# Use of a Personal Response System in Engineering 101

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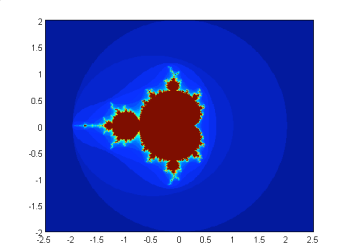
## Reasons for Introducing PRS

- Encourage regular attendance
  - Attendance may help reduce attrition.
  - Inculcate good habits in first year class.
- Make lecture more active.
- Engage students in learning.

## How was it implemented?

- COE first year programs purchased 250 transmitters and installed 4 receivers in Cheseborough Auditorium.
- Students picked up assigned transmitters from the back of the auditorium on their way into class and returned them after class.

## Programming Example: The Mandelbrot Set




## Programming Example: The Mandelbrot Set

- Fractals are of interest because, in addition to being mathematically beautiful objects, they have the property of self-similarity.
- In this respects they are like a number of natural and man-made systems like coastlines and rough surfaces.

## The Mandelbrot set

- Is generated from the equation:

$$z_{m+1} = z_m^2 + c$$

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**c=1**

**$z_1$=0 $z_2$=1 $z_3$=2 $z_4$=5 $z_5$=26 $z_6$=677 $z_7$=458330**

**c=0.1**

**$z_1$=0 $z_2$=0.1 $z_3$=0.11 $z_4$=0.1121 $z_5$=0.11256…**

## The Mandelbrot set

- We determine the value of a point by determining how many iterations it takes to grow greater than 2 and dividing by the total number of iterations.
- For example if we considering 10 iterations M(1) = 0.4 and M(0.1) = 1 (it never becomes greater than 2)

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## The Mandelbrot set

- The trick is we do this with complex numbers.
- So every point in the plane has a real value given by the x axis and an imaginary value given by the y axis.
- Squares of imaginary numbers are taken in the standard way

  $(1+2i)^2 = (1+2i)(1+2i) = 1+2i+2i+4i^2$

  $= 1+4i -4 = -3+4i$
- The condition to stop the iteration will be that the norm of the number (the number times its complex conjugate) is greater than 2.

## The Mandelbrot Set

- So to make the set we must first write a function that will take as input
  - a matrix c where each element of the matrix is a complex number
  - a number of iterations, niters
- It will have to set the initial values of z for each c to 0.
- Then we must make a loop that will repeatedly apply the equation to each value of z $z_{m+1} = z_m^2 + c$

## The Mandelbrot Set

```
function res = mandelbrotIterate (c, niters)

z = zeros(size(c));

for i = 1:niters
   z = z.^2 + c;
end
```

## The Mandelbrot Set

- Since we only want to continue to iterate the z's that are less than 2 we will use a logical array called active
- The value of active will be 1 if abs(z) is still less than or equal to 2

## The Mandelbrot Set

```
function res = mandelbrotIterate (c, niters)

z = zeros(size(c));
active = ones(size(c));

for i = 1:niters
   z(active) = z(active).^2 + c(active);
   active = abs(z) <= 2;
end
```

## The Mandelbrot Set

- As a final step we need to make sure than when a site first becomes inactive, the program determines the iteration in which it exceeded 2 and calculates the value of iteration/total iterations for the result, res.

## Exercise 2

- As a final step we need to make sure than when a site first becomes inactive, the program determines the iteration in which it exceeded 2 and calculates the value of iteration/total iterations for the result, res.
- Which function does this?

## Video of Class

Link to webpage

## Difficulties in Implementing PRS

- Technology was 95% reliable, but occasionally would not respond due to server problems.
- Requires the instructor to create questions (2-3 per lecture) that are neither trivial nor too difficult to be answered in a short time.
- Students report that responding to questions for a grade during class is stressful even if the contribution to their grade is minimal.

## Survey of Students

| | Mean (Std. Dev) | Strongly disagree | Disagree somewhat | Agree somewhat | Strongly agree |
|---|---|---|---|---|---|
| I was more engaged in thinking during class because of the PRS questions. | 3.24 (.819) | 4 (3.6%) | 15 (13.4%) | 43 (38.4%) | 50 (44.6%) |
| I attended class more often than I otherwise would have because the PRS was used. | 3.04 (1.02) | 12 (10.6%) | 20 (17.9%) | 32 (28.6%) | 48 (42.9%) |
| I recommend implementing the PRS in all sections of Engin 101. | 3.12 (.941) | 8 (7.1%) | 19 (17.0%) | 36 (32.1%) | 49 (43.8%) |

(*n=112*)

## Differences Between Sections

| | Overall (*n=230*) | Falk (*n=112*) | Holloway (*n=118*) |
|---|---|---|---|
| I found myself paying close attention during lecture | 2.91 (.796) | 2.98 (.782) | 2.84 (.800) |
| I was strongly motivated to attend lecture. | 3.03 (.879) | 3.13 (.800) | 2.93 (.940) |
| During the lectures, I frequently engaged in thinking about concepts. | 2.88 (.811) | 3.03 (.753)* | 2.74 (.842)* |

*Significant difference, *p=.007, d=.36*

**All question on ordinal scale: 1 - strongly disagree, 2 - disagree somewhat, 3 - agree somewhat, 4 - strongly agree

## Benefits of Implementing PRS

- Attendance was higher in the latter part of the term.
- Students actively engaged in thinking about the subject material during lecture.
- Students interactions helped break up lecture time into intervals of lecture and activity.
- Immediate feedback was obtained regarding student understanding of lecture material.