Graduate School of Science and Technology Master's Thesis Abstract

Laboratory name (Supervisor)	Computational Systems Biologoy (Shigehiko Kanaya (Professor))		
Student ID	2311413	Submission date	2025 / 7 / 24
Name	KPALEMON ABENA SAMUEL		
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Abstract

Osteoporosis is the leading cause of bone fractures in the elderly, yet it often goes undiagnosed mainly due to the high cost and limited accessibility of dual-energy X-ray absorptiometry (DEXA), the current gold standard for diagnosis. Additionally, deep learning algorithms like Generative Adversarial Networks (GANs) have shown promising results in diagnosing osteoporosis by estimating bone mineral content (BMC). However, previous GAN-based approaches have not addressed uncertainty estimation, which is critical to improving reliability in clinical decision-making. To build on previous work, we propose a novel algorithm that we call *Random Fast DDPM*. It consists of training like Denoising Diffusion Probabilistic Method (DDPM) and sampling like Fast DDPM for BMC estimation with a Bayesian-based uncertainty quantification technique to measure epistemic and aleatoric uncertainty. Unlike GANs, which only estimate BMC, our method also captures abnormalities in proximal femur (PF) prediction, the region involved in Bone mineral content (BMC) estimation. The proposed method achieved a high Pearson correlation coefficient $r = 0.82$ for BMC prediction, indicating strong agreement with the actual BMC values. Leveraging the Bayesian approach, the algorithm successfully quantified both **epistemic** and **aleatoric** uncertainties in the predicted proximal femur (PF), especially when evaluated on our generated toy X-ray dataset. However, when specifically examining BMC uncertainty, our method still faces challenges in fully aligning the estimated uncertainties with actual prediction errors. This limitation indicates that further improvements are necessary before clinical adoption for osteoporosis diagnosis can be recommended.