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| **Academic Year : 2024-25** | |
| SUBJECT **: Machine Learning** | |
| CLASS: TY(A) | SEMESTER: V |
| ASSIGNMENT NO. : - 2 | DATE OF SUBMISSION: |
| NAME OF STUDENT: Vedanti kavitkar | ROLL NO.45 |
| TOPIC: **Feed-forward neural network &**  **Feedback neural network** |  |
| WEBSITE URL REFERRED:  **HTTPS://**[**WWW.GOOGLE.COM/SEARCH?Q=HOP**](http|  |

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| **Summary/Abstract/Review:** |
| * **Hopfield Networks Revisited:** The video introduces a groundbreaking paper from researchers at Johannes Kepler University and the University of Oslo, where modern Hopfield Networks are enhanced to manage both binary and continuous patterns. The update rule within these networks is shown to be equivalent to the attention mechanism widely used in transformers. * **How Hopfield Networks Work:** The basic idea of a Hopfield Network is to store patterns (initially binary strings) in a network of neurons, where connections between neurons hold weights that represent the stored patterns. Upon partial input, the network retrieves the closest stored pattern, ensuring pattern recall even if incomplete information is provided. * **Update Rule and Attention Mechanism:** The video explains how the retrieval update rule in Hopfield Networks minimizes an energy function. This energy minimization process parallels the attention mechanism in transformers. In Hopfield Networks, the update rule refines input over several iterations until a stored pattern is retrieved, while transformers use a similar method to route attention between tokens. * **From Binary to Continuous Patterns:** One of the most revolutionary aspects of the paper is its extension of Hopfield Networks to continuous patterns. Instead of just binary strings (0s and 1s), the modern version handles floating-point numbers as patterns, allowing it to store exponentially more information. This advancement makes it highly useful in complex data tasks where information needs to be processed continuously. * **Real-world Applications and Impact:** The paper also applies these modern Hopfield Networks in biological fields like immunology, where they achieve state- of-the-art results in tasks that require pattern retrieval from complex data. By improving memory storage and retrieval, these networks can revolutionize deep learning applications across various fields. * **Exponential Storage Capacity:** Unlike traditional networks, modern Hopfield Networks can store **exponentially many patterns** due to the continuous nature of stored vectors. This ability significantly boosts their utility in high-dimensional machine learning tasks. * **Attention Mechanism Equivalent:** The update rules in these Hopfield Networks effectively operate like the attention mechanism in transformer models, which is central to processing large datasets, such as language models. This deepens the understanding of transformers by linking them to classical neural networks.   **Insights Based on Numbers**   * **Exponential Growth in Storage:** The network can store exponentially many patterns in relation to the dimension of the patterns, providing a massive increase in capacity for memory storage. * **Energy Convergence:** The energy function, minimized by the update rule, converges after repeated iterations, allowing the network to retrieve the most relevant patterns based on input, mirroring how transformers resolve attention. |

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| * **Multiple Applications:** The paper’s findings are tested across various fields, including biology, demonstrating its flexibility and effectiveness in handling complex datasets like **immunology** studies, enhancing task performance. | | |
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| **Conclusion:** | | |
| The modern Hopfield Networks described in this paper extend beyond binary patterns to handle continuous data, allowing exponentially greater storage capacity. By aligning with the attention mechanism in transformers, they enhance both memory retrieval and  practical applications, offering a powerful tool for complex machine learning and biological tasks. | | |
| **Name & Sign of Subject In-charge:** | **Marks:** |  |