Attention via Convolutional Nearest Neighbor

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Project Context and Focus

My senior honors project investigates the theoretical foundations underlying two dominant concepts in artificial intelligence: convolutional neural networks and attention mechanisms. These architectures represent fundamentally different approaches to processing visual information. Convolutional networks analyze images through localized, sliding windows that examine fixed spatial neighborhoods, while attention mechanisms (underlying algorithm in ChatGPT/Similar Models) evaluate relationships between all elements simultaneously, regardless of spatial proximity.

My research introduces Convolutional Nearest Neighbors (ConvNN), a novel algorithm that generalizes these seemingly separate approaches as variations within a unified structure. The central commonality in both convolution and attention is performing neighbor aggregation operations, differing primarily in the criteria for neighbor selection rather than in their fundamental principles. This unifying idea has significant implications for the development of more efficient artificial intelligence systems.

Our project addresses three research questions:

1. Does ConvNN provide a unifying framework that connects convolution and attention mechanisms?
2. How does hard neighbor selection in ConvNN compare to the soft weighting in the transformer architectures.
3. Do hybrid architectures allow this unified framework to achieve better performance?

Methodology and Timeline

During Fall 2025, I will complete the implementation of ConvNN-Attention, which extends our previous ConvNN to incorporate key characteristics of self-attention. This phase includes implementing and testing the algorithm, conducting baseline experiments on standardized benchmark data, and presenting preliminary findings at the IEEE MIT Undergraduate Research Technology Conference in October.

Spring 2026 will focus on scaling experiments to more complex datasets and conducting comprehensive comparisons with established baselines. We will be preparing a

publication submission to the Conference on Computer Vision and Pattern Recognition (CVPR), one of the premier venues in computer science. I will be completing my honors thesis by the end of spring semester.

Throughout both semesters, I am meeting weekly with Professor Farias to review progress, refine methodology, and guidance throughout the project. Bowdoin's high performance computing resources will be used for computational experiments of this project.

Preparation and Qualifications

My preparation for this project combines both academic foundations and previous research experience. Coursework in algorithms, artificial intelligence, linear algebra, and probability provides the mathematical background for this research. I conducted research with Professor Farias since January 2024 and received Bowdoin Christenfeld Summer Research Fellowship in summer 2024 and have been working as a research assistant since spring 2025.

Project Impact and Future Plans

This honors project directly supports my goals to pursue doctoral studies in computer science, providing both research experience and potential publications essential for competitive graduate applications. The skills I developed from my time at Bowdoin have prepared me for careers in either academic research or industrial research positions. Successfully completing this project and publishing the results would establish my credentials as an emerging researcher while contributing meaningful advances to the field of computer science.