The Future Evolution and Development of Biometrics Studies

MIZUNO Masayuki

Abstract

In this paper, we will discuss the future evolution of biometrics — a rapidly evolving technology that has become a part of most people's everyday life. We begin with the assumption that biometrics will evolve in the direction of increased efficiency, introducing a number of case studies that focus on how biometrics can increase efficiency — including efficient manipulation of massive amounts of data, efficiency in terms of "things", and efficiency in the real world. We also assume that biometrics will become a reliable way of measuring people's mental states and look at some case studies which point to future developments in this area, from targeting and understanding specific individuals to targeting and understanding groups. Finally, we will look at AI technology and how biometrics can be used as a driver to enable exponential growth that will lead to future sustainable growth in the economy.

Keywords

biometrics, deep learning, face recognition, Maslow's hierarchy of needs, exponential growth

1. Introduction

Since 2012, research and development has led to dramatic advances in the field of deep learning, greatly increasing the recognition accuracy of various AI technologies including image recognition. A good example of how this technology has evolved is the ImageNet Large Scale Visual Recognition Challenge (ILSVRC), which is an international competition for object detection and image classification on a large scale.

In 2017 the ILSVRC achieved a 2.3% error rate in object classification tasks. To understand just how good that performance is, all we have to do is compare it with humans. For humans performing the same tasks, the error rate is 5.1%. While the number of the participants in the ILSVRC increased steadily from 2012 — the year when deep learning was introduced — to 2016, it dropped substantially in 2017, falling from 172 in 2016 to 115 in 2017. The winner in 2014 — Google — has not participated since then. Many of the participants in recent challenges were from China. Faced with declining participation, ILSVRC wrapped up for good in 2017.

The evolution and development of deep learning has been driven by various factors including the rapid concentration of knowledge in both software and hardware, as well as cost reduction and commodification of the R&D environment.

Public availability of open-source software (OSS) libraries and development frameworks for deep learning such as TensorFlow (Google), Chainer, (PFN), and Caffe (CMU, etc.) has played a significant role in increasing the power of this technology. In addition the availability of large-scale data sets such as ImageNet (Stanford University) and COCO (Microsoft) that can be used as learning and evaluation data has created an environment in which anyone can easily experiment with deep learning. Furthermore, companies like Google, Microsoft, and Amazon have introduced various recognition functions such as image recognition and speech recognition as cloud services. In recent years, even learning processes have been turned into cloud services.

The same applies to hardware. Performance improvements and price reductions of accelerators in AI inference and training such as NVIDIA AI inference platform played a major role in achieving results that helped attract renewed attention in 2012. Constant improve-

ments in hardware provide a platform that supports the evolution and development of deep learning.

Advances in deep learning have had a significant impact on biometrics. NEC was ranked first in benchmark tests for fingerprint, face, and iris recognition performed by the U.S. National Institute of Standards and Technology (NIST) and has also obtained top-class results in voice recognition tests.

The net effect of these developments has been to turn biometrics into a technology whose benefits can now be enjoyed by anyone.

Without conscious deliberation, without taking any specific actions, without even being aware of it, anyone — from the very young to the very old — can now enjoy the benefits of biometrics independent of such characteristics as height, skin color, or ethnicity, as well as individual preferences such as fashion. Safe, reliable, and unobtrusive, biometrics is becoming a part of everyday life.

In this paper we will look at where biometrics is going and highlight the potential benefits it can bring in the future.

2. Using Biometrics to Improve Efficiency

Because biometrics authenticates an individual's identity based on their bioinformation, it offers several important benefits; these include the prevention of spoofing, the elimination of the inability to be authenticated due to a lost key or password, and the prevention of illegitimate authentication by someone else using that "key". In the future, we believe biometrics' ability to ensure safety and reliability will be enhanced by its ability to improve efficiency in many different fields.

2.1 More efficient processing of massive amounts of data

For example, face recognition technology — a key biometric technology — makes it possible to track a specific individual by isolating the data representing that individual from high-volume video recordings of large crowds. It also makes it possible to identify anyone accompanying the individual in question[1)].

Thus, biometrics provides an extremely efficient way to detect and track specific individuals despite the enormity of data available. This can help solve unsolved cases or guide people to safety by detecting danger in advance.

2.2 More efficient utilization of "things"

When biometrics is combined with "things", those "things" can be utilized much more efficiently by changing the environment from one where "things" are owned to one where they are shared.

Take a private car, for example. Until recently, the most common way to have unrestricted access to the benefits of a car was to own one. Now, thanks to the development of biometrics technology, it is possible to let other people use your car when not using it. In other words, you can improve efficiency by changing permanent ownership to occasional ownership.

Moreover, when it becomes possible to use the car only when it is necessary, you can boost efficiency to the next level, stepping up from occasional ownership to non-ownership.

In this way, biometrics has the potential to improve efficiency by changing each and every "thing" from being owned to being shared. Let's look at another example — smartphones. In the near future, biometrics will not merely serve as a means to log in, but also to share the smartphone with other users. Ultimately, you may be able to enjoy all the benefits of a smartphone without actually owning one.

2.3 Improved real-world efficiency

Biometrics also has the potential to change the status of "humans" in the real world from anonymous to identified.

For example, it is increasingly common for biometrics to be used to confirm your identity at the entrance to a building. In other words, your real name is known in that building. However, the real-name condition is limited to that building; it does not follow you when you leave. But once biometrics are used everywhere, you will always be in the real-name condition, no matter where you are.

In the virtual world, there are two types of social media service — real-name and anonymous. For instance, on Facebook you must use your real name, while on Twitter and Instagram you can be anonymous. Likewise, as we have just mentioned, real-name and anonymous conditions coexist in the real world. Therefore, it is fair to say that biometrics is what defines the boundary between real-name and anonymous conditions.

The real-name condition in the real world focuses on efficiency. By disclosing who you are and what you have done when and where, you can receive services matched specifically to you. At the same time, you sacrifice some of your privacy, which is an important characteristic of anonymity. Balancing these two issues — the efficiency of being known versus the benefits of anonymity — is crucial to the future evolution and development of this technology.

3. From Understanding the Superficial Characteristics of People to Understanding Their Internal Condition

Currently, biometrics is a technology used to authenticate who a specific individual is. That is, it is a technology that recognizes the external characteristics or appearance of a given individual. In the future, however, biometrics will evolve to the point where it is able to comprehend an individual's internal condition.

For example, technology now exists that can highly precisely estimate long-term stress one step at a time based on vitals collected from wearable sensors[2)3)].

Who an individual is — the target of authentication — does not change over time. On the other hand, the internal condition of that person does change over time. This will make it possible to offer time-dependent services in addition to conventionally available individual-dependent services.

Once biometrics can understand the long-term internal conditions of the people who are the target of services, it will make it possible to offer services matched to their personality, for example. Similarly, when biometrics understands an individual's short-term internal condition, it will be able to offer services focused on their real-time emotional state.

When technology is able to understand our changing moods, detect our internal stress, or understand the nuances of our personality, it will be better able to offer us services custom-tailored to our needs at any given moment.

3.1 From individuals to groups

In order to offer the best-possible services to individuals according to their internal conditions, it will be necessary to treat them as groups.

For example, to offer more advanced sales services using biometrics, you must not only pay attention to the targeted individual, but also to their companion(s). In other words, it is important to understand the relationships between individuals, as well as the relationship between an individual human and a "thing"[4)]. This in turn will lead to a deeper understanding of the internal aspects of that individual.

At the same time, this kind of analysis will also improve understanding of the overall "trends" of an individual rather than just their tendencies[5)6)]. In other words, by treating individuals as groups you can go beyond merely understanding individual characteristics to understanding their behaviors.

3.2 From understanding to fulfilling

To get a better idea of where biometrics is heading, let's look at the hierarchy of needs proposed by American psychologist Abraham Harold Maslow (1908–1970). First published in 1943, this theory's powerful insights into human behavior make it as relevant today as it was back then.

Between the Industrial Revolution, which began in the latter half of the 18th century, and the Information Revolution, which started in the mid-20th century, it is fair to say that four of the five layers of needs in Maslow's theory have been satisfied, ranging from basic layer so-called "Physiological needs" such as hunger and thirst to the higher level up to layer 4 so-called "Esteem" such as self-esteem, recognition, and status. Today, one of the most familiar examples of something that meets the need for esteem needs is the "like" button in social media.

At the top of Maslow's pyramid of needs sits self-actualization. We have already seen how biometrics will be able to understand an individual's internal condition once the technology has sufficiently evolved. From there, the next step is to predict what an individual will want and to help them fulfill that need. By supporting self-actualization and creative activity, this will satisfy the ultimate need in Maslow's heirachy[7)].

Compared to physiological needs for food, clothing, and shelter, the needs of self-actualization differ from one person to the next.

Let's take a look at how self-actualization might manifest itself when buying something at a store, for example.

It is already common practice to make recommendations based on an individual's previous purchases, as well as on the past purchase records of other similar "humans".

With a deeper understanding of an individual's personality, it will be possible to recommend something to an individual that may tap into their potential. To put it differently, in the future, biometrics will be an enabler, helping to fulfill the individual personality and ability of each "human".

4. Conclusion

Exponential growth has been one of the dominant characteristics of both the Industrial Revolution and the Information Revolution.

The Industrial Revolution made possible expansion and efficient use of foodstuffs and resources due to advances it made possible in a wide range of technologies. This contributed to the increase in overall population and human resources engaged in productive activities — a

segment of the population called the production workforce. In turn, the increase in human resources propelled further technological advances, creating a virtuous cycle that led to exponential growth and laid the foundation for the Information Revolution.

The same virtuous cycle is true for the Information Revolution. Thanks to the miniaturization of semiconductors, the performance and functions of IT devices improved. This spurred further miniaturization, ever-increasing efficiency, and ever-decreasing costs, making it possible to achieve exponential growth.

The miniaturization of semiconductors is expected to reach an endpoint soon. Once this happens, one of the most important drivers of exponential growth will be gone.

What will replace it?

We believe that AI technology — including biometrics — will become the next driver of exponential growth, ensuring continued growth of the economy in the future[8].

To improve recognition precision using AI technology, vast amounts of data are required. As AI technology with high recognition precision is already used in many different locations, it is possible to acquire even more data which will in turn support further progress in AI technology (achievement of new services). In other words, the reason why companies that promote data-driven growth continue to grow is because they take advantage of this mechanism of exponential growth.

Biometrics is a key component of these AI technologies and we believe it will play a significant role in driving exponential economic growth. We also expect that the individual self-actualization facilitated by biometrics as it moves from understanding needs to predicting and fulfilling them will also be part of this virtuous cycle of growth, supporting the creation of completely new AI technology.

Reference

1) Jianquan Liu, Shoji Nishimura, Takuya Araki, Yuichi Nakamura: A Loitering Discovery System Using Efficient Similarity Search Based on Similarity Hierarchy, IEICE TRANSACTIONS on Fundamentals of Electronics, Communications and Computer Sciences, Vol.E100-A No.2, pp.367-375, 2017.2
http://search.ieice.org/bin/summary.php?id=e100-a_2_367
2) Yoshiki Nakashima, Masanori Tsujikawa, Yoshifumi Onishi, Improvement in Chronic Stress Level Recognition by Using Both Full-term and Short-term Measurements of Physiological Features, The 32nd Annual Conference of the Japanese Society for Artificial Intelligence, 2018.6
https://confit.atlas.jp/guide/event-img/jsai2018/2F3-OS-4b-05/public/pdf?type=in
3) Terumi Umematsu, Akane Sano, Sara Taylor, Rosalind W. Picard: Improving Stress Forecasting using LSTM Neural Networks, The 40th International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), 2018.7
https://www.media.mit.edu/publications/improving-stress-forecasting-using-lstm-neural-networks/
4) Chih-Yao Ma, Asim Kadav, Iain Melvin, Zsolt Kira, Ghassan AlRegib, Hans Peter Graf: Attend and Interact: Higher-Order Object Interactions for Video Understanding, Computer Vision and Pattern Recognition, CVPR 2018, 2018.3
https://arxiv.org/pdf/1711.06330v2.pdf
5) Ikeda, et al., *Gunsyu Pacchi Gakusyu ni Motozuku Ninzu Suitei no Koseido-ka*, The 21st Symposium on Sensing via Image Information, (SSII2015), IS3-13-1 - IS3-13-6, 2015.6 (in Japanese)
6) Ikeda, et al., *Particle PHD Filter to Gunsyu Pacchi Gakusyu ni Motozuku Ninzu wo Mochiita Jinryu Suitei, ViEW2016 Bijon Gijutsu no Jitsuriyo Workshop*, ROMBUNNO.OS1-H4 (IS1-10), pp. 37-44, 2016.12 (in Japanese)
7) Mizuno, et al., *Handotai Solution Platform Sangyo eno Tenbo*, Japan Electronics and Information Technology Industries Association, STRJ Workshop, Panel Discussion, 2016.3 (in Japanese)
8) Masayuki Mizuno, Looking for something that leads to exponential growth with big data and AI, HKUST Big Data and AI Day, 2017.5

Authors' Profiles

MIZUNO Masayuki
General Manager
Biometrics Research Laboratories

Information about the NEC Technical Journal

Thank you for reading the paper.
If you are interested in the NEC Technical Journal, you can also read other papers on our website.

Link to NEC Technical Journal website

Japanese English

Vol.13 No.2 Social Value Creation Using Biometrics

Vol.13 No.2
April 2019

Special Issue TOP

Remarks for Special Issue on Social Value Creation Using Biometrics
Committed to Supporting Social Values via Biometrics

Papers for Special Issue

Commitment to Biometrics NEC Is Promoting
Bio-IDiom — NEC's Biometric Authentication Brand
The Future Evolution and Development of Biometrics Studies
Privacy Measures of Biometrics Businesses

Services and Solutions That Leverage Biometrics
The Western Identification Network: Identification as a Service in a Federated Architecture
Use of Face Authentication Systems Associated with the "My Number Card"
Face Recognition Cloud Service "NeoFace Cloud"
NEC Enhanced Video Analytics Provides Advanced Solutions for Video Analytics
New In-Store Biometric Solutions Are Shaping the Future of Retail Services
ID Service Providing Instantaneous Availability of User's Desired Financial Services
Biometrics-Based Approach to Improve Experience from Non-routine Lifestyle Fields
Construction Site Personnel Entrance/Exit Management Service Based on Face Recognition and Location Info
The Importance of Personal Identification in the Fields of Next-Generation Fabrication (Monozukuri)

Core Technologies and Advanced Technologies to Support Biometrics
How Face Recognition Technology and Person Re-identification Technology Can Help Make Our World Safer and More Secure
Advanced Iris Recognition Using Fusion Techniques
Advanced New Technology Uses New Feature Amount to Improve Accuracy of Latent Fingerprint Matching
Safety, Security, and Convenience: The Benefits of Voice Recognition Technology
Ear Acoustic Authentication Technology: Using Sound to Identify the Distinctive Shape of the Ear Canal
Automatic Classification of Behavior Patterns for High-Precision Detection of Suspicious Individuals in Video Images
Facial-Video-Based Drowsiness Estimation Technology for Operation on Low-End IoT Devices

NEC Information

NEWS
2018 C&C Prize Ceremony