Exploring Mathematics through Advanced Technology Applications from Popular Culture

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Background

• Creative and technical fields are often viewed as an either/or dichotomy. Students
  - “either” like STEM or arts
  - see the two as unrelated

• That is not the case, especially in the digital age
Background

• This project has as its goal to challenge the traditional distinctions between STEM and the arts by

  - seeing connections between “technical” fields and the creative and performing arts
  - learning the scientific ideas behind the technology used in the arts
  - engaging with STEM concepts in the context of an arts or everyday application
Goals

• Design a set of computer based labs that
  - allow students to “see” the connections between their interests, their lives, and STEM ideas
  - provide an opportunity for students to consider STEM as a possible college/career option
Current State of the Project

- Multiple labs developed
- Implementing labs in the Philadelphia High School for the Creative and Performing Arts
- Early in analysis of results
Outline of the Talk

• Introduce you to three labs, aspects of each can be used with your students

• Labs discussed today include:
  - Exploring Geometry with the Roomba
  - Bioinformatics
  - Image Processing
Geometry with iRobot
Geometry with iRobot

• Day 1: Experiencing d=rt
  - “Distance accrues as the iRobot travels at a constant speed for a specific amount of time”

• Mathematical Ideas
  - distance-rate-time
  - unit conversion
  - measurement
  - trigonometry
Geometry with iRobot

• **Day 1: Distance = Rate * Time**
  - get comfortable with iRobot and interface
  - “experience” d=rt

• **Activities involve exploring iRobot syntax**
  - `roombacomm.goForward(500);`  
    Distance in millimeters
  - `roombacomm.goForwardAt(500);`  
    Speed in millimeters per second
  - `roombacomm.Pause(500);`  
    Time in seconds
Geometry with iRobot

• Activities
  - Given two quantities (ex. speed/time), predict third and test using iRobot
  - Explore for different quantities and try your own

• Extension: Weight Test
Geometry with iRobot

• Day 2: Triangles
  - Given a triangle (taped on floor), program robot to traverse the triangle
    • Only given ruler (no protractor)
    • Multiple Step Program (go distance, turn, go another distance...)
    • Calculate or approximate angles (if approximate, allowed to program, then facilitator encouraged to use trig)
Geometry with iRobot

- **Day 2: A-MAZE-ing**
  - Estimate a path that will allow the robot will travel through the maze
  - Dead Reckoning: estimating one’s position based on previous and current values.
Image Processing

- Mathematical Ideas
  - understanding and applying mean/median
  - thresholding
  - matrices (and operations)
Introduction to Image Processing

• Math and physics behind a practical engineering application
• Technology behind digital imagery
• Lab components:
  - Short lecture with take-home notes
  - Activity worksheet with examples and questions
  - Custom software developed for lab to illustrate concepts and encourage student experimentation (MATLAB GUIs)
Technology background

• Pixels to represent an image

• Why?
  - You need to understand how the image is constructed if you want to manipulate it mathematically

• IP Mathematical Algorithms
  - Edge Detection
  - Denoising an image
Edge Detection

• **Algorithms**
  - Calculate difference between pixels; compare to threshold
  - Calculate difference between averages of pixels; compare

• **Activity sheet for calculations**
  - Work algorithm out by hand on an array to solidify concept

• **Experiment w/ GUI**

• **Questions for students**
  - Compare performance between the two algorithms
  - What can you say about most of the transitions between pixels in your image?

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Edge detection pixel array; threshold 20
Edge Detection
Denoising an Image

• Explain the concept of image noise
  - Gaussian (Snowy) Noise
  - Salt & Pepper (Grainy) Noise

• Algorithm
  - Choose block size; calculate mean/median
  - Replace center block with mean/median

• Activity Sheet

• Experiment w/ GUI

• Question
  - As you experimented with the window size what trade-offs in image quality did you notice?
Denoising an Image
Denoising an Image

• Extend concept from images to video
  - Video is a series of still images
  - Experiment with denoising on video clip of soccer game

• Questions
  - What are the tradeoffs?
  - How fast must the algorithm perform on each image so that you can still watch the soccer game in real-time?
Where we are

- Based on the activity sheets students, observations during lab implementations, and survey results, students were learning STEM content
- Analysis of connections to Arts and Pop-culture still evolving
- They had fun.
What’s Available

• Lab activity to be posted online
  - [http://dk12.ece.drexel.edu/](http://dk12.ece.drexel.edu/)

• MATLAB GUI code to be converted to a web-based language (i.e. Java)

• Other resources available
Thank You.

http://dk12.ece.drexel.edu/