Virtual Reality and Anaglyph Stereoscopic Technology

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Lesson Focus

With the mass production and availability of low cost and robust head-mounted displays (HMDs), there has been increasing interest in virtual reality technologies - for example the Oculus Rift, HTC Vive, Samsung VR Gear, Microsoft HoloLens, and Sony's PlayStation VR. These display technologies are based around artificial stereo images, and provide a view with illusions of 3D depth in virtual environments. Students will use the scientific method to study 'anaglyph' (movie 3D) technologies to model computer science design and learn how stereo images create the illusion of 3D.

Age Levels

Intended for ages 11-14

Objectives

Introduce students to
- ✦ how VR technologies exploit human depth perception,
- ✦ the use of stereo images to provide the illusion of 3D depth,
- ✦ use the scientific method to compare anaglyph technologies.

Anticipated Learner Outcomes

Students will be able to
- ✦ explain how VR technologies are based on stereoscopic images
- ✦ explain how anaglyph technology provides the illusion of 3D
- ✦ analyze the trade-offs between green/red, and red/cyan techniques
- ✦ demonstrate how to align two images to create 3D illusions.

Alignment to Curriculum Frameworks

See attached curriculum alignment sheet.

Internet Connections

- ✦ Building Worlds in Virtual Reality: Exploring Careers in Engineering and Technology. http://ieeetv.ieee.org/careers/building-worlds-in-virtual-reality-exploring-careers-in-engineering-and-technology

VR Technology
- ✦ Oculus: https://www.youtube.com/user/oculusvr and https://www.oculus.com
- ✦ HTC Vive: https://www.youtube.com/watch?v=qYfNzhLXYGc and https://www.vive.com
- ✦ Hololens: https://www.youtube.com/watch?v=aThCr0PsyuA and https://www.microsoft.com/microsoft-hololens
- ✦ VR Gear: https://www.youtube.com/watch?v=o1MK-zkM3qk and http://www.samsung.com/us/mobile/virtual-reality/
- ✦ Playstation VR: https://www.youtube.com/watch?v=cw6x80Qdzak and https://www.playstation.com/en-us/explore/playstation-vr/

Play with anaglyph glasses:
- ✦ How Do 3D Glasses Work? - Instant Egghead #22 (Scientific American): https://youtu.be/sc47Yna8rZE
- ✦ Website to view through 3D glasses: http://www.math.brown.edu/~banchoff/Yale/project14/glasses.html

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✦ Make your own glasses: http://www.wikihow.com/Make-Your-Own-3D-Glasses

Videos to view in 3D
✦ 3D Green/Red: https://www.youtube.com/watch?v=QalbbipAW2w
✦ 3D Green/Red: https://www.youtube.com/watch?v=YuAAhnBfi54
✦ 3D Red/Cyan: https://www.youtube.com/watch?v=fScKyTiMNwc
✦ 3D Red/Cyan: https://www.youtube.com/watch?v=bWD5K9x3GmY

Recommended Reading
✦ A Simple Overview of Anaglyphs -
http://www.math.brown.edu/~banchoff/Yale/project14/glasses.html
✦ The Human Eye - https://en.wikipedia.org/wiki/Human_eye
✦ Depth Perception - https://en.wikipedia.org/wiki/Depth_perception
✦ Stereoscopy - https://en.wikipedia.org/wiki/Stereoscopy
✦ Head-mounted Displays - https://en.wikipedia.org/wiki/Head-mounted_display
✦ Anaglyph 3D - https://en.wikipedia.org/wiki/Anaglyph_3D

Optional Writing Activity
Write up your findings on anaglyph technology. This lesson focused on green/red and red/cyan. Which worked better for you and why? These are not the only alternatives for 3D glasses. Research online what other alternatives exist. Make a case for your preferred technology: does it give a better experience, is it cheaper? How does the movie/online video industry play into it?

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For Teachers:
Teacher Resources

Anticipated Learner Outcomes

Students will be able to

- ✦ explain how VR technologies are based on stereoscopic images
- ✦ explain how anaglyph technology provides the illusion of 3D
- ✦ analyze the trade-offs between Green/Red and Red/Cyan techniques using the scientific method
- ✦ demonstrate how to align two images to create 3D illusion.

◆ Materials

3D Glasses:

- ✦ purchase paper glasses sufficient for your class, you will need both green/red and red/cyan, see Rainbow Symphony - https://www.rainbowsymphonystore.com/collections/3d-glasses
- ✦ use found objects:
  - o collect old/cheap glasses sufficient for sharing in your class
  - o scissors
  - o thin, clear hard plastic that can be cut with scissors (thick acetate works)
- ✦ a template for paper glasses is attached, use card stock paper, transparency sheets, and permanent markers to make glasses, requires scissors.

White paper sufficient for at least 2 pair per team.
Transparency sheets (3 per student).
Permanent markers in red, green, and cyan (or blue if cyan is not available). Share markers between teams if necessary.

Please note that the minor cost increase of purchasing paper glasses in bulk is well worth it. The students can focus on experimenting with stereoscopic technology rather than assembling glasses that won't work nearly as well.

Rulers sufficient for teams of three or four to share.

◆ Procedure
Overview

Computer science is a science, and as such, uses scientific outcomes to create technologies. Systematic experimentation before building technology is an essential part of design. Understanding how a natural phenomenon works only occurs when good results are achieved from an experiment. This lesson provides students with a taste of how VR headset designers made choices when designing their technology.

Virtual reality head-sets project two different images, one to each eye. Some technologies mix actual background with a 3D rendering technique analogous to 'anaglyphs'. Students experiment with anaglyph glasses to begin to understand the complexity of the computing involved in rendering a 3D image inside the headset.

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Procedure During First Hour

1. Watch the IEEE Career video with your students. Select more from the videos about various technologies. Discuss the following important points in the video.
   a. What does it take to create VR?
   b. How is this computer science?
   c. How do scientific outcomes impact design?
   d. Of the VR technologies shown in the videos which were most impressive and why?

2. Review the webpage "A good website/video on anaglyph technology." (http://www.snapily.com/blog/the-difference-between-3d-stereograms-and-anaglyphs/), but don't get bogged down in the cross-eye effect. Either show your students the webpage or use it to create your own short presentation. Keep this step down to 5 minutes.

3. Distribute 3D glasses and view the website through 3D glasses (http://www.math.brown.edu/~banchoff/Yale/project14/glasses.html). (Note that you can use purchased glasses or the ones you make.)
   a. If you are making glasses, this is the time to do it. See the resources for teachers if you are making your own paper glasses.
   b. See this video (http://www.wikihow.com/Make-Your-Own-3D-Glasses) if you are using found objects.

4. Select from the sample 3D images listed in the resources section, or find your own. Take care that the images you select are appropriate for your classroom and school culture. Have your students experiment and keep notes:
   a. Can you see green/red images with red/cyan glasses?
   b. Which technology appears to work better?
   c. What happens if you put the glasses on upside down? Do they still work?
   d. Why is it green/red and red/cyan? Does the order of the color matter?

5. Divide your students into small teams of 3 or 4 students per team, and have them answer the questions on Worksheet 1.
6. Leave sufficient time at the end for one member of each group to give a 'lightening talk' of at most 3 minutes summarizing their findings. Leave time for a summary analysis of all the presentations.
7. If the second hour does not immediately follow the first, inform them that in the next hour the teams will conduct some experiments and collect data. They should prepare by thinking about what kind of drawing they could make that would produce a 3D effect with just two colors. Use the samples you have viewed as a basis, but emphasize that they should keep it simple.
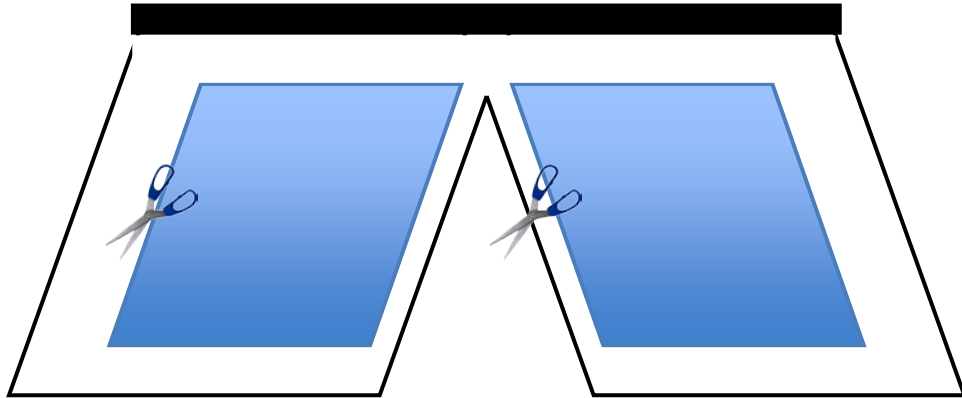
Procedure During Second Hour

1. Divide your students into teams (maximum of four students each). Make sure you leave at least 10 minutes at the end of the session to discuss their results.
2. Distribute Worksheet 2, and the materials listed on the worksheet. Reinforce that during the first hour they were exploring, and in this hour they are doing formal experiments.
3. Worksheet 2 asks them to draw a simple image. A sample of red and green are provided. Share these with your students or create your own samples.

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4. Your students are going to be asked to measure the distance between two images. Have a brief discussion about what that means. You can give them a definition, or have them agree to one. Typically you will need to define a 'center' of an image. You can create a 'bounding box' around the image, locate the midpoints of the horizontal and vertical edges, and place a small discrete point at the intersection of the lines draw from the respective vertical and horizontal edges. (In other words create a four pained window, but only mark the center, not the intersecting lines.)

5. While they are working, create a grid on the board (or on a flip chart), where the first column identifies each team. The labels for the remaining columns should be 'preferred technology', 'best distance for green/red', 'best distance for red/cyan', 'best distance for cyan/green'. Remind your students to enter their data before they wrap up their work space.

6. During the wrap up, discuss the results, and also discuss the difference between the exploratory and experimental activities. Ask your students to draw conclusions from their collaborative data collection. Challenge them as to how the industry might proceed based on their results.
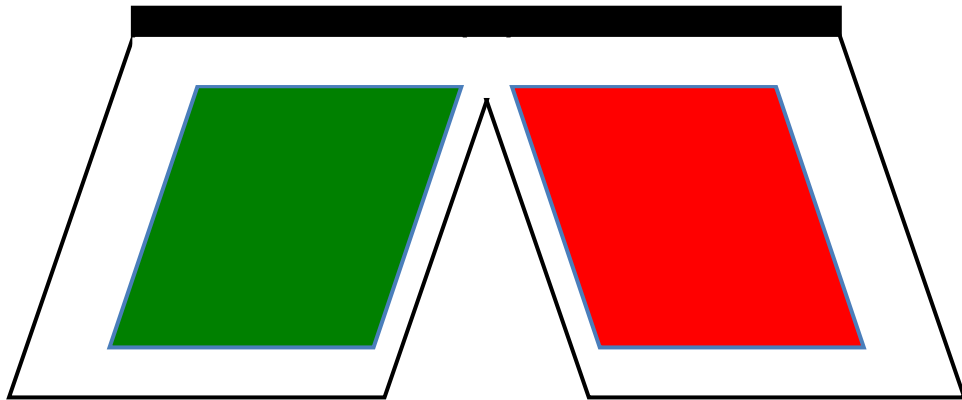

◆ **Time Needed**

2 sessions, at most 1 hour each. In the first hour students watch videos that explain both VR and anaglyph techniques, and informally view 3D images. In the second hour, students do an actual experiment on anaglyph techniques that includes extending the experiment to address questions they have raised themselves.

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Cut out

Add red and green coloured acetate windows, use permanent markers to color clear acetate.
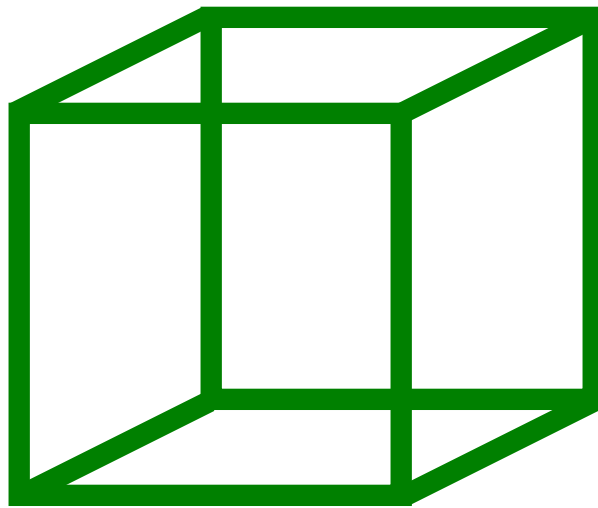
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Green square (copy to acetate)

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Red square (copy to acetate)

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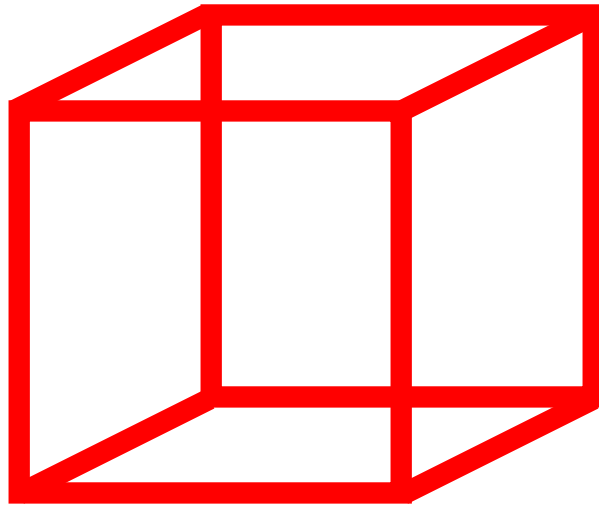
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Student Resource: Summarizing what you learned.

Your teacher showed you some videos and websites about virtual reality technology. On this page, create your own resource of terminology. Work with your teammates to agree on the answers, or use the Internet to locate information that you don't remember.

1. Briefly explain what virtual reality is, and how it works.

_____

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2. Anaglyph Stereoscopic glasses create the illusion of '3D'. Why does it work - that is, how does it trick your eyes?

_____

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3. The technology is labeled green/red, red/cyan. The order matters. Why?

_____

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_____

3. This is a try 'computing' lesson. What does it have to do with computing?

_____

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Student Worksheet 1:

This worksheet guides you through exploring 3D VR and Anaglyph Technology. Your teacher has organized your class into teams. Complete this exercise as a team, and be prepared to have a member of your team present your findings. This activity is an informal exploration.

1. As a group, complete the resource page. If you don't know the answer to something, ask people in another group. If no one in the class remembers, go on the Internet and find the answers. This technique of finding relevant resources is critical to computing. When technologies are so new, and not often well-documented, being able to do background research is critical.

2. Your next task is to do some informal exploring. Your teacher will provide you with some images either on a computer screen or on paper. Some are intended as 'green/red', some are intended as 'red/cyan'. Within your group, answer the following questions, then come up with your own additional questions.

    a. Can everyone in your group actually get the 3D effect? If not why?

    b. Can you see green/red images with red/cyan glasses?

    c. Which technology appears to work better? Why? Do you all agree?

    d. What happens if you put the glasses on upside down? Do they still work? If not, why not?

3. In the next hour you will do some formal testing with 3D glasses. To prepare, you will need to create a simple 3D image. Within your group, make a decision about what image to use for your experiment. You will need to draw the image in three colors on a transparency. If you have time you can begin to do the drawings, or simply note here your proposed image. Or sketch the image on the back of the paper. Things to keep in mind: Keep it simple: you will have to draw the image four times. Think about what kind of images will give the best effect.

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Student Worksheet 2:

This worksheet guides you through experimenting with 3D glasses.

Materials:
- Two pieces of white paper.
- Three transparency sheets.
- Three permanent markers, one each of red, green, and cyan.
- A ruler.
- A pencil or pen to record results on this page.
- A non-permanent marker in black for writing on paper, to create the original image.
- 3D glasses, at least one each of green/red, and red/cyan.

Goals:
1. To collect data on which technology in preferred, green/red or red/cyan.
2. To determine the optimal distance for two images. (Your class will have to agree on what 'distance between two images' means.

Task:
1. Have on member of your team draw a very simple image on a piece of paper. (Perhaps you prepared this in the first hour.) Mark the center of the image as discussed by your teacher. Your teacher may provide sample images.

2. Place a transparency sheet over the drawing, and using one of the permanent markers, have a member of your team copy the drawing.

3. Using the paper drawing and the one just created on a transparency, draw two more copies in each of the remaining colors. When you are finished you should have a black image on white paper, and duplicate images on transparencies, one each of red, green and cyan (or blue). Put aside the drawing in black.

4. Place the blank piece of paper on the desk or table. Place two of the three transparency images on top so that they overlap exactly. Look at the image through the 3D glasses with the same colors. For example if you chose the green and red images, then use the green/red glasses.

5. Gently move the images apart, watching for when the 3D image 'pops'. In which direction do you have to move them? When the images 'pop', measure the distance between the images.

6. Repeat steps 4 and 5 for the other combinations, so that you have data on 'green/red', 'red/cyan.' If you have time try combining cyan with green using either set of glasses and record the results. Team members should state the combination that worked best for them. Note how many people could see the 3D effect for each combination. Note the distance at which the image popped for each person.

7. Record your results on the table your teacher provides so that the entire class can draw conclusions. Be prepared to contribute your conclusions to the final analysis.

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Teacher Resource:
Alignment to Curriculum Frameworks

Note: All lesson plans in this series are aligned to the Computer Science Teachers Association K-12 Computer Science Standards, the U.S. Common Core State Standards for Mathematics, and if applicable also to the National Council of Teachers of Mathematics' Principles and Standards for School Mathematics, the International Technology Education Association's Standards for Technological Literacy, and the U.S. National Science Education Standards which were produced by the National Research Council.

◆ **National Science Education Standards Grades 5-8 (ages 10-14)**
CONTENT STANDARD E: Science and Technology
As a result of activities, all students should develop
✦ Understandings about science and technology

◆ **Next Generation Science Standards & Practices Grades 6-8 (ages 11-14)**
Practice 2: Generating and Using Models
✦ Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales.
Practice 5: Using Mathematics and Computational Thinking
✦ Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations

◆ **Principles and Standards for School Mathematics (all ages)**
Representations
✦ Use representations to model and interpret physical, social, and mathematical phenomena

◆ **Common Core State Practices & Standards for School Mathematics**
✦ CCSS.MATH.PRACTICE.MP4 Model with mathematics.

◆ **Standards for Technological Literacy – All Ages**
The Nature of Technology
✦ Standard 2: Students will develop an understanding of the core concepts of technology.

◆ **CSTA K-12 Computer Science Standards Grades 3-6 (ages 11-14)**
5.1 Level 1: Computer Science and Me (L1)
Community, Global, and Ethical Impacts (CI)
2. Identify the impact of technology (e.g., social networking,

cyber bullying, mobile computing and communication, web

technologies, cyber security, and virtualization) on personal

life and society.

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◆CSTA K-12 Computer Science Standards Grades 6-9 (ages 11-14)
5. 2 Level 2: Computer Science and Community (L2)
✦ Collaboration (CL)
3. Collaborate with peers, experts, and others using collaborative practices such as pair programming, working in project teams, and participating in group active learning activities.

CSTA K-12 Computer Science Standards Grades 9-12 (ages 14-18)
5.3.A   Computer Science in the Modern World (MWJ)
✦ Computational Thinking (CT)

8. Use modeling and simulation to represent and understand

natural phenomena.

◆CSTA K-12 Computer Science Standards Grades 9-12 (ages 14-18)
5.3.B   Computer Science Concepts and Practices
✦ Computational Thinking (CT)
8. Use models and simulations to help formulate, refine, and test scientific hypotheses.

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