DR∧PER®

Embracing the Artificial Intelligence Age of RAM

A Journey into Digital Engineering Data Management

Mary "Lisa" Bates

November 6th-7th, 2024

Types of Reliability Data

AI can facilitate the ability for RAM engineers to effectively collect, analyze, and interpret various types of data to make informed decisions and recommendations to enhance the reliability and performance of systems and assets through out the life cycle of the product.

DRAPER ®

Effective Data Management Enabled by AI

- Automated data collection and ingestion
- Data quality assessment and enhancement
- A Queryable Integrated System for all types of data from design to field
- A Coordinated Distributed Data Management Approach
- Natural Language Processing (NLP) for data understanding
- AI detection of cyber intrusion to enhance data security
- Automated Data governance
- Automated Data change notification and management
- Automated Configuration Management

Using AI technologies, organizations can enhance their data management practices, improve data quality and integrity, and derive valuable insights from their data assets to drive better decision-making and achieve business objectives.

DRAPER®

Enhancement of Asset Performance Maintenance Strategies

- Predictive maintenance
- Condition monitoring
- Failure Modes and Effects Analysis
- Digital twins
- Cognitive maintenance advisors
- Autonomous maintenance robots
- Prescriptive analytics
- Pinpoint Maintenance Training Deficiencies
- Spares Replenishment Analysis

Leveraging these new tools and methodologies facilitated by AI, organizations can transform their maintenance practices, improve asset reliability, and achieve cost savings by optimizing maintenance strategies and enhancing asset performance.

DRAPER®

Reliability Engineers use AI for Data Insights

- Anomaly Detection
- Root Cause Analysis
- Data Visualization and Exploration
- Health Monitoring Systems
- Reliability Prediction Models
- Decision Support Systems
- Automated Software Reliability

Incorporating AI technologies into their work, Reliability Engineers can unlock the potential of their data, gain deeper insights into asset performance, and optimize maintenance practices to enhance reliability and efficiency.

D R A P E R®

Reduce Program Reliability Risk using Digital Threads

- Automated Reliability Requirements Mapping to hardware, software, simulation, Integration, Test and field data
- Real time what-if impact analysis through modeling
- Proactive Maintenance Strategies
- Automated Metrics for Reliability measures of effectiveness
- Automated linking of business intelligence data to equipment reliability cost
- Enhanced integration of the warfighter, project office and contractor through data workflows

Leveraging AI technologies within digital threads, reliability engineering can proactively identify and mitigate risks, optimize maintenance practices, and enhance asset reliability and performance in a more efficient and effective manner.

DRAPER®

Reliability Data Collection Best practices Using AI

- Automated Data Collection of both batch and real-time data
- Use of tools like data orchestrators, data object stores
- Practicing Extract, Load Transform for network and time efficiency
- Data Quality: Ensure that the data collected is accurate, relevant, and of high quality. Use automated data validation techniques to check for errors and inconsistencies.
- Data Security: Implement robust data security measures to protect sensitive information. Use encryption and access controls to safeguard the data.

DRAPER®

Reliability Data Storage Best practices Using AI

- Scalability: Choose a storage solution that can scale horizontally to accommodate large volumes of data.
- Redundancy: Implement data redundancy to ensure high availability and fault tolerance. Use distributed storage solutions like Hadoop Distributed File System (HDFS) or Amazon S3.
- Data Backup: Regularly back up your data to prevent data loss in case of failures.

Reliability Data Analysis Best practices Using AI

- AI Algorithms: Utilize machine learning algorithms to analyze reliability data and identify patterns or anomalies.
- Distributed Computing: Use distributed computing frameworks like Apache Spark or Hadoop to process large datasets efficiently.
- Real-time Analysis: Implement real-time data analysis to quickly detect and respond to issues as they arise.

DRΛPER®

Reliability Software Containerization Best practices Using AI

- Container Orchestration: Use container orchestration tools like Kubernetes to deploy and manage containers at scale.
- Isolation: Ensure that each component of your system runs in its own isolated container to prevent conflicts and improve security.
- Portability: Containers provide portability, allowing you to easily move your applications across different environments.
- Use of Containerization to mirror your development and production environments

DRAPER®

Reliability Monitoring and Logging Best practices Using AI

- Monitoring: Implement monitoring tools to track the performance of your AI models, distributed computing infrastructure, and containerized applications.
- Logging: Use centralized logging to collect and analyze logs from all components of your system for troubleshooting and analysis.

DRAPER®

Reliability Compliance and Regulations Best practices Using AI

- Data Privacy & Classification: Ensure compliance with data privacy and classification regulations when collecting and storing reliability data.
- Ethical Considerations: Be aware of ethical considerations when analyzing data, especially when using AI algorithms that may have biases.

DRAPER®

Reliability Documentation and Collaboration Best Practices Using AI

- Documentation: Maintain detailed documentation of your data collection, storage, and analysis processes to ensure transparency and reproducibility.
- Collaboration: Utilize shared workspaces, shared models, share code repositories for better team cohesion and better products

Utilizing the FTA or FMECA structure for Graphical Data Analysis using AI

- Edges and Nodes Graph Databases:
  - Graph Representation: Graph databases like edges and nodes graph databases provide a flexible way to represent complex relationships between entities using nodes (vertices) and edges (relationships). You can use graph databases to model the connections between components, failure modes, requirements, and other relevant entities in a system.
  - Querying and Traversal: Graph databases allow you to perform complex queries and traversals to extract insights from the relationships between different entities. You can use graph algorithms to analyze the dependencies and impact of failures on system requirements.

Leveraging Graphical Data Analysis AI and traditional FTA or FMECA tied to requirements or supplier data bring unique data insights through visualization

DRAPER ®

Driving Reliability Excellence in the Age of AI

Implement Robust Automated Quality Assurance Processes:

- Automated Testing: Implement automated testing frameworks to continuously test AI models for reliability, accuracy, and performance.
- Code Reviews: Conduct regular code reviews to identify potential issues early in the development process and ensure adherence to best practices.
- Validation and Verification: Establish processes for validating and verifying AI models to ensure they meet the required reliability standards.
- Automated Software Reliability: Implement a dashboard with automated metrics gathering, history storage, and updated plots based on tools already in use in most companies. This would provide assessment of software reliability prediction accuracy.

DRAPER®

Driving Reliability Excellence in the Age of AI

Embrace Automated Data Quality and Governance

- Data Quality Assurance: Implement data quality assurance processes to ensure that the data used to train AI models is accurate, complete, and representative.

- Data Governance: Establish data governance frameworks to govern the collection, storage, and usage of data in compliance with regulations and internal policies.

Driving Reliability Excellence in the Age of AI

Focus on Explainability and Transparency

- Interpretability: Ensure that AI models are interpretable and provide explanations for their decisions to build trust and confidence in their reliability.
- Transparency: Maintain transparency in the AI development process by documenting decisions, assumptions, and data sources to facilitate auditing and troubleshooting.

D R A P E R®

Driving Reliability Excellence in the Age of AI

Monitor and Maintain AI Models

- Continuous Monitoring: Implement monitoring systems to track the performance of AI models in real-time and detect anomalies or degradation in reliability.

- Model Maintenance: Establish processes for regular model maintenance, retraining, and updating to ensure that AI models remain reliable, precise and relevant over time.

DRAPER®

Driving Reliability Excellence in the Age of AI

Mitigate Risks and Plan for Failures

- Risk Management: Use AI to Identify potential risks and vulnerabilities in systems and develop mitigation strategies to address them proactively.

- Failure Planning: Develop contingency plans and resilience strategies to minimize the impact of failures on business operations and customer experience utilizing AI driven what-if scenarios and simulations

DRΛPER®

Driving Reliability Excellence in the Age of AI

Collaborate and Learn from Failures:

- Cross-functional Collaboration: Foster collaboration between data scientists, engineers, domain experts, and stakeholders to leverage diverse perspectives and expertise in ensuring reliability by implementing Web Services and Dashboards powered by AI

- Post-mortem Analysis: Conduct post-mortem analyses of failures to identify root causes, learn from mistakes, and implement improvements to prevent similar incidents in the future. Feed the data back into the AI algorithms to improve failure/ reliability prediction algorithms in both hardware and software

Describe Strategies for Developing Explainable AI in Reliability Analysis

Feature Importance Analysis

- Conduct feature importance analysis to identify which features have the most significant impact on the reliability analysis results.
- Techniques such as permutation importance, SHAP (SHapley Additive exPlanations), LIME (Local Interpretable Model-agnostic Explanations) can help in understanding the contribution of each feature to the model's predictions.

Describe Strategies for Developing Explainable AI in Reliability Analysis

Model Transparency

- Use interpretable models such as decision trees, linear regression, or rule-based models that are inherently more explainable compared to complex models like deep neural networks.
- Ensure that the model architecture and parameters are well-documented and easily understandable.

Describe Strategies for Developing Explainable AI in Reliability Analysis

Local Explanations

- Provide explanations at the individual prediction level to understand why a specific prediction was made.
-   Techniques like LIME and SHAP can generate local explanations by highlighting the features that influenced a particular prediction.

DRAPER®

Describe Strategies for Developing Explainable AI in Reliability Analysis

Visualizations

- Create visualizations to represent the model's decision-making process and how different features impact the reliability analysis.
- Visual aids like feature importance plots, partial dependence plots, graphical data analysis and decision trees can help stakeholders understand the model's behavior.

DRAPER®

Describe Strategies for Developing Explainable AI in Reliability Analysis

Rule-based Systems

- Develop rule-based systems that mimic human decision-making processes and are easier to interpret.
- Incorporate domain knowledge into rule-based systems to ensure that the rules align with expert understanding of reliability analysis.

DRAPER®

Describe Strategies for Developing Explainable AI in Reliability Analysis

Contextual Explanations

- Provide explanations in the context of the specific domain or application to make them more relevant and understandable to stakeholders.
- Relate the model's predictions to real-world scenarios or business outcomes to enhance interpretability.

DRAPER®

Describe Strategies for Developing Explainable AI in Reliability Analysis

Documentation and Reporting

- Document the entire model development process, including data preprocessing steps, feature engineering, model selection, and evaluation metrics.
- Provide clear and concise reports that explain the model's performance, limitations, and assumptions to stakeholders.

D R A P E R ®

Describe Strategies for Developing Explainable AI in Reliability Analysis

Human-in-the-Loop Approaches

- Incorporate human feedback into the model development process to validate model decisions and improve transparency. Soldier Touch points and working groups are a good avenue throughout the life cycle of the product
- Allow users to interact with the model, ask questions, and provide feedback to enhance trust and understanding.

DRAPER®

Describe Strategies for Developing Explainable AI in Reliability Analysis

Compliance and Regulations

- Ensure that the AI model complies with relevant regulations which require transparency and accountability in automated decision-making processes.
- Implement mechanisms to audit and explain the model's decisions when required.

DRAPER®

Conclusions - Artificial Intelligence Age of RAM

- Effective Data Management & Insights
- Enhancement of Asset Performance Maintenance Strategies
- Reduce Program Reliability Risk
- Automate Best Practices
- Provide Unique ways to visualize Reliability Data tied to program and business intelligence data
- Drive Reliability Excellence
- Developing Strategies for Explainable AI

DRAPER®

Questions

DRAPER®