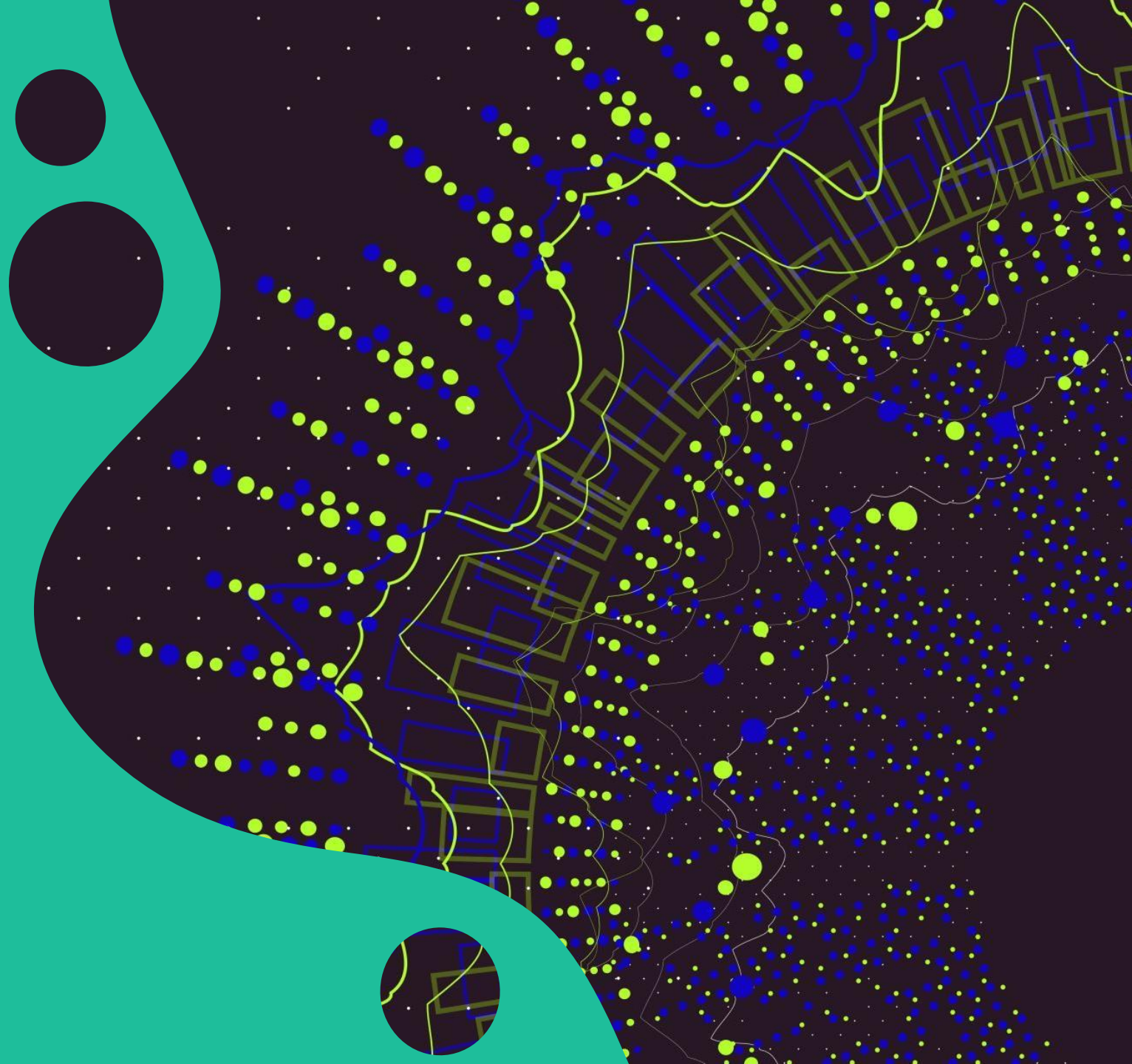# AI Basics

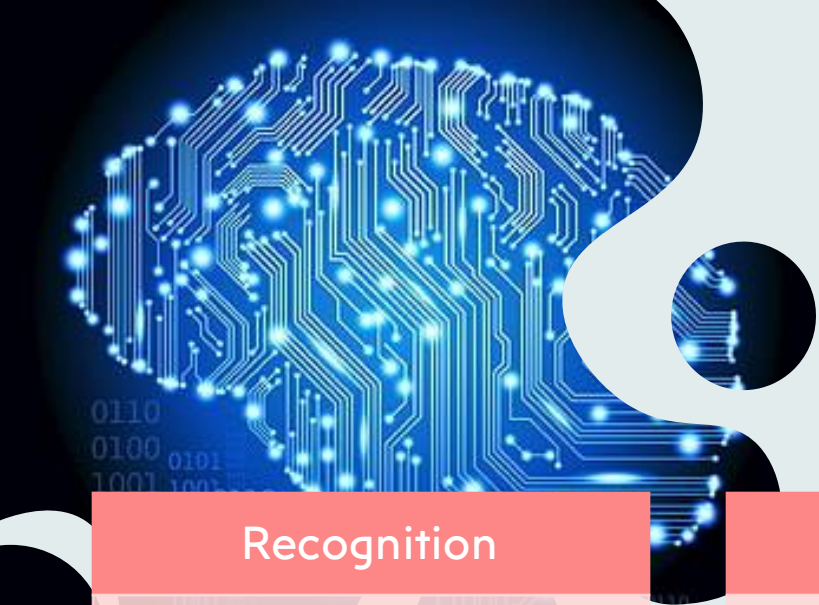*From* **Intuition** *To* **Implementation**

- Mahesh Awasare

Chapter 1
Intelligence and Mathematics

What you will learn after this chapter?

- Define Intelligence types

- Applied Mathematics intuition in AI

Intelligence – Abstracted to 4 types!

Recognition

- Ability to identify patterns and similarities/differences
- **Reasoning**, social intelligence

Calculation

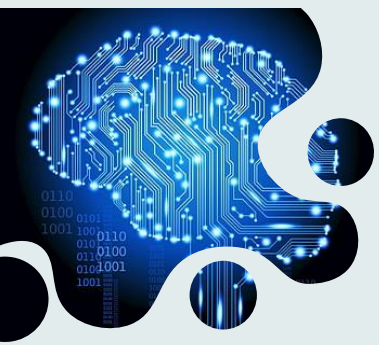- Use logic or mathematics to derive or understand unknown

Creation

- Goes beyond existing patterns to create new things

Self Awareness

- An understanding of one's own capabilities, strengths, weaknesses etc. that enables continual self-improvement

BIG QUESTION?

HOW TO IMPART THESE DIFFERENT INTELLIGENCE(S) TO MACHINES?

Humans vs Machines

- Humans are biological models

- Machines are calculative models

- It is important to convert the biological intelligence in such a way that calculative models can understand.

- Mathematics is the language of machine learning, providing a foundational framework that allows machines to learn, process information, and make decisions.

Mathematics – Best friend of machines!

Mathematics helps Machines in following areas.

- Data Representation
- Similarity and Distance Metrics
- Optimization Algorithms
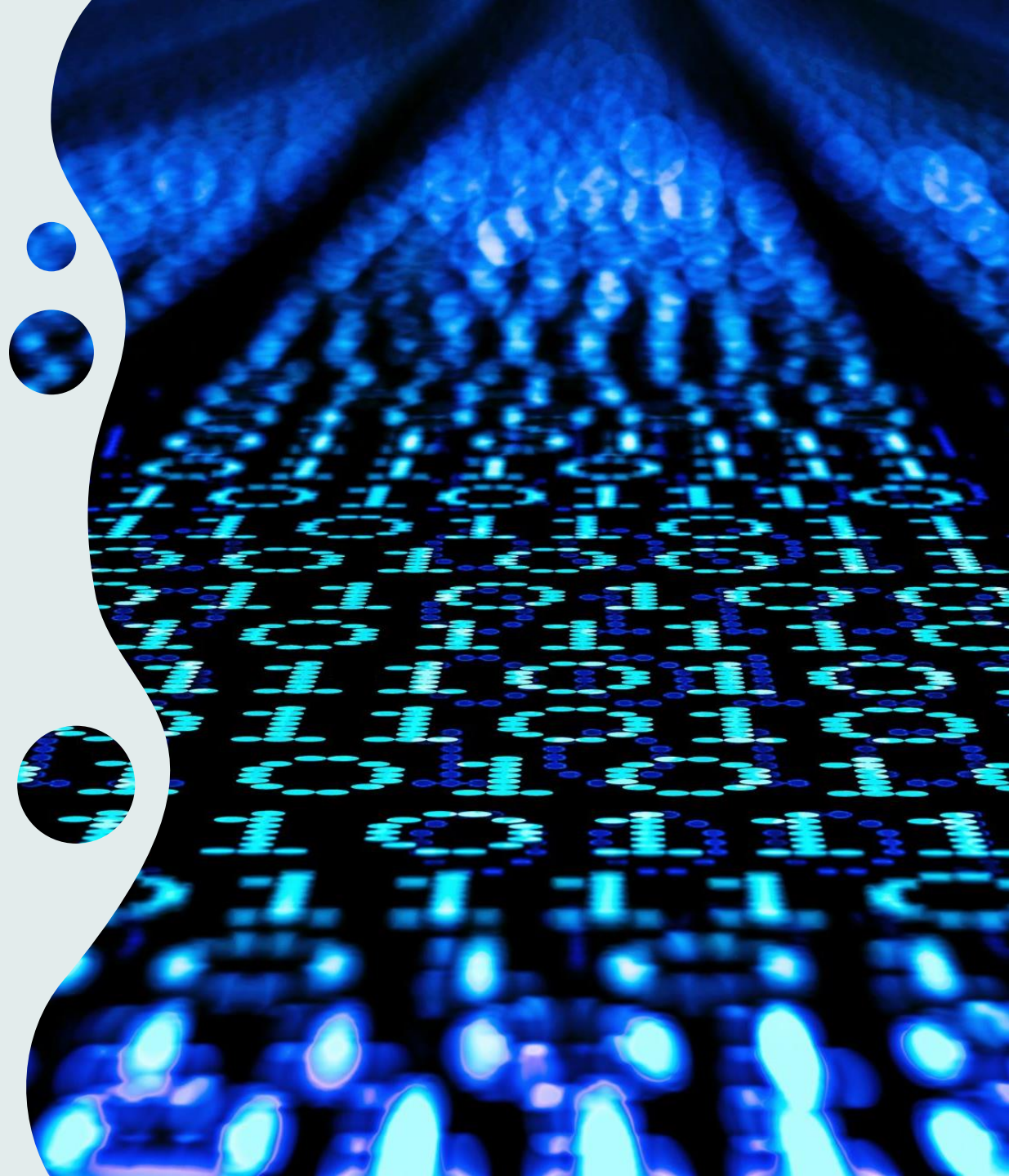- Probability and Statistics
- Neural Networks

Data Representation for Machines

- Text Data – Text data is converted into number tokens.

- Image Data – Images are converted into grids (row and columns) of numbers

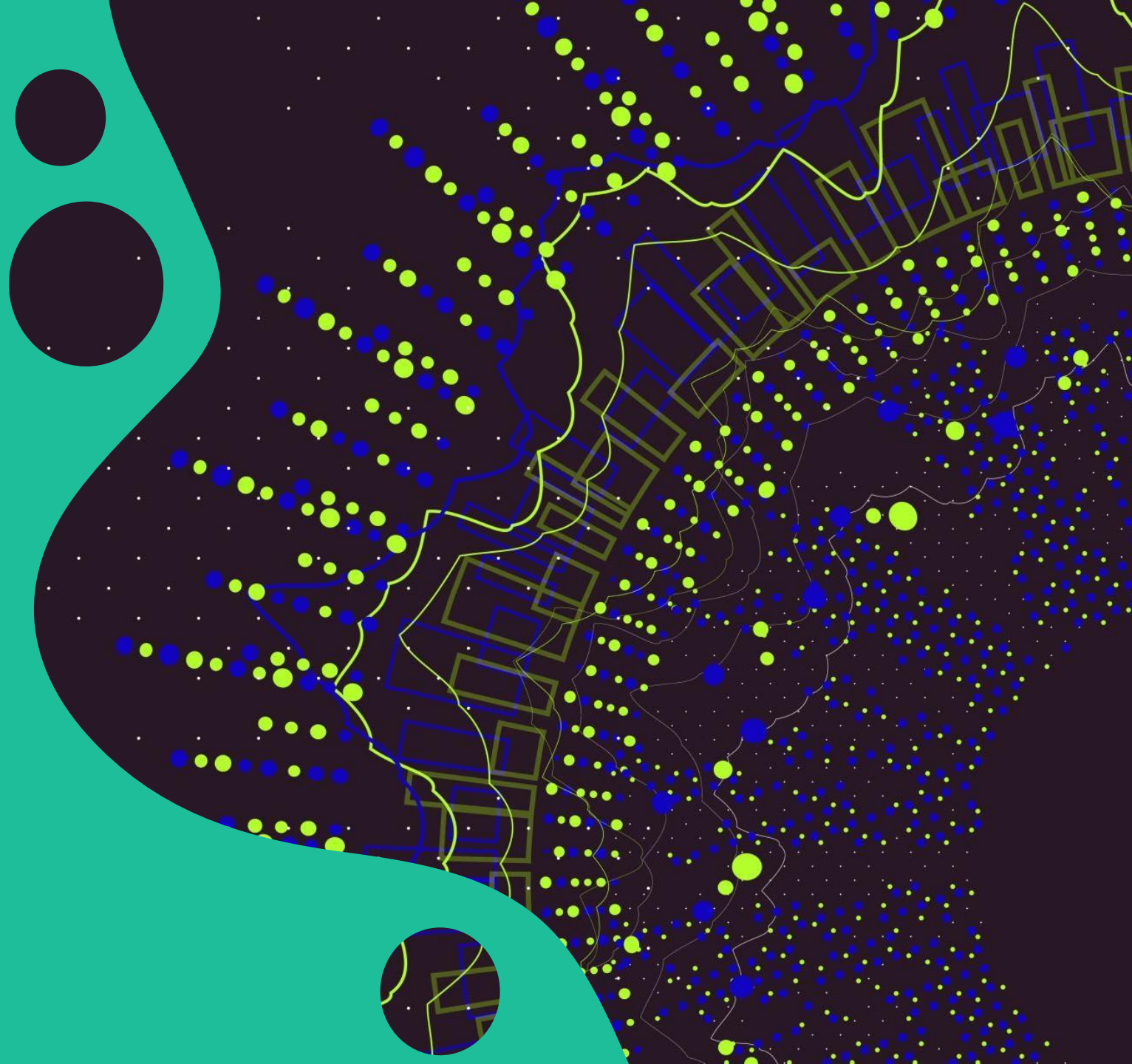- Audio Data – Audio samples are converted into set of numbers

LET US SEE THESE IN ACTION!

Chapter 2

Data is food!

How machines "understands" data?

Vector Representations

Intuition – Vectors can represent various entities like images, documents, or features in a dataset.

Question: What is mathematically meant by vectors in AI?

Mathematical Explanation: In AI, vectors are used to represent multi-dimensional data points. A vector consists of elements that could represent pixel values in an image, word frequencies in a document, or feature values in a dataset.

How a vector look like?

House1 = [2000sqft, 3 bedrooms, 2 bathrooms]

House1 = [1000sqft, 2 bedrooms, 2 bathrooms]

How machines "see" images?

Intuition – Images should be presented to machines in some way so that image processing operations can be performed on it.

Question: Image has colors, shapes how to capture this information and provide to machines?

Which Mathematical tool : Matrices

Mathematical Explanation: Matrices are employed in image processing to perform operations like scaling (changing size), rotation, and flipping. Any operation on matrix will result in changing the image.

Implementation

How machines "listen" to music?

Intuition – For humans, perceiving music intuitively means breaking it down into conceptual building blocks like notes, beats, melodies, harmonies etc. AI models do the same statistically.

Question: But how can the continuous streaming sound waves be mathematically interpreted as discrete patterns? What structures should be uncovered to represent musical logic?

Mathematical Explanation: In AI, vectors are used to represent multi-dimensional data points. A vector consists of elements that could represent pixel values in an image, word frequencies in a document, or feature values in a dataset.

How a music wave looks like to a computer?

Simple Conversion from wave to data [-79 -104 -153 … -429 -379 -60]

Covariance and Correleation

Intuition – As you walk or exercise, your mood becomes better so there is a relation between walking and exercise.

Question: How to capture relation between two entities mathematically

Mathematical tool: **Covariance**

Correlation
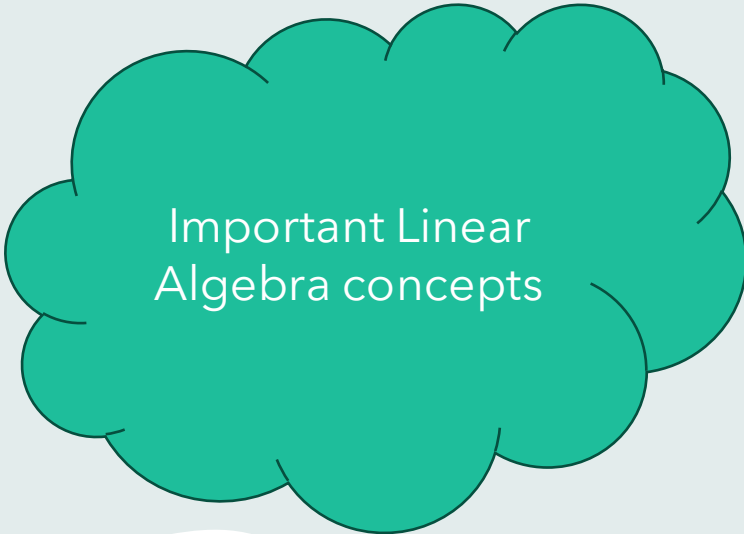
So we learned..

Vectors

About Matrices

About matrix operations

About Sound sampling
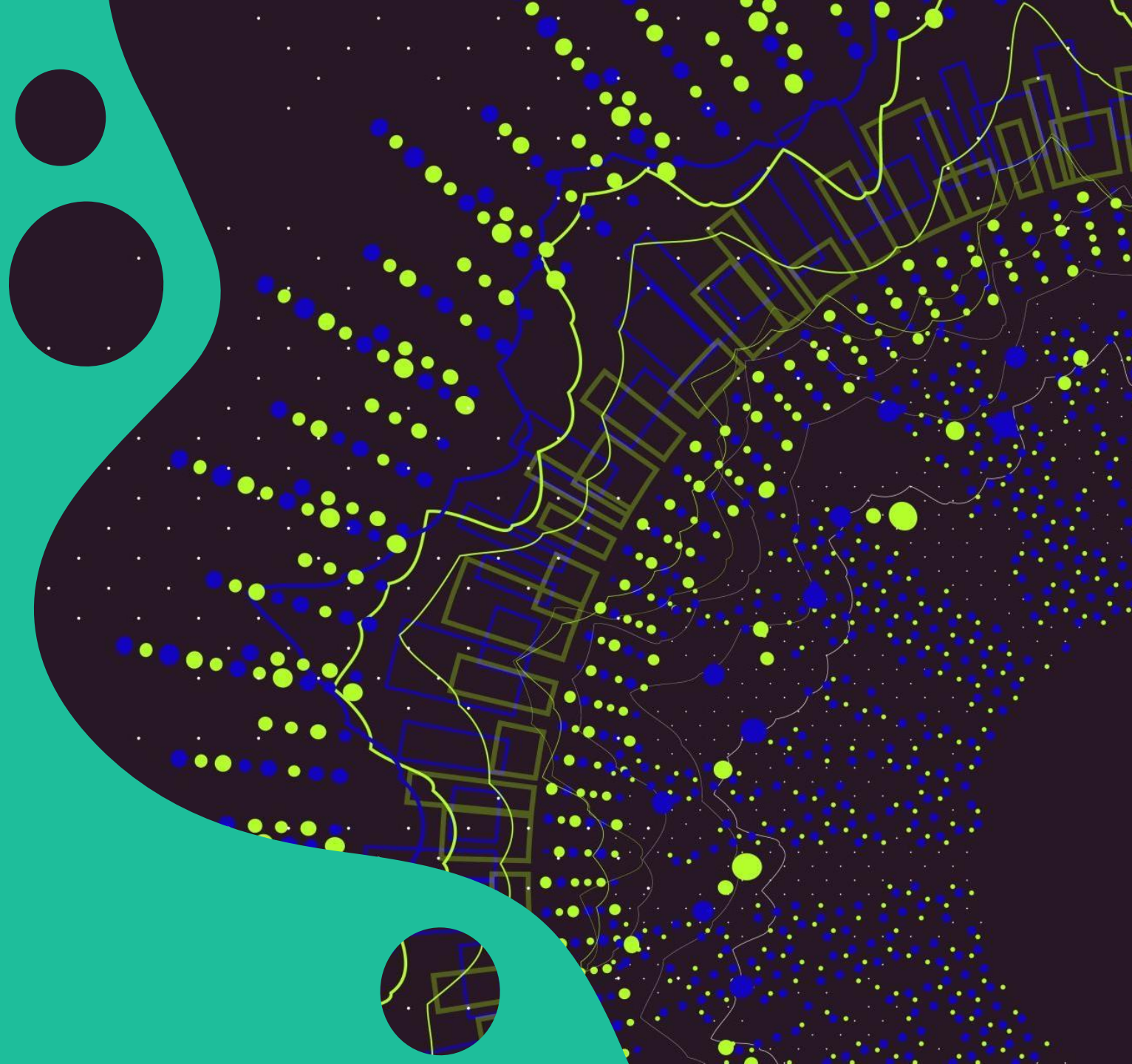
Fourier Transform

Covariance and Correlation

Important Linear Algebra concepts

Chapter 3
Suggest and Predict!

What you will learn after this chapter?

Mathematics behind

- How machines predict next behavior/move?

- How song personalization is done?

- How AI generates new faces?

- How AI generates new text?

What I will buy next?

Intuition – System must know what I bought previously and then it should apply some rules to suggest me next product. It should also find out which items are bought together?

Question: How to calculate next purchase mathematically?

Mathematics tools Used : (example, If a person buys mobile, he/she will mostly buy charger)

Conditional Probability

If a person buys pack of bread, he will most probably buy butter or jam.

Joint Probability – Calculating the probability of co-occurrence of items in transactions.

Implementation!

What song I will like to listen next?

Intuition – Based on my general Genre interests and **my current mood** the next song should be suggested

Question: How to update the belief in system based on my latest interest.

Mathematics tool Used : Example, If a person likes sad song Genre but right now he just played some disco song then what kind of song should be suggested.

How to retain your long term interests but still consider your current mood?

Bayesian Statistics and Bayesian Personalization

As more data comes in, the posterior interests probabilities get revised dynamically. It still holds the older interests.

Implementation!

How AI generates new human faces?

Intuition – It should create nose, eyes, lips at exact **location** with overall face structure and overall look should be different.

Question: What is mathematically meant by face structure and exact location of organs? How to generate different look?

Which Mathematics tool can be used ?

Probability Distribution

It selects the values from range of values (range of probabilities). It does not select exact value but values close to **"accepted range of values"**

There are different types of distributions but the most commonly used is Normal Distribution.

Normal distribution is present in most real world phenomena.

Implementation!
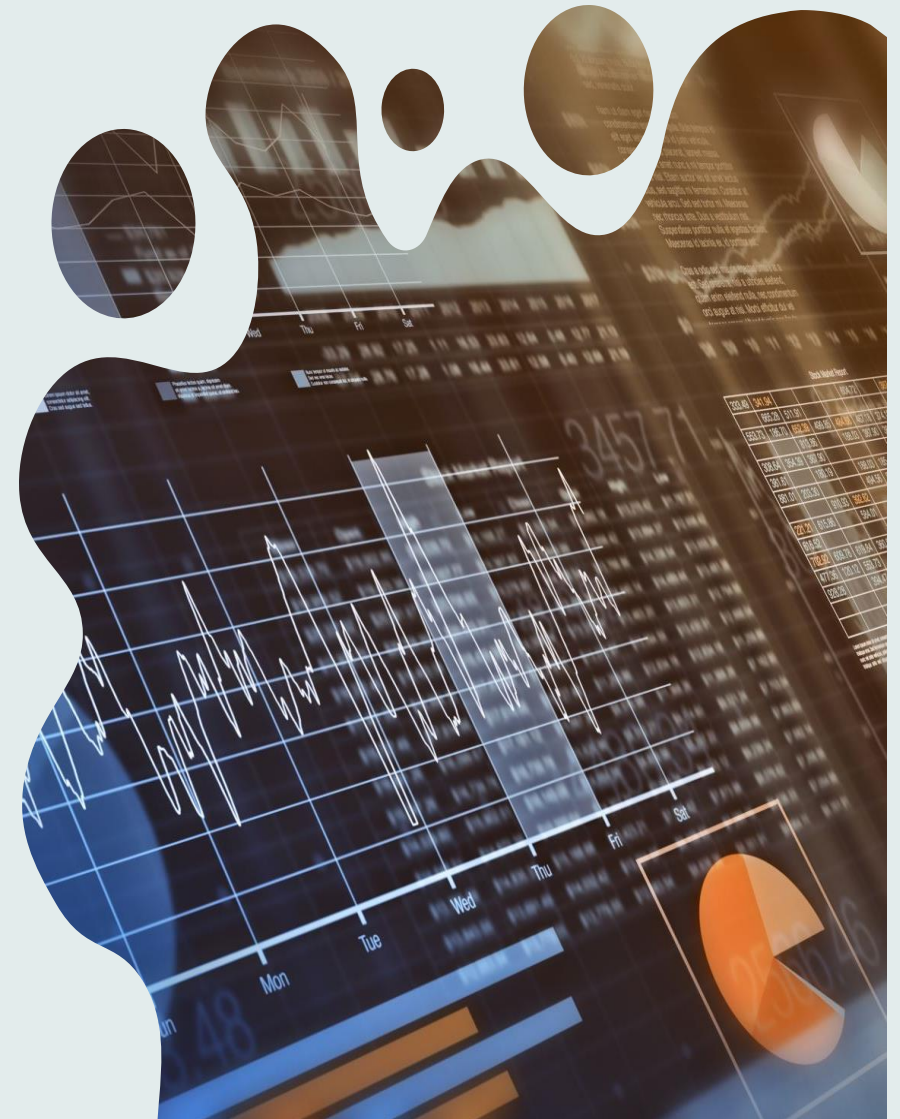
How AI generates new text?

Intuition -To create coherent text, an AI needs to model the probability of sequences of words, just like constructing meaningful sentences. This requires capturing context, grammar, and overall linguistic style statistically.

Question What does it mean mathematically to model "text style" and logical word ordering?

How to generate variable wording which is syntactically correct ?

Mathematics tools used?

Probability Distribution - Categorical Distributions

Language models represent possible next words as probability distributions. Instead of fixed predictions, they assign likelihoods to word candidates based on previous context.

A common one is the Categorical Distribution over the whole vocabulary. By sampling from this, it selects plausible but variable word options at each step. Other distributions model higher-level style and topical aspects.

N Grams

How Weather app predicts weather transitions?

Intuition – The idea is to understand the likelihood of transitions between different weather states based on historical data.

Question: What tool be applied to predict changes in weather with historical data and what mathematical structures are involved?

Markov Chains

A Markov chain is a stochastic model that describes a sequence of events where the probability of transitioning to another state depends solely on the current state.

Implementation

So we learned..

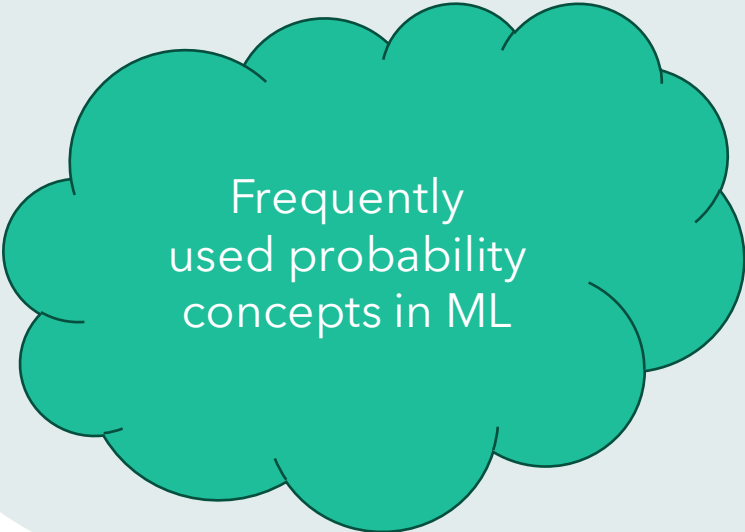Conditional Probability

Joint Probability

Bayesian Statistics

Probability Distributions

Normal or Gaussian Distribution
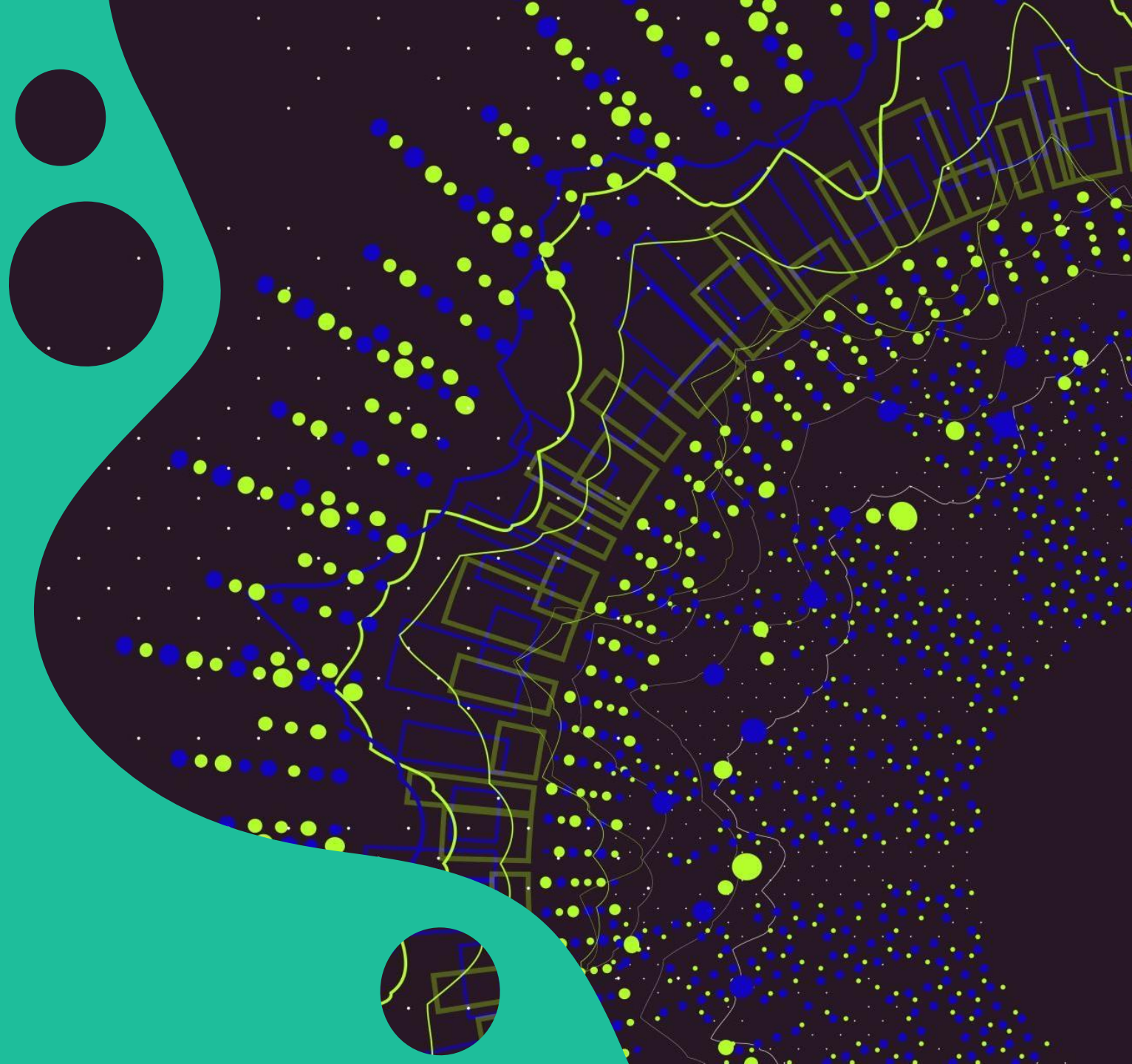
Categorical Distribution

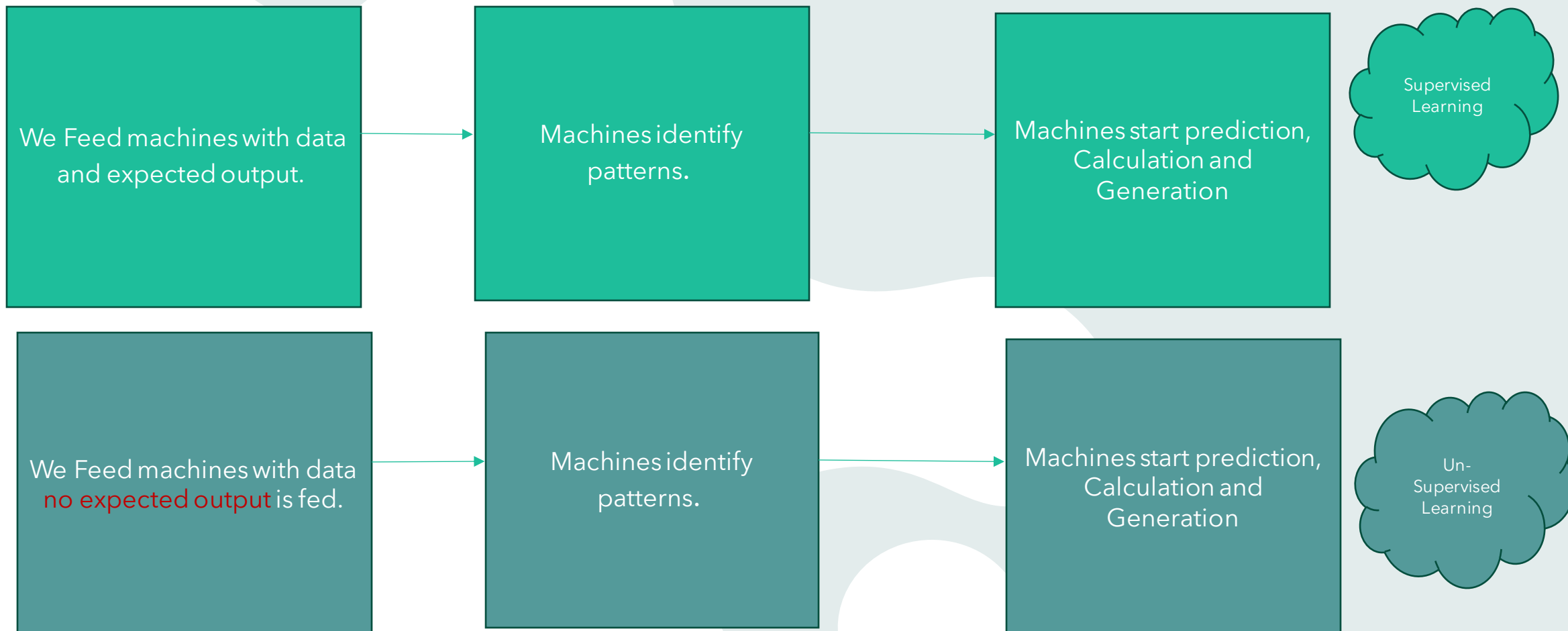Markov Chains

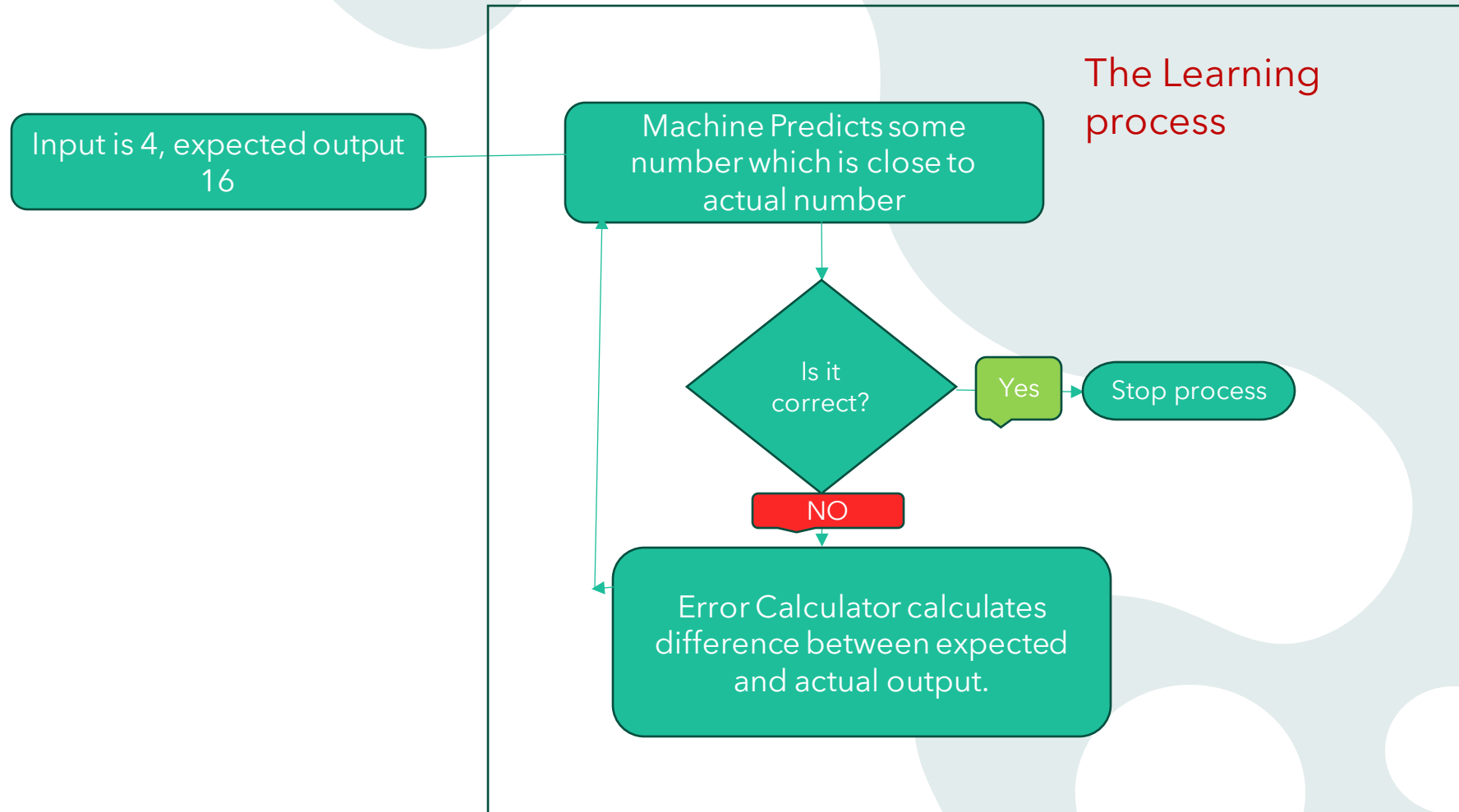Frequently used probability concepts in ML

Chapter 4
The
Learning
Hero!!!!

How machines "learn" from data?

| We Feed machines with data and expected output. | Machines identify patterns. | Machines start prediction, Calculation and Generation | Supervised Learning |

| We Feed machines with data no expected output is fed. | Machines identify patterns. | Machines start prediction, Calculation and Generation | Un-Supervised Learning |

The Learning Process

Input is 4, expected output 16

The Learning process

Machine Predicts some number which is close to actual number

Is it correct?

Yes → Stop process

NO

Error Calculator calculates difference between expected and actual output.

Maths Behind Learning

Intuition -Just like humans gather knowledge through experience, machines learn by looking at many examples in data. But they don't manually program rules; instead they mathematically optimize complex models to capture patterns.
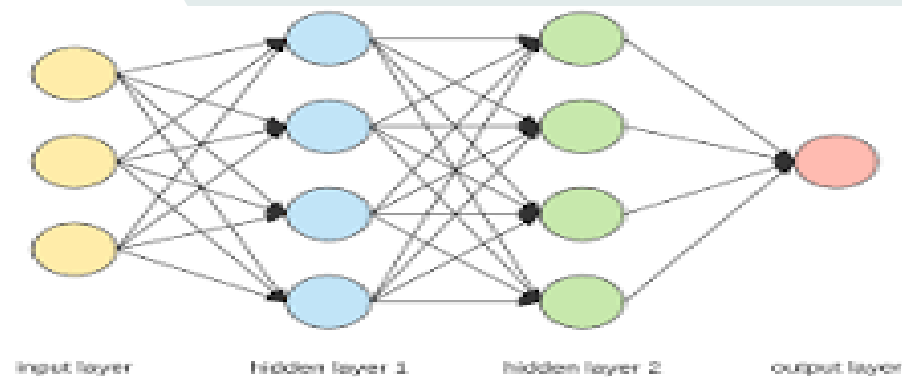
Question But how exactly does exposure to data change or improve the system? What is happening with all those mathematical operations under the hood?

Mathematics tools used?

Loss Functions

Calculus – Partial differential equations

Implementation!

input layer   hidden layer 1   hidden layer 2   output layer

So we learned..

Probability Concepts

Linear Algebra

Statistical concepts

Calculus

That's all is basic for today. For next session we will dive deep into algorithms for ML

Thank you!