<u>Experiment 24</u>
<u>Quick Sort and Merge Sort</u>

Date: 07-02-2021

Aim: Implement Quick sort and Merge Sort

Data Structures used: Array

Algorithm for Quick Sort (Quicksort)

Input: The array to be sorted and the index of the first and the last element
Output : The sorted Array
Data Structure : Array

Steps

1. Step 1: Start
2. Step 2: if(first<last) then
3. Step 1: q = Partition(arr,first, last)
4. Step 2: Quicksort(arr,first,q-1)
5. Step 3: Quicksort(arr,q+1,last)
6. Step 3: endif
7. Step 4: Stop

Algorithm for Partition (Partition)

Input: The array to be partitioned and the first and the last node(also known as the pivot)
Output: The correct index of the pivot in the sorted array
Data Structure used: Array

Steps

1. Step 1: Start
2. Step 2: pivot = arr[last]
3. Step 3: i = first-1
4. Step 4: j = first
5. Step 5: while j<=last-1 then
6. Step 1: if arr[j] <= pivot then
7. Step 1: i=i+1
8. Step 2: swap arr[i] and arr[j]
9. Step 2: EndIf
10. Step 6: End While
11. Step 7: swap arr[i+1] and arr[last]
12. return i+1

Algorithm for Merge Sort (merge_sort)
Input: The array and the starting and the ending index of the array to be sorted
Output : The sorted array
Data Structure used: Array

Steps

1. Step 1: Start
2. Step 2: if(first<last) then
3. Step 1: (first+last)/2
4. Step 2: merge_sort(arr,first,mid)
5. Step 3: merge_sort(arr,mid+1,last)
6. Step 4: merge(arr,first,mid,last)
7. Step 3: Endif
8. Step 4: Stop

Algorithm for Merge (merge)

Input: The array and upperbound and the lower bound and the middle element in the array
Output : The array is sorted
Data Structure used: Binary trees

Steps

1. Step 1: Start
2. Step 2: n1 = middle-lower+1
3. Step 3: n2 = upper – middle
4. Step4: let L[1...n1+1] and R[1….n2+1]
5. Step 5: for i=1 to n1 do
6. Step 1: L[i] = arr[lower+i-1]
7. Step 6: Done
8. Step 7: for j = 1 to n2 do
9. Step 1: R[j] = arr[middle+j]
10. Step 8: done
11. Step9: L[n1+1] = ∞
12. Step 10: R[n2+1]= ∞
13. Step 11: i=1
14. Step 12: j=1
15. Step 13: for k=first to last
16. Step1: if L[i]<=R[j] then
17. Step 1: A[k] = L[i]
18. Step 2: i++
19. Step 2: else
20. Step 1: A[k] = R[j]
21. Step 2: j++
22. Step 3: endif
23. Step 14: Done
24. Step 15 :Stop

Program Code

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

#define MAX_SIZE 100

typedef struct student_structure{
    char name[101];
    float height;
    float weight;
}student;

enum prop{NAME,HEIGHT,WEIGHT};
char prop_name[][10]={"Name","Height","Weight"};

/*******************************
 * Quick Sort
 * ****************************/
int partition(student *list, int first, int pivot, enum prop a){
    int i,j;

    i = first;
    j = first-1;
    while(i<pivot){
        int flag = 0;

        switch(a){
            case NAME:
                if(strcmp(list[i].name,list[pivot].name)<=0) flag = 1;
                break;
            case HEIGHT:
                if(list[i].height<=list[pivot].height) flag = 1;
                break;
            case WEIGHT:
                if(list[i].weight<=list[pivot].weight) flag = 1;
                break;
        }
        if(flag){
            j++;
            student temp = list[i];
            list[i] = list[j];
            list[j] = temp;
        }
        i++;
    }
    j++;
    if(pivot != j){
        student temp = list[pivot];
        list[pivot] = list[j];
        list[j] = temp;
    }
    return j;
```

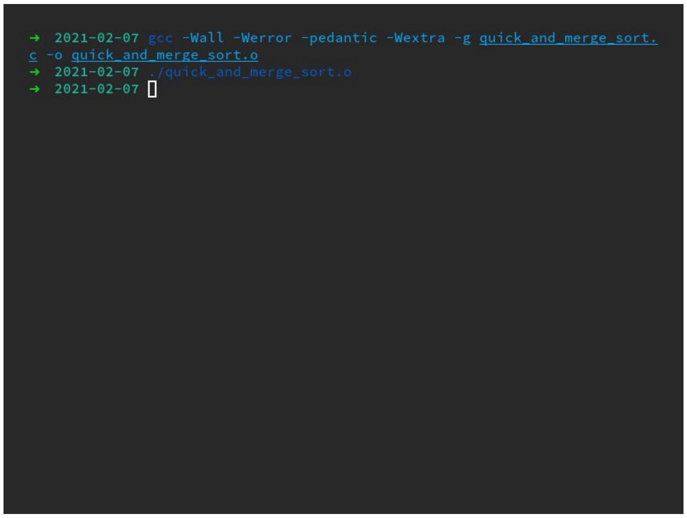
```
}

void quick_sort(student *list,int first,int last,enum prop a){
    if(first<last){
        int q = partition(list, first,last,a);
        quick_sort(list, first, q-1,a);
        quick_sort(list,q+1,last,a);
    }
}

/******************************
 * Merge Sort
 * ******************************/
void merge(student *list,int first,int mid,int last,enum prop a){
    int n = last-first+1;
    student *temp =(student*)malloc(n*sizeof(student)) ;

    int i,j,flag,k=0;
    for(i=first,j=mid+1;i<=mid&&j<=last;)
    {
        flag = 0;
        switch(a){
            case NAME:
                if(strcmp(list[i].name,list[j].name)<0){
                    flag = 1;
                }
                break;
            case HEIGHT:
                if(list[i].height<=list[j].height){
                    flag =1;
                }
                break;
            case WEIGHT:
                if(list[i].weight<=list[j].weight){
                    flag =1;
                }
                break;
        }
        if(flag){ //if the flag is true then add i, else add j;
            strcpy(temp[k].name,list[i].name);
            temp[k].height= list[i].height;
            temp[k].weight = list[i].weight;
            i++;
        }
        else{
            strcpy(temp[k].name,list[j].name);
            temp[k].height= list[j].height;
            temp[k].weight = list[j].weight;
            j++;
        }
        k++;
    }
    while(i<=mid){
        temp[k] = list[i];
        i++;k++;
    }
```

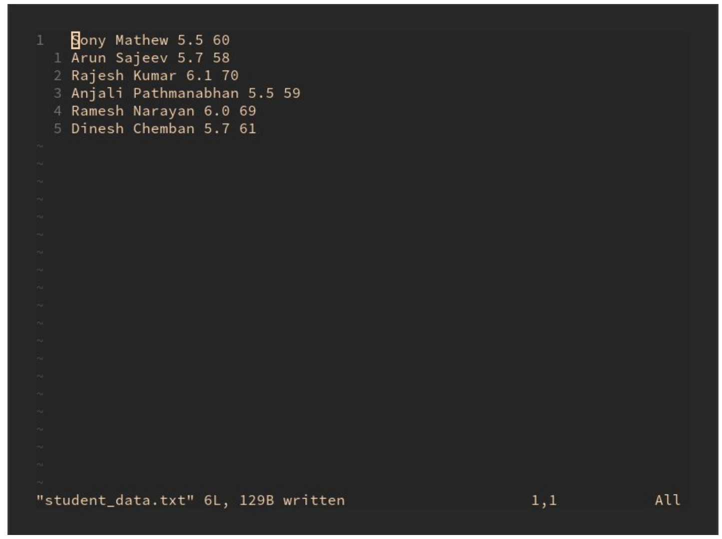
```c
    while(j<=last){
        temp[k] = list[i];
        j++;k++;
    }
    k=0;
    for(i = first;i<=last;i++){
        strcpy(list[i].name,temp[k].name);
        list[i].height= temp[k].height;
        list[i].weight = temp[k].weight;
        k++;
    }
}

void merge_sort(student *list, int first, int last, enum prop a)
{
    if(first<last){
        int mid = (first+last)/2;
        merge_sort(list,first,mid,a);
        merge_sort(list,mid+1,last,a);
        merge(list,first,mid,last,a);
    }
}

void list_copy (student* l1, student* l2,int n){
    for(int i=0;i<n;i++){
        strcpy(l1[i].name,l2[i].name);
        l1[i].height = l2[i].height;
        l1[i].weight = l2[i].weight;
    }
}

int main(){

    student *student_list = (student*) malloc(MAX_SIZE*sizeof(student));
    student *temp_list = (student*) malloc(MAX_SIZE*sizeof(student));
//    FILE *file = fopen("./output.txt","w");

    char first_name[50];
    char last_name[50];
    int n = 0;
    int i;
    enum prop a = HEIGHT;

    clock_t t;
    double time_taken;

    if(freopen("./student_data.txt","r",stdin)){
        FILE *quickSortOp = fopen("./quicksortop.txt","w");
        FILE *mergeSortOp = fopen("./mergesortop.txt","w");
        while(scanf("%s %s %f %f\n", first_name,last_name,&(student_list[n].height),
                    &(student_list[n].weight))==4) {
            //conactinate the first and the last names
            strcat(student_list[n].name, first_name);
            strcat(student_list[n].name, " ");
            strcat(student_list[n].name, last_name);
            n++;
```

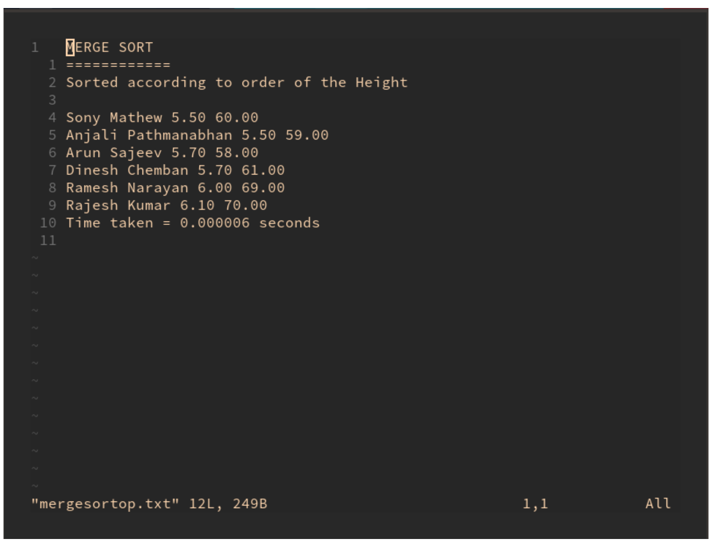
```
        }
        fprintf(quickSortOp,"QUICK SORT\n");
        fprintf(quickSortOp,"============\n");

//        for(int a=NAME;a<=WEIGHT;a++ ){ //For iterating through all the
            list_copy(temp_list,student_list,n);

            t = clock();
            quick_sort(temp_list,0,n-1,a);
            t = clock()-t;

            i=0;
            fprintf(quickSortOp,"Sorted according to order of the %s\n\
n",prop_name[a]);
            while(i<n){
                fprintf(quickSortOp,"%s %.2f %.2f\
n",temp_list[i].name,temp_list[i].height,temp_list[i].weight);
                i++;
            }

            time_taken = ((double)t)/(CLOCKS_PER_SEC);
            fprintf(quickSortOp,"Time taken = %lf seconds",time_taken);
            fprintf(quickSortOp,"\n\n");
 //       }

        fprintf(mergeSortOp,"MERGE SORT\n");
        fprintf(mergeSortOp,"============\n");

 //       for(int a = NAME; a<=WEIGHT;a++){
            list_copy(temp_list,student_list,n);

            t = clock();
            merge_sort(temp_list,0,n-1,a);
            t = clock()-t;

            i=0;
            fprintf(mergeSortOp,"Sorted according to order of the %s\n\
n",prop_name[a]);
            while(i<n){
                fprintf(mergeSortOp,"%s %.2f %.2f\
n",temp_list[i].name,temp_list[i].height,temp_list[i].weight);
                i++;
            }

            time_taken = ((double)t)/(CLOCKS_PER_SEC);
            fprintf(mergeSortOp,"Time taken = %lf seconds",time_taken);
            fprintf(mergeSortOp,"\n\n");
//        }
    }

    return 0;
}
```

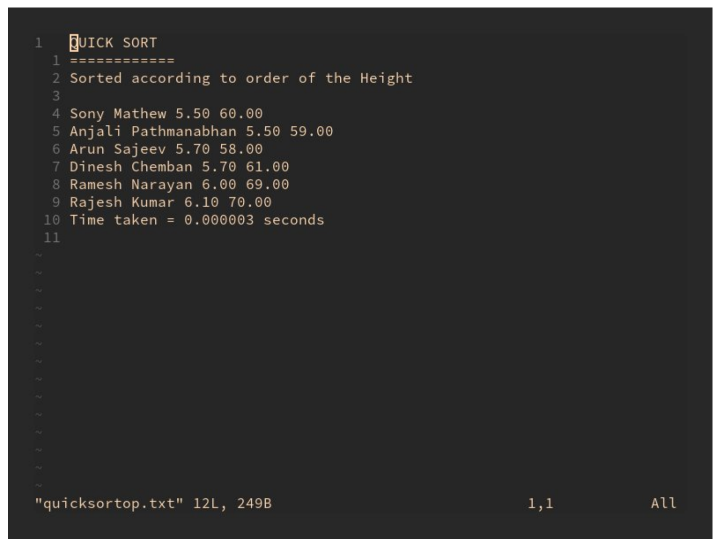
Result: The program compiled successfully and required output was obtained

Sample input and output









Experiment 25
Heap Sort

Date: 07-02-2021

Aim: Sort an array of numbers using heap sort and find an element in the array using binary search

Data Structures used: Array

Algorithm for Create Heap (create_heap)

Input: The array to be sorted and size of the array
Output : The elements of the array now follows the heap property
Data Structure : Array

Steps

1. Step 1: Start
2. Step 2: i = 1
3. Step 3: while i<=n do
4. Step 3: j = i
5. Step 4: while j>1 do
6. Step 1: if A[j] > A[j/2] then
7. Step 1: swap (A[j],A[j/2])
8. Step 2: j=j/2
9. Step 2: else
10. Step 1: j = 1
11. Step 3: endif
12. Step 5: EndWhile
13. Step 6: i = i+1
14. Step 4: endWhile
15. Step 5: Stop

Algorithm for Remove max (remove_max)

Input: The largest element in the heap and the index
Output: The largest and the element at the bottom of the heap
Data Structure used: Array

Steps
1. Step 1: Start
2. Step 2: temp = A[i]
3. Step 3: A[i] = A[1]
4. Step 4: A[1] = temp
5. Step 5: Stop

Algorithm for Rebuild Heap (rebuild_heap)
Input: The Array after the remove_max algorithm
Output: The array satisfies the heap property
Data Structure used: Array

Steps
1. Step 1: Start
2. Step 2: if(i == 1)then
3. Step 1: retun

4. Step 3: else
5. Step 1: j = 0
6. Step 2: flag = true
7. Step 3: while(flage == true) do
8. Step 1: leftchild = j*2
9. Step 2: rightchild = j*2+1
10. Step 3: largest = j
11. Step 4: if(leftchild<=i and A[largest]<A[leftchild]) then
12. Step 1: largest = leftchild
13. Step 5: endIf
14. Step 6: if(rightchild<=i and A[largest]<A[rightchild]) then
15. Step 1: largest = rightchild
16. Step 7: endIf
17. Step 8: if(largest!=j) then
18. swap(A[j], A[largest])
19. Step 9: else
20. Step 1: flag = flase
21. Step 10: endif
22. Step 4: endWhile
23. Step 4: Endif
24. Step 5: Stop

Result: The program was compiled successfully and the required output was obtained

Program Code

```
/***************************
 * Heap Sort
 * Done By: Rohit Karunakaran
 ***************************/
#include<stdio.h>
#include<stdlib.h>

void swap(int* arr, int i, int j){
    int temp = arr[i];
    arr[i] = arr[j];
    arr[j] = temp;
}

void create_heap(int *arr,  int n){
   int i = 0;
   int k,j;
   while(i<n){
        j = i;
        while(j>0){
            k = j%2==0?j/2-1:j/2;
            if(arr[j]>arr[k]){
                swap(arr,j,k);
                j = k;
            }
            else{
                j=0;
            }
        }
    i++;
   }
```

```
   //printf("Entered heap sort");
}

void heapify(int *arr, int i){
//i is the upper bound
    if(i == 0){
        return; //the array is sorted
    }
    else{
        int j=0;
        int flag = 1;
        while(flag){
            int largest = j;//initially assume the parent is the largerst which in
the first loop is'nt
            int lc = 2*j+1;
            int rc = 2*(j+1);

            if(lc<=i && arr[lc]>arr[largest])largest = lc;
            if(rc<=i && arr[rc]>arr[largest])largest = rc;

            if(j!=largest){
                swap(arr,j,largest);
            }
            else{
               // printf("swapped\n");
                flag =0; //if there is no change in the largest element then the
array is heapified
            }
        }

    }
}

void heap_sort(int *arr, int n){
    create_heap(arr,n);
    for(int i = n-1;i>=0;i--){
        swap(arr,i,0);
        heapify(arr,i-1);
    }
}

int binary_search(int *arr, int first, int last, int elem){
    if(first<=last){
        int mid = (first+last)/2;
       if(arr[mid]== elem){
            return mid;
       }
       else if(arr[mid]>elem){
            return binary_search(arr,first,mid-1,elem);
       }
       else{
            return binary_search(arr,mid+1,last,elem);
       }
    }
    else{
```

```c
        return -1;
    }
}

int main(){
    int n;
    int elem;
    int* arr = (int*)malloc(20*sizeof(int));

    printf("Enter the number of elements: ");
    scanf("%d",&n);

    printf("Enter the elements : ");
    for(int i = 0; i<n;i++){
        scanf("%d",arr+i);
    }

    heap_sort(arr,n);
    printf("The sorted array is : ");

    for(int i = 0;i<n;i++){
        printf("%d ",arr[i]);
    }
    printf("\n");
    printf("Enter the element to be searched: ");
    scanf("%d", &elem);
    int index = binary_search(arr,0,n-1,elem);
    if(index!=-1){
        printf("The element is found at index %d\n",index);
    }
    else{
        printf("The element doesnt exist\n");
    }

    free(arr);

    return 0;
}
```

Sample input/output

```
➜  2021-02-07 ./heap_sort.o
Enter the number of elements: 6
Enter the elements : 12 13 18 91 2 1
The sorted array is : 1 2 12 13 18 91
Enter the element to be searched: 13
The element is found at index 3
➜  2021-02-07 ./heap_sort.o
Enter the number of elements: 6
Enter the elements : 12 0 9 3 6 12
The sorted array is : 0 3 6 9 12 12
Enter the element to be searched: 1
The element doesnt exist
```