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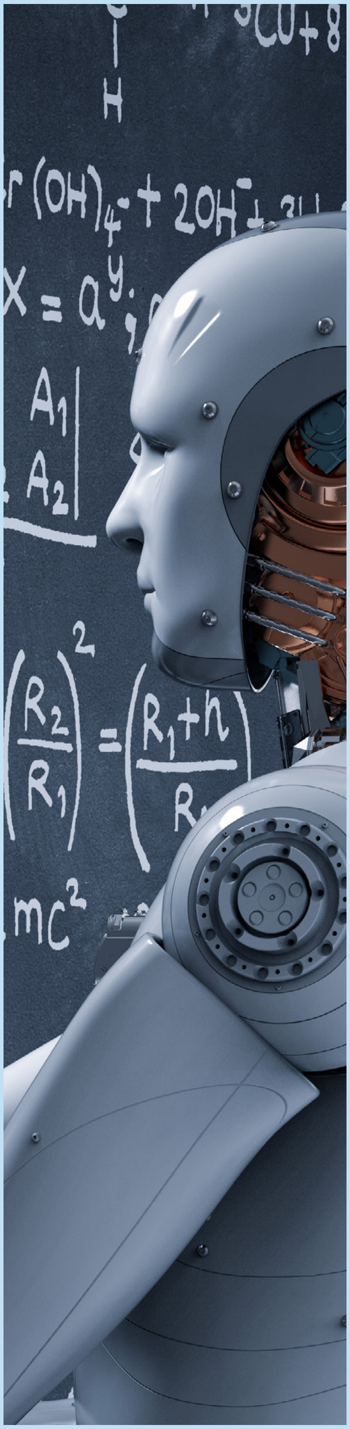

LINEAR ALGEBRA IN AI

Abstract

As the BFSI industry begins to realize the benefits of artificial intelligence, this whitepaper introduces linear algebra as a computational tool and its advantages when compared to conventional artificial intelligence technology. Linear algebra belongs to a branch of mathematics that improves machine learning algorithms and data analytics. This paper also presents a couple of potential use cases and represents how linear algebra will be the potential growth path, foreseeing the increasing acceptance of AI-enabled solutions.

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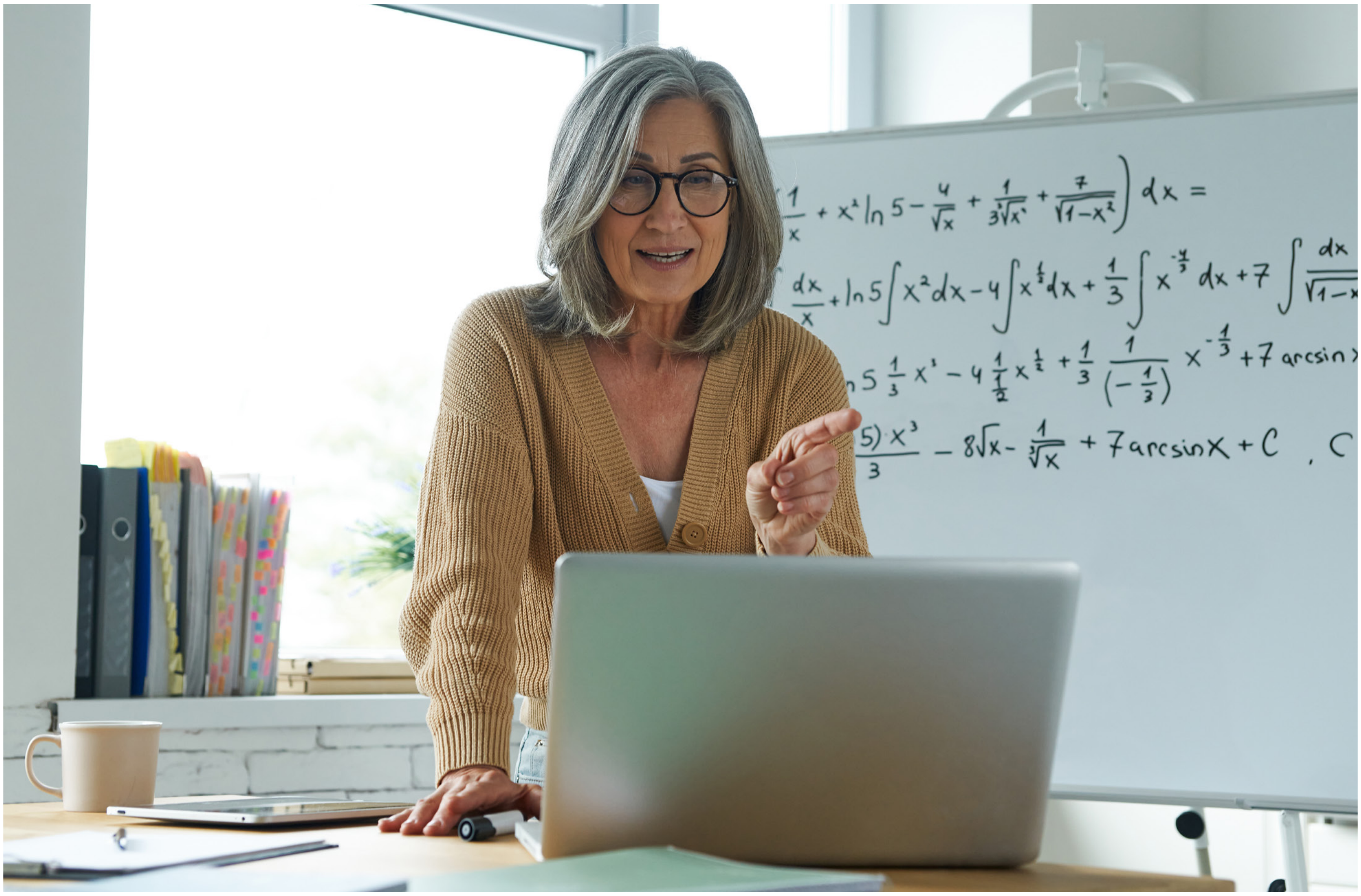

Why linear algebra?

Linear algebra plays a vital role in better understanding artificial intelligence and quantum computing, as currently BFSI is heading towards advanced tools and techniques of deep learning, a subset of artificial intelligence. Linear algebra, widely considered as the "guru of mathematics", is a computational tool for science, engineering, and data analytics. Four pillars of linear algebra are vectors, matrices, tensors, and scalars. This paper will explain these in detail.

Data is an important factor in the outcome of any event. The four pillars mentioned above will be used as repositories to store data and operate on it as per provided instructions. Linear algebra by large is considered as a "storage space".

In simple terms linear algebra can be widely used as a "data guru" for machine learning and artificial intelligence (deep learning) by exposing itself to data clustering, data classification, data validation, and data fitting. Any time-consuming deep analysis of data requires storage, and linear algebra provides the perfect solution for this, by using vectors, matrices, tensors, and scalars as a central data repository.

The history of linear algebra

The year 1637 is when linear algebra was first introduced. The concept of the coordinate system was developed by Rene Descartes, who founded a geometric approach known today as Cartesian geometry. Use of determinants to solve linear systems was found in 1693 by a German mathematician. This was further enhanced as Cramer's Rule in the year 1750. However, the complex theory of dynamic values in a data set has been discovered by Irish scientist William Rowan Hamilton in 1843.

Mathematical objects in linear algebra

Scalar: This is a real or natural number.

$$\begin{bmatrix} 4 \end{bmatrix}$$

Vector: This represents an axis that requires a coordinate for each element. To identify each element, focus on an index where a list of numbers is arranged in an order. A simple vector is used to identify points in a given space. This is a typical mathematical object which is widely used in current machine learning techniques.

$$\begin{bmatrix} 4 \\ 3 \end{bmatrix}$$

Matrix: A matrix is used to identify each element in a number of arrays in two dimensions; each element in a matrix is ascertained by two indices. An example is given below. The matrix is a combination of two indices; one is for rows, which are 48 and 36, and the other is for columns, which are 43 and 86

$$\begin{bmatrix} 48 \\ 36 \end{bmatrix}$$

Tensors: Unlike a matrix which is a two-dimensional array, a tensor is an n-dimensional array. The generic nature is carried across all the other objects, such as scalars, vectors, and matrices. An array of elements are arranged on a variable axis. For instance, in a typical software coding language, a tensor is used as a variable to declare multiple data sets and extract the information from a given set of files.

Linear algebra: A bird's-eye view

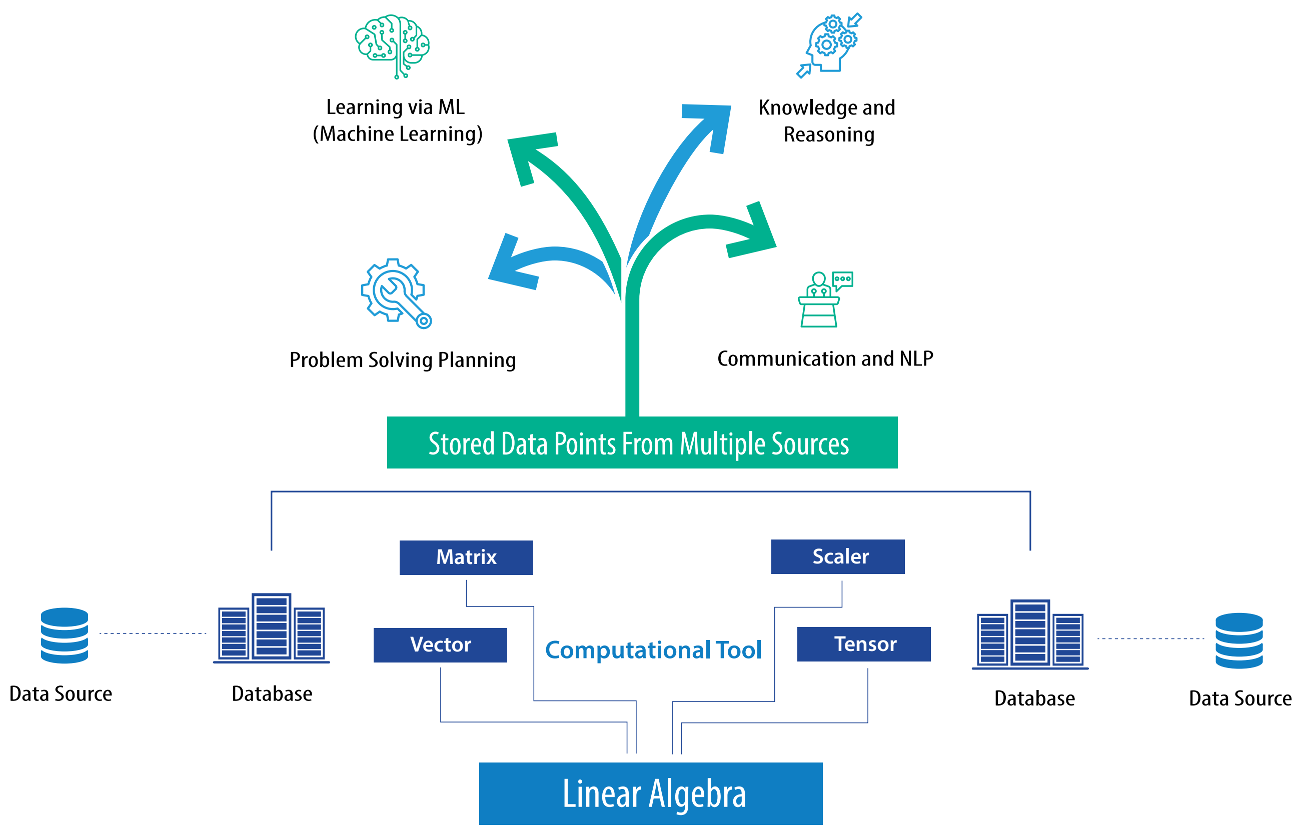

Fig 1: The linear algebra computational tool

In the current BFSI industry we deal with high intense documents, which are a combination of structured and dynamic documents, to validate customer details in a typical onboarding process. The document may include pure dynamic data received from a customer via multiple channels.

We all know that there are several tools and techniques which are already introduced in the markets for image recognition and data visualization. Firstly, let's understand a few top image recognition tools in the BFSI industry, such as Azure Content Moderator, Amazon Rekognition, Google Cloud Vision API, and IBM Watson Visual Recognition. These tools at the current business requirements have fairly matured to perform auto identification of subjects and objects in an image and unify the images in a logical list. Having said that, on these tools we still see some disadvantages which are mentioned below.

1) Misidentification of images

2) Lack of image clarity and unclear background

3) Data insecurity or exposures

4) Technological imperfections

5) Increase In fraud

On the other hand, we also have a few top data visualization tools in the BFSI industry, such as Tableau, Google Chart, Jupyter, and Power BI. These tools, in terms of the current business requirements, are fairly matured and provide a range of advanced databases as well as data visualizations with the help of big data applications, artificial intelligence, and machine learning.

To further enhance the capabilities of these tools, we can take advantage of linear algebra with its most common five advantages mentioned below.

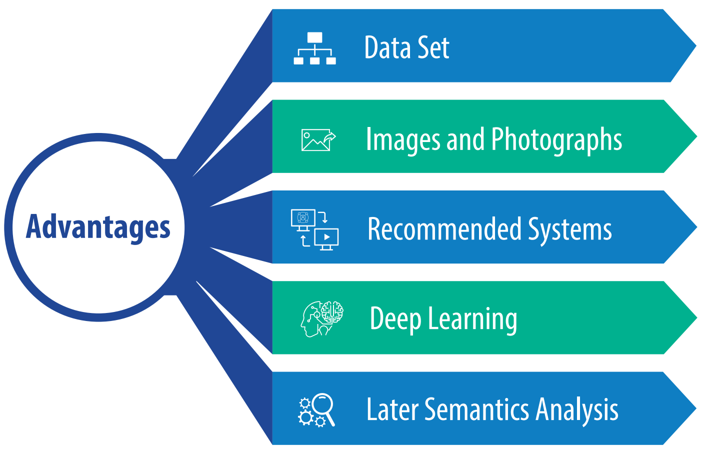

Fig 2: Advantages of Linear Algebra

1) Data and its importance

In any organization, data is very important. Linear algebra utilizes its capabilities in machine learning as a model using data sets with a tabular structure of rows and columns. In a typical BFSI example where "free format" messages are received for corporate actions or events, a matrix data set can be applied. In this case, the free format message is considered as input in a matrix to identify observations, and after analysis the output will be stored in various formats (important texts extracted from free format messages).

2) Images and photographs

Linear algebra applies a table structure view in machine learning which will further apply the matrix algorithm on images or photographs. In BFSI, digital onboarding is the best example where images and photographs of customers are validated. Machine learning applies linear algebraic notations and operations to perform additional actions such resizing, scaling, and cropping for the desired result.

3) Latent semantic analysis

When words and text are involved in any domain then the only solution for transforming the sentences is natural language processing (NLP). A contact center is a typical BFSI example where customers' dynamic requests are received via multiple channels. NLP large metrices are used to store words, paragraphs, pages, etc., in a matrix and marks total words in the form of a count or frequency in which they occur. This output helps the machine learning model to easily compare queries and produce appropriate responses.

4) Recommended systems

Machine learning applies predictive analysis of linear algebra. This is currently available with a fair amount of output. As an example: We see "Recommendations for you" in major apps such as Amazon Prime and Netflix.

5) Deep learning

As mentioned earlier tensors are multi-dimensional matrices that is used in deep learning artificial neural networks. ANNs utilize larger datasets to work on challenging tasks such speech recognition, machine translation, etc.

Use case 1: Handling text data using LSI (latent semantic indexing)

Typically, in BFSI operations, resources must read and understand free formats received as part of corporate events and dynamically written text, generated as part of a case workflow. This is time-consuming and requires manual effort. The below flow diagram represents the current transformation of these texts.

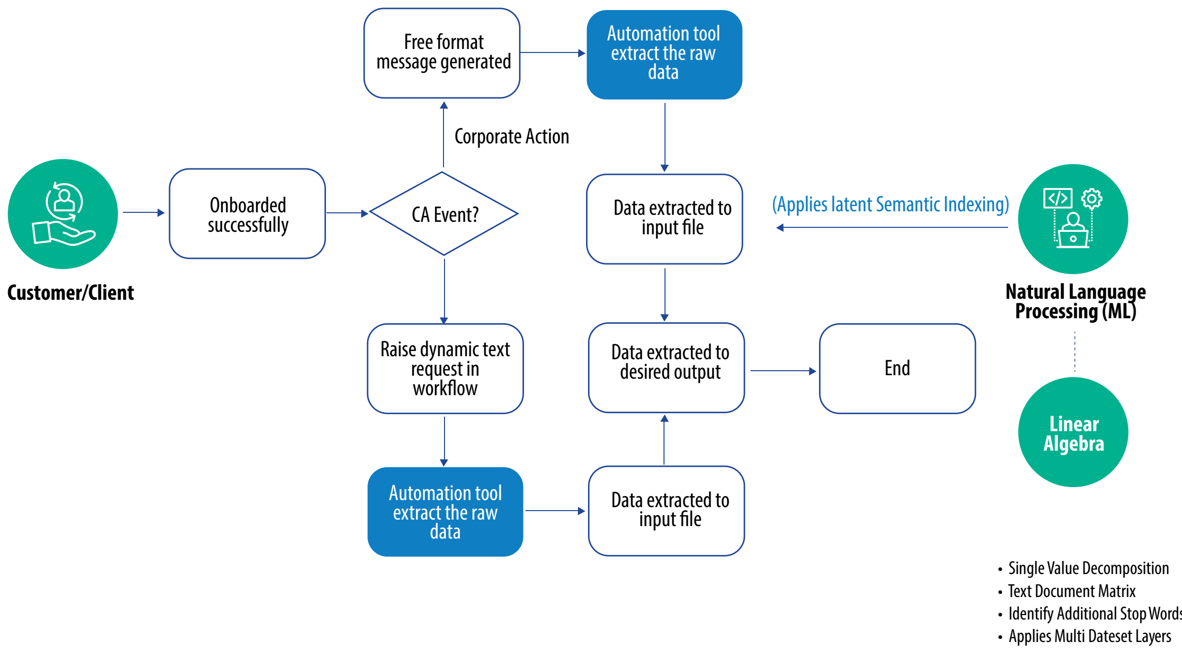

Fig 3: Text data (latent semantic indexing)

With linear algebra in collaboration with NLP (natural language processing) the output from the desired input format will be much more effective and can increase data accuracy. The main components that provide these results are "single value decomposition" and "text document matrix", which are multi-dimensional tensors.

Use case 2: Digital onboarding (image recognition and matching)

In BFSI operations KYC is the key process for end-to-end onboarding of a customer. Image validation is a key element in digital onboarding. Although there are numerous tools in the market to perform image validation, linear algebra has its own flavor to mark up the received images with additional information. The below picture depicts the importance of it.

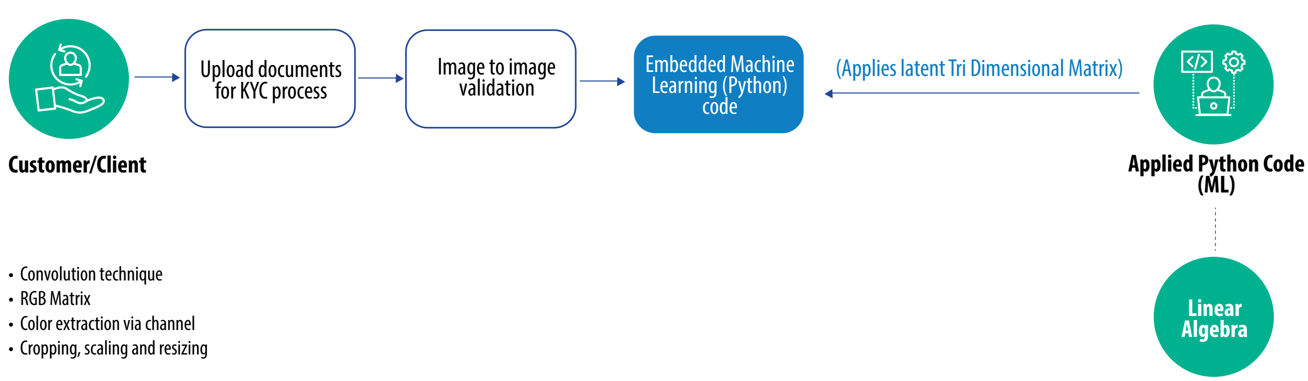

Fig 4: Tri-dimensional image recognition

With the application of linear algebra, we gain some additional advantages, such as convolution technique being added to each element from pixel to local space and vector (multidimensional matrix) to RGB conversion, which helps in color extraction via different channels. This helps recognize the image and process it as required through cropping, scaling, and resizing.

Going forward: AI hand in hand with linear algebra

Not all conventional approaches of artificial intelligence provides desired results in the context of BFSI, keeping in view of the dynamic nature of the processes and the Documents associated with them. There are constraints in linear algebra as it is a large mathematical component with high complexity. Still, one must truly push towards linear algebra as a primary tool, considering its depth analysis with the help of notations, arithmetic, various matrices, statistics for data representation, and most importantly the multi-dimensional matrix approach. While building a solution, we think of Plan A and Plan B; however, with linear algebra, we can derive executable Plans A, B, and C. It can surely enhance the capabilities of modern machine learning techniques and also speech to text implementations such NLP, NLU and NLG.

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*For organisations on the digital transformation journey, agility is key in responding to a rapidly changing technology and business landscape. Now more than ever, it is crucial to deliver and exceed organisational expectations with a robust digital mindset backed by innovation. Enabling businesses to sense, learn, respond, and evolve like living organisms will be imperative for business excellence. A comprehensive yet modular suite of services is doing precisely that. Equipping organisations with intuitive decision-making automatically at scale, actionable insights based on real-time solutions, anytime/anywhere experience, and in-depth data visibility across functions leading to hyper-productivity, Live Enterprise is building connected organisations that are innovating collaboratively for the future.

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