Through the use of IoT and AI, the medical environment can be tailored to the needs of each patient

Practical use of AI and IoT in clinical settings by medical and non-medical staff

Artificial Intelligence (AI) and the Internet of Things (IoT) have captured the public imagination, and their use is becoming common throughout society, including widespread applications in the medical field. Systems using AI that can assist screening and diagnosis of disease using information such as patient complaints and test results are currently in use. Other systems acquire data from sensors affixed to a patient or collect information on the environment of a patient's home.

Although no systems that include AI can be universally used in the clinical setting, some systems are available for practical use that are good examples of what can be done through the application of IoT. This article discusses these applications and shows practical examples of the systems now in use and how they might be further developed.

AI and IoT use in the medical field

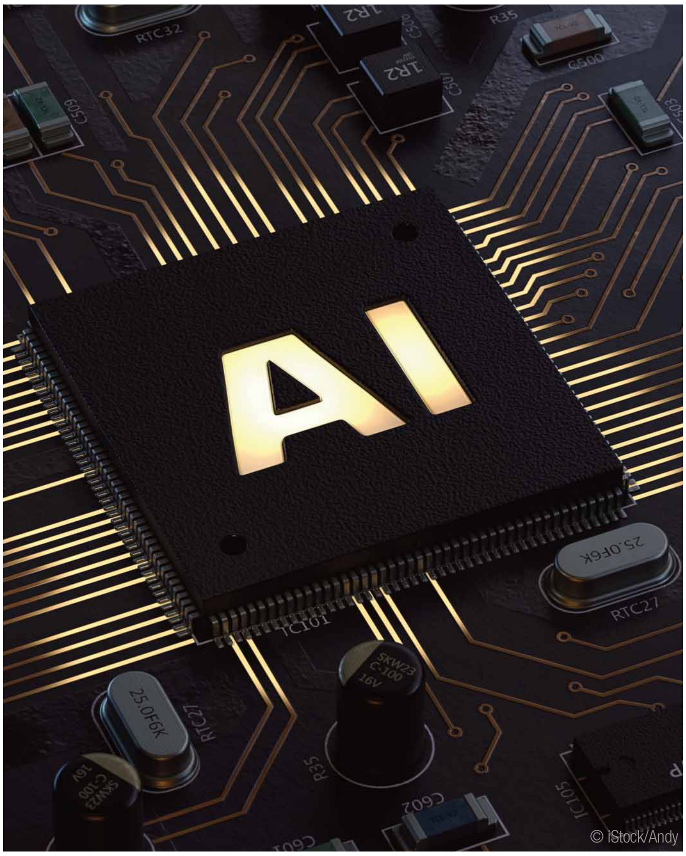
AI

Of the experimental systems designed for the use in clinical settings, many were created with the initiative of physicians. Systems that use AI have the following traits that allow a system to learn:

1) The system can imitate human judgement;
2) There is no concern with time; and
3) The system always outputs the same result when the same data is input.

The latter two functions are not generally true for humans. These traits make AI ideal for assisting doctors with diagnosis, and many other systems have been developed and are currently being tested. Some of them support diagnosis by supplying pictures and others suggest possible diseases based on patient complaints and test results.

Many of the current systems use AI with a neural network structure that can do deep learning. The effective use of AI in clinical settings is limited by both the system structure and data to be leaned. In such cases, the network design greatly affects the results. For many applications, a huge amount of



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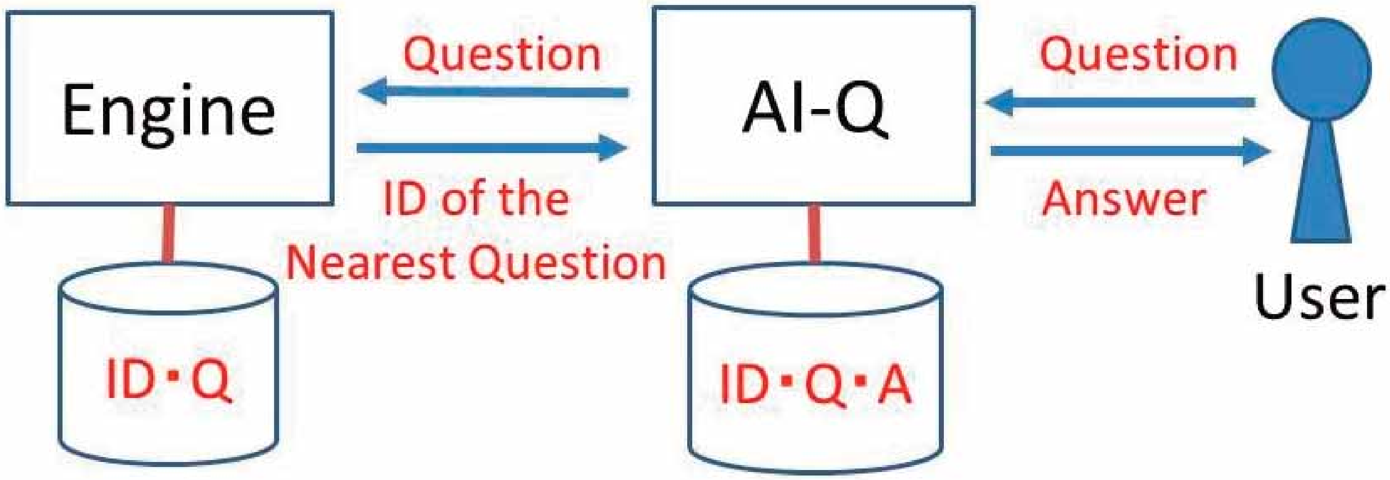
data is required for learning. When creating a system that can learn, each piece of data must be classified as presence or absence of findings. It is quite difficult to collect the large quantities of ‘no findings’ data necessary. Furthermore, the judgment of the presence or absence of findings may vary with a patient's age, sex, and the base disease.

Here we assume an example system that supports physician diagnosis through the use of a *fundusoculi* photograph. The physician typically examines the blood vessel pattern and transparency. This is complicated because it is extremely difficult to obtain data related to both a patient’s ‘normal’ and ‘abnormal’ image, as well as the fact that *fundus* vascular patterns differ from individual-to-individual. Due to this complexity, the design of an AI system is difficult and must be done with careful consideration.



The type(s) of disease that a system can deal with is also a factor. In large university hospitals, the expertise of each physician is especially high and specialised. However, the level of expertise means that the physicians have a narrower focus than was historically seen or is often seen in general hospitals. An AI system that allows for the high degree of specialty and that also covers all the aspects of the broad clinical domain, is necessary. Unfortunately, no single system is currently available that can do this; thus, hospitals must have multiple systems, which in turn increases the risk of misdiagnosis. It is important to keep the above in mind when considering the use of AI.

IoT

It is my impression that the use of IoT is not spreading in clinical settings as quickly or with as much inventiveness as in other sections of society. IoT is commonly used simply for data collection or as a system to control the collected data. Systems that use IoT are already in place in some hospitals, and communication mediums are not limited to internet applications. One such system is that used for 'medical telemetry' in which data from sensors affixed to a patient is relayed to a monitor installed in a central location of a ward or hospital. Examples of data that can be acquired this way are heart rate, blood pressure, respiration rate, the blood oxygen saturation rate, and electrocardiographic waveforms.

Products that use analogue based IP communication for information gathering can be found in some medical telemetry systems in Japan, thus some people do not consider them to meet the strict definition of IoT which has evolved since its inception. What can be considered as IoT is a developing concept that may in the future include many processes and applications that do not currently exist today. An example of this is the relatively new term 'IoMT', meaning the 'Internet of Medical Things'.

Non-medical staff use of AI and IoT in hospitals

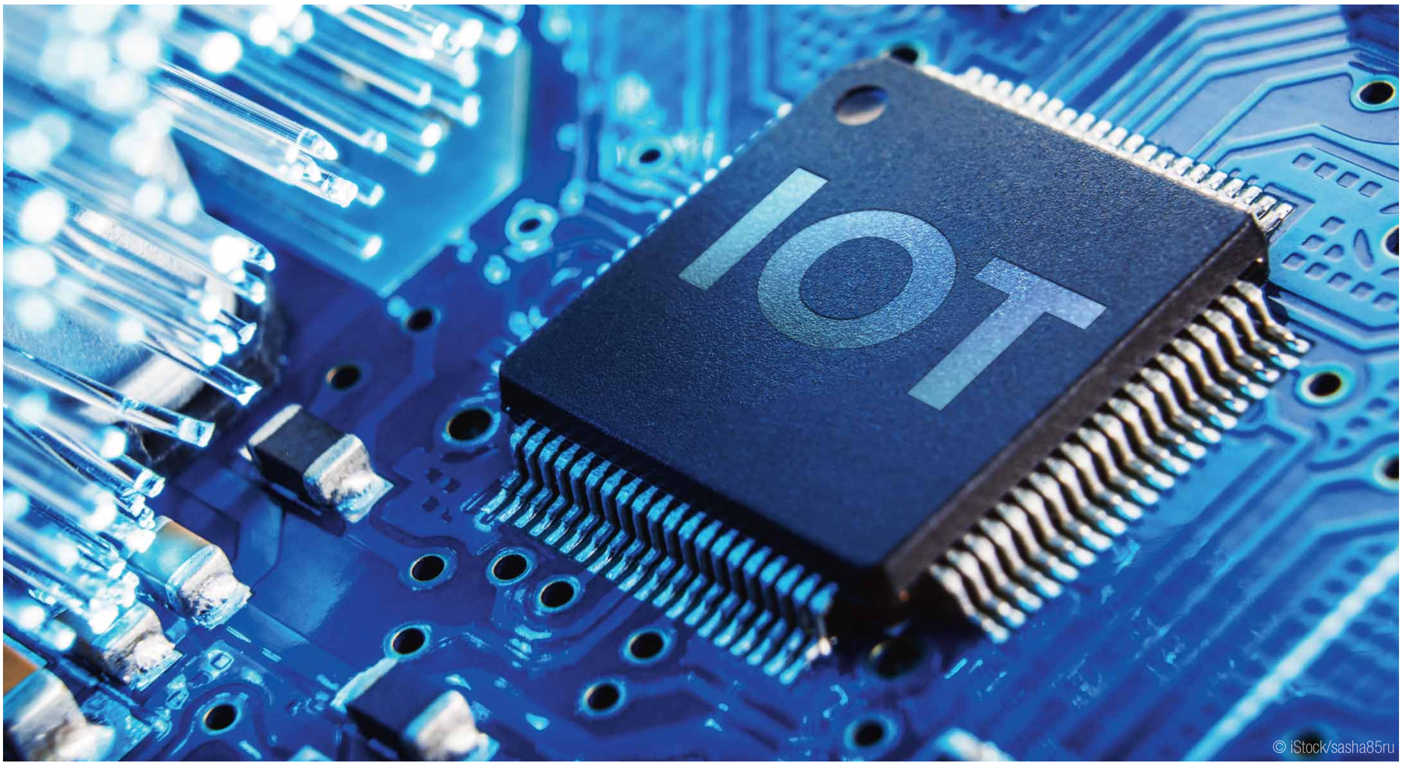
In Japan, over 20 health professional occupations require a government mandated qualification. Many have operation monopolies that mean that certain work can be done only by a qualification holder. In contrast with many modern office buildings, hospital buildings have much smaller rooms, such as patient rooms and consultation/ examination rooms, which means that there are more walls and doors than in other buildings.

Large hospitals also have specialised equipment that is not found elsewhere, such as operating rooms, sterile zones, and piping to each bed. Building and operating such facilities is the responsibility of non-medical staff. AI and IoT systems that assist with the management of facilities would be of great benefit to this.

A Q&A system that classifies data and makes judgments based on the data gathered is an example of the practical use of AI. Kimura Information Technology Inc. (Japan) has released a Q&A system (AI-Q) that is based on IBM Watson.[1] AI-Q consists of an 'engine' and an interface. It is currently used mainly in the call centres of drug companies.

It is also important to note that AI-Q is not a rule based system. It analyses data learned in advance, and then outputs and accumulates meaningful information. This system matches the question stored in the engine with what is closest to the question input by the user.

The Natural Language Classifier (NLC) of IBM Watson is used as the AI-Q engine. We are currently testing a Q&A system for its use with medical devices that are managed by certified clinical engineers (CCE). There is a shortage of CCEs, even in large hospitals, and it is impossible for one engineer to have full knowledge about all the medical devices they must manage. Our system will ameliorate the problem by giving the CCEs a Q&A system that will provide them with quick and accurate access to the information they need for



each device. In addition, medical devices require intensive management as they move through the various wards and operating rooms of large hospitals. AI and IoT would be of great value in tracking and monitoring these devices. Our system will also reduce the burden on CCEs by making access to routine information available to the medical staff, so they do not have to consult a specialist.

Otherwise, no practical system with AI and big data analysis is currently available for use in hospitals. However, as the following example shows, it will be possible in the future to do various types of analysis and to provide useful data for hospital management through the introduction of IoT.

IoT in hospitals

The following are possible targets for systems with IoT that are practical for hospital use:

Environmental Control

Almost all hospitals manage the temperature and humidity in units, such as for individual rooms or the whole of a ward. Patients with various diseases and conditions are roomed together, however the air-conditioning in a multi-patient room is still uniform, even though the heat sensitivity of patients differs. Lighting is a similar problem, with the regulation of brightness only being available for the whole room in many cases. Brightness can differ for the patients near a window and those on the opposite side of the room.

These problems are solvable by making each bed a data acquisition unit, which would allow the building of an environment for each patient based on the acquired data and patient information provided by the nursing staff and doctors.

Facility Management

An important mater related to the facilities of a large hospital involves the complicated piping provided at the bedside. This can include piping to remove body fluids, and piping used to supply compressed air, oxygen, carbon dioxide, or anaesthetics. At present, management of the pressure in the piping is usually from a central point in a ward or for a whole floor. IoT would allow pressure to be measured at each bed, anytime, and to adjust it at each outlet.

Another important aspect of IoT for environment control involves the use of IC card keys for security, and in many hospitals, they are already in practical use. They can control physical access through a log in system connected to each lock. Card keys are useful for limiting access to restricted areas, such as rooms where medicines, medical implements, or machines are stored.

Personnel Management

Positioning systems based on GPS or IC tags are already in practical use. The indoor use of GPS requires special equipment, which adds expenses that hospital administrators are often averse to providing. Their effectiveness varies, notably that of positioning systems that use IC tags, which in many cases do not have adequate precision. This is because of the many walls and doors of a hospital building that can interfere with radio wave transmission. Cooperation between the building constructor, the maintenance staff, and the hospital staff will allow the gathering and use of information about the quality of the materials that are necessary in order for the problem to be solved.

Other examples of IC tag use include systems to prevent patients without permission from leaving a ward and to track and manage the workflow of the hospital staff. In the future, IC tag sensors may be used to monitor the health status and stress levels of staff members. Moreover, Vending machines and convenience stores are ubiquitous in Japan, and Japanese hospitals are no exception. An IC card supplied to each patient could be used to monitor and pay for patient purchases. This would be advantageous to the staff nutritionists who are responsible for the management of strict patient diets and also reduce the problems related to patients keeping cash in their rooms.

Device and surgical instrument management

CCEs are responsible for the intensive management of hospital medical devices, some of which are fixed in one location and others that are mobile and move around the hospital. It is difficult to monitor the location of medical devices, especially those that move with a patient. The use of IC tags allows the monitoring of the location of any medical device, any time. When a sensor is affixed, it is possible to collect the operating status, alarm information, and other data that is important to the functioning of the device.[2] Some systems that use IC tags are already in use for managing surgical instruments or medical materials.[3] Use and/or consumption records can be attained using the database and information stored by these systems.

Points to be considered at the time of introduction

The systems described in this article tend to collect huge amounts of data, which can be problematic if they are not carefully constructed. The type and amount of information to be collected must be carefully planned, including pre- and follow-up testing.

Another consideration is time sensitivity. For some data, analysis of time trends is important and useful; however, when there are two or more systems collecting data, the clock of all the systems must be synchronised. It is also important to have confirmation checks for numerical data to eliminate the possibility of error. Furthermore, when acquiring data through wireless communication systems, it is important to ensure an environment in which signals can be transmitted and received at the required strength.[4] If the system is always collecting data, anything that blocks communication can then interfere with the functioning of the system which then can greatly impacts patient care.

In this article, I have considered the demand for and practical use of AI and IoT in hospitals based on viewpoints of both the medical and non-medical staff. Through the use of IoT and AI, the medical environment can be tailored to the needs of each patient, which will not only raise the effectiveness of patient care but also increase satisfaction, make them safer, and improve labour efficiency. Moreover, advanced medicine has brought about increased specialisation – each hospital has its own needs, and sections within a hospital have needs specific only to them. Programs must be developed to meet these needs, which creates a complex environment that would benefit from AI. However, at the same time, this puts constraints on its use.

Raising the labour efficiency of the co-medical and non-medical staff will also raise the physicians' labour efficiency. This not only relieves the burden of the staff but raising labour efficiency leads to increased face time with patients, which in turn raises patient satisfaction. The introduction of ICT into hospitals has progressed to the point that almost all hospitals have a hospital information system, a patient information sharing system among hospitals, and wireless LAN. Hopefully, IoT will soon be as common.

Society 5.0 is a trending word, and the concept is expected to be realised in the near future. Society 5.0 is a society that is driven by big data, and it will have a great impact on clinical medicine. AI and IoT will be important to realising the potential benefits of Society 5.0.

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