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What Is Data Mining? How It Works, Benefits & Techniques

Learn what data mining is, explore key data mining techniques, see practical data mining examples and discover how it helps uncover valuable insights.

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OVERVIEW

Data mining is a technique that uses algorithms and statistical analysis principles — often paired with machine learning and data analytics — to analyze large data sets and uncover patterns, anomalies and other insights. The wide availability of data collection and storage tools means that even small organizations can gather and analyze large troves of data, whether it's related to customer preferences, user activity, inventory management or any other business functions.

Organizations use data mining to make powerful predictions, identify system bottlenecks and catch potential issues before they have an impact. New AI capabilities can democratize access to data mining insights, as they allow stakeholders to inquire about data patterns and test hypotheses about that data without the direct input of an analyst or data engineer.

In this piece, we'll discuss the fundamentals of data mining and describe how you can use the technology to gain key business advantages.

WHAT IS DATA MINING?

Data collection happens all around us and all the time, tracking everything from products we purchase to our heart rate as we go about the day. Businesses collect even more data about their operations, and by using data mining techniques, they can benefit from this information. Data mining identifies associations among data points and/or historical data to generate insights or forecast the future.

As an example, consider the data that a grocery chain generates, where sales data shows an increase in ice cream sales during the summer and increased demand for cold medicine during the winter. This data might not surprise you, but data mining techniques help organizations unearth unexpected patterns hidden in the data. For example, a data mining analysis may show that an increase in the demand for certain foods or vitamin supplements correlates with an increase in diaper sales nine months later, suggesting these products are popular with expecting mothers.

The sheer volume of data that organizations wrestle with can make these sorts of insights impossible to detect without the assistance of machine learning tools and statistical analysis. Data mining tools can cluster related data points and categorize data in unexpected ways, allowing organizations to react quickly to unforeseen changes and predict future needs.

WHY IS DATA MINING USEFUL? 4 BENEFITS

Data mining and data analytics provide organizations with an understanding of operational performance, customer choices and historical patterns, allowing them to make more informed decisions. Here are four key benefits that data mining delivers:

IMPROVES DECISION-MAKING

Rather than basing choices on assumptions or industry best practices, data mining empowers organizations with data-backed support, helping them understand the benefits and tradeoffs of each choice and reducing guesswork when making decisions.

DETECTS FRAUD AND ANOMALIES

By analyzing real-time and historical data, data mining tools can identify patterns or other variables that might indicate malicious or risky behavior. For example, examining patterns in ATM usage can help banks detect activity that correlates with card skimming or other scams. This allows them to freeze suspicious transactions and flag them for investigation.

OPTIMIZES BUSINESS PROCESSES

Analyzing service usage data, purchase flow behavior and support ticket response times can point to operational bottlenecks and overtaxed systems across the organization. This can help improve resource allocation, lower mean time to repair (MTTR) and reduce system latency.

SUPPORTS PREDICTIVE MODELING

One of the most powerful applications of data mining is forecasting, which extrapolates patterns in historical data to predict future behavior. This can be useful for logistics and planning by helping to manage inventories to ensure product availability and in resource management by predicting how much compute demand a particular operation or product launch will need.

DATA MINING CHALLENGES

Despite its massive potential, data mining also involves some unique challenges that can reduce its efficacy. Here are some of the biggest potential issues:

HIGH DATA VOLUME AND COSTS

Data mining requires a large amount of data to be useful, and this can lead to storage and processing burdens at scale. Every part of the data mining process, from ingestion to storage to processing, requires computational resources and a high level of investment that some organizations may not be able to justify.

UNCERTAINTY IN RESULTS

Even if a data mining process uncovers a pattern or makes a prediction, there is no guarantee that the prediction will be correct or the pattern will offer business value. Unexpected shifts in the market or consumer preferences can also reduce the usefulness of data-mined insights.

COMPLEXITY OF ALGORITHMS

Data mining techniques tend to be fairly complex, requiring iterative testing, assessment and ongoing improvement to continually adapt to changes. This can be expensive and labor-intensive, pulling resources away from other important business operations.

DATA QUALITY ISSUES

Data mining depends on the availability of accurate and usable data to provide value. Data pipeline inefficiencies, biases in the data set, the inadvertent inclusion of sensitive data and other issues can create risks or reduce the quality of analytics.

HOW DOES DATA MINING WORK?

Data mining does not involve a standalone algorithm or piece of software, but is rather a strategic mining process with several steps. Here's how it works:

1. DEFINE BUSINESS OBJECTIVES

Before collecting and processing any data, organizations need to establish a clear set of goals for their efforts. Because data collection and storage is compute-intensive, it's important to choose the most appropriate and complete data sources and determine whether there is enough data available to extract meaningful insights from them. Choosing realistic objectives also helps analysts choose the best data mining model.

2. COLLECT AND CONSOLIDATE DATA

Fine-tuning the collection process means setting efficient collection parameters to apply to the data sources you have identified. Collecting too much data can be burdensome, taxing storage and processing resources, but having too little data can limit the data set's usefulness. It's also important to identify any potential risks within the data sources before anonymizing and securing any sensitive data.

3. CLEAN AND PREPARE DATA

Data cleaning is a critical processing step that removes outliers and noise and accounts for any missing data values. Standardizing data formats is also important, particularly when gathering data from many different sources.

4. TRAIN THE MODEL

Before you can use models to recognize useful patterns, you may need to first train and refine them. Training involves adjusting the weights of different variables, for example, by assigning more weight to recently collected data over much older data, or adjusting the data set size and the number of dimensions you're analyzing.

5. PATTERN MINING

Deploying a trained model to analyze a large raw data set allows it to identify any statistically significant patterns, relationships or trends within the data. The specifics of this step will depend on your objectives. For a predictive model, this could involve analyzing historical trends to forecast changes in user behavior, while a text analysis model might track consumer sentiment by analyzing customer reviews.

6. EVALUATE MODEL PERFORMANCE

Even if a data mining model achieves its desired goal, it will likely benefit from further refinement, particularly if new data sources become available or a more computationally efficient way to analyze the data is developed.

DATA MINING TECHNIQUES

There are a range of different data mining techniques, each suited to a particular set of goals or type of data. Here are some of the most popular approaches:

REGRESSION ANALYSIS

A regression analysis examines the relationship between a particular data point, called a dependent variable, and one or multiple independent variables. A common example would be an analysis of price elasticity, measuring how changes in the price of a particular product could impact the demand for that product.

PREDICTIVE ANALYTICS

Using historical data, predictive algorithms create a mathematical model that forecasts possible future behavior. Manufacturing businesses deploy this model to assess machinery usage and identify components that may be at risk of failure, prompting a proactive repair or replacement.

CLASSIFICATION

Data classification is used to group data which shares a predefined characteristic, for example, classifying certain types of user behavior (such as email messages) as suspicious or not suspicious. Refining these classifications allows organizations to deploy them to detect spam or malicious network activity. Classification is often a form of supervised machine learning, which means the algorithm is trained on data which has already been labeled according to these predefined characteristics.

CLUSTERING

Clustering algorithms create groups of data based on their shared characteristics rather than predefined classifications. Organizations use this to discover new groups or behavior patterns — for example, identifying a segment of customers who have similar product preferences. Clustering is typically a form of unsupervised ML, meaning it can be deployed to analyze unlabeled data.

DECISION TREES

A decision tree is a visual structure that breaks a data set up according to different decisions, which cascade down into further decisions before ending in a possible outcome or probability. Some medical diagnostic algorithms employ this method, sorting patients based on their age, blood pressure and the presence of certain symptoms to determine the likelihood of a particular medical issue or illness.

ANOMALY DETECTION

Anomaly detection identifies and monitors data activity which falls outside of the baseline of expected behaviour — for example, a database query which suddenly starts to utilize much more CPU power to run. Using this information can help organizations identify and remediate a bottleneck or inefficiency before it causes performance issues.

DATA MINING EXAMPLES AND USE CASES

Teams in every industry rely on data-driven insights to improve their decision-making and productivity. Here are some examples of how organizations are using data mining throughout their operations:

CUSTOMER SEGMENTATION AND TARGETING

Using clustering, marketing teams can segment their addressable market more efficiently, grouping consumers based on their shared preferences. This allows them to cater their marketing efforts directly to the needs and expectations of each segment, improving returns and identifying new opportunities.

FRAUD DETECTION IN BANKING

Security teams can classify different types of user activity, setting a baseline of expected behavior and flagging potential fraud activity that breaks from the norm, such as overseas or overly high credit card charges. They can also analyze historical data around security incidents, using anomaly detection to search for data patterns that presage malicious activity.

OPERATIONAL EFFICIENCY IN LOGISTICS

Forecasting models can help logistics teams improve supply chain efficiency by predicting shifts in demand, which helps ensure consistent product availability. They can also mine complex supply chain data sets for unseen patterns, such as the effect weather can have on the price of particular raw materials.

PATIENT RISK ANALYSIS IN HEALTHCARE

Healthcare analysts use data clustering to identify new risk factors, including those which might fall out of the range of conventional medical diagnostics. By relating characteristics like a patient’s location, profession or other factors to specific medical issues, data mining can increase positive health outcomes and help healthcare professionals provide more specialized care.

CONCLUSION

Data mining has become an essential part of many businesses, allowing organizations to identify new opportunities, create better products and increase operational efficiency. The breadth of different data mining models allows organizations to extract useful information from many different types of data and to identify key patterns between seemingly unrelated variables. Although data mining can be computationally demanding and require a significant investment, most organizations find that these costs are greatly outweighed by its many analytical benefits.

DATA MINING FAQS

- **What are the functions of data mining?**
- **What software tools are available for data mining?**
- **How is data mining applied in business analytics?**

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