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Bridging Human and Machine Cognition: Advances in Brain-Machine Interface and Reverse Engineering the Brain

Yudan Whulanza[1]*, Eny Kusrini[2,3,4], Arun Kumar Sangaiah[5], Heri Hermansyah[2], Muhamad Sahlan[2], Muhamad Asvial[6], Ruki Harwahyu[6], Ismi Rosyiana Fitri[6]

[1]*Department of Mechanical Engineering, Faculty of Engineering, Universitas Indonesia, Kampus Baru UI, Depok 16424, Indonesia*
[2]*Department of Chemical Engineering, Faculty of Engineering, Universitas Indonesia, Kampus Baru UI, Depok 16424, Indonesia*
[3]*Research Group of Green Product and Fine Chemical Engineering, Laboratory of Chemical Product Engineering, Department of Chemical Engineering, Universitas Indonesia, Kampus Baru UI, Depok, 16424, Indonesia*
[4]*Tropical Renewable Energy Research Center, Faculty of Engineering, Universitas Indonesia, Kampus Baru UI, Depok, 16424, Indonesia*
[5]*National Yunlin University of Science and Technology International Graduate Institute of Articial Intelligence No. 123, Section 3, Daxue Rd, Douliu City, Yunlin Country, 64002, Taiwan (ROC)*
[6]*Department of Electrical Engineering, Universitas Indonesia, Kampus Baru UI, Depok 16424, Indonesia*

The convergence of neuroscience, biotechnology, and artificial intelligence (AI) is revolutionizing our comprehension of the brain and our interactions with computers. Central to this revolution are two fundamental principles: brain-machine interfaces (BMIs) and the reverse engineering of the brain. Furthermore, these technologies have the potential to not only revolutionize healthcare and human-machine interaction but also to drive significant advancements in artificial intelligence, education, and personalized therapies for neurological disorders.

Understanding Brain-Machine Interfaces

Brain-machine interfaces (BMIs) are a revolutionary technology that facilitates direct interaction between the human brain and external technological equipment. Although the notion originated from the bioelectric phenomena found in the 1930s, contemporary BMIs leverage state-of-the-art developments in electrode arrays, signal processing, and AI-driven algorithms (Liu *et al.,* 2024). Organizations such as Neuralink are currently spearheading initiatives to develop devices that enable smooth communication between the brain and machines, with the goal of enhancing human cognitive and motor capacities (Musk, 2019).

BMIs have diverse applications such as (i) the neurorehabilitation for sensory-motor impairments, (ii) exoskeleton control, and (iii) cognitive state acceleration (Chen *et al.,* 2023; Hramov, Maksimenko, and Pisarchik, 2021). The passive BMIs are increasingly recognized as effective tools for examining emotional and cognitive conditions without the need for explicit instructional input (Niso *et al.,* 2023). In addition, these breakthroughs are offering the potential to broaden the capabilities and availability of BMIs in areas like healthcare,

*Corresponding author's email: yudan.whulanza@ui.ac.id, Tel.: +62-217270032; Fax.: +62-217270033
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robotics, and personal performance improvement.

Significant technological achievements in the development of BMI have played a vital role in influencing this advancement. For example, the implementation of Michigan array electrodes in the 1970s enabled scientists to accurately observe brain activity (Jarosiewicz and Morrell, 2021). Recent innovations, including microfluidic channels, bioelectronic interfaces, and three-dimensional (3D) probes, have improved the precision and security of BMI diagnostic equipment. Significant accomplishments include the development of 1,000-channel platforms for brain recording in 2019 and advancements in reliable electrophoretic recording modalities (Musk, 2019).

Reverse Engineering the Brain: A Complex Challenge

Reverse engineering the brain is a multidisciplinary undertaking that integrates neuroscience, engineering, and technology domains. This effort aims to decipher the complex biochemical and electrical pathways of the brain, therefore offering an understanding of its working mechanisms in both normal and pathological conditions. A collaborative effort between engineers and neuroscientists is undertaken to create sophisticated technology capable of observing and quantifying the electrical and anatomical activity of the brain. These technologies facilitate the analysis of brain activity at unparalleled levels of sophistication, therefore revealing novel prospects for intervention in disorders such as Alzheimer's and Parkinson's (Paulk *et al.,* 2022).

Elucidating the intricate operations of the brain has extensive consequences for the fields of medicine, education, and computing (Breier *et al.,* 2022). Through the identification of impaired electrical circuits in Alzheimer's disease, scientists have the opportunity to create pharmaceuticals that specifically target brain signals, so potentially enhancing the efficacy of clinical interventions. Furthermore, the ramifications of reverse engineering the brain also encompass the domain of individualized learning (Dehais, Karwowski, and Ayaz, 2020). Understanding the cognitive processes of the brain would enable educators to tailor learning approaches to meet the specific needs of students, thereby improving results for individuals with diverse learning preferences.

Artificial Intelligence and Cognitive Computing

Reverse engineering the brain provides valuable knowledge that has the capacity to transform artificial intelligence and computing capabilities. Emulating the neural networks of the brain has the potential to facilitate the advancement of artificial intelligence systems that exhibit enhanced flexibility, adaptability, and problem-solving capacities. By emulating human cognition, these systems can potentially enhance AI's intuitiveness, capability, and efficiency.

The practical implications of this knowledge span several sectors, such as robots, healthcare, and communication. Artificial intelligence (AI) systems that emulate the human brain have the ability to analyze and adjust to input in real-time, similar to the human mind. This characteristic renders them valuable for intricate and changeable jobs. The convergence of brain-inspired artificial intelligence (AI) and brain machine interface (BMI) technologies has the potential to ultimately result in smoother interactions between humans and computers, hence further eroding the distinction between biological cognition and machine intelligence.

Ethical and Societal Implications

Although the technological progress in BMI and reverse engineering of the brain is certainly thrilling, it also gives rise to ethical concerns around privacy, autonomy, and the possibility of exploitation. The growing sophistication of BMIs raises significant ethical concerns about the potential to monitor, influence, and even manipulate brain function. The careful development and responsible deployment of these technologies will be crucial in order to optimize their societal advantages.

The notion of technological singularity, popularised by futurists such as Ray Kurzweil, posits that while these continuous developments persist, artificial intelligence may surpass human intelligence (Kurzweil, 2005). This phenomenon prompts significant inquiries regarding the prospective developments in human-machine interactions and the attendant societal shifts that may emerge as a result of this reconfiguration. Within this framework, the advancement of BMI and the process of reverse-engineering the brain are significant technological achievements and ethical dilemmas that need to be thoughtfully addressed.

Conclusion

The intersection of brain-machine interfaces and the reverse engineering of the brain marks a pivotal moment in the advancement of neuroscience and bioengineering. The aforementioned technologies possess significant promise for transformation in the fields of healthcare, artificial intelligence, and personalized education. Nevertheless, as we continue to push the boundaries of human-machine interaction, it is essential to actively consider the ethical and societal implications of these advancements

As researchers persist in investigating the enigmas of the brain and formulating increasingly advanced BMI, the capacity to augment human cognition and motor function will expand. This expedition symbolizes not just an advancement in scientific knowledge but also a significant chance to influence the future of interactions between humans and machines for the overall benefit of mankind.

This issue

This volume documents the investigation of human well-being, energy-environment partnerships, and industrial practices. Additionally, it includes studies on a proof of concept involving the maritime and manufacturing industries.

The first paper is written by Pragiwaksana, A., Irsyad, M., Nadhif, M.H., Muradi, A., Jasirwan, C.O.M., Juniantito, V., Syaiful, R.A., and Antarianto, R.D., the paper presents the development of a perfusion bioreactor integrated with the SHINTA system to maintain hepatocytes derived from human iPSCs. The bioreactor demonstrated improved cell viability, distribution, and maturation compared to other methods. Histological and immunofluorescence analyses confirmed enhanced hepatocyte differentiation and reduced extracellular matrix collagen. This research highlights the system's potential for liver tissue engineering and regenerative medicine.

The second paper is written by Kryuchkov, S., Smorodin, K., Stepakova, A., Atlaskin, A., Tsivkovsky, N., Atlaskina, M., Tolmacheva, M., Kazarina, O., Petukhov, A., Vorotyntsev, A., and Vorotyntsev, I., the paper examines the gas transport characteristics of polymeric hollow-fiber membranes used for air separation. The study compares permeance values for pure gases and gas mixtures, highlighting significant discrepancies in membrane performance predictions based on ideal vs. mixed permeances. The research shows that relying on ideal permeances can lead to substantial errors in designing membrane units, impacting both technical and economic outcomes in industrial applications. The study

emphasizes the need for accurate modeling to minimize costs and optimize membrane-based gas separation processes.

The third paper, authored by Ali, F., Lestari, D.W., Putri, M.D., and Azmi, K.N., analyzes strategies for addressing clean water needs in a metropolitan city during the COVID-19 pandemic, with a specific focus on piped-water services provided by the Regional Drinking Water Company. The study finds that water consumption increased by 5% during the pandemic, putting pressure on the company's capacity, which was already insufficient to meet the 35% service coverage target. To address this, the study recommends increasing production capacity by 2.13 times, reducing water loss, and improving infrastructure to ensure a consistent water supply. These measures align with the goals of Indonesia's National Medium-Term Development Plan 2020–2024.

The fourth paper is written by Salma, S.A., Widyanti, A., Muslim, K., Wijayanto, T., Trapsilawati, F., Arini, H.M., and Wibawa, A.D., the paper investigates the intention to use mobile health (mHealth) in Indonesia during the COVID-19 pandemic, focusing on the roles of perceived usefulness, perceived ease of use, and perceived health risk. The study found that perceived usefulness influenced non-users more, while perceived ease of use was more significant for current users. Trust, however, did not significantly affect the intention to use mHealth. The findings highlight the importance of addressing these factors to enhance mHealth adoption in Indonesia, particularly for promoting public health and managing pandemics.

The fifth paper is written Yeligbayeva, G., Moldabayeva, G.Z., Azzam, K.M.A., Bekbayeva, L., Negim, E-.S., Shalash, M., and Usman, A., the paper focuses on the synthesis and characterization of anticorrosion polyurethane coatings, particularly examining the effect of varying bisphenol F content. The study found that polyurethane coatings with 11.5% bisphenol F exhibited the best mechanical properties, including tensile strength, hardness, and adhesion, as well as excellent chemical and corrosion resistance. These properties make the coating highly suitable for protecting metal surfaces, offering a balance of durability and protection against harsh environmental conditions.

The sixth paper is written by Putri, I.Z.D., Jiwanti, P.K., Supriyanto, G., Savitri, I.N.I., Kurnia, K.A., Setyaningsih, W., Yuliarto, B., and Darmawan, N., the paper reports the development of a highly sensitive electrochemical sensor for detecting aspartame in beverage samples using a glassy carbon electrode modified with a boron-doped nanodiamond/ZnO nanoparticles composite. The sensor demonstrated a low limit of detection (0.07 μM) and high sensitivity (1.23 μA μM-1) using square wave voltammetry. The study highlights the sensor's effectiveness in real beverage samples, showing high accuracy and precision, making it a promising tool for practical applications in aspartame detection.

The seventh paper is written by Shofinita, D., Bindar, Y., Samadhi, T.W., Jaelawijaya, A.A., Theodric, D., and Achmadi, A.B., this paper examines the effects of extraction and spray drying temperatures on the bioactive material content in red dragon fruit skin, focusing on its use as a natural food colorant. The study found that higher extraction temperatures (up to 50°C) significantly increased phenolic and betacyanin compounds, as well as antioxidant activity. For spray drying, if the inlet temperature is above 170°C, it can lead to a decrease in the recovery of bioactive material due to degradation. However, the addition of maltodextrin as a carrier agent can improve the yield of the powder. This research offers valuable insights into optimizing the production of natural food additives from dragon fruit skin.

The eighth paper is written by Siripath, N., Suranuntchai, S., and Sucharitpwatskul, S., this paper models dynamic recrystallization (DRX) kinetics in BS080M46 medium carbon

steel using experimental data and finite element simulation. The study developed DRX and grain size models based on the JMAK equation, which were integrated into QForm software. The simulations closely matched experimental results, confirming the models' accuracy in predicting DRX behavior and grain size during hot compression. This research aids in optimizing the hot working process for medium carbon steel.

The ninth paper is written by Suyanti, Pusporini, N.D., Adi, W.A., and Petrus, H.T.B.M., the paper investigates the extraction of cerium from cerium hydroxide concentrate using Tri Butyl Phosphate (TBP) as a solvent in kerosene. The study developed a liquid-liquid equilibrium model to predict the distribution of cerium in the extraction system, achieving a 70.01% extraction efficiency under optimal conditions. The model showed an average relative error of 8.53% when compared to experimental data, indicating its reliability for designing industrial-scale cerium extraction processes.

The tenth paper is written by Santoso, A.K., Sulistyo, D., Awaludin, A., Setiawan, A.F., Satyarno, I., Purnomo, S., and Harry, I., compares the seismic performance of simply supported prestressed concrete box girder bridges equipped with shear panel dampers (SPDG) and lead rubber bearings (LRB). The study found that both SPDG and LRB effectively increased structural flexibility and reduced seismic responses compared to conventional bridges with elastomeric bearings (ERB). Furthermore, SPDG demonstrates comparable performance to LRB, as it significantly reduces top pier displacement, base shear, and bending moments. This highlights SPDG's potential as a cost-effective alternative for implementing seismic isolation in bridges.

The eleventh paper is written by Annamdasu, M.L., Lingeshwaran, N., Challagulla, S.P., Ahmed, O.S., and Adamu, M., this paper investigates the dynamic interaction between primary and secondary structures during near- and far-field earthquakes, analyzing its impact on the Elastic Floor Response Spectra (FRS). The study uses a single-degree-of-freedom model for both structures and conducts time-history analyses to evaluate the effects of mass ratio, damping ratio, and tuning ratio on the FRS. The results show significant reductions in peak acceleration for coupled systems, with near-field excitations inducing higher seismic demands. The findings suggest revising Eurocode 8 to incorporate dynamic interaction effects.

The twelfth paper is written by Ayuningtyas, K.N.S., Kusumawati, A., Pangestika, S.H., and Hadiyanti I., explores the relationship between the iRAP Star Rating Score (SRS) and various crash parameters, including the number of crashes, fatalities, crash rate, and fatality rate, on Indonesian toll roads. The study found a positive correlation between higher SRS values and increased crash parameters, indicating more hazardous road segments. However, the R^2 values were relatively low, indicating that the observed relationship may not fully capture the complexities due to unique environmental and human factors in Indonesia that are not encompassed by the iRAP methodology.

The thirteenth paper is written by Heindri, N., Dewi, O.C., Putra, N., Flynn, A., Hanjani, T., and Rahmasari, K., this paper investigates the effectiveness of Vertical Greenery Systems (VGS) as microbial air quality filters for community houses located near a landfill site in Kampung Nambo, South Tangerang, Indonesia. The study found that Hedera helix was the most effective plant in filtering microbes from the air, improving air quality in densely populated areas. The research highlights VGS's potential to enhance air quality and reduce health risks in communities near landfill sites.

The fourteenth paper is written by Yamin, L.M.S., Zulkarnain, M., Darmawan, S., Ariyanti, S., Veza, I., and Bakri, M.B., this paper investigates reducing vehicle HVAC noise using low-cost, biodegradable coconut fiber materials. The study demonstrated that coconut fiber composites could effectively reduce noise levels by up to 11 dBA, with a

significant decrease in sound pressure levels at different blower speeds. This eco-friendly solution showed minimal impact on airflow and temperature, making it a viable and sustainable option for improving acoustic comfort in vehicles.

The fifteenth paper, authored by Zohbi, B.E., Hassan, M.E., Afyouni, N., Meraim, K.A., Sakout, A., and Assoum, H.H., reviews the dynamics of aero-acoustics and heat transfer in impinging jets, with a particular focus on their industrial applications. The study highlights the relationship between vortex dynamics, heat transfer, and acoustic emissions, suggesting control mechanisms to optimize heat transfer while minimizing noise. The research underscores the importance of understanding the complex interactions between flow dynamics and thermal behavior in impinging jets, with implications for improving the efficiency and sustainability of industrial processes.

The sixteenth paper is written by Kumoro, A.C., Wardhani, D.H., Kusworo, T.D., Djaeni, M., Ping, T.C., and Alhanif, M., the paper reviews the use of Deep Eutectic Solvents (DESs) and Natural Deep Eutectic Solvents (NADESs) for the extraction and purification of proteins from animal and botanical sources. The study highlights the efficiency and environmental benefits of using DESs and NADESs over conventional solvents, emphasizing their potential in sustainable protein production. The review also discusses challenges related to protein recovery, solvent reuse, and the need for further research to optimize industrial applications.

The seventeenth paper is written by Velásquez, C., Espín, F., Iturra, F., and Chasi, C., the paper presents an optimized calibration plan for physical-photometric and chemical laboratories using the Gray Model GM (1,1) to improve calibration intervals. The study applied this model to LED luminaire testing and gold determination in minerals, demonstrating that the optimized plan reduced calibration costs by 11% in a physical-photometric lab and 54% in a chemical lab. The methodology effectively extends calibration intervals while ensuring the maintenance of technical proficiency, thereby providing considerable financial savings and improving equipment availability.

The eighteenth paper is written by Sutarman, A., Kadim, A., and Garad, A., examines the impact of organizational commitment and competence on employee productivity in Indonesia's manufacturing industries. The study found that organizational commitment significantly boosts employee productivity, while competence has a positive but non-significant effect. However, organizational commitment effectively mediates the influence of competence on productivity. The research highlights the importance of fostering organizational commitment to enhance productivity and suggests that improving employee competence could further strengthen this relationship.

The nineteenth paper is written by Jandhana, I.B.M.P., and Agustini, H.N., this paper evaluates the Industrial Resilience Index (IRI) using the cross-correlation method to assess its effectiveness in predicting the performance of Indonesia's manufacturing sector. The study found a strong correlation between IRI and the Gross Domestic Product (GDP) of the manufacturing industry, indicating that IRI can be a reliable indicator of industry resilience. The findings indicate that IRI can effectively forecast manufacturing trends and detect periods of economic distress, thereby offering a valuable tool for policymakers and industry stakeholders.

The twentieth is written by Alwan, H.M., Nikolaevic, V.A., Hasan, S.F., and Vladmerovna, K.O., the paper presents a kinematic and dynamic modeling approach for trajectory tracking control of a mobile robot with Mecanum wheels. The study introduces a hybrid controller combining a Linear Quadratic Regulator (LQR) and Ant Colony Optimization (ACO) to optimize the control of robot actuators. The proposed controller effectively minimized

trajectory tracking errors in simulations involving circular and infinity-shaped paths, demonstrating its potential for precise control in mobile robotics applications.

The next paper is written by Ha, V.T., Thuong, T.T., and Thanh, N.T., the paper presents the design of an Adaptive Fuzzy Logic Dynamic Surface Controller (AFDSC) combined with the A* pathfinding algorithm for motion control of mobile robots. The proposed controller effectively compensates for wheel slippage and adapts to parameter variations, improving trajectory tracking performance. Simulation and experimental results demonstrate the controller's accuracy, with minimal trajectory deviation, highlighting its potential for practical applications in robotics, particularly in navigating complex environments with varying terrain and obstacles.

The twenty-second paper is written by Ayub, F.A., and Furukawa, F., this paper compares cubic and quadratic models of hydrodynamic derivatives to assess their impact on the ship course stability index. The study reanalyzes hydrodynamic forces from model ships, demonstrating that the cubic model provides more accurate predictions of ship stability over a wider range of motion, while the quadratic model is better suited for smaller ranges. The findings highlight the importance of selecting the appropriate model depending on the range of motion when evaluating ship maneuverability and stability.

The twenty-third paper is written by Waskito, K.T., Siahaan, J.A.C., Chuzain, M.A.N., Yanuar, and Pal, S., this paper focuses on the design optimization of a Point Absorber and Hydraulic Power Take-Off (HPTO) unit for a Wave Energy Converter (WEC). The study utilizes Sequential Quadratic Programming (SQP) to optimize components such as hose diameter and check valve configuration in order to enhance power output. The optimized HPTO system with a 2-inch hose diameter achieved the highest power output, improving hydraulic, mechanical, and electrical power efficiency. The findings contribute to advancing wave energy conversion technology through effective system design.

The twenty-fourth paper is written by Simanjuntak, J.P., Zainon, M.Z., Zulkifli, N.W.M., Tambunan, B.H., Sihombing, J.L., and Riduwan. The paper explores the thermal cracking of mixed-plastic waste without using a catalyst as a method to produce alternative fuel. The study achieved pyrolytic distilled oil (PDO) yields with heating values at around 30.000 MJ/kg. The oil contained a significant number of aromatic hydrocarbons, such as styrene and benzene, comparable to products from catalytic processes. However, the heating value was relatively low, indicating a need for further treatment or blending to improve fuel quality.

The twenty-fifth paper is written by Pramono, W.B., Wijaya, F.D., Hadi, S.P., Indarto, A., and Wahyudi, M.S., this paper develops a load noise model for power transformers using a Backpropagation Neural Network (BPNN). The model, which incorporates power, impedance, and winding geometry factors, outperformed traditional methods such as Multiple Linear Regression (MLR) and the Reiplinger method. The BPNN model achieved a high prediction accuracy with a mean absolute percentage error (MAPE) of 0.007 and a correlation coefficient (R) of 0.998, making it a promising tool for predicting load noise during the design stage of power transformers.

The twenty-sixth paper is written by Ajiwiguna, T.A., and Kirom, M.R., the paper compares two design strategies for off-grid solar PV systems in remote areas to ensure uninterrupted electricity supply. The first strategy minimizes battery capacity, leading to higher electricity costs, while the second strategy uses a larger PV module capacity to reduce battery size, which results in significant energy dumping. The study concludes that the second strategy is more economically feasible, reducing electricity costs to 29% of the first strategy, despite the energy wastage.

The twenty-seventh is written by Rodionov, D., Rudskaia, I., Krasnova, D., and Zhogova, E., this paper examines the role of universities in regional innovation and socio-economic development in Russia. Using Data Envelopment Analysis (DEA), the study identified regions where universities significantly contribute to innovation, including Moscow, St. Petersburg, and Tatarstan. The research highlights the effectiveness of universities in fostering regional innovation, though it also notes that many regions are not efficiently utilizing their resources. The study suggests the need for enhanced collaboration between universities and regional innovation systems to optimize development outcomes.

The last paper is written by Kusumalestari, A.S., Suryanegara, M., Sudibyo, H., Soekirno, S., Ruseno, N., the paper proposes a method for predicting airframe noise to benefit Indonesian aircraft design, utilizing the Ffowcs Williams and Hawkings (FWH) equation and OpenFOAM software. This method aims to optimize aircraft design for noise reduction during the conceptual phase, focusing on low subsonic speeds relevant to Indonesian civil and military aircraft. The proposed method is not only cost-effective and suitable for local computational capabilities but also aligns with international noise reduction regulations, thereby promoting sustainable aerospace development in Indonesia.

For the purpose of addressing difficult issues in a variety of domains, the incorporation of modern technology with the most current advancements has resulted in the opening of new avenues of possibility. With the ongoing progress of scientific knowledge, it is quite probable that innovation will play an increasingly significant role in determining the course of our future. IJTech warmly invites you to submit your articles for publication, aiming to share your research contributions with our audience and advance the field.

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