COMPUTER PROGRAMMING-I

"SEMESTER PROJECT"

By

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INTRODUCTION

- **Objective**: Determine the minimum number of chess knights needed to attack every square on an 8x8 chessboard.
- **Approach:** Implement a genetic algorithm for an optimized solution to this chess optimization problem.
- **Significance:** This project combines chess strategy with computational techniques, showcasing the practical application of genetic algorithms in real-world problem-solving.
- **Challenges:** Chessboard dynamics and computational intricacies present unique challenges in achieving an efficient solution.
- **Documentation:** This report serves as a comprehensive record of the project's journey, including theoretical foundations, methodology, challenges faced, and achieved results.
- **Practical Application:** Highlights the adaptability of genetic algorithms, demonstrating their role in solving complex problems within the context of course of Computer Programming (CP-1).

METHODOLOGY

Below is the detailed methodology and explanation of the code:

```
#include <stdio.h>
#include <time.h>
#include <stdlib.h>

#define boardsize 8
#define knights 16
#define populationsize 500
#define parents populationsize / 2
```

Header Files and Definitions:

- Includes necessary header files **(‘stdio.h’, ‘time.h’, ‘stdlib.h’).**
- Defines constants for the chessboard size **(‘boardsize’)**, the number of knights **(‘knights’)**, the population size **(‘populationsize’)**, and the number of parents **(‘parents’).**

```
int boards[populationsize][boardsize][boardsize];
int fitnessArray[populationsize];
```

Global Variables:

- Declares a 3D array '**boards**' to represent the population of chessboards.
- Declares an array '**fitnessArray**' to store fitness values for each individual in the population.

```
void initialize_pop(int boards[populationsize][boardsize][boardsize], in
{
    // Function to initialize the population with all zeros
    // 'start' parameter is used to initialize a subset of the populatio
}
```

Population Initialization Function (initialize_pop):

- Function to initialize the chessboard population with all elements set to zero.
- The **'start'** parameter is used to initialize a subset of the population.

```
void placeRandomKnights(int boards[populationsize][boardsize][boardsize])
{
    // Function to randomly place knights on the chessboards
}
```

Random Knight Placement Function (placeRandomKnights):

- Function to randomly place a specified number of knights on each chessboard, avoiding duplicate placements.

```
void Placement(int board[boardsize][boardsize])
{
    // Function to print the current placement of knights on a chessboar
}
```

Chessboard Placement Function (Placement):

- Function to print the current placement of knights on a single chessboard

```
void applyingattacks(int board[populationsize][boardsize][boardsize])
{
    // Function to mark squares attacked by knights on all chessboards
}
```

Applying Attacks Function (applyingattacks):

- Function to mark squares attacked by knights on all chessboards based on their possible moves.

```
void fitnesscalculation(int boards[populationsize][boardsize][boardsize]
{
    // Function to calculate the fitness of each individual in the popula
    // Fitness is based on the number of unattacked squares on the chessb
}
```

Fitness Calculation Function (fitnesscalculation):

- Function to calculate the fitness of each individual in the population based on the number of unattacked squares on the chessboard.

```
void selectionofparents(int fitnessArray[populationsize], int boards[popu
{
    // Function to perform tournament selection and sort individuals base
}
```

Parent Selection Function (selectionofparents):

- Function to perform tournament selection, sorting individuals based on fitness, and swapping their positions in the population accordingly.

```
void RemoveAttacksForNextPopulation(int boards[populationsize][boardsize]
{
    // Function to reset attacked squares to 0 for the next generation
}
```

Reset Attacks Function (RemoveAttacksForNextPopulation):

- Function to reset attacked squares to 0 on all chessboards in preparation for the next generation.

```
void evolution(int boards[populationsize][boardsize][boardsize])
{
    // Function to create the next generation by combining selected parer
}
```

Evolution Function (evolution):

- Function to create the next generation by combining selected parents, preserving the fittest individuals, and introducing mutations to enhance genetic diversity.

```
int main()
{
    // Main function
}
```

Main Function (main):

- Entry point of the program.
- Initializes the random number generator.
- Calls functions to initialize the population, place knights, apply attacks, and perform the genetic algorithm loop.

```
srand(time(NULL));
initialize_pop(boards, 0);
placeRandomKnights(boards);
applyingattacks(boards);
int i;
for (i = 0; i < 10000; i++)
{
    // Main loop for the genetic algorithm
}
```

Initialization in Main:

- Seeds the random number generator with the current time.
- Initializes the population, places knights randomly, and applies attacks to the chessboards.
- Starts a loop for the genetic algorithm, iterating up to 10,000 generations or until a solution is found.

```
fitnesscalculation(boards, fitnessArray);
selectionofparents(fitnessArray, boards);
printf("generation no. %d\n", i + 1);
printf("Most fittest offspring has fitness: %d\n", fitnessArray[0]);
if (fitnessArray[0] == 0)
{
    // Output if a solution is found
}
RemoveAttacksForNextPopulation(boards);
initialize_pop(boards, parents);
evolution(boards);
applyingattacks(boards);
```

Genetic Algorithm Steps in Main Loop:

- Calculates fitness, performs parent selection, and prints information about the current generation.
- Checks for a solution and outputs information if found.
- Resets attacked squares, initializes the second half of the population, performs evolution, and applies attacks for the next generation.

```
if (fitnessArray[0] != 0)
{
    // Output if no solution is found after the loop
}
return 0;
```

Solution Output or Termination:

- If no solution is found after the loop, outputs the most fit individual of the last generation.
- Returns 0, indicating successful program execution.

PSEUDO CODE

```
// Constants
boardsize = 8
knights = 16
populationsize = 500
parents = populationsize / 2
// Global Variables
boards[populationsize][boardsize][boardsize]
fitnessArray[populationsize]
// Function to initialize the population
initialize_pop(boards, start)
for z from start to populationsize
 for x from 0 to boardsize
 for y from 0 to boardsize
 boards[z][x][y] = 0
// Function to randomly place knights on the chessboards
placeRandomKnights(boards)
for z from 0 to populationsize
 for k from 0 to knights
 x = random number from 0 to boardsize
 y = random number from 0 to boardsize
 if boards[z][x][y] != 1
 boards[z][x][y] = 1
 else
 k = k - 1
// Function to print the placement of knights on a chessboard
Placement(board)
k = 0
print " a b c d e f g h"
for i from 0 to boardsize
```

```
print boardsize - i, "|"
for j from 0 to boardsize
 if board[i][j] == 1
print "k"
k = k + 1
else if board[i][j] == 2
print "X"
else
print " "
print "|"
print "\n +-+-+-+-+-+-+-+-+"
print "no. of knights = ", k
// Function to mark squares attacked by knights on all chessboards
applyingattacks(boards)
knightMoves = [[2, 1], [2, -1], [-2, 1], [-2, -1], [1, 2], [1, -2], [-1, 2], [-1, -2]]
for z from 0 to populationsize
for x from 0 to boardsize
for y from 0 to boardsize
  if boards[z][x][y] == 1
  for attack from 0 to 7
Rx = x + knightMoves[attack][0]
Ry = y + knightMoves[attack][1]
if Rx >= 0 and Rx < boardsize and Ry >= 0 and Ry < boardsize and boards[z][Rx][Ry] != 1
boards[z][Rx][Ry] = 2
// Function to calculate the fitness of each individual in the population
fitnesscalculation(boards, fitnessArray)
for P from 0 to populationsize
fitness = 0
for i from 0 to boardsize
for j from 0 to boardsize
if boards[P][i][j] == 0
```

fitness = fitness + 1

fitnessArray[P] = fitness

// Function to perform tournament selection and sort individuals based on fitness

selectionofparents(fitnessArray, boards)

for i from 0 to populationsize

for j from i + 1 to populationsize

if fitnessArray[j] < fitnessArray[i]

swap fitnessArray[i] and fitnessArray[j]

swap boards[i] and boards[j]

// Function to reset attacked squares to 0 for the next generation

RemoveAttacksForNextPopulation(boards)

for P from 0 to populationsize

for R from 0 to boardsize

for C from 0 to boardsize

if boards[P][R][C] == 2

boards[P][R][C] = 0

// Function to create the next generation by combining selected parents and introducing mutations

evolution(boards)

final_position[populationsize][2]

k = 0

for p from 0 to parents

for r from 0 to boardsize

for c from 0 to boardsize

if boards[p][r][c] == 1

boards [p + parents][r][c] = 1

k = k + 1

if k == knights / 2

break

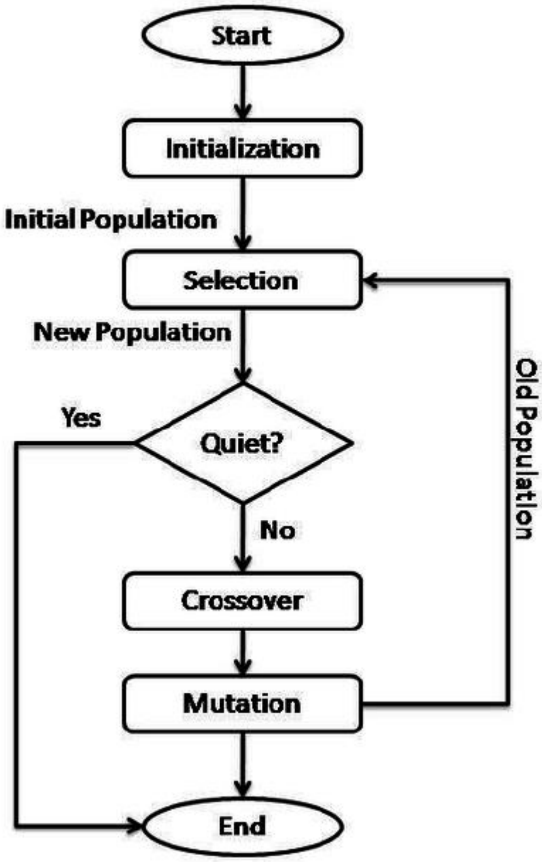
if k == knights / 2

break

```
final_position[p][0] = r
final_position[p][1] = c
k = 0
for p from 0 to parents - 1
for r from 0 to boardsize
for c from 0 to boardsize
if boards[p][r][c] == 1 and r > final_position[p][0] and c > final_position[p][1]
boards [p + 1 + parents][r][c] = 1
k = k + 1
if k == knights
break
if k == knights
break
k = 0
// mutation
for i from 0 to populationsize
k = 0
for r from 0 to boardsize
for c from 0 to boardsize
if boards[i][r][c] == 1
k = k + 1
if k < knights
while k < knights
row = random number from 0 to boardsize
col = random number from 0 to boardsize
if boards[i][row][col]! = 1
boards[i][row][col] = 1
k = k + 1
else if k > knights
while k > knights
row = random number from 0 to boardsize
```

```
col = random number from 0 to boardsize
if boards[i][row][col] == 1
boards[i][row][col] = 0
k = k - 1
// Main Function
main ()
srand(time (NULL))
Initialize_pop(boards, 0)
placeRandomKnights(boards)
 applyingattacks(boards)
 for i from 0 to 10000
fitnesscalculation(boards, fitnessArray)
selectionofparents(fitnessArray, boards)
print "generation no. ", i + 1
print "Most fittest offspring has fitness: ", fitnessArray[0]
if fitnessArray[0] == 0
print "Solution found after ", i, " generations”.
Placement(boards [0])
Break
RemoveAttacksForNextPopulation(boards)
initialize_pop(boards, parents)
evolution(boards)
 applyingattacks(boards)
  if fitnessArray[0] != 0
  print "No solution found after ", i, " generations”.
  print "Here's the fittest offspring:"
  Placement (boards [0])
  return 0
```

FLOWCHART OF GENETIC ALGORITHM



RESULT

```
generation no. 29
Most fittest offspring has fitness: 0
Solution found after 28 generations
   1   2   3   4   5   6   7   8
_________________________________
1| X | X | X | X | X | X | X | X |
_________________________________
2| X | X | k | X | k | X | X | X |
_________________________________
3| X | X | k | k | k | k | k | k |
_________________________________
4| X | X | X | X | X | X | X | X |
_________________________________
5| X | X | k | X | X | X | X | X |
_________________________________
6| X | k | k | k | k | k | k | k |
_________________________________
7| X | X | X | X | X | X | X | X |
_________________________________
8| X | X | X | X | X | X | X | X |
_________________________________
no. of knights = 16
PS E:\OneDrive\Desktop\cp project\output>
```

PROBLEMS FACED

New Algorithm Concept: Understanding the genetic algorithm concept, especially for a problem different from the familiar N-Queens, posed a learning curve.

Transition to 3D Array: Adapting from a 2D array (N-Queens) to a 3D array for the knight's problem introduced new complexity in representing solutions.

Fitness Function Design: Designing an effective fitness function for the knight's problem presented challenges in determining what constitutes a 'fit' solution.

Crossover and Mutation Strategies: Implementing appropriate crossover and mutation operations for knights required experimentation and tuning.

Implementing Genetic Operators: Implementing selection, crossover, and mutation operations demanded a deep understanding of their impact.

Understanding Output: Interpreting the algorithm's output, especially in cases where no solution was found, required careful analysis.

Overcoming these challenges involved a mix of theoretical understanding, experimentation, and debugging to fine-tune the genetic algorithm for the knight's problem.

REFERENCES

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