Imperial Prize and Japan Academy Prize to:

Masahiro Hara
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for "Contributions to Development and Worldwide Dissemination of the QR Code System"

Outline of the work:

Every day, people all over the world use QR codes for obtaining product information, making mobile payments, and getting hyperlinks to URLs. Mr. Masahiro Hara invented the fundamental principle of the QR Code, and made many years of contributions to its continued technical development and standardization for its worldwide dissemination.

Invention of the QR Code

The bar-code system, still used today in retail stores, consists of striped patterns arranged in one dimension, and thus, the amount of information that it can carry is limited. In the early 1990's, Mr. Hara, an engineer at DENSO Corporation, started working on creating a new code to be used for parts inventory management in automobile manufacturing. Since the number of parts is large, the code must be able to contain a large amount of information, and because its primary use is in factories, it must be robust against damage such as stains and scratches, and readable at high speeds.

In 1994, the QR Code system was invented as a fast machine-readable 2D matrix code that can handle up to 200 times more information than barcodes. The invention consisted of three key ideas: the *finder pattern* for quick localization, *data recovery* against damage, and the *alignment pattern* for correcting distortion. The finder pattern is a 2D black-and-white square pattern that has a distinctive 1:1:3:1:1 ratio of white-to-black cells for any scanline passing through its center. By placing this pattern at the three corners, the code can be quickly located (position and rotation) in the captured image.

Robustness against damage is realized by using Reed-Solomon coding, which allows for reading the code correctly even when 30% of the area is damaged. In addition, by allocating black and white cells evenly, the recovery rate has been further increased to 60%. Finally, one to several alignment patterns are placed in the code so that it is readable even when the code is viewed in a slanted angle or printed on a curved surface.

The original QR Code was invented in 1994 and equipped with these unique features, achieving reading of as much as 5 times more information than the barcode in 30 ms even with the low performance CPU at that time. As a side note, the name QR Code comes from its original purpose "Quick Response."

Further Development, Standardization and Dissemination of QR Code

As we experience while shopping, reading a one-dimensional barcode is done by aligning, often manually, the scanning direction with that of the code. In contrast, reading a QR code, which is two dimensional and more detailed, requires automatic detection of its location and rotation plus complex two-dimensional pattern recognition. Interestingly, this requirement for the QR Code turns out to be its advantage. With the advancement of 2D image sensors and powerful CPUs reliable and fast automatic reading of QR

codes became possible, and its installation on cellphones, in particular, triggered an explosive use of QR codes in all the situations in the society far beyond the original purpose.

Mr. Hara led a team at DENSO for this QR Code evolution. In the beginning, three types of code readers were provided, but today, 50 types are available and can be used with most smartphones. To meet the ever growing need of society, various QR Codes have been developed. Examples include the secure QR Code that can handle confidential and personal information (2007); the anti-counterfeiting QR Code that cannot be duplicated with a copy machine (2011); the user-engaging QR Code that can incorporate logos and illustrations in the code (2014); and the robust QR Code (now used on a platform door at train stations) with better reading performance in tough outdoor environments (2017).

Mr. Hara also contributed to the QR Code obtaining the standard certification necessary for global dissemination: most notably AIM (Association for Automatic Identification and Mobility) International Standard in 1997, JIS X 0510 in 1999, and ISO/IEC 18004 in 2000.

In this way, the QR Code has become a socially indispensable infrastructure that people in the world use every day and everywhere for all kinds of purposes. The QR Code is not just a clever method of placing black and white dots. It is an ever evolving QR Code system that makes our society more convenient, productive, and safe. Most recently, with the COVID-19 pandemic, we observe that QR Code decals have replaced paper menus at many restaurants, and that QR Codes are used as vaccination certificates for international travel. The impact of the QR Code system is unmeasurable.

List of Main Publications

長屋隆之・山崎知彦・原　昌宏・野尻忠雄（1996）高速読取り対応二次元コード［QR コード］の開発、全国大会講演論文集（第 52 回）、情報処理学会、253–254.
原　昌宏（2008）QR コードの開発、自動車技術、62、59–64.
原　昌宏・岩井誠人・佐波孝彦・菊間信良（2013）日本発・世界に広がる二次元コード：QR コード、通信ソサイエティマガジン、7、126–132.
Hara, M. (2019) Development and popularization of QR code—Code development pursuing reading performance and market forming by open strategy—. Synthesiology, English edition, 12, 19–28.
原　昌宏（2019）QR コードの開発と普及―読み取りを追究したコード開発とオープン戦略による市場形成―、Synthesiology、12、19–27.
原　昌宏（2021）QR コードの特長と進化、日本画像学会誌、60、553–557.
原　昌宏（2022）QR コードの進化と普及―QR コードの軌跡と今後―、情報処理、63、e1–e7.