Getting Smarter:

The Promise and Potential of Artificial Intelligence in Healthcare

Chris Hayhurst

Artificial intelligence (AI) is poised to transform healthcare, as well as the development of medical devices. This burgeoning AI revolution also will undoubtedly infuse the healthcare technology management (HTM) field with new tools for optimizing all manner of device management activities. With big changes looming, the importance of HTM and other health professionals staying out in front of discussions surrounding AI has never been more vital.

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According to a forecast from Marketsand-Markets, the worldwide market for AI—where computers are "trained" to simulate human learning and intelligence—in healthcare is expected to balloon from $2.1 billion in 2018 to more than $36 billion in 2025.[1] The growth of big data is a major driver of this expansion, as is the increasingly pressing need for healthcare organizations to reduce costs. The management consulting company Accenture estimated that AI applications have the potential to create $150 billion in annual savings by 2026 for the U.S. healthcare sector alone. "With immense power to unleash improvements in cost, quality, and access, AI is exploding in popularity," Accenture reported.[2]

"AI is going to impact all areas of healthcare," predicted Vishal Malhotra, chief technology officer at EQ2, a Charlotte, NC–based company that develops computerized maintenance management systems (CMMSs). "And for clinical engineers, I think it's going to make their jobs easier."

Capital equipment management in particular, said Malhotra, will see great improvements in the coming years, thanks in part to upcoming advancements in AI. "AI will help us increase equipment uptime and

AI 101

AI terminology can be confusing. Here are a few important definitions, as listed by Merriam-Webster (www.merriam-webster.com).

- **Artificial intelligence:** a branch of computer science dealing with the simulation of intelligent behavior in computers

- **Machine learning:** the process by which a computer is able to improve its own performance (as in analyzing image files) by continuously incorporating new data into an existing statistical model

- **Neural network:** a computer architecture in which a number of processors are interconnected in a manner suggestive of the connections between neurons in a human brain and which is able to learn by a process of trial and error

minimize maintenance costs, and it's going to reduce the total cost of ownership of devices."

G. Wayne Moore, BSc, MBA, FASE, president and chief executive of Acertara Acoustic Laboratories in Longmont, CO, has spent most of his professional life focused on diagnostic ultrasound. Recently, however, he's had something new on his mind: How AI might affect the world of HTM.

Acertara, Moore explained, does acoustic power testing on ultrasound machines, makes ultrasound test equipment used by HTM staff and original equipment manufacturers (OEMs), and, as a certified repair center for Siemens, provides repair services for that company's ultrasound probes. Acertara's testing technology employs AI, said Moore (who prefers the word "augmented" instead of "artificial"), so it's easy for him to imagine AI algorithms gaining ground in nearly all aspects of HTM.

"In our case, we rely on augmented intelligence for calculating estimated lifespans for specific probes," said Moore. Acertara has an app that lets users input any number of parameters, such as how often a probe is used or its typical infection exposure. Having that information allows HTM

professionals to make good decisions, explained Moore: "If it's otherwise in good shape and likely to last a while, then maybe they'd send it out right away for repair. But if it's predicted that this probe will only last a couple months, then they may just decide to retire it and get a new one."

Moore can envision a near future in which similar AI-driven applications change almost everything about HTM. "Picture this tool in the hands of an HTM professional, who may be responsible for all kinds of equipment," including magnetic resonance imaging (MRI) machines, computed tomography (CT) scanners, infusion pumps, and patient monitors. With the facility's use-case data and the ability to track how each device is doing at all times, "they'd be able to say, 'I need to do my preventive maintenance more often or less often because we don't fit the average use case as defined by the OEM,'" said Moore.

Similarly, HTM professionals could more easily determine when it makes sense for a device to be on a service contract, for example. Replacements and repairs could be scheduled according to actual needs instead of general timetables based on industry trends.

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"As augmented intelligence becomes more common," Moore said, "we're going to see HTM professionals making better service decisions, and we're going to see better business decisions as well."

Big Potential

Moore is far from the only person who believes in the potential of AI for the healthcare setting:

- Scott Gottlieb, MD, commissioner of the Food and Drug Administration (FDA), has called AI "one of the most promising digital health tools."[3]
- A recent editorial in the *Journal of the American Medical Association* noted that "AI and deep learning are entering the mainstream of clinical medicine."[4]
- Deloitte noted that AI engines "are enabling healthcare systems with faster decision making, helping them focus on more valuable, patient-facing activities."[5]
- The Healthcare Information and Management Systems Society (HIMSS) maintains a dedicated "Artificial Intelligence Channel" that provides education sessions on all things related to AI in healthcare.[6]
- According to a survey conducted by HIMSS among 142 professionals working in settings across the healthcare industry, 77% of organizations are either leveraging or "likely to leverage" AI to support clinical decision making, while 66% are doing the same (or have plans to do so soon) to "extract meaning from big data." A report on the survey findings stated that although AI has certainly seen its fair share of "hype," it's already making an impact on healthcare, with new uses for AI being tested all the time.[7]

Use cases for AI include new CMMSs that deploy AI algorithms to assist with capital equipment planning and electronic health record (EHR) systems that use AI-enabled tools to support data collection and clinical note taking.[8] One company, Eko, a maker of digital stethoscopes, has developed an AI algorithm that can detect pediatric heart murmurs with accuracy rivaling that of trained cardiologists.[9] A firm in China is using AI software to automatically pinpoint polyps during colonoscopies.[10] In addition, GE Healthcare announced the launch of an "intelligence platform" called Edison. As the company explained, the platform uses data collected from millions of imaging devices to develop new applications and technologies that support clinical, financial, and other healthcare operations.[11]

AI Takes Center Stage

Look no further than this year's AAMI Exchange—the revamped and reimagined AAMI Annual Conference & Expo—for evidence that the AI revolution is in full swing. The Exchange will feature a variety of AI-related content, ranging from hands-on exhibitions on the Expo Floor to the following education sessions:

- *Healthcare AI: Not as Scary as You'd Think*
- *Reduce Costs and Downtime with AI-Enabled Predictive Maintenance*
- *Data Analytics, Artificial Intelligence, Predictive Modeling, and HTM*
- *Artificial Intelligence in Ultrasound Imaging: Yesterday, Today, and Tomorrow*
- *Using AI with CMMS for Capital Equipment Planning*

Join your colleagues at the AAMI Exchange, June 7–10, in Cleveland, OH, to learn how AI is reshaping healthcare. To register, visit **www.aami.org/2019registration.**

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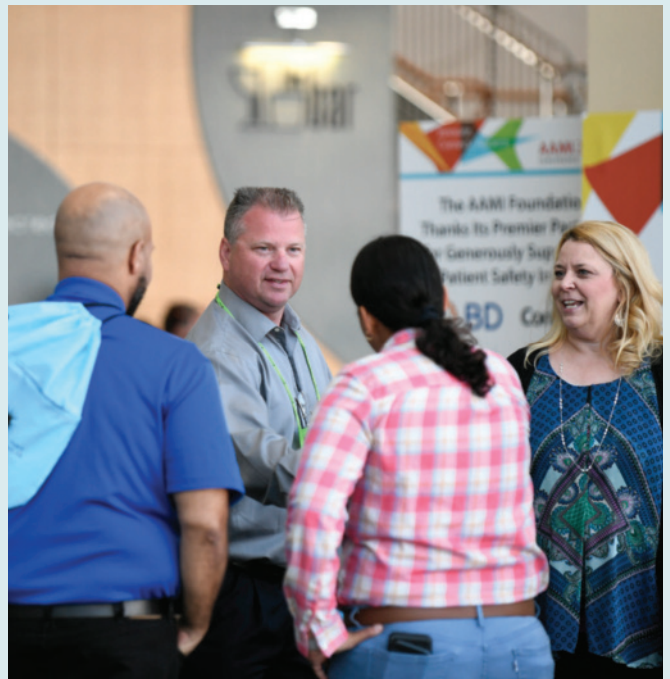
AI also is being used to drive efficiency and improve effectiveness in the medical device manufacturing process. Software engineers at Wovenware in Puerto Rico, for example, are developing AI algorithms that help device makers create better products. According to chief operating officer Carlos Meléndez, one Wovenware customer "had a process where if they found a defect on a device, they would take it off the manufacturing line and then send it to their engineering team to determine if it was something that could be fixed or not."

Wovenware, said Meléndez, used data from the company's manufacturing execution system to create an algorithm that can predict, with 99% accuracy, whether a defect to any given part will require the device to be scrapped. "Now they know immediately if they should throw it away; they don't have to waste time and labor to figure that out."

"AI is going to revolutionize the device-production process, particularly in the area of quality, where it really matters most," added Meléndez.

Importance of 'Good' Data

Any conversation about AI in healthcare must begin with a look at healthcare data. "The promise of AI is tightly coupled to the availability of relevant data," noted the independent advisory group JASON. "In the health domains, there is an abundance of data. However, the quality of, and accessibility to, these resources remain a significant challenge in the United States." Data-related challenges include patient privacy concerns, expenses associated with data collection, and limitations of current EHR systems, especially when it comes to interoperability.[12]

According to a widely cited estimate from the research firm IDC, the volume of global healthcare data will expand from about 153 exabytes in 2013 to more than 2,300 exabytes by 2020 (48% annual growth rate).[13] With healthcare digitization and medical device integration, organizations are collecting data like never before.

However, not all data are created equal—and not all data are appropriate for AI—said Pat Baird, senior regulatory specialist and head of global software standards at Philips and chair of the *BI&T* Editorial Board.

"With AI, a huge part of the quality of the output is the quality of the training data that goes into the system," he said. In healthcare, patient data are typically scattered in multiple databases and don't always include everything physicians might need to know.

An AI engine created from that incomplete picture could prove problematic, noted Baird. He pointed to an example outside of healthcare in which an AI application that was designed to identify a person's gender based on a picture of their face was really picking up on the person's hair length. Another case involved an AI system that supposedly could discern between photographs of a wolf and a dog. However, the application could really only tell when snow was present in an image, in which case it would determine the subject was a wolf.

"You need enough data to make a training set that is reflective of the real world," said Baird. "It can't be just a little snapshot of one aspect of the real world."

Eliezer Kotapuri, CEng, CCE, PEng, chief clinical technology officer with Mass Technologies in Columbus, OH, also has concerns about data and their limitations. "The data need to be standardized and optimized before they can be utilized," he said. "They have to be meaningful for the circumstances in which you want to use them; only then can you manipulate and turn the data into knowledge."

Mass Technologies provides clinical engineering technology planning and optimization services to its health-system clients. According to Kotapuri, most of the HTM departments with which he has worked are not ready to deploy AI solutions because the data they have at their disposal remain frustratingly out of reach.

Make the Most of Your CMMS

The third edition of *Computerized Maintenance Management Systems for Healthcare Technology Management* tackles CMMS essentials, including how to use the system for standards compliance, financial management, and equipment planning; how to maintain data integrity so the CMMS provides useful information; and how to select and implement a CMMS product.

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Machine Learning: Pushing the Envelope

When IBM computer scientist Arthur Samuel coined the term "machine learning" in the late-1950s, he purportedly described this new branch of AI as a computer's "ability to learn without being explicitly programmed."[14] While AI entails the programming of computers to perform specific tasks according to the rigid algorithms that constitute its code, machine learning involves feeding a computer data and allowing its algorithms to continuously evolve.

In 1959, Samuel demonstrated how machine learning could be used to teach computers to play checkers. "As a result of these experiments," he wrote in an article describing this work, "one can say with some certainty that it is now possible to devise learning schemes which will greatly outperform an average person and that such learning schemes may eventually be economically feasible as applied to real-life problems."[15]

Sixty years later, in Baltimore, MD, one medical device company—Galen Robotics—may soon join a growing number of innovators from a variety of industries in proving the accuracy of Samuel's predictions. With its headquarters in the shadow of The Johns Hopkins Hospital, Galen Robotics is exploring applications for machine learning in the realm of highly delicate surgical procedures.

"We've designed a robot whose initial purpose is to hold surgical instruments and enhance the surgeon's capabilities," explained Dave Saunders, the company's cofounder and chief technology officer. "But in the future, our goal is to use surgical data to train an AI system that can make surgeons 'superhuman.'"

For example, if the robot was integrated with a rigid endoscope or surgical microscope, allowing it to "see" what the surgeon sees, then "it could then do things like pathology detection and maybe add false coloring to a cancerous lesion and essentially enhance the physician's vision," explained Saunders.

What if a physician was performing vocal cord surgery, only to have the patient spasm and suddenly move her head? "The robot could move the surgical tools automatically with the patient while keeping track of the doctor's hands and keep everything stable," until the spasms subsided, said Saunders.

A rendering of the Galen Mk2 robot. Image courtesy of Galen Robotics.

Taking an algorithm-based approach to developing such capabilities "would be very difficult—a really high bar," he added. "But if you had enough surgical imaging data to train that AI system—to allow machine learning to do that work—then it starts to become a lot more feasible."

For now, Galen's robot remains under development. According to Saunders, the company anticipates filing for FDA 510(k) clearance sometime in early 2020. Therefore, the manner in which the robot might ultimately incorporate AI and machine learning remains to be seen.

One thing Saunders does know, however, is that if the device does involve an AI system, most people will barely notice it. "When properly applied, machine learning should be boring as heck—just another part of the device's infrastructure," he said. "Nobody's going to say, 'Wow, this thing sure has a great algorithm!' They're going to be focused on the solution—that this a tool that can help surgeons do their job."

"AI could help hospitals with equipment acquisition and servicing," he said, "but they don't know where to find the data that they need. They don't necessarily know how to access it or whether accessing it is even possible, or they don't have it or don't know how to use it."

With AI tailored toward equipment servicing, HTM departments that understand their data could anticipate the next service call before it's even placed. "But what I see instead, in 99% of cases, are HTM professionals who are working on technologies that are already down," said Kotpuri.

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"The department gets the call and they send out a technician, and they have no idea what equipment might go down next."

As a result of nonhomogenized data, added Kotapuri, "deployment of AI solutions may yield more favorable results in the areas of application and acquisition of healthcare technologies than service or support of healthcare technologies."

Hussain Ali, FACCE, PE, PMP, CCE, CLSSMBB, a healthcare technology consultant with Texas-based MAHTECS LLC, agreed with Kotapuri: Progress must be made in the realm of data management if AI's potential is going to be fully realized.

"The whole challenge," said Ali, "is that databases are only as good as the data inside them. If nobody is making a concerted effort to scrub that data and clean it up, it's 'garbage in, garbage out, 'and it's probably not going to be of much use."

Still, he added, the possibilities for AI in HTM are undeniable, beginning—in his opinion—with the typical CMMS. "A lot of organizations are relying on a CMMS to get their equipment-related information, but the way it is now, almost nobody is doing it right." Today's CMMSs, Ali explained, usually are incapable of incorporating the "dynamic healthcare data" required to develop algorithms that could assist an HTM department.

"Capital planning is very complicated. An executive might sit down and say, 'OK, our MRI machines are getting really old, and they don't have this or that important function, and patients are going across the street to the competition to do their MRIs.'" That might lead the executive to replace the organization's MRI machines one year, while the next year the driving factor might be cuts in reimbursement or the need to reduce costs.

"So then they're asking: 'How do we do that? Do we need more efficient technology? Should we use this CT versus that CT? Is

Supporting Smart Use of AI in Healthcare

In February, AAMI and BSI, with support from the Medicines & Healthcare products Regulatory Agency (MHRA), published a white paper that provides recommendations for the standardization and regulation of AI and machine learning algorithms in healthcare.

The report, which is titled *The Emergence of Artificial Intelligence and Machine Learning in Healthcare: Recommendations to Support Governance and Regulation,* calls for a phased program of standardization activities, including the development of guidelines to cover AI terminologies and validation approaches. To accomplish this goal, AAMI and BSI propose:

- Creating an international task force to provide oversight for the direction of standardization activities related to AI in healthcare.
- Reviewing the current standards landscape and identifying opportunities for new or modified publications.
- Developing a scope and proposal for a standard covering terminologies and categorization for AI in healthcare.
- Developing a scope and proposal for guidance to cover validation processes for AI in healthcare.
- Building stakeholders' understanding of market challenges and educating communities on the benefits of standardization.

"Making sure the introduction and deployment of these tools into everyday healthcare is done safely is a priority for us as regulators. Standards will be a critical element of this," said Mark Birse, group manager, device safety and surveillance at the MHRA, in a statement. "We were pleased to be able to initiate this important work and will continue to support both the emerging challenges, and the solutions."

The report is available for immediate download via the AAMI Store **(www.aami.org/ai_paper).**

Representatives from AAMI and BSI will discuss these recommendations in more detail during the 2019 International Conference on Medical Device Standards and Regulations, April 24–25 in Reston, VA, and will explain how they relate to other efforts being undertaken by the Consumer Technology Association, the Medical Imaging & Technology Alliance, and the International Organization for Standardization.

For more information about this conference, including a tentative program, visit **www.aami.org/InternationalStandards.**

The emergence of artificial intelligence and machine learning algorithms in healthcare: Recommendations to support governance and regulation

Position paper
Prepared by BSI and AAMI

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one more user friendly, requiring fewer people to operate, or will one give us better results than the other?'" Ali said. "All these data points factor into the decision—operational data, financial data, depreciation markers, service data—and then there's the fact that your priorities are always shifting."

Ali has yet to see a CMMS vendor that has made AI a core part of its system. "But I think when they do, we'll finally have a way to look at those parameters and trends all at once, and I think most organizations will find that information very useful."

AI For Better Asset Management

Although it's not in the CMMS business, Zingbox, a company based in Mountain View, CA, is using AI to help HTM professionals better manage their devices. May Wang, PhD, cofounder and chief technology officer, explained that Zingbox provides security solutions for the "Internet of Things" (IoT), which in healthcare includes nearly any connected device found in a healthcare facility.

"It used to be that most devices were isolated—they weren't really connected to anything else," Wang said. However, she added that given the increasing number of devices from a wide variety of vendors, the current-day situation is much different: "And that's led to all kinds of challenges for HTM."

The first big hurdle involves identifying the assets within a facility. "When we walk into a hospital, we ask information technology (IT) and HTM to each provide us with a list of all the connected devices that they have," said Wang.

That request, she said, is most often met with spreadsheets that are disparate and incomplete. The next step is deployment of a solution Zingbox calls "IoT Guardian," which shows the IT and HTM departments just what they missed.

"Within 24 hours, using AI, we can show them how many medical devices they really have, what these devices are, their makes and models and versions, where they're located, and what's being used or not being used," said Wang. "And we can provide them that information in real time, so that at any given moment, they can know exactly what's on their network."

AI Ready or Not?

A 2018 survey by the management consulting firm Accenture sought to determine the readiness of healthcare consumers for "AI-powered virtual doctors."[16] The reasons cited by consumers for being open to such technology included:

- Available whenever I need it (47%)
- Saves time by avoiding a trip to the doctor (36%)
- Assess vast amounts of relevant information (24%)

Consumers said they were reluctant to use AI technology in place of an in-person physician visit for the following reasons:

- I like visiting the physician (29%)
- I don't understand enough about how AI works (26%)
- I don't like to share my data (23%)

After they have an accurate picture of the assets under a facility's management, Zingbox uses AI algorithms to automatically "learn" the normal behaviors of individual devices and then monitor those devices for abnormal activity.

"We build up our AI model using three layers," explained Wang. "The first layer, for example, might be that all X-ray machines share some common behaviors; whether they're from GE, Siemens, Philips, or another maker, they all have certain functionalities."

The second AI layer is based on the model and the maker: A GE DR 6000 machine, for example, has certain features and behaviors that are different from those found in a digital model made by Siemens.

"Then, the third layer on top of that involves the specific configurations and behaviors of each device based on the organization where it's been deployed," said Wang, while also noting that IoT Guardian never physically connects to any device. "It just sits on the network and monitors the traffic 24×7, and that gets us all the data we need."

The way Wang sees it, Zingbox's use of AI is about freeing up HTM professionals to do the work they've been trained to do. "HTM professionals have a tremendous amount of expertise in medical devices and medical information, but you cannot expect every one of them to also become an IT or security expert."

Zingbox's AI-enabled solution automates the "tedious tasks" of medical device security "so HTM can focus on their jobs and do the

things that AI can't do—things like operating and managing these devices and working to provide better patient services," said Wang.

Solutions and Opportunities

Looking ahead, said Pat Baird, we're likely to see many more companies like Zingbox using AI to augment their services and products. In the realm of HTM, he predicted that AI will prove most adept at helping HTM professionals "identify certain patterns—what is breaking more often than normal, or what is breaking under what circumstances."

Baird foresees AI-enabled chatbots being embraced by medical device manufacturers as tools that can help explain service manual instructions or even demonstrate how a device is meant to be used. AI also will help hospitals become more efficient and improve the patient experience.

"A lot of people think about AI in healthcare and stop with its applications for things like radiology, where you're triaging images so the radiologist knows which ones are most important to look at right away. But what I find really intriguing are some of the other areas for AI that maybe aren't quite as obvious or that might come out a little further down the road," said Baird.

For example, rather than a patient making a trip to the local walk-in clinic, "where he sits in the clinic while everyone is coughing on him," the patient stays home and consults an AI chatbot. "He interacts with it and tells it his symptoms, and eventually it makes a recommendation and connects him"—via a webcam—"to a doctor," described Baird.

That doctor would have, at her fingertips, a point-by-point summary of the reasons the patient checked in, the symptoms he's exhibiting, his medical history, and any other relevant information—all collected through a combination of AI and telehealth technology. "And all she'd have to do is sign off on the chatbot's treatment plan—to OK the prescription or whatever it is. It would improve the efficiency of the whole process and would improve the overall healthcare experience," added Baird.

Baird also can envision a future in which interactive, AI-enabled systems are used to provide patients with detailed information about their particular conditions and treat-

ment plans after they've had an in-person physician visit.

Currently, said Baird, many patients feel as though they're rushed; they leave their visits with a lot of unanswered questions and don't understand critical details about their treatment plans: "You're feeling sick, you see the doctor for eight minutes, and he tells you what you have and writes a prescription and is off to see his next patient."

"But what if you had an AI chatbot that could answer all your questions and explain everything to you?" asked Baird. "That might make the experience a lot better."

Others have expressed concerns that low-quality data could inhibit high-quality AI. Baird, however, is optimistic that such challenges will be overcome eventually: "We can do this. Manufacturers, when they're making a medical device, they don't just get their raw materials from anyone. They do audits on their suppliers, they check them and assess them, and they make sure that they meet certain specifications. And they do that because they know that the quality of the input affects the quality of the output."

AI data just have to be handled exactly the same way, added Baird. "Can we do some simple quality checks on the data we want to use? We definitely can; we know how to do that."

G. Wayne Moore, of Acertara Acoustic Laboratories, also sees AI as a tool that physicians, HTM professionals, and others will use to complement the services they have provided traditionally.

"It's not going to obviate the need for a doctor or the need for HTM," he said. Instead, it's going to give medical and technological professionals "the ability to rapidly diagnose and get the patient-management routine accelerated—or the opportunity to address issues with medical devices in a more thoughtful and efficient way than they could have otherwise. We'll have AI systems doing the background work and the busy work so the clinicians and HTM professionals can pay more attention to other things."

AI algorithms are "heavily dependent" on data; therefore, for truly groundbreaking AI to become a reality, Moore predicted, hospitals around the country will have to

collaborate to ensure enough data are made available for their development.

"Every hospital is basically a data-rich silo," said Moore. "What we need is something like a national clearinghouse of data—a place where those data can be aggregated" and put to use.

Moore frequently speaks with HTM professionals, and lately AI is coming up more and more in those discussions. "One of the things I always say is, 'Don't let this sneak up on you—become engaged early on in the discussions.' Because AI is not just a clinical issue for hospitals; it's also an administrative issue, a budgeting issue, and an issue for every department in your facility."

He emphasized that it's important "to have a really good understanding of AI and what it does and how it works. I tell them they should be reading about this stuff, asking questions, and getting in with the appropriate people in their hospital," including those who will be making the decisions about how AI will be used in the facility in the future.

"Now is the time to offer to help, to get involved," added Moore. "Here is an opportunity for HTM professionals to get in front of this and become engaged in the conversation. You should know what is coming and the ways you can influence how it is implemented within your hospital to your advantage."

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