KR-IST - Lecture 4b
Heuristic search in Java

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This lecture (which may be skipped if we are behind time) works through an implementation of heuristic search for the 8-puzzle.
import java.util.*;

class Node {
    int[] state = new int[9];
    int cost;
    Node parent = null;
    Vector<Node> successors = new Vector<Node>();

    Node(int s[], Node parent) {
        this.parent = parent;
        for (int i = 0; i < 9; i++) state[i] = s[i];
    }

    public String toString() {
        String s = "";
        for (int i = 0; i < 9; i++) {
            s = s + state[i] + " ";
        }
        return s;
    }
}
public boolean equals(Node n) {
    boolean result = true;
    for (int i = 0; i < 9; i++) {
        if (n.state[i] != state[i]) result = false;
    }
    return result;
}

Vector<Node> getPath(Vector<Node> v) {
    v.insertElementAt(this, 0);
    if (parent != null) v = parent.getPath(v);
    return v;
}

Vector<Node> getPath() {
    return getPath(new Vector<Node>());
}
class EightPuzzleSpace {

    Node getRoot() {
        int ex[] = {3, 1, 2, 4, 7, 5, 6, 8, 0};
        int rn[] = {7, 2, 4, 5, 0, 6, 8, 3, 1}; // the Russell and Norvig
        return new Node(ex, null);
    }

    Node getGoal() {
        int state[] = {0, 1, 2, 3, 4, 5, 6, 7, 8};
        return new Node(state, null);
    }

    Node transformState(int r0, int c0, int r1, int c1, Node parent) {
        int[] s = parent.state;
        int[] newState = {s[0], s[1], s[2], s[3], s[4], s[5], s[6], s[7],
                         newState[(r1 * 3) + c1] = s[(r0 * 3) + c0];
                         newState[(r0 * 3) + c0] = 0;
        return new Node(newState, parent);
    }
}
Vector<Node> getSuccessors(Node parent) {
    Vector<Node> successors = new Vector<Node>();
    for (int r = 0; r < 3; r++) {
        for (int c = 0; c < 3; c++) {
            if (parent.state[(r * 3) + c] == 0) { /* hole here */
                if (r > 0) { /* move tile from left */
                    successors.add(transformState(r-1, c, r, c, parent));
                }
                if (r < 2) { /* move tile from right */
                    successors.add(transformState(r+1, c, r, c, parent));
                }
                if (c > 0) { /* move tile from below */
                    successors.add(transformState(r, c-1, r, c, parent));
                }
                if (c < 2) { /* move tile from above */
                    successors.add(transformState(r, c+1, r, c, parent));
                }
            }
        }
    }
    parent.successors = successors; /* used in getTree */
    return successors;
}
public class EightPuzzleSearch {
    EightPuzzleSpace space = new EightPuzzleSpace();
    Vector<Node> open = new Vector<Node>();
    Vector<Node> closed = new Vector<Node>();

    int h1Cost(Node node) {
        int cost = 0;
        for (int i = 0; i < node.state.length; i++) {
            if (node.state[i] != i) cost++;
        }
        return cost;
    }
}
The h2 heuristic

```java
int h2Cost(Node node) {
    int cost = 0;
    int state[] = node.state;
    for (int i = 0; i < state.length; i++) {
        int v0 = i, v1 = state[i];
        if (v1 == 0) continue; /* don’t count the hole */
        int row0 = v0 / 3, col0 = v0 % 3, row1 = v1 / 3, col1 = v1 % 3;
        int c = (Math.abs(row0 - row1) + Math.abs(col0 - col1));
        cost += c; }
    return cost;
}

int hCost(Node node) { /* set to call either h1 or h2 */
    return h2Cost(node);
}
```
Node getBestNode(Vector nodes) {
    int index = 0, minCost = Integer.MAX_VALUE;
    for (int i = 0; i < nodes.size(); i++) {
        Node node = (Node)nodes.elementAt(i);
        if (node.cost < minCost) {
            minCost = node.cost;
            index = i; } }
    Node bestNode = (Node)nodes.remove(index);
    return(bestNode);
}

Node getUniqueNode(Node node) {
    int i = open.indexOf(node);
    if (i != -1) {
        node = open.get(i); } 
    else if ((i = closed.indexOf(node)) != -1) {
        node = closed.get(i); } 
    return(node);
}
void printPath(Vector path) {
    for (int i = 0; i < path.size(); i++) {
        System.out.print(" "+ path.elementAt(i) + \\
    }
}

void run() {
    Node root = space.getRoot();
    Node goal = space.getGoal();
    Node solution = null;
    open.add(root);
    System.out.print("\nRoot: "+ root + "\n\n");
while (open.size() > 0) {
    Node node = getBestNode(open);
    int pathLength = node.getPath().size();
    closed.add(node);
    if (node.equals(goal)) { solution = node; break; }
    Vector<Node> successors = space.getSuccessors(node);
    for (int i = 0; i < successors.size(); i++) {
        Node successor = getUniqueNode(successors.get(i));
        int cost = hCost(successor) + pathLength + 1;
        int previousCost = successor.cost;
        boolean inClosed = closed.contains(successor);
        boolean inOpen = open.contains(successor);
        if (!(inClosed || inOpen) || cost < previousCost) {
            if (inClosed) closed.remove(successor);
            if (!inOpen) open.add(successor);
            successor.cost = cost;
            successor.parent = node;
        }
    }
}
// new TreePrint(getTree(root));
if (solution != null) {
    Vector path = solution.getPath();
    System.out.print("\nSolution found\n");
    printPath(path); }
}

public static void main(String args[]) { // do the search
    new EightPuzzleSearch().run();
}
Search space explored

Root: 3 1 2 4 7 5 6 8 0

3 1 2 4 7 5 6 8 0
|-- 3 1 2 4 7 0 6 8 5
|-- 3 1 2 4 7 5 6 0 8
 ||-- 3 1 2 4 0 5 6 7 8
 | ||-- 3 0 2 4 1 5 6 7 8
 | ||-- 3 1 2 4 7 5 6 0 8
 | ||-- 3 1 2 0 4 5 6 7 8
 | | ||-- 0 1 2 3 4 5 6 7 8
 | | ||-- 3 1 2 6 4 5 0 7 8
 | | ||-- 3 1 2 4 0 5 6 7 8
 | | ||-- 3 1 2 4 5 0 6 7 8
|-- 3 1 2 4 7 5 0 6 8
|-- 3 1 2 4 7 5 6 8 0
Solution path

3 1 2 4 7 5 6 8 0
3 1 2 4 7 5 6 0 8
3 1 2 4 0 5 6 7 8
3 1 2 0 4 5 6 7 8
0 1 2 3 4 5 6 7 8
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