	Finolex Academy of Management and Technology, Ratnagiri		
	Department of Information Technology		
Subject name: Intelligent Systems Labs			Subject Code: BEITC703
Class	BE IT	Semester – VII (CBGS)	Academic year: 2019-20
Name of Student		**QUIZ Score :**	
Roll No		Assignment/Experiment No.	04
Title: **To implement 8 puzzle problem with Heuristic function using Best first search.**			

1. Course objectives applicable: COB2.Understand the different informed searching techniques to solve the different AI problems on the basis heuristic functions.

2. Course outcomes applicable:

CO2 –Solve the problems based on heuristic functions used for searching.

3. Learning Objectives:

1. To understand concept of informed search.
2. To understand heuristic functions.
3. To program for 8 puzzle problem by using best first search algorithm.
4. To get the output which will calculate heuristic function values ad returns the steps towards goal state.

4. Practical applications of the assignment/experiment: complex problems used for gaming like chess and 8 puzzle.

5. Prerequisites:

1. To learn the use of intelligent agents in informed search.
2. To understand the programming methodology for best first search using heuristic functions.

6. Hardware Requirements:

1. PC with minimum 2GB RAM

7. Software Requirements:

1. Windows installed
2. JDK/Net beans

8. Quiz Questions (if any): (Online Exam will be taken separately batch wise, attach the certificate/ Marks obtained)

1. What do you mean by heuristic functions?
2. What is Best First Search algorithm?
3. What is fringe?
4. What is space complexity of best first search algorithm?

9. Experiment/Assignment Evaluation:

Sr. No.	**Parameters**	**Marks obtained**	**Out of**
1	Technical Understanding (Assessment may be done based on Q & A **or** any other relevant method.) Teacher should mention the other method used -		6
2	Neatness/presentation		2
3	Punctuality		2
Date of performance (DOP)		**Total marks obtained**	**10**
Date of checking (DOC)		**Signature of teacher**	

11. Precautions:

1. Find heuristic function values h(n) and general function f(n).
2. Calculate both functions to find the goal state.

12. Installation Steps / Performance Steps –

```
import java.util.Arrays;
import java.util.Comparator;
import java.util.HashSet;
import java.util.PriorityQueue;

public class EightPuzzle {


   static final byte [] goalTiles = { 1, 2, 3, 8, 0, 4, 7, 6, 5 };

   // A* priority queue.
   final PriorityQueue <State> queue = new PriorityQueue<State>(100, new Comparator<State>()
         {
      @Override
      public int compare(State a, State b)
         {
         return a.priority() - b.priority();
      }
         });

   // The closed state set.
   final HashSet <State> closed = new HashSet <State>();

   // State of the puzzle including its priority and chain to start state.
   class State
         {
         final byte [] tiles;    // Tiles left to right, top to bottom.
                  final int spaceIndex;   // Index of space (zero) in tiles
         final int g;            // Number of moves from start.
         final int h;            // Heuristic value (difference from goal)
         final State prev;       // Previous state in solution chain.

      // A* priority function (often called F in books).
      int priority()
         {
         return g + h;
      }

      // Build a start state.
      State(byte [] initial)
         {
         tiles = initial;
         spaceIndex = index(tiles, 0);
         g = 0;
         h = heuristic(tiles);
         prev = null;
      }

      // Build a successor to prev by sliding tile from given index.
```

```
State(State prev, int slideFromIndex)
   {
   tiles = Arrays.copyOf(prev.tiles, prev.tiles.length);
   tiles[prev.spaceIndex] = tiles[slideFromIndex];
   tiles[slideFromIndex] = 0;
   spaceIndex = slideFromIndex;
   g = prev.g + 1;
   h = heuristic(tiles);
   this.prev = prev;
}

// Return true iif this is the goal state.
boolean isGoal()
   {
   return Arrays.equals(tiles, goalTiles);
}

// Successor states due to south, north, west, and east moves.
State moveS() { return spaceIndex > 2 ? new State(this, spaceIndex - 3) : null; }
State moveN() { return spaceIndex < 6 ? new State(this, spaceIndex + 3) : null; }
State moveE() { return spaceIndex % 3 > 0 ? new State(this, spaceIndex - 1) : null; }
State moveW() { return spaceIndex % 3 < 2 ? new State(this, spaceIndex + 1) : null; }

// Print this state.
void print()
   {
   System.out.println("  p = " + priority() + " = g+h = " + g + "+" + h);
   for (int i = 0; i < 9; i += 3)
      System.out.println("  " + tiles[i] + " " + tiles[i+1] + " " + tiles[i+2]);
}

// Print the solution chain with start state first.
void printAll()
   {
   if (prev != null) prev.printAll();
   System.out.println();
   print();
}

@Override
public boolean equals(Object obj)
   {
   if (obj instanceof State)
      {
      State other = (State)obj;
      return Arrays.equals(tiles, other.tiles);
   }
   return false;
}

@Override
public int hashCode()
   {
   return Arrays.hashCode(tiles);
}
```

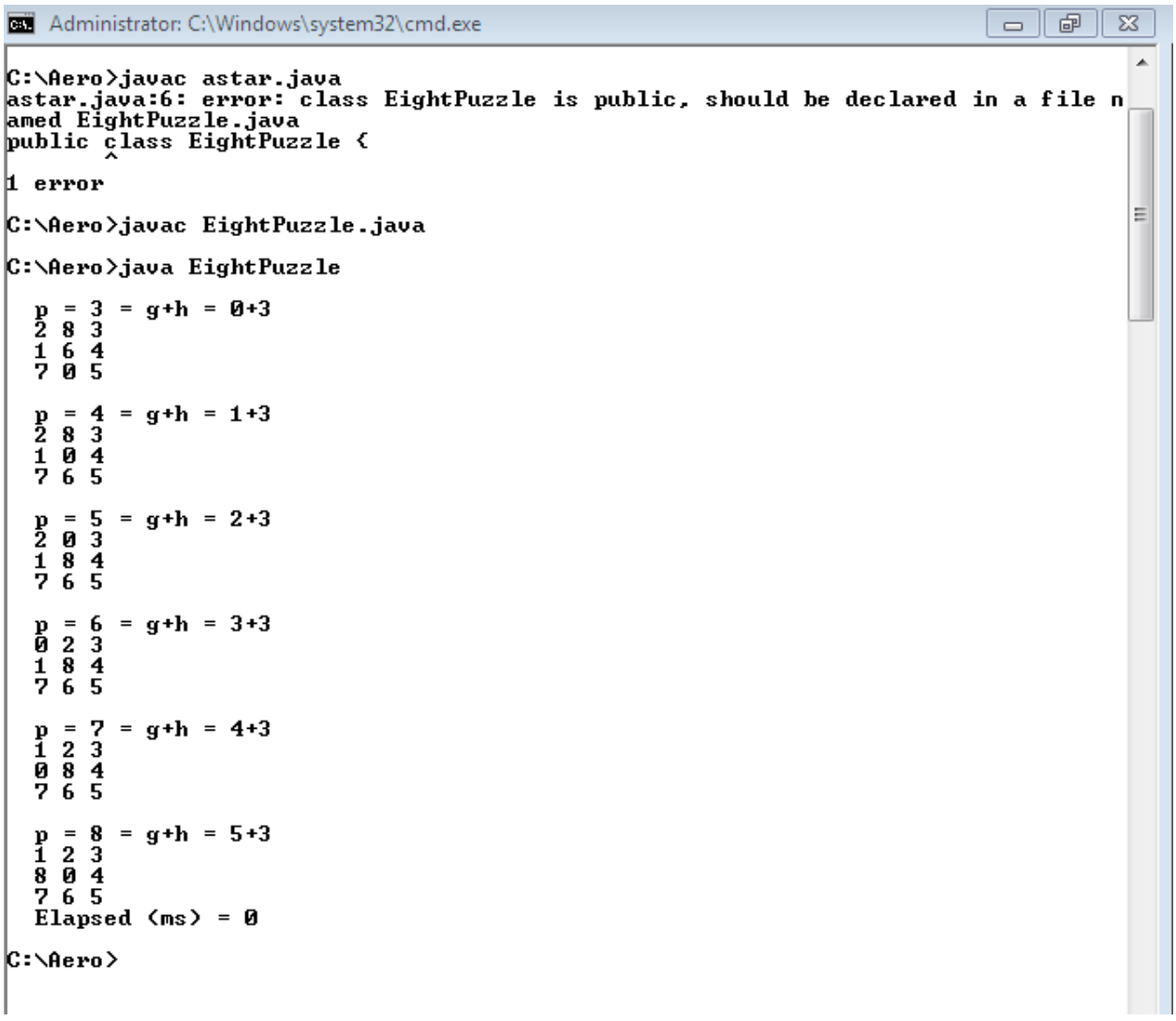
```
}

// Add a valid (non-null and not closed) successor to the A* queue.
void addSuccessor(State successor) {
   if (successor != null && !closed.contains(successor))
      queue.add(successor);
}

// Run the solver.
void solve(byte [] initial) {

   queue.clear();
   closed.clear();

   // Click the stopwatch.
   long start = System.currentTimeMillis();

   // Add initial state to queue.
   queue.add(new State(initial));

   while (!queue.isEmpty()) {

      // Get the lowest priority state.
      State state = queue.poll();

      // If it's the goal, we're done.
      if (state.isGoal()) {
         long elapsed = System.currentTimeMillis() - start;
         state.printAll();
         System.out.println("  Elapsed (ms) = " + elapsed);
         return;
      }

      // Make sure we don't revisit this state.
      closed.add(state);

      // Add successors to the queue.
      addSuccessor(state.moveS());
      addSuccessor(state.moveN());
      addSuccessor(state.moveW());
      addSuccessor(state.moveE());
   }
}

// Return the index of val in given byte array or -1 if none found.
static int index(byte [] a, int val) {
   for (int i = 0; i < a.length; i++)
      if (a[i] == val) return i;
   return -1;
}

// Return the Manhatten distance between tiles with indices a and b.
static int manhattanDistance(int a, int b) {
   return Math.abs(a / 3 - b / 3) + Math.abs(a % 3 - b % 3);
}
```

```
    // For our A* heuristic, we just use max of Manhatten distances of all tiles.
    static int heuristic(byte [] tiles) {
        int h = 0;
        for (int i = 0; i < tiles.length; i++)
            if (tiles[i] != 0)
                h = Math.max(h, manhattanDistance(i, tiles[i]));
        return h;
    }
    public static void main(String[] args) {

        // This is a harder puzzle than the SO example
        byte [] initial = { 2, 8, 3, 1, 6, 4, 7, 0, 5 };

        // This is taken from the SO example.
        //byte [] initial = { 1, 4, 2, 3, 0, 5, 6, 7, 8 };

        new EightPuzzle().solve(initial);
    }
}
```

13. Observations

1. The output will give the sequence of steps to find the solution path or goal node.

14. Results:



15. Learning Outcomes Achieved

1. Understanding the concept of informed search.
2. Understanding the eight puzzle problem solved by informed search technique.

16. Conclusion:

1. **Applications of the studied technique in industry**
    a. Best first algorithm used to develop intelligent systems which will be used to develop games like 8 puzzle.
2. **Engineering Relevance**
    a. Such algorithms are very useful in searching techniques where number of solutions are more than one and complex.
3. **Skills Developed**
    a. Implementation of Best first search for 8 puzzle problem.

17. References :

[1] G. Görz, C.-R. Rollinger, J. Schneeberger (Hrsg.) “Handbuch der künstlichen Intelligenz” Oldenbourg Verlag, 2003, Fourth edition
• [2] Turing, A. "Computing Machinery and Intelligence", Mind LIX (236): 433–460, Ocotober, 1950.
• [3] Aristotle “On Interpretation”, 350 B.C.E, see: http://classics.mit.edu/Aristotle/interpretation.html
• [4] Newell, A., Simon, H.A. “Human Problem Solving” Englewood Cliffs, N.J.: Prentice Hall, 1972
• [5] Newell, A. “The Knowledge Level”, AI Magazine 2 (2), 1981, p. 1-20.