ENHANCED IN-CONTEXT LEARNING FOR CODE ANALYSIS WITH COMPACT LARGE LANGUAGE MODELS AND MONTE CARLO TREE SEARCH

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AUGUST, 2024

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A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE MASTER OF SCIENCE (M.Sc.) DEGREE IN BIOINFORMATICS IN THE DEPARTMENT OF COMPUTER AND INFORMATION SCIENCES, COLLEGE OF SCIENCE AND TECHNOLOGY, COVENANT UNIVERSITY, OTA, OGUN STATE, NIGERIA

AUGUST, 2024

ACCEPTANCE

This is to attest that this dissertation is accepted in partial fulfilment of the requirements for the award of the Master of Sciences in Bioinformatics degree in the Department of Computer and Information Sciences, College of Science and Technology, Covenant University, Ota, Nigeria.

Miss Adefunke F. Oyinloye

(Secretary, School of Postgraduate Studies) **Signature and Date**

Prof. Akan B. Williams
(Dean, School of Postgraduate Studies) **Signature and Date**

DECLARATION

I declare that **Ajibola, Ifedayo Olabode**, with matriculation number **22PCG02417**, conducted this research entitled "**Enhanced In-Context Learning for Code Analysis with Compact Large Language Models and Monte Carlo Tree Search**". It was carried out under the supervision of Dr. Azubuike Ezenwoke. Concepts of this research project are the results of the research carried out by Ajibola, Ifedayo Olabode, and other researchers' ideas have been fully recognised.

AJIBOLA, IFEDAYO OLABODE

Signature and Date

CERTIFICATION

This is to certify that this dissertation titled "**Enhanced In-Context Learning for Code Analysis with Compact Large Language Models and Monte Carlo Tree Search**". is original research carried out by **AJIBOLA, IFEDAYO OLABODE (22PCG02417)** in the Department of Computer and Information Sciences, College of Science and Technology, Covenant University, Ota, Ogun State, Nigeria under the supervision of Dr. Azubuike Ezenwoke. We have examined and found this work acceptable as part of the requirements for the award of Master of Science (M.Sc.) in Computer Science.

Dr. Azubuike Ezenwoke

(Supervisor) **Signature and Date**

Prof. Olufunke Oladipupo
(Head of Department) **Signature and Date**

Prof. Zacchaeus Omogbadegun
(External Examiner) **Signature and Date**

Prof. Akan B. Williams
(Dean, School of Postgraduate Studies) **Signature and Date**

DEDICATION

I dedicate this work to God Almighty for His grace, wisdom and knowledge given to me throughout my master's degree Programme.

ACKNOWLEDGEMENTS

I express my deepest gratitude to God Almighty for His unwavering guidance, wisdom, and strength throughout this season of my life. This journey would not have been possible without His divine intervention. I extend my sincere appreciation to my supervisor, Dr. Azubuike Ezenwoke, for his invaluable guidance, sacrifices, and unwavering support. His dedication has been instrumental to the success of this work. I am also deeply grateful to my friends and colleagues, Ademolu Ajao, Julius Odunuga, Otavie Okuoyo, and Rifin Ashuza, for their insightful discussions, care, and support throughout my academic journey. To my family, Mr. Tajudeen Ajibola, Mrs. Atoke Ajibola, and Oyindamola Ajibola, thank you for your constant support and encouragement. Your belief in me has been a driving force behind my academic pursuits. I would also like to acknowledge Mr. Bayo Atekoja for his support throughout this endeavor. Finally, I thank all those who have supported me directly or indirectly, your contributions are deeply appreciated.

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ABBREVIATIONS

Artificial Intelligence	AI
Automatic Software Engineering	ASE
Abstract Syntax Tree	AST
Bidirectional Auto-Regressive Transformers	BART
Bilingual Evaluation Understudy	BLEU
Continuous deployment	CD
Continuous integration	CI
Central Processing Unit	CPU
Gigabyte	GB
Graphical Processing Unit	GPU
Integrated Development Environment	IDE
Longest Common Subsequence	LCS
Large Language Model	LLM
Monte Carlo Tree Search	MCTS
Natural Language Processing	NLP
Retrieval Augmented Generation	RAG
Random Access Memory	RAM
Recall-Oriented Understudy for Gisting Evaluation	ROUGE
Solid-State Drive	SSD
Terabyte	TB
Upper Confidence Bound	UCB
Upper Confidence Bound applied to Trees	UCT

ABSTRACT

Large Language Models (LLMs) demonstrate impressive reasoning abilities, yet their performance can falter when dealing with extensive context lengths. Techniques like Retrieval Augmented Generation (RAG) and Chain-of-Thought prompting seek to bridge this gap, but they face limitations when applied to large code-based contexts due to the complexity of representing inter-object relationships. Monte Carlo Tree Search (MCTS), a heuristic search algorithm, offers a potential solution by aiding LLMs in identifying crucial code repository aspects, thus facilitating downstream tasks. This research focuses on applying MCTS to enhance the performance of "Compact LLMs" - models small enough to run inference on consumer-grade GPUs. Our findings confirm that MCTS indeed boosts performance compared to the baseline Compact LLM. However, these compact models, even with MCTS, still lag behind larger models in performance.

Keywords: large language model, compact LLM, chain-of-thought, monte carlo tree search, in-context learning, code analysis