Journal of Cellular Automata, Vol. 18, pp. 391–395
Reprints available directly from the publisher
Photocopying permitted by license only
DOI: 10.32908/jca.v18.Obituary

Obituary

PROFESSOR KENICHI MORITA

March 30, 1949–July 19, 2025

Professor Kenichi Morita was a researcher in theoretical computer science and natural computing with a broad perspective. Born in Osaka in 1949, he became familiar with electronics from his student years, influenced by his father who was an electrical engineer. He entered the School of Engineering Science at Osaka University in 1967, becoming one of the first students in the Department of Biophysical Engineering, which was established that same year. The department conducted research and education in the interdisciplinary fields of biology, neuroscience, physics, and information science, offering numerous foundational courses for undergraduate and graduate students in molecular biology, biophysics, neurophysiology, quantum mechanics, control theory, information theory, and automaton theory. This diverse content greatly influenced his later research.

He began research on automata theory as a graduate student under Associate Professor Kazuhiro Sugata [1]. From 1974-1987, he served as a research assistant in the department. He taught formal logic exercises and electrical circuit experiments. In 1974, he focused on two-dimensional information processing [2, 3], and in 1978 submitted his doctoral dissertation:

"Computational complexity in one- and two-dimensional tape automata" (advisor: Professor Tadao Kasami).

This dissertation defined tape-bounded two-dimensional Turing machines and addressed the fundamental problem of how the capabilities of various automata with one- and two-dimensional input tapes are characterized by the amount of working memory relative to input size. Subsequently, for research on two-dimensional formal languages, he worked on several types of array grammars, including isometric regular array grammar and uniquely parsable array grammar [8].

In the mid-1980s, following suggestions from Professor Toshio Mitsui of the department, an expert in biophysics with an interest in computational theory, he became interested in the relationship between physical reversibility and computational processes–namely, how computation can be executed in physically reversible environments–and began to seriously engage with the topic of "reversible computing." While exploring the pioneering work of Landauer, Feynman, Bennett, Fredkin, and Toffoli, he realized that reversible computing had many unsolved problems from the perspective of automata theory, which led to his subsequent series of research.

He moved to the Faculty of Engineering at Yamagata University in 1987, where he served as associate professor from 1987-1990 and professor from 1990-1993. During this period, he made important contributions to reversible cellular automata (CA), demonstrating in 1989 the computational universality of one-dimensional reversible CA [4]. This showed that Toffoli's results for two or more dimensions also held in one dimension, establishing the foundation for the computational capabilities of reversible CA. He also derived fundamental results in reversible computing, including showing that Bennett's 3-tape reversible Turing machine could be simulated with 1 tape and 2 symbols [5], and introducing partitioned CA that generalized Margolus's two-dimensional reversible CA [7].

During his tenure at Yamagata University, he also worked on formal reasoning systems for knowledge processing, extending classical syllogisms by introducing term operations such as conjunction and complement for noun terms, and further introducing "verb sentences" that directly handle verbs (binary relations) and proper nouns to expand the scope of application. He published research [6] providing completeness for all these extended systems. This was a precursor to later relational syllogistic/natural logic and was inherited and developed into decidability and complexity research based on quantified noun phrases and relations.

He moved to the Graduate School of Engineering at Hiroshima University in 1993, where he served as professor until 2013. At Hiroshima

University, he intensively developed research on reversible computing and reversible CA, broadly encompassing fundamental reversible computational models including construction methods for reversible circuits and reversible counter machines [9]. Particularly noteworthy were the 1996 reversible self-reproduction model [10] and the self-reproduction model using shape-encoding mechanism [11], which had a significant impact on the artificial life field.

Regarding research on generative grammar, he proposed uniquely parsable grammar [12], which incorporated the idea of uniquely parsable array grammar into generative grammar. He also has broad interests in unconventional computing and conducts research on computational models including DNA computation [13, 16].

His lifework during his time at Hiroshima University was particularly notable for research on reversible logic elements with memory (RLEM). RLEM was initially proposed as a "gadget" for embedding computational functions in reversible CA [14, 15], but recognizing its versatility, he advanced its generalization and systematization of properties [18, 20]. RLEM is a kind of generalization of reversible flip-flops and provides a systematic method for constructing reversible sequential machines. The relationship with elements used in token-driven asynchronous delay-insensitive circuits was also clarified [17], and its importance is recognized in the context of computational systems closely tied to matter and in-memory computing [21].

Domestically, he was active as a key member from the early days of the language and automaton research community (LA Symposium), and during his time in Hiroshima, actively promoted international exchange, broadly interacting with researchers from the European Association for Theoretical Computer Science (EATCS) and IFIP Working Group 1.5: Cellular Automata and Discrete Complex Systems. Furthermore, he supported the International Conference on Reversible Computation (RC) that began in 2009 and the Asian Symposium on Cellular Automata Technology (ASCAT) that started in 2022, continuing to support the reversible computing and cellular automaton research communities.

After retiring from Hiroshima University in 2013 and becoming professor emeritus, he continued his research and writing energetically, publishing a survey paper on reversible computing [19] as well as the following two volumes summarizing research on reversible computing and reversible CA:

- Theory of Reversible Computing (Monographs in Theoretical Computer Science: An EATCS Series), Springer, 2017, 474pp.
- Reversible World of Cellular Automata: Fantastic Phenomena and Computing in Artificial Reversible Universe (WSPC Book Series in Unconventional Computing 4), World Scientific, 2024, 346pp.

Additionally, a collection of essays commemorating his 70th birthday was published:

- Reversibility and Universality: Essays Presented to Kenichi Morita on the Occasion of his 70th Birthday (Emergence, Complexity and Computation, 30, edited by Andrew Adamatzky), Springer, 2018.

He also authored the following book in Japanese:

- Reversible Computing, Kindai Kagaku Sha, 2012, 212pp.

Just as computational processes in quantum computing are described by unitary evolution, the concept of reversible computing will remain important for considering computational processes closely tied to matter. Professor Morita was a rare researcher who, from the 1980s, deepened friendships with Bennett, Fredkin, Toffoli, and Margolus, developed their ideas, and systematized the field of reversible computing.

Matthew Cook* described his impressions when discussing RLEM with him as follows:

“I sent Kenichi a lot of very detailed emails about it back when I discovered it. It was funny because I was doing simulations by hand using magnets on whiteboards, and making ASCII art diagrams, like an old person, while he was doing very fancy simulations in Golly like a young person! He introduced me to the benefits of using Golly – without him, I’d still just be using the whiteboard!”

Consulting original works by Aristotle and Gödel (in Greek and German), running the Game of Life on PDP-12, designing reversible self-reproducing CA in Prolog, and simulating reversible logic circuits in Python–he was indeed also a “hacker.”

Katsunobu Imai
Fukuyama University, Japan

REFERENCES

[1] K. Sugata, K. Morita. (1973). A Method for Mutual Conversion between Turing Machines and Wangs Primitive Computers (B-machines), *IECE Transactions*, 56-D, 133–139.

[2] K. Sugata, H. Umeo, K. Morita. (1977). The language accepted by rebound automaton and its computing ability, *IECE Transactions*, 60-A, 367–374.

* personal communication, August 2025

[3] K. Morita, H. Umeo, K. Sugata. (1977). Language recognition abilities of several two-dimensional tape automata and their relation to tape complexities, *IECE Transactions*, 60-D, 1077–1084.

[4] K. Morita, M. Harao. (1989). Computation universality of one-dimensional reversible (injective) cellular automata, *IEICE Transactions*, E72 (6), 758–762.

[5] K. Morita, A. Shirasaki, Y. Gono. (1989). A 1-tape 2-symbol reversible Turing machine, *IEICE Transactions*, E72 (3), 223–228.

[6] N. Nishihara, K. Morita. (1990). An extended syllogistic system with conjunctive and complementary terms, and its completeness proof, *Systems and Computers in Japan*, 21(1):96–111.

[7] K. Morita, S. Ueno. (1992). Computation-universal models of two-dimensional 16-state reversible cellular automata, *IEICE Transactions on Information and Systems*, 75(1):141–147.

[8] Y. Yamamoto, K. Morita. (1992). Two-dimensional uniquely parsable isometric array grammars, *International Journal of Pattern Recognition and Artificial Intelligence*, 6(2-3):301–313.

[9] K. Morita. (1996). Universality of a reversible two-counter machine, *Theoretical Computer Science*, 168(2):303–320.

[10] K. Morita, K. Imai. (1996). Self-reproduction in a reversible cellular space, *Theoretical Computer Science*, 168(2):337–366.

[11] K. Morita. (1997). A simple self-reproducing cellular automaton with shape-encoding mechanism, *Proc. Artificial Life V*, 489–496.

[12] K. Morita, N. Nishihara, Y. Yamamoto, Z. Zhang. (1997). A hierarchy of uniquely parsable grammar classes and deterministic acceptors, *Acta Informatica*, 34(5):389-410.

[13] H. Hosokawa, K. Morita, C. Iwamoto, K. Imai. (2001). Universality of the Language Generating Ability of Two-Point Splicing Systems, *IEICE Transactions on Information and Systems*, J83-D-1, 55–59.

[14] K. Morita. (2001). A simple universal logic element and cellular automata for reversible computing, *Proc. International Conference on Machines, Computations, and Universality*, 102–113.

[15] K. Morita, Y. Tojima, K. Imai, T. Ogiro. (2002). Universal computing in reversible and number-conserving two-dimensional cellular spaces, in Collision-Based Computing, 161–199, Springer.

[16] C. Iwamoto, T. Andou, K. Morita, K. Imai. (2002). Computational complexity in the hyperbolic plane, *International Symposium on Mathematical Foundations of Computer Science*, 365–374.

[17] J. Lee, S. Adachi, F. Peper, K. Morita. (2003). Embedding universal delay-insensitive circuits in asynchronous cellular spaces, *Fundamenta Informaticae*, 58(3-4):295–320.

[18] K. Morita, T. Ogiro, K. Tanaka, H. Kato. (2004). Classification and universality of reversible logic elements with one-bit memory, *Proc. International Conference on Machines, Computations, and Universality*, 245–256.

[19] K. Morita. (2008). Reversible computing and cellular automata–A survey, *Theoretical Computer Science*, 395(1):101-131.

[20] K. Morita, T. Ogiro, A. Alhazov, T. Tanizawa. (2012). Non-degenerate 2-State Reversible Logic Elements with Three or More Symbols Are All Universal, *Journal of Multiple-Valued Logic & Soft Computing*, 18, 37–54.

[21] F. Peper, J Lee, J Carmona, J Cortadella, K Morita. (2013). Brownian circuits: fundamentals, *ACM Journal on Emerging Technologies in Computing Systems*, 9(1):1–24.