

# Methodology

This section describes the implementation methodology and experimental setup used in the optimization project.

## Algorithm Implementation

### Gradient Descent Algorithm

The core algorithm implements the following iterative procedure for unconstrained optimization:

**Input:** Initial point  $x_0 \in \mathbb{R}^d$ , step size  $\alpha > 0$ , tolerance  $\epsilon > 0$ , maximum iterations  $N_{\max} \in \mathbb{N}$

**Output:** Approximate solution  $x^* \approx \arg \min f(x)$

#### Algorithm 1: Gradient Descent

***Input:** Initial point  $x_0$ , step size  $\alpha$ , tolerance  $\epsilon$ , max iterations  $N_{\max}$*

1. Initialize  $k \leftarrow 0$
2. **While**  $k < N_{\max}$  **do:**
  - ▶ Compute gradient  $g_k = \nabla f(x_k)$
  - ▶ **If**  $\|g_k\|_2 < \epsilon$  **then return**  $x_k$  (converged)
  - ▶ Update:  $x_{k+1} \leftarrow x_k - \alpha \cdot g_k$
  - ▶  $k \leftarrow k + 1$