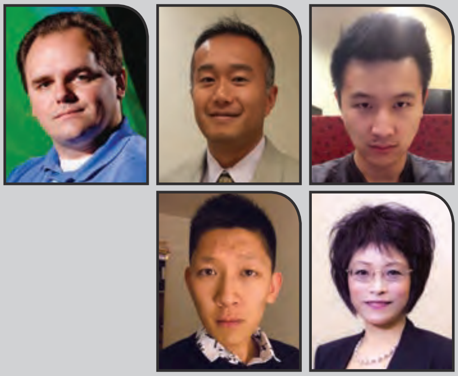
Enhancement of Steel Industry Safety Training Through Incident Visualization Development

Hazards are ever-present in the steel plant environment, and a heightened awareness and emphasis on safety is a necessary priority for our industry. This monthly column, coordinated by members of the AIST Safety & Health Technology Committee, focuses on procedures and practices to promote a safe working environment for everyone.

Authors



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Comments are welcome. If you have questions about this topic or other safety issues, please contact safetyfirst@aist.org. Please include your full name, company name, mailing address and email in all correspondence.

Don B. Daily Memorial Fund — To Promote Steel Industry Safety and Health

This article is the fourth in a series of Safety First articles featuring the reports from the recipients of the 2013 Don B. Daily Memorial Fund. The first, second and third articles in the series were published in the August 2014, September 2014 and October 2014 issues of *Iron & Steel Technology,* respectively. For a complete list of Don B. Daily Memorial Fund grant recipients, visit AIST.org.

Ironmaking and steelmaking are hazardous processes. Some of the most costly factors in industry are injuries and deaths resulting from workplace accidents.[1] According to the U.S. Bureau of Labor Statistics, nearly 3.0 million non-fatal workplace injuries and illnesses were reported by private industry employers in 2012. Of those, a preliminary total of fatal work injuries was 4,383.[2] Although the total number of fatal work injuries was the second lowest since 1992, when the Census of Fatal Occupational Injuries was first conducted, these still could have been saved. According to the Bureau of Labor Statistics, the manufacturing sector was the only industry to record increased injury and illness rates in 2010. Furthermore, although the number has declined slightly, manufacturing sectors accounted for 322 fatalities in 2011. As indicated in the safety bulletin issued by the State of New York, approximately 95% of all workplace accidents are preventable by someone at the employee, supervisor, manager and/or corporate level.[3] This is also supported by a U.S. Occupational Safety and Health Administration area director in Appleton, Wis., USA, who indicated, "Injuries such as amputation and fatalities from accidents are preventable."[4] Studies have found that severe injuries and fatalities from accidents are preventable. Waehrer and Miller found that safety training appears to be effective in preventing these types of incidents.[5]

Safety training interventions have been shown to lead to positive effects on safety knowledge, adoption of safe work behaviors and practices, and safety and health outcomes.[6] Methods of safety training can vary widely, however, ranging from passive (lectures, videos and pamphlets) to moderately engaging (programmed instruction, feedback interventions) to very engaging (training in behavioral modeling, hands-on training). More engaging training is generally found to provide the most positive impacts, but all forms of safety training can be beneficial.[7] Video training is widely used due to its scalability, ease of implementation and cost.[8]

3D visualization for safety training has been used and evaluated in some industries to enhance the learning experience.[9] The use of 3D visualization implemented into scaffold safety training within the construction industry has been shown to improve understanding through pre-test/post-test assessment. Another industry that has developed visualization training materials is the mining industry. These virtual environments simulate a number of hazardous conditions and replicate the results of neglected safety procedures and unsafe behaviors, resulting in virtual characters getting injured or killed.[10] While these methods have been shown to be useful, there is little emphasis on using them in the steel manufacturing industry. In particular, the use of 3D visualization within video training has not been widely studied and should be investigated to determine the scope of its impact on safety training.

One of the main items being explored in this study is the use of 3D visualization to re-create a real incident, as opposed to a general or fictional incident. This is intended to tie safety concepts to a real environment and real circumstances, providing an additional sense of relevance to trainees. In addition to the incident itself, 3D visualization allows viewers to see the events that led up to and factors that contributed to the incident. Using the virtual space of the 3D environment, it is possible to view the incident from multiple locations to provide additional insights, such as what things looked like from the injured worker's point of view, or from other key locations within the environment. Additionally, once an incident has been re-created, the environment and events can be modified to show how the incident could have been prevented. Leveraging these strengths of 3D visualization has potential to provide a new way of seeing how safety incidents occur so that they can be avoided in the future.

Methodology

The research project being undertaken is creating a 3D visualization that re-enacts an incident from the steel manufacturing industry and integrating it into traditional safety training videos. This visualization will show the environment and conditions leading up to an incident and a re-creation of the incident itself, showing consequences that are often lacking in traditional safety training environments. The resulting visualization will be delivered in a format that can be integrated into safety training, providing a concrete example of how the safety training is relevant to the trainees' work environment, and enhancing the safety training experience. The project will be accomplished through the following steps:

1. Identification of the incident.
2. Re-creation of the incident.
3. Incorporating the developed visualization into safety training within the steel industry.

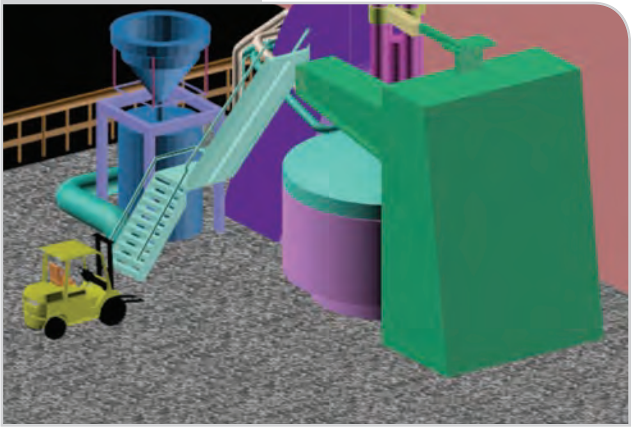
Identification of the Incident — To increase impact on safety training, a severe injury or fatality incident will be selected with guidance from industry. The incident will be selected based on accessibility of information that is necessary to create the visualization, and on the most common types of incidents within the steel manufacturing industry.

Re-Creation of the Incident — Based on information gathered with the industrial collaborator, the incident will be re-created using 3D visualization. This will include the conditions leading up to the incident, the incident itself and the resulting consequences. Narration will accompany the visualization to explain key details.

Incorporating the Visualization Into Safety Training — The result of this project will be a video that can be merged with existing video training materials or viewed individually on the Web. 3D visualization offers the potential to provide unique insights into the circumstances and environment surrounding a safety incident, and the video resulting from this project is intended to be widely accessible for use across many companies.

The technical approach of the incident re-creation involves several steps to collect appropriate data, create 3D models, and animate characters and equipment to re-create the circumstances surrounding the incident. The selected incident was chosen based on the availability of information to successfully re-create the environment and actions leading up to and immediately following the incident. In particular, video footage of the incident was found to be particularly useful. The video source was from a distance, so it did not provide a clear view of details during the incident; however, it did provide a general view of the large pieces of equipment, the injured worker and sequence of events. This source footage,

Figure 1

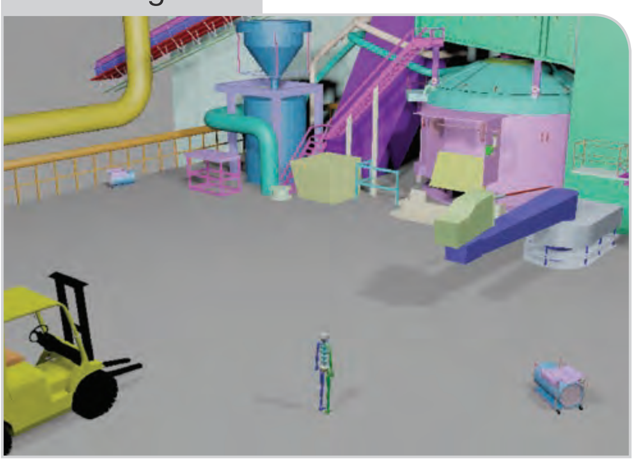


Geometry of the environment in a steel manufacturing facility.

combined with descriptions of the event from personnel and the accident investigation report, provided sufficient detail to devise a re-creation of the event.

While general 3D models of the environment could be created from the source video, there was not sufficient detail to discern certain pieces of equipment, so additional data gathering was necessary. Project personnel traveled to the incident site and took additional photos for reference in modeling equipment and surrounding structures. Initial modeling of the environment can be seen in Figure 1. While these models provide the general layout of the environment, they lack elements required for photorealism, such as lighting and shadows (Figure 2). The additional steps necessary to create photorealistic images, such as texturing and applying materials, is in progress.

Figure 2



Geometry of the facility with additional detail, lighting, and human stand-in for reference.

Once the 3D models of the environment are complete, virtual cameras will be placed to show the events leading up to the incident from key points of interest, such as an external observer's point of view, or from the location of the injured worker (Figures 3 and 4). Timing can also be adjusted to slow down important moments leading up to and including the incident, allowing the camera to zoom in for close views, highlighting critical factors that are important for viewers to understand.

Summary and Future Work

A research project is under way to explore the use of 3D visualization in safety training in the steel industry. While the project is still being developed, the methods of creating 3D environments and utilizing virtual cameras and timing to enhance presentation of critical information is well established. The project is expected to provide insights into the events leading to a safety incident in the steel industry, and can be merged with existing video training materials or viewed independently. In addition to re-creating a real safety incident, the visualization will also provide a modified version of events, showing what things could have been done differently to avoid the incident. Once completed, the visualization will be integrated into safety training and assessed for effectiveness and potential for future applications.

Acknowledgment

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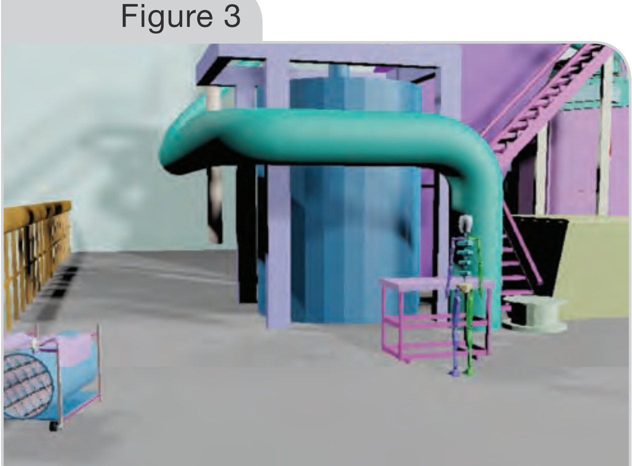
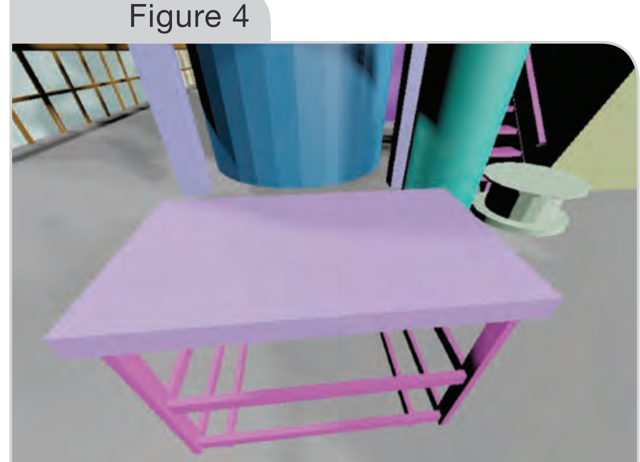
Figure 3



View of the human figure from an observer's point of view.

Figure 4



View of the environment from the human figure's location.

authors would like to thank Nucor for its commitment to safety and its guidance as this research moves forward.

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Appendix

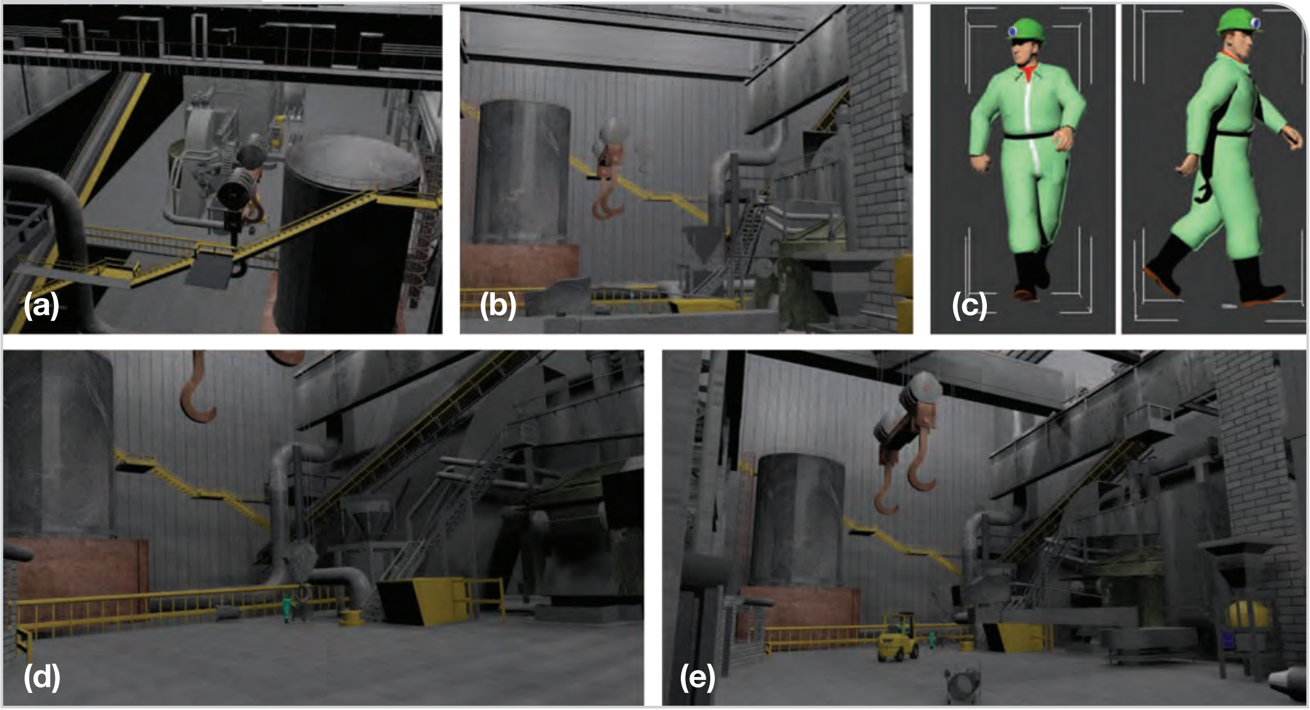

Image from completed 3D model (a), environment models showing location of the overhead crane (b), character model in Nucor clothing (c), view from the floor of Nucor team member operating crane by remote, lowering chain into storage box (d) and view from the floor of subsequent rescue of team member by another team member who used a fork truck to lift the storage box off the pinned team member's foot (e).