an AI for a cloud-based telemedicine service. They used a dataset of over 35,000 optical coherence tomography images from age-related AMD patients to train three types of CNNs to perform AMD diagnosis. The cloud-based AI service gives results better than medical students and approximately equal that of retinal specialists.



Macula Aging



Brain Tumor Treatment

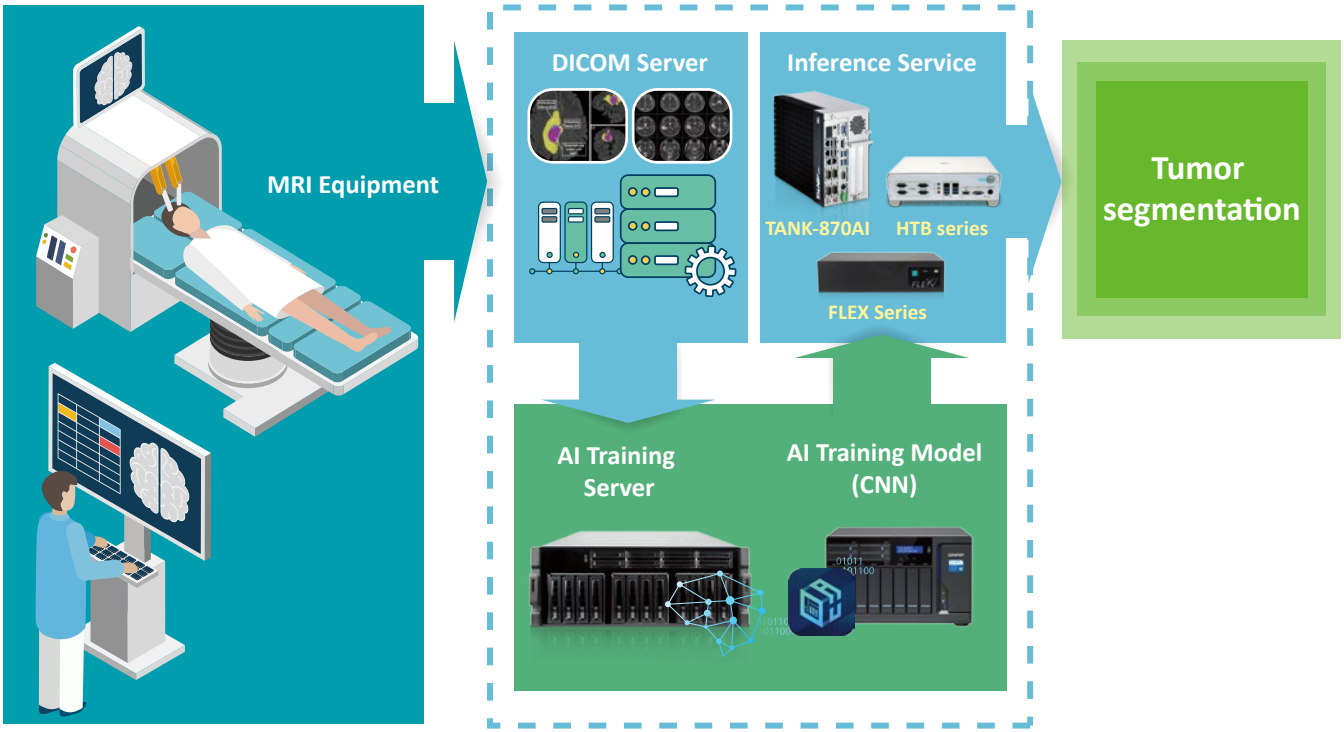
Treating tumors in the brain with radiation requires the most accurate approach available. The primary objective is to focus high doses of radiation to the tumor with extreme precision, directing radiation only to the tumor, while protecting highly sensitive brain tissue and basal.

In the traditional scenario, physicians need to manually mark and shape the brain tumor in every single image before proceeding with a brain tumor treatment plan. This is a complicated process that requires high accuracy and can take a day to develop just a single plan. Time spent manually marking images is time away from patients.

AI has stepped into the forefront, with leading inference systems reducing the processing time of medical images to just a few seconds. This pre-processing almost eliminates the tedious initial work, and instead of starting from scratch, the oncologist can immediately double-check the results.

One very popular and well-known application of this technology is the futuristic Cyberknife, a robotic radiation system using advanced imaging and realtime motion synchronization to target cancerous tumors. Leveraging these technologies, the Cyberknife can follow the movement of the tumor that occurs when a patient moves when breathing, so there is no need to sedate the patient or use a head frame to keep them still during the procedure. The whole procedure is non-invasive and non-surgical. Patients can often continue with their daily activities after a session.

The HTB-100 is a high-performance medical-grade embedded system used for AI inference in brain tumor diagnosis. Expansion options allow VPU and GPU accelerator cards to be added as needed.



Vehicle License Plate Analysis

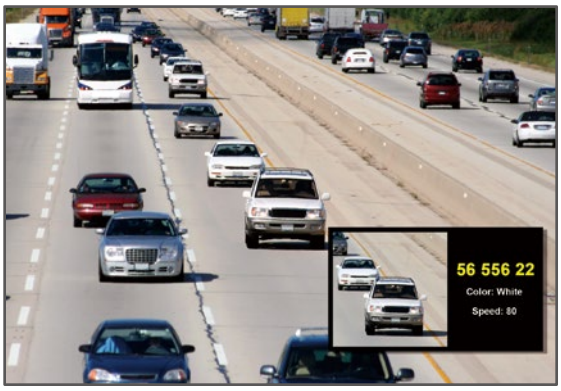
The sheer volume of motor traffic and the movement of millions of vehicles every day makes every small increase in efficiency a massive boost for traffic flow and management.

License plate recognition is an early example of AI technology at play. There has always been a disconnect between having every vehicle labeled with a unique number but always needing manual processing to do anything useful with it. In terms of algorithms and processing, license plates are an ideal application of AI because of the relatively simple identification of the license plate and the decoding of the license number. License plate numbers are a combination of a limited set of predictable characters as opposed to recognizing facial features or objects in the environment. The speed of processing is now sufficient to process hundreds of license plates a second, which has led to the applications outlined below.

> *Rapid processing of license plates, powered by AI, opens up new opportunities for traffic management and parking lots.*

Traffic Management

The first two applications are provided by license plate recognition along highways with high-speed cameras placed above the freeway. Firstly, automatic tolling is possible, and the vehicle can be charged for use as per regulations. The system's inherent flexibility allows for a post-usage charge, pre-pay, or even a combination with an electronic tag system. The second upside to the constant processing of license plates is the immediate identification of stolen vehicles or vehicles belonging to wanted criminals, allowing police tracking without necessitating possibly deadly high-speed chases.



Parking Management

Parking lots are almost as old as roads themselves, a novel way to deal with the influx of cars to bustling centers, but until now, mostly a manual affair. In most modern lots, drivers are issued a magnetic stripe card or plastic chip upon entry that stores the entry time data. This method is effective but has some room for improvement. The cards are prone to get lost or damaged and force the driver to care for one more item while they go about their business. Using AI to recognize the number plate means that the driver doesn't need to put yet another card in their wallet because the parking management remembers the car number for them. Payment for parking can be based on a monthly fee, by the day, by the hour, or any combination that suits the parking lot management, and can also be done automatically with a membership linked to an automatic payment method.

Smart Retail

AI applications in retail allow for the recognition of real-world objects and people, offering possibilities for streamlined and personalized customer experience.

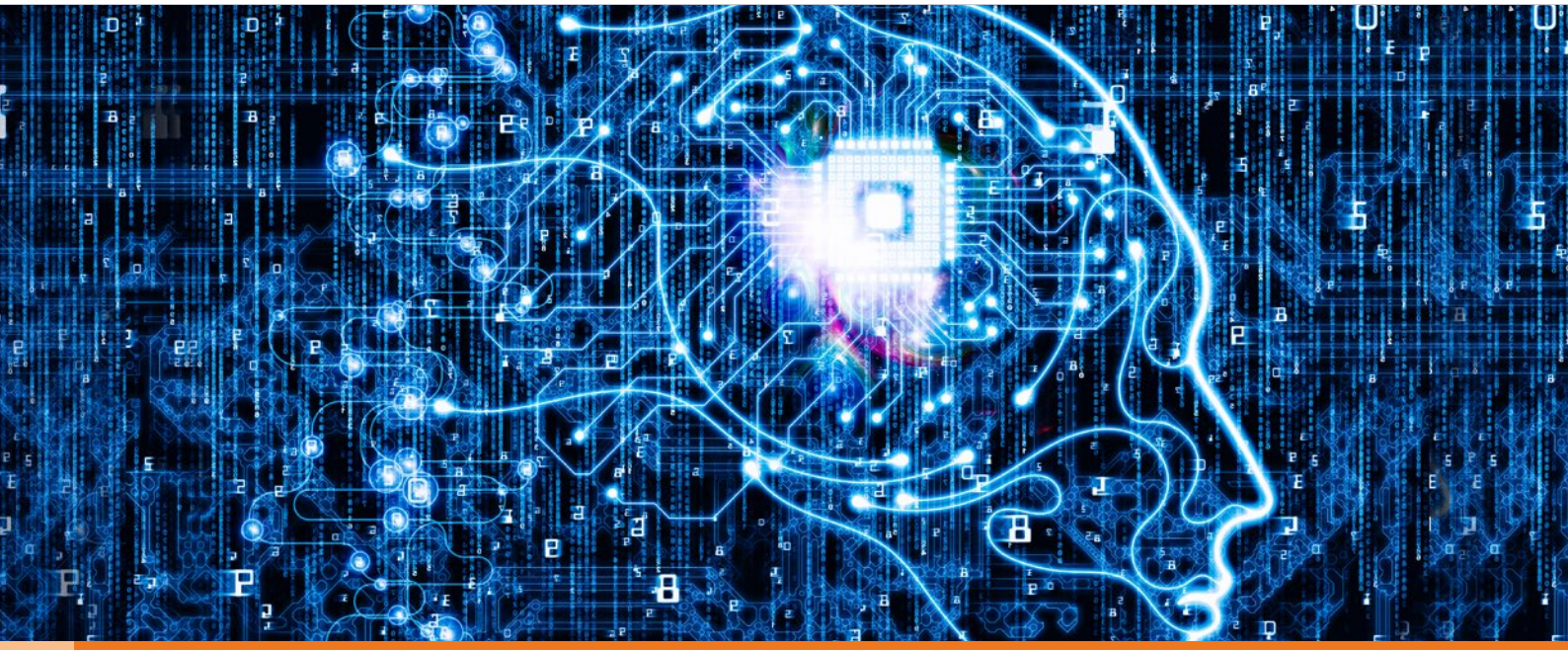
Self-checkout has seen increasing adoption, particularly in major retail outlets. With the competition between large retail outlets, the cost of staff can be a make-or-break cost when profit margins are laser-thin. Self-checkout puts the responsibility for checking out and paying in the hands of the customer. To encourage self-checkout, customers are incentivized through a discount on their purchase or other perks. Gas stations employ a similar technique when switching from full-service to self-service, with rewards and cashless payment.

Digital signage benefits from AI vision processing by identifying the age and gender of someone and providing a customized selection of products suited to their tastes. This ultra-targeted approach does what a good salesperson would do anyway, leading to what you're looking for.

The final upside to all these technologies is the potential business insights. In the online world, for example, cart abandonment is a hot topic because if a customer put the product in their cart, they were very interested in it, but didn't buy. The cart abandonment followup email tries to draw them back so they can make the purchase. With all the collected data, similar processes can now be applied in the real world.

Using the Mustang series for computer vision solutions at the edge of retail sites can quickly recognize the gender and age of the customers and provide relevant product information through digital signage display to improve product sales and inventory control. Self-checkout can reduce human resource cost so that retail owners can spend more resources on promoting products and understanding business patterns.

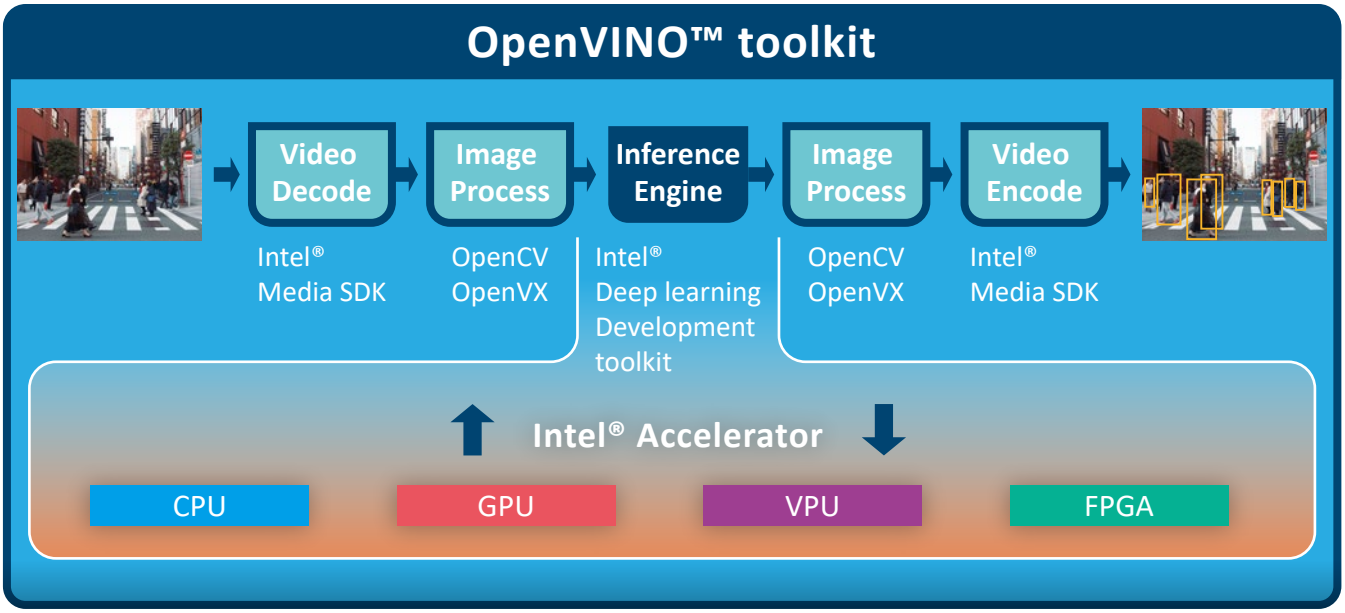
In addition, it can help to analyze customer's in-store behavior, and provide customer information based on gender and age to facilitate product positioning. Quickly converting the business intelligence gained and help build better business practices and increase profitability.



Intel® Distribution of OpenVINO™ toolkit

Intel® Distribution of OpenVINO™ toolkit is based on convolutional neural networks (CNN), the toolkit extends workloads across multiple types of Intel® platforms and maximizes performance.

It can optimize pre-trained deep learning models such as Caffe, MXNET, and ONNX Tensorflow. The tool suite includes more than 20 pre-trained models, and supports 100+ public and custom models (includes Caffe*, MXNet, TensorFlow*, ONNX*, Kaldi*) for easier deployments across Intel® silicon products (CPU, GPU/Intel® Processor Graphics, FPGA, VPU).



So What's Next?

That's a brief introduction to just some of the current applications of AI technology. The IEI range of computers and expansion cards are designed specifically to harness and optimize for AI development applications.

There are further online resources for further reference:

IEI AI Ready Solution Introduction

IEI AI Ready Solution Catalogue

IEI AI Introduction on YouTube

The full scope of the complexities of the machine learning models and frameworks are beyond the scope of this document, but if you have any questions at all, please fill out the sales inquiry form and you will be contacted shortly by an IEI sales representative. Thank you.

Sales Inquiry

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