How Computers Think

Data, Abstraction and Hierarchy, Hardware and Software

Alexander Perry – 4/9/19

http://www.cs.bsu.edu/cs4ms/docs/HowComputersThinkLessonPlan.pdf
http://www.cs.bsu.edu/cs4ms/docs/HowComputersThinkSlides.pptx
http://www.cs.bsu.edu/cs4ms/docs/WaveActivity.pdf
http://www.cs.bsu.edu/cs4ms/docs/PixelGridActivity.pdf

How Computers Think Lesson Plan

Objective: Teach the basics of how we interact with computers and how they remember and process information.

Materials: The included lesson Powerpoint. For each student, a ruler and prints of the two worksheets (wave activity and grid activity).

Lesson:

- **Essential Computer Architecture**
    1. We interact with computers via **input devices** such as a keyboard, mouse, microphone, or touchscreen.
    2. Computers provide us with information via **output devices** such as a monitor or speakers.
    3. Inside a computer, **data** is **remembered and processed.**
- **How Computers Remember**
    1. Computers contain many different kinds of storage that are good for different things.
        - **Long-term memory**, such as a hard drive or solid state, is the slowest form of storage, but can hold the most data.
        - **Medium-term memory,** such as RAM, is far faster than long-term memory, allowing data to be changed out frequently. It is smaller and more expensive to produce than long-term memory.
        - **Short-term memory**, such as the cache on a processor, is the fastest form of memory. It is also the smallest and most expensive to produce.
    2. To illustrate this, we will use the example of a machine which accepts wood and produces chairs. In order to produce the chairs, you must first store wood, then make it available to the machine.
        - **Short-term memory**, is like keeping wood directly in front of the machine. There's not much space, but you can quickly take the wood to the machine.
        - **Medium-term memory**, is like storing wood in the same building. This opens up more space for storage, but takes considerably longer to get wood to the machine.
        - **Long-term memory**, is like keeping wood in a warehouse down the street. The building is big enough to hold all the wood you could need, but it takes a very long time to travel from the warehouse to the machine.

- **What Computers Remember**
    1. **Binary** is the universal language of computers. Just like the English alphabet contains the characters A-Z, **binary** contains only the characters 0 and 1, making it easy for computers to read and remember.
        - **Binary** is used to represent everything in a computer, including numbers, images and sounds. All of these things are **abstracted** in **binary**.
        - You can think of **binary** as a switch, with 0 representing off and 1 representing on. These numbers are only used to represent this on/off state: any two opposites would work.
    2. **Analog** describes the way the world stores data. It is perfectly precise.
    3. **Digital** data is an exact figure, used to estimate **analog** data.
        - Computers can only remember **digital** data.
        - When we **abstract analog** data into **digital** data, precision is lost in the process.
- **Ruler Activity**
    1. Give each student a ruler. Have them try to line something up against a specific line of the ruler. Question them as to whether they've lined it up perfectly, with no error whatsoever between the position on the ruler and their item.
        - With **analog** data, such as the ruler, the item can be anywhere between the different lengths of the ruler. **Digital** data can only be represented exactly.
- **Wave Activity**
    1. Give each student a copy of the included worksheet.
    2. Instruct them on how to fill out the various spaces of the activity. Lead them through each section linearly, comparing their results to those displayed on the Powerpoint.
    3. After completing sections a through c, explain that the points they were connection represented different **resolutions** of **digital** data.
        - Each section took a different number of samples from the **analog** data provided. The larger the number of samples, the more closely the **digital** data resembled the **analog** data.

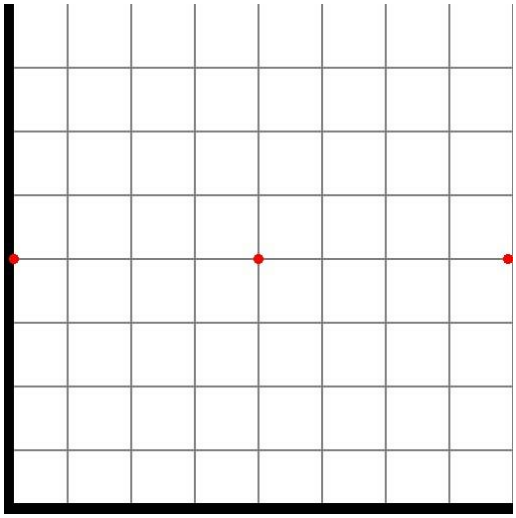
- **How Computers Remember Images**
    1. If you look very closely at a monitor, you can see the individual **pixels** making up the displayed image.
        - The more **pixels** there are, the more samples can be taken of the image.
        - The number of samples of analog data taken is called the **resolution**.
    2. Examples of low **resolution** you might recognize might be Minecraft or Mario.
        - Notice how you can distinguish individual **pixels**.
    3. The lower the **resolution**, the less detail is present, the more difficult an image is to understand (Do not reveal the image is the Mona Lisa until the students recognize it).
        - As the Mona Lisa becomes higher **resolution**, it becomes easier to recognize.
        - Observe the differences between lower and higher **resolution** images of the Mona Lisa.
    4. In order to remember images, computers must **abstract** them into its language: **binary**.
        - Images are made out of individual points, called **pixels**.
        - Each **pixel** holds a color.
        - Each **color** is stored as a combination of numbers and letters called a **HEX value** (colorspire.com/rgb-color-wheel).
        - **HEX values** are stored as **binary**.
        - Thus, the whole image is finally stored as **binary**. This picture of the Mona Lisa is remembered by the computer as 2.5 million ones and zeros!
- **Pixel Grid Activity** (This activity requires a basic understanding of grid coordinates)
    1. Each student needs an activity sheet. The first page contains columns of grid coordinates. Begin filling out the coordinates on the grid provided on the second page, completing the columns as ordered.
    2. When complete, the correct arrangement will spell out **C O M P U T E R S !**

Analog vs. Digital Data (Wave Activity)

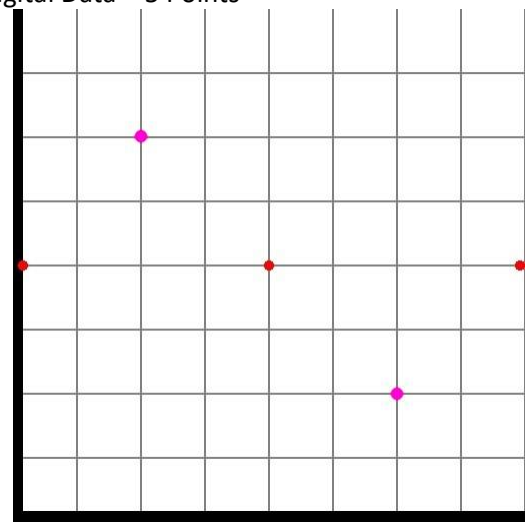
Name: _____ Date: _____

Connect the dots in each of the following **digital** figures.
Each **digital** figure is a different **resolution** of the **analog data** (d).
The more points, the higher **resolution** the **digital data**.

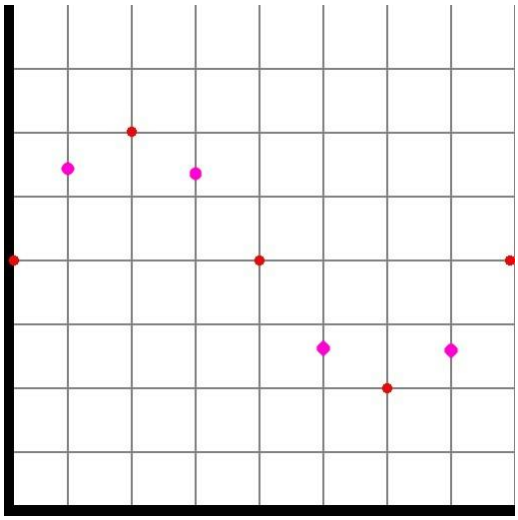
(a) Digital Data – 3 Points



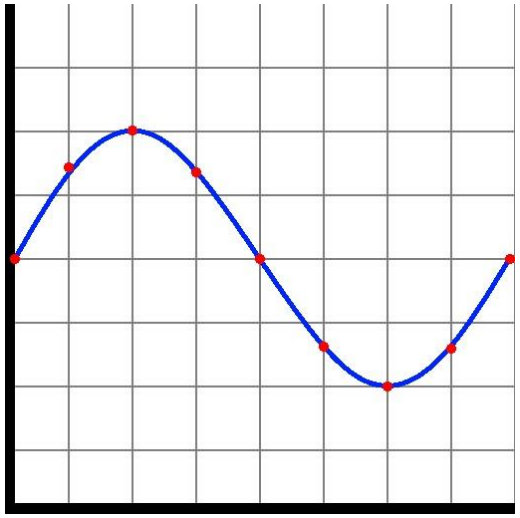
(b) Digital Data – 5 Points



(c) Digital Data – 9 Points



(d) Analog Data



Notice how as the **resolution** of the **digital data** increases,
It starts to look more like the **analog data!**

How Computers Store Images… Digitally (Pixel Grid Activity)

Name: _____ Date: _____

Fill in the space at each coordinate on the grid provided on page 2.

X	Y
4	10
5	10
6	10
4	11
4	12
4	13
4	14
5	14
6	14

X	Y
8	10
9	10
10	10
8	11
10	11
8	12
10	12
8	13
10	13
8	14
9	14
10	14

X	Y
12	10
13	10
15	10
16	10
12	11
14	11
16	11
12	12
14	12
16	12
12	13
16	13
12	14
16	14

X	Y
18	10
19	10
20	10
18	11
20	11
18	12
19	12
20	12
18	13
18	14

X	Y
22	10
24	10
22	11
24	11
22	12
24	12
22	13
24	13
23	14
24	14

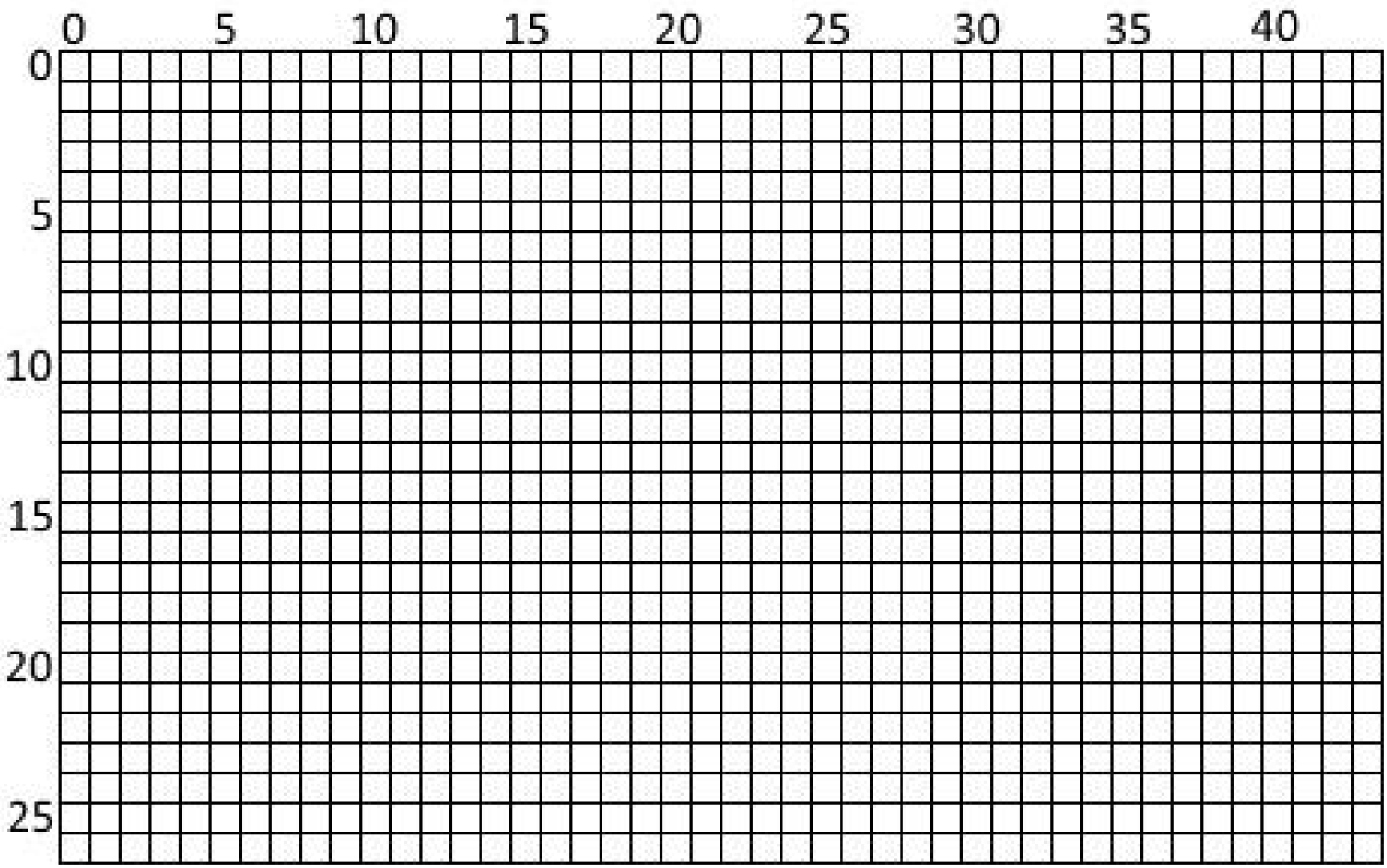
X	Y
26	10
27	10
28	10
27	11
27	12
27	13
27	14

X	Y
30	10
31	10
32	10
30	11
30	12
31	12
30	13
30	14
31	14
32	14

X	Y
34	10
35	10
36	10
34	11
36	11
34	12
35	12
34	13
36	13
34	14
36	14

X	Y
38	10
39	10
38	11
38	12
39	12
39	13
38	14
39	14

X	Y
41	10
41	11
41	12
41	14


0
5
10
15
20
25
30
35
40
0
5
10
15
20
25