Earth Science Data Visualization Through Augmented Coloring Books

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Abstract

The process of scientific visualization often involves making design choices- colors being one one them, to effectively communicate and highlight features in the data (e.g. high/low temperatures). Using the techniques of registration and image tracking, which are widely used in Augmented Reality (AR) applications to anchor digital content to the real world, an iPad/iPhone application has been developed that visualizes hand colored earth science datasets. The application would scan a student's hand-colored page of a rectangular image of some global dataset, obtain the colors used, and convert that to an AR interactive, 3D globe with the dataset in study, animated with the students' colors. This exercise could also be used to educate students about different map projections and is a flexible, customizable, inexpensive tool for teachers to teach a variety of geoscience topics. This engaging interactive environment could help instill a sense of ownership of the data and encourage the student to be more engaged with the science being presented.

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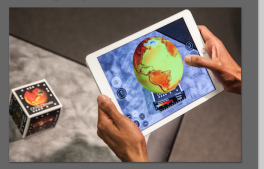
What is Augmented Reality (AR) ?

AR is a visualization environment in which the users' view of the real world is enhanced with virtual objects, when viewed through a screen or an optical head mounted display. This give the user the illusion of virtual objects coexisting with real world objects. The term Mixed Reality (MR) is sometimes used interchangeably with AR.

Figure 1. The photograph on the right shows a user interacting with an AR application. The app displays a virtual globe on top of the physical box with a marker creating an illusion of the globe being present in the physical world.

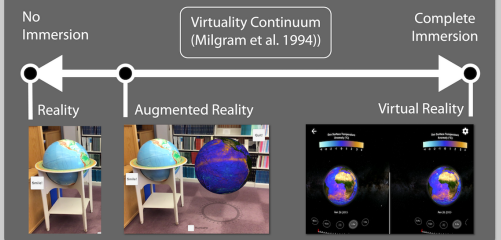
Photograph credit - Eliott Foust, NCAR.



How is Augmented Reality (AR) different from Virtual Reality (VR) ?

VR is an environment in which the user wears a head mounted display whose display is updated in-sync with the users physical movement. This creates an illusion of being visually immersed in a new environment. In a nutshell- AR brings virtual content to real world where as VR transports the user into a virtual world.

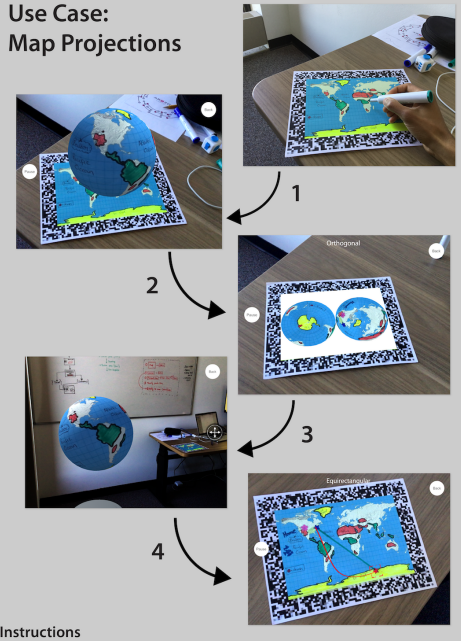
Figure 2. Virtuality Continuum, Milgram et al. 1994. The level of immersion increases from left to right with the user's view of the real world on the left and VR's fully immersive environment on the right.



Advantages and Challenges of AR in Education

- Enhances spatial ability, learning achievement, learning motivation (Akçayır et al. 2017, Martín-Gutiérrez et al., 2010).
- Technological complexity, Potential distraction, Novelty effect (Akçayır et al. 2017).

Use Case: Map Projections



Instructions

1. Students draw a visualization pertaining to some global data on a map. The page is then scanned by viewing it through a smartphone/ tablet computer running the visualization app. The app detects the map texture and converts it to a 3D globe in AR. The globe responds to the user's touch input while being anchored to the page.
2. Using the drop down menu, different map projections can be selected. This allows the user to explore and investigate the distortions caused by various projections.
3. The globe can also be viewed in roomscale markerless AR if desired.
4. Additionally, the map in cylindrical equidistant projection can be used to explore great circle distances. The student draws the best guess shortest path between two locations (blue line in the figure) which can be verified within the app (red line in the figure).

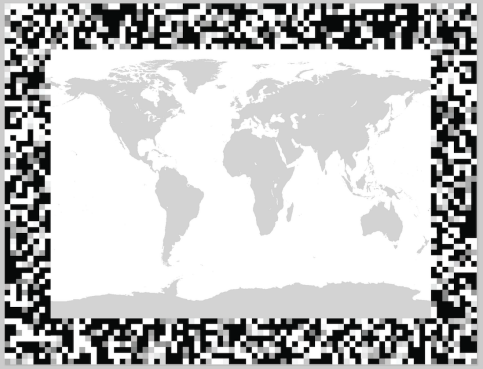
Overview

- Students are accustomed to seeing flat maps of the earth, often in Mercator or Cylindrical-Equidistant projections which introduce severe distortions near the poles.
- The following activity helps teach map projections and great circle distances through an interactive smartphone/tablet application.
- The application allows students to color blank maps (cylindrical equidistant projection) with geographical features or visualizations which can then be view in different map projections interactively using AR.
- Using AR helps to connect the coloring activity with digital enhancements making the learning activity intuitive and engaging.

Relevant Work

- One of the first applications of interactive books was demonstrated by Billinghurst et al., 2001. Markers in story books were used as a trigger and an anchor to drive a relevant VR content.
- Clark et al., 2012 demonstrated an AR pop-up book application in which the hand drawings were used to texture 3D AR objects.

Demonstration



Preliminary Findings (Informal)

- The application was demonstrated at a local outreach event (NCAR Super Science Saturday event) at Boulder,CO and Cheyenne, WY giving us an opportunity to identify the primary audience and gather preliminary user feedback.
- The activity received a positive feedback overall with the primary users being K-12 students. The Great Circle distance activity was popular with parents as well.
- Younger students were primarily interested in seeing their drawings transferred onto a a globe with a few of them identifying continents and some places on the map with the parents help.
- Most of the older students actively tried switching between different map projections to identify the projection which best visualized their drawing.
- Very few students knew about Great Circle arc and appeared very fascinated with the activity. Many students repeated the great circle path activity multiple times while trying to relate the Cylindrical Equidistant Map with the Globe.

Figure 3. Kids trying the activity during Super Science Saturday, Bounder, CO.

Summary & Future Work

- An interactive application of AR to teach map projections using a coloring book approach is presented.
- This activity could build on the GLOBE, 2014 exercise on drawing your own visualizations to add a component on map projections.
- A formal user/instructor evaluation study to assess the advantages and disadvantages of using this approach needs to be conducted using focus groups. This will also help identify other avenues where AR could be used to address a pedagogical need beyond the novelty effect.
- This application (and AR in general) is not accessible for students with visual impairments. In order to make the activity inclusive, it is recommended to use AR as a supplemental feature along with an option to view/print the scanned map projections, thereby allowing the students to obtain large or tactile prints if required.

Are you Interested in Collaborating?

Inspiring, educating, and informing the public about NCAR research and about the wonder and relevance of science is one of the primary missions of our organization. Implementing new technologies that enhance our storytelling capabilities and engage our audiences plays a key role in making that possible. We are always looking for collaborators.

Please contact us if you are an educator interested in participating in AR/VR technology evaluation studies or interested in using AR as a tool to address a pedagogical need.

Information regarding the NCAR-CISL Visitor program can be found here: https://www2.cisl.ucar.edu/cisl-visitor-program

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