UNIVERSITI TEKNOLOGI MARA

HYBRID CONJUGATE GRADIENT METHOD UNDER EXACT LINE SEARCH FOR AN ULTRASOUND INVERSE PROBLEM

ALEYA MAISARAH BINTI MOHD HAKIM

BSc

July 2025

ABSTRACT

The Conjugate Gradient (CG) method is one of the popular methods that many researchers often use in solving unconstrained optimization problems. It has been proven that the CG method is preferred for solving optimization problems due to its simplicity, low memory requirements, and global convergence properties. While the CG method is widely used for solving large-scale problems, this method often faces limitations in real-world applications due to slow convergence and a lack of robustness in the presence of numerical tests. These problems reduce its efficiency and robustness when applied in complex systems. Therefore, this research focuses on the performance of the hybrid CG method under exact line search and its implementation in the ultrasound inverse problem. There are four hybrid CG coefficients used in this study, which are Polak-Ribiere-Polyak (PRP) as the main CG coefficient to hybrid with Hestenes-Stiefel (HS), Dai-Yuan (DY), Norrlaili-Rivaie-Mustafa-Ismail (NRMI) and Linda-Aini-Mustafa-Rivaie (LAMR). Fifteen test functions with different initial points and variable ranges from 2, 4, 10, 100, 1000 and 10,000 are selected to conduct the numerical tests. The numerical results are measured based on the number of iterations (NOI) and CPU time. These four hybrid CG coefficients successfully solve all fifteen test functions, thereby determining their efficiency and robustness. Therefore, the PRPLAMR coefficient is determined as the best hybrid CG coefficient in terms of lesser number of iterations (NOI) and central processing unit (CPU) time. Lastly, the PRPLAMR coefficient is implemented in ultrasound inverse problems, achieving excellent performance with the PSNR value of 27.03 dB and the SSIM value of 0.9079 under a low noise level.

ACKNOWLEDGEMENT

First and most significantly, I would like to express my gratitude to Allah SWT for His blessings and guidance throughout this research path. I am sincerely thankful to my supervisor, Dr. Norhaslinda Binti Zull Pakkal, for her guidance, continuous support and helpful comments throughout this research. Her knowledge of optimization methods has been greatly helpful in finishing this research on hybrid Conjugate Gradient methods for the Ultrasound inverse problem.

I would like to extend my appreciation to UiTM Kuala Terengganu for providing the necessary resources and academic environment for me to complete this research. A special appreciation goes to my family, especially my parents and sisters, for their unwavering support, love and encouragement throughout my academic pursuit. Their sacrifices and support in my abilities have been my continuous source of motivation.

I extend my appreciation to all individuals who directly or indirectly contributed to the completion of this research. Finally, I am thankful for the opportunity to explore and complete this research which has greatly improved my academic and personal growth.

TABLE OF CONTENTS