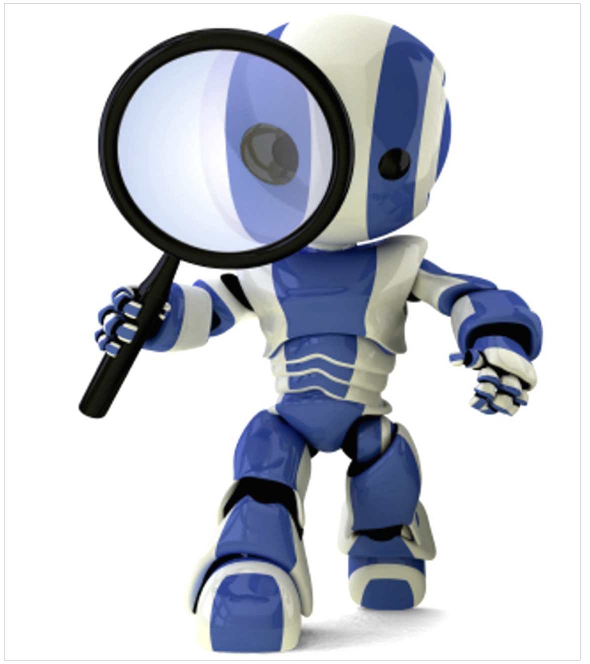
# P8.py



# 8 puzzle in python

- Look at a simple implementation of an eight puzzle solver in python
- p8.py
- Solve using A* with three different heuristics
  - NIL: h = 1
  - OOP: h = # of tiles out of place
  - MHD: h = sum of manhatten distance between each tile's current & goal positions
- All three are admissible

# What must we model?

- A state
- Goal test
- Actions
- Result of doing action in state
- Heuristic function

# Representing states and actions

- Represent state as string of nine characters with blank as *

  E.g.: s = '1234*5678'

| | | |
|---|---|---|
| **1** | **2** | **3** |
| **4** | ***** | **5** |
| **6** | **7** | **8** |

- Position of blank in state S is

```
> s.index('*')
4
```

- Represent an action as one of four possible ways to move the blank:

```
up down right left
```

# Legal Actions

```
def actions8(s):  # returns list of legal actions in state s
    action_table = {
        0:['down', 'right'],
        1:['down', 'left', 'right'],
        2:['down', 'left'],
        3:['up', 'down', 'right'],
        4:['up', 'down', 'left', 'right'],
        5:['up', 'down', 'left'],
        6:['up', 'right'],
        7:['up', 'left', 'right'],
        8:['up', 'left'] }
    return action_table[s.index('*')]
```

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

Function maps a **position** to a list of **possible moves** for a tile in that position

# Result of action A on state S

```
def result8(S, A):
    blank = S.index('*')    # blank position
    if A == 'up':
        swap = blank - 3
        return S[0:swap] + '*' + S[swap+1:blank] + S[swap] + S[blank+1:]
    elif A == 'down':
        swap = blank + 3
        return S[0:blank] + S[swap] + S[blank+1:swap] + '*' + S[swap+1:]
    elif A == 'left':
        swap = blank - 1
        return S[0:swap] + '*' + S[swap] + S[blank+1:]
    elif A == 'right':
        swap = blank + 1
        return S[0:blank] + S[swap] + '*' + S[swap+1:]
    raise ValueError('Unrecognized action: ' + A)
```

# Heuristic functions

```
class P8_h1(P8):
    """ Eight puzzle using a heuristic function that counts number
    of tiles out of place"””
    name = 'Out of Place Heuristic (OOP)’

 def h(self, node):
        ""”OOP 8 puzzle heuristic: number of tiles 'out of place'
        between a node's state and the goal"""
        mismatches = 0
        for (t1, t2) in zip(node.state, self.goal):
            if  t1 != t2: mismatches =+ 1
        return mismatches
```

# Path_cost method

Since path cost is just the number of steps, we can use the default version define in Problem

```
def path_cost(self, c, state1, action, state2):
    """Return cost of a solution path that arrives at state2 from
    state1 via action, assuming cost c to get up to state1. If problem
    is such that the path doesn't matter, this function will only look at
    state2.  If the path does matter, it will consider c and maybe state1
    and action. The default method costs 1 for every step in the path."""
    return c + 1
```

# How can we test this?

- Need solvable test problems that aren't too hard
  - Recall that the state space has two disjoint sets!
  - Generating a random initial & goal states will result in no possible solution 50% of the time
- Idea: take a random walk of N steps from the goal
  - Resulting state is solvable in $\leq$ N moves
  - Ensure random walk has no loops for a better test
- What metrics can we use to compare heuristics?
  - # of states generated, # of states expanded, effective branching factor (efb), and run time

# Example

- Generate tests of different distances from *12345678

  15 steps: 4*3275681 => *12345678

  19 steps: 4258361*7 => *12345678

- Solve using three heuristics, collect data

| heuristic used | solution length | states generated | successors computed | effective branching fac. | runtime in seconds |
|---|---|---|---|---|---|
| NIL | 15 | 14,386 | 5,173 | 1.77 | 5.47145 |
| OOP | 15 | 761 | 283 | 1.46 | 0.02097 |
| MHD | 15 | 87 | 31 | 1.26 | 0.00086 |
| | | | | | |
| NIL | 19 | 78,872 | 28,567 | 1.72 | 159.1051 |
| OOP | 19 | 3,906 | 1,457 | 1.47 | 0.4217 |
| MHD | 19 | 499 | 185 | 1.32 | 0.1238 |

# P8 Problem on Colab

- See our collection of AI notebooks on Colab and the code and data in our repo
- P8.ipynb which uses p8.py and search.py