Demystifying algorithms and artificial intelligence (AI)

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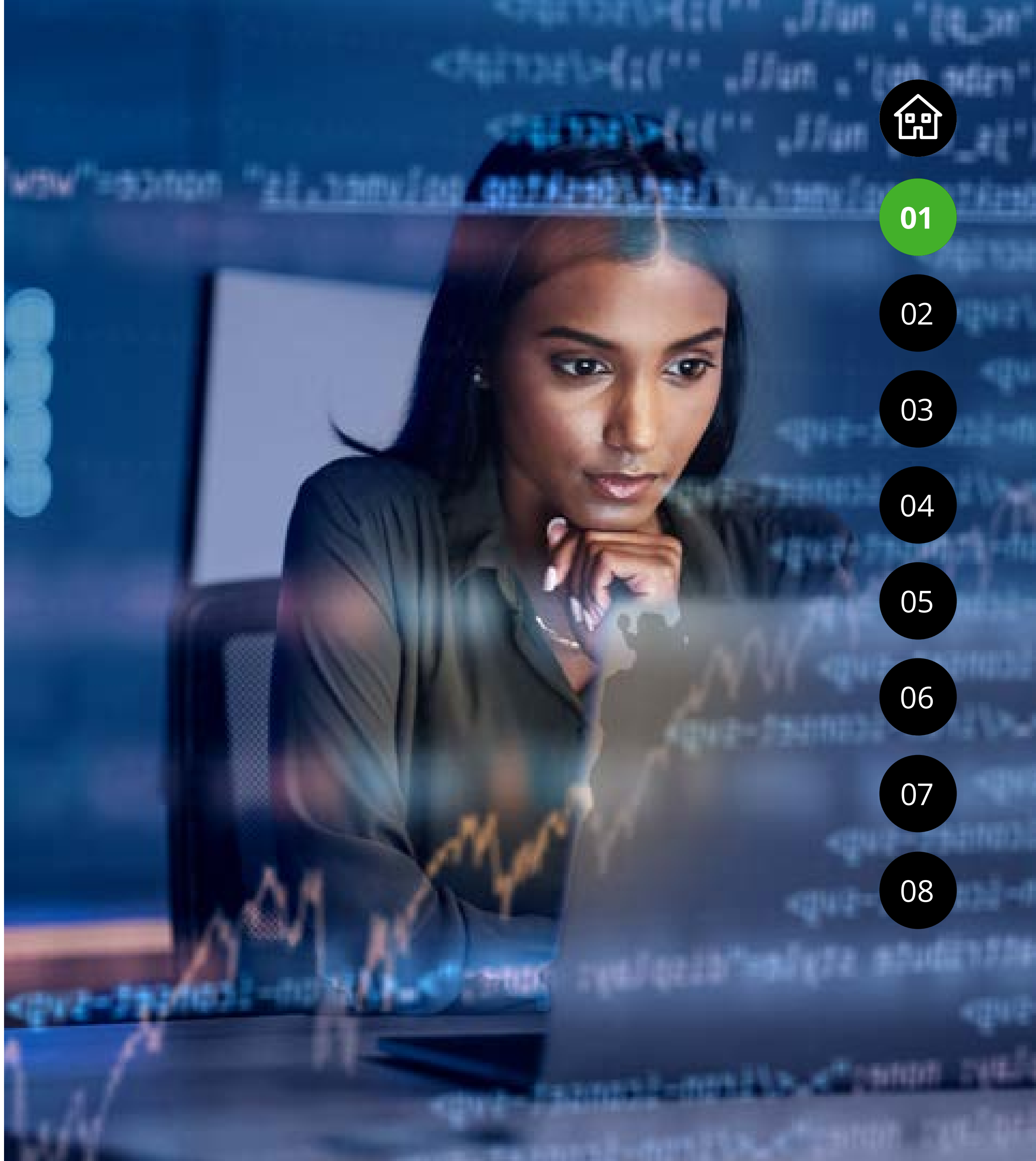
Introduction

Introduction

Algorithms could have an outsized impact on our everyday lives. Algorithms can help determine what music we listen to, what products we buy, where we eat for dinner, and what route we take to work. They can provide structure, optimization, and efficiency to consumers. But the influence of algorithms extends beyond the individual. Both directly and indirectly, algorithms can help with key decisions for businesses around the globe. Due to their replicability and scalability, algorithms can save time, reduce costs, and improve operational consistency.



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Introduction

Many finance departments have already realized benefits from algorithms. Rather than manually approve invoices, personnel may utilize automated decision systems, a subset of algorithms, to provide approvals based on predetermined thresholds, vendor lists, and other criteria.

Given their historical familiarity with algorithms, finance departments are poised to take advantage of emerging trends in algorithms.

Five of the most common use cases for algorithms in finance departments include[1]:

- Accounting processes
- Financial analysis
- Back-office processing
- Cash flow forecasting
- Financial statement forecasting

Algorithms may present unique benefits and challenges to auditors. The methodical nature of algorithms may provide opportunities for more sophisticated audit techniques and may present some efficiencies. As with any emerging area or technology, auditors, both internal and external, may have to adapt to the shifting landscape. The audit of the future may require in-depth knowledge of algorithms. As discussed next, existing audit approaches can address these new risks. But before auditing an algorithm, it is important for audit teams to identify and uncover algorithms embedded within relevant processes.

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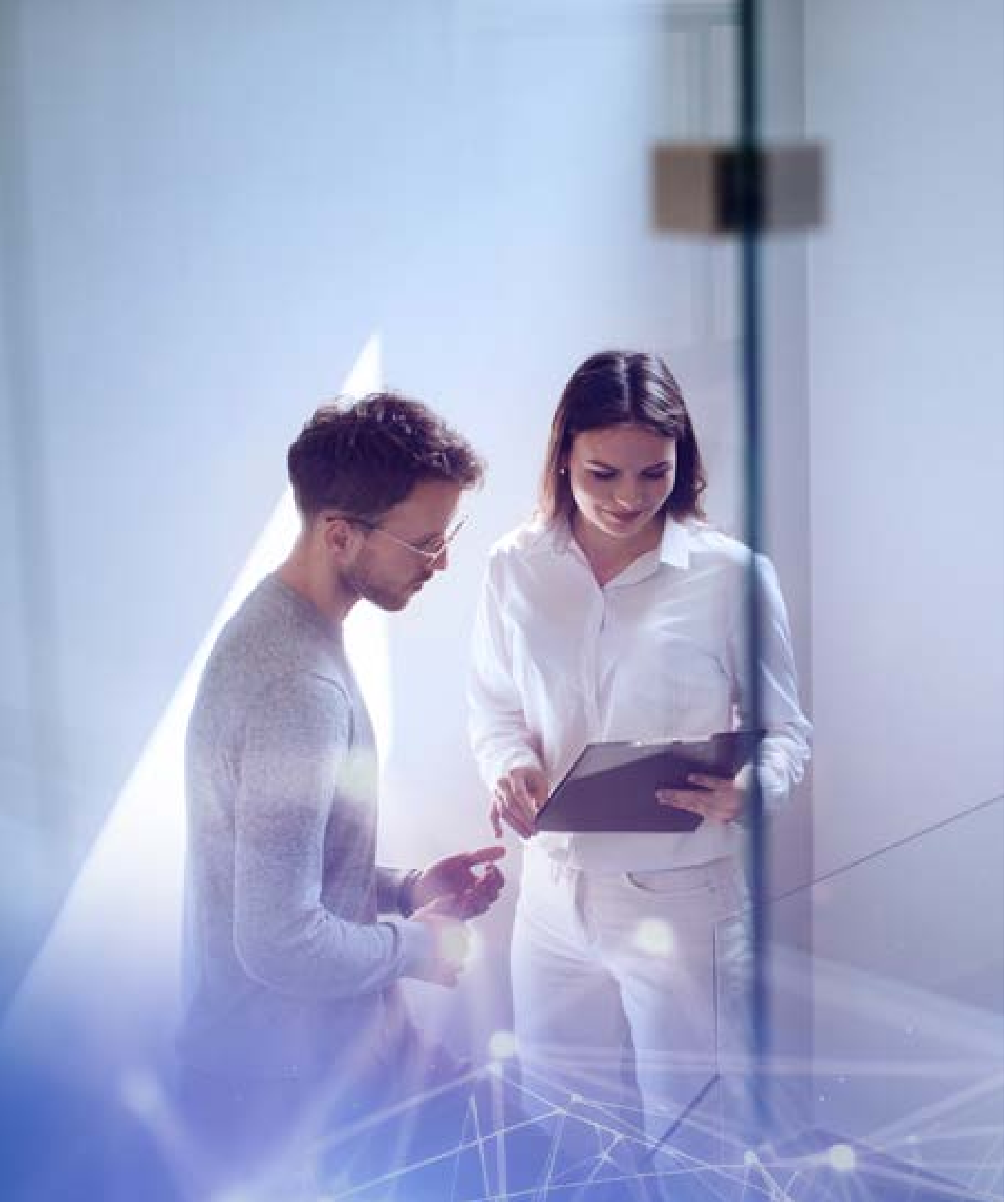
What is an algorithm?



What is an algorithm?

An algorithm is a process or set of rules to be followed in calculations or other problem-solving operations.

With such a broad definition, many simple procedures embedded in technology might be considered algorithms. If-then statements and similar formulas are a common example of rule-based algorithms that can be found in simple spreadsheets. While greater attention may be paid to the more complex algorithms, it's nonetheless important to acknowledge the existence of simpler logic. For one, even simple algorithms can have tremendous impact when applied at scale. Additionally, understanding simpler algorithms may provide insight into risks posed by more complex algorithms. The fundamentals—inputs, rules, and outputs—hold true for any algorithm, including real-world examples on the following page.

What is an algorithm?

Robotic Process Automation (RPA)[2]

Rules-based "bots" can complete high-volume and repetitive tasks. For example, bots can extract key data from documents, including bank statements, checks, and invoices, and summarize cash balance reconciling items in a single report. RPA replaces a human process with a series of algorithms. In this case, structured (clearly defined data) and unstructured (no predefined format) input data is aggregated into a summary document—allowing the knowledge worker to focus on tasks that require more judgment.

For a more comprehensive discussion of RPA use cases and auditing considerations, refer to [Financial Reporting RPA Risks and Controls | Deloitte US]

Algorithmic trading

Algorithms can drive which positions to enter and close based on a predetermined set of rules. Traders design these algorithms to generate profit or rebalance portfolios to manage risk. No matter how sophisticated the concept, every algorithmic trading platform executes trades automatically based on a predefined set of rules.

Artificial intelligence and machine learning (ML)[3]

Machine-learning algorithms, such as neural networks, interpret data, recognize patterns, and generate outputs—in certain cases mimicking human intelligence. Based on an overarching goal, such as error minimization, and a set of training data, neural networks and other machine-learning algorithms generate models. The models, which consist of data-driven "rules," in turn generate optimal outputs based on new data. Relative to RPA and most trading algorithms, ML algorithms learn from each successive set of input data. Generally, the intelligence in artificial intelligence stems from the underlying algorithm's ability to dynamically adapt to training data and improve the model.

Pattern recognition can be applied to a wide variety of tasks. For instance, ML techniques can be used to process, highlight, and extract information from documents. These ML tools can perform these activities without instructions set by the human user. The tools learn the optimal rules to apply through practice on each successive dataset.

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Classifying algorithms

Classifying algorithms

In addition to understanding what algorithms are, auditors may also need to understand the characteristics of an algorithm. These characteristics, such as the intelligence, complexity, and type associated with a given algorithm, vary along a sliding scale. The degree of intelligence and complexity will influence the level of inherent risk associated with a given algorithm. All else equal, more complexity typically leads to greater risk. With a more complex process, there is a greater likelihood that the algorithm is implemented incorrectly or may not operate as intended—which may lead to suboptimal results. As such, it's important for the auditor to consider these characteristics when identifying algorithms. See below for further information regarding each characteristic.

Classifying algorithms

Intelligence

In the context of algorithms, intelligence can be defined as "adaption with insufficient knowledge and resources"[4] Low-intelligence algorithms lack the ability to adapt. Algorithms with predefined rules typically cannot deviate or expand upon these rules in a generalized way. The developer must manually update the rules to accommodate new use cases not previously anticipated.

Conversely, intelligent algorithms are intended to mimic human reasoning to dynamically solve problems even as input data deviates from the type of data used for model training. Intelligent algorithms may "learn" from data fed into the model—identifying patterns and improving the algorithm with each additional production run. The high-intelligence, "black-box" algorithm "learns" based on predetermined goals—such as optimization of the output—and configuration stipulating the rate at which the algorithm learns. As data changes and the algorithm gains additional experience, the intelligent algorithm can adapt the rules or pathway by which it achieves its stated goal.

FIGURE 1:
INTELLIGENCE—RISK SPECTRUM

Classifying algorithms

Complexity

In relation to algorithms, complexity "refer[s] to the technical sophistication or quantity of its components or elements."[5] In decision tree algorithms, for instance, the greater number of branches in the tree lend to more nuanced or complex outputs (tree leaves). Conversely, a simple decision tree with a binary output would be classified as non-complex. See figure 2 for an example decision tree.

While not synonymous, the degree of intelligence in an algorithm can also lend to its complexity. Gradient-boosted decision trees, a machine learning technique, compound complexity by generating thousands of similar decision trees to solve classification problems. With respect to black-box algorithms like those utilized in machine learning, quantifying complexity can be difficult. An algorithm's processing time (i.e., the time taken to iterate through each programmed step) serves as a proxy for the complexity inherent in the underlying logic.

FIGURE 2:
BASIC MOMENTUM TRADING ALGORITHM

FIGURE 3:
COMPLEXITY—RISK SPECTRUM

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Classifying algorithms

Type

The algorithm type influences both
a) the set of rules comprising the algorithm and b) the output generated by the algorithm. Algorithm types include, but are not limited to, the chart on the right.

Put differently, the algorithm will vary depending on the problem the algorithm is designed to solve. When identifying and assessing risks association with algorithmic outputs, auditors should consider whether the business has selected an algorithm that is well suited to its task. Understanding the problem, the goal, and the related algorithm type is important to any assessment of an algorithm and its risks.

Classification

Based on predefined or learned rules, a classification algorithm groups items into cohorts based on the characteristics of the item.

Calculation

While often simplistic in nature, many algorithms involve applying formulas to input data to generate an output; the selection of the appropriate formulas may depend on input criteria.

Optimization

An optimization algorithm tries to solve for the optimal or near optimal solution to a problem. In the case of machine learning, algorithms are used to minimize a loss function (prediction error) and generate a performing model.

Classifying algorithms

Understanding the way algorithms differ—in terms of intelligence, complexity, and type—will likely better prepare the auditor for identifying algorithms implemented in business processes. Additionally, these characteristics may also influence the auditor’s risk assessment process and testing approach. As discussed earlier, implementation of higher intelligence, higher complexity algorithms may result in higher risk associated with the process or account balance. Furthermore, the degree of risk should influence the control environment encompassing the algorithm. To sufficiently address the risk inherent in algorithmic processes, auditors may expect intelligent, complex algorithms to be accompanied by both automated and manual review controls. Finally, the intelligence, complexity, and type of algorithm can affect how auditors plan their substantive response to address the risks associated with the algorithm.

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Identifying algorithms

Identifying algorithms

While identification seems simple in theory, algorithms are often hidden within larger business processes, systems, applications, and software.

While finance and accounting personnel depend on the outputs of business operations, which frequently rely on algorithms, they may not be aware how algorithms used in upstream business operations impact outputs used in accounting and financial reporting. To identify algorithms, auditors may consider a) adopting a questioning mindset when reviewing business processes and b) holding walkthrough discussions with finance, operations, and operational support personnel.

Identifying algorithms embedded within a process or control typically requires in-depth understanding of the domain and open lines of communication with the business. Depending on the scope and scale of the business process, audit teams may need to enlist subject -matter resources (SMRs) with technical knowledge (i.e., individuals with programming or data analysis experience). Armed with requisite knowledge and experience, auditors can uncover algorithms during regular meetings, such as controls walkthroughs, with business personnel. Teams can adequately prepare for these meetings with upfront investment of time and resources.

Identifying algorithms

First, audit personnel (e.g., staff, seniors, and managers) may take technical training programs to educate themselves on algorithm functionality, algorithm use cases, and common areas reliant on algorithms.

Additionally, the audit team may enlist SMRs to assist in the engagement team's identification efforts. Enlisting SMRs can help to achieve effective communication with the business's technical experts, such as the IT personnel and model or algorithm owners. Given that SMRs may assist with the substantive testing of algorithms, embedding SMRs in the identification process can facilitate a smooth transition between the audit planning and testing phases.

Second, the audit team may obtain a general understanding of the technologies used by the business.

As established previously, algorithms often accompany the applications, software, and models used throughout business processes. In addition, finance and accounting personnel may not always be cognizant of the specific role algorithms play in these technologies. When evaluating whether these technologies rely on algorithms or whether an algorithm plays a key

role in a financial reporting process, there are common hallmarks of an algorithm's presence to consider. For instance, algorithms commonly exist where input data is transformed into output data that differs from the input data. For example, consider a bank's internal risk-rating process for originated loans. When deriving a risk rating (e.g., a letter grade ranging from A to F), the bank will consider loan-level input data such as the loan balance, borrower income, borrower credit score, collateral, if any. Based on predetermined criteria, the bank will group these loans into credit rating buckets. Most likely, the bank accomplishes the risk-rating process using a classification algorithm.

Prior to walkthroughs, the audit team may obtain an understanding of a) the organization's process flows outlining the flow of information[6] from upstream databases to downstream end-user processes, and b) inventories of applications and models, both internally and externally developed, used throughout the organization. Performing these information-gathering exercises can allow the audit team to more effectively deploy its resources, particularly its SMRs, when performing walkthroughs.

Identifying algorithms

When performing walkthroughs, an auditor may consider pursuing a consistent line of inquiry to establish whether the business uses algorithms. No matter the use case, algorithmic processes tend to share certain similar characteristics. The auditor may further tailor its questions based on the unique nature of the business or the process under review. Additionally, the audit may enlist the assistance of SMRs when discussing complex algorithmic processes. Nonetheless, the following queries may serve as a strong starting point when identifying algorithms used by the business:

Walkthrough questions

What are the inputs and outputs to a process?

While somewhat self-evident, the auditor may confirm the inputs and outputs of a process before proceeding any further. As noted earlier, inputs and outputs typically accompany algorithms. Furthermore, the substantive assessment of the algorithm may entail evaluation of both the input data fed into the algorithm and the output generated by the algorithm. The nature of the input and output data may impact how the audit team proceeds in the testing phase.

Does the output of a given process vary based upon specific input criteria?

Algorithms consist of a set of rules which, taken together, transform input data into a synthesized output. Identification of variants in a process's output may imply the existence of algorithms within the technology used to complete the process.

For a given process, what are the logic, conditionals, or rules used to generate the output?

In instances where a business process makes use of programmed logic, the auditor may hold meetings with the process owner and the upstream users. By performing walkthroughs with these stakeholders, the audit team may be able to gain an understanding of the methodology and assumptions underpinning the algorithm. Potentially, the walkthrough leader can further contextualize the algorithm by iterating through an example dataset or transaction.

Identifying algorithms

Are any of the underlying inputs transformed prior to initiation of the process?

The auditor may also consider algorithms built into data preparation processes. Business processes are often supported by upstream data transfer, preparation, or cleaning steps. Data transfers generally involve lift and shift of input data from upstream source systems to downstream business users. In some instances, however, the business may use an algorithm or series of algorithms to transform data for further use. By asking probing questions of database management personnel, audit teams can ascertain the degree to which algorithms are deployed throughout the data prep process.

Has the business automated any of the component processes in a recent period?

Automated processes likely require algorithms or algorithm-based bots, like RPA, to complete tasks normally performed with human assistance. Assessment of these processes may require the same skillset and techniques reserved for auditing algorithms.

Does the process owner independently review the outputs of the process?

For simpler algorithmic processes, the process owner may simply review output logs to verify that the process has been completed without issue. For complex algorithmic processes, the process owner may independently assess the reasonableness of the algorithmic output.

What is the frequency with which the process operates?

Business processes completed many times a day are generally accompanied by or made possible throughtechnological efficiencies—such as algorithms. Understanding the process frequency may lead to discovery of algorithmic process components.

Identifying algorithms

This list of potential walkthrough questions is not comprehensive; it serves as a starting point for auditing algorithms. As stated previously, audit teams may tailor their questions to match the specific environment associated with each unique audit engagement. By broaching the questions with both common audit contacts, such as accounting and financial reporting managers, and business operations managers, as well as individuals responsible for the development and implementation of algorithms, auditors can establish a baseline understanding of which business processes use algorithms. Having identified the algorithms used across the organization, the audit team can better tailor its risk assessment and planned controls and substantive procedures to address identified risks of misstatement.

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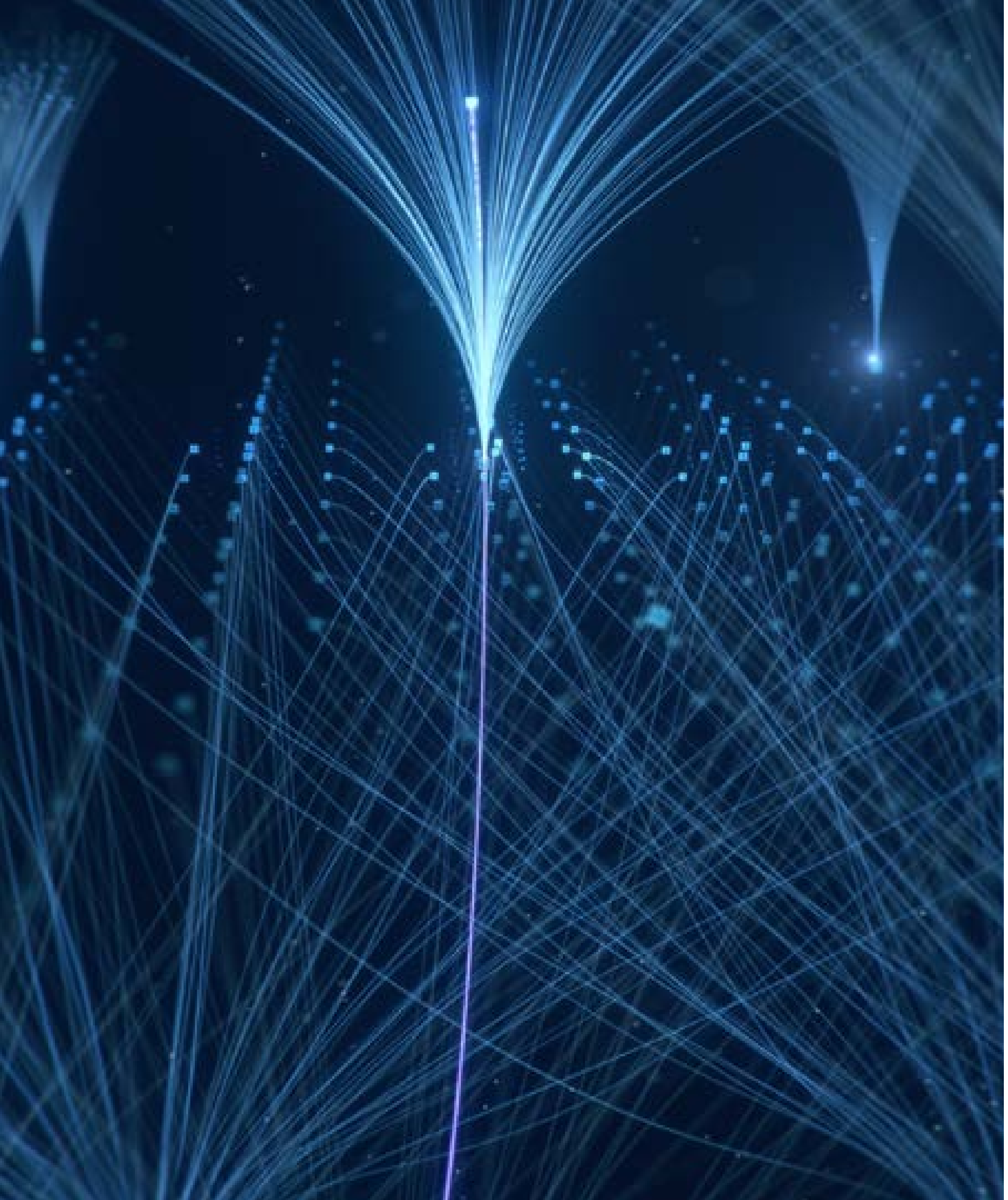
Risks associated with algorithms



Risks associated with algorithms

When considering risks associated with algorithms, auditors may first identify and assess risks of material misstatement to the financial statements. As such, the auditor may focus on algorithms that directly affect an account balance, line item, or disclosure within the financials. Algorithms may pose operational risk, which may impact account balances, estimates, or disclosures within financial statements and accompanying footnotes.

While the auditor may tailor its risk assessment, control testing, and planned substantive procedures based on the intelligence, complexity, and purpose of the algorithm, one of the auditor's primary objectives may be to assess whether the algorithm's output is reasonable and appropriate. Similar to the risk assessment process associated with management estimates, the auditor can disaggregate this fundamental risk into the four key areas on the next page.

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Risks associated with algorithms

Data

The quality of an algorithm typically depends on the quality of the input data. If the input data consumed by an algorithm is incomplete or inaccurate, there is a risk that the algorithm will generate an erroneous output—adversely affecting the financial statements. To address this risk, the audit engagement team may test data validation and data transfer controls designed to maintain the algorithm's data sources. Further, the audit engagement may directly test the accuracy and completeness of input data as part of its substantive procedures.

Assumptions

Assumptions involve areas in which the algorithm developer or entity management has deployed judgment in selecting a specific input or rule to facilitate the algorithm's processing. Together with relevant SMRs, the audit engagement team may identify and assess risks associated with significant algorithmic assumptions. Significant assumptions often include assumptions sensitive to variation, susceptible to bias, or predicated on unobservable data. The risk level associated with an assumption may vary based on the degree of judgment involved in developing the assumption.

Methodology

Fundamentally, the methodology involves the application of input data and assumptions to derive an output. The methodology of an algorithm (i.e., the rules or logic underpinning the algorithms processing) determines how the output of the algorithm is generated. An algorithm's methodology should be both designed appropriately and implemented correctly to achieve its intended result. When auditing the methodology, the audit team may enlist SMRs to assess the appropriateness of the method in relation to both a) the stated goal of the algorithm and b) the relevant accounting standards governing the financial statement line item or disclosure impacted by the algorithm.

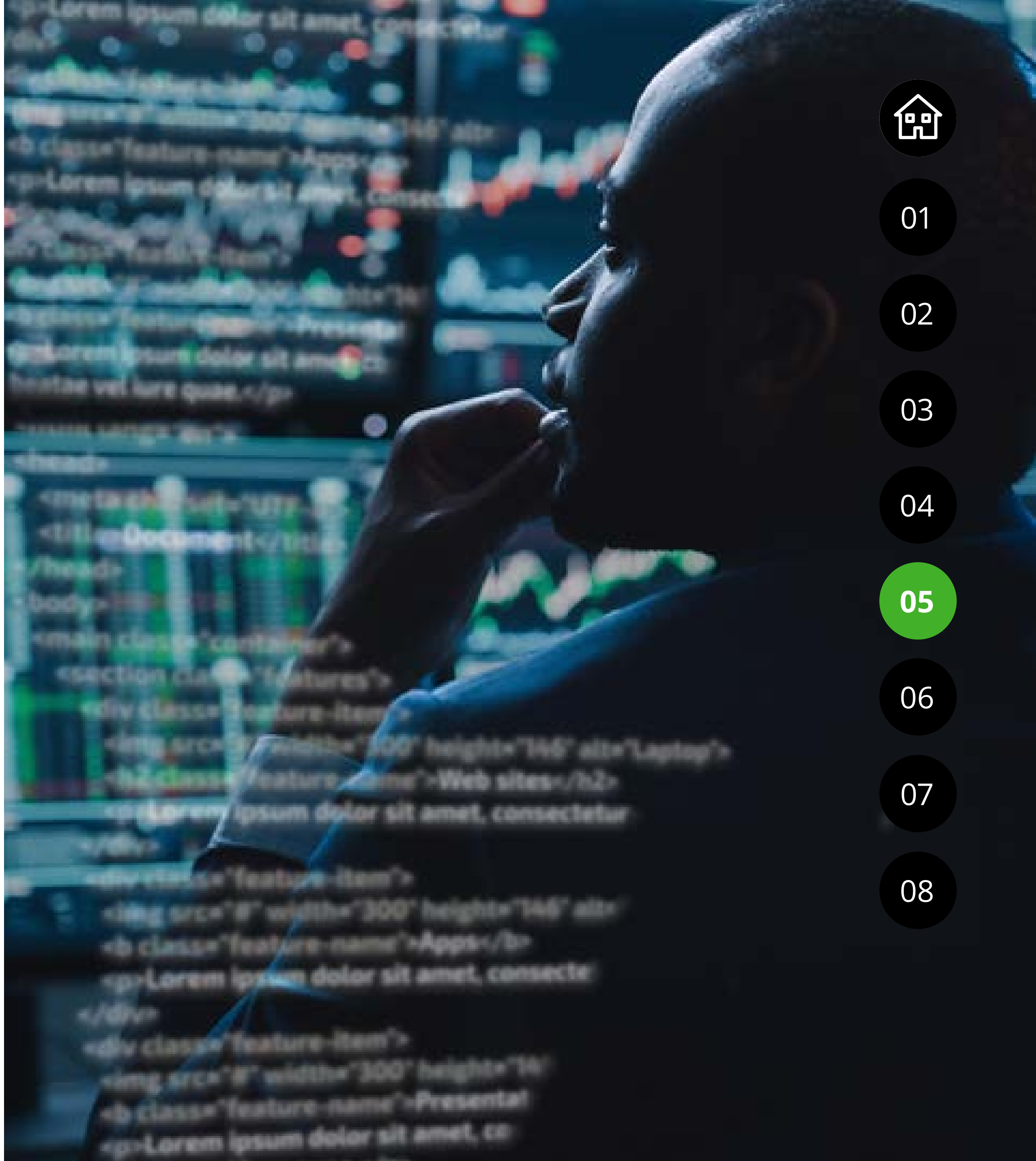
IT environment

In addition to evaluation of the algorithm itself, the audit team may consider the algorithm in the context of the information technology (IT) architecture in which it resides. The information technology that houses the algorithm, such as cloud-based infrastructure, can itself be complex in nature—introducing incremental risk to the algorithm output. Furthermore, even if the algorithm inputs and methodology are sound, insufficient IT controls may negatively affect the algorithm's processing. The audit team may identify and test general IT controls, including controls over change management and user access, to address technological risks associated with the algorithm's operation.

Risks associated with algorithms

By assessing the risks associated with an algorithm, the audit team can work with the SMRs to design the appropriate audit response.

The previously mentioned risks primarily relate to audits of algorithms that directly have an impact on financial statement account balances, line items, or disclosures. The capabilities of algorithms and AI are rapidly changing. In response, the regulatory landscape continues to evolve, and audit teams may need to reevaluate risks associated with algorithms based on the context and requirements of each unique audit engagement. Additionally, as the regulatory environment continues to mature, auditors may provide attestation services over algorithms in a variety of different areas and use cases.



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Conclusion

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Conclusion

The influence of algorithms has proliferated throughout modern organizations. As algorithms become more prevalent, it is important for audit teams to develop new capabilities. In particular, audit teams may identify algorithms embedded within systems, applications, and software deployed by businesses.

To identify algorithms and risks associated with these algorithms, audit teams and relevant SMRs may:

- Educate themselves on common algorithms, their uses cases, and their potential roles in financial reporting processes.
- Hold discussions with entity management, financial reporting personnel, and business process owners to determine in which areas, if any, the entity has deployed algorithms.
- Evaluate how the algorithm complexity, intelligence, and type influences the degree of risk associated with an algorithm.
- Consider the following components in the risk assessment process:
  - Algorithm inputs
  - Assumptions
  - Methodologies
  - The IT environment in which the algorithm resides

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Endnotes

1 Melissa Davis and Bern Elliot, *Applying AI – Business Domains*, Gartner, May 12, 2023.

2 For a comprehensive discussion of RPA use cases and accounting considerations, refer to Financial Reporting RPA Risks and Controls | Deloitte US.

3 Splunk, *5 Big Myths of AI and Machine Learning Debunked*, accessed June 30, 2023.

4 Wang, Pei. “On Defining Artificial Intelligence,” *Journal of Artificial General Intelligence*. 10, no. 2 (2019): pp. 1–37.

5 Open Risk Manual, “Model complexity,” accessed June 30, 2023.

6 In instances where internal process flows are not available, the audit team may consider independently mapping the flow of information across the organization.

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