Comparison of the Hebbian Algorithm Based on Input and Output Patterns in the Prediction of Lung Cancer in Smokers

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Abstract: The Hebbian algorithm learning method is a learning method that is carried out by fixing the weight values so that if there are 2 neurons connected and both are alive at the same time, the weight between the two is increased. This study's main problem is finding the best performance of the Hebbian algorithm to predict lung cancer in smokers. There are 15 attributes to determine lung cancer, namely: gender(x1), age(x2), smoking(x3), yellow finger(x4), anxiety(x5), social pressure(x6), chronic diseases(x7), fatigue(x8), allergies(x9), wheezing(x10), consumption of alcohol(x11), cough (x12), shortness of Breath(x13), hard to swallow(x14) and chest Pain(x15). This study compares the Hebbian algorithm with four forms of test simulation with four states of input and output patterns. The test simulation results show the best accuracy is with binary data input patterns and binary and bipolar output patterns. The accuracy obtained is 65%.

1 INTRODUCTION

Lung cancer is an abnormal condition found in the lungs characterized by abnormal cell growth or what is known as a dangerous tumor. Abnormal cell growth conditions can originate from cells present in the lungs. However, this abnormal cell growth can originate from cancer cells in other body parts that spread to the lungs. Lung cancer can occur in both men and women (Bisri et al., 2013), (Prasetio and Susanti, 2019), (Setyadi et al., 2020).

Research (Pedersen and Risi, 2021), the results of this study add to the argument about generalization, overfitting, and OOD adaptation. Hebbian learning mixed with managing "genomic bottlenecks" could be a viable research direction for creating agents adapting to a larger range of unexpected scenarios.

Research (Kwessi, 2022), researchers propose an inspired synaptic plasticity rule from the Allee effect, a frequent occurrence in population dynamics. Researchers exhibited properties, namely synaptic normalization, weight competition, decorrelation potential, and satisfactory stability. Researchers have shown that Allee's effect on synaptic plasticity can be enhanced in the lack of plasticity.

Research (Osakabe et al., 2021), the results of the researcher's numerical simulation show that proposes a modified version of the Hebb rule and increases the anti-Hebb learning achievement. In addition, the researcher revealed that the possibility of taking the target pattern from several studied patterns is quite high. Research (Napole et al., 2020), the outcome is analyzed regarding guidance, mistake, and control signals, and performance is assessed using the integral of absolute error (IAE). Experiments reveal that FF-ANN compensation in conjunction with SNPID is appropriate.

Research (Qin and Duan, 2020), the experimental finding showed that the single-neuron adaptive hysteresis compensation approach successfully tracks continuous and discontinuous trajectories. It outperforms the rate-dependence of the PEA's hysteresis in adaptive and self-learning performance. Research (Napitupulu and Situmorang, 2020), redevelop this final project by optimizing the application of employee ownership assessment using the Hebb rule neural net-

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work approach.

Research (Illing et al., 2021), this research proposed a hybrid fuzzy-rough set strategy called RS-HeRR to generate effective, editable, and concise rule sets. It incorporates strict rules fuzzy generation and reduction systems, called Hebbian-based and novel rule-based reduction algorithms, attribute selection algorithms for withdrawal rules. The proposed hybridization uses the pull-through rule consolidation of partial dependencies and system performance improvements to significantly reduce problems redundancy in HeRR. However, it provides similar or better accuracy. RS-HeRR exhibits these characteristics in more than four practical classification problems, such as diabetes assistance, urban air treatment monitoring, sonar target classification, and ovarian cancer detection. It showed very good performance-biased data sets.

Research (Muscoloni and Cannistraci, 2021), the study came to the conclusion that SPM and a straightforward brain bioinspired rule like CH performed much better than both the AI-created brute-force method and did not do any better. Stacking is ideal but incomplete, which is consistent with Gödel's incompleteness. What is already in your feature cannot be pushed any farther. Hench, we also need to work toward AI that matches a human's physical make-up and "knowledge" of basic, complicated laws. AIs that "stole fire from the Gods for mankind," and are on their way to machine intelligence, may live in the future.Research (Liu et al., 2021), this paper proposes a hybrid fuzzy-rough set approach called RS-HeRR to generate effective, editable, and concise rule sets. It incorporates strict rules fuzzy generation and reduction systems, named Hebbian-based and novel rule-based reduction algorithms, and attribute selection algorithms for withdrawal rules. The proposed hybridization uses the pull-through rule consolidation of partial dependencies and system performance improvements to significantly reduce problems redundancy in HeRR. However, it provides similar or better accuracy. RS-HeRR exhibits these features in more than four practical classification issues, namely diabetes assistance, urban air treatment monitoring, sonar target classification, and ovarian cancer detection. It showed a very good product of biased data sets.

Research (Isomura and Toyoizumi, 2019) demonstrated that a neural network that implements Hebbian error-gated rules (EGHR) with sufficiently redundant sensory input could successfully learn this task. After training, the network can do multi-context BSS without further synapse updating by keeping all memory experienced context. It showed an interest in EGHR usage for dimension reduction by extracting low-dimensional resources across contexts. Lastly, if common features are presented in contexts, EGHR could identify and categorize them even in green contexts. The finding highlighted the usefulness of the EGHR as a perceptual adaptation in the animal model.

Research (Najarro and Risi, 0 12), researchers found from a completely random weight, Hebbian found rules allow agents to navigate dynamic 2D pixel environments. Furthermore, They enable a simulated 3D quadrupedal robot in less than 100 steps while compensating for morphological damage not visible during training and without explicit reward or error signal. Research (Journé et al., 2022) SoftHebb demonstrates with a very different approach from BP i.e. Deep Learning through multiple layers of sense in the brain and increasing the accuracy of bio-sense machine learning.

Research (Tsai, 2021), in the PE-SM system, which is made of stacked atomic-thick materials, graphene acts as a charge storage layer, hexagonal boron nitride as a tunneling dielectric, and rhenium diselenide as a powerful photosensor. Under the optical fingernail, it executes synaptic metaplasticity thanks to the PE-SM function. A additional 24 24 PESM are included in the simulated spiking neural network, which uses Hebbian rules to recognize images in an unsupervised machine learning environment. In addition to improving neuromorphic processing effectiveness, PE-SM also makes the circuit size structure more uniform. The electro-photoactive concept offers a revolutionary method for creating photonic synaptic devices or other photosensitive 2D materials, and it can also be used to other photosensitive materialsResearch (Magotra and Kim, 2020) , the proposed HTL algorithm can increase learning transfer performance, especially in terms of heterogeneous source and target data, according to experimental results using the CIFAR-10 (Canadian Institute for Advanced Research) and CIFAR-100 datasets in various combinations.

Research (Golkar et al., 0 12) The researchers detailed how, in the researchers' model, potential calcium plateaus could be interpreted as a signal of backpropagation error. Researchers demonstrated that, despite relying solely on biologically reasonable local learning rules, our algorithm performs competitively with existing implementations of RRMSE and CCA.

Research (Pogodin and Latham, 0 12), the resulting rules feature a three-component Hebbian structure: they call for pre- and post-synaptic firing rates, and a third factor, an error signal, is made up of a global teaching signal and a layer-specific term that are both accessible without top-down access. They rely on convenience between partners rather than a suitable label to produce the desired results. Furthermore, our rules demand divided normalization, a characteristic well-known to tissue biology, in order to achieve strong performance on challenging challenges while maintaining biological plausibility.. Lastly, the simulations show that our performance rules are almost the same as well as backpropagation (Solikhun et al., 2020b), (Solikhun et al., 2020a) in the image classification task.

Research (Nicola and Clopath, 2019) Researchers utilized advanced techniques in network iterative spiking training to demonstrate how especially interneuron networks can: 1) generate internal theta sequences for binds external spike elicited in presence of obstruction from medial septum, 2) compresses studied spike Sequence in SPW-R form when septal block is removed, 3) generates and fixes high frequency assembly during SPW-mediated compression, and 4) timing the interripple between the SPW-Rs in the ripple cluster. From fast timescales of neurons to slow timescales of behavior, Network interneurons serve as a scaffold for one-shot learning by replaying, inverting, refining, and setting spikes of Sequences.

Research (Gillett et al., 2020), the researcher discovered that non-linearity in the learning rules might determine how sparsely the recalled sequences were composed. Additionally, sequences maintain good decoding while exhibiting very labile dynamics as synaptic connection is continuously updated as a result of noise or other pattern storage, comparable to these recent discoveries in the parietal cortex and hippocamal pus. Finally, the researchers showed that their findings preserved spiny neuron repeat networks with distinct excitatory and inhibitory populations. This study's main problem is finding the best performance of the Hebbian algorithm in predicting lung cancer in smokers. Researchers signify lung cancer in smokers by using 15 attributes. Researchers compare the Hebbian algorithm based on input patterns and output patterns. There are four forms of input and output patterns, namely binary input and output patterns, bipolar input and output patterns, binary input and bipolar output patterns and bipolar input and binary output patterns.

2 RESEARCH METHODOLOGY

2.1 Research Data

Data on lung cancer prediction in smokers is taken from Kaggle. The data consists of 16 attributes. Fifteen input data attributes and one target data attribute. The 15 attributes are gender(x1), age(x2), smoking(x3), yellow finger(x4), anxiety(x5), social pressure(x6), chronic diseases(x7), fatigue(x8), allergies(x9), wheezing(x10), consumption of alcohol(x11), cough (x12), shortness of Breath(x13), hard to swallow(x14) and chest Pain(x15). The target's attribute is lung cancer. The data used for the simulation test is 20 data. Here is the raw data of lung cancer prediction in smokers with 20 data.

Table 1: Raw Data on Lung Cancer Prediction in Smokers.

No	X1	X2	..	X15	T
1	M	69	..	1	YES
2	M	74	..	1	YES
3	F	59	..	1	NO
4	M	63	..	1	NO
5	F	63	..	0	NO
6	F	75	..	0	YES
7	M	52	..	1	YES
8	F	50	..	0	YES
9	F	68	..	0	NO
10	M	53	..	1	YES
11	F	60	..	0	YES
12	M	72	..	1	YES
13	F	60	..	0	NO
14	M	58	..	1	YES
15	M	69	..	1	NO
16	F	48	..	0	YES
17	M	75	..	1	YES
18	M	57	..	1	YES
19	F	68	..	0	YES
20	F	60	..	0	NO

Lung cancer medical record data is converted with the following rules:

1. Gender:
   - If M(Male) then 1;
   - If F(Female) then 0
2. Age :
   - If old age(46-55 years), late old(56-65 years) and old age(>65years) then 1; otherwise 0.
3. Smoking:
   - If smoking then 1;
   - If don't smoke then 0.
4. Yellow Finger:
   - If have jaundice then 1
   - If don't have jaundice then 0.
5. Anxiety:
   - If have anxiety disease then 1;
   - If don't have Anxiety disease then 0.

6. Peer Pressure :
   - If have Peer Pressure then 1;
   - If don't have Peer Pressure then 0.
7. Chronic Disease:
   - If have Chronic Disease then 1;
   - If don't have Chronic Disease then 0.
8. Fatigue:
   - If have Fatigue then 1;
   - If don't have Fatigue then 0.
9. Allergies:
   - If have an allergic disease then 1;
   - If don't have an allergic disease then 0.
10. Wheezing :
    - If have Wheezing disease then 1;
    - If do not have Wheezing disease then 0.
11. Consumption of alcohol:
    - If consuming alcohol then 1;
    - If don't consume alcohol then 0.
12. Cough:
    - If have cough disease then 1;
    - If don't have cough disease then 0.
13. Shortness of Breath:
    - If have shortness of breath then 1;
    - If don't have shortness of breath then 0.
14. Hard to Swallow:
    - If have difficulty swallowing then 1;
    - If do not have Difficult Swallowing then 0
15. Chest Pain:
    - If have chest pain then 1;
    - If don't have chest pain then 0.
16. Lung Cancer:
    - If YES then 1;
    - If NO then 0.

2.2 Research Stages and Hebbian Algorithm Architecture

To achieve the research objectives, the following steps were taken to complete the research. The following is a picture of the stages of the research.

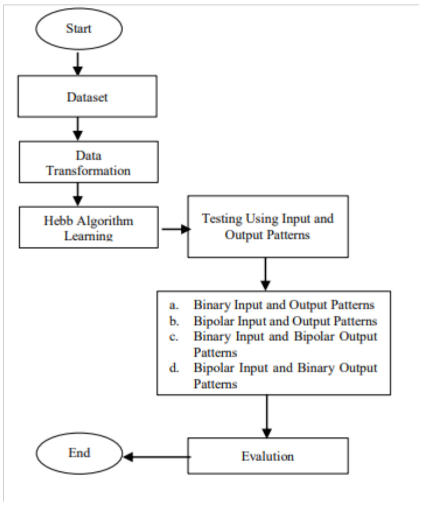

Figure 1: Research Stages.

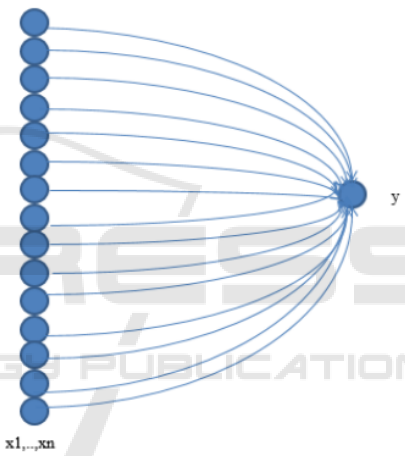

Figure 2: Hebbian Architecture.

3 RESULTS AND DISCUSSION

The simulation results of Hebbian's algorithm testing to predict lung cancer in smokers with 4 forms of input and output patterns produce accuracy that is not much different from one another. The following is the result of the summation of the test with 4 forms of input and output patterns.

3.1 Bipolar Input and Output Patterns

The results of the simulation test using the Hebbian algorithm to predict lung cancer with bipolar input and output patterns yield an accuracy of 60%. The following is the simulation result of lung cancer prediction testing in smokers.

Table 2: Test Simulation Results with Bipolar Input and Output Patterns.

x1	x2	x3	...	x15	y=f(net)	t	Result
1	1	-1	...	1	1	1	True
1	1	1	...	1	1	1	True
-1	1	-1	...	1	1	-1	False
1	1	1	...	1	1	-1	False
-1	1	-1	...	-1	1	-1	False
-1	1	-1	...	-1	1	1	True
1	-1	1	...	1	1	1	True
-1	-1	1	...	-1	1	1	True
-1	1	1	...	-1	1	-1	False
1	-1	1	...	1	-1	1	False
...	...	...	...	...	...	...	...
-1	1	1	...	-1	1	1	True
-1	1	-1	...	-1	1	-1	False

3.2 Binary Input and Output Patterns

Simulation test results using the Hebbian algorithm to predict lung cancer with binary input and output patterns produce an accuracy of 65%. The following is the simulation result of lung cancer prediction testing in smokers.

Table 3: Test Simulation Results with Binary Input and Output Patterns.

x1	x2	x3	...	x15	y=f(net)	t	Result
1	1	0	...	1	1	1	True
1	1	1	...	1	1	1	True
0	1	0	...	1	1	0	False
1	1	1	...	1	1	0	False
0	1	0	...	0	1	0	False
0	1	0	...	0	1	1	True
1	0	1	...	1	1	1	True
0	0	1	...	0	1	1	True
0	1	1	...	0	1	0	False
1	0	1	...	1	1	1	True
...	...	...	...	...	...	...	...
0	1	1	...	0	1	1	True
0	1	0	...	0	1	0	False

3.3 Patterns of Bipolar Input and Binary Output

The results of simulation tests using the Hebbian algorithm to predict lung cancer with bipolar input and binary output patterns yield an accuracy of 60%. The following is the simulation result of lung cancer prediction testing in smokers.

Table 4: Test Simulation Results with Bipolar Input and Binary Output Patterns.

x1	x2	x3	...	x15	y=f(net)	t	Result
1	1	-1	...	1	1	1	True
1	1	1	...	1	1	1	True
-1	1	-1	...	1	1	0	False
1	1	1	...	1	1	0	False
-1	1	-1	...	-1	0	0	True
-1	1	-1	...	-1	0	1	False
1	-1	1	...	1	1	1	True
-1	-1	1	...	-1	0	1	False
-1	1	1	...	-1	0	0	True
1	-1	1	...	1	1	1	True
-1	1	1	...	-1	0	1	False
...	...	...	...	...	...	...	...
-1	1	1	...	-1	0	1	False
-1	1	-1	...	-1	0	0	True

3.4 Patterns of Binary Input and Bipolar Output

The results of simulation testing using the Hebbian algorithm to predict lung cancer with a bipolar input pattern and binary output yield an accuracy of 65%. The following is the simulation result of lung cancer prediction testing in smokers.

Table 5: Test Simulation Results with Bipolar Input and Binary Output Patterns.

x1	x2	x3	...	x15	y=f(net)	t	Result
1	1	0	...	1	1	1	True
1	1	1	...	1	1	1	True
0	1	0	...	1	1	-1	False
1	1	1	...	1	1	-1	False
0	1	0	...	0	1	-1	False
0	1	0	...	0	1	1	True
1	0	1	...	1	1	1	True
0	0	1	...	0	1	1	True
0	1	1	...	0	1	-1	False
1	0	1	...	1	1	1	True
...	...	...	...	...	...	...	...
0	1	1	...	0	1	1	True
0	1	0	...	0	1	-1	False

Based on the simulation results of the Hebbian algorithm testing to predict lung cancer for smokers with binary input and output patterns producing 65% accuracy, with bipolar input and output patterns producing 60% accuracy, with binary input and bipolar output patterns producing 65% accuracy and with bipolar input pattern and binary output give 60% accuracy.

3.4.1 Comparison of Simulation Results of Hebbian Algorithm Testing

After conducting a simulation test using the Hebbian algorithm, the best accuracy value is Hebbian learning with binary input patterns, both with binary output and with bipolar output, which produces an accuracy value of 65

4 CONCLUSIONS

The conclusion of this study is that the Hebbian algorithm can predict lung cancer in smokers with an accuracy of 65% with binary input patterns and binary and bipolar output patterns. To produce better test results for accuracy, it is necessary to study with other algorithms.

REFERENCES

Bisri, H., Bustomi, M., and Purwanti, E. (2013). Image classification of the lungs by histogram feature extraction and backpropagation neural networks. *J. Sains Dan Seni Pomits*, 2(2):68–71,.

Gillett, M., Pereira, U., and Brunel, N. (2020). Characteristics of sequential activity in networks with temporally asymmetric hebbian learning. *Proc. Natl. Acad. Sci. U. S. A*, 117(47):29948–29958,.

Golkar, S., Lipshutz, D., Bahroun, Y., Sengupta, A., and Chklovskii, D. (2020-12). A simple normative network approximates local non-hebbian learning in the cortex. *Adv. Neural Inf. Process. Syst*, (NeurIPS):1–13,.

Illing, B., Ventura, J., Bellec, G., and Gerstner, W. (2021). Local plasticity rules can learn deep representations using self-supervised contrastive predictions. *Adv. Neural Inf. Process. Syst*, 36(NeurIPS):30365–30379,.

Isomura, T. and Toyoizumi, T. (2019). Multi-context blind source separation by error-gated hebbian rule. *Sci. Rep*, 9(1):1–13,.

Journé, A., Rodriguez, H., Guo, Q., and Moraitis, T. (2022). Hebbian deep learning without feedback. Available:.

Kwessi, E. (2022). Strong allee effect synaptic plasticity rule in an unsupervised learning environment. Available:.

Liu, F., Sekh, A., Quek, C., Ng, G., and Prasad, D. (2021). Rs-herr: a rough set-based hebbian rule reduction neuro-fuzzy system. *Neural Comput. Appl*, 33(4):1123–1137,.

Magotra, A. and Kim, J. (2020). Improvement of heterogeneous transfer learning efficiency by using hebbian learning principle. *Appl. Sci*, 10(16).

Muscoloni, A. and Cannistraci, C. (2021). Short note on comparing stacking modelling versus cannistraci-hebb adaptive network automata for link prediction in complex networks. *Preprints*, (May).

Najarro, E. and Risi, S. (2020-12). Meta-learning through hebbian plasticity in random networks. *Adv. Neural Inf. Process. Syst.*

Napitupulu, S. and Situmorang, Z. (2020). Optimization of giving employee craft assessment using artificial neural network with hebb algorithm,"iop conf. *Ser. Mater. Sci. Eng*, 725(1).

Napole, C., Barambones, O., Calvo, I., and Velasco, J. (2020). Feedforward compensation analysis of piezoelectric actuators using artificial neural networks with conventional pid controller and single-neuron pid based on hebb learning rules. *Energies*, 13(15):1–16,.

Nicola, W. and Clopath, C. (2019). A diversity of interneurons and hebbian plasticity facilitate rapid compressible learning in the hippocampus. *Nat. Neurosci*, 22(7):1168–1181,.

Osakabe, Y., Sato, S., Akima, H., Kinjo, M., and Sakuraba, M. (2021). Learning rule for a quantum neural network inspired by hebbian learning. *IEICE Trans. Inf. Syst*, D(2):237–245,.

Pedersen, J. and Risi, S. (2021). *Evolving and merging hebbian learning rules: Increasing generalization by decreasing the number of rules*, volume 1. Association for Computing Machinery.

Pogodin, R. and Latham, P. (2020-12). Kernelized information bottleneck leads to biologically plausible 3-factor hebbian learning in deep networks. *Adv. Neural Inf. Process. Syst.*

Prasetio, R. and Susanti, S. (2019). Prediction of life expectancy in lung cancer patients after thoracic surgery using boosted k-nearest neighbor. *J. Responsif*, 1(1):64–69,. Available:.

Qin, Y. and Duan, H. (2020). Single-neuron adaptive hysteresis compensation of piezoelectric actuator based on hebb learning rules,"micromachines.

Setyadi, Y., Asror, I., and Wibowo, Y. (2020). Prediction of life expectancy after thoracic surgery in patients with lung cancer using genetic algorithm methods for feature selection and naïve bayes classifier. *e-Proceeding Eng*, 7(20):8349–8360,.

Solikhun, M., Safii, M., and Zarlis, M. (2020a). Backpropagation network optimization using one step secant (oss) algorithm. *IOP Conf. Ser. Mater. Sci. Eng*, 769(1).

Solikhun, M., Safii, M., and Zarlis, M. (2020b). Resilient algorithm in predicting fertilizer imports by major countries. *IOP Conf. Ser. Mater. Sci. Eng*, 769(1).

Tsai, M. (2021). Photoactive electro-controlled visual perception memory for emulating synaptic metaplasticity and hebbian learning. *Adv. Funct. Mater*, 31(40):13–14,.