ABSTRAK

PENGEMBANGAN PERANGKAT LUNAK "GIM" BERBASIS PYTHON DENGAN GUI UNTUK *FORWARD MODELING* GAYABERAT

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Metode gayaberat mengukur variasi medan gravitasi bumi akibat kontras densitas bawah permukaan. Dalam interpretasi data, *forward modeling* diperlukan untuk memvalidasi hipotesis geologi. Namun, perangkat lunak komersial saat ini umumnya bersifat tertutup (*black box*) dan berbiaya lisensi tinggi. Keterbatasan tersebut menghambat transparansi algoritma yang sangat krusial dalam proses pembelajaran mahasiswa untuk memahami konsep fisika dan validitas perhitungan secara mendalam.

Penelitian ini bertujuan mengembangkan perangkat lunak GIM (*Gravity Interactive Modelling*) berbasis Python 3 dengan *Graphical User Interface* (GUI) menggunakan pustaka PyQt5. Algoritma yang diimplementasikan mencakup solusi analitik benda bola, prisma tegak segi empat, serta penerapan *staircase approximation* untuk struktur patahan. Metodologi penelitian meliputi implementasi algoritma secara vektorisasi dengan NumPy, integrasi antarmuka interaktif, serta uji validitas fisis melalui analisis statistik *Root Mean Square Error* (RMSE) dan *Normalized Root Mean Square Error* (NRMSE) terhadap model sintetik tervalidasi.

Hasil penelitian berupa perangkat lunak GIM berformat *executable* (.exe) dengan fitur visualisasi dinamis. Uji validitas menunjukkan akurasi sangat tinggi pada geometri bola (99,56%) dan prisma (99,87%). Pada pemodelan patahan, akurasi karakteristik mencapai 61,41%-85,65% akibat perbedaan pendekatan fisis antara model volumetrik GIM dengan *thin sheet* referensi. Mengingat unit penyusunnya yakni blok prisma telah teruji valid (>99%), GIM dinyatakan reliabel dan lebih representatif dalam menggambarkan volume struktur geologi yang masif. Integrasi Python dan PyQt5 menjadikan GIM sebagai instrumen pembelajaran yang transparan dan akurat.

Kata kunci: *Forward Modeling*, Gayaberat, GIM, GUI, Python.

ABSTRACT

DEVELOPMENT OF PYTHON-BASED "GIM" SOFTWARE WITH GUI FOR GRAVITY FORWARD MODELING

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The gravity method measures variations in the Earth's gravitational field caused by subsurface density contrasts. In data interpretation, forward modeling is essential for validating geological hypotheses. However, current commercial software is generally closed-source (black box) and involves high licensing costs. These limitations hinder algorithmic transparency, which is crucial for students to deeply understand physical concepts and computational validity.

This research aims to develop GIM (Gravity Interactive Modeling) software based on Python 3 with a Graphical User Interface (GUI) using the PyQt5 library. The implemented algorithms include closed-form analytical solutions for spheres and rectangular prisms, as well as the staircase approximation for fault structures. The methodology involves vectorized algorithm implementation using NumPy, interactive interface integration, and physical validity testing through Root Mean Square Error (RMSE) and Normalized Root Mean Square Error (NRMSE) statistical analysis against validated synthetic models.

The results consist of GIM software in an executable (.exe) format with dynamic visualization features. Validity tests demonstrate high numerical accuracy for sphere (99.56%) and prism (99.87%) geometries. In fault modeling, characteristic accuracy reaches 61.41%-85.65% due to the fundamental physical approach difference between GIM's volumetric model and the reference thin sheet. Since the building blocks, namely the rectangular prisms, have been proven valid (>99%), GIM is declared reliable and more representative in depicting massive geological volumes. The integration of Python and PyQt5 establishes GIM as a transparent and accurate educational instrument for visualizing forward modeling concepts.

Keywords: Forward Modeling, GIM, Gravity, GUI, Python.