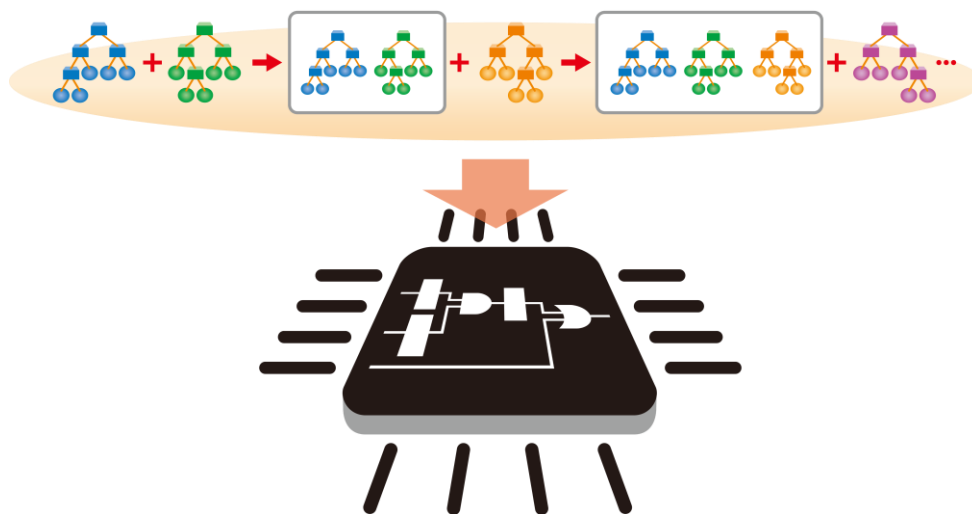


December 26, 2018

## 26xFaster and 90x More Power Efficient AI Model Training - Logic architecture for GBDT model training -

Ricoh Company, Ltd. has developed a logic architecture that greatly speeds up Gradient Boosting Decision Tree (GBDT) model training and has significantly lower power consumption compared with traditional methods. GBDT has been gaining increasing attention in the area of machine training, a form of AI training.

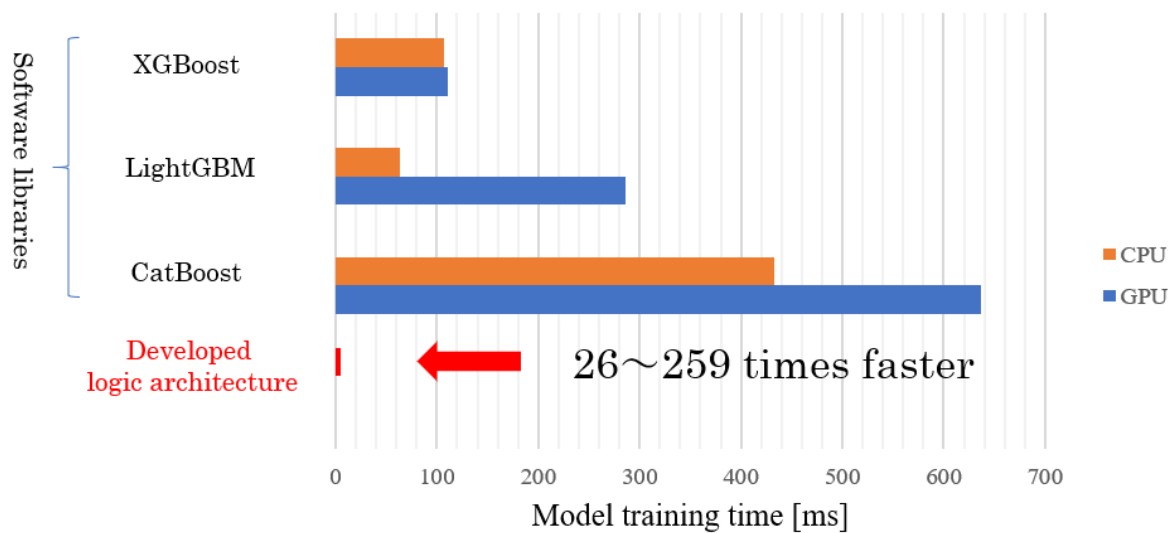


A logic architecture capable of training the GBDT model

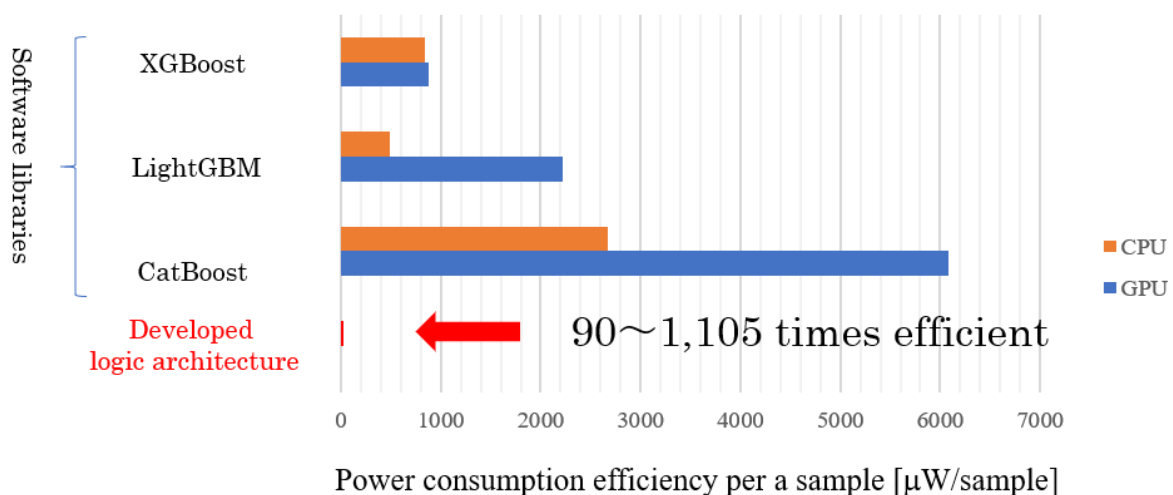
The developed logic architecture was implemented in a Field-Programmable Gate Array (FPGA: an integrated circuit where the designer can change the settings through programming) and we compared training times and power efficiency with three general GBDT software libraries (XGBoost (extreme gradient boosting), LightGBM, CatBoost) using CPU and GPU. We saw that the training speed of the logic architecture on the FPGA was 26-259 times faster compared to the software libraries. Training and updating the GBDT model in a shorter timeframe is now a reality. In addition, power consumption during the training is low, and the power efficiency of the model training was 90-1,105 times lower compared with general GBDT software libraries using GPU and CPU. This low level of power consumption is especially suited to edge computing. We also confirmed that the prediction accuracy of the trained model is equivalent to that learned from the software libraries.

GBDT performs highly in the training of large volumes of structured data. We think high-speed training based on the developed logic architecture can contribute to online applications especially in areas such as real-time bidding in online advertisements and recommendations in e-commerce.

In finance, the solution can be used in high-frequency trading of financial products by computer and in the security arena, the detection of cyber attacks, as well as in robotics. In addition, the developed logic architecture is suitable for edge devices and computing, which requires low power consumption.



Comparison of training times



Comparison of power consumption efficiency per a sample

A research group at the Ricoh Institute of Information and Communication Technology has announced the results of this study on arXiv.org, a world-class paper contribution website run by Cornell University, USA. (<https://arxiv.org/abs/1812.08295>)

Last year, Ricoh established the Applied AI Research & Development Center, an organization specializing in AI development. The Center is studying how to implement AI in products, how AI can be applied to internal business innovation, and more. Evolution is fast in the AI technology field and Ricoh is cooperating with a number of partners in the field. By developing proprietary advanced technologies and accelerating collaboration with leading-edge partners, Ricoh aims to develop world-leading technologies. The development of the hardware logic architecture is part of that aim.

Ricoh has developed a hardware logic architecture for fast GBDT training by importing its skills in circuit designs, nurtured through the development of copy machines and other optical products, into AI training. Ricoh will continue to unite the technologies it has nurtured as a manufacturer with the latest AI technologies, creating new value to contribute to its customers.

*LightGBM is a trademark or registered trademark of Microsoft Corporation.*

*CatBoost is a trademark or registered trademark of Yandex.*

*arXiv® is a registered trademark of Cornell University.*

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## **| About Ricoh |**

Ricoh is empowering digital workplaces using innovative technologies and services enabling individuals to work smarter. For more than 80 years, Ricoh has been driving innovation and is a leading provider of document management solutions, IT services, commercial and industrial printing, digital cameras, and industrial systems.

Headquartered in Tokyo, Ricoh Group operates in approximately 200 countries and regions. In the financial year ended March 2018, Ricoh Group had worldwide sales of 2,063 billion yen (approx. 19.4 billion USD).

For further information, please visit [www.ricoh.com](http://www.ricoh.com)