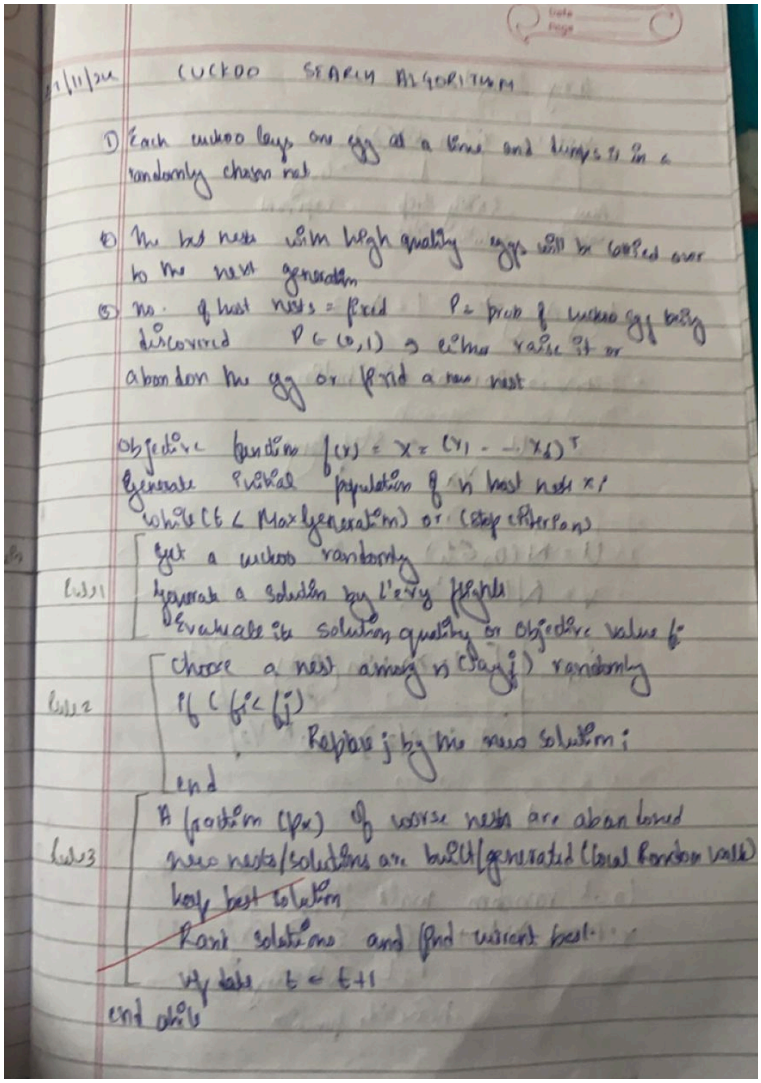
Program 5

Problem statement:Cuckoo Search (CS)

Algorithm:



Lévy Flight

$x_i^{t+1} = x_i^t + \alpha \oplus L(\lambda)$

- x_i^{t+1} : new solution
- x_i^t : existing solution
- α : step size
- $L(\lambda)$: Lévy exponent

$\text{Levy}(\lambda) = g^{-\lambda} \quad 1 < \lambda < 3$

$u, v \rightarrow$ normal distribution

$s = \frac{u}{|v|^{1/\lambda}}$ ← step length

$u = N(0, \sigma_u^2)$

$v = N(0, \sigma_v^2)$

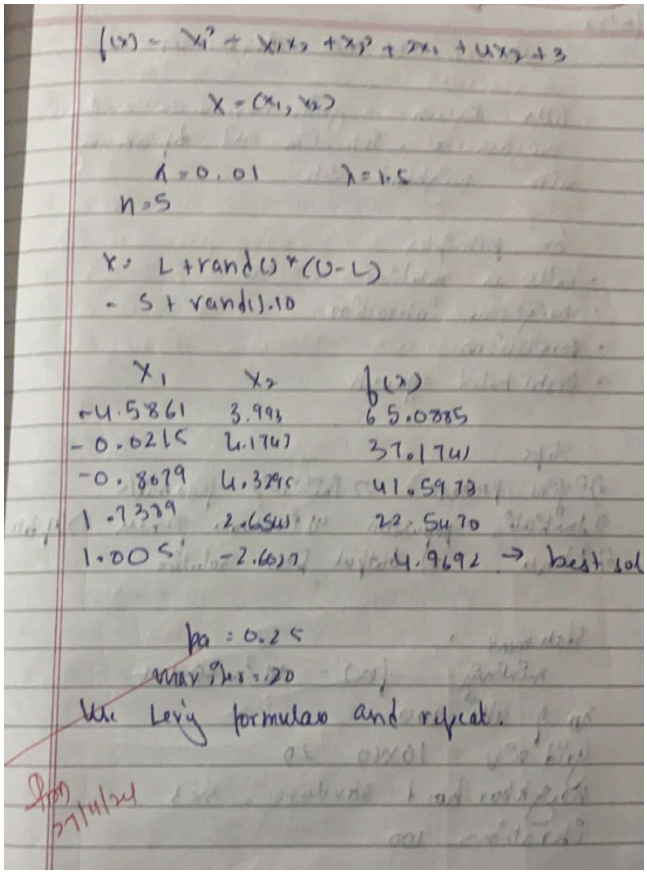
$$\sigma_u^2 = \left[\frac{\Gamma(1+\lambda) \sin\left(\frac{\pi\lambda}{2}\right)}{\Gamma\left(\frac{1+\lambda}{2}\right) \times \lambda \, 2^{\frac{\lambda-1}{2}}} \right]^{1/\lambda}$$

$\sigma_v^2 = 1$

Local random walk

$x_i^{t+1} = x_i^t + h(p_a - \varepsilon) \otimes (x_j^t - x_k^t)$

- random solution
- random no.
- switching parameter
- Heaviside function



Code:

```
import numpy as np
def objective_function(x):
    return np.sum(x**2)
class CuckooSearch:
    def __init__(self, objective_function, dim, num_nests, max_iter, pa=0.25, lb=-5, ub=5):
        self.objective_function = objective_function
        self.dim = dim
        self.num_nests = num_nests
        self.max_iter = max_iter
        self.pa = pa
        self.lb = lb
        self.ub = ub
        self.nests = np.random.uniform(self.lb, self.ub, (self.num_nests, self.dim))
        self.fitness = np.array([self.objective_function(nest) for nest in self.nests])
        self.best_nest = self.nests[np.argmin(self.fitness)]
        self.best_fitness = np.min(self.fitness)
    def levy_flight(self):
        step = np.random.normal(0, 1, self.dim) * np.random.uniform(0, 1)**(1/1.5)
        return step
    def generate_new_solution(self, nest):
        step = self.levy_flight()
        new_nest = nest + step
```

```
        new_nest = np.clip(new_nest, self.lb, self.ub)
        return new_nest
    def abandon_worst_nests(self):
        num_worst = int(self.pa * self.num_nests)
        worst_indices = np.argsort(self.fitness)[-num_worst:]
        for i in worst_indices:
            new_nest = np.random.uniform(self.lb, self.ub, self.dim)
            self.nests[i] = new_nest
            self.fitness[i] = self.objective_function(new_nest)
    def run(self):
        for t in range(self.max_iter):
            for i in range(self.num_nests):
                new_nest = self.generate_new_solution(self.nests[i])
                new_fitness = self.objective_function(new_nest)
                if new_fitness < self.fitness[i]:
                    self.nests[i] = new_nest
                    self.fitness[i] = new_fitness
                if new_fitness < self.best_fitness:
                    self.best_nest = new_nest
                    self.best_fitness = new_fitness
            self.abandon_worst_nests()
            print(f"Iteration {t+1}/{self.max_iter}: Best Fitness = {self.best_fitness}")
        return self.best_nest, self.best_fitness
dim = 2
num_nests = 30
max_iter = 10
pa = 0.25
lb = -5
ub = 5
cs = CuckooSearch(objective_function, dim, num_nests, max_iter, pa, lb, ub)
best_nest, best_fitness = cs.run()
print(f"\nBest Nest: {best_nest}")
print(f"Best Fitness: {best_fitness}")
```

```python
import numpy as np
def objective_function(x):
    return np.sum(x**2)
class CuckooSearch:
    def __init__(self, objective_function, dim, num_nests, max_iter, pa=0.25, lb=-5, ub=5):
        self.objective_function = objective_function
        self.dim = dim
        self.num_nests = num_nests
        self.max_iter = max_iter
        self.pa = pa
        self.lb = lb
        self.ub = ub
        self.nests = np.random.uniform(self.lb, self.ub, (self.num_nests, self.dim))
        self.fitness = np.array([self.objective_function(nest) for nest in self.nests])
        self.best_nest = self.nests[np.argmin(self.fitness)]
        self.best_fitness = np.min(self.fitness)
    def levy_flight(self):
        step = np.random.normal(0, 1, self.dim) * np.random.uniform(0, 1)**(1/1.5)
        return step
    def generate_new_solution(self, nest):
        step = self.levy_flight()
        new_nest = nest + step
        new_nest = np.clip(new_nest, self.lb, self.ub)
        return new_nest
    def abandon_worst_nests(self):
        num_worst = int(self.pa * self.num_nests)
        worst_indices = np.argsort(self.fitness)[-num_worst:]
        for i in worst_indices:
            new_nest = np.random.uniform(self.lb, self.ub, self.dim)
            self.nests[i] = new_nest
            self.fitness[i] = self.objective_function(new_nest)
    def run(self):
        for t in range(self.max_iter):
            for i in range(self.num_nests):
                new_nest = self.generate_new_solution(self.nests[i])
                new_fitness = self.objective_function(new_nest)
                if new_fitness < self.fitness[i]:
                    self.nests[i] = new_nest
                    self.fitness[i] = new_fitness
                if new_fitness < self.best_fitness:
                    self.best_nest = new_nest
                    self.best_fitness = new_fitness
            self.abandon_worst_nests()
            print(f"Iteration {t+1}/{self.max_iter}: Best Fitness = {self.best_fitness}")
        return self.best_nest, self.best_fitness
dim = 2
num_nests = 30
max_iter = 10
pa = 0.25
lb = -5
ub = 5
cs = CuckooSearch(objective_function, dim, num_nests, max_iter, pa, lb, ub)
best_nest, best_fitness = cs.run()
print(f"\nBest Nest: {best_nest}")
print(f"Best Fitness: {best_fitness}")
```

Output:

```
Iteration 1/10: Best Fitness = 1.1321338482886207
Iteration 2/10: Best Fitness = 1.1321338482886207
Iteration 3/10: Best Fitness = 0.9581521162910784
Iteration 4/10: Best Fitness = 0.9581521162910784
Iteration 5/10: Best Fitness = 0.4939211503841384
Iteration 6/10: Best Fitness = 0.026043904239381056
Iteration 7/10: Best Fitness = 0.008822631651070133
Iteration 8/10: Best Fitness = 0.003456235504629316
Iteration 9/10: Best Fitness = 0.003456235504629316
Iteration 10/10: Best Fitness = 0.003456235504629316

Best Nest: [-0.01878645 -0.05570731]
Best Fitness: 0.003456235504629316
```