Software Development (cs2500)

Lecture 11: Iteration (Continued)

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October 16, 2013

Software Development

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Sentinel Values

break and continue

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Sentinel Values

- Some programs must deal with variable numbers of input.
  - For example, the bank accounts of a bank.
  - You don't know how many accounts there are in advance.
  - You must process them all.
- The program must have some way to stop.
- You could use the number of bank accounts as inputs.
  - This is a bit inconvenient.
- Most such programs stop when they read a special input value.
  - Programs dealing with files use a special *end of file* (EOF) value.
  - Programs dealing with numbers could use "disallowed" numbers.
  - E.g. -1 if the program deals with non-negative numbers.
- Such values are called *sentinels*.

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Computing the Salary

Java

```
public static void main( String[] args ) {
    final Scanner scanner = new Scanner( System.in );

    double sum = 0.0;
    double next = readNextSalary( scanner );
    while (next != -1.0) {
        sum += next;
        next = readNextSalary( scanner );
    }

    System.err.println( "Total salary is " + sum );
}

private static double readNextSalary( final Scanner scanner ) {
    System.err.print( "Enter salaries, -1 to finish: " );
    return scanner.nextDouble( );
}
```

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`break` and `continue`

- `Java` has two more loop-related statements.

`break`	Jumps out of the loop.
`continue`	Jumps to the end of the current loop.

- They are perfectly valid `Java`.
- However, we will not use them for cs2500.
  - Leads to spaghetti code.
  - Makes reasoning about program flow more difficult.
  - Makes if difficult to write proper invariants.
  - Avoiding the statements is a good mental exercise.
  - You will find better, cleaner, more elegant algorithms.
- If you use them, you will lose marks.

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Computing Averages

Java

```
final Scanner scanner = new Scanner( System.in );
int numbersRead = 0;
int total = 0;

while (scanner.hasNextInt( )) {
    total += scanner.nextInt( );
    numbersRead++;
}

final String average;
if (numbersRead != 0) {
    average = Double.toString( total/(double)numbersRead );
} else {
    average = "undefined";
}

System.err.println( "Total: " + total );
System.err.println( "#Iterations: " + numbersRead );
System.err.println( "Average: " + average );
```

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Computing Averages

Java

```
final Scanner scanner = new Scanner( System.in );
int numbersRead = 0;
int total = 0;

while (scanner.hasNextInt( )) {
    total += scanner.nextInt( );
    numbersRead++;
}

final String average;
if (numbersRead != 0) {
    average = Double.toString( total/(double)numbersRead );
} else {
    average = "undefined";
}

System.err.println( "Total: " + total );
System.err.println( "#Iterations: " + numbersRead );
System.err.println( "Average: " + average );
```

Computing the Maximum

We Assume there is Some Input

Java

```
final Scanner scanner = new Scanner( System.in );
int currentMax = Integer.MIN_VALUE;

do {
    final int next = scanner.nextInt( );
    currentMax = currentMax < next ? next : currentMax;
} while (scanner.hasNextInt( ));

System.err.println( "Maximum: " + currentMax );
```

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Computing the Maximum

We Assume there is Some Input

Java

```
final Scanner scanner = new Scanner( System.in );
int currentMax = Integer.MIN_VALUE;

do {
    final int next = scanner.nextInt( );
    currentMax = currentMax < next ? next : currentMax;
} while (scanner.hasNextInt( ));

System.err.println( "Maximum: " + currentMax );
```

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Computing the Maximum

We Assume there is Some Input

Java

```
final Scanner scanner = new Scanner( System.in );
int currentMax = Integer.MIN_VALUE;

do {
    final int next = scanner.nextInt( );
    currentMax = Integer.max( next, currentMax );
} while (scanner.hasNextInt( ));

System.err.println( "Maximum: " + currentMax );
```

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Number Conversion

Java

```java
private static final int BASE = 10;

public static String toString( final int value ) {
    String absStringValue = "";
    final boolean negative = value < 0;
    int residue = value;

    while ((residue <= -BASE) || (BASE <= residue)) {
        // strip off last digit.
        final int lastDigit = residue % BASE;
        // add last digit.
        absStringValue = makeDecimalString( lastDigit ) + absStringValue;
        // get rid of last digit.
        residue = residue / BASE;
    }
    // add remaining digit.
    absStringValue = makeDecimalString( residue ) + absStringValue;

    // add sign if needed.
    return (negative ? "-" : "") + absStringValue;
}
```

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        // add last digit.
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        // get rid of last digit.
        residue = residue / BASE;
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        // get rid of last digit.
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        // add last digit.
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        // get rid of last digit.
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    }
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}
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Number Conversion

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        // add last digit.
        absStringValue = makeDecimalString( lastDigit ) + absStringValue;
        // get rid of last digit.
        residue = residue / BASE;
    }
    // add remaining digit.
    absStringValue = makeDecimalString( residue ) + absStringValue;

    // add sign if needed.
    return (negative ? "-" : "") + absStringValue;
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        // add last digit.
        absStringValue = makeDecimalString( lastDigit ) + absStringValue;
        // get rid of last digit.
        residue = residue / BASE;
    }
    // add remaining digit.
    absStringValue = makeDecimalString( residue ) + absStringValue;

    // add sign if needed.
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    int residue = value;

    while ((residue <= -BASE) || (BASE <= residue)) {
        // strip off last digit.
        final int lastDigit = residue % BASE;
        // add last digit.
        absStringValue = makeDecimalString( lastDigit ) + absStringValue;
        // get rid of last digit.
        residue = residue / BASE;
    }
    // add remaining digit.
    absStringValue = makeDecimalString( residue ) + absStringValue;

    // add sign if needed.
    return (negative ? "-" : "") + absStringValue;
}
```

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Number Conversion

Java

```
private static String makeDecimalString( final int digit ) {
    final char character = (char)(Math.abs( digit ) + (int)'0');
    final char[] characterArray = { character };
    return new String( characterArray );
}
```

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Java

```
private static String makeDecimalString( final int digit ) {
    final char character = (char)(Math.abs( digit ) + (int)'0');
    final char[] characterArray = { character };
    return new String( characterArray );
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    return new String( characterArray );
}
```

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Java

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private static String makeDecimalString( final int digit ) {
    final char character = (char)(Math.abs( digit ) + (int)'0');
    final char[] characterArray = { character };
    return new String( characterArray );
}
```

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Java

```
private static String makeDecimalString( final int digit ) {
    final char character = (char)(Math.abs( digit ) + (int)'0');
    final char[] characterArray = { character };
    return new String( characterArray );
}
```

Nested Loops

- Printing columns of the rows in a spreadsheet.
- Colouring pixels at x- and y-coordinates of a picture.
- ...

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Power Table

Unix Session

```
$
```

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Power Table

Unix Session

```
$ java PowerTable
```

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Power Table

Unix Session

```
$ java PowerTable
Enter maximum power:
```

Power Table

Unix Session

```
$ java PowerTable
Enter maximum power: 4
```

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Power Table

Unix Session

```
$ java PowerTable
Enter maximum power: 4
Enter last integer:
```

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Power Table

Unix Session

```
$ java PowerTable
Enter maximum power: 4
Enter last integer: 6
```

Power Table

Unix Session

```
$ java PowerTable
Enter maximum power: 4
Enter last integer: 6
     1     2     3     4
    x     x     x     x
------------------------
    1     1     1     1
    2     4     8    16
    3     9    27    81
    4    16    64   256
    5    25   125   625
    6    36   216  1296
```

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The main

Java

```
public static void main( String[] args ) {
    final Scanner scanner = new Scanner( System.in );
    System.err.print( "Enter maximum power: " );
    final int maxPower = scanner.nextInt( );
    System.err.print( "Enter last integer: " );
    final int lastInteger = scanner.nextInt( );

    printColumnHeadings( maxPower );
    printRows( lastInteger, maxPower );
}
```

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The main

Java

```
public static void main( String[] args ) {
    final Scanner scanner = new Scanner( System.in );
    System.err.print( "Enter maximum power: " );
    final int maxPower = scanner.nextInt( );
    System.err.print( "Enter last integer: " );
    final int lastInteger = scanner.nextInt( );

    printColumnHeadings( maxPower );
    printRows( lastInteger, maxPower );
}
```

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printColumnHeadings( )

Java

```
private static void printColumnHeadings( final int maxPower ) {
    for (int power = 1; power <= maxPower; power++) {
        System.err.print( String.format( "  %4d", power ) );
    }
    System.err.println( );
    for (int power = 1; power <= maxPower; power++) {
        System.err.print( String.format( " %4s ", "x" ) );
    }
    System.err.println( );
    for (int power = 1; power <= maxPower; power++) {
        System.err.print( "------" );
    }
    System.err.println( );
}
```

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printRows( )

Java

```java
private static final void printRows( final int maxRow,
                                     final int maxPower ) {
    for (int row = 1; row <= maxRow; row++) {
        for (int power = 1; power <= maxPower; power++) {
            final int rowPower = Math.pow( row, power );
            System.err.print( String.format( " %4d ", rowPower ) );
        }
        System.err.println( );
    }
}
```

printRows( )

Java

```
private static final void printRows( final int maxRow,
                                     final int maxPower ) {
    for (int row = 1; row <= maxRow; row++) {
        for (int power = 1; power <= maxPower; power++) {
            final int rowPower = Math.pow( row, power );
            System.err.print( String.format( " %4d ", rowPower ) );
        }
        System.err.println( );
    }
}
```

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printRows( )

Java

```
private static final void printRows( final int maxRow,
                                     final int maxPower ) {
    for (int row = 1; row <= maxRow; row++) {
        for (int power = 1; power <= maxPower; power++) {
            final int rowPower = computePower( row, power );
            System.err.print( String.format( " %4d ", rowPower ) );
        }
        System.err.println( );
    }
}
```

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computePower( )

Java

```
private static int computePower( final int number, final int power ) {
    int result = 1;

    for (int product = 1; product <= power; product++) {
        result = result * number;
    }

    return result;
}
```

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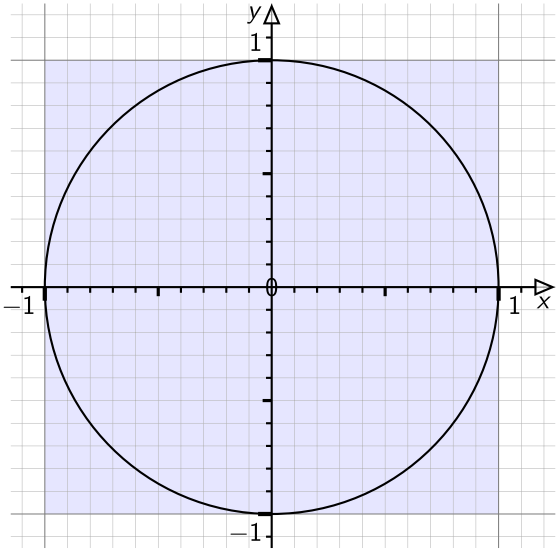
Monte Carlo Integration



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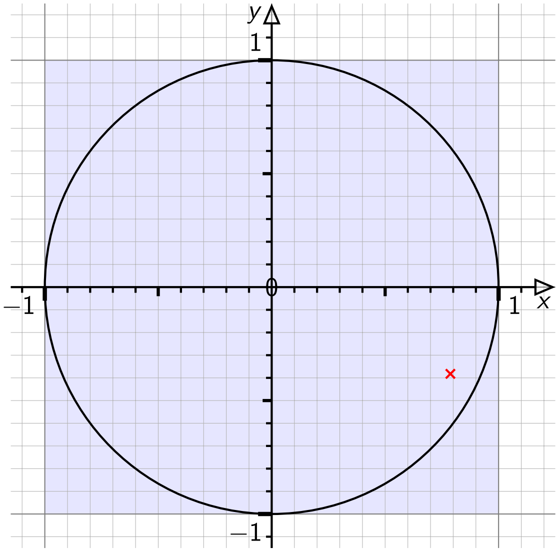

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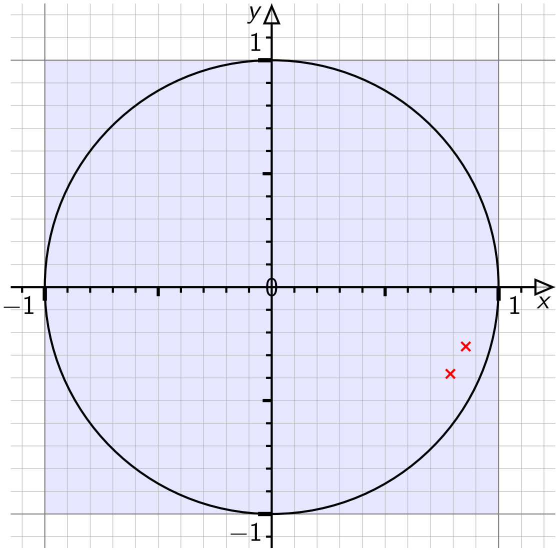
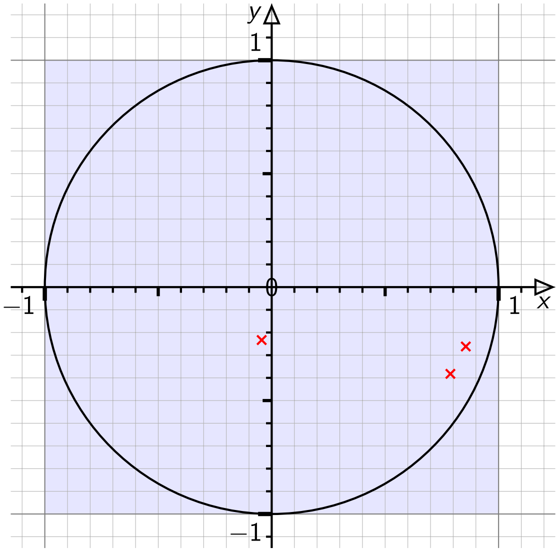


Throwing Random Darts



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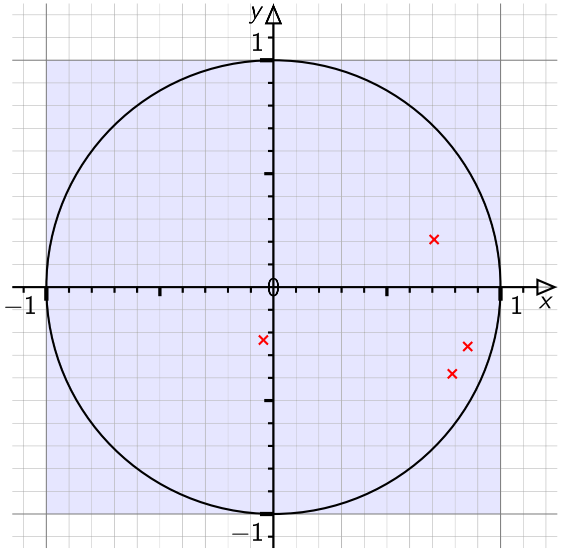

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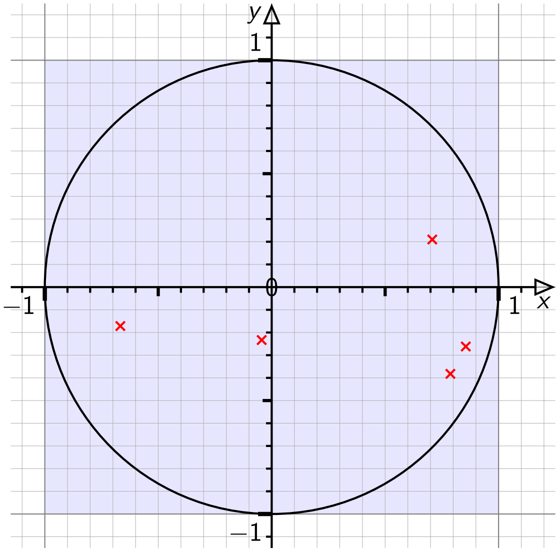

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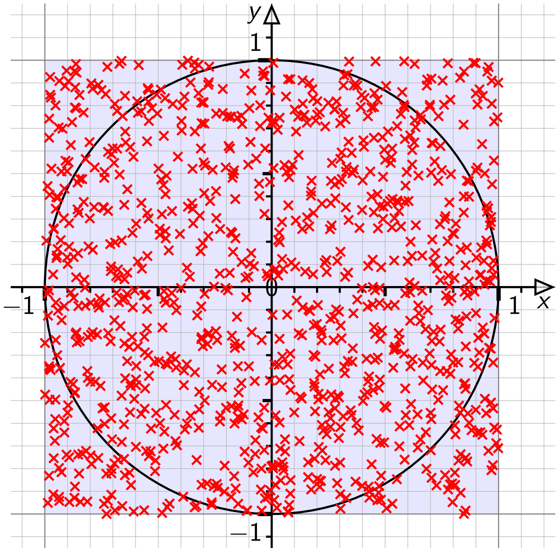

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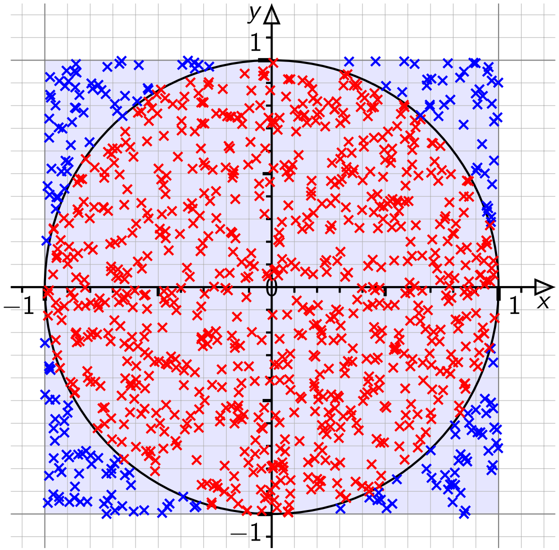

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Implementation

Java

```
import java.util.Random;
public class MonteCarlo {
    // Total number of random points.
    private static final int TOTAL_SAMPLES = 1000000;
    // Radius of base circle.
    private static final double RADIUS = 1.0;
    // Total area of extended square.
    private static final double TOTAL_AREA = 4.0 * RADIUS;

    public static void main( String[] args ) {
        final Random rand = new Random( );
        // Initialise number of random points inside circle.
        int hits = 0;
        for ( int sample = TOTAL_SAMPLES; sample-- != 0; ) {
            // Generate next random point.
            final double x = 2.0 * RADIUS * (rand.nextDouble( ) - 0.5);
            final double y = 2.0 * RADIUS * (rand.nextDouble( ) - 0.5);
            // Increment hits if point is inside circle.
            hits += x*x + y*y <= RADIUS * RADIUS ? 1 : 0;
        }
        // Compute approximation of area of circle.
        final double ratio = (double)hits / TOTAL_SAMPLES;
        final double approximation = TOTAL_AREA * ratio;
        System.out.println( "PI = " + Math.PI );
        System.out.println( "PI ~ " + approximation );
    }
}
```

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            final double y = 2.0 * RADIUS * (rand.nextDouble( ) - 0.5);
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For Friday

- Implement the integer to string conversion method.
  - You should be able to do this from scratch.
- Study Sections 5.5, and 5.7–5.9.

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- This lecture corresponds to [*Big Java, Early Objects*, Sections 5.5, 5.7–5.9].

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About this Document

- This document was created with `pdflatex`.
- The LaTeX document class is `beamer`.

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`break` and `continue`

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