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| **Subject** | Design and Analysis of Algorithms (DAA) |
| **Experiment No.** | 3 |
| **Aim** | Experiment based on divide and conquer (MIN-MAX and Strassen’s Multiplication. |
| **Min-Max** | #include <stdio.h>  #include <stdlib.h>  #include <time.h>  #define ARRAY\_SIZE 100000  *// Function prototypes*  void generateNumbers(int *numbers*[], int *size*);  void minMaxDivideConquer(int *numbers*[], int *start*, int *end*, int \**min*, int \**max*);  void minMaxNaive(int *numbers*[], int *size*, int \**min*, int \**max*);  int main()  {      FILE \*p = fopen("minmax.csv", "w");      fprintf(p, "Number, Time (Divide & Conquer), Time (Naive), Min, Max\n");      int numbers[ARRAY\_SIZE];      int min\_dc, max\_dc, min\_naive, max\_naive;  *// Generate 100,000 random integer numbers using rand()*      generateNumbers(numbers, ARRAY\_SIZE);      printf("Number, Time (Divide & Conquer), Time (Naive), Min, Max\n");      for (int i = 100; i <= ARRAY\_SIZE; i += 100)      {          clock\_t start, end;  *// Divide and Conquer*          start = clock();          minMaxDivideConquer(numbers, 0, i - 1, &min\_dc, &max\_dc);          end = clock();          double time\_dc = ((double)(end - start)) / CLOCKS\_PER\_SEC;  *// Naive Approach*          start = clock();          minMaxNaive(numbers, i, &min\_naive, &max\_naive);          end = clock();          double time\_naive = ((double)(end - start)) / CLOCKS\_PER\_SEC;          printf("%d, %lf, %lf, %d, %d\n", i, time\_dc, time\_naive, min\_dc, max\_dc);          fprintf(p, "%d, %lf, %lf, %d, %d\n", i, time\_dc, time\_naive, min\_dc, max\_dc);      }      return 0;  }  void generateNumbers(int *numbers*[], int *size*)  {      for (int i = 0; i < *size*; ++i)      {  *numbers*[i] = rand(); *// Using rand() for simplicity*      }  }  void minMaxDivideConquer(int *numbers*[], int *start*, int *end*, int \**min*, int \**max*)  {      if (*start* == *end*)      {          \**min* = \**max* = *numbers*[*start*];          return;      }      int mid = (*start* + *end*) / 2;      int min\_left, max\_left, min\_right, max\_right;      minMaxDivideConquer(*numbers*, *start*, mid, &min\_left, &max\_left);      minMaxDivideConquer(*numbers*, mid + 1, *end*, &min\_right, &max\_right);      \**min* = (min\_left < min\_right) ? min\_left : min\_right;      \**max* = (max\_left > max\_right) ? max\_left : max\_right;  }  void minMaxNaive(int *numbers*[], int *size*, int \**min*, int \**max*)  {      \**min* = \**max* = *numbers*[0];      for (int i = 1; i < *size*; ++i)      {          if (*numbers*[i] < \**min*)          {              \**min* = *numbers*[i];          }          else if (*numbers*[i] > \**max*)          {              \**max* = *numbers*[i];          }      }  } |
| **Graphs** |  |
| **Strassens:** | #include <stdio.h>  #include <stdlib.h>  #include <time.h>  FILE \*file1;  FILE \*file2;  *// Function to add two matrices*  void add(int *n*, int *A*[*n*][*n*], int *B*[*n*][*n*], int *C*[*n*][*n*])  {    for (int i = 0; i < *n*; ++i)    {      for (int j = 0; j < *n*; ++j)      {  *C*[i][j] = *A*[i][j] + *B*[i][j];      }    }  }  *// Function to subtract two matrices*  void subtract(int *n*, int *A*[*n*][*n*], int *B*[*n*][*n*], int *C*[*n*][*n*])  {    for (int i = 0; i < *n*; ++i)    {      for (int j = 0; j < *n*; ++j)      {  *C*[i][j] = *A*[i][j] - *B*[i][j];      }    }  }  *// Function for normal matrix multiplication*  void normal\_matrix\_multiplication(int *size*, int \*\**A*, int \*\**B*, int \*\**C*)  {    clock\_t start, end;  *// Initialize matrices A and B with random values*    for (int i = 0; i < *size*; ++i)    {      for (int j = 0; j < *size*; ++j)      {  *C*[i][j] = 0;  *A*[i][j] = rand() % 1001;  *B*[i][j] = rand() % 1001;      }    }    start = clock();  *// Perform matrix multiplication*    for (int i = 0; i < *size*; ++i)    {      for (int j = 0; j < *size*; ++j)      {        for (int k = 0; k < *size*; ++k)        {  *C*[i][j] += *A*[i][k] \* *B*[k][j];        }      }    }    end = clock();  *// Calculate execution time*    double exec\_time = (double)(end - start) / CLOCKS\_PER\_SEC;  *// Write execution time to file*    fprintf(file2, "%d,%lf\n", *size*, exec\_time);  }  *// Function to multiply two matrices using Strassen's algorithm*  void strassen(int *n*, int \*\**A*, int \*\**B*, int \*\**C*)  {    if (*n* == 1)    {  *C*[0][0] = *A*[0][0] \* *B*[0][0];      return;    }  *// Divide matrices into 4 submatrices*    int size = *n* / 2;    int \*\*A11 = malloc(size \* sizeof(int \*));    int \*\*A12 = malloc(size \* sizeof(int \*));    int \*\*A21 = malloc(size \* sizeof(int \*));    int \*\*A22 = malloc(size \* sizeof(int \*));    int \*\*B11 = malloc(size \* sizeof(int \*));    int \*\*B12 = malloc(size \* sizeof(int \*));    int \*\*B21 = malloc(size \* sizeof(int \*));    int \*\*B22 = malloc(size \* sizeof(int \*));    int \*\*C11 = malloc(size \* sizeof(int \*));    int \*\*C12 = malloc(size \* sizeof(int \*));    int \*\*C21 = malloc(size \* sizeof(int \*));    int \*\*C22 = malloc(size \* sizeof(int \*));    for (int i = 0; i < size; ++i)    {      A11[i] = malloc(size \* sizeof(int));      A12[i] = malloc(size \* sizeof(int));      A21[i] = malloc(size \* sizeof(int));      A22[i] = malloc(size \* sizeof(int));      B11[i] = malloc(size \* sizeof(int));      B12[i] = malloc(size \* sizeof(int));      B21[i] = malloc(size \* sizeof(int));      B22[i] = malloc(size \* sizeof(int));      C11[i] = malloc(size \* sizeof(int));      C12[i] = malloc(size \* sizeof(int));      C21[i] = malloc(size \* sizeof(int));      C22[i] = malloc(size \* sizeof(int));    }  *// Rest of the strassen function remains unchanged...*  *// Free dynamically allocated memory*    for (int i = 0; i < size; ++i)    {      free(A11[i]);      free(A12[i]);      free(A21[i]);      free(A22[i]);      free(B11[i]);      free(B12[i]);      free(B21[i]);      free(B22[i]);      free(C11[i]);      free(C12[i]);      free(C21[i]);      free(C22[i]);    }    free(A11);    free(A12);    free(A21);    free(A22);    free(B11);    free(B12);    free(B21);    free(B22);    free(C11);    free(C12);    free(C21);    free(C22);  }  *// Function to randomly initialize matrices A and B*  void randomize\_matrix(int *n*, int \*\**A*, int \*\**B*)  {    for (int i = 0; i < *n*; ++i)    {      for (int j = 0; j < *n*; ++j)      {  *A*[i][j] = rand() % 1025;  *B*[i][j] = rand() % 1025;      }    }  }  int main()  {  *// Seed for random number generation*    srand(time(NULL));  *// File to store Normal Matrix Multiplication results*    file2 = fopen("Normal\_Matrix\_Multiplication\_File.csv", "w");    fprintf(file2, "Size,Execution Time\n");  *// Perform Normal Matrix Multiplication for various matrix sizes*    for (int i = 2; i <= 500; i += 2)    {      int \*\*A = malloc(i \* sizeof(int \*));      int \*\*B = malloc(i \* sizeof(int \*));      int \*\*C = malloc(i \* sizeof(int \*));      for (int j = 0; j < i; ++j)      {        A[j] = malloc(i \* sizeof(int));        B[j] = malloc(i \* sizeof(int));        C[j] = malloc(i \* sizeof(int));      }      normal\_matrix\_multiplication(i, A, B, C);  *// Free dynamically allocated memory*      for (int j = 0; j < i; ++j)      {        free(A[j]);        free(B[j]);        free(C[j]);      }      free(A);      free(B);      free(C);    }    fclose(file2);  *// File to store Strassen's Matrix Multiplication results*    file1 = fopen("Strassens\_Matrix\_Multiplication\_File.csv", "w");    fprintf(file1, "Size,Execution Time\n");  *// Perform Strassen's Matrix Multiplication for various matrix sizes*    for (int i = 2; i <= 256; i \*= 2)    {      int \*\*A = malloc(i \* sizeof(int \*));      int \*\*B = malloc(i \* sizeof(int \*));      int \*\*C = malloc(i \* sizeof(int \*));      for (int j = 0; j < i; ++j)      {        A[j] = malloc(i \* sizeof(int));        B[j] = malloc(i \* sizeof(int));        C[j] = malloc(i \* sizeof(int));      }      randomize\_matrix(i, A, B);      clock\_t start = clock();   strassen(i, A, B, C);      clock\_t end = clock();      double exec\_time = (double)(end - start) / CLOCKS\_PER\_SEC;      fprintf(file1, "%d,%lf\n", i, exec\_time);  *// Free dynamically allocated memory*      for (int j = 0; j < i; ++j)      {        free(A[j]);        free(B[j]);        free(C[j]);      }      free(A);      free(B);      free(C);    }    fclose(file1);    return 0;  } |
| **Graphs** |  |
| **Pseudo Code & Example** |  |
| **Conclusion** | Hence, by completing this experiment I came to know about divide and conquer (MIN-MAX and Strassen’s Multiplication. |