

# FreeU: Free Lunch in Diffusion U-Net

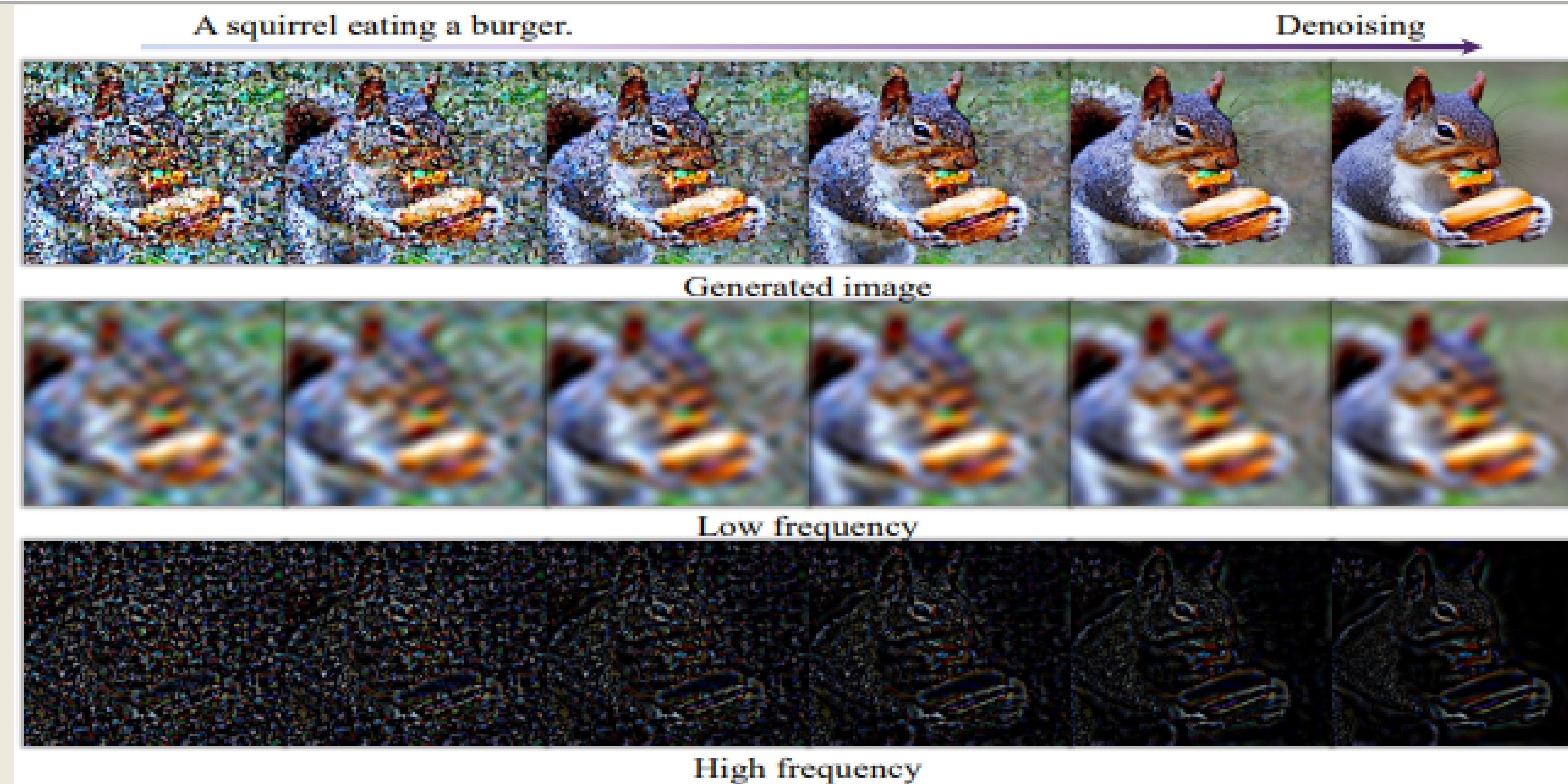
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## 01. Introduction

Diffusion models are a leading category of generative models, gaining attention for their effectiveness in computer vision tasks. These models consist of two processes: diffusion and denoising. This paper investigates the U-Net architecture used in these models to enhance image generation quality.

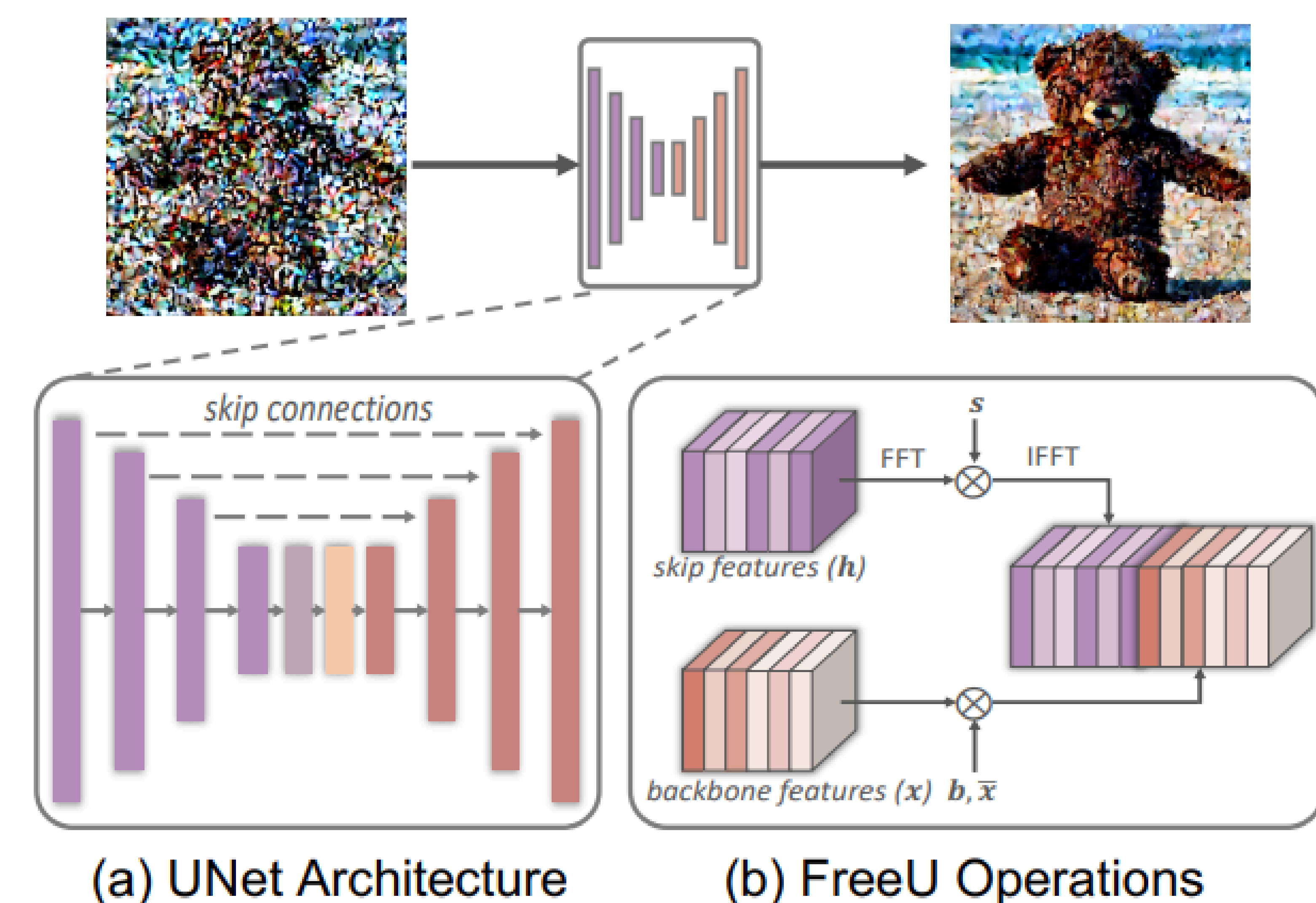


## 02. Objective

To explore the internal workings of the diffusion U-Net and improve generation quality without additional training or parameters by re-weighting contributions from backbone and skip connections.

## 03. Methodology

- Denoising Process Analysis: Investigated how images are generated from noise during the denoising process.
- FreeU Method: Introduced modulation factors to balance contributions from backbone features and skip connections.



## 04. Analysis

The figure on the left illustrates how FreeU modifies the standard U-Net operations by introducing two modulation factors:

- Backbone Feature Scaling Factor ( $b$ ): This factor amplifies the contributions from the backbone features, enhancing the denoising capability of the model. By increasing  $b$ , the model can better suppress noise, leading to clearer images.
- Skip Feature Scaling Factor ( $s$ ): This factor modulates the influence of skip connections. While skip connections are crucial for preserving high-frequency details, excessive reliance on them can lead to noise artifacts in generated images.

## 05. Results/Findings

- Quality Improvement: FreeU significantly enhances image generation quality without any additional computational costs or training requirements.
- Empirical Evaluations: Our experiments demonstrate that by adjusting two scaling factors during inference, we can achieve substantial improvements in generated samples across various tasks.
- Adaptability: The method shows promising results when integrated with multiple diffusion models, indicating its versatility and effectiveness.

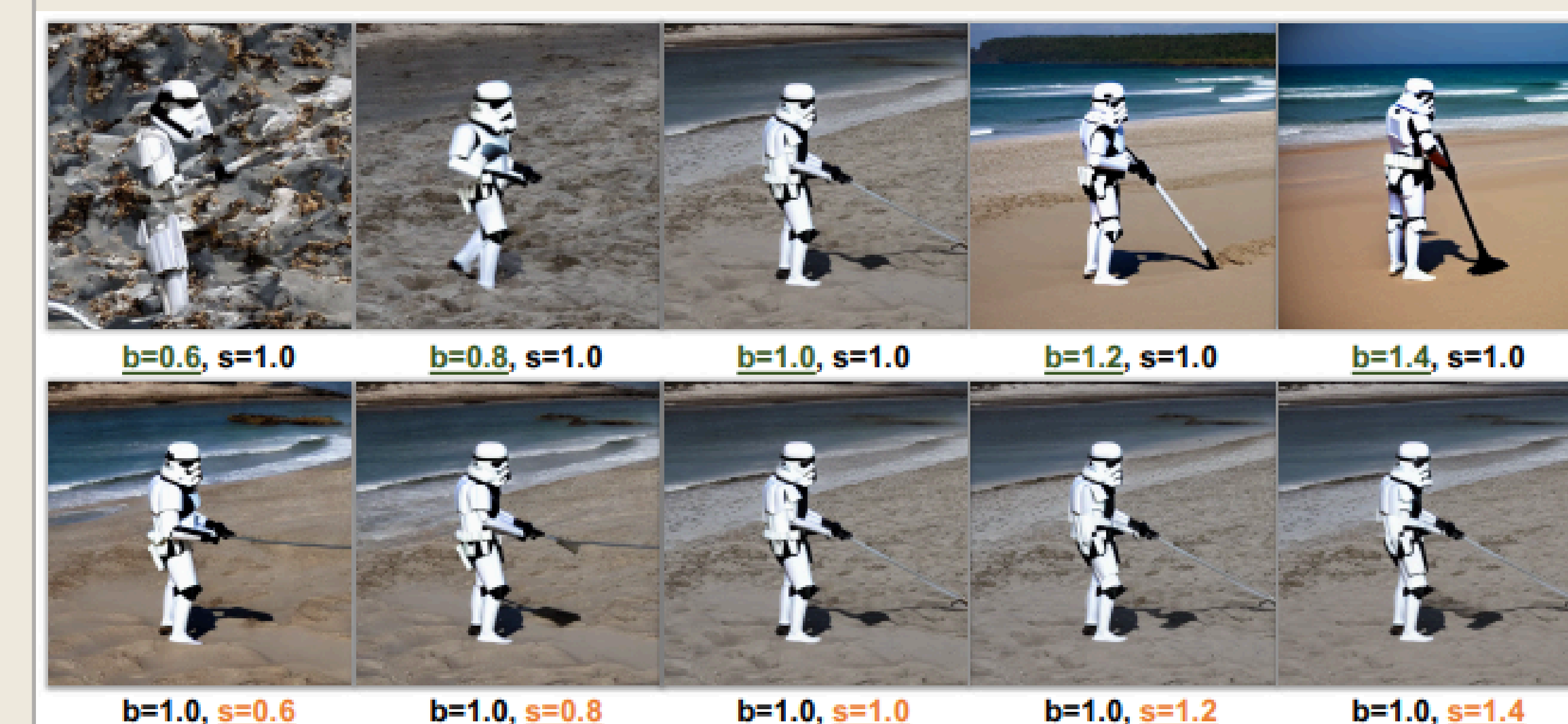


Figure 5. Effect of backbone and skip connection scaling factors ( $b$  and  $s$ ).