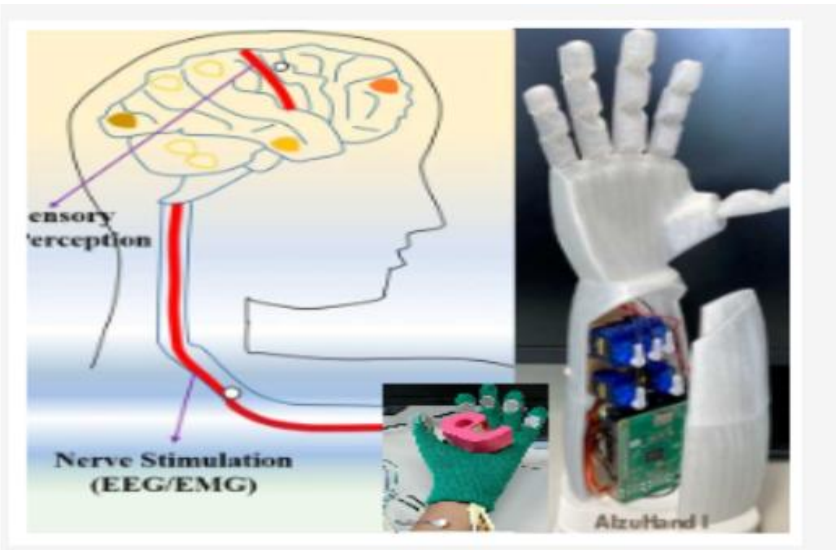
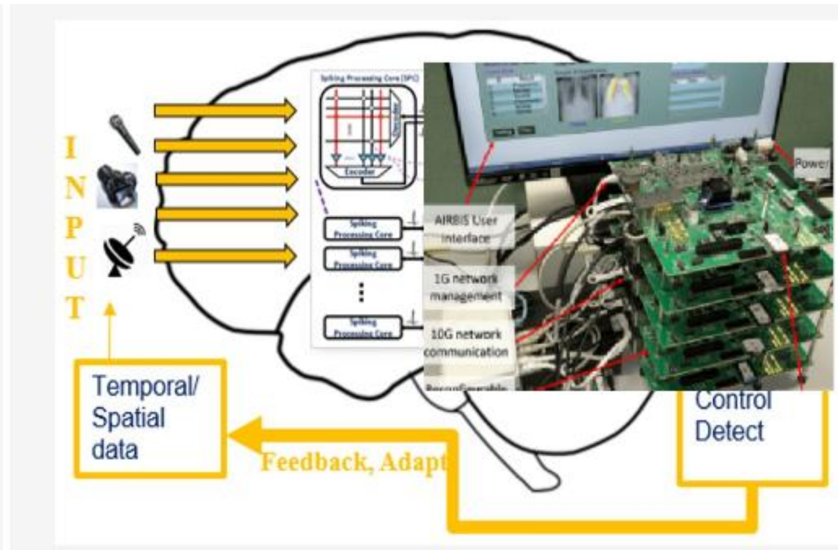




Abderazek Ben Abdallah

School of Computer Science and Engineering
The University of Aizu

Dec. 08, 2023

Faculty/教授 (SMM repository)

BEN ABDALLAH Abderazek [profile]
ベン アブダラ　アブデラゼク

Email: benab @ u-aizu(dot)ac(dot)jp

DANG Nam Khanh [profile]
ダン ナム カイン

Email: khanh @ u-aizu(dot)ac(dot)jp

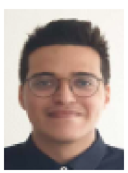
Postdoctoral Researcher/博士研究員

WANG Zhishang [profile]
ワン ジーシャン
- Ph.D. in Computer Engineering, UoA, 3/2023
- M.Sc. in computer sci., Univ. of Freiburg, Germany
- BSc in computer sci., Wuhan Univ., China

Doctoral Students/博士後期課 程

D3 LIANG Yuxiao
-M.Sc. in geotechnical Eng. from China Univ. of Mining and Technology, China
-BSc. in C ivil Eng. from Tianjin Univ., China
-Research: Secure Energy Trading in Vehicle-to-Grid Network

D4 WILLIAMS Yerima
-M.Sc. in computer sci., AUST, Nigeria
-BSc. in telecoms control and computer, Ahmadu Bello Univ. Zaria, Nigeria
-Research: NASH: 3D Digital Spiking Neuromorphic System



D2 MAATAR Mohamed (Md)
-M.Sc. in data science & big data, CY CERGY Paris Univ., France
-BSc. in computer science, ESPRIT School of Engineering , Tunisia
-Research: NASH: 3D Digital Spiking Neuromorphic System

Master's Students/博士前期課 程

M1 Aung Myint Myat

-BSc. in Business Information Technology, University of Greenwich, Myanmar, 2019

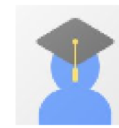
Research: AIzuHand-II

M1 NGUYEN Ngo Doanh

-BSc. in electronics and telecommunications, Vietnam National University, Hanoi, Vietnam

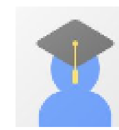
-Research: Spiking Neural Networks with Stacking Memory

Bachelor Students/学士課程の 学生



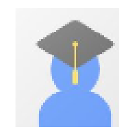
B4 OKOCHI Kengo

-BSc. in computer Science, UoA, (in progress)
-Research



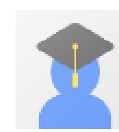
B3 KOMEDA Takeshi

-BSc. in computer Science, UoA, (in progress)
-Research



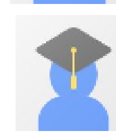
B3 KOBAYASHI Ryoji

-BSc. in computer Science, UoA, (in progress)
-Research: TBC



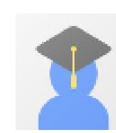
B3 HANYU Yuga

-BSc. in computer Science, UoA, (in progress)
-Research: TBC



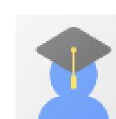
B4 MIYAZAWA Haruki

-BSc. in computer Science, UoA, (in progress)
-Research



B3 KANEKO Kaisei

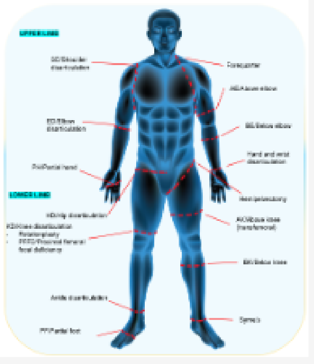
-BSc. in computer Science, UoA, (in progress)
-Research



B3 SHIOTA Rui

-BSc. in computer Science, UoA, (in progress)
-Research: TBC

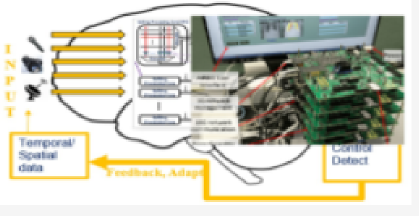
Research Areas
研究分野



Restoring grasping and movement for people with amputations and neurological impairment is imperative for retrieving independence of amputees. Prosthetic limbs, which are becoming widespread therapeutic solutions, can significantly restore grasping and improve the quality of life of people with amputations or neurological disabilities. However, unlike living agents that combine different sensory inputs to perform a complex task accurately, most prostheses use uni-sensory input, offer limited degrees of freedom and need long patient training.
Sensors enabling environmental perception and efficient control algorithms are needed since they strengthen the system's reliability while reducing the cognitive burden for the amputees.

We study limb prostheses and anthropomorphic robotics based on non-invasive innovative neural interfaces and advanced low-power neuromorphic SoC control for real-time communication and processing.
Currently, we develop adaptive neuromorphic multi-degree-of-freedom prosthesis limbs with tactile feedback to restore grasping and sensation for persons with amputation or neurological impairments. We use non-invasive technologies directly interfacing the environment with the residual arm or legs.

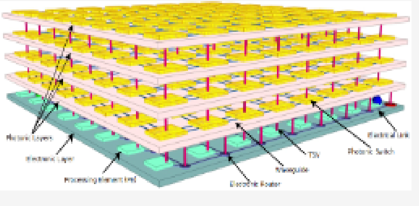
Ultra Low-power Neuromorphic Systems and AI-Accelerators



Neuromorphic computing uses spiking neuron network models to solve machine learning problems in a more power/energy-efficient way when compared to the conventional artificial neural networks.

We research adaptive low-power spiking neuromorphic systems and SoCs empowered with our earlier developed fault-tolerant three-dimensional on-chip interconnect technology.
In particular, we investigate adaptive configuration methods to enable the reconfiguration of different network parameters (spike weights, routing, hidden layers, topology, etc.), fault-tolerant and thermal-aware mapping methods, and on-line learning algorithms.
Applications of our research range from anthropomorphic robotics to medical and energy management.

Fault-tolerant Interconnect Technologies for SoCs (2D, 3D, Si-Photonics, Hybrid)



Complex signal processing systems-on-chip contain dozens of components made of processor cores, DSPs, memory, accelerators, and I/Os, all integrated into a single die area of just a few square millimeters. Such complex systems need a novel on-chip interconnect closer to a sophisticated network than current bus-based solutions. This network must provide high throughput and low latency while keeping area and power consumption low.

We investigate and develop advanced interconnect technology for embedded multicore SoCs targeting both FPGA and ASIC platforms. In particular, we investigate 3D-TVS integration, fault tolerance methods, photonic communication protocols, low-power mapping techniques, and low-latency adaptive routing.

A1

Low-power Neuromorphic SoC
低消費電力ニューロモーフィック SoC

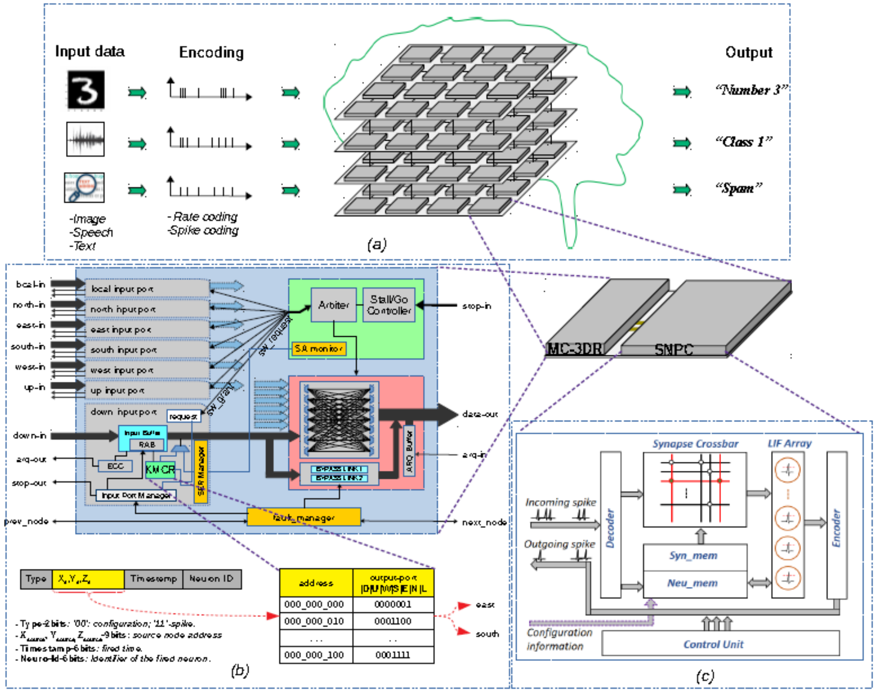
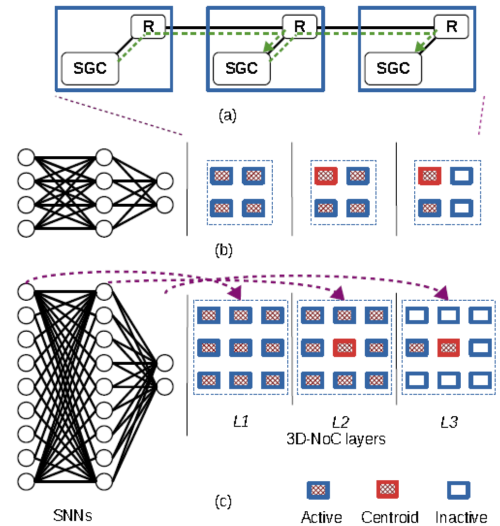
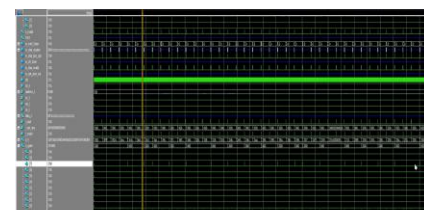
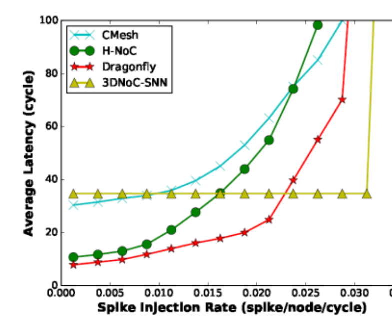
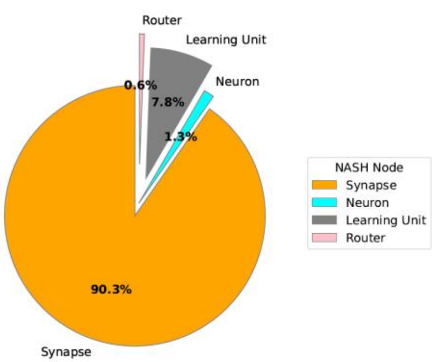


Fig. 5: System architecture: (a) 3DNoC-SNN organization, (b) Multicast router architecture (MC-3DR), (c) Spiking neuron processing core (SNPC).

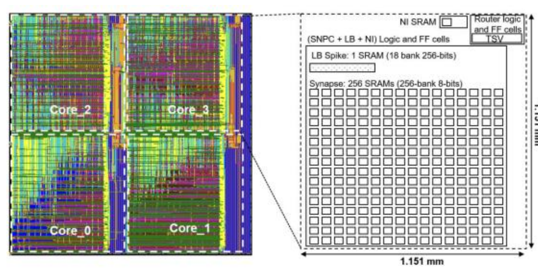








Area analysis of a NASH node



Parameter/System	XY-UB	XYZ-UB	SP-KMCR		FTSP-KMCR	
Architecture	Baseline	NASH	Baseline	NASH	Baseline	NASH
Area (mm^2)	1.312	1.316	1.322	1.322	1.320	1.325
Power (mW)	66.16	66.63	66.50	66.84	68.22	70.10

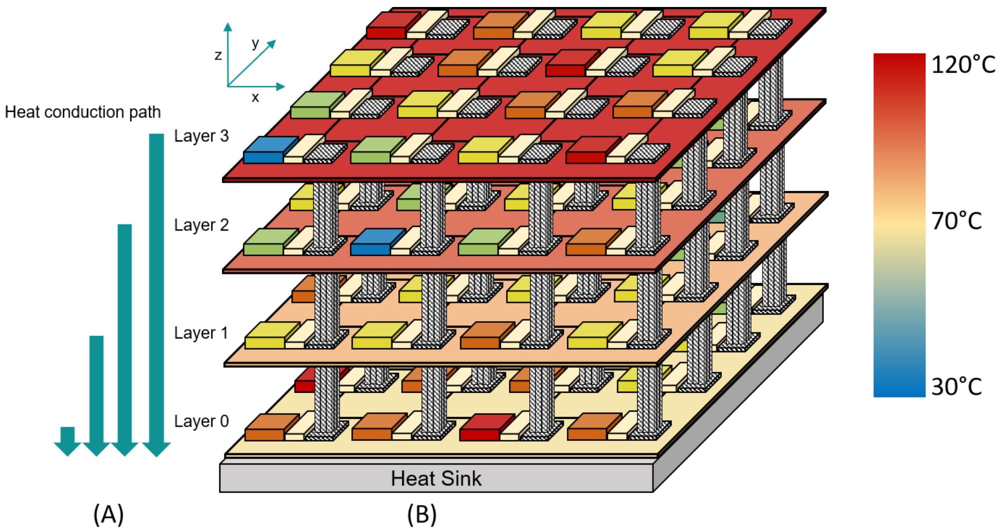
Design complexity comparison of NASH and Baseline nodes

Evaluation Result, Average latency evaluation, and comparison over various SIRs.

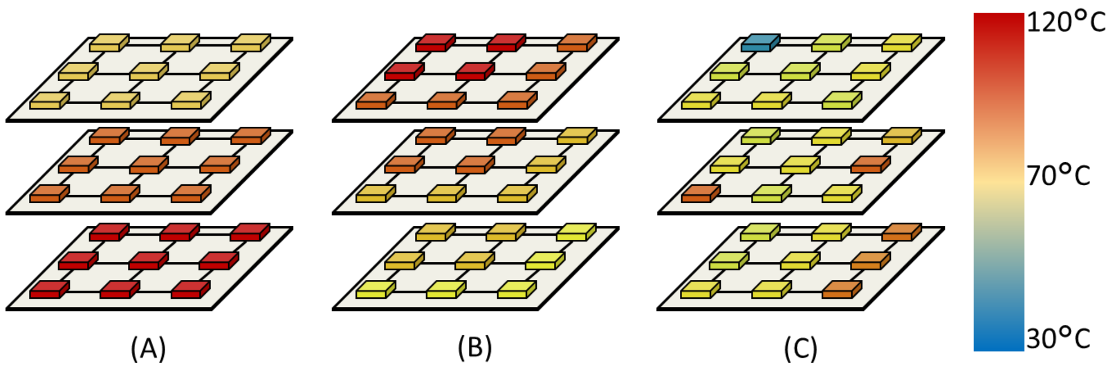
O. M. Ikechukwu, K. N. Dang and A. Ben Abdallah, "On the Design of a Fault-Tolerant Scalable Three Dimensional NoC-Based Digital Neuromorphic System With On-Chip Learning," IEEE Access, vol. 9, pp. 64331-64345, 2021, doi: 10.1109/ACCESS.2021.3071089

A1

Thermal-Aware Mapping Method for 3D-NoC Neuromorphic System



(A) shows the difference in the Heat conduction path to the heat sink between the layers. (B) Represents an illustration of the temperature in each layer and neurons cluster



Different temperature scenarios, (A) Hot layer.(B) Hotspot in one layer.(C) Moderated temperature

A1

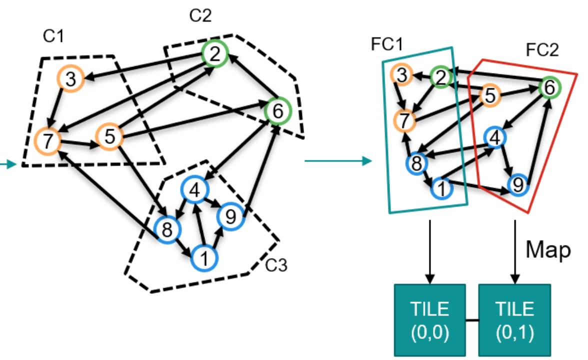
Thermal-Aware Mapping Method for 3D-NoC Neuromorphic System

N	T1	T2	T3	T4	T5
1	0	0	1	0	1
2	0	1	0	0	1
3	1	0	0	1	0
4	1	0	1	0	0
5	1	0	1	1	0
6	0	0	0	0	1
7	1	1	0	1	0
8	0	0	1	0	1
9	1	0	1	0	1

(a)

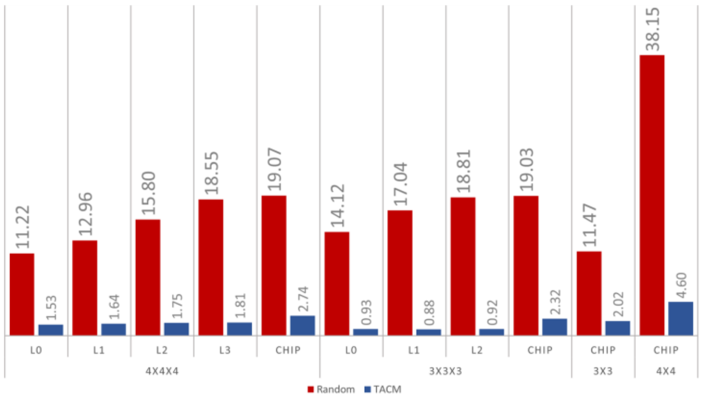
C1	C2	C3
4	1	1
4	1	3
0	3	2
2	3	1
1	4	2
3	0	3
1	4	4
4	1	1
3	2	0

(b)

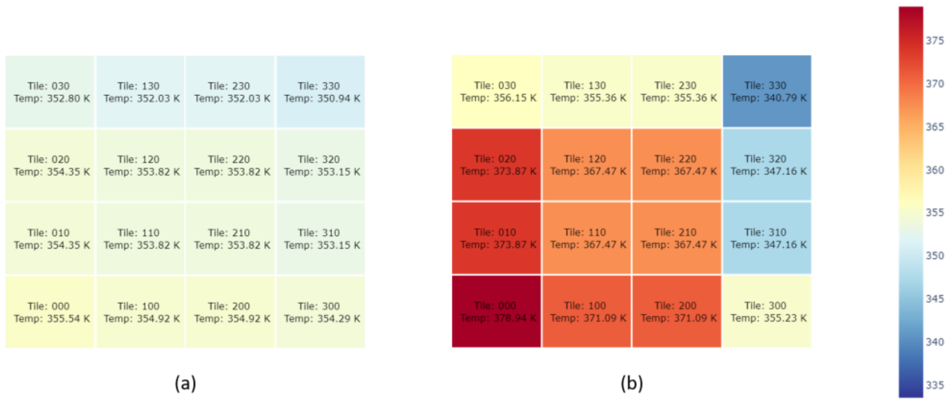


(c) (d)

ustration of an example of the TACM method. a represents a sample of neuron activity. (b) is the difference between the neurons activities and the centroids. (c) is the resulting clusters from (b). (d) represents the re-clustering to the final clusters and map them to the tiles



Maximum and minimum temperature difference for the different architectures between the tiles within the layers and the whole chip for the lowest maximum temperature case



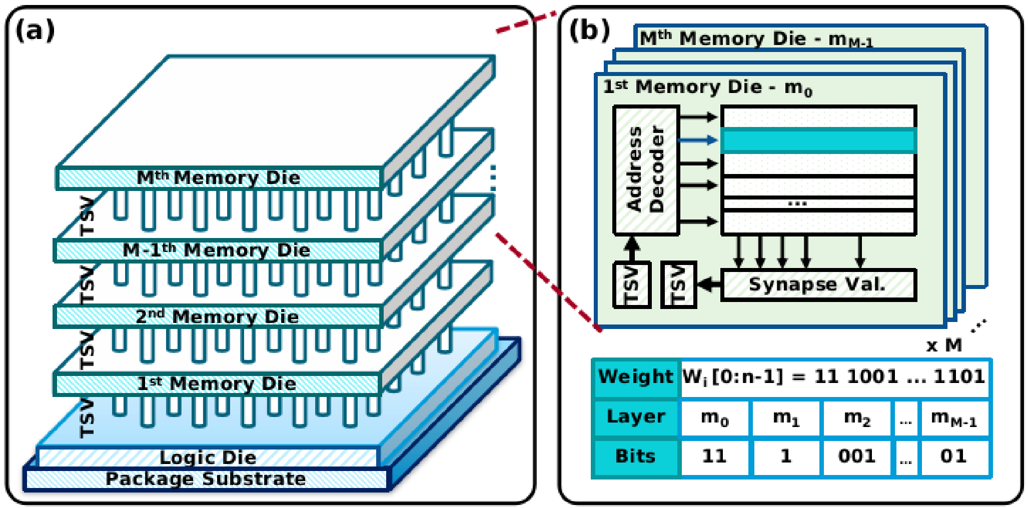
Highest maximum temperature of the 4x4 2D-NoC chip for the two different mappings: (a) is from TACM method. (b) is from a random mapping method

References:

[1] M. Maatar, K. N. Dang, and A. B. Abdallah, “Thermal-aware task- mapping method for 3d-noc-based neuromorphic systems,” in 2023 6th International Conference on Electronics Technology (ICET), 2023, pp. 1067–1076

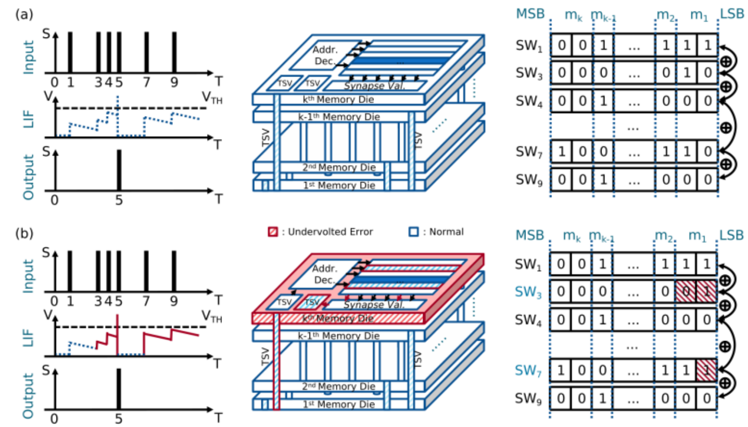
A3 3-D IC-based Stacking Synaptic Memory for Spiking Neural Networks | スパイキング・ニューラル・ネットワークのための3次元ICベースのスタッキング・シナプティック・メモリー

The idea is to distinguish the critical levels of synaptic weights and then isolate them using stacking layers of 3-D architectures. Hence, applying the low-power techniques for low-important bits to gain power efficiency.



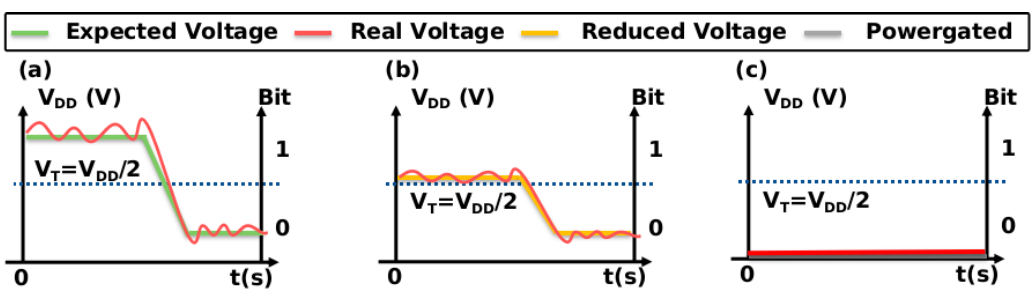
(a) 3D Architecture. (b) Bit Placement.

(a) 3次元構造。 (b) ビット配置。



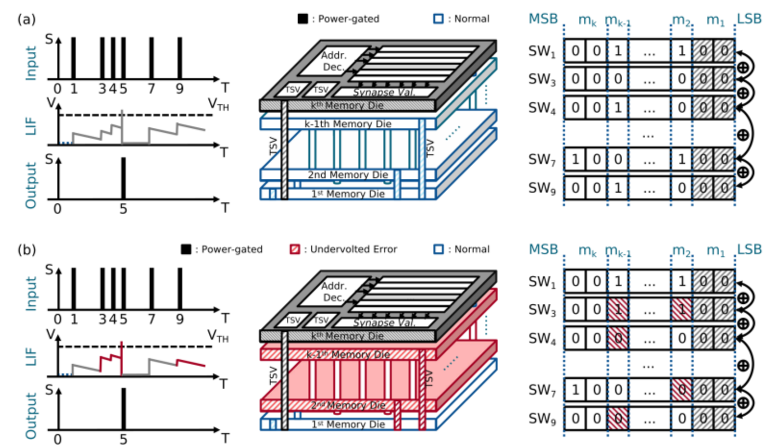
(a) Normal operation. (b) RV synaptic operation.

(a) 通常動作。 (b) RV動作。



(a) Normal operation. (b) RV operation. (c) PG operation.

(a) 通常動作。 (b) RV動作 (c) PG動作。

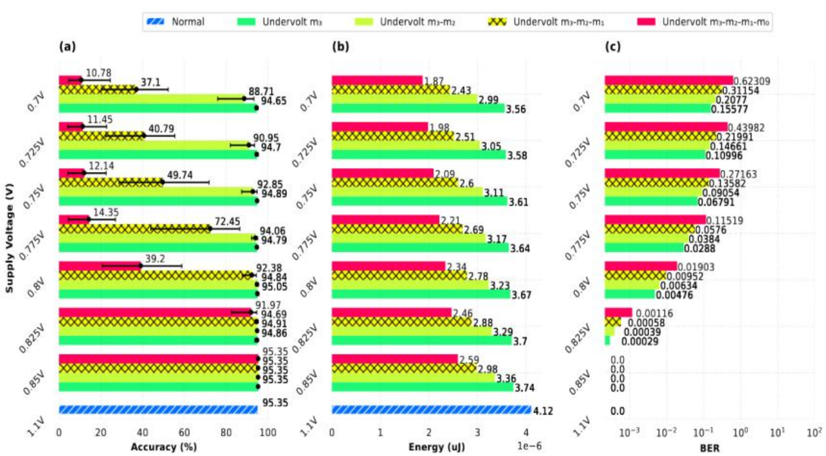


(a) PG operation. (b) PG & RV synaptic operation.

(a) PG動作。(b) PG & RV動作。

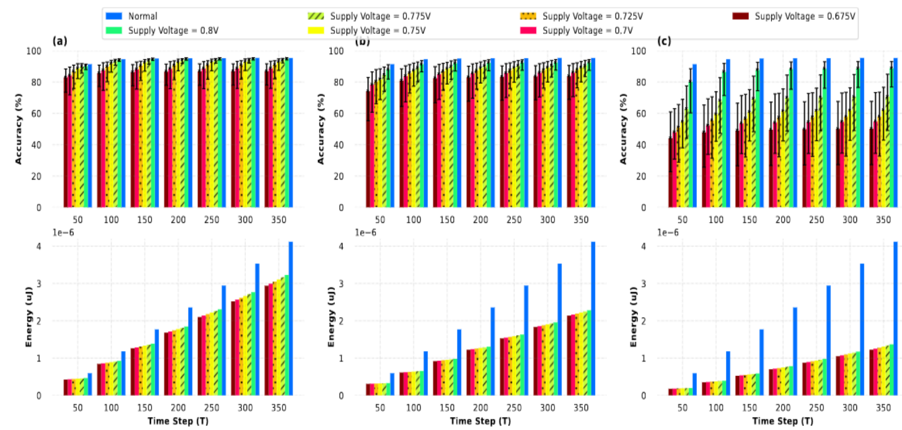
A3 3-D IC-based Stacking Synaptic Memory for Spiking Neural Networks | スパイキング・ニューラル・ネットワークのための3次元ICベースのスタッキング・シナプティック・メモリー

MNIST dataset - Three perception layers of SNN [784 48 10]
・MNIST データセット ・SNN の 3 つの認識層 [784 48 10]



(a) Accuracy. (b) Energy consumption. (c) Bit-Error-Rate.

(a) 精度。 (b) 消費エネルギー。 (c) ビットエラー率。



Accuracy vs Energy with RV & PG:
(a) RV 2 layers. (b) PG 1 layer & RV 2 layers.
(c) PG 2 layers & RV 2 layers.

精度 vs エネルギー ・ RV & PG:

(a) RV 2層。 (b) PG 1層 & RV 2層。
(c) PG 2層 & RV 2層。

References:

[1] N.-D. Nguyen and *et al.,* "Power-aware Neuromorphic Architecture with Partial Voltage Scaling 3D Stacking Synaptic Memory``, IEEE Transactions on Very Large Scale Integration (VLSI) Systems, doi: 10.1109/TVLSI.2023.3318231.

[2] N. -D. Nguyen and *et al.,* "An In-Situ Dynamic Quantization With 3D Stacking Synaptic Memory for Power-Aware Neuromorphic Architecture,`` in IEEE Access, vol. 11, pp. 82377-82389, 2023, doi: 10.1109/ACCESS.2023.3301560.

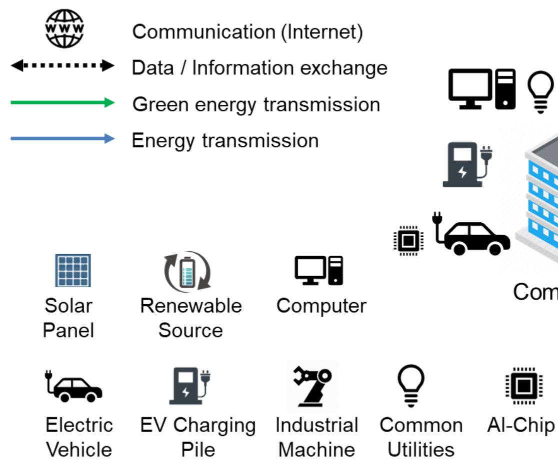
(a) PG動作。(b) PG & RV動作。

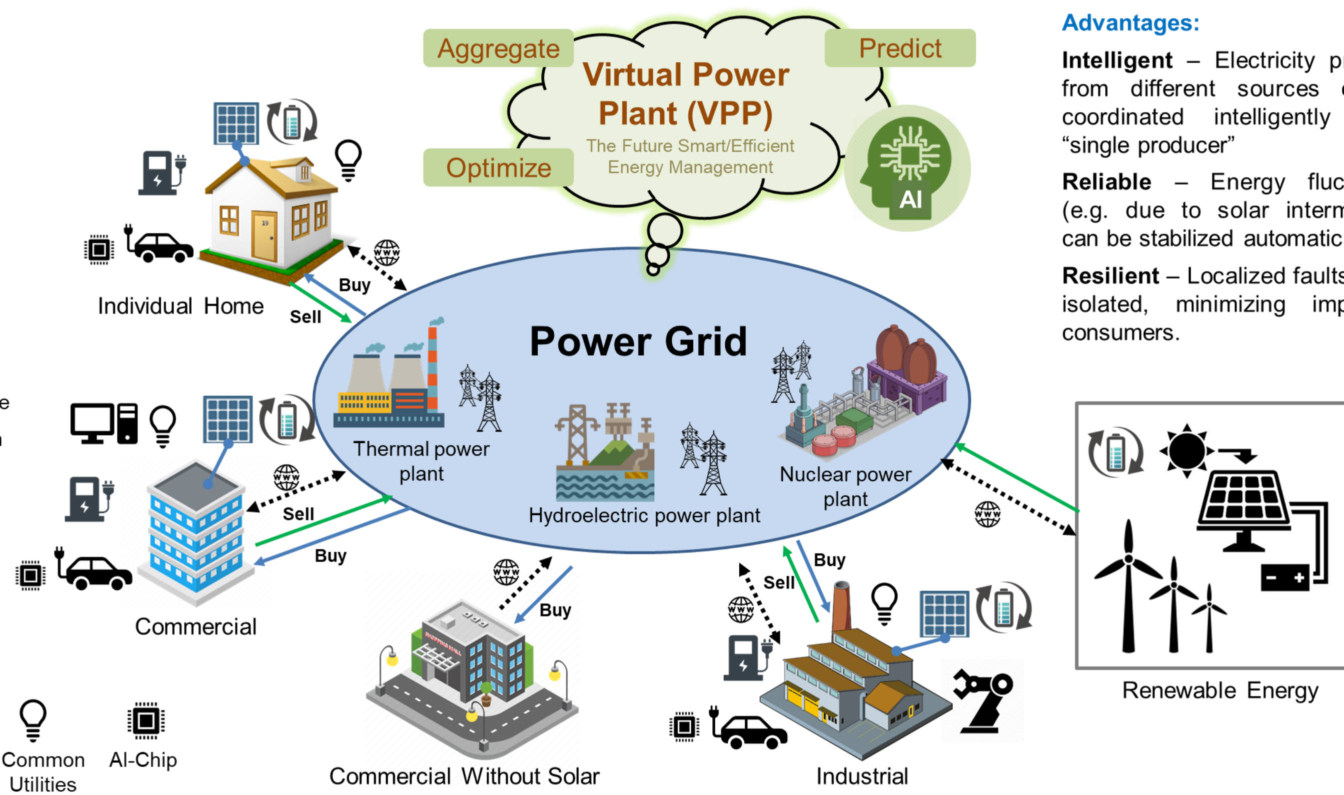
A4

Off-Grid Energy Storage Solar Carport
オフグリッドエネルギー貯蔵ソーラーカーポート

Optimized Energy Distribution for a Cleaner, Greener Energy Future

VPP is a digital platform that links decentralized energy resources across different locations in Japan and optimizes energy usage.





Advantages:

Intelligent – Electricity produced from different sources can be coordinated intelligently as a “single producer”

Reliable – Energy fluctuations (e.g. due to solar intermittency) can be stabilized automatically.

Resilient – Localized faults can be isolated, minimizing impact to consumers.

Z. Wang, M. Ogbodo, H. Huang, C. Qiu, M. Hisada, A. Ben Abdallah, "AEBIS: AI-Enabled Blockchain-based Electric Vehicle Integration System for Power Management in Smart Grid Platform," IEEE Access, vol. 8, pp. 226409-226421, 2020, doi:10.1109/ACCESS.2020.3044612.

Off-Grid Energy Storage Solar Carport
オフグリッドエネルギー貯蔵ソーラーカーポート

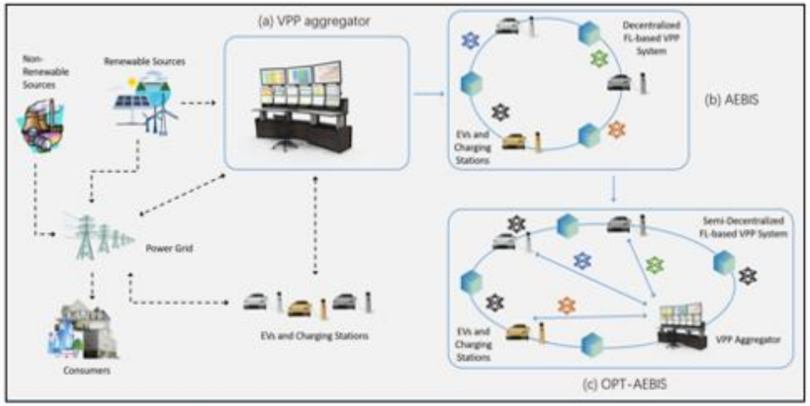


Fig. 1. Virtual Power Plant (VPP): (a) conventional VPP aggregator, (b) AEBIS, (c) optimized AEBIS (O-AEBIS).

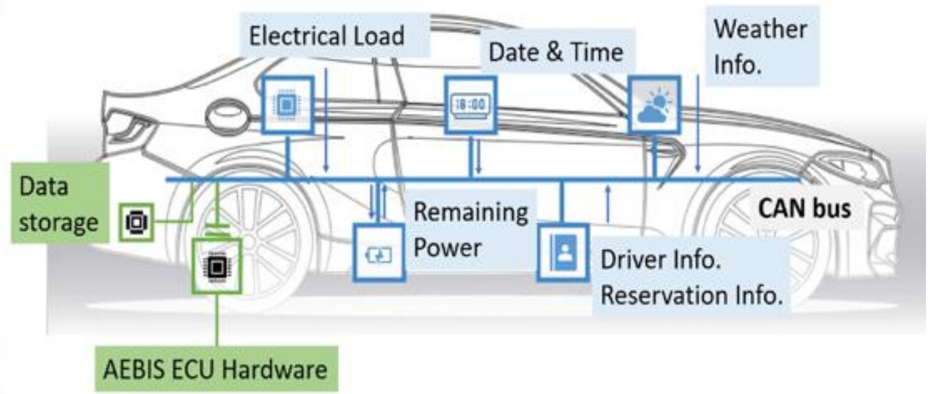
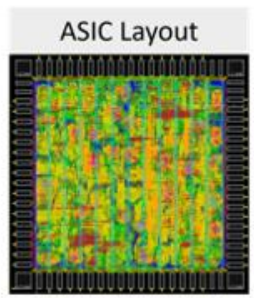


Fig. 2. Neural Network for Power Consumption Prediction of Electric Vehicle (EV).



Area	0.265 mm²
Voltage	1.1 V
Power	318.224 mw
Temperature	25℃

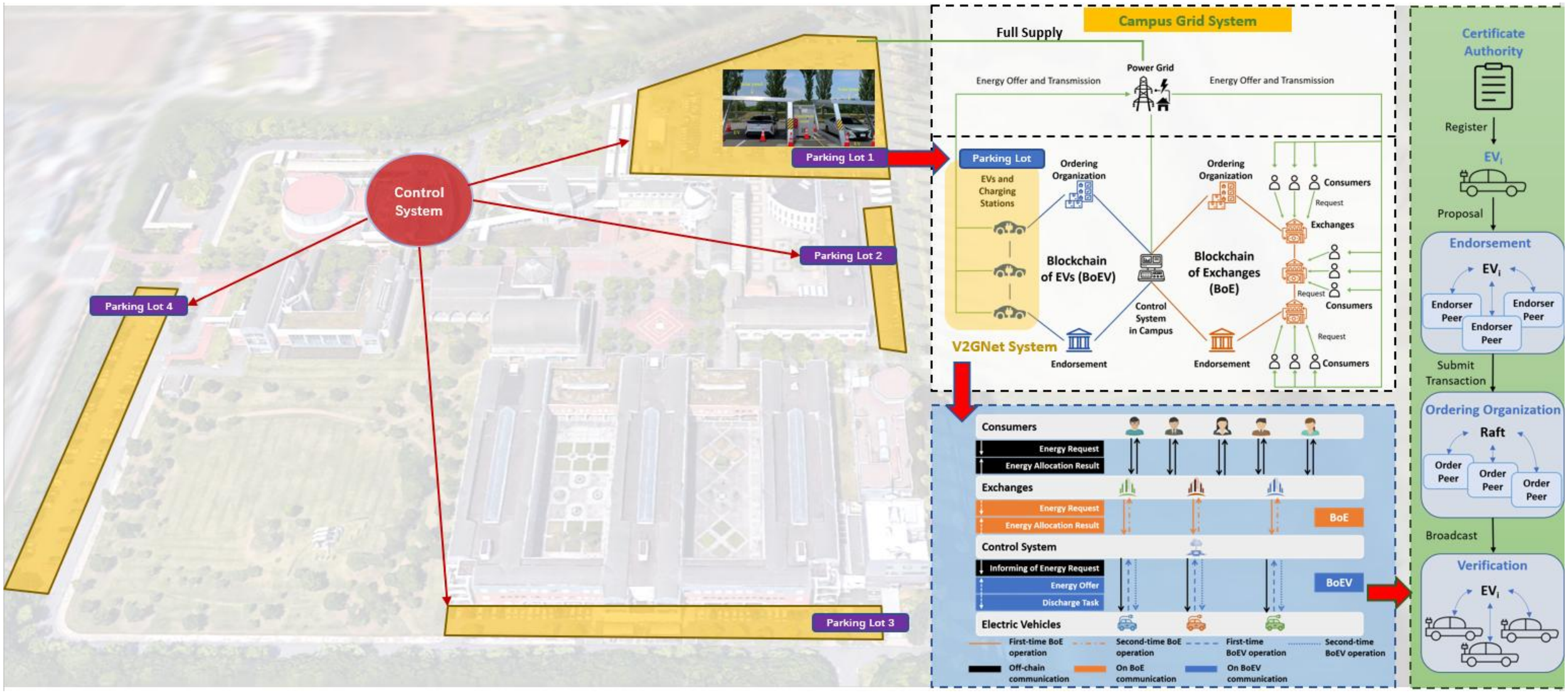
Fig. 5. A demonstration of the energy management system based on our system named AEBIS and its optimized version O-AEBIS.

Name	BRAM_18K	DSP48E	FF	LUT
Expression	-	-	0	493
Instance	-	5	414	950
Memory	2	-	320	20
Multiplexer	-	-	-	627
Register	-	-	454	-
Total	2	5	1188	2090
Available	120	80	35200	17600
Utilization (%)	1	6	3	11
Weights	**Memory required**			
Weights	568 Bytes			
Biases	60 Bytes			
Inputs	44 Bytes			
Total	672 Bytes			

Fig. 6. Hardware complexity of power consumption prediction system on the Zynq-7010 FPGA. The system utilized 3% of the FF, 11% of the LUT, 6% of the DSP48, and approximately 1% 18k BRAM.

A4

Off-Grid Energy Storage Solar Carport
オフグリッドエネルギー貯蔵ソーラーカーポート



[特許第6804072号] (2020.12.04) ベンアブダラ　ア ブデラゼク (Abderazek Ben Abdallah), 久田雅之, "Virtual Power Platform Control System [仮想発電所制御システム]", 特願2020-033678号 (2020.02.28)

ネルギーの取引方法とシステム/Energy Trading Method and System
Abderazek Ben Abdallah, Wang Zhishang, Masayuki Hisada, ‘’An electricity trading system and an electricity trading method [電力取引システム及び電力取引方法に関する], 特願2022-022472 Power Consumption Prediction Method and System for Power Management in Smart Grid/ スマートグリッドにおける電力管理のためのEV消 費電力予測 方法とシステム

Abderazek Ben Abdallah,Wang Zhishang, Khanh N. Dang, Masayuki Hisada, "EV Power Consumption Prediction Method and System for Power Management in Smart Grid [スマートグリッドにおける電力管理のためのEV消 費電力予測 方法とシステム]", 特願2022-022472

A5 AI-Powered Hardware-Software Platform for Pneumonia Detection/ 肺炎検出のための AI を活用したハードウェアとソフトウェアのプラットフォーム

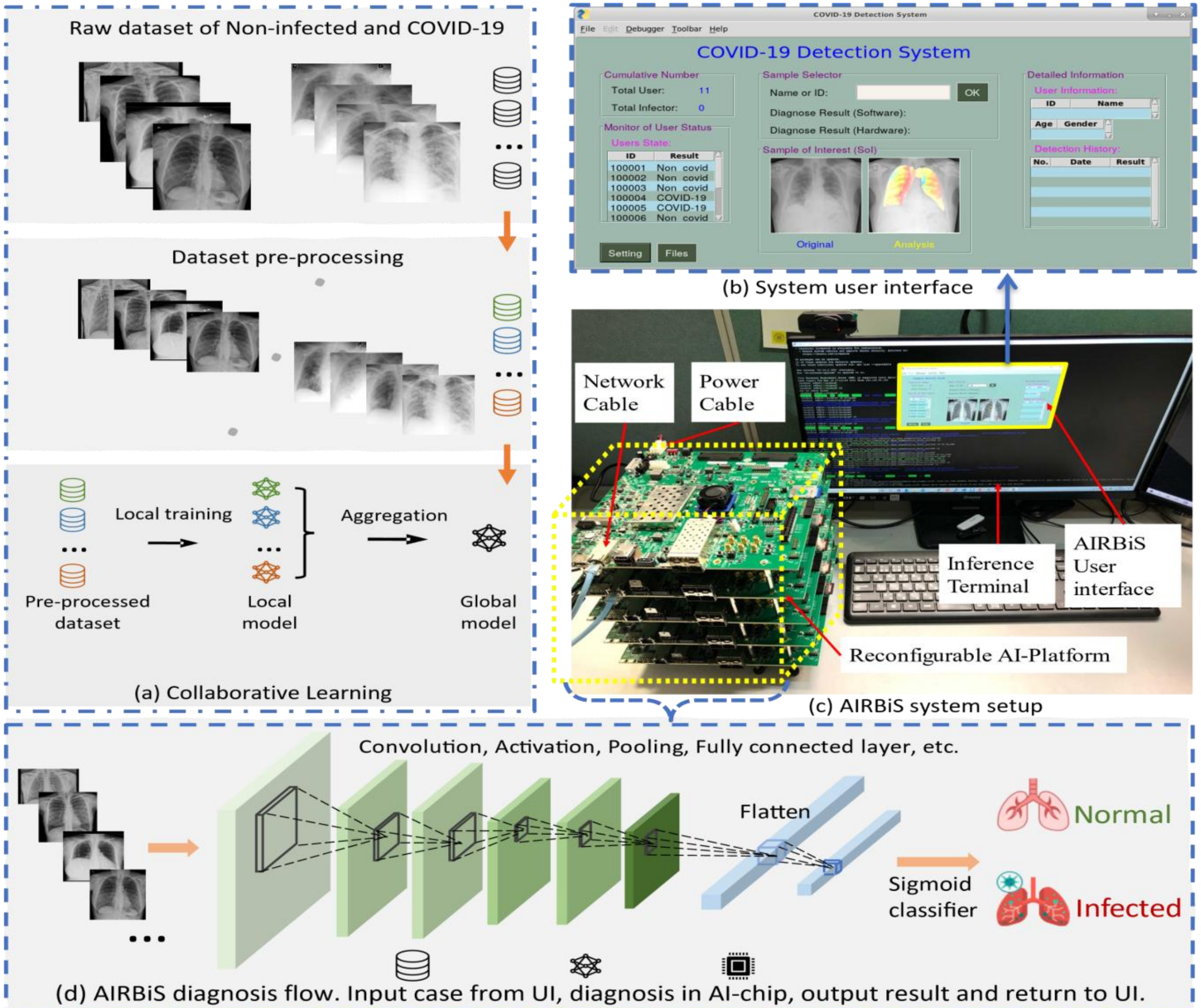


Table 7.3. FPGA Resource Utilization Estimates.

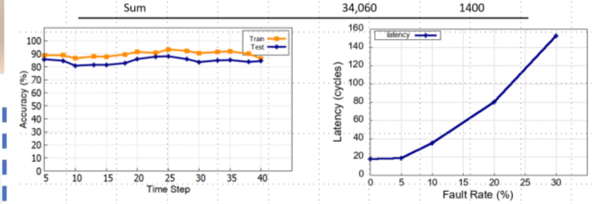
Resource	Utilization		Available	Utilization (%)	
	ANN	SNN		ANN	SNN
LUT	54,585	27,288	274,080	19.9	9.9
LUTRAM	3668	2048	144,000	2.5	1.28
FF	53,035	37,098	548,160	9.7	6.77
BRAM	824	0	912	90.4	0
DSP	35	0	2520	1.4	0
BUFG	4	18	404	1.0	4.45
MMCM	1	0	4	25	0

Table 7.4. Hardware Complexity.

Core/Parameter	Area (mm²)		Power (mW)	
	SNN	ANN	SNN	ANN
Convolution core	0.0748	0.0755	0.007	0.011

Table 7.2. Dataset description.

Label	Class	Train	Test
COVID	COVID	2870	700
	COVID(Augmented)	14,349	-
Non-COVID	Normal	9791	400
	Lung_Opacity	5762	250
	Viral_Pneumonia	1288	50
Sum		34,060	1400

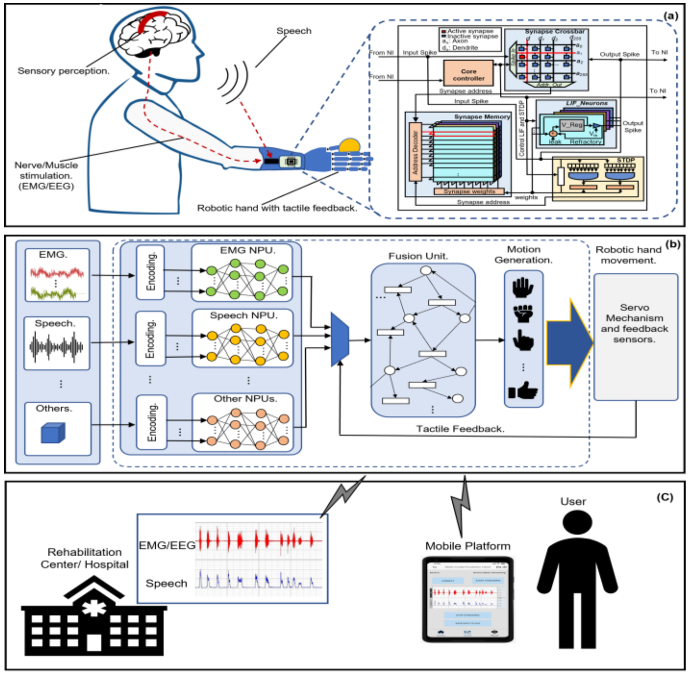


(a) Detection accuracy over various time-steps (b) Detection Latency over various fault-rate

Figure 7.6. Accuracy and fault-rate evaluation result

A6

Neuromorphic Robot Arm and Prostheses
ニューロモーフィック ロボット アームと義足



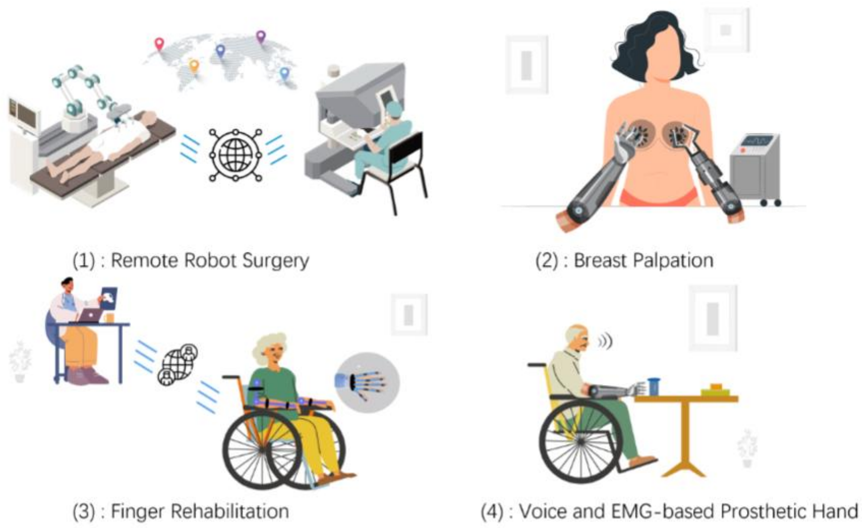


FIGURE 4. The Neuromorphic AIzuHand target applications. (1) Remote Robot Surgery, (2) Breast Palpation, (3) Finger Rehabilitation, (4) Voice and EMG-based Prosthetic Hand.

Abderazek Ben Abdallah, Huankun Huang, Nam Khanh Dang, Jiangning Song, “AIプ ロセッサ [AI Processor]," *特願2020-194733 (2020 年11 月24 日)*

AIzuHand I, July 2022

- Device Name: AIzuHand I
- Total Weight: 422g (276g without controller)
- Control: sEMG
- DoF: 5
- Feedback: No
- Related patent: 特 願2019-124541
- Contact "benab(at)u-aizu.ac.jp"

https://www.u-aizu.ac.jp/misc/neuro-eng/aizuhand.html

AlzuHand for Autonomous Painting

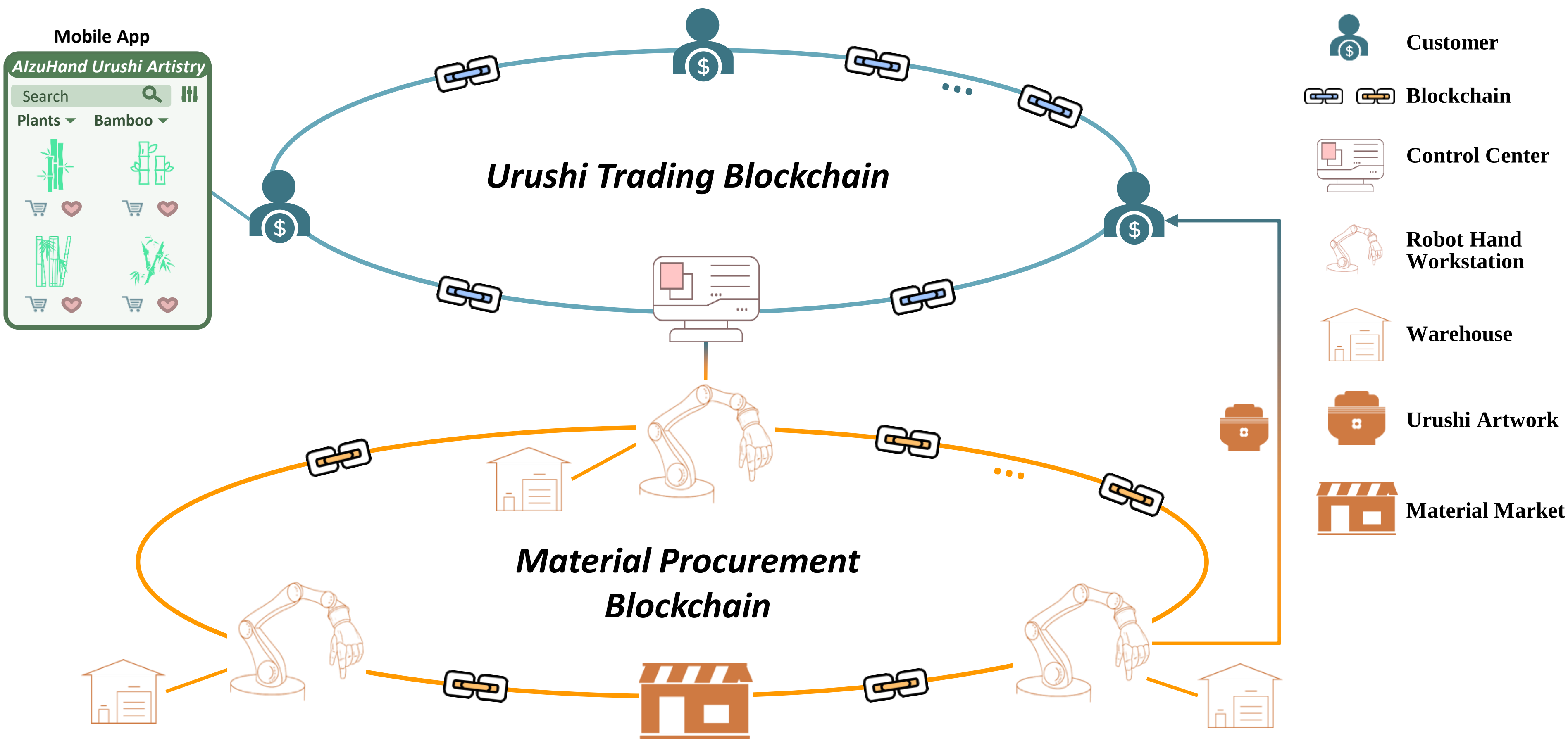


Fig. 1: Overview of The Autonomous Robot Hand Painting Platform and System.

天気図を用いた発電量予測AIモデル

AI model for predicting power generation amount using weather maps