

# For Wednesday

- Read Weiss, chapter 10, section 1
- No homework

# Program 4

- Any questions?

# Research Paper

- Any questions?

# Warshall's Algorithm

- Note that if there is a path from  $X$  to  $Y$  and there is a path from  $Y$  to  $Z$ , then there is a path from  $X$  to  $Z$
- for ( $y = 0; y < V; y++$ )  
  for ( $x = 0; x < V; x++$ )  
    if ( $a[x][y]$ )  
      for ( $j = 0; j < V; j++$ )  
        if ( $a[y][j]$ )  
           $a[x][j] = 1;$

# All Shortest Paths

- In sparse matrix, just run Dykstra's algorithm for each vertex
- In dense graphs, use a matrix and use an algorithm similar to Warshall's algorithm
- Computes all shortest paths in  $O(V^3)$  time
- To determine actual path, need an additional matrix.

# Floyd's Algorithm

- for ( $y = 0; y < V; y++$ )  
  for ( $x = 0; x < V; x++$ )  
    if ( $a[x][y]$ )  
      for ( $j = 0; j < V; j++$ )  
        if ( $a[y][j] > 0$ )  
          if ( $!a[x][j] \parallel$   
              ( $a[x][y] + a[y][j] < a[x][j]$ ))  
             $a[x][j] = a[x][y] + a[y][j];$

# Graph Searching

- Depth-first
- Breadth-first
- Best-first

# Difficulty Levels

- Undecidable
  - Example is halting problem
- Intractable
  - Example is ?
- Exponential problems are considered intractable. Why?

# Another Class of Intractable Problems

- Polynomial problems are considered tractable.
- What does NP mean?

# Non-deterministic Polynomial

- A deterministic machine must always make a single choice.
- Suppose you had a non-deterministic computer.
- Then you could “pick” all of the different choices at once (or automatically pick the best solution).

# The Class NP

- Can determine that a solution is the correct solution in polynomial time.
- All problems with polynomial time solutions fit into this class.
- Some decidable problems do not. Consider problems for which the solution is of exponential length.

# The Big Question

- Are there problem in NP that are not in P?
- Brings us to the class of NP-complete and NP-hard problems.
- NP-complete problems are reducible to one another.

# Examples

- Traveling Salesman
- Hamiltonian Cycle
- Satisfiability (technically, 3Sat)
- Graph coloring
- Knapsack
- Bin packing