DIGITAL TWIN WORKSHOP

CATCH_VR

UNIVERSITY OF ENGINEERING AND TECHNOLOGY, PESHAWAR

15-16 NOV, 2025

Co-funded by the European Union

Meet the Team

Team Lead

Prof. Dr. Tahir Khan

Team Member

Dr. Shahzad Anwar

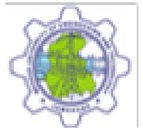
Team Member

Dr. Imran Ahmad

Team Member

Mr. Muhammad Zubair

Co-funded by
the European Union



Welcome Speech

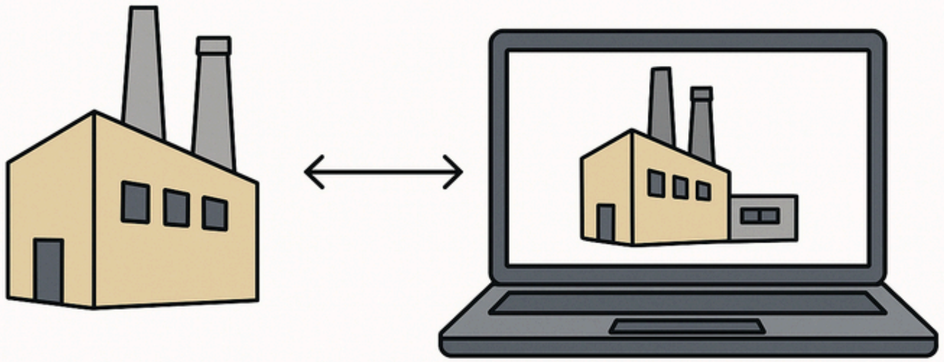
Outline

Co-funded by the European Union

Preliminaries

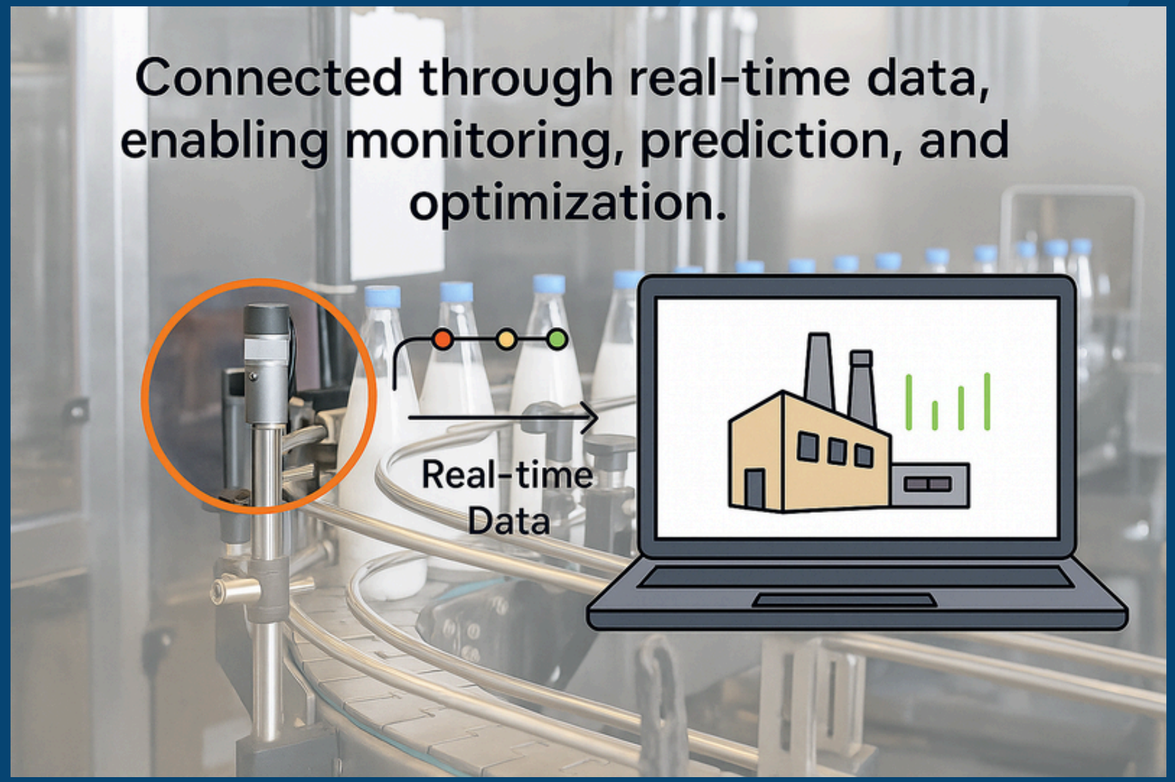
What is digital Twin

A Digital Twin (DT) is a virtual replica of a real system, process, or product.



Physical System

Digital Model



PRELIMINARIES

Core components of Digital twin

- Physical Entity – Real machine, process, or environment.
- Virtual Model – Simulation or computational model.
- Data Connection – Real-time or periodic data exchange.
- Analytics/AI Layer – For prediction and decision support.

Preliminaries

Traditional (Model-Based) Digital Twin

- Built primarily from engineering models, assumptions, and manual parameters.
- Data is limited or static (e.g., fixed process times).
- Accuracy depends on expert knowledge and initial design assumptions.
- Common in early-stage design and what-if analysis

Data-Driven Digital Twin

- Built from real operational data collected via IoT sensors, logs, or databases.
- Uses statistical modelling, machine learning, and simulation to mirror real dynamics.
- Enables adaptive, real-time, and predictive insights.
- Example: Using production line data to predict bottlenecks or machine downtime.

Preliminaries

Data-driven twins are living models that evolve with data — that’s why SIMIO and statistical modelling are essential.

Perlimineries

Why Use SIMIO for Data-Driven Twins

- Object-Oriented and data-driven simulation environment.
- Integrates statistical inputs, real datasets, and external data links.
- Enables visualization, experiment design, and digital twin validation.
- Supports integration with IoT, SQL, Excel, and live dashboards.

Statistical Modeling

Statistical models are mathematical representations of reality, often simplified, that show how variables interact.

Example

14
6 8
2
4 1
2

Example

8

14

6

2

4

1

2

Machining Time (minutes)	Class Width	Frequency
5–7	2	3
7–9	2	8
9–11	2	15
11–13	2	12
13–15	2	8

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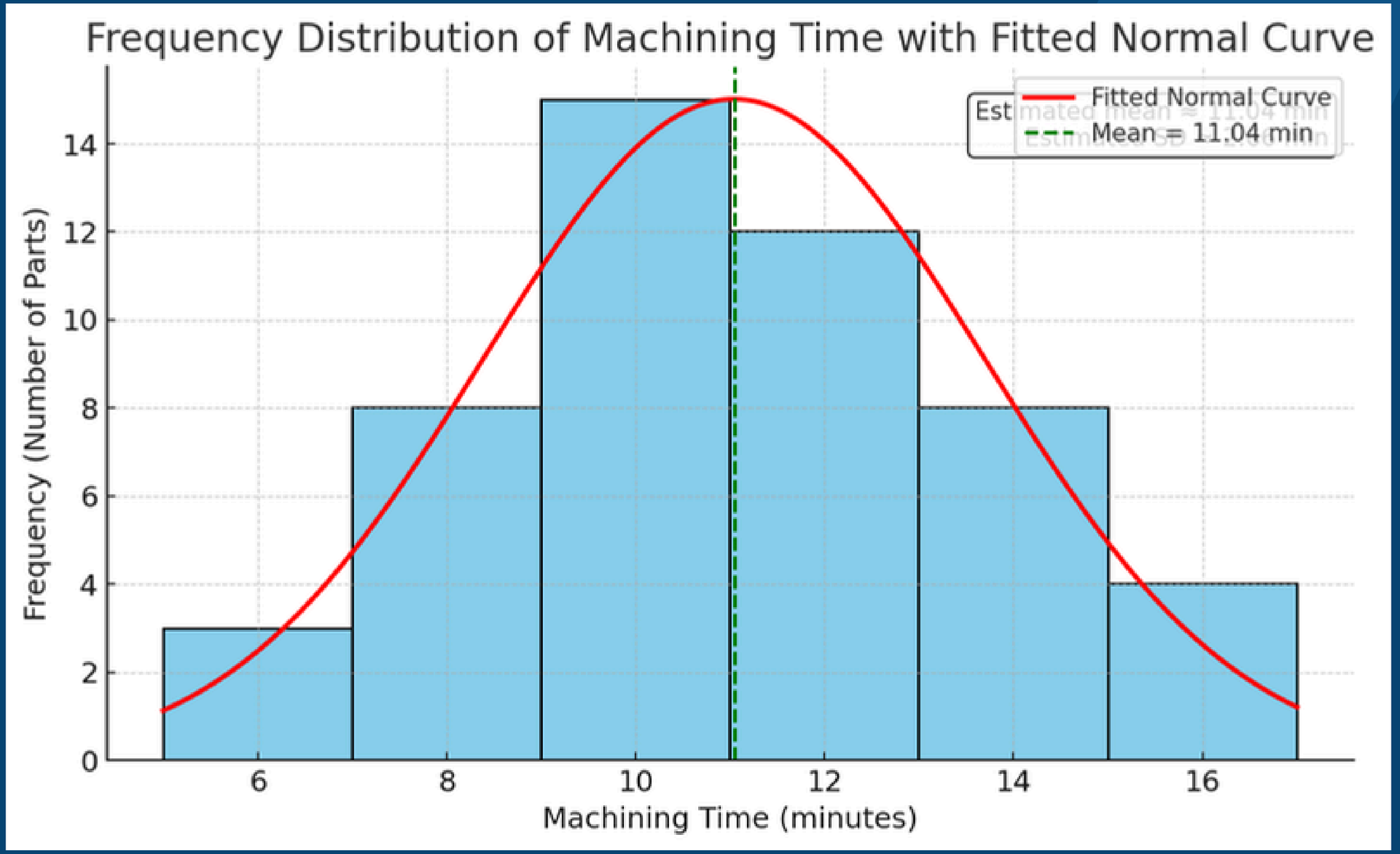


Normal Distribution Formula

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-(x-\mu)^2}{2\sigma^2}}$$

$\mu =$ mean of x

$\sigma =$ standard deviation of x

$\pi \approx 3.14159 \ldots$

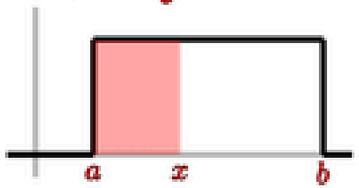
$e \approx 2.71828 \ldots$

Probability Distributions

Ace Tutors

Continuous

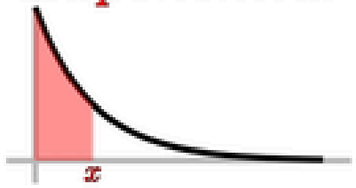
Uniform



$$\mu = \frac{a+b}{2} \qquad \sigma = \sqrt{\frac{(b-a)^2}{12}}$$

$$P(X < x) = \frac{x-a}{b-a}$$

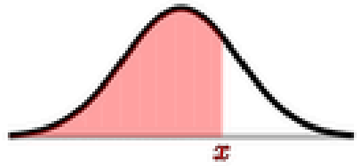
Exponential



$$\mu = \frac{1}{\gamma} \qquad \sigma = \frac{1}{\gamma}$$

$$P(X < x) = 1 - e^{-\gamma x}$$

Normal



$$z = \frac{x-\mu}{\sigma}$$

$P(X < x) \Rightarrow$ Use Z-Chart

Key

γ = rate parameter

z = z-score

p = probability of success

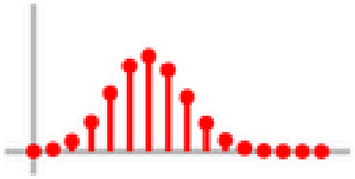
n = # of trials

N = population size

K = # of success states

Discrete

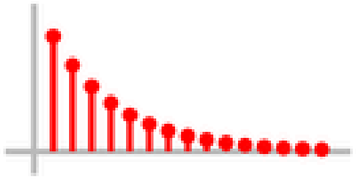
Binomial



$$\mu = n \cdot p \qquad \sigma = \sqrt{n \cdot p \cdot (1-p)}$$

$$P(X = x) = \binom{n}{x} p^x (1-p)^{n-x}$$

Geometric



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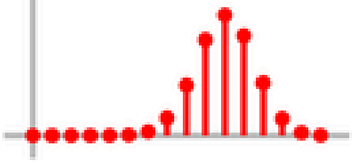
Hypergeometric



$$\mu = n\frac{K}{N} \qquad \sigma = \sqrt{n\frac{K(N-K)(N-n)}{N^2(N-1)}}$$

$$P(X = x) = \frac{\binom{K}{x}\binom{N-K}{n-x}}{\binom{N}{n}}$$

Reference : https://www.onlinemathlearning.com/normal-distribution.html

Probability Distributions

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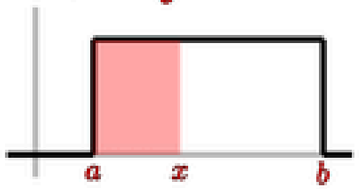

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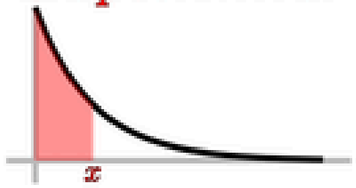

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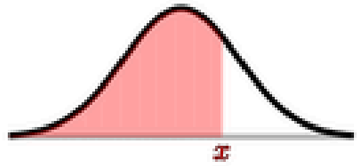

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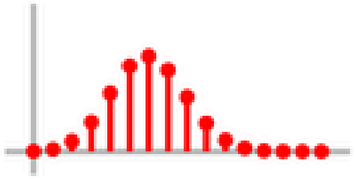

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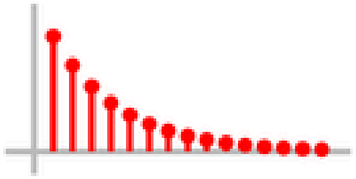

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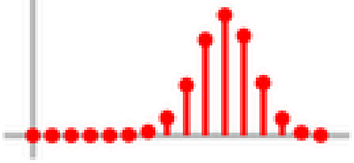

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Statistical Modeling

Why Statistical Modelling Matters

- **Real systems are uncertain — arrivals, failures, processing times vary.**
- **Statistical modelling converts variability into quantitative form.**
- **Enables realistic simulation behavior in SIMIO**

Statistical Modeling

Example:

- **Number of customers arriving**
- **Downtime between equipment failure**
- **Service time of machines**

Statistical Modeling

Data Input

Trace driven

Emperical distribution

Theoratical Distributions

Arena® Simulation Software
Rockwell Automation

Simio

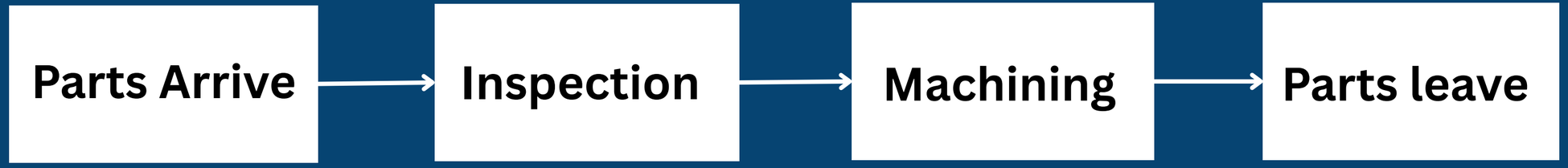
anylogic®

SIMIO Licence and Interface

Example Manufacturing Unit

Parts Arrive → Inspection → Machining → Parts leave

Example



I.T 6mins 5 mins 8.8 mins

Performance Metrics

- Server Utilization
- Avg Time in system
- Avg Number in ssystem

THANK YOU