Innovative Technologies in Teaching and Learning: Incorporating Recent Developments in Virtual and Augmented Reality into Active Learning at the University of Georgia

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Abstract

This work presents system concepts, integration efforts and results of the incorporation of recent advances in geospatial technologies, including augmented reality, virtual reality and unmanned aerial systems (UAS), into teaching and learning in the geosciences. Descriptions include the exploration of multiple technological alternatives and introduce system design and integration to enhance and innovate instructional materials in classrooms. The 3D Immersion and Geovisualization (3DIG) system, implemented at the Center for Geospatial Research at the University of Georgia incorporates augmented/customized commercial-off-the-shelf solutions for data acquisition, visualization and human-machine interaction. Through the immersive capabilities of 3DIG, students can be involved in a full data acquisition-processing-analysis workflow. Data streams are used for system integration, with emphasis to model generation/manipulation and remote sensing applications, including multispectral data acquisition/analyses, structure-from-motion based point-cloud/model generation, DEM and texture extraction, and orthomosaics. Resulting products are used with virtual and mixed reality holographic devices, a Geographic Information System (GIS) and with game engines (Unreal Engine and Unity) to create realistic multi-scale multi-theme 3D reconstructions of planet Earth, landscapes and/or objects. Among other system components, an augmented reality digital sandbox equipped with two depth cameras supports experiential learning and experimentation involving scaled down replicas of landscapes or user-defined topographies. The system allows for fast representation of landscape changes (near-real time response), which simulates fluid flow over modified terrain, as well as quantitative analyses, modeling and what-if scenarios through the integration with a GIS. The 3DIG system has been incorporated into classwork and results have been evaluated. This work introduces the interconnected and complementary technologies of 3DIG; presents lessons learned during system design; introduces system implementation and evolution (including the recent integration of new components); describes system use for hands-on and immersive experiential learning; and discusses system evaluation.

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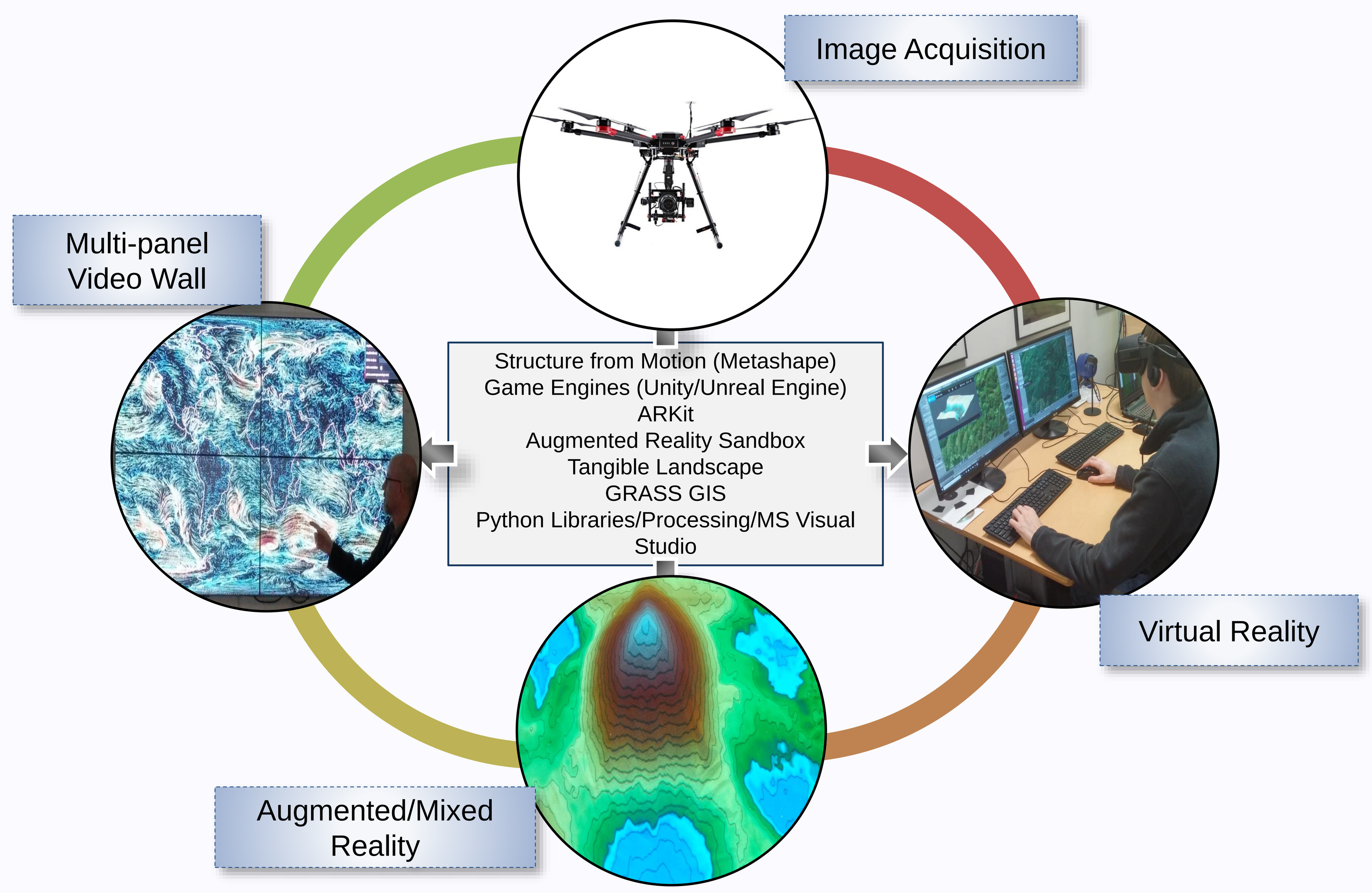
CGR DGTL Disruptive Geospatial Technologies Laboratory

UNIVERSITY OF GEORGIA

BACKGROUND

Students are increasingly visual learners and come to universities with a high level of expectation and experience in visualization strategies, including 3D graphics. Recent advances in technologies already being used by students, including a variety of mobile-based applications, computer gaming related hardware/software, and unmanned aerial systems, among others, can be used to facilitate data acquisition and visualization. Although some of these technologies are progressively finding their way towards classrooms, materials for education and outreach in the geosciences rely predominantly on two-dimensional displays of images, maps, photographs, data graphs and conceptual diagrams. This work summarizes efforts at the Center for Geospatial Research (CGR) to integrate a system for cutting-edge data acquisition, virtual/augmented reality and immersive geovisualization for enhanced Earth Science teaching and learning.

Technologies & Technology Integration



The 3D Immersion and Geovisualization System (3DIG)

http://cgr.uga.edu/projects/3dig/

Multi-component system integrated for data acquisition and visualization using multiple hardware platforms and commercial-off-the-shelf and free (also open source) software.

Software and hardware received different degrees of augmentation and in-house customizations. 3DIG uses technologies that can be interconnected and that create opportunities for hands-on and immersive learning experiences spanning from system design to application.

System design emphasizes component integration and identified solutions that facilitate data flow between components. Major components of 3DIG include: Image Acquisition, Virtual Reality, Augmented/Mixed Reality and 2D Panel (Video Wall).

System Components

UAS

Matrice 600 Pro
- Ronin-MX gimbal
- Multisensor integration
- 25+ min. flight

Phantom 4 Pro
- camera: RGB, 20 MP 1 inch CMOS sensor
- ~25 min. flight/battery
- collision avoidance
- First Person View

MicaSense RedEdge
- RGB, NIR, red edge
- 3.6 MP, global shutter
- downwelling radiation sensor
- GPS
- calibration Panel

LiDAR
Velodyne VLP-16 Hi-Res

Thermal
FLIR Duo Pro R

Virtual Reality

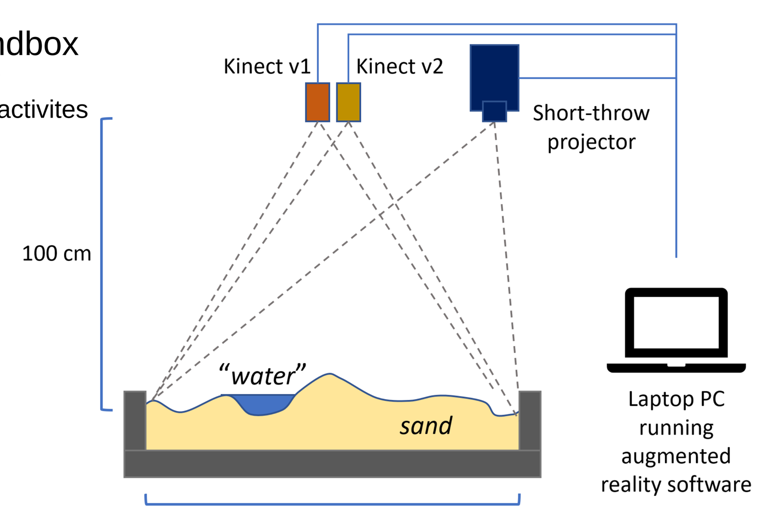
Devices support individual VR interactions involving groups of students and entire classes.

Oculus Rift/Go/Quest

VR goggles for mobile + remote

Augmented/Mixed Reality

Digital Sandbox
- multi-sensor
- customized activites
- mobile



iPads
Devices support individual AR interactions involving groups of students and entire classes.

Microsoft HoloLens
- multi-camera
- depth sensor
- non-tethered
- hologram rendering

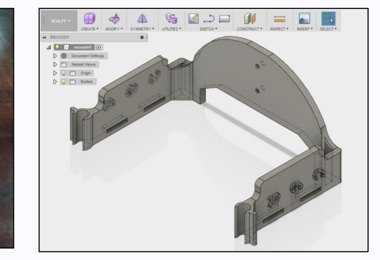
Magic Leap
(soon to be integrated)
- multi-camera
- depth sensor
- non-tethered
- hologram rendering

Video Wall

Nine 46" displays (3x3)
(2x2 implemented)
Displays: NEC X464 unv2 commercial grade
Daisy chained
Embeded computer
Networked

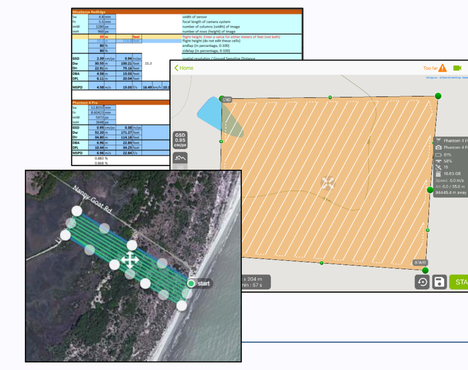
Use in Teaching, Learning and Research

Experiential learning: undergraduate and graduate students are paid hourly or offered research assistantships and are involved in all phases of system development, configuration and use.



UAV system integration and customization. Development of in-house 3D printed solution for mounting multispectral sensor.

Students learn how to fly UAVs and are trained in aerial system operations and data collection methods.

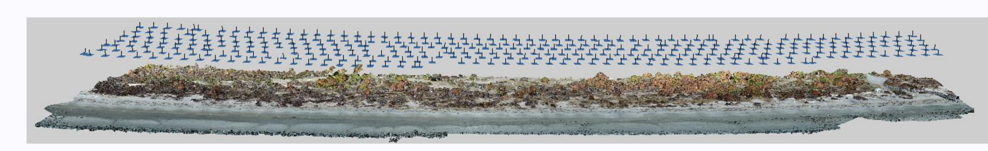


Training on flight planning for simultaneous RGB and multispectral image collection.

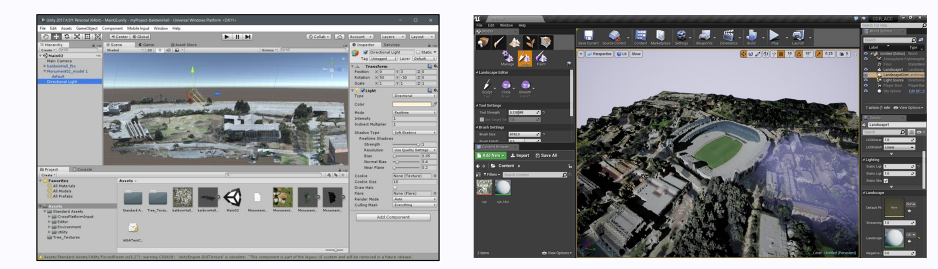
Processing of results for integration into other components of the system.

Products:
- orthomosaics
- 3D models (Structure from Motion-SfM)
- very-high resolution (<1 in) calibrated reflectance images and mosaics (5 bands)
- processed images (filtered, classified)
- spectral indices

Geovisualization: use of 3D models and images to create realistic and immersive environments.



Realistic 3D visualization derived from single flight mission (367 images)



Game Engines (Unity, Unreal Engine)

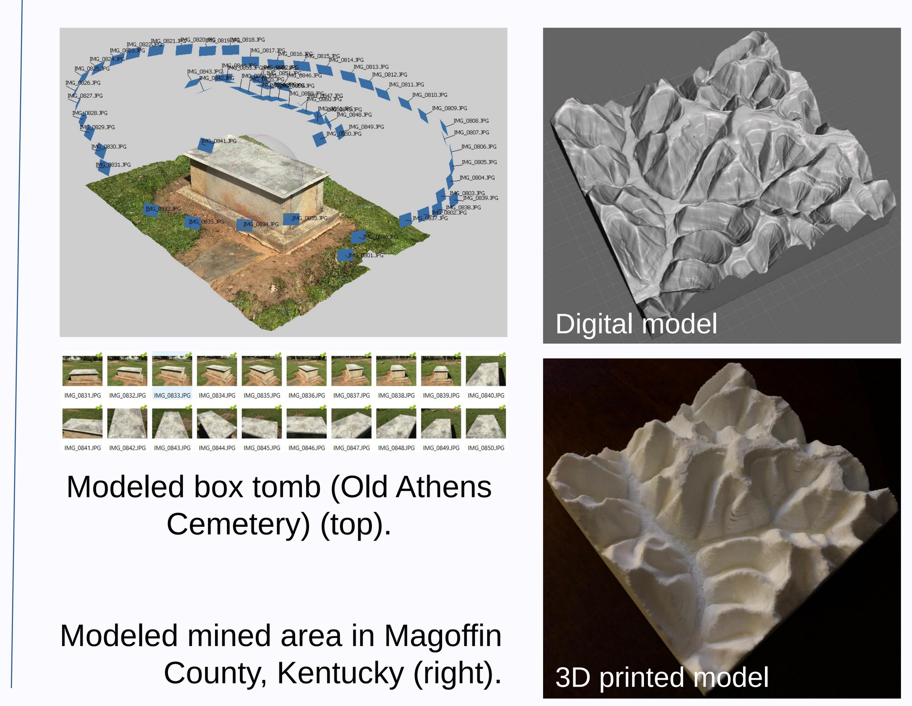
Visualization of virtual 3D environment derived from SfM models and DEMs

Integration of 3DIG system components into classroom activities and projects.

The Digital Sandbox and other technologies are used in the classroom and events to present concepts in Earth Sciences.

Students build a 3D model of southern Appalachia to be used with the Digital Sandbox as part of their NASA DEVELOP fire modeling project.

3D modeling and printing of natural and modified objects and landscapes.

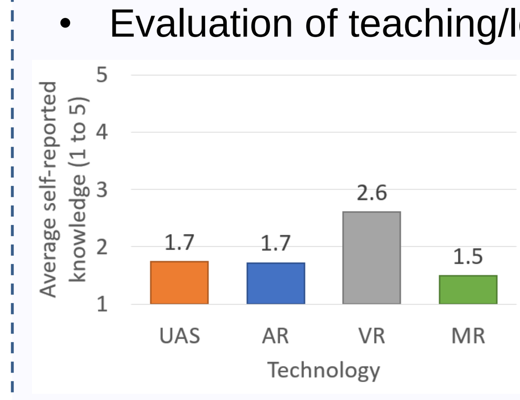


Modeled box tomb (Old Athens Cemetery) (top).

Modeled mined area in Magoffin County, Kentucky (right).

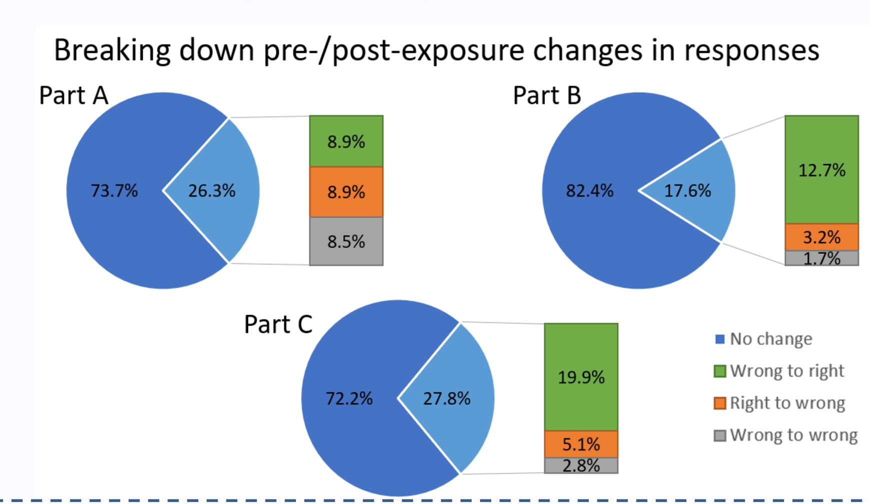
System Statistics & Evaluation (since Nov 2016)

- Estimated audience: over **6,000** students (college pre-K, elementary and middle schoolers), as well as other members of the community.
- Use for teaching/learning: **50 courses/sessions** (Geography [Physical Geography, Weather and Climate, GIS], Geology (Earth Science for Middle School Teachers), Environment and Design and Psychology (Environmental Psychology), multiple First Year Odyssey courses.
- New courses created: **2** graduate-level seminar on UAV-based multispectral image collection, processing and analysis.
- Participation in outreach: **14 events**.
- Number of students involved in developing the project: **14**.
- Evaluation of teaching/learning: **472** pre- and post-exposure/use surveys.



In general, "use [in games]" and "having heard" about a technology are linked to higher understanding

3-part question	Pre-exposure	Post-exposure	% Change
Part A	39.6%	39.6%	0%
Part B	83.7%	93.2%	+9.5%*
Part C	72.2%	87.1%	+14.8%*



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