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Finding Health & Safety Buried Treasure with AI

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Abstract

The challenge to glean understanding and insight from an array of historical safety-related reports and observations has existed since the dawn of the HSE discipline. While most organizations today use traditional methods to analyze past events and activities along structured elements (time, place, risk rating and so on), a vast amount of wisdom around hazard identification, root causes and risk control measures remains buried in textual descriptions and reports, and teachable moments become lessons lost.

The hands and minds that developed these textual artifacts may be among the most seasoned in the organization, bringing years of experience to bear on the issues and opportunities involved. Such artifacts are then clearly buried treasure. Exploring and surfacing the insights contained in artifact repositories calls for new tools. Using these, a new type of H&S performance indicator could emerge: latent indicators, lying concealed within the written record, offering as much or more value as the leading and lagging indicators used today.

This paper describes leveraging the power of artificial intelligence (AI) to absorb large amounts of safety-related textual information, find common themes and identify similar events, which are then analyzed for patterns in causes and controls. This solution, used in concert with traditional analytics, offers unprecedented power to comprehend and visualize collective safety knowledge from historical record. Transforming words to wisdom in this manner not only illuminates the past but also provides a basis for actioning improvements in operational excellence.

Keywords: Safety, Hazards, Risk Assessment, Investigation, Lessons Learned, Observations, Bowtie, Integration with Operations

1 What is AI?

Artificial Intelligence (AI) is both a powerful and a misunderstood technology. An AI system can be characterized by four key behaviors:

- Understanding: Making sense of images, language and unstructured data through human tutoring
- Reasoning: Grasping underlying concepts, forming hypotheses, inferring ideas
- Learning: New data, interactions and outcomes are automatically added to its knowledge foundation so that further interactions are improved
- Interacting: Listening to, interpreting and conversing with humans in a natural way

Rather than defining any particular software platform, or programming language, AI has evolved rapidly in a very short number of years to comprise a suite of services that represent a number of distinct behaviors, which when integrated are intended to perform a very specific function. Figure 1 display a diagram with several of these services depicted.

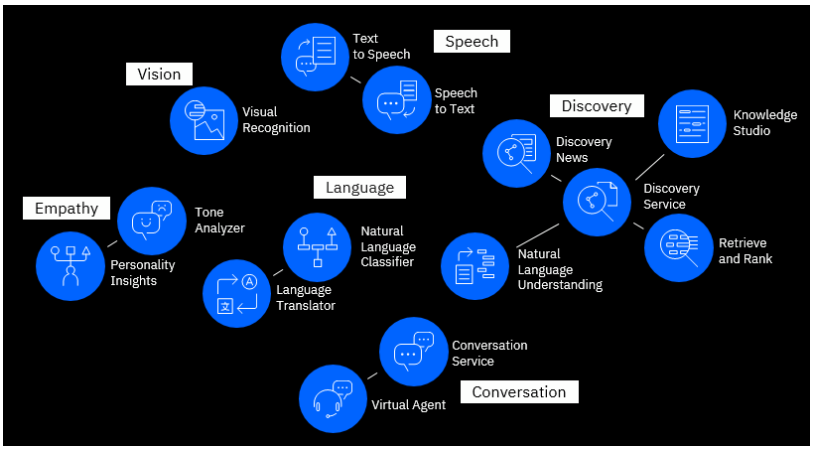

Figure 1 - AI-related services

Without going into the technical details of these services, one could easily surmise by the above selection that they are targeting particular human artifacts – spoken language, written word, penned drawing. This is indeed the case, with the intention being to uncover meaning, relevance or sentiment, not only within one instance of such an artifact, but within large collections of such artifacts. That this is not only feasible but blindingly effective was demonstrated in 2011 when IBM's Watson defeated the reigning Jeopardy champions, by analyzing the equivalent of about one million books and responding to Jeopardy questions in under three seconds [1].

AI itself can be considered a component of a larger landscape of modern technologies aimed at value-adding interactions with humans (see Figure 2 below). With today's data deluge from more and more sources - internet-connected devices, social media, the digitizing of new organizations and even nations - such tools are invaluable for automating workflows, detecting anomalies, and analyzing the numerous forms of evidence of modern human existence. Make no mistake – such

tools are not nearly capable of replacing humans at this stage, but clearly they are "force multipliers" for assimilating data and exploring for treasure (insights).

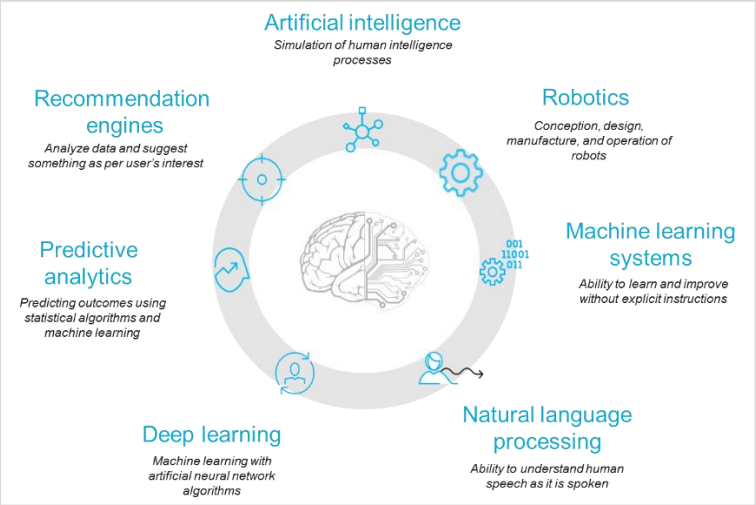

Figure 2 - AI universe of emerging technologies

2 What are the Benefits of AI in HSE?

Most of the valuable information in the world today exists in an unstructured form; by some estimates, 80 to 90 percent [2]. In addition, the growth rate of the information universe has been said to be exponential, doubling every 12 months [3]. Without a fast and effective means to explore this expanding universe, one can get a sense of falling behind the pace and failing to leverage the wisdom and insights buried within, expressed in unstructured forms. Some have used the appropriate term "dark data" to describe this buried treasure, which remains hidden due to the limitations of traditional analytical tools and techniques.

The Health and Safety domain is awash in unstructured data sources. Internal documents such as incident investigations, safety observations, risk assessments, hazard studies and the like exist everywhere, and go back years in time; even our treasured incident reporting databases, primary sources of HSE performance indicators, contain important textual observations and lessons learned which are all but invisible to traditional analytical methods.

Extracting the buried treasure from these resources calls for new technologies and approaches, in order to surface the hidden insights and discover undiscerned patterns that may be "hiding in plain sight". While text analytics has been around for some years as a tool for probing unstructured data, AI has evolved into a much more powerful approach for understanding meaning and context, both within unstructured data and from the querying human analyst, expressed in natural language. Gartner has used the term "augmented analytics" to describe this new approach, defining it as "a next-generation data and analytics paradigm that uses machine learning to automate data preparation, insight discovery and insight sharing" [4]. In a subsequent paper, Gartner predicted "By 2020, augmented analytics will be the dominant driver of data and analytic systems" [5].

Numerous advantages can be seen in leveraging AI in the HSE domain. Among them:

- Time and effort savings: HSE analysts and others spend a large amount of time on investigations, audits and studies, poring over past incident reports and other artifacts to find specific bits of information from textual entries. This type of exercise is repeated for each new study or research request. An AI solution trained to recognize key elements within unstructured text such as hazard conditions, activities, equipment, materials and so on, can illuminate such elements within hundreds or thousands of documents in seconds. In addition, an AI solution can gather the set of key concepts within one document (such as an incident report), and search an entire document repository to find reports similar in thematic content, returning those documents in order of relevance. The value of near-instant identification of incidents similar to one being investigated is difficult to overestimate for the analyst/auditor.

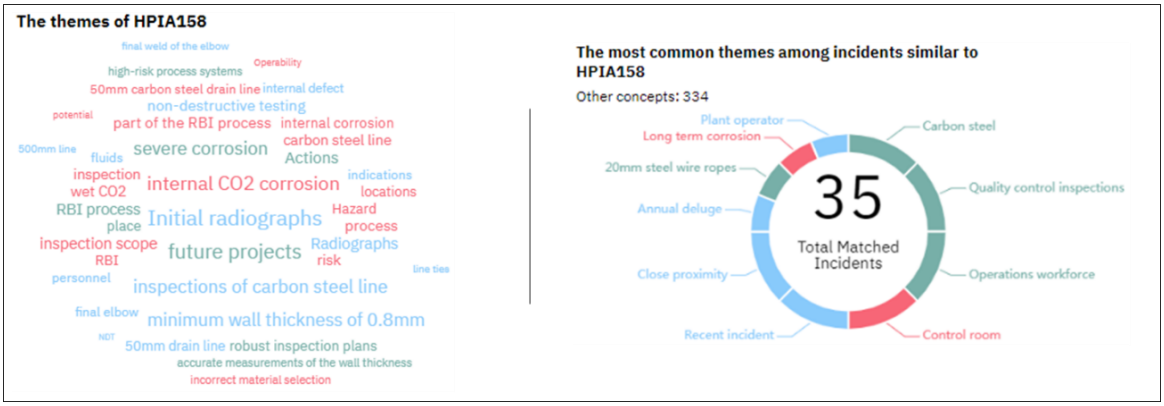

Figure 3 - Example search results from an AI query for similar incidents, illuminating key concepts and common themes. Incident Report source: APPEA [13]

- Scaling expertise: An AI solution targeted for use in a specific domain such as HSE must be trained in the key concepts, terms and important elements pertinent to that domain, so that they can be recognized within reports and other documents. Training is done by subject matter experts (SMEs), and the AI solution grows in competency and accuracy with continued training and analysis of more and more documents. Whereas traditional software tools encapsulate knowledge of "how" to perform certain tasks, with myriad subroutines and calculations, an AI solution encapsulates the "what" – the key elements imparted by SMEs, which enable the solution to find those elements, interpret meanings and even identify new concepts. AI both preserves and scales knowledge of a handful of SMEs across an entire organization, especially when distributed via an enterprise-wide medium such as the cloud.
- Finding Lessons Lost: Operating companies often internally broadcast specific incident reports and outcomes with the hope that the lessons contained within will be absorbed and retained by all. With today's information overload and dynamic properties, many such missives do not make it to the top of the stack; staff and contractor turnover can also contribute to the lessons being lost over time. Safety alerts and broadcasts may also be confined to business unit or even site battery limits. Corporate centralized databases for

lessons learned are clearly a step in the right direction for establishing a knowledge repository, but these may be subject to the same constraints as traditional relational databases, with limited search capability. Moreover, such internal resources do not tap into the wealth of lessons and insights available in publicly-available repositories such as those supported by BSEE, IOGP, APPEA and many others. An AI solution is able to explore both internal and external information sources and illuminate the key elements within, automating and accelerating insight discovery

- Accelerated time-to-value: Numerous points along the value creation chain for analyzing HSE information are accelerated with an AI solution. The typical process includes data location and gathering, cleansing and loading, followed by analysis and presentation. Once pointed at an information resource, an AI solution can reduce data exploration and discovery of buried insights to near-real-time, which in turn enables faster time to actioning the discovered insights. An indicative example of AI's instant transformation of unstructured data to insights is shown in Figure 4 below, with the bowtie report illustrating a set of entities recognized by the AI model (Causes, Controls, Hazards, Activities etc.).

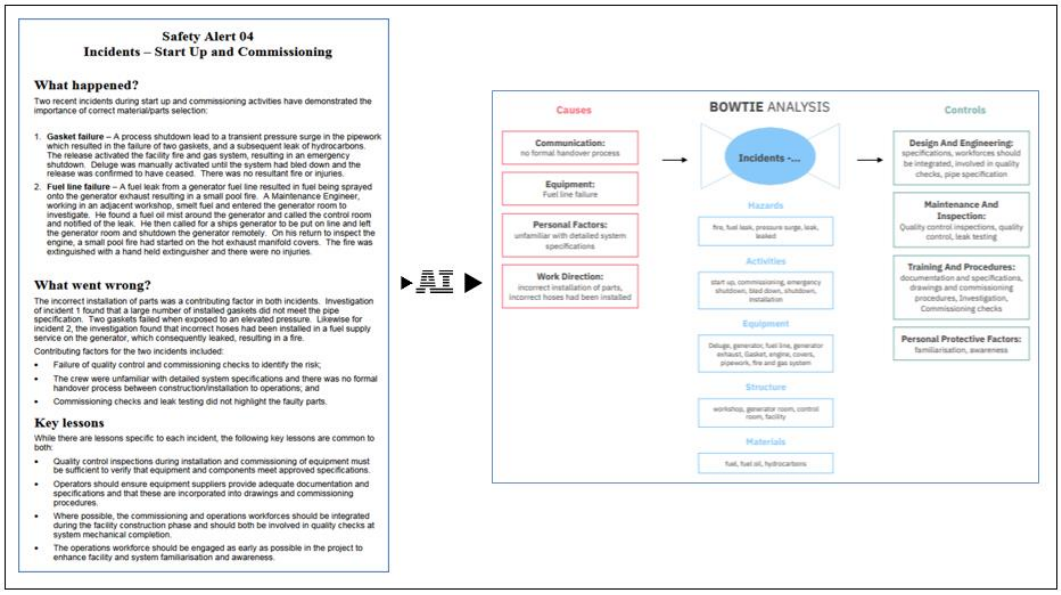

Figure 4 - Example of insight extraction from an incident report by an AI model for HSE. Incident Report source: NOPSA [14]

3 Future Value

Surfacing new insights: An AI tool able to understand natural language structure and concepts can leverage this ability with domain-specific information sources to identify safety themes and patterns which may go unnoticed by HSE analysts. For example, in a recent trial, a model trained to recognize "inspection" and "testing" as two risk controls, automatically identified the phrase "Incomplete inspection and testing regime" as a causal factor within an incident report. In another example, a model trained on hazardous conditions in the natural resources industry but no specific

training on medical risks or symptoms of deep vein thrombosis, correctly identified both "blood clot" and blood pooling as hazard conditions in long-haul flights, as a result of context understanding. Similarly, this model is being extended to recognize a "malware infection" as a hazard in the cybersecurity space, "food poisoning" from the galley of an offshore platform, and a "rockfall" in mining.

Asking new questions: The value of an AI solution originates from its ability to understand unstructured data, and interpret unstructured queries. The "naturalness" of this approach is the opposite of traditional software solutions, which depend heavily on pre-defining and storing discrete data elements. The latter approach constrains the types of queries against that data, as they are limited to the pre-defined parameters, and therefore the types of analyses are also bounded. The AI approach allows much more flexibility in analysis, and responds easily to questions that are difficult if not impossible to ask of traditional systems – for instance, "Find incidents dealing with poor risk assessments in lifting operations", or "which sites have the most number of incidents where training is mentioned as a risk control". An AI solution empowered with the ability to recognize activities, risk controls, equipment and other items greatly expands analytical capabilities and the ability to ask more questions.

Discovering latent indicators: The majority of today's incident reporting solutions are geared to be backward-looking, focusing on the details of what happened, and the causes. They are most appropriate for use with lagging indicators, which are reactive in nature. For leading indicators, the focus is typically on planned versus actual activities and other targets or expectations, which, when not met, may increase risk or the probability of incident occurrence. Leading indicators are typically used as preventive measures. To be truly forward-looking and more predictive in our assessments of future risk, we need a more holistic understanding of our past safety incidents combined with the past wisdom of the experts involved who left advice for future incident prevention. This is the realm of *latent indicators*: the underlying and evidential patterns of behavior, situations, or conditions occurring over time that present clear and present risk for an enterprise. Such indicators can be site-specific, regional or enterprise-wide; at any level, the discovery and addressing of these hidden characteristics could enable more proactive incident prevention and lead to improved safety statistics. Given their predictive nature, latent indicators could better equip operations and maintenance functions with improved risk assessment capability in future work.

4 Finding YOUR Treasure

There are many approaches a company may take on its journey to becoming a "cognitive enterprise", one which infuses concepts such as AI and machine learning throughout its internal functions, and exploits to competitive advantage its vast data "natural resource" in all its myriad forms. In such an enterprise, technology is often the easy part – the cognitive enterprise

incorporates organizational components such as a top leadership vision of scaled intelligence, to re-engineered internal workflows, to "citizen data scientist" knowledge workers driving innovation. In order to execute a successful cognitive journey, a carefully thought out journey management plan is mandatory, which considers key elements such as starting position, competencies, risks and resolve to reach the destination. From an AI project perspective, one possible path is outlined below in three key steps, with a set of five attributes to consider in each.

1. **Proof of Value** – set the example for AI value with a strong use case
    a. Business value: be able to demonstrate clear business value and ROI
    b. Tight use case: define clear scope boundaries and expectations
    c. Success criteria: make it clear what success looks like
    d. Proven technology: Don't go for the bleeding edge, which could introduce project or sustainability risks
    e. Good data: Assure the quality, availability and richness of your data source

2. **Pilot Program** – establish a scalable foundation
    a. Capability assessment: Perform an honest assessment of internal AI competencies
    b. Data sources: Identify additional data sources supporting the value case
    c. Infrastructure: Establish a scalable technical foundation
    d. Resourcing: Onboard project team and dedicate subject matter experts
    e. Advertise: Promote the project across functions and business lines

3. **Enterprise Launch** – execute a formal implementation campaign
    a. Leadership resolve: assure top line support and advocacy
    b. Education plan: promote training in AI value exploration and publish lessons learned
    c. Deployment trajectory: set realistic rollout goals, considering business readiness, data quality, resource availability and program sustainability
    d. Change management: be mindful that organizational impacts of AI and human factors must be considered; new ways of working and modified functional integrations can result
    e. Ground support: establish both a technical support team and a business-facing center of excellence

5 AI Successes

Business interest in AI has grown tremendously over the past few years, in concurrence with the maturity, accessibility and advances in the technology. It also coincides with the rise of "big data", and the perception that AI is a necessary tool for gleaning insights from the staggering amount of data now being generated across the globe. According to some estimates, by next year we will see the equivalent of 1.7MB of data generated every second for every person on earth [6]. The rise in interest is not limited to business – a Google search for "AI arms race" produces over 100,000 hits, finding recent articles from notable publications such as Foreign Policy, Wall Street Journal, and

Financial Times describing billions of dollars being spent by China, Russia and the US toward national AI strategies.

In the HSE domain, there have been several success stories over the years. Most recently, Woodside Energy was awarded in 2018 by both the Australian Petroleum Production & Exploration Association (APPEA) and Institute of Chemical Engineers (IChemE) for its innovative implementation of IBM's Watson AI platform in HSEQ. The safety solution is used across the company for scanning hundreds of thousands of documents for past insights, aiming for improved hazard identification and risk assessments in operations and capital projects [7, 8].

The rail transportation industry has been keenly interested in detailed analysis of safety information. In the UK, the Rail Safety and Standards Board (RSSB) has taken particular interest in machine learning and its value propositions for automated classification and analysis of safety-related records, automating inspection and predictive maintenance, and improved operational performance [9]. RSSB and the Institute of Railway Research have worked jointly on a program termed Big Data Risk Analysis (BDRA). One of the primary data sources utilized in this program is RSSB's Close Call System, a centralized repository of text-based close call (near miss) incident reports. The "Learning from Close Calls" project under BDRA developed a natural language software program for automatically analyzing free text entries [10].

In the aviation field, NASA's Aviation Safety Program and the System-wide Safety and Assurance Technologies (SSAT) project have developed text analytics for scanning hundreds of thousands of safety reports and logs looking for hidden patterns which could lead to better understanding of incident precursors. Their efforts have been recognized and incorporated by several major carriers, as well as the Federal Aviation Administration [11].

6 Summary

Like any expedition setting out to uncover buried treasure, the deployment of an AI solution for HSE must be methodically and purposefully planned. The treasure is certainly out there – we would not go to such great lengths to develop detailed incident investigations, record HAZIDs and HAZOPs and compile lessons learned if capturing critical safety information and insights was not the goal. In a slower-moving world where workers retained the lessons, businesses retained the workers, and technology was relegated to numbers, advanced mining of unstructured data was not considered a necessity. But business velocity has changed significantly, and data of all kinds is considered by some to be the world's most valuable business resource [12]. Exploring data for insights buried within unstructured data is not only possibly today, but is all but impossible without AI, in order to assimilate the vast space and maintain pace. "AI-power" must now be considered along with manpower to find the buried treasure efficiently, and scale corporate knowledge effectively.

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