Lab Experiment: 3

Aim

Designing a Heuristic Driven Hypothesis (HDH) Matrix for Smart Home Occupancy Detection using IoT Sensor Data

Tools & Technologies

- Python 3.x
- Pandas, NumPy
- Matplotlib / Seaborn
- UCI Occupancy Detection Dataset

Dataset Description

The UCI Occupancy Detection dataset: https://archive.ics.uci.edu/dataset/357/occupancy+detection

Features (Sensors):

- Temperature (°C)
- Humidity (%)
- Light (Lux)
- CO2 (ppm)
- Humidity Ratio

Target:

- Occupancy (0 = Empty, 1 = Occupied)

Theory

Problem Universe in IoT

The Problem Universe represents the complete system context consisting of:

- Connected assets (room, sensors, appliances)
- Connected operations (monitoring, control, automation)
- Environmental variables
- Business objectives
- Constraints

Heuristic Driven Hypothesis (HDH)

HDH is a structured matrix that connects:

- Observed symptoms
- Possible causes
- Sensor indicators
- Business impact
- Testable hypotheses

It bridges domain knowledge with data-driven modelling.

Step 1: Define the IoT Problem Universe

Connected Assets

Asset	Description
Room	Smart home environment
Sensors	Temperature, Humidity, Light, CO2
Appliances	Lights, Fan
Gateway	Data collection unit

Connected Operations

- Sensor monitoring
- Occupancy detection
- Appliance automation
- Energy optimization

Business Objective

Reduce unnecessary power consumption while maintaining user comfort.

Step 2: Identify Latent Problems

Problem ID	Description
P1	Lights ON when room is empty
P2	Fan running unnecessarily
P3	False occupancy detection
P4	High CO2 when occupied

Step 3: Sensor–Problem Mapping

Sensor	Related Problem
Temperature	P2
Light	P1
CO2	P3, P4
Humidity	P3

Step 4: Design HDH Matrix

Example 1

Observation	Sensor Feature	Heuristic Rule	Hypothesis
High light but occupancy=0	Light	If light>300 & occupancy=0	Artificial lighting on unnecessarily

Observation	Sensor Feature	Heuristic Rule	Hypothesis
High temperature	Temperature	If temp>28 & occupancy=1	Fan required
High CO2	CO2	If CO2>1000	Room is occupied
Low light + motion	Light	If light<200	Turn ON lights

Example 2

Observation	Sensor	Heuristic Rule	Hypothesis	Business Impact
High CO_2 level	CO_2	$CO_2 > 900$	Room is occupied	Turn ON appliances
Low light intensity	Light	Light < 200	Lights needed	Switch ON lights
High temperature	Temperature	Temp > 28	Cooling required	Turn ON fan
Low CO_2 level	CO_2	$CO_2 < 600$	Room empty	Turn OFF appliances

Step 5: Load and Analyze Dataset

Step 6: Validate Heuristics using Data

Step 7: Automation Logic Based on HDH

Step 8: Test Automation Using Dataset Samples

Observations

- CO2 strongly correlates with occupancy
- Light values help detect artificial lighting usage
- Temperature impacts cooling requirements
- Heuristics align well with real data patterns

Result

Successfully designed and validated an HDH matrix for smart home occupancy detection using real IoT sensor data.

Learning Outcomes

Students will be able to:

- Model real-world IoT systems using Problem Universe approach
- Design HDH matrices
- Map sensors to business problems
- Validate heuristics using real datasets