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Lab Question: Genetic Algorithm

Code:

```
import numpy as np

def objective(x):
    return x[0] ** 2

def initialize_population(bounds, n_pop):
    return [np.random.uniform(bounds[0], bounds[1], 1).tolist() for _ in range(n_pop)]

def evaluate_fitness(pop):
    return [objective(ind) for ind in pop]

def roulette_wheel_selection(pop, scores):
    total_fitness = sum(scores)
    probabilities = [1 - (score / total_fitness) for score in scores]
    selection_ix = np.random.choice(len(pop), p=np.array(probabilities) / sum(probabilities))
    return pop[selection_ix]

def crossover(p1, p2, alpha=0.5, r_cross=0.9):
    if np.random.rand() < r_cross:
        offspring = alpha * p1[0] + (1 - alpha) * p2[0]
        return [offspring]
    else:
        return [p1[0]]

def mutation(individual, bounds, r_mut):
    if np.random.rand() < r_mut:
        return [np.random.uniform(bounds[0], bounds[1])]
    return individual

def genetic_algorithm(bounds, n_iter, n_pop, r_mut, r_cross, min_fitness=None):
    pop = initialize_population(bounds, n_pop)
    best, best_eval = pop[0], objective(pop[0])

    for gen in range(n_iter):
        scores = evaluate_fitness(pop)

        for i in range(n_pop):
            if scores[i] < best_eval:
                best, best_eval = pop[i], scores[i]
                print(f">{gen}, new best f({pop[i]}) = {scores[i]:.6f}")
```

```
        if min_fitness is not None and best_eval <= min_fitness:
            print(f"Early stopping: Fitness threshold reached at generation {gen}.")
            break

        children = []
        for _ in range(n_pop):
            p1 = roulette_wheel_selection(pop, scores)
            p2 = roulette_wheel_selection(pop, scores)
            offspring = crossover(p1, p2, alpha=0.5, r_cross=r_cross)
            offspring = mutation(offspring, bounds, r_mut)
            children.append(offspring)

        pop = children

    return [best, best_eval]

# Parameters
bounds = [-10.0, 10.0]
n_iter = 50
n_pop = 100
r_mut = 0.1
r_cross = 0.9
min_fitness = 1e-6

best, score = genetic_algorithm(bounds, n_iter, n_pop, r_mut, r_cross, min_fitness)
print('Done!')
print(f'f({best}) = {score:.6f}')
```

Output:

```
>0, new best f([6.9990666056033675]) = 48.986933
>0, new best f([-0.025765319038683288]) = 0.000664
>2, new best f([0.0031183075944212213]) = 0.000010
>2, new best f([0.0013267396664704556]) = 0.000002
>16, new best f([-0.0012355699066274317]) = 0.000002
>23, new best f([0.0002906445005846914]) = 0.000000
Early stopping: Fitness threshold reached at generation 23.
Done!
f([0.0002906445005846914]) = 0.000000
```