WORKtoZERO

an nsc program

Using Data and AI to Gain Insights into Your Safety Program

Executive Summary

This white paper looks at the use of data, data science and artificial intelligence (AI) in Environment, Health and Safety (EHS) applications and how its deployment can reduce the risk of serious injuries and fatalities (SIFs). Exploring key use cases – computer vision, natural language processing, predictive and prescriptive analytics engines – we cover the streamlined, augmented and fully-automated workflows enabled by AI-powered data analytics. We explore how small organizations may benefit from open-source or pay-as-you-go pre-built, modular and flexible tools, while large enterprises may proceed with lengthy and costly customized data collection, model training and worldwide deployment with greater capability and effectiveness within EHS. Advances in data analytics, artificial intelligence, machine learning and user-friendly graphical user interfaces can provide powerful insights to safety management personnel from any device, on-site or remote, through cloud computing.

Key Findings:

1. Data collected across an industrial enterprise in various forms (i.e., written reports, forms, images, video and audio) can all be used by modern data analytics and AI systems to derive powerful insights and deliver actionable risk predictions.

2. AI-assisted computer vision offers automated object recognition from images and videos for uses including spills, fires, PPE adherence and site inspections. The technology can be further combined with EHS software and other safety workflows.

3. Natural language processing can rapidly summarize written reports and extract quantitative insights and sentiments to help EHS personnel perform incident analysis and make quicker decisions.

4. Predictive and prescriptive analytics engines can use large datasets to review permit-to-work requests, predict the risk for future incidents and deliver suggested solutions based on best-practice guidelines and historical data.

5. Drawbacks include high costs for building models from the ground up, bias exacerbation due to learning from world-scale datasets, data privacy issues, lack of general intelligence and tough tradeoffs between effectiveness, cost and complexity.

Introduction and Background

NSC Work to Zero

Despite concerted efforts to reduce serious injuries and fatalities (SIF), workplace fatalities have not seen a drastic reduction in the United States. Between 1992 and 2020, the OSHA recordable injury rate dropped from 8.9 injuries per 100 workers to 2.7 injuries per 100 workers, a nearly 70% decrease (Injury Facts, 2021). In the same period, the workplace fatality rate (preventable fatalities) dropped only 17%, with 4,113 preventable fatalities occurring in the workplace in 2020 (Bureau of Labor Statistics, 2021). There were 4,764 total fatal work injuries recorded in the United States in 2020, an 11% decrease from 5,333 in 2019, although this is likely due in part to the economic disruptions triggered by the COVID-19 pandemic. Between 2019 and 2020, the fatal work injury rate fell from 3.5 to 3.4 per 100,000 full-time equivalent workers. Thus, the expansive efforts by companies to reduce workplace injuries do not seem to translate into impactful reductions in workplace fatalities.

Recognizing this trend, in 2019 the National Safety Council (NSC) kicked off its Work to Zero Initiative, supported by a grant from the McElhattan Foundation, to focus on combatting the lagging decline in workplace fatalities and serious injury events. The end goal of the Work to Zero initiative at NSC is to eliminate workplace fatality risk through the use of technology. Using decades of insight and data, and leveraging the expertise of its membership and network, Work to Zero will identify promising technology innovations geared towards eliminating workplace fatalities within our lifetime.

Digital Technology as an Approach to Reducing Workplace SIF events

In 2020, the Work to Zero initiative released its first white paper detailing the top eighteen hazardous workplace situations (e.g., work at height, machinery operation, confined space entry) and associated situational risks (e.g., falls, struck-by, hazardous gas exposure). The report went further and identified the systemic contributing factors (e.g., lack of training, fatigue and work design) that can exacerbate risk within these hazardous situations. Next, NSC worked with Verdantix researchers to identify over 100 relevant EHS technologies helpful in mitigating both situational and systemic risks and mapped these risks in ways surveyed EHS professionals perceived to be most effective.

The initial Work to Zero report identified several key technologies garnering the most interest and value among the surveyed professionals. In addition, safety leaders within the Campbell Institute at NSC have demonstrated interest in assessing and evaluating certain technologies – such as virtual reality, wearables, sensors and unmanned aerial vehicles (drones). This is one in a series of reports taking a more focused look at specific risks and an associated promising technology.

This white paper will dive into the use of data analytics enabled through artificial intelligence (AI) and its subdomains of machine learning (ML) and deep learning technologies to reduce serious injuries and fatalities in the workplace. Additionally, the identified and proposed benefits of this technology as well as the limitations and risks associated with adoption will be explored.

The Role of Data and Artificial Intelligence in Workplace Safety

To date, AI has achieved impressive feats. For example, Jukebox can generate music samples from raw audio and DALL-E synthesizes unique artwork based on keywords (Ramesh, A. et al, 2021). However, today's real-world AI systems lag far behind the multi-disciplinary general intelligence and knowledge demonstrated by experienced EHS personnel, still lacking the ability to comprehend, learn or perform tasks humans can. Instead, AI-based EHS systems deployed in industrial workplaces specialize in a small subset of tasks, such as recognizing people and objects in images or video streams, finding correlations between large quantities of facility data and safety incidents, or summarizing and condensing natural language into numerical data for easier analysis (Brown, T. et al, 2020). **Critically, AI offers an opportunity for organizations to focus on leveraging large volumes of data to drive predictive and prescriptive insights instead of relying on lagging indicators (i.e., post-incident reviews, recordable injury rates, etc.) after employees are already harmed.**

Research Approach

The methodology of this paper consisted of two separate actions:

- **Identification of case studies and applications for data and AI tools**
- **Discussion of emerging capabilities of data and AI in the EHS landscape**

Data for this paper came from literature reviews of academic and industrial journals related to this technology. This paper will focus on aspects of data and AI technology specifically tailored to identifying, recording, quantifying and reporting workplace incidents that may lead or have led to illness, injury or death.

Introduction to Data and AI

Big data analytics examine huge, rapidly expanding and disparate data sets to identify patterns, trends, correlations and other information providing organizations with insights for making better decisions. EHS professionals likely already deal with significant quantities of data in the form of written reports, images, videos, discussions with workers and statistical visualizations from existing EHS software. However, by leveraging automated monitoring systems for real-time data across an organization in context with historical data, they stand to gain a deeper understanding of their employees' health and safety. Furthermore, many commercial end-to-end data management and analytics systems offer intuitive multi-platform user interfaces and additional functionality for EHS professionals to streamline reporting and auditing by automatically tracking data lineage and ensuring the entire organization accesses a single source of data (Verdantix, 2021).

Artificial intelligence and its subdomain of machine learning – where a decision tree, a rule-based statistical model or artificial neural network, can perform an action by learning by example – have seen great success in real-world applications in recent years, driven largely by maturing algorithms, advances in computer hardware and the availability of large datasets. Most organizations already use AI-accelerated functionality developed by global technology providers in email spam filters, word processing software and when they search the web. However, the availability of off-the-shelf low-code and no-code AI tools offer EHS professionals powerful new capabilities with larger datasets and data types, uncovering hidden risks, developing predictive analytics and revealing new insights into industrial operations (Verdantix, 2021).

Types of AI

Machine learning is performed by providing a model – such as an artificial neural network – with a set of inputs (an image, a sequence of numbers or block of text) and labels (a category name, a risk level or a summary of the text), and training of the model to estimate a correct label when a particular input is given. Training is usually performed on many input/label pairs before its accuracy is sufficient for implementation, though commercial implementations of machine learning systems are often designed to adjust to new data through continuous learning. In EHS applications, AI's ability to predict outcomes based on observed real-time data can enhance the decision-making processes of EHS personnel (European Agency for Health and Safety at Work, 2022) by identifying and suggesting how to reduce risk. Additionally, commercial AI systems have been developed for rapidly searching large and disparate datasets across written reports, images, CCTV and audio during post-incident investigations to determine potential causes that would otherwise require hours of expensive review that may be prone to human error.

Three machine learning subfields exist that can reinvent traditional EHS processes (Verdantix, 2021):

1. Computer Vision

Computer vision technologies can be used to monitor images and video footage, detecting and tracking objects, vehicles, PPE, people and their relative proximity – which can be combined with additional data such as location, time and safety guidelines to deliver automated alerts for PPE non-compliance, equipment malfunctions, person-down events and vehicle collisions. Commonly deployed within CCTV video management system environments, AI-powered computer vision can provide real-time monitoring of industrial sites and immediately alert EHS personnel to potential risks and incidents (Verdantix, 2022).

2. Natural Language Processing

Natural language processing (NLP) can streamline EHS documentation and compliance. NLP technologies have seen significant advances in recent years, with Google rolling out its Bidirectional Encoder Representations from Transformers (Chang, M., et al, 2018) model in 2019 to interpret natural language Google search queries. A variety of methods are used in modern NLP systems – some employ simple keyword and rule-based techniques, while others utilize large, compute-intensive deep neural networks to attain a rich understanding of human language, such as OpenAI's GPT-3.

Large language model (LLM) systems can find meaningful information from text and speech and be used for creating transcripts of speech, language translations, text summarizations and sentiment analysis (Brown, T. et al, 2020). Currently, the most effective LLM NLP systems are trained on billions of words and sentences from books and internet sites, which makes their development infeasible to all but the largest technology organizations. However, powerful NLP models like GPT-3 can be accessed through pay-as-you-go APIs, and some publicly available smaller pre-trained models can be fine-tuned on much smaller datasets – allowing smaller organizations to leverage their capabilities in specific use cases and allow continuous re-training in the field. EHS personnel can leverage NLP to enhance productivity, streamline reporting and compliance, and reduce laborious manual processes associated with reviewing historical reports.

3. Predictive and Prescriptive Analytics Engines

Predictive and prescriptive analytics engines are designed to leverage the ability of AI and ML to learn cause-and-effect from historical data. Rule-based AI systems can be configured to deliver recommendations when a particular event occurs, or a series of thresholds are exceeded. For example, such software can advise on the most suitable PPE for a specific task or outline contractors based on reported safety metrics. Additionally, ML systems can use large datasets of historical sequences of events and examples of successful mitigation strategies to automatically detect potential risks and incidents and trigger alerts to EHS personnel. Some predictive and prescriptive analytics systems can integrate directly with facility controls and permit management systems – for example, automatically activating facility lockdown procedures if a potential ongoing workplace violence incident is detected (Verdantix, 2021).

Use Cases

Data and AI offer a variety of use cases, which may include:

Automation	
Ergonomic assessments	Cameras and wearable sensors collect data while AI/ML model determines posture and motion during lifting and other physical activities and provides feedback
PPE detection	CCTV cameras with computer vision to monitor and detect PPE non-compliance
Hazardous environment monitoring	CCTV cameras with computer vision to detect spills, fires and/or poor housekeeping
Driver behavior monitoring	AI model for dashcam footage and telematics data to monitor driver behavior, assign driver safety scores and reduce insurance premiums
Legal document interpretation	NLP to understand and summarize EHS legislation and identify changes relevant to existing enterprises processes
Natural language query	EHS professionals can search EHS data with natural language questions via text
Inspections and site reviews	Drones controlled using AI autonomously monitor sites to avoid manual completion of hazardous tasks, such as work-at-height
Incident analysis	Identify the root cause of potentially serious injuries and fatalities (pSIFs)
EHS decision making	AI is used to select the most appropriate control for a specific task
Permit to work	Permit risk scores and training requirements are autonomously modified and updated
Analytics	
AI analytics	Automated insights, data visualization and improved correlations between leading indicators
Risk analysis	Calculate EHS risk levels in real time and automatically alert employees when a risk threshold is reached
Data cleansing	Autonomously fixing or removing incorrect, corrupted, wrongly formatted, duplicate or incomplete data

Source: (Verdantix, 2021)

There are three particularly important use cases, detailed below:

1. **Incident Analysis**
2. **PPE Detection**
3. **Inspections and Site Reviews**

Commercial implementations of AI-assisted risk analysis can predict high-risk scenarios by leveraging multiple data streams from real-time internet of things (IoT) data and predictive insights from AI analytics. Organizations can continuously update their perception of risk, allowing improvement of existing EHS management processes and driving innovation within risk mitigation activities.

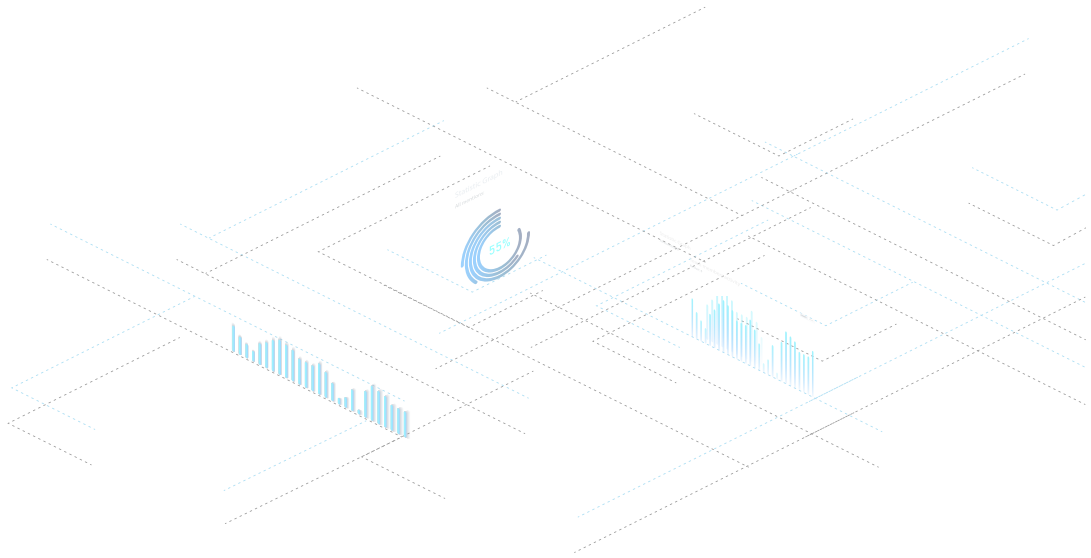
Computer vision can be employed across several facets of a safety management system to automate risk detection. In addition to PPE compliance, computer vision is used to identify unsafe work environments, poor housekeeping, near-misses and to monitor physical task ergonomics such as lifting posture. Additionally, advancements in control systems and sensors combined with computer vision already enable robots and drones to carry out high-risk inspection tasks.

Case Studies

1. **Newmetrix, a Massachusetts-based AI-focused workplace risk prediction software firm, worked with JE Dunn (JE Dunn, 2021), a Missouri-headquartered building contractor employing 3,500 workers across the U.S., to deploy its safety observation system across multiple sites. Initial challenges involved the storage of project documentation, images and video on individual smartphones and other devices, meaning workflows had to be implemented to ensure all data was accessible to Newmetrix's predictive AI software. JE Dunn data in various forms including project location, weather, staffing, images and videos from 2016 to 2021 were used to prompt site superintendents to have 350 additional safety conversations with workers and predict 75% of recordable incidents on the top seven ranked projects for risk every week. Overall, Newmetrix's data and AI-based risk prediction software offered JE Dunn an actionable safety analytics solution.**

2. **Cority, a Toronto-based EHSQ vendor, partnered with the Los Alamos National Laboratory (LANL, Cority, 2022), a U.S. Department of Energy laboratory and multidisciplinary research institute for strategic science and national security, to improve their data quality and safety culture. Their existing data management system was unable to reliably track data, resulting in difficulties during reporting, trending or checking environmental, health and safety indicators. Additionally, their status as a government contractor entailed high-security requirements and resulted in low IT flexibility. LANL chose Cority's cloud-based SaaS EHS and data management solution, which allowed them to decommission 75 surplus software applications and unify EHS management, employee wellness, operational management and reporting within a single-source-of-truth platform. Dashboards were now generated automatically alongside the availability of advanced trend analytics, automated error-checking and safety reporting resulting in 1-2 FTEs of work to other initiatives.**

3. **VelocityEHS, a Chicago-headquartered EHS and ESG software firm, partnered with Contech Engineered Solutions (VelocityEHS, 2022), an Ohio-headquartered construction and erosion control firm with 50 locations across the U.S., to manage chemical safety data sheets (SDS) across many temporary and fast-moving projects. Previously, their paper binder SDS distribution system resulted in difficulties with ensuring the latest data made its way to workers performing high-risk chemical-related processes. After deploying VelocityEHS's Chemical Management software, Contech was able to make crucial data available across its workforce quickly through web-based portals or mobile devices, increasing awareness for staff and reducing pSIFs.**



Benefits of Leveraging Data and AI

Three central benefits to utilizing data and AI in the workplace include (Verdantix, 2021)**:**

1. Cost Savings

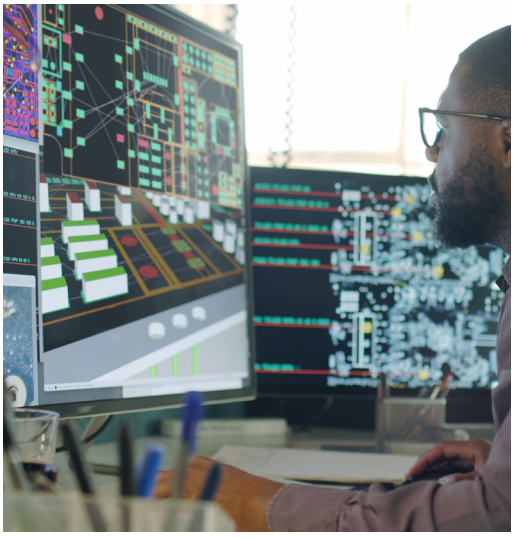
2. Enhanced Performance

3. Time Savings

Cost savings from AI deployments can be realized in multiple ways such as time saving; proactive identification of potentially costly lost-time incidents, occupational illnesses and asset losses; reduced fines and litigation fees due to compliance improvements; and improved risk identification to enable the planning of remediation strategies.

By improving accuracy and eliminating the potential for human error in the workplace, AI can help reduce employee incidents. Machine learning can also provide insights and identify analytical trends that humans may not recognize or ultimately miss in the data – providing project managers insights to increase productivity.

In many instances, AI and data management tools facilitate faster decision-making and streamline manual tasks, freeing up time for EHS professionals to focus on value-added initiatives. This is particularly true for time-consuming data and document analysis tasks such as extraction, cleaning, contextualization and archiving.



Risks, Limitations and Considerations in Using Data and AI for Workplace Safety

Barriers to Adoption

As with any new and powerful technology, data and AI encounters issues that prevent its widespread adoption:

1. High Cost of Development

2. Complex Data Protection and Privacy Considerations

3. Bias Exacerbation

4. Lacking General Intelligence

The cost of AI can deter companies from implementing it. However, it should be recognized that the cost of using AI can vary greatly depending on the type used. The cloud computational resource cost alone for training OpenAI's powerful natural language processing model GPT-3 was $12 million (Brown, T. et al, 2020), not including the large development team of expensive software engineers and data scientists. However, usage-based pricing of existing GPT-3 (OpenAI, 2022) and other similar models from Google and Amazon Web Services are around $1 for generating an accurate summary of 10,000 words of written reports. More application-specific off-the-shelf solutions like chatbots and process automation begin at around $40 per month, while enterprise implementations can exceed $1,000 per month (HubSpot, 2022).

Concerns exist surrounding data privacy (Gowling WLG. 2019) as companies feed ever-greater volumes of customers' and workers' personal data into advanced and difficult-to-understand neural networks where it is not possible to ensure powerful insights are not exploited unfairly through bias. Data lineage and model explainability is critical to mitigating this problem.

Most individuals view AI-based decision-making as more objective than human-based approaches since they are based on sophisticated methods and large volumes of data. However, such approaches, where the most powerful examples learn and evolve from historical data, might amplify the subjective and harmful biases and beliefs of the data on which they are trained. For instance, businesses can research the contexts in which AI is being deployed to assess whether there is a high risk for AI to exacerbate bias. In doing so, businesses can become more selective about their AI deployment. Equally, it is useful to establish a set of debiasing processes and practices within a company's overall AI strategy.

The often-repeated phrase, "artificial intelligence is a tool, not an outcome," describes the fact that AI in 2022 is not yet intelligent in a general sense. While NLP and sophisticated risk prediction systems may display superhuman abilities, these are always only within a narrow range of tasks. For example, an LLM for summarizing and quantifying written incident reports would only summarize the report content – it would be unable to detect the wider context of possible social issues within the facility. A human EHS coordinator would read the summary, check some of the original reports and visit the facility and speak to the workers to formulate a remedy, establishing friendships, actioning changes to working conditions and drawing from multidisciplinary knowledge about not just worker safety, but the wider world. Additionally, a risk prediction AI may be able to detect 100 high-likelihood risk factors within a facility, but it may fail to identify less common outcomes or less likely, site-specific incidents.

Conclusion and Future Direction

Data and AI tools are some of the fastest-progressing technologies available to EHS professionals, with powerful capabilities available through open-source communities, cloud service providers and EHS software vendors. Recent advances in natural language processing, image and video processing, and big data predictive and prescriptive analytics can provide organizations with new insights and tools to solve problems – enabling wide visibility across industrial facilities, concise views of thousands of written reports and the ability to make faster decisions.

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