The future of AI in healthcare

AI is helping prioritize the patient experience, improve outcomes, and streamline clinical workflows with smarter healthcare solutions.

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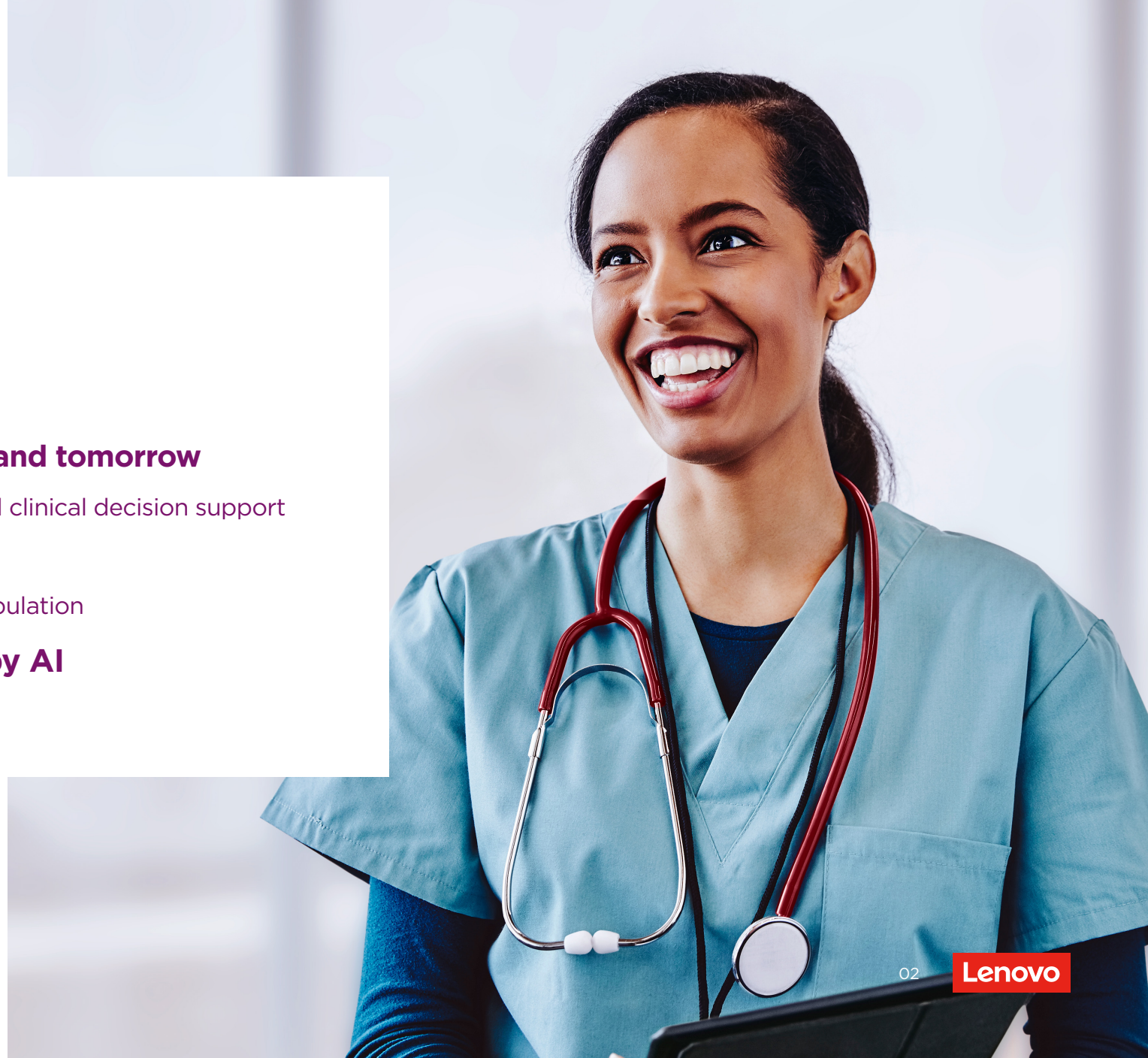

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AI transformation

The Brookings Institution's Artificial Intelligence and Emerging Technology (AIET) initiative identifies four areas where AI is expected to benefit healthcare[1]:

- Pushing the boundaries of human performance
- Democratizing medical knowledge and excellence
- Automating drudgery in medical practice
- Managing patients and medical resources

According to market analysts at Deloitte, tasks performed by AI "...can range from simple to complex and include everything from answering the phone to medical record review, population health trends and analytics, therapeutic drug and medical device design, reading radiology images, making clinical diagnoses and treatment plans, and even talking with patients."[2]

Reductions in healthcare spending

The National Bureau of Economic Research says broader adoption of AI could save 5%–10% a year in healthcare spending (up to $360 billion) without sacrificing quality or access.[3]

While the goal is to deliver better-quality healthcare less expensively, incorporating AI capabilities into a healthcare organization requires considerable upfront investment and planning.

Research suggests a variety of powerful applications that may revolutionize the prediction, prevention, and treatment of disease.

"We need to make sure that we don't implement systems that are going to have inherent bias. This is one of the reasons why, at least in my mind, we will need a physician at the end of that chain to make sure that whatever the AI robot comes up with actually makes sense in the context of this given patient and this given set of circumstances."

Dr. Robert Groves
Executive Vice President and Chief Medical Officer
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At Lenovo, we believe AI encompasses both the art of possible and the art of practical, from enabling personalized medicine and transforming research to practical efficiencies that can be used throughout the patient care and administrative environment.

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“AI is the ability for machines to mimic the cognitive functions and decision making of humans with limited human intervention.”

Robert Daigle

Director, Global AI Business, Lenovo

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Defining AI in healthcare

Artificial intelligence (AI) has a growing range of applications in healthcare, including the use of computer-driven analysis for clinical decision support, streamlining both clinical and administrative workflows, and moving precision medicine forward.

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Anatomy of AI

The broad term “artificial intelligence” includes subsets of related technologies, which often work together to enable healthcare capabilities and breakthroughs.

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Machine learning (ML)

Machine learning gives systems the ability to automatically learn and improve from experience without being explicitly programmed. ML uses algorithms to analyze data, detect patterns, form conclusions, and make predictions. Most traditional ML algorithms need structured (labeled) data.

Natural language processing (NLP)

Natural language processing is a subset of machine learning used to convert human language into computable data formats that can be compared and analyzed.

Deep learning (DL)

Deep learning is a subset of machine learning. A deep learning model analyzes data not unlike the way a person would. It uses a layered structure of algorithms called an artificial neural network that imitates the way the human brain filters information and learns to classify and predict. In this model, an algorithm can determine on its own if a prediction is accurate or not. While ML requires the features used for classification to be provided (labeled data), DL can automatically figure out the features. It allows machines to solve complex problems even with diverse, unstructured data. DL requires huge amounts of data and therefore powerful computing capability.

Federated learning (FL)

Federated learning allows AI algorithms to use and learn from data located at different sites. This means organizations can collaborate on the development of models without needing to directly share sensitive clinical data with each other.

Computer vision (CV)

Computer vision is the use of AI to compare and analyze images — training computers to see and interpret them the same way human vision does. Computer vision models take information from thousands of images and outcomes, then apply deep learning to analyze and reach conclusions.

Imaging analytics

Medical image analysis applies deep learning and computer vision to provide clinical decision support to clinician specialists including oncology, cardiology, and pathology.

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Applications of AI in healthcare*

Diagnosis and treatment

- Clinical decision support
- Symptoms analyzer
- Treatment efficacy vs. effectiveness
- Pathology

Computer vision

- Radiological image analysis
- ECG and EEG analysis

Workflows

- Patient flow optimization
- Detect process inefficiencies
- Electronic health record (EHR) integration
- Prior authorization
- Billing and coding

Predictive modeling risk stratification

- Readmission rate
- Hospital-acquired infections
- Emergence of complications

Discovery

- Clinical trials
- Hypothesis generation
- Proofs of concept

Precision medicine

- Genomics

Mobile apps

- Wellness
- Chronic disease management

Matching engines

- Patients with similar profiles
- Treatments with similar cost-benefit ratios

Virtual assistants

- Voice assistant/medical scribes
- Electronic health record (EHR) integration

Patient engagement

- Augmented reality (AR)
- Virtual reality (VR)
- Generative AI reference materials

*Adapted from Cognity AE.

Applying AI in healthcare today and tomorrow

Diagnosis and treatment | Workflows | Precision medicine

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Diagnosis and treatment:

Imaging and clinical decision support

AI uses computer-driven analysis to support clinician decision-making in diagnosis and treatment and to provide deeper insights to healthcare researchers, providers, and patients.

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Diagnosis and treatment:

Reducing invasive procedures

Deep learning is increasingly being applied in oncology and holds promise for better accuracy in detecting an image's clinically relevant features than computer-aided detection (CAD).

Another advantage of AI in imaging is the potential to reduce the need for tissue samples and their risk of infection in favor of far less invasive MRIs, CT scans, and X-rays.

In addition to diagnostics, AI in imaging may also aid treatment by speeding the discovery of new drugs and vaccines. Machine vision image analytics is an emerging technology that can identify which molecules might be effective for which biological targets.

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Diagnosis and treatment:

Radiology as early adopters of AI

An early application of AI in healthcare is medical image analysis in radiology, where understaffing, increasing demand, and rising costs are significant concerns.

Globally, 30% of radiologists say they are already using AI, according to a survey conducted by the European Society of Radiology.[4] Although mostly used to aid in screenings, AI is also being used to create synthetic images for training purposes and to help create the reporting needed for routine imaging processes.

AI has the potential to reduce costs and save time in breast cancer screenings. Millions of women have routine screening mammograms every year. The majority of them show normal, healthy breast tissue. Yet reading the images needed to confirm breast health represents a substantial burden on radiologists.

AI transforms the reading workflow — making worklists intelligent and highlighting and prioritizing studies that need deeper review and evaluation.

Diagnosis and treatment:

Pathology's in-house second opinion

Pathologists are using AI to improve accuracy and increase efficiency with pattern detection capabilities that serve as a digital "thought assistant."[5] In essence, the technology has given pathologists a second opinion to refer to, but without the wait.

As stated in the journal *Diagnostics*, "Using AI approaches that computationally evaluate the entire slide image, researchers can detect features that are difficult to detect by eye alone, which is now the state of the art in digital pathology."[6]

According to a survey published by *The Lancet*, "Experts agreed that AI would be routinely and impactfully used within AP laboratory and pathologist clinical workflows by 2030."[7]

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Diagnosis and treatment:

Detecting hypoglycemia in diabetes patients

Tracking blood sugar levels is essential in diagnosing diabetes and even more vital for patients undergoing treatment. A sudden drop in blood sugar resulting in hypoglycemia can have serious consequences, including death.

A study published in the *Journal of Diabetes Science and Technology* on using machine learning (ML) for real-time hyperglycemia detection concluded, "Machine learning enables more precise and timely predictions in comparison with baseline models."[8]

A review of studies of ML and AI for predicting blood glucose levels from wearable devices (WD) was positive as well, stating, "WDs in general have the potential to remove the need for invasive devices completely for glucose monitoring in the not-too-distant future."[9]

It doesn't stop at detection, though. According to a study in *Diabetes Care*, AI can be used to help guide the management of glucose levels. The researchers concluded, "Among adults with type 2 diabetes, use of an integrated digital healthcare platform with AI-driven dietary management resulted in better glycemia and more weight loss."[10]

Diagnosis and treatment:

Earlier mental health pattern detection

AI has proven particularly adept at detecting the presence of, or precursors to, certain mental health issues. In fact, a study published by *Nature* stated, "AI technologies offer great promise in diagnosing mental health disorders. Healthcare professionals in the field should cautiously and consciously begin to explore the opportunities of AI-based tools for their daily routine."[11]

Mental illness often goes undetected and accounts for 7% of all total disability-adjusted life years. Having AI as a detection or prevention tool could improve the quality and quantity of life for countless people.[11]

Detection isn't limited to pre-existing mental illness, either — as AI can use data to predict where impacts on mental health may occur in the future. In fact, Stanford University used AI to help predict when dependency or addiction was likely to occur from certain opioid prescriptions.[12]

Diagnosis and treatment:

Early and effective prostate cancer detection

Prostate cancer affects one in eight men.[13] The quality of life for millions of men could be improved with earlier and more effective means of prostate cancer detection, as could the prevention of unnecessary biopsies.

AI has already been shown to be effective in helping pathologists detect the presence and extent of prostate cancer. In fact, research shows pathologists who used AI to detect prostate cancer performed better than those who didn't, reducing detection errors by 70%.[14]

Before that study, the FDA had already reported that AI improved detection of prostate cancer on individual slides of biopsies by an average of 7.3%.[15]

AI can also help determine the extent of prostate cancer that is present. Researchers at University of California, Los Angeles (UCLA) Jonsson Comprehensive Cancer Center and the Department of Urology at UCLA have developed an AI model for just this purpose and tested it with patients at Stanford University School of Medicine. The team's model was found to be more accurate at predicting tumor margins than conventional methods.[16]

Researchers in Canada have reported that, after patients' first oncology consult and with an AI-based review of the patient's full medical history, their algorithm could predict the survival rates of patients with a variety of cancers with 80%–90% accuracy.[17]

Diagnosis and treatment:

Heart attack and stroke prevention

Researchers at the Iowa Institute for Biomedical Imaging of the University of Iowa are studying the use of AI and optical coherence tomography (OCT) imaging to detect changes in heart tissue. They are using AI to help predict the likelihood of a patient having a heart attack.

The project uses AI to classify coronary tissues and predict coronary plaque vulnerability over the year following an initial physician visit. Successful AI-based prediction of coronary plaque vulnerability allows physicians to take preventive action at the first visit, making future heart attacks less likely to occur.[18]

Florida's Memorial Healthcare System Comprehensive Stroke Centers is using AI right now to help detect strokes and take immediate action. AI detects stroke identifiers in the neuroimaging performed on all stroke patients. A stroke intervention team is notified immediately, and expedited treatment is provided.

Stroke neurologist and neuro-interventional surgeon Dr. Haris Kamal of Memorial Healthcare System Comprehensive Stroke Centers told CBS News, "AI allows us to shave off all the time that it would have taken for a radiologist to read the picture and then call the ER doctor. This direct pathway provides patients access to neuro-endovascular specialists directly, without even anyone having to make a phone call."[19]

Diagnosis and treatment:

Elder care for an aging planet

By 2050, there will be 2.1 billion people over the age of 60.[20] AI will be needed to supplement the healthcare of so many by so few.

AI systems via wearables and other devices are already in place to detect falls and changes in indicators of heart health or cognitive issues. A new system developed at the University of Waterloo goes a step further, using very low-power, millimeter-wave radio systems with machine learning and artificial intelligence to alert healthcare workers to sudden falls without the need to install cameras.[21]

Researchers at Massachusetts General Hospital are using an AI model based on deep learning of MRI imaging to help detect Alzheimer's disease. Analyzing the data from over 10,000 patients across all risk levels, the researchers were able to detect Alzheimer's disease with a 90.2% accuracy rate.[22]

As many as 40%–60% of adults with probable dementia are not being diagnosed. The researchers concluded that AI could help diagnose patients earlier, providing more time for treatment.[22]

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Workflows:

Clinical and administrative

AI has undeniable potential to transform many aspects of healthcare. One big category is the streamlining of workflows by building efficiency into each role and each task, whether clinical or administrative. The ultimate goal is delivering better quality of experience for patients, families, and providers — from first contact through every encounter, whether in the clinic, the hospital, online, or at home.

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Workflows:

Clinical workflows

On the clinical side, AI can significantly impact efficiency by reducing the time to develop treatment plans. A good example is in oncology. These plans are complex and time-consuming, with consideration for available treatment modalities and targeting cancer cells while preserving healthy tissue. With thousands of ongoing clinical trials, there is more data than one oncologist could possibly synthesize. Yet this information could be critical to the patient.

ML and NLP can interpret volumes of study results and compare the data to a specific case — informing not only the treatment, but the best way to deliver it (another painstaking process that takes significant time). Microsoft Research reports that specialists using AI can plan radiotherapy treatments about 2.5 times faster with AI than without.[23]

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Workflows:

Administrative workflows

The administrative side of healthcare is one of the most recognized areas of AI value. According to McKinsey, administrative overhead currently accounts for 25% of total US healthcare spending.[24]

Many of these tasks are ripe for automation, including prior authorization, following up on unpaid bills, and maintaining records. In fact, McKinsey estimates that AI-enabled prior authorization can automate 50%–75% of manual tasks.[24]

NLP can be used to parse data from electronic health records (EHRs) and to convert unstructured data into computable form. This is valuable in consolidating handwritten notes, voice dictation, and computer-entered information in a patient's EHR.

Process automation can be applied to a wide range of administrative activities including patient scheduling, claims processing, and medical records management. AI could also help process routine inbox requests like medication refills and test result notifications.

All these AI use cases let front office staff spend more time addressing patient concerns and less time checking people in. Physicians and nurses can spend more time on patient interaction and less on paperwork, electronic or otherwise.

Data analytics has also become a key component of organizational operations and efforts to increase efficiency and profitability — from reception to back-end offices, even to supplies inventory.

Workflows:

Streamlining clinical documentation

The average nurse in the United States spends 15% of work time on documentation activities alone.[25] This includes dealing with more than 10,000 Current Procedural Terminology (CPT®) codes, as well as more than 71,000 procedure and 69,000 diagnosis codes in the International Classification of Diseases, Tenth Revision (ICD-10).[26,27] McKinsey estimates that 10%–20% of a nurse's shift is spent on activities that could be optimized with the right technology.[25]

For doctors, the news is even better. New AI tools, including solutions from Microsoft, are able remove hours of typing from a doctor's day — summarizing, organizing, tagging, and transcribing interactions. Transcription summaries can even be leveled to the understanding of the patient.

For patients, it's empowering. For doctors, it's freeing. According to family physician Dr. Michelle Thompson, when interviewed in *The New York Times* about AI documentation, "AI has allowed me, as a physician, to be 100% present for my patients."[28]

Workflows:

Patient engagement and convenience

Industries are increasingly adopting self-service models that allow customers to complete tasks when and where they want, on their own devices. AI can help healthcare do the same. Self-service benefits could help reduce costs, patient waiting times, and administrative errors while increasing patient satisfaction. Some provider organizations are also offering interactive online portals with NLP-driven chatbots to help with medication refills and other simple administrative tasks for a personalized, always-available experience.

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Workflows:

Easing workloads

Radiology workloads are overwhelming, with 36% of radiologists reporting they feel burned out.[29] AI helps ease radiology workloads by conducting initial image screening for indicators of disease. It can also offer radiologists additional insights, confirming a diagnosis or flagging a possible human error. Based on these deeper data-based insights, radiologists can more confidently make a final diagnosis.

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Precision medicine:

Individual and population

One of the most exciting and fastest-growing areas in healthcare is precision medicine. Precision medicine personalizes the diagnosis, treatment, and prognosis of an individual patient — informed by analysis of data not only from that patient but also from population health data, now and over time. This level of insight is what many believe will allow scientists and clinicians to predict and begin to prevent today's chronic diseases and much more.

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Precision medicine:

Making it personal

In precision medicine, insights from AI tools can improve accuracy in diagnosis and efficacy of treatment by tailoring solutions to the patient's unique manifestation of their illness and receptivity to therapies. Genetics and life experience, including the social determinants of health (SDOH) like birthplace, housing, diet, workplace, and income, factor into these personalized treatments.[30]

- ML provides physicians with more diagnostic information from sources like wearable devices than has ever been available.
- ML can compare data collected on an individual patient to data from a group of patients with the help of NLP, which standardizes patient records into data sets from large numbers of patients.
- The data from ML and NLP can identify disease trends and predict which treatments are most successful for individuals.
- This data can also forecast the likelihood of a specific patient contracting a disease.
- "Digital twins," or representative data models, can be used for each patient's individual body, physiology, and medical history, enabling more precise treatment testing.

Lenovo AI Innovative Solutions enable you to find tailored solutions including computer vision, audio recognition, prediction, security, and virtual assistants. The Lenovo AI Discover Center of Excellence provides access to AI experts, workshops, and best practices.

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Precision medicine:

Accelerating population-level genomics

Achieving population-scale precision medicine requires unprecedented levels of high-performance computing. In fact, two out of three analysis stages in genomics-based biomedical analyses require supercomputer power.[31]

Scaling up genomics production largely depends on scaling high-performance computing technologies. Performing the scope of analytics needed to gain timely, meaningful insight across populations means speed as well as processing capacity. Technology companies are working to develop hardware and software that will optimize existing systems so they can perform orders of magnitude more analytics in shorter timeframes.

Take genomics to the next level with the Lenovo ThinkStation® PX, powered by up to Intel® Xeon® Platinum 8490H processors and Windows 11 Pro for Workstations.

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Precision medicine:

Lenovo accelerates genomic analytics

Lenovo has extensively tested the performance of the Broad Institute's Genome Analysis Tool Kit (GATK) Germline Variant Calling Workflow — tools used by researchers to perform genomics analytics. The project examined variants in hardware, system tunings, data types, execution modes, and software implementations. The goal was to find the optimum configuration to accelerate the speeds at which genomes are assembled and analyzed. As a result, Lenovo developed its Genomics Optimization and Scalability Tool (GOAST).

For data centers not using optimized hardware and software, processing a single genome takes 150 to 160 hours. Work by Intel® in 2017 reduced that processing time to 10.8 hours.

Now, with Lenovo GOAST solutions, researchers can analyze an entire human genome in 47 minutes and whole exomes in a matter of seconds. In a standard cloud or on-premises environment, the same analysis takes 40–150 hours.

With Lenovo ThinkEdge solutions, your organization can run AI applications in the cloud or on-premises, depending on your needs, with purpose-built server compute power closer to the source of the data.

"Improving predictive modeling — I think that can definitely save a lot of time and resources. You're wasting less with faster insights, less money, and more accurate results. I think that's very exciting and has a lot of promise."

Dana Alegre

Solutions Architect–HPC Life Sciences
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The Lenovo GOAST, based on a Lenovo ThinkSystem® SR630 server powered by two Intel® Xeon® Platinum 8480+ processors — and the GOAST Plus, based on a ThinkSystem® SR950 powered by eight Intel® Xeon® Platinum 8280L processors — are validated, preconfigured, and built for high-performance reliability.

Better human health enabled by AI

Developing secure and responsible AI solutions to improve healthcare delivery around the world is the work of many organizations and thousands of individuals. As research and development continue, new possibilities and potential healthcare applications will emerge, expanding the horizon still further.

Even as scientists work to fulfill the promise of AI for moving healthcare from treating disease to preventing it, early applications are making their way into clinical settings.

- **For clinicians,** that means easing their workload — streamlining patient screening and expanding the diagnosis and treatment of disease.
- **For health systems,** it means greater efficiency, enhanced security for patient data, and improved patient outcomes.
- **For patients,** it means a more convenient healthcare system — physicians able to make more informed diagnoses and treatments tailored to the individual.
- **For researchers and pharmaceutical companies,** it means greatly accelerating drug screening, drug discovery, and vaccine delivery.

AI research and application add up to better human health — the goal of everyone involved in the quest.

The Lenovo AI Discover Center of Excellence can help with the technical knowledge to discover optimized solutions and valuable insights from your data quickly, responsibly, and ethically. Lenovo makes adopting AI faster with access to AI experts, workshops, and best practices.

"Technology should be a tool to serve the primary relationship between caregiver and patient."

Dr. Robert Groves

Executive Vice President and Chief Medical Officer
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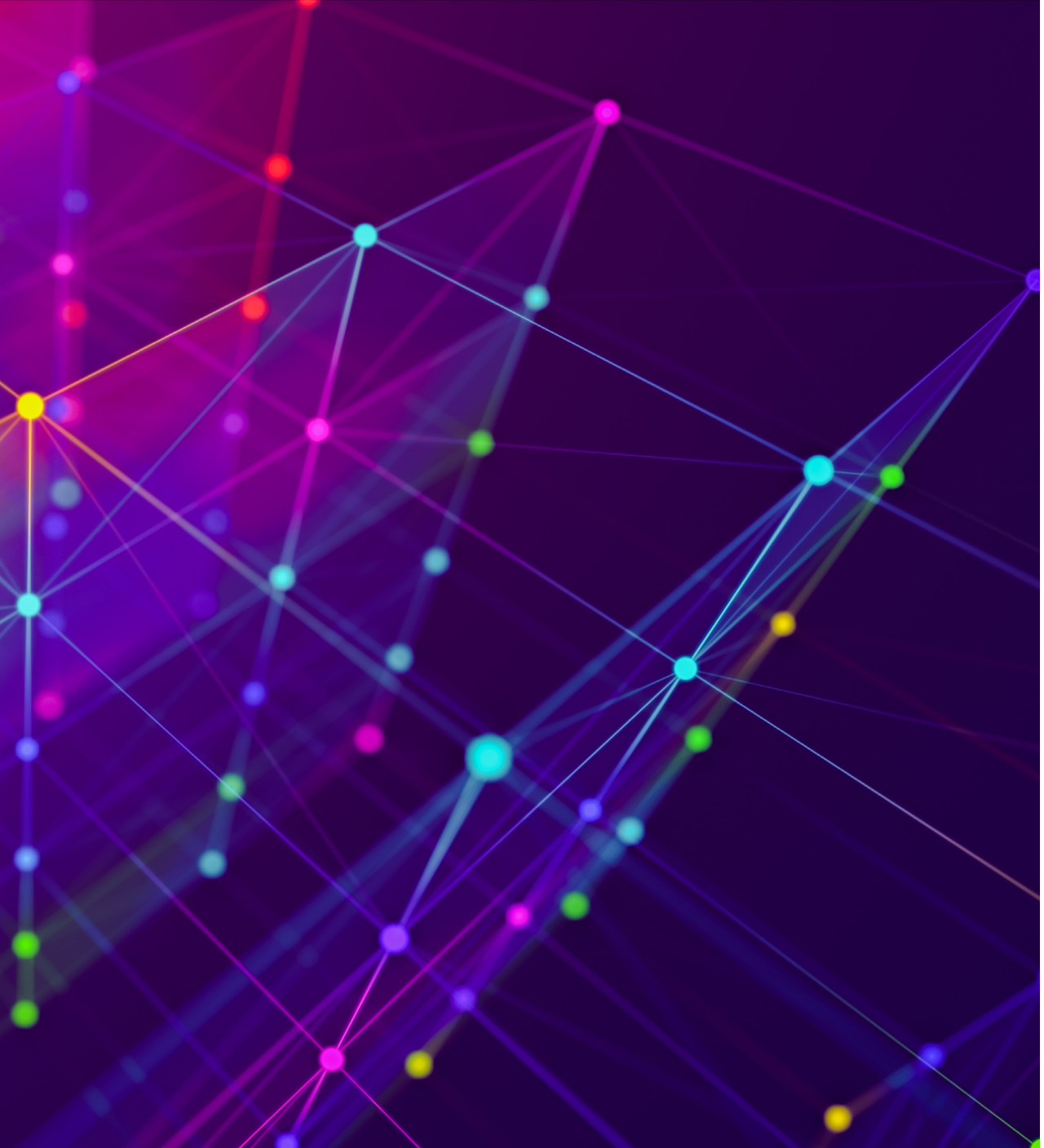

Generative AI in healthcare

Generative AI offers unprecedented promise for time and cost savings because it touches every area of healthcare, offering relief from mundane, repetitive tasks while providing improved experiences.

McKinsey states that generative AI can help healthcare by "...automating tedious and error-prone operational work, bringing years of clinical data to a clinician's fingertips in seconds, and by modernizing health systems infrastructure."[32]

Generative AI has made it possible to automate the delivery of information to patients, in their native language, at their learning level, and offer summaries of lab results, notes, and clinical orders for clinicians in real time.

According to Accenture, generative AI could potentially automate or augment 37% of healthcare practitioner and technical tasks, as well as 35% of healthcare support tasks.[33] Imagine how much time that will free up for direct patient care. And imagine the improvement in employee experience for healthcare workers everywhere.

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