Interactive Visualization of a Base Metal Concentrator

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Abstract

Virtual reality, a 3D computer-generated environment, has become recognized a delivery system for many forms of education. This paper describes the application of virtual reality to mineral processing education. An interactive mineral processing visualization module developed at the University of New South Wales, Australia, provides students with an overview of a base metal concentrator and details about each stage of the process, as well as revealing how the mined ore progresses theough stages in processing. The module also involves developing instructional based plant layouts and flowsheets in the virtual environment that are intended to assist the user in understanding the essential components of the base-metal concentrator.

Keywords

Mineral processing, Mineral processing education, Processing plant, Virtual reality (VR)

Introduction

Virtual reality (VR) is the creation of an artificial environment that is experienced through sights and sounds provided by a computer (Squelch, 2001). The simulated environment is achieved through a technologies such as 3D graphics, audio feedback, and special peripheral devices to produce interactive environments.

Virtual reality has been used in diverse fields including medicine (Riener & Harder, 2012), entertainment (Hsu, 2011), military (Manojlovich, Prasithsangaree, Hughes, Chen, & Lewis, 2003), manufacturing (Zimmermann, 2008; Jiang, 2011), and chemical processing (Schofield, Lester, & Wilson 2005; Squires, Andersen, Reklaitis, Jayakumar, & Carmichael, 2014). Virtual reality is also becoming the recognized delivery system for education in many fields, including engineering (Bell & Fogler, 1996, 1998; Shin, 2002). For example, VR laboratories have been designed and developed to teach students fundemental features of heterogeneous catalytic mechanisms and absorption columns (Bell & Fogler, 1995), the multi-phase and multi-component blast furnace iron making process (Babich & Senk, 2009), and to guide students to identify various safety measures while working in real laboratory (Bell & Fogler, 1996).

The School of Mining Engineering at the University of New South Wales (UNSW), Australia has developed and deployed immersive, interactive simulations within the mining engineering education sector at undergraduate and postgraduate levels. Virtual underground and open-cut mines have been developed, where students can experience various aspects of a mining operation and assess the feasibility of different mine design options (Laurence & Stothard, 2010). VR modules have also been developed to traincoal mine workers and raise community awareness (Mitra & Saydam, 2011; Saydam, Mitra, & Russell, 2011). These modules y focus primarily on understanding mine environment hazards, identifying and eliminating hazards sources, and reducing risks through taking appropriate action to rectify a situation.

In this study, a virtual environment has been developed that simulates a base metal concentrator, consisting of grinding and flotation circuits. The purpose is to place students in an environment that allows them to navigate through a virtual plant to understand its operation, equipment functionality, and layout.

Virtual Reality Module

Simulated Concentrator

The virtual mineral processing plant was developed based on the Northparkes copper concentrator, which is in central New South Wales, Australia, approximately 300 km from west of Sydney. The concentrator has two identical parallel modules, each consisting of grinding and conventional flotation circuits. The ore is crushed and ground in a semi-autogenous grinding mill, followed by two stages of ball milling, and a flash flotation unit where high-grade fast-floating particles are removed. The flash flotation tailings are processed in rougher, scavenger, cleaner, re-cleaner, and cleaner scavenger banks to produce the final copper-gold concentrate. The ore has a grade of approximately 1.4% copper and 0.4 g/t gold. The final concentrate produced for each module assays 36–40% copper.

3D Mineral Processing Plant

In the current version of the virtual reality module, students are provided with an overview of a mineral processing plant where the mined ore is processed through a conventional grinding and froth flotation circuit to produce a gold-rich copper concentrate for export. This is done through a combination of 3D interactive models: 360° panoramas of the concentrator and individual units, videos, and aerial photographs. Figures 1–5 show screenshots from the module.

The module allows students to walk through the concentrator to any place of interest. The tour provides the plant flowsheet to display the locations of all major pieces of equipment, along with descriptions of the equipment and technical information. Streams of material entering and leaving the

Figure 1: Screenshot of the module showing stockpiles

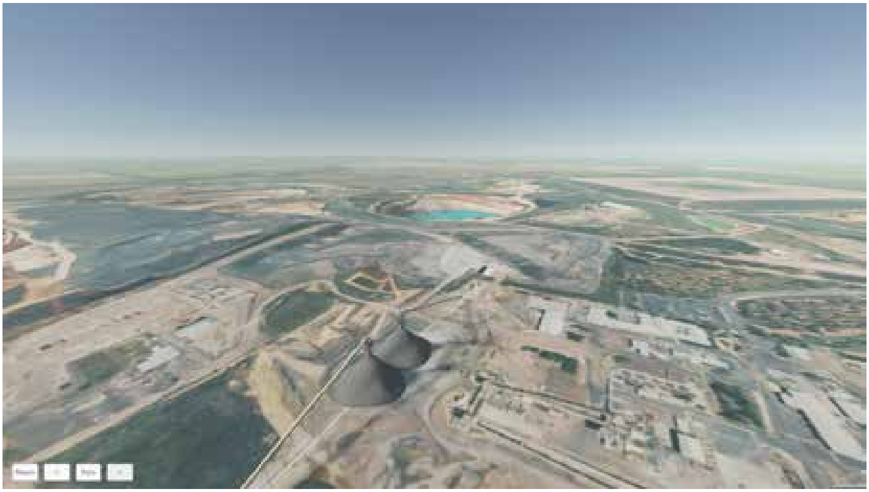


Figure 2: Screenshot of the module showing grinding circuit

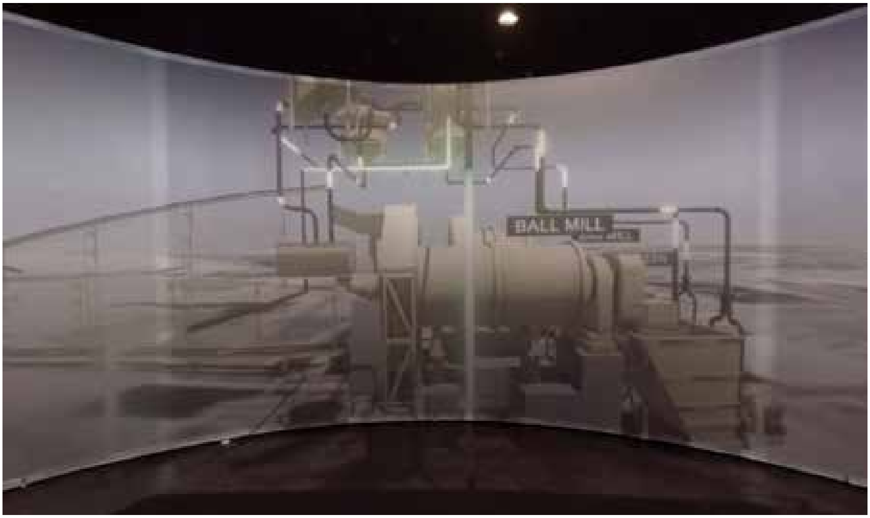
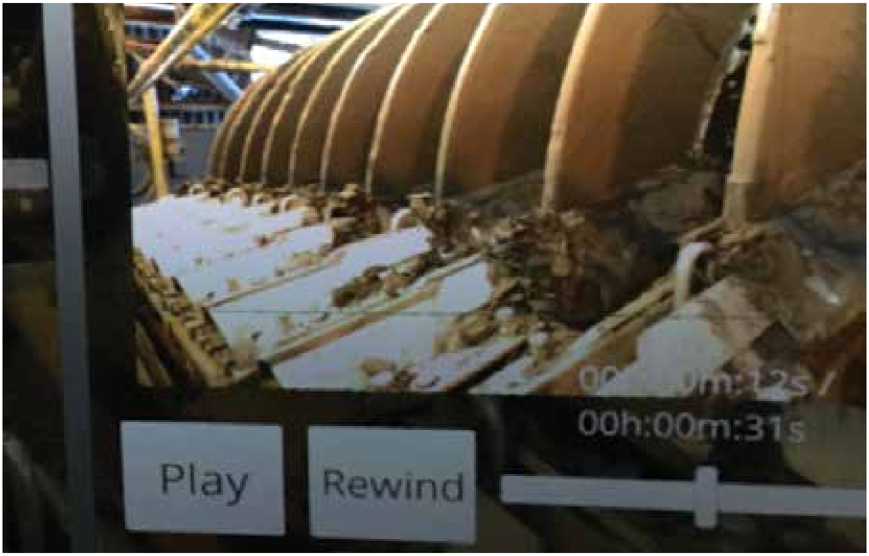


Figure 3. Screenshot of the module showing flotation circuit

Figure 4: Screenshot showing the flotation circuit panorama

Figure 5: Screen capture of the module showing a video of the filtration unit



individual unit operations and sub-circuits are displayed on the flowsheet as animated lines. The direction of the streams is identified by one or more animated lines of different colours to allow the user to follow how the material is moved through the various stages. The module is designed so that the user can easily switch to the 3D mode and explore the major units in the virtual environment. For example, a user looking at a flotation cell on the flowsheet mode could easily shift into the interactive, virtual mode and observe from any angle how a flotation cell in the rougher bank operates in 3D. The user could also directly access the information such as feed rate, particle size, grade, and recovery of the each cell in the bank. These data are displayed in an accompanying summary table.

The module also offers a media library for each of the major unit process. Within the media library, the user can access short videos of the unit in operation, pictures taken at different angles, and a 360° panoramic view of the location, which gives a strong sense of immersion and brings the user into the scene.

Although lecture-based teaching approaches equip students with a general knowledge of the individual components of a mineral processing plant, students often have difficulty in understanding how the various stages work together and the interrelationship between them. The current module achieves this–not only by demonstrating the inputs and outputs of each stage of the process–but also allowing the user to view adjacent stages of the pipeline at any time. For example, if the user is viewing the semi-autogenous grinding mill, they are able to "zoom out" and view the mill, the vibrating screen, the cone crusher, and the ball mill. The adjacent stages are represented by 3D models, with all inputs and outputs clearly identified. Users can then rapidly jump to adjacent stages to view them in greater detail, or move back to the bird's eye view.

Further, the virtual reality module allows users to build a particular copper-gold mineral processing circuit and perform a mass balance based on the information provided. The student is initially given a basic description of a flowsheet and key information such as feed composition, mineralogy, particle size, reagents schemes, grinding properties, and the flow rate of streams. They are also presented with 2D and 3D representations of unit processes that might be used in the flowsheet. The students' task is to construct a plant layout using the sources available in the virtual environment and explain the basic operation of all major components used in the flowsheet. They must perform a mass balance for each sub-circuit and carry out calculations to estimate the diorection and composition of unknown stream(s).

Software and Platform

The module was developed with Unity, a powerful development platform for creating multiplatform 3D and 2D games and interactive experiences. All of the digital assets within the module (such as the 3D models of the terrain, the mineral processing equipment, and any surface textures used for the equipment) were created with two software packages. Foundry Modo® and Autodesk® 3ds Max® were used to construct the 3D model geometry using photo references and animate the objects and/or run simple physics simulations, respectively. The digital assets were then imported into the

Figure 6: AVIE at the School of Mining Engineering, UNSW

Unity game engine and interactivity added via programming in the C# language. The textures used for mapping the 3Dobjects were constructed using Adobe® Photoshop®.

The School of Mining Engineering at UNSW has advanced visualization and interactive environment (AVIE) facilities that provide a virtual learning platform for mine safety training and mining engineering education modules developed over the years (Figure 6). The mineral processing interactive module runs in the AVIE. The module is also able to run on a single computer, on a smartphone using VR glasses or similar technologies, and on an Oculus® Rift® VR headset using a computer. The VR glasses will enable the module to be used on site without the need for a VR theatre.

Conclusions

Mineral processing education can be greatly enhanced and facilitated by the use of VR. This paper presented the design and development of an interactive base metal concentrator module developed at UNSW, Australia. The main goal of the virtual reality module is to bring a virtual mineral processing plant to the university environment, where students can experience a real plant, and visualize unit operations in 3D and the interrelation between the sub-unit processes. The module presented is not driven by dynamic process simulations. Future work includes implementation of dynamic simulated processes by importing real data into the module to improve the realistic representation of the actual systems.

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