NPTEL MOOC

PROGRAMMING, DATA STRUCTURES AND ALGORITHMS IN PYTHON

Week 6, Lecture 4

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Data structures

- *Algorithms + Data Structures = Programs*
  Niklaus Wirth
- Arrays/lists — sequences of values
- Dictionaries — key-value pairs
- Python also has sets as a built in datatype

Sets in Python

- List with braces, duplicates automatically removed

```
colours = {‘red','black','red','green'}

>>> print(colours)
{'black', 'red', 'green'}
```

- Create an empty set

```
colours = set()
```

  - Note, not `colours = {}` — empty dictionary!

Sets in Python

- Set membership

```
>>> 'black' in colours
True
```

- Convert a list into a set

```
>>> numbers = set([0,1,3,2,1,4])
>>> print(numbers)
{0, 1, 2, 3, 4}

>>> letters = set('banana')
>>> print(letters)
{'a', 'n', 'b'}
```

Set operations

```
odd = set([1,3,5,7,9,11])
prime = set([2,3,5,7,11])
```

- Union
  `odd | prime` ⟶ `{1, 2, 3, 5, 7, 9, 11}`
- Intersection
  `odd & prime` ⟶ `{3, 11, 5, 7}`
- Set difference
  `odd - prime` ⟶ `{1, 9}`
- Exclusive or
  `odd ^ prime` ⟶ `{1, 2, 9}`

Stacks

- Stack is a last-in, first-out list
  - `push(s,x)` — add `x` to stack `s`
  - `pop(s)` — return most recently added element
- Maintain stack as list, push and pop from the right
  - `push(s,x)` is `s.append(x)`
  - `s.pop()` — Python built-in, returns last element

Stacks

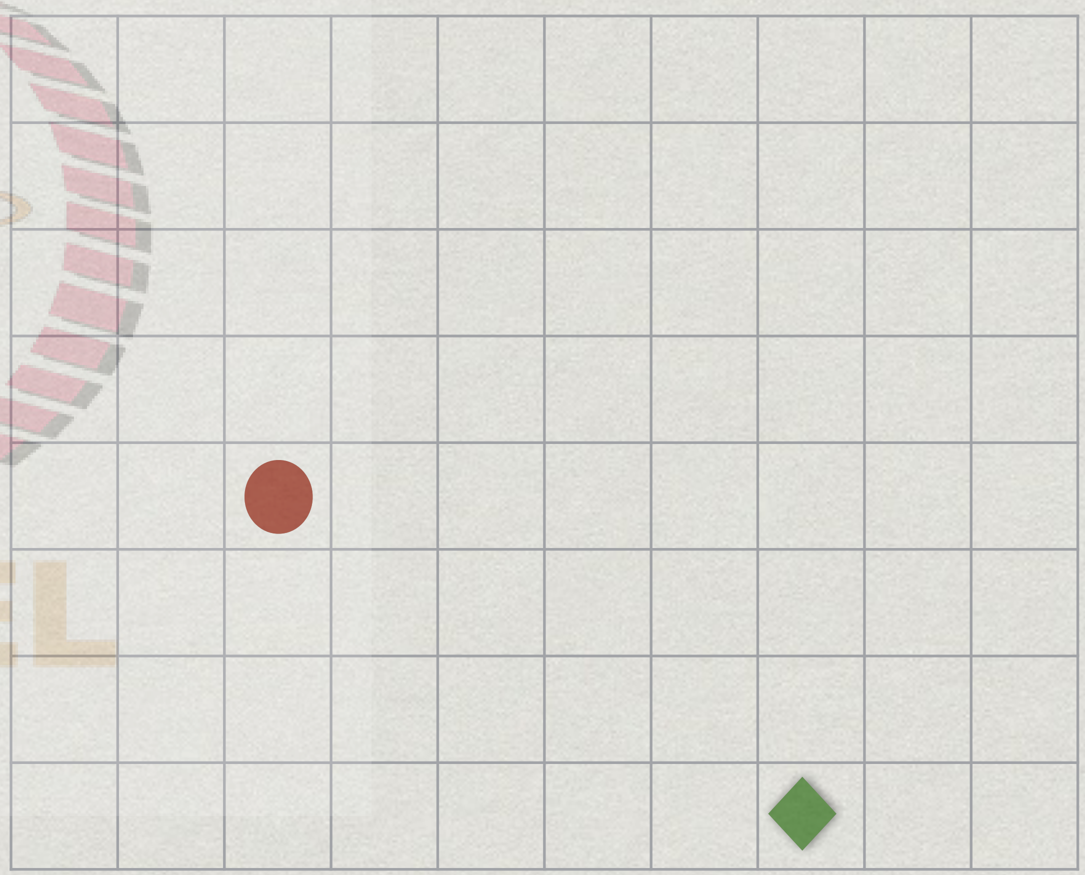
- Stacks are natural to keep track of recursive function calls
- In 8 queens, use a stack to keep track of queens added
  - Push the latest queen onto the stack
  - To backtrack, pop the last queen added

Queues

- First-in, first-out sequences
  - `addq(q,x)` — adds `x` to rear of queue `q`
  - `removeq(q)` — removes element at head of `q`
- Using Python lists, left is rear, right is front
  - `addq(q,x)` is `q.insert(0,x)`
    - `l.insert(j,x)`, insert `x` before position `j`
  - `removeq(q)` is `q.pop()`

Systematic exploration

- Rectangular m x n grid
- Chess knight starts at (sx,sy)
    - Usual knight moves
- Can it reach a target square (tx,ty)? ◆



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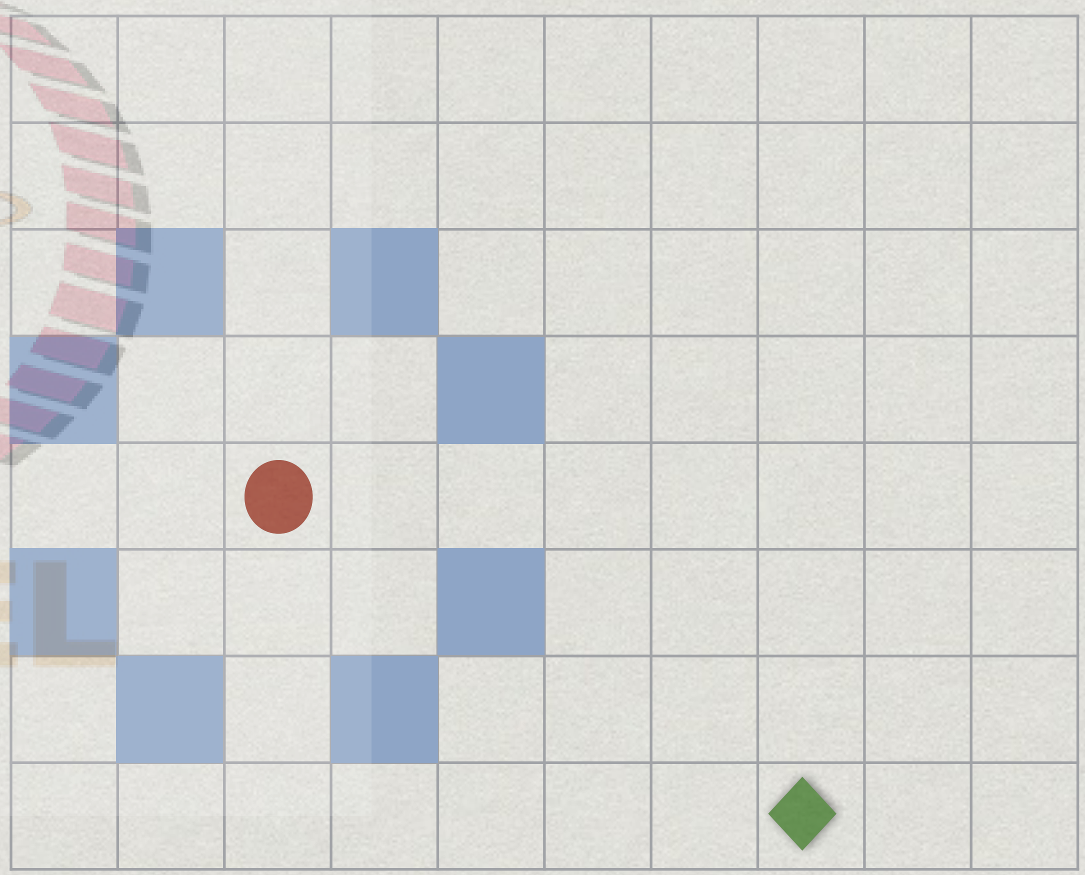

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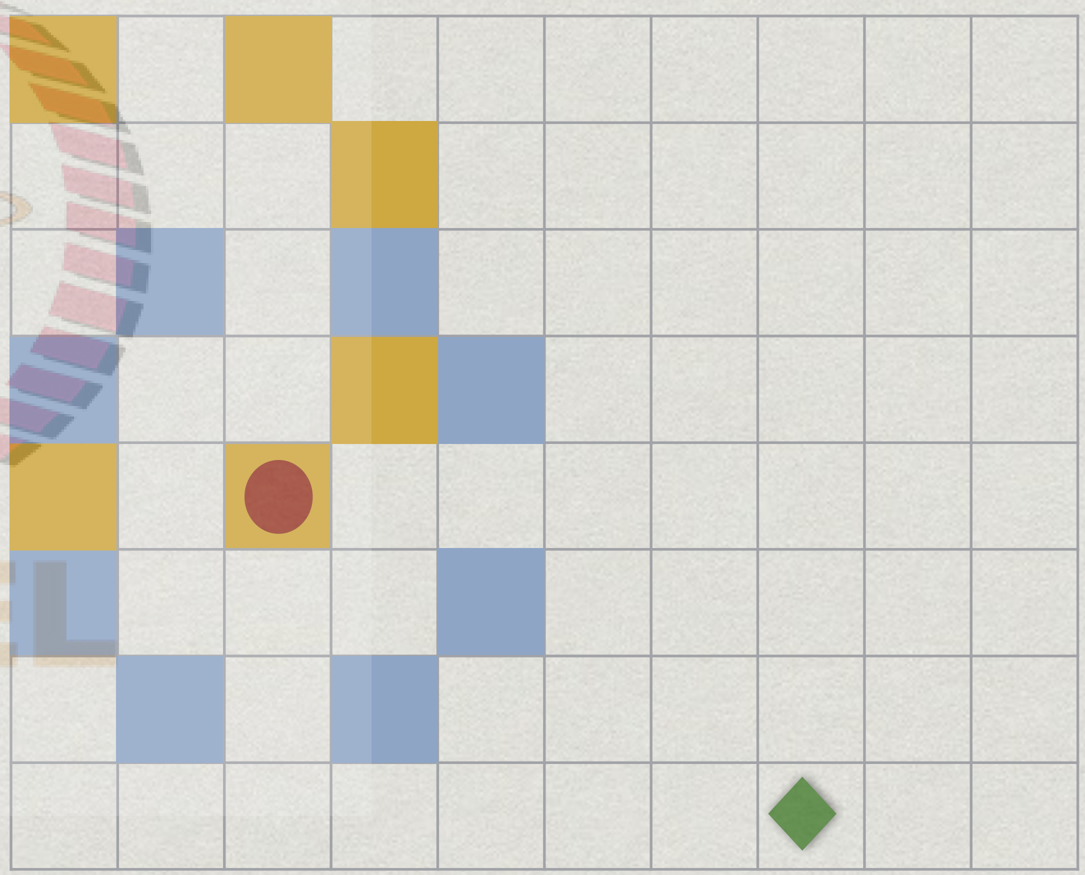

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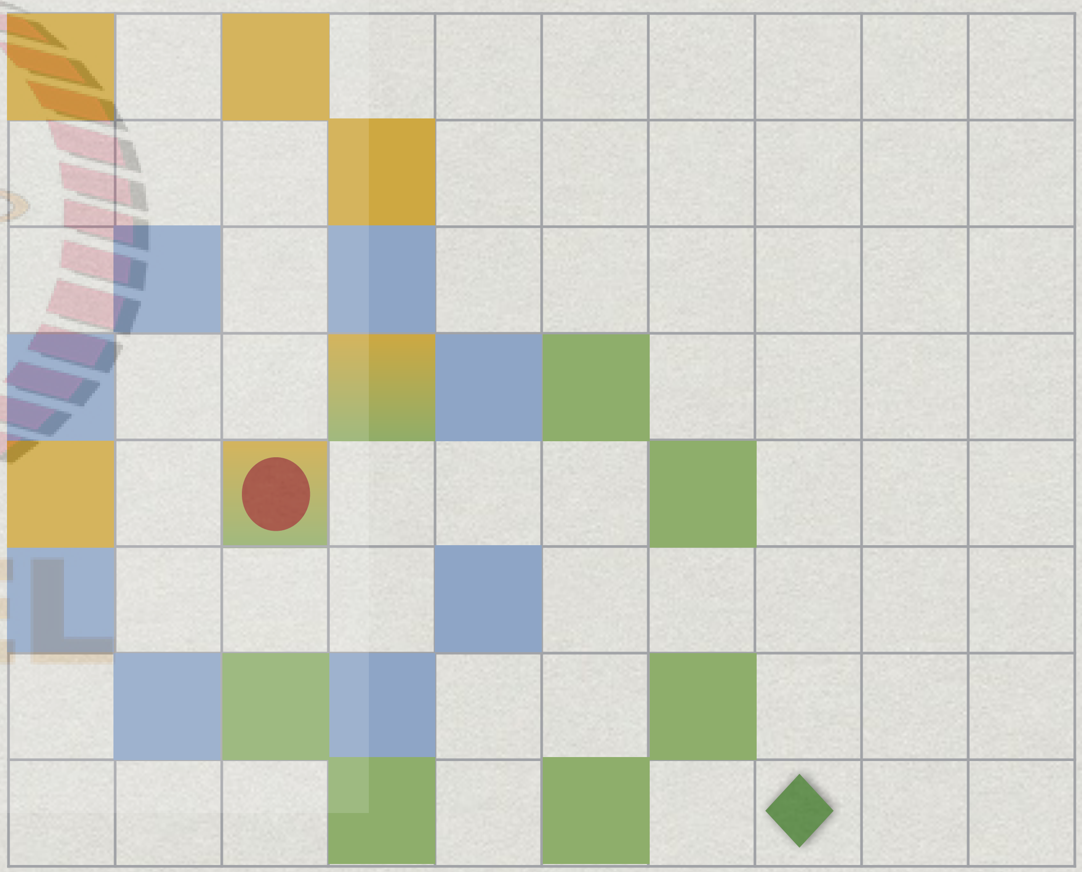


Systematic exploration

- X1 — all squares reachable in one move from (sx,sy)
- X2 — all squares reachable from X1 in one move
- . . .
- Don't explore an already marked square
- When do we stop?
  - If we reach target square
  - What if target is not reachable?

Systematic exploration

- Maintain a queue Q of cells to be explored
- Initially Q contains only start node (sx,sy)
  - Remove (ax,ay) from head of queue
  - Mark all squares reachable in one step from (ax,ay)
  - Add all newly marked squares to the queue
- When the queue is empty, we have finished

Systematic exploration

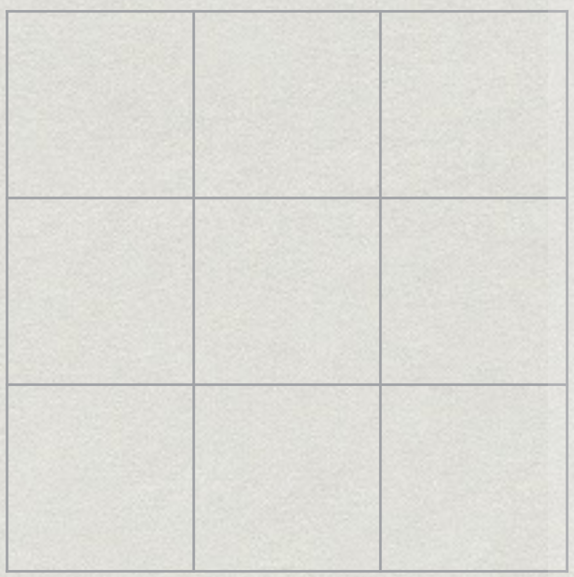
```
def explore((sx,sy),(tx,ty)):
  marked = [[0 for i in range(n)]
                      for j in range(m)]
  marked[sx][sy] = 1
  queue = [(sx,sy)]

  while queue != []:
    (ax,ay) = queue.pop()
    for (nx,ny) in neighbours((ax,ay)):
      if !marked[nx][ny]:
        marked[nx][ny] = 1
        queue.insert(0,(nx,ny))

  return(marked[tx][ty])
```

Example

src = (0,1) **tgt =(1,1)**



- This is an example of breadth first search

Summary

- Data structures are ways of organising information that allow efficient processing in certain contexts
- Python has a built-in implementation of sets
- Stacks are useful to keep track of recursive computations
- Queues are useful for breadth-first exploration