Creating new worlds inside the computer

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Pseudocode

- Simple instructions: involve +, -, ×, ÷
- Compound instructions
  - Conditionals
  - Loops

- Exact syntax unimportant
  (unless it changes meaning of program!)
Algorithm

- Pseudocode for turning a set of inputs into outputs in a finite amount of time

- Questions to think about:
  - What class of computational tasks can be solved by algorithms?
  - How dependent is this class on the exact definition of pseudocode?
Clicker Question:

Did you read the Hayes article?
A=yes
B=no
Conway’s Game of life

- **Rules:** At each step, in each cell
  - **Survival:** Critter survives if it has 2 or 3 neighbors.
  - **Death:** Critter dies if it has 1 or fewer neighbors, or more than 3.
  - **Birth:** New critter is born if it has 3 critters as neighbors and cell was empty.

\[ n \times n \text{ array } A \]
\[ A[i, j] = 1 \text{ means critter lives in square, } 0 \text{ means empty square } \]
Pseudocode for each step

Do for $i = 1$ to $n$
{
    Do for $j = 1$ to $n$
    {
                   $A[i + 1, j] + A[i + 1, j + 1]$
        if (neighbors = 2 OR neighbors = 3) then
            { $B[i, j] ← 1$ }
        else if (neighbors = 1 ...)
            ...etc. //see handout//
    }
}
Do for $i = 1$ to $n$
{
    Do for $j = 1$ to $n$
    {
        $A[i, j] ← B[i, j]$
    }
}
Moral of the Game of Life?

- Simple local behavior can lead to complex global behavior

(cf. Brian Hayes article)
Physics of snow crystals

- "Cooling" – reduce amount of molecular motion
- Crystal growth: capture of nearby floating molecules
Movie
Twister simulation

- Divide region into 3D grid
- Identify laws of physics for air

**Navier Stokes equations:**

How does a block of air move when certain pressure, temperature and velocity differentials exist on its boundary?
Simulator pseudocode

- Initialize Grid using data from observations: surface and aircraft measurements, radar (NEXRAD) readings, etc.

```plaintext
Do for i = 1 to n
{
    Do for j = 1 to n
    {
        Do for k = 1 to n
        {
            Update state of Grid[i, j, k]
        }
    }
}
```

- 10°C, 15 psi, 20% humidity
- 11°C, 15 psi, 23% humidity
- etc.
Other examples of simulation

[Turk 91] following:

Display

Q: How to display result of simulation?

A: Computer graphics (later in course)

[Enright and Fedkiw 02]
Bigger questions

- Can computer simulation be replaced by a “theory of weather”? A “theory of tornadoes”?

- Is there a “theory” that answers this type of problem:
  - Given: A starting configuration in the game of life
  - Output: “Yes” if the cell at position (100, 100) is ever occupied, “No” otherwise

Alan Turing

Albert Einstein
Actually, reverse trend: “theory of matter” (particle physics) is becoming computational.

Hayes: The universe as a “cellular automaton”
Another startling fact:

Game of life is actually a “computer.”