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المحاضرة الخامسة

Data Visualization in Medical Simulation

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المادة: **Simulation and Modeling**
المرحلة: **الرابعة**
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Definition of Data Visualization

Data Visualization is the process of representing data and information through graphs, charts, and visual elements to make patterns and relationships easier to understand.

It transforms raw numbers into visual stories that the human brain can quickly interpret.

Example (Medical Context):

Visualizing blood pressure trends over time.

Comparing heart rate responses before and after treatment.

Observing glucose level distribution among patients.

Visualization helps see what's happening inside the data, instead of reading large tables.

Purpose and Objectives of Data Visualization

Goal	Explanation	Medical Example
1. Understanding	Simplifies complex medical data	ECG waveform visualization
2. Pattern Detection	Identifies trends or abnormal changes	Blood pressure over time
3. Communication	Makes medical reports easier to explain	Charts in patient dashboards
4. Decision Support	Supports diagnosis and treatment planning	Comparing patient responses
5. Validation	Helps verify model or simulation outputs	Simulation result charts



Why Visualization Matters in Medicine

Main Idea:

Medical data is often complex, multidimensional, and time-based visualization helps transform this data into clear, actionable insights.

Key Points:

Doctors and researchers deal with large datasets (e.g., thousands of lab results).

Visualization helps them see what's important not just read numbers.

It connects simulation results with real medical interpretation.

Example:

A line chart showing patient heart rate recovery over 7 days → makes it easier to detect abnormal recovery trends.

Benefits of Data Visualization in Medical Simulation

Benefit	Explanation	Medical Example
Simplifies Complexity	Makes big medical data easier to read	Brain MRI heatmaps
Reveals Hidden Patterns	Detects relations between symptoms	Diabetes vs Blood Pressure
Improves Communication	Helps doctors explain results to patients	Patient dashboards
Supports Simulation	Shows how parameters change in models	Drug dose simulation plots
Enhances Accuracy	Detects data errors and outliers visually	ECG noise detection



Visualization in Real Medical Practice

How Visualization Helps in Real Healthcare:

1. Diagnostic Support:

Graphical ECG and CT-scan simulations make anomalies visible.

2. Surgery Planning:

3D organ visualization helps surgeons plan before operating.

3. Disease Monitoring:

Trend plots track chronic diseases (e.g., diabetes, hypertension).

4. Simulation Validation:

Researchers visualize model output to check its medical realism.

Overview of Common Visualization Types

1. Line Chart

Used to display changes in data over time, where data points are connected by lines showing trends or patterns.

Example: Sales growth throughout the year.

2. Bar Chart

Used to compare values across different categories using separate bars. The length of each bar represents the category's value.

Example: Number of students in each department.

3. Histogram

Used to display the distribution of numerical data across intervals (bins). Bars are adjacent to show frequency in each range.



Example: Distribution of ages in a population.

4. Scatter Plot

Used to show the relationship between two numerical variables, where each point represents a pair of (x, y) values.

Example: Relationship between height and weight.

5. Box Plot

Displays a statistical summary of a dataset, including median, quartiles, and outliers.

Example: Comparing exam scores among different student groups.

Chart Type	Purpose	Medical Example
Line Chart	Shows trends over time	Heart rate or temperature
Bar Chart	Compares categories	Number of patients by age group
Histogram	Shows data distribution	Glucose level frequency
Scatter Plot	Shows relationships	BMI vs Blood Pressure
Box Plot	Detects outliers	Cholesterol levels variation

Line Chart (Trend Over Time)

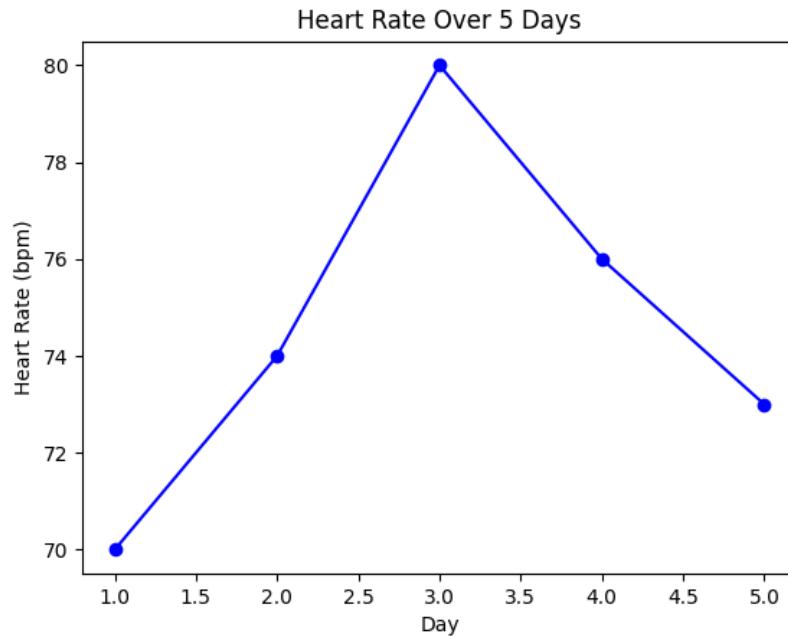
Purpose:

To visualize changes in a variable over time ideal for monitoring patient progress.

Medical Example:

Tracking heart rate or body temperature during recovery.

Monitoring drug concentration in the bloodstream.



Bar Chart (Comparing Categories)

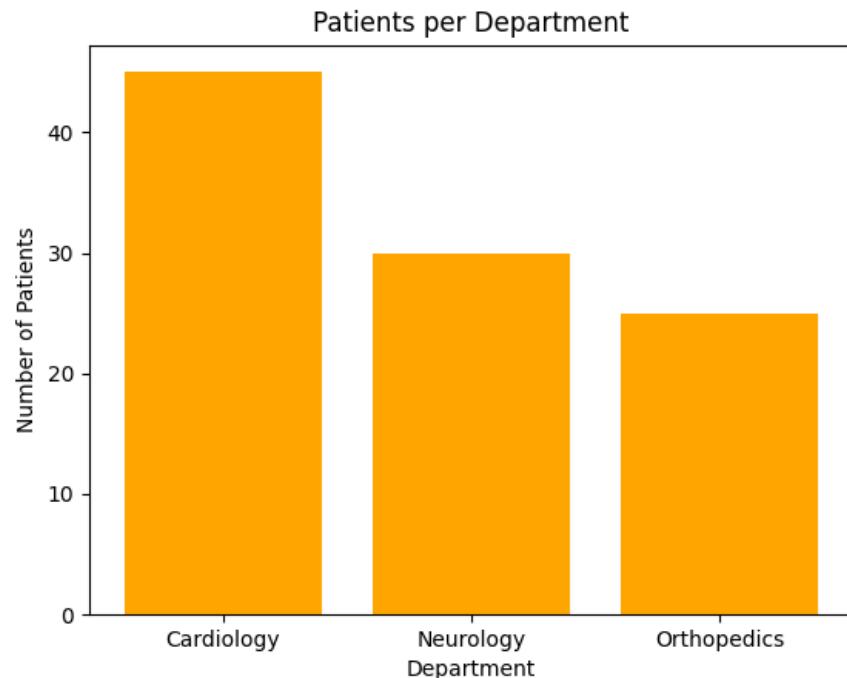
Purpose:

Displays differences between categories helps compare patient groups or lab results.

Medical Example:

Comparing average glucose levels among different age groups.

Showing number of cases per department (cardiology, neurology, etc.).



Histogram (Data Distribution)

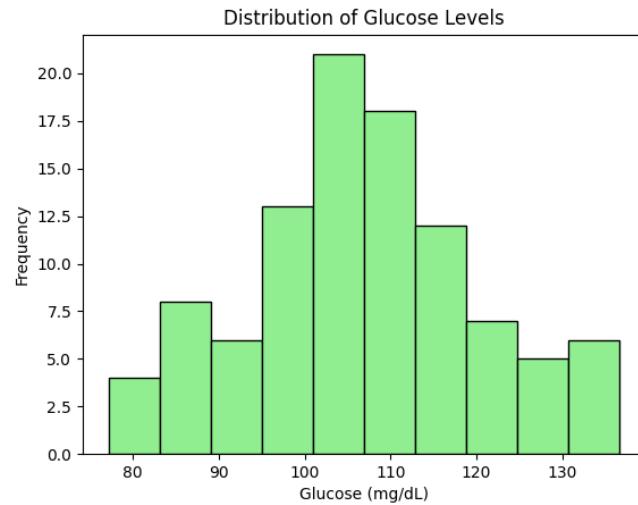
Purpose:

Shows the frequency of medical measurements and detects skewness or abnormal values.

Medical Example:

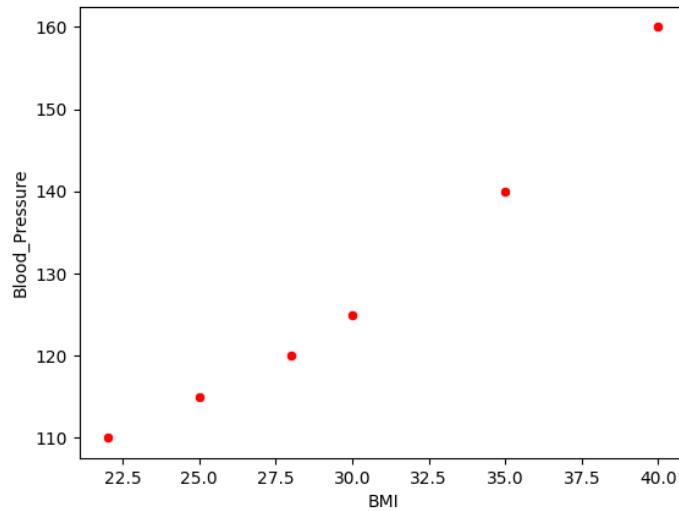
Distribution of blood glucose readings for diabetic patients.

Frequency of body temperature in fever cases.



Scatter Plot

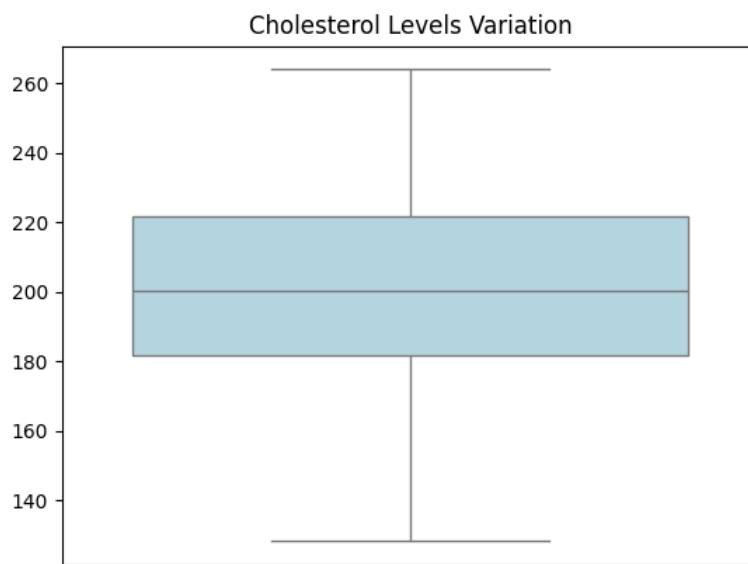
- Purpose: Shows relationships between two variables.
- Example: Relation between BMI and Blood Pressure.





Box Plot

- Purpose: Detects outliers and visualizes data spread.
- Example: Variation in cholesterol levels among patients.



Interpreting Data” Mean?

Data Interpretation means understanding what a visualization tells us about the medical situation.

It's the process of converting a graph into insightful conclusions that support diagnosis or research.

Key Steps to Interpret a Graph:

Read the title and axes – Know what variable is being measured.

Look at the trend or shape – Is it increasing, decreasing, stable, or irregular?



Identify anomalies – Outliers, spikes, or missing data points.

Connect with context – What does that pattern mean medically?

Example:

If a line chart of heart rate suddenly spikes, it may indicate stress or arrhythmia.

How to Read Medical Visualizations

Chart Type	What to Look For	Medical Meaning
Line Chart	Trend over time	Recovery speed
Histogram	Shape of distribution	Normal vs abnormal lab data
Scatter Plot	Direction of points	Positive/negative correlation
Box Plot	Spread and outliers	Data quality and risk detection

From Visualization to Decision

Visualization is not the end it's the bridge to clinical understanding.

In Practice:

Doctors use graphs to validate treatment response.

Researchers analyze trends to refine medical simulations.

AI systems visualize model outputs to ensure realism.

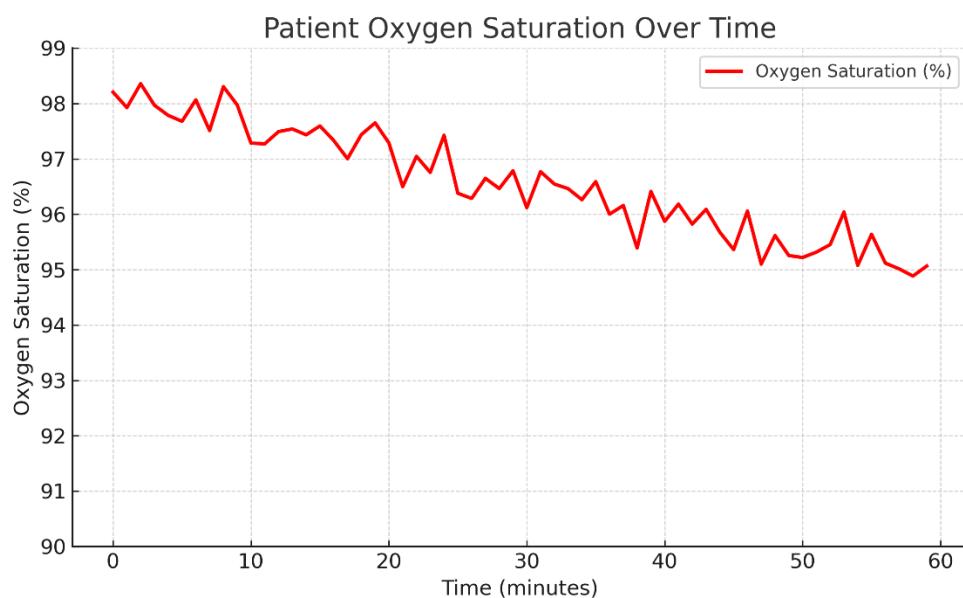
Case Example:

A simulation showing a patient's oxygen saturation over time if the curve gradually declines, it may signal respiratory distress.



Real Example

The image shows a simulation of the patient's oxygen saturation changing over time. A gradual decline in the curve can be observed, which may indicate the onset of respiratory distress, a condition that requires the clinician to intervene and adjust the oxygen level.



Case Study: Monitoring Blood Glucose Simulation

Scenario:

A medical simulation was conducted to monitor blood glucose levels for three patients over a 12-hour period after receiving different doses of insulin.

Objective:

To visualize how the insulin dose affects the glucose decay rate and detect abnormal responses



Visualization Interpretation:

Patient A (Red): Glucose drops rapidly strong insulin response.

Patient B (Green): Gradual and healthy glucose reduction.

Patient C (Blue): Slow decay possible insulin resistance.

Medical Insight:

Doctors can use this simulation to adjust insulin dosage.

Helps identify patients at risk of poor glucose control.

Combines mathematical modeling + visualization to make real clinical predictions.

