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The Game of Pig for CS1

Fun / SLoC

- Game/puzzle exercises are fun, engaging
- Overhead of complex rules can spoil a project
  - E.g. chess: en passant, castling
- For educators good games/puzzles with simple rules can be pedagogical treasures
  - E.g. recursion: Towers of Hanoi, mazes
- The Game of Pig
  - Jeopardy dice game
  - Rules in two sentences
  - Outstanding **Fun per Source Lines of Code**

The Game of Pig

- The first player to reach 100 points wins.
- On a turn, a player rolls a die repeatedly until:
  - the player holds, scoring the sum of the rolls ("turn total"), or
  - a 1 ("pig") is rolled, and there is no score change.
- Example turns:
  - roll 4, roll 5, roll 2, hold → add 4 + 5 + 2 = 11 to score
  - roll 3, roll 6, roll 6, roll 1 → score remains the same

Pig Preliminaries

- Player's decision is always to *roll*/*hold*
  - *Roll* – possibly increase turn total, or lose it
  - *Hold* – definitely score current turn total
  - Pig is the simplest of a class of *jeopardy dice games*; ancestor of *Pass the Pigs*
- Hold at 20 - a simple (suboptimal) strategy that maximizes expected points per turn

Bottom-up Development

- CS1 student hurdle: nested loops
  - Methodology: elaboration, milestones, stepping stones, bottom-up development
- Text-based Pig game application proceeds by neat stages:
  - Hold at 20 turn: single loop
  - Hold at 20 or goal turn: add score, stop for win
  - Solitaire game: nest turn loop within game loop
  - Two-player game: toggle players/scores, factor out common code
  - Human vs. Computer game: replace random player strategy with human input

Hold at 20 Turn – Comments

```
// Initialize variables
while () { // Turn not over
     // Roll die
     if () { // 1 rolled
          // Reset turn total and end turn
     }
     else {
          // Add roll to turn total
     }
}
```

Hold at 20 Turn – Java

```
final int HOLD_AT = 20;
Random random = new Random();
int turnTotal = 0;
boolean pigRolled = false;
while (!pigRolled && turnTotal < HOLD_AT) {
    int roll = random.nextInt(6) + 1;
    System.out.println("Roll: " + roll);
    pigRolled = (roll == 1);
    if (pigRolled)
        turnTotal = 0;
    else
        turnTotal += roll;
}
System.out.println("Turn total: " + turnTotal);
```

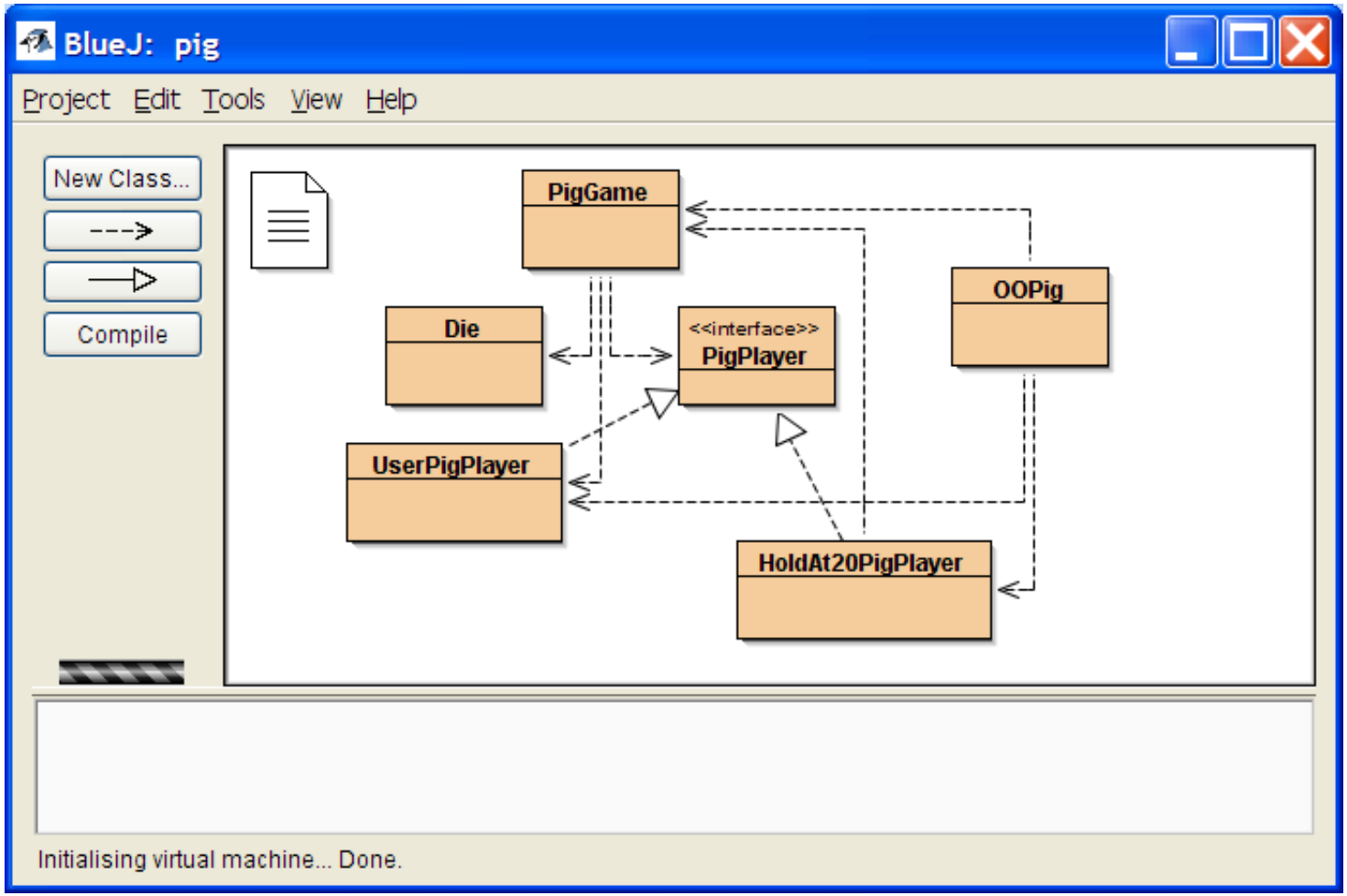
Hold at 20 Turn – Python

```
import random
holdAt = 20
turnTotal = 0
pigRolled = False
while not pigRolled and turnTotal < holdAt:
    roll = random.randint(1, 6)
    print('Roll:', roll)
    pigRolled = (roll == 1)
    if pigRolled:
        turnTotal = 0
    else:
        turnTotal = turnTotal + roll
print('Turn total:', turnTotal)
```

Monte Carlo Explorations

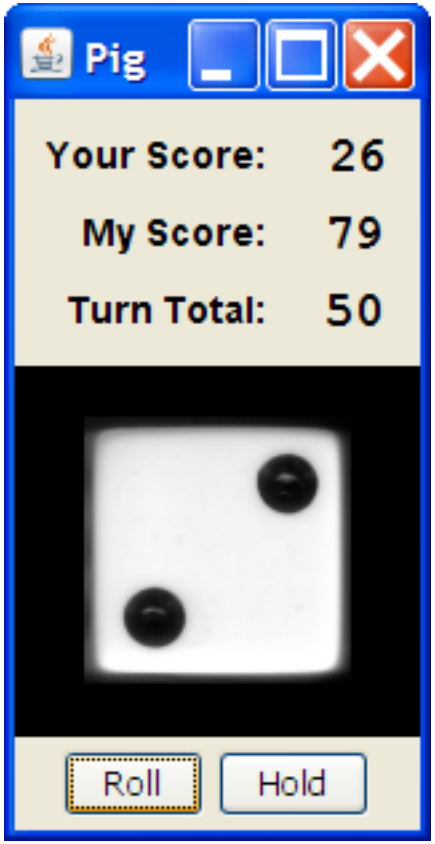
- In this simple context, there are interesting questions that can be explored with Monte Carlo simulation:
  - Probability distribution of hold-at-20 turn scores?
  - Average turns in solitaire game?
  - First-player advantage in two-player games?
- In each case, students nest previous work within trials loop and collect statistics.

Object-Oriented Exercises



Event-driven GUI Exercise

- Dice images supplied in PNG, JPG formats
- Component specification (labels, buttons, etc.), not layout
- Functional specification
- *Keep Pace and End Race* policy:
  - Either score ≥ 71? Go for goal!
  - Otherwise, hold at 21 + round((your score – my score)/8)



Beyond CS1

- Links to paper and assignments making good use of Pig in:
  - Artificial Intelligence: reinforcement learning for optimal policy computation
  - Networking: fun client-server exercise with little overhead
  - Scientific Visualization: visualizing the optimal policy roll/hold boundary with Marching Cubes Algorithm

Theme and Variations

- Pig is the simplest of a family of jeopardy dice games.
  - Many variants exist (e.g. Piglet, Two-dice Pig, Pass the Pigs™, Hog)
  - A link to a catalog of all known variants is provided
  - Why? So assignment variants can be easily created to avoid plagiarism.

Conclusion

- Pig offers:
  - Excellent Fun/SLoC ratio
  - CS1 exercises for …
    - Bottom-up development with nested loops
    - Monte Carlo simulation opportunities
    - Simple O-O and GUI exercises
  - Further CSE uses in AI, networking, sci. vis., …
  - Easy variation for unique assignments
- Best wishes for good application!