THE USE OF ARTIFICIAL INTELLIGENCE IN GEOPHYSICAL SOFTWARE DEVELOPMENT FOR MAPPING SUBSURFACE FEATURES AND ENHANCING SEISMIC IMAGES IN 3D

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B.Sc. (Uniben), MSc. (Unilag)

A Thesis Submitted to the Department of Physics, College of Physical Sciences, Federal University of Agriculture, Abeokuta, in partial fulfillment of the requirements for the award of Doctor of Philosophy (Ph.D.) in physics (Geophysics).

April, 2025

ABSTRACT

umerous challenges arise when attempting to detect superficial deposits within the Earth's ıbsurface. These include the complexity of wave reflections, velocity variations, multiple flections and diffractions, geological heterogeneity, irregular conformations, and intricate ave propagation paths. This study developed intelligent algorithms and applied artificial ıtelligence (AI) principles to seismic modelling. The research utilised forward finite ifference modelling of the seismic wave equation by incorporating a small vertical resolution ement into the model formulation, producing a tensor-based wavefield. The combined avefield comprising both diffraction and reflection components was decomposed using ingular Value Decomposition (SVD) and refined using a well-designed digital filter based on ıe Fast Fourier Transform (FFT). The processed output was subsequently analysed using a equence of geophysical algorithms, including Normal Moveout (NMO), Migration and oststack Analysis (MPA), Continuous Wavelet Transform (CWT), Attribute Analysis (AA), ımplitude Variation with Offset (AVO), Automatic Horizon Picking (AH), Fault Detection FD), Reservoir Characterization (RC), Workflow Modelling (WM), and Petrophysical Modelling (PM). A Convolutional Neural Network (CNN) was trained using 60% of the data or training, 20% for testing, and 20% for validation, derived from the treated seismic data. inite difference models with varying inclinations demonstrated that for angles $\theta \leq 2.5$ radians, ıe wavefields displayed sharp resolution. In contrast, angles $\theta > 2.5$ radians resulted in blurred eismic images. The SVD analysis revealed that diffraction components occurred at low requencies (0–10 Hz), low energy levels (around 2 dB), and exhibited deeper penetration >2000 m below datum) with omnidirectional energy scattering. Conversely, reflections were haracterised by high frequencies (11–500 Hz), higher energy ($\geq$ 45 dB), and shallow enetration ($\leq$ 1 m), with energy localised in specific seismic regions.

he NMO analysis confirmed the parabolic nature of seismic wave travel paths, indicating a onlinear behaviour. Unmigrated wavefields produced distorted seismic images, emphasising e need for migration. Machine learning techniques, particularly CNNs, proved reliable for utomatic horizon picking and fault detection, especially in complex scenarios. Attribute and VO analyses further revealed that certain geophysical features are only detectable through ese methods, which are essential for petrophysical modelling, well logging, and reservoir aracterisation. CNN-based predictions of horizons and faults yielded a 2% loss in dropout gions and an overall accuracy of 98% across both synthetic and field datasets. The research vealed that the integration of AI into geophysical software development significantly hances the ability to map subsurface features. The suite of algorithms developed in this study fectively interprets field data and addresses numerous challenges associated with 3D seismic alysis.