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

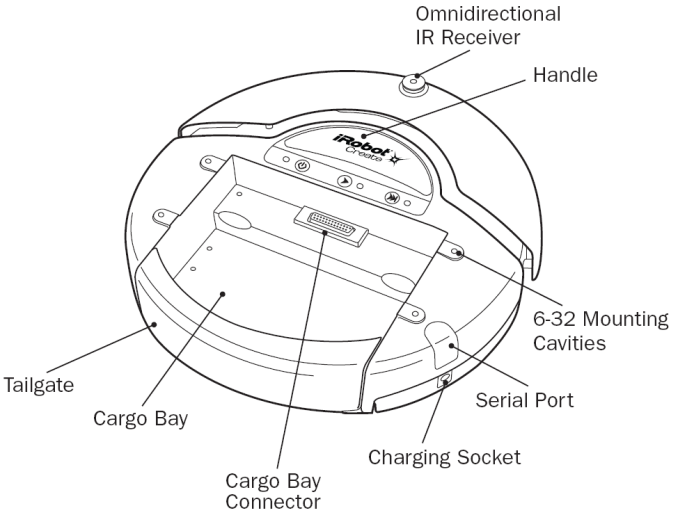
Current State of the Project

- 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.

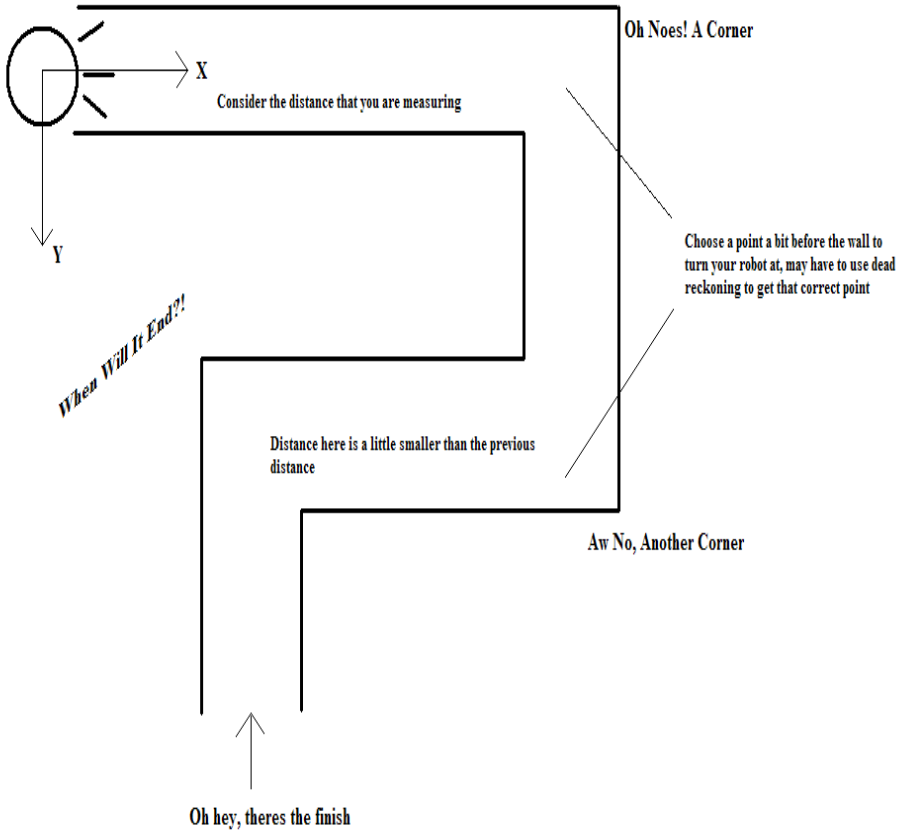
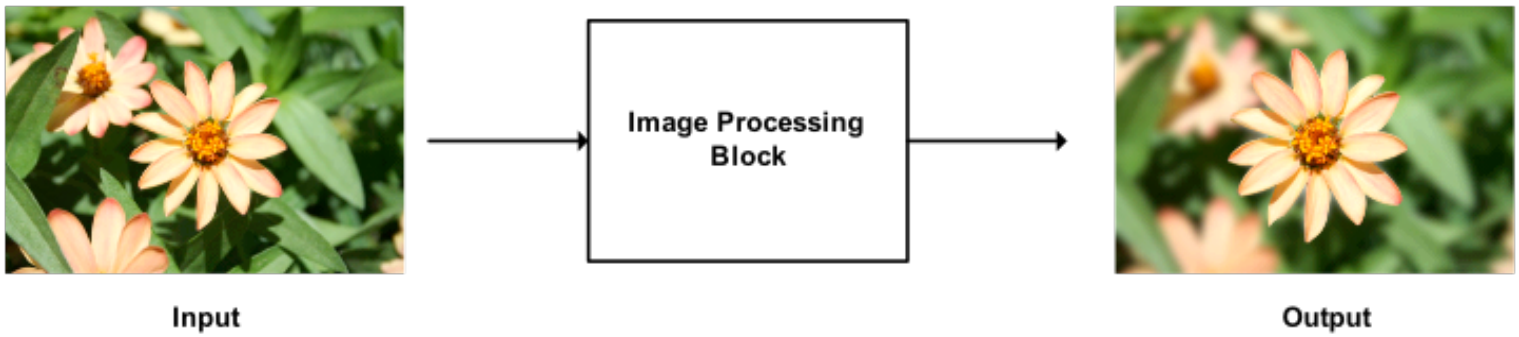


Image Processing

- Mathematical Ideas
  - understanding and applying mean/median
  - thresholding
  - matrices (and operations)

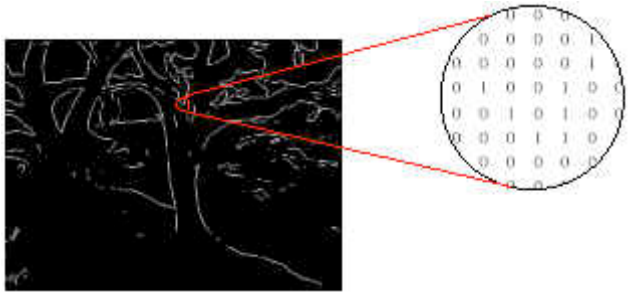
Introduction to Image Processing

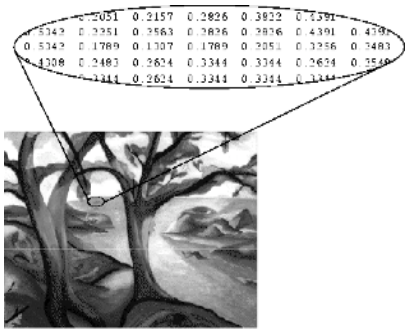
- Math and physics behind a practical engineering application
- Technology behind digital imagery
- Lab components:
  - Short lecture with take-home notes
  - Activity worksheet with examples and questions
  - Custom software developed for lab to illustrate concepts and encourage student experimentation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

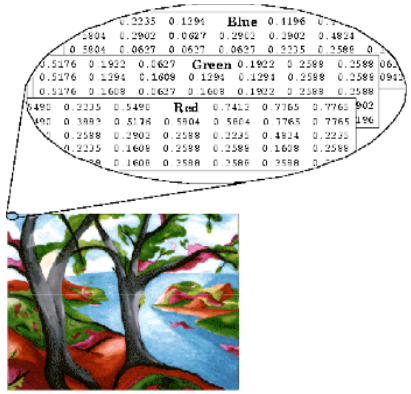


Technology background

- 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







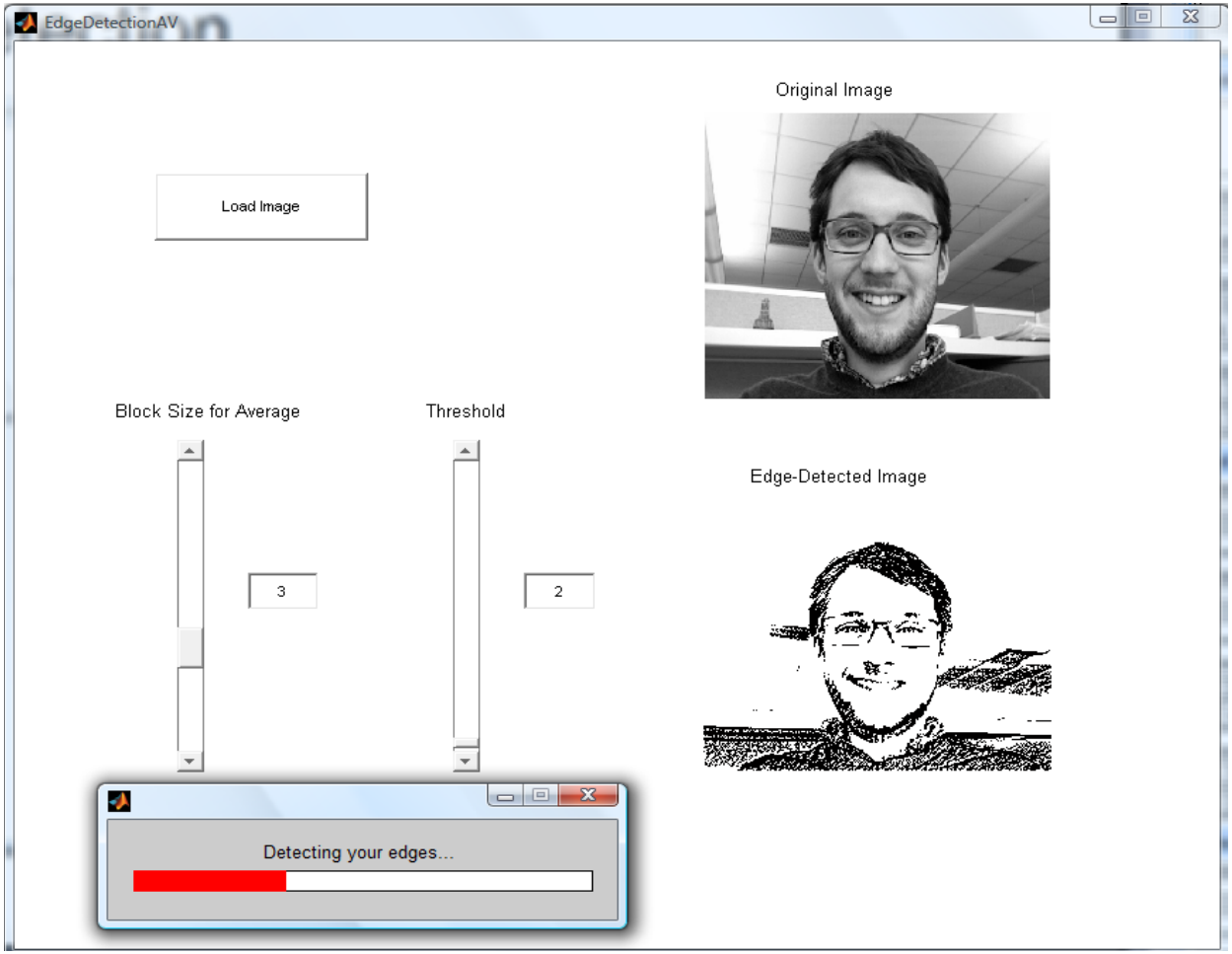
Edge Detection

- 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?

45	55	105	98	95
102	21	18	40	45
95	100	110	155	162
15	105	140	110	125

Edge detection pixel array; threshold 20

Edge Detection



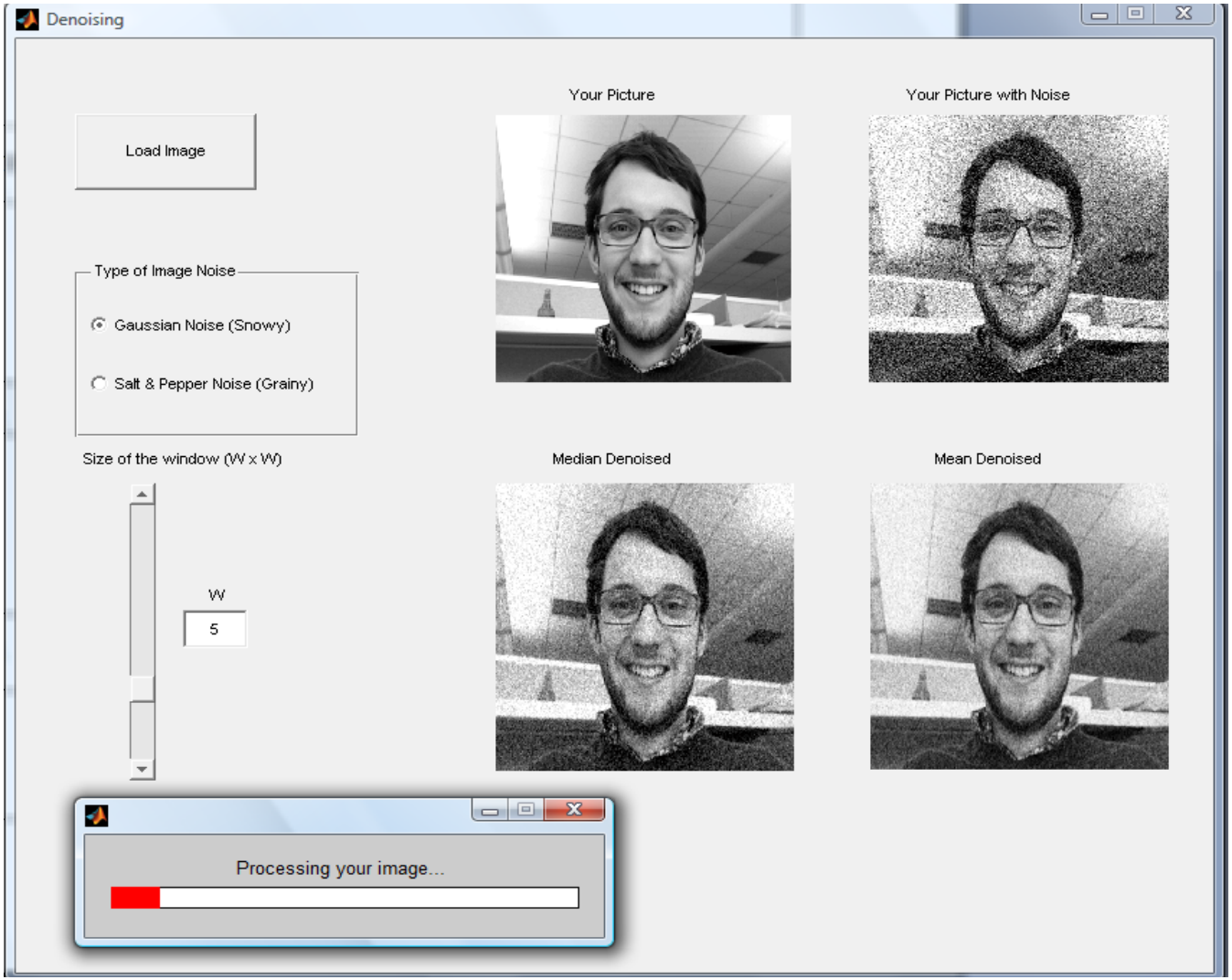
Denoising an Image

- 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?

43	55	105	94
102	22	18	40
95	125	155	160
21	105	140	135

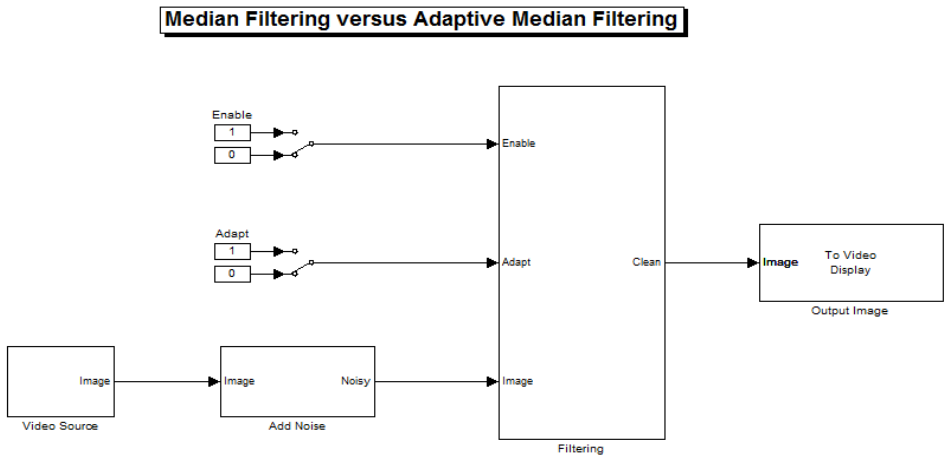
Denoising pixel array; 3x3 blocks

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 a 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/
- MATLAB GUI code to be converted to a web-based language (i.e. Java)
- Other resources available

Thank You.

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