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Aier Eye Hospital Brings Deep Learning to Blindness Prevention

Intel® technologies and Caffe* optimized for Intel® architecture help speed deep-learning throughput for efficient, high-quality, and cost-effective eye-health screening

At a Glance

A deep-learning solution developed by Aier Eye Hospital Group and MedImaging Integrated Solutions (MiiS) will use Intel® Xeon® Scalable processors and Caffe* optimized for Intel® architecture to help China's government improve screening for two common causes of preventable blindness.

- China gains a powerful tool to extend high-quality eye-health screening from urban hospitals to community clinics, covering more patients in an affordable way.

- MiiS strengthens the diagnostic capabilities of its handheld ophthalmoscope with deep-learning inferencing at the edge and in the cloud.

- Aier uses artificial intelligence to serve more customers and continue its rapid business growth.

Aier Eye Hospital Group and MedImaging Integrated Solutions (MiiS) developed a deep-learning solution to improve screening for diabetic retinopathy and age-related macular degeneration. But the team wasn't satisfied with the performance or cost profile it was seeing from its original architecture. MiiS worked with Intel to explore whether Intel® architecture could deliver better performance for practical clinical workflows. The speedups were so impressive that MiiS and Aier are moving forward with an Intel® Xeon® Scalable processor-based appliance for clinical inferencing in community clinics and small hospitals.

Challenge

With skyrocketing rates of diabetes, China is expanding its efforts to screen for common complications, including diabetic retinopathy. As China's leading hospital network in eye care, Aier Eye Hospital Group is in a strong position to help. Aier and MiiS collaborated to add deep-learning capabilities to MiiS's handheld ophthalmic scope, strengthening its ability to identify clinically significant diseases. As the companies looked toward deploying the solution, they sought a practical architecture that could deliver outstanding performance without driving up total cost of ownership (TCO).

Solution

MiiS worked with Intel to port the solution and test its performance on Intel® Xeon® processors using Caffe* optimized for Intel architecture, Intel® Math Kernel Library for Deep Neural Networks, and several optimized open source math and imaging libraries. The companies were so pleased with the results that they created an edge appliance based on the Intel® Xeon® Bronze processor to run the optimized algorithms in clinical workflows.

Results

The optimized solution on an Intel Xeon Bronze processor loaded models more than 100 times faster than standard Caffe on the previous generation processor. It also offered high accuracy and accelerated the time needed to classify the patient's condition more than sevenfold. China's national government plans to use the solution to enable high-quality, eye-health screening in clinics and smaller hospitals across the country. Health workers and general practitioners can identify patients needing follow-up care. Ophthalmic specialists can focus on patients with the greatest need.

SPED MODEL LOADING BY 103x

Compared to standard Caffe* with previous-generation Intel® Xeon® processors

Solution Benefits

- Workflow improvements for faster screening throughput, enhanced productivity, and optimal use of trained experts
- Accuracy in identifying patients who need further screening or treatment for two common causes of vision loss
- Screening capacity for medical centers, clinics, and national health systems, particularly outside top-tier hospitals in big cities
- Business growth for MedImaging Integrated Solutions and Aier Eye Hospital Group

Smarter, Faster Screening to Reduce Blindness

Diabetic retinopathy and age-related macular degeneration are among the leading causes of blindness around the world. Both conditions can remain symptomless for years and can be difficult to diagnose without examination by an ophthalmic expert. With populations aging, obesity rising, and diabetes rates soaring, the number of people at risk is approaching epidemic proportions.

While these are global concerns, China's need is particularly acute. The nation's rates of diabetes and prediabetes are nearly as high as those of the United States,[1] and the National Health and Family Planning Commission expects the number of citizens with age-related macular degeneration to double by 2020, reaching 8 million.[2] China also has severe shortages of ophthalmology specialists, especially outside large, urban hospitals.

> "Aier can help address the shortage of ophthalmologists and bring high-quality care to people in rural areas."
>
> **—Xu Ming**
>   General Manager, Aier Eye Health Group

Preventing diabetes and finding sustainable ways to treat its complications will be a strong focus for China's government in the coming years,[3] as it will be around the world. China's approach will include shifting much of its diabetes care, including retinopathy screening, from hospitals to primary care clinics. In China and elsewhere, success will require scalable, cost-effective ways of identifying retinopathy, along with macular degeneration, before life-altering vision damage occurs. In addition, because it can be difficult in China's rural areas to reach people for follow-up once they have left the point-of-care, the ability to provide diagnostic results within a single visit will be crucial.

MiiS Finds Deep Learning Helps Improve Accuracy

To meet these needs, Aier Eye Hospital Group and MiiS added deep learning to the SC1* image processing software for MiiS's award-winning Horus* digital handheld fundus cameras. Horus cameras capture and process images of the eye's inner lining, enabling clinicians to observe damage to nerves, blood vessels, and structures, including those that can indicate incipient vision loss.

With the integration of deep-learning capabilities, general practitioners and community health workers can capture images that are then transferred to the solution's inferencing system—a high-performance appliance for rapid analysis "at the edge"— in rural clinics or small hospitals. The inferencing engine, which can also run on Aier's secure private cloud, classifies and labels problem areas and advises the health worker whether to refer the patient to an ophthalmic specialist. Captured images and exam results are automatically entered into Aier's electronic health record system, saving time and facilitating collaboration when referrals are needed, and enabling patients to learn immediately if they need further assessment or treatment.

Aier and MiiS used thousands of privacy-protected images from Aier's data files, along with a 26-layer SqueezeNet* convolutional neural network, to train the deep-learning model to recognize and classify the key indicators of diabetic retinopathy and age-related macular degeneration. In an analysis of imaging data from 5,000 Aier patients, MiiS and Aier reported that accurate detection, which had averaged 70–80 percent for screening conducted by humans, skyrocketed to 93 percent with the deep-learning solution.

"It is not uncommon for high-quality deep-learning solutions to surpass the overall accuracy of even expert human clinicians, since computers don't experience things like fatigue, eye strain, or momentary lapses in concentration," explained Tang Shibo, president of Aier. "Increased accuracy is one of the reasons we are committed to being on the leading edge of medical imaging analytics, since it helps us get patients into treatment more quickly and make optimal use of our clinical staff."

Speeding the Workflow with Intel® Technologies and Expertise

While pleased with their model's accuracy, MiiS and Aier wanted better performance for clinical workflows than the original architecture was providing. Could Intel Xeon Scalable processors, with their powerful compute engines and large memory capacities, relieve the performance bottlenecks MiiS was observing?

MiiS reached out to Intel for assistance porting the solution. Deep-learning optimization experts from Intel worked with MiiS to take advantage of a version of the popular Caffe deep-learning framework that Intel engineers have optimized for Intel architecture. The optimization team ran the inferencing

code using standard Caffe on an Intel® Xeon® processor E5-2620 v4, followed by runs using Caffe optimized for Intel architecture on the Intel Xeon processor E5-2620 v4 and the newer Intel® Xeon® Bronze processor E3-1245 v5. The team also used optimized versions of the open source Numerical Python* (NumPy) and SciKit* Image (SKImage) libraries.

Even using an entry-level member of the Intel Xeon Scalable processor, MiiS and Aier achieved dramatic speedups. With Caffe optimized for Intel architecture and the Intel Xeon Bronze processor, the solution performed the critical task of loading the model and creating the memory buffers for a batch of images more than 100 times faster than standard Caffe on the previous-generation Intel Xeon processor. The optimized Caffe on the Intel Xeon Bronze processor also accelerated the time needed to perform the inferencing needed to classify a patient's condition by more than 7.4 times (see Table 1).

"The combination of Intel's expertise, the new Intel Xeon Scalable processors, and Caffe optimized for Intel architecture provided such impressive results that we are moving forward with Intel Xeon Bronze processor and Intel's optimized Caffe framework," said Stefan Zheng, CEO of MiiS. "We also plan to add enterprise-class solid state drives from Intel to our infrastructure. These technologies will deliver outstanding capacity and power efficiency for our customers' clinical workflows, and because they are compatible with so much other infrastructure, they will help reduce IT costs."

Better Care and Business Growth

With its combination of performance, accuracy, and TCO, the MiiS solution offers broad benefits for health systems that deploy the solution. Aier plans to use the solution in its 200 branch hospitals in 2018 and has set a target of reaching 30,000 primary care clinics in China and screening 30 million Chinese patients for diabetic retinopathy. China's central government has said it will refresh all primary clinics by 2020 and plans to make the MiiS and Aier eye-health screening system a standard part of the clinics.

Deep learning is an important part of Aier's plans for growth throughout China and internationally. "The need for affordable, high-quality eye-health screening is enormous and growing," said Xu Ming, general manager of Aier Eye Health Group. "By enabling our clinics to offer fast, accurate screening, Aier can help address the shortage of ophthalmologists and bring high-quality care to people in rural areas, where the only care available is through a rural clinic. Even in the biggest cities, we can help save time for eye-care professionals and enable them to devote themselves to patients with the most serious problems. Through early detection, we provide opportunities for earlier diagnosis and treatment, to help preserve vision."

Solution Ingredients

- **MedImaging Integrated Solutions Horus* Digital Handheld Fundus Camera.** Portable device for capturing high-resolution images of the eye's interior. Flexible Horus cameras are used in settings such as community clinics, ambulances, and hospital wards.
- **Intel® Xeon® Scalable processor.** Intel's latest family of high-performance, energy-efficient processors optimized for data center and cloud computing environments.
- **Intel® Solid State Drive Data Center Family.** Throughput-enhancing solid state drives for data-intensive applications and high-performance storage.
- **Caffe* optimized for Intel® architecture.** An open source deep-learning framework developed by the Berkeley Vision and Learning Center (BVLC). Caffe optimized for Intel architecture is now an official branch of the BVLC.
- **Intel® Math Kernel Library (Intel® MKL) for Deep Neural Networks.** A high-performance library designed to accelerate popular image recognition functions, increase application performance, and reduce development time on multiple generations of Intel® processors. Intel MKL for Deep Neural Networks is available as part of Intel MKL or as a stand-alone, open source package.

Table 1. Accelerating Throughput for Clinical Workflows

Task	Intel® Xeon® Processor E5-2620 v4 with Standard Caffe*	Intel Xeon Processor E5-2620 v4 with Caffe Optimized for Intel® Architecture	Intel® Xeon® Bronze Processor E3-1245 v5, Caffe Optimized for Intel Architecture
Load, model, and create memory buffers for image batch	5,537.00 ms	56.82 ms	53.32 ms
Perform inferencing per patient	271.21 ms	49.87 ms	36.47 ms

Tests were performed on an IBM ThinkStation* P320 with 256 GB of DDR4 RAM, and a 1 TB hard disk drive running Ubuntu* Linux* with standard Caffe and Centos* Linux with Caffe optimized for Intel architecture.

"Deep learning and other forms of artificial intelligence are going to bring great value to healthcare," said Stefan Chang, general manager of MiiS. "Through this solution and our collaboration with Aier and Intel, Aier Eye Hospital Group increases their skills in this exciting area and advances their leadership in eye-health services around the world."

Find the solution that is right for your organization. Contact your Intel representative or visit **intel.com/healthcare**.

Learn More
- Solution brief: Inferencing Solution Simplifies AI Adoption for Medical Imaging
- MiiS Horus* Scope in Use

Relevant Intel® products
- Caffe* optimized for Intel® architecture
- Intel® Xeon® Scalable processor
- Intel® SSD Data Center Family
- Intel® Math Kernel Library for Deep Neural Networks

Other solution elements
- MiiS Horus Digital Fundus Camera

Spotlight on Aier Eye Hospital Group
Aier Eye Hospital Group is China's leading hospital network in eye care. The group has established more than 200 specialized eye hospitals and clinics covering 30 Chinese provinces and provides more than 4 million outpatient visits annually.

Aier is experiencing rapid growth as an international provider of high-quality ophthalmic services. It is headquartered in Changsha, China, and has facilities in Austria, France, Italy, and Spain. In 2017 Aier acquired the Wang Vision Institute in Nashville, Tennessee, marking its expansion into the United States. For more information, visit **en.aierchina.com**

Spotlight on MedImaging Integrated Solutions (MiiS)
Launched in 2010, MiiS designs and manufactures digital, handheld, diagnostic scopes. Its comprehensive line of Horus digital medical scope products are integrated with a high-quality optical system and real-time imaging processing, and have qualified for numerous ISO and other certifications. The company is based in Taiwan. For more information, visit **miis.com.tw**

Solution Provided By:
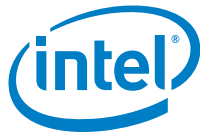
1 The JAMA Network, High Prevalence of Diabetes, Prediabetes in China, June 27, 2017, media.jamanetwork.com/news-item/high-prevalence-diabetes-prediabetes-china.

2 China Ministry of Health, "Notice of the General Office of the State Health and Family Planning Commission on Printing and Distributing Technical Schemes for Classifying and Treating Diabetic Retinopathy," April 1, 2017, moh.gov.cn/yzygj/s7653/201704/3524f29f1599419aa04bbe4e068c962a.shtml. [Translated from Chinese using Google Translate*.]

3 Ling-Zhi Kong, "China's Medium-to-Long Term Plan for the Prevention and Treatment of Chronic Diseases (2017–2025) under the Healthy China Initiative," ScienceDirect, September 2017, sciencedirect.com/science/article/pii/S2095882X17300324.