SmartPilot: A Multiagent CoPilot for Adaptive and Intelligent Manufacturing

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CONTENTS

BACKGROUND AND MOTIVATION

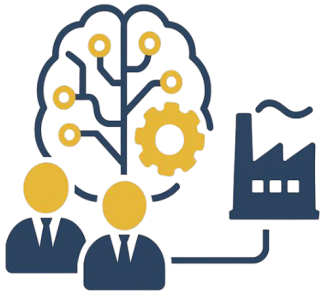
⚙️ Motivation

❌ *Siloed AI systems:* Current solutions treat tasks like anomaly detection and causal discovery in isolation

⚠️ *Lack of reasoning:* Minimal support for interdependency analysis or root cause explanation

⏱️ *Real-time need:* Manufacturing requires compact, fast, and interpretable systems

📉 *Low trust in black-box models:* Operators require explainable, reliable outputs



SmartPilot: An agent-based copilot for intelligent manufacturing supported by a custom, compact, neurosymbolic AI model

Demo Video

GitHub Repository

MAIN CONTRIBUTIONS OF THE PAPER

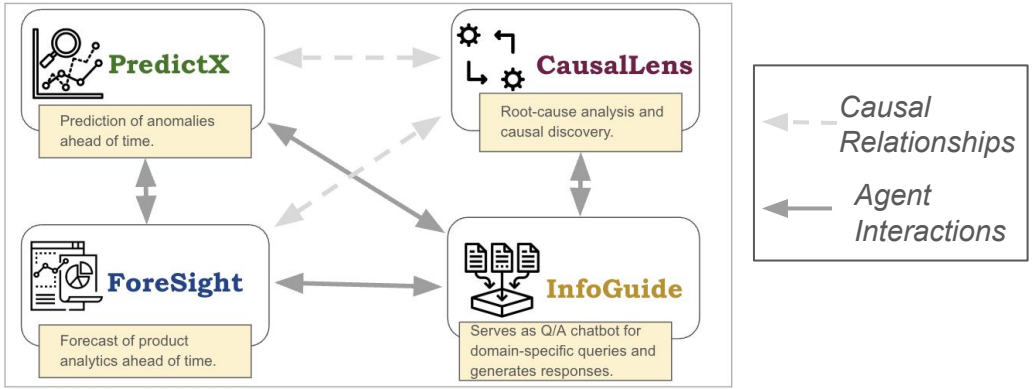
- Development of SmartPilot
- Innovative algorithms
- Multiagent system design
- Neurosymbolic methods
- Enhanced explainability
- Comprehensive evaluation

RELATED WORK

- **Traditional ML**: Narrow task focus
- **Knowledge Graphs**: Low adaptability
- **LLM-based assistants**: Lack structured memory & domain integration
- **SmartPilot**: Combines strengths of all above using agentic and neurosymbolic design

CORE SYSTEM FRAMEWORK

A. Multiagent Architecture:



B. Multimodal Data Integration (Time series, Images and Text)

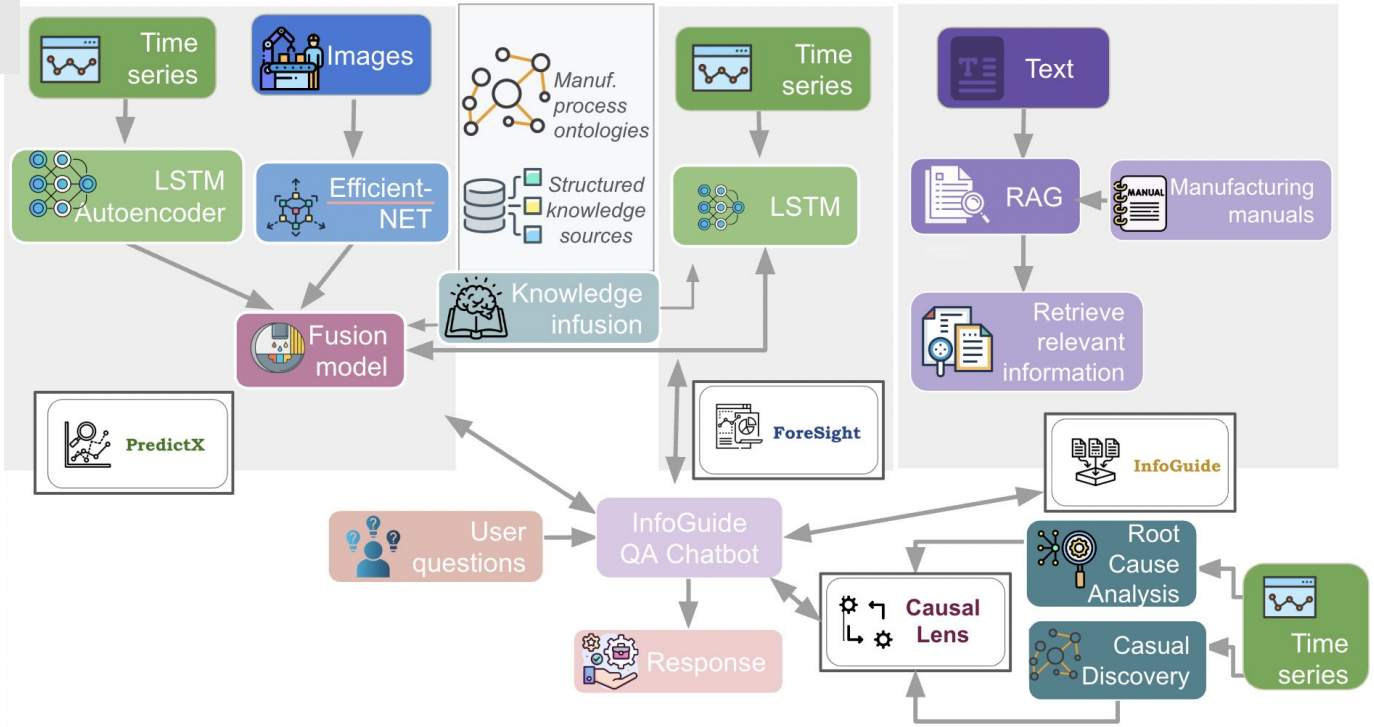
C. Custom, Compact, and Neurosymbolic AI Model

Compact, Custom
- Task-specific Agents
- Domain Knowledge Infusion
- Real-Time + Lightweight components

End Users of SmartPilot:
- *Manufacturing specialists*
- *Shop floor operators*
- *Practitioners working in industrial AI*

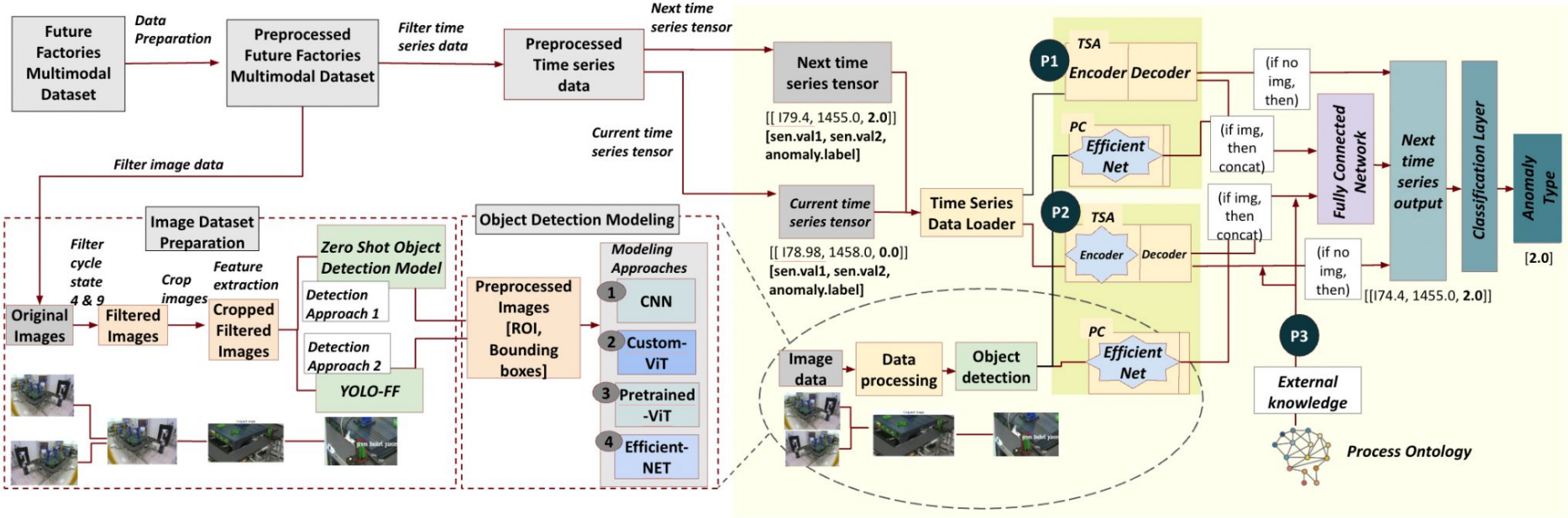
Neurosymbolic
- Neural + Symbolic Fusion
- Causal & Commonsense Reasoning
- Transparent + Context-Aware

Agent-based architecture of SmartPilot and their interac

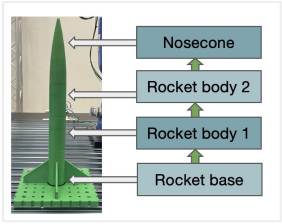


Composite AI system: A framework that includes the technical components such as the inputs to each agent and agent interactions

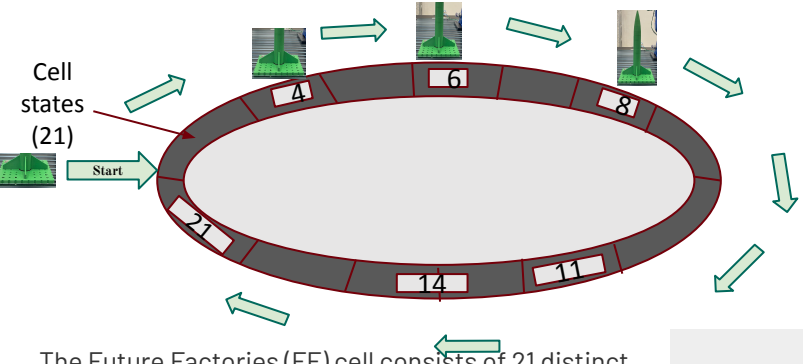
Architecture of PredictX Agent



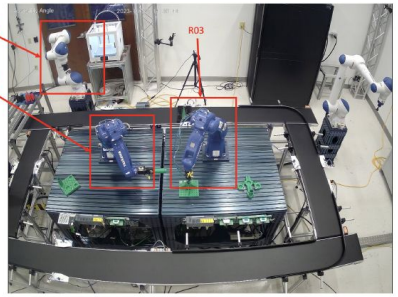
Use Case 1: Rocket Assembly Use Case

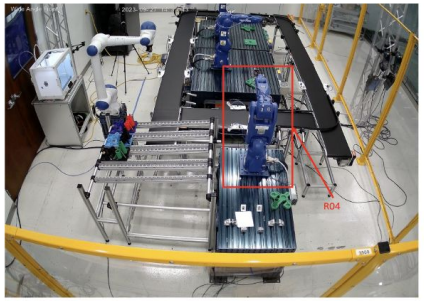


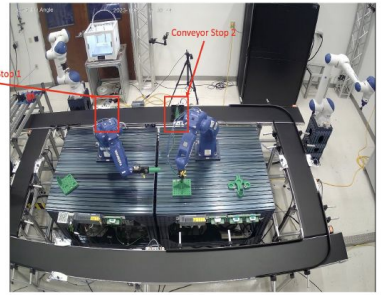
Rocket assembled by the Future Factories Lab. Any missing part is considered an anomaly: absence of Rocket body 1 - "NoBody1,"
absence of both Rocket body 1 and body 2 - "NoBody2, NoBody1."



The Future Factories (FF) cell consists of 21 distinct states:
- State 4: Body Part 1 is assembled.
- State 6: Body Part 2 is assembled.
- State 8: The Nose Cone is assembled.
- States 11-14: The rocket is being disassembled.
- States 15-21: Rocket parts are returned to their original trays.



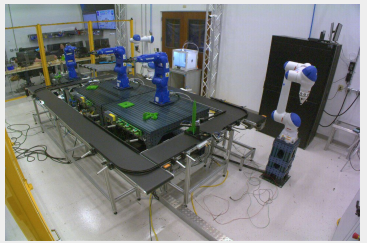




Future Factories Setup. R01-Robot, 1, R02-Robot 2, R03-Robot 3, R04-Robot 4

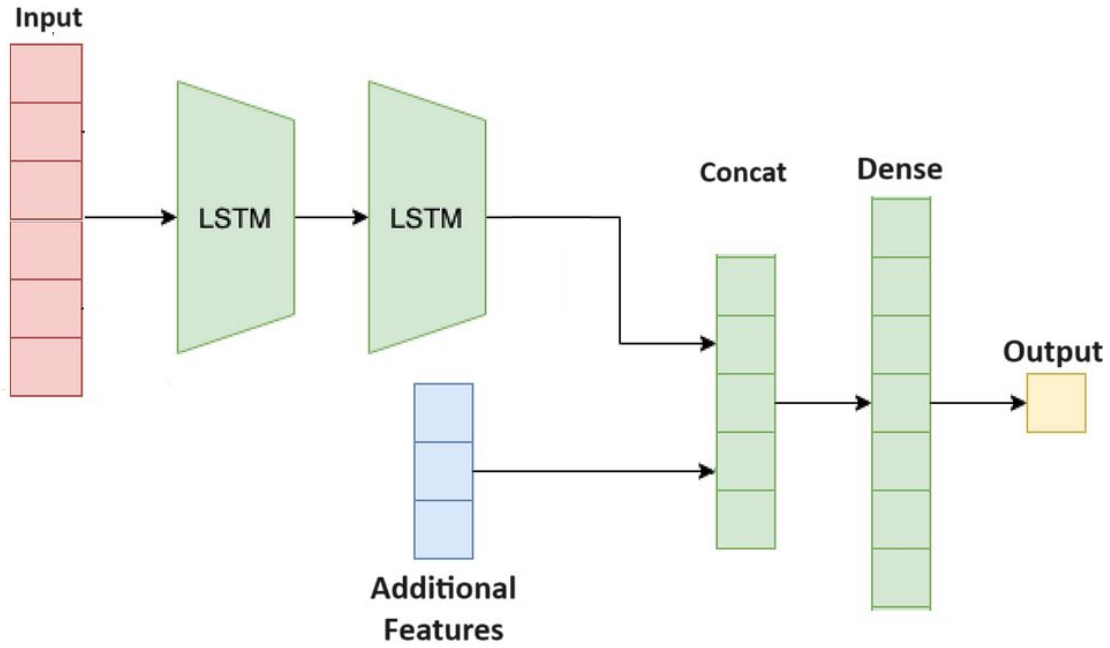
Multimodal Data (Time series + Images)


```
"records": [
    {
        "time": "50:52.1",
        "Q_VFD1_Temperature": 73.13000488,
        "Q_VFD2_Temperature": 72.13002014,
        "Q_VFD3_Temperature": 73.13002014,
        "Q_VFD4_Temperature": 73.36352539,
        "M_Conv1_Speed_mmps": 111,
        "M_Conv2_Speed_mmps": 83,
        "M_Conv3_Speed_mmps": 111,
        "M_Conv4_Speed_mmps": 111,
        "I_R01_Gripper_Pot": 5269,
        "I_R01_Gripper_Load": 462,
        "I_R02_Gripper_Pot": 11688,
        "I_R02_Gripper_Load": 1297,
        "I_R03_Gripper_Pot": 2413,
        "I_R03_Gripper_Load": 1384,
        "I_R04_Gripper_Pot": 13243,
        "I_R04_Gripper_Load": 681,
        "I_SafetyDoor1_Status": true,
        "I_SafetyDoor2_Status": true,
        "Q_Cell_CycleCount": 1,
        "I_MHS_GreenRocketTray": true,
        "Cam1": "Dataset/BATCH1000/000000_0.png",
        "Cam2": "Dataset/BATCH1000/000000_1.png",
        "Description": "NoNose",
        "CycleState": 2,
        "Cycle_Count_New": 1,
        "actual_state": "Normal"
    }
]
```

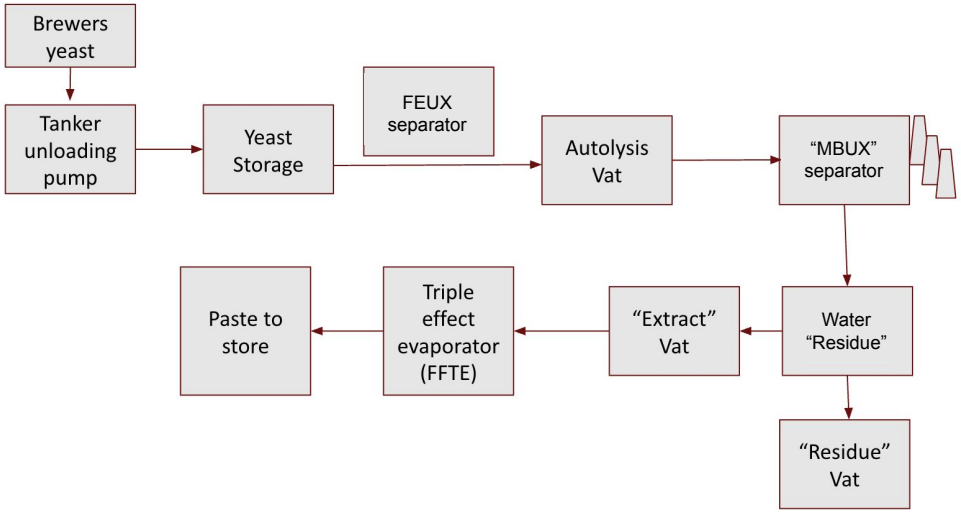



Sample images produced for the corresponding sample time series (left)

Architecture of ForeSight Agent



Use Case 2: Vegemite Production Use Case

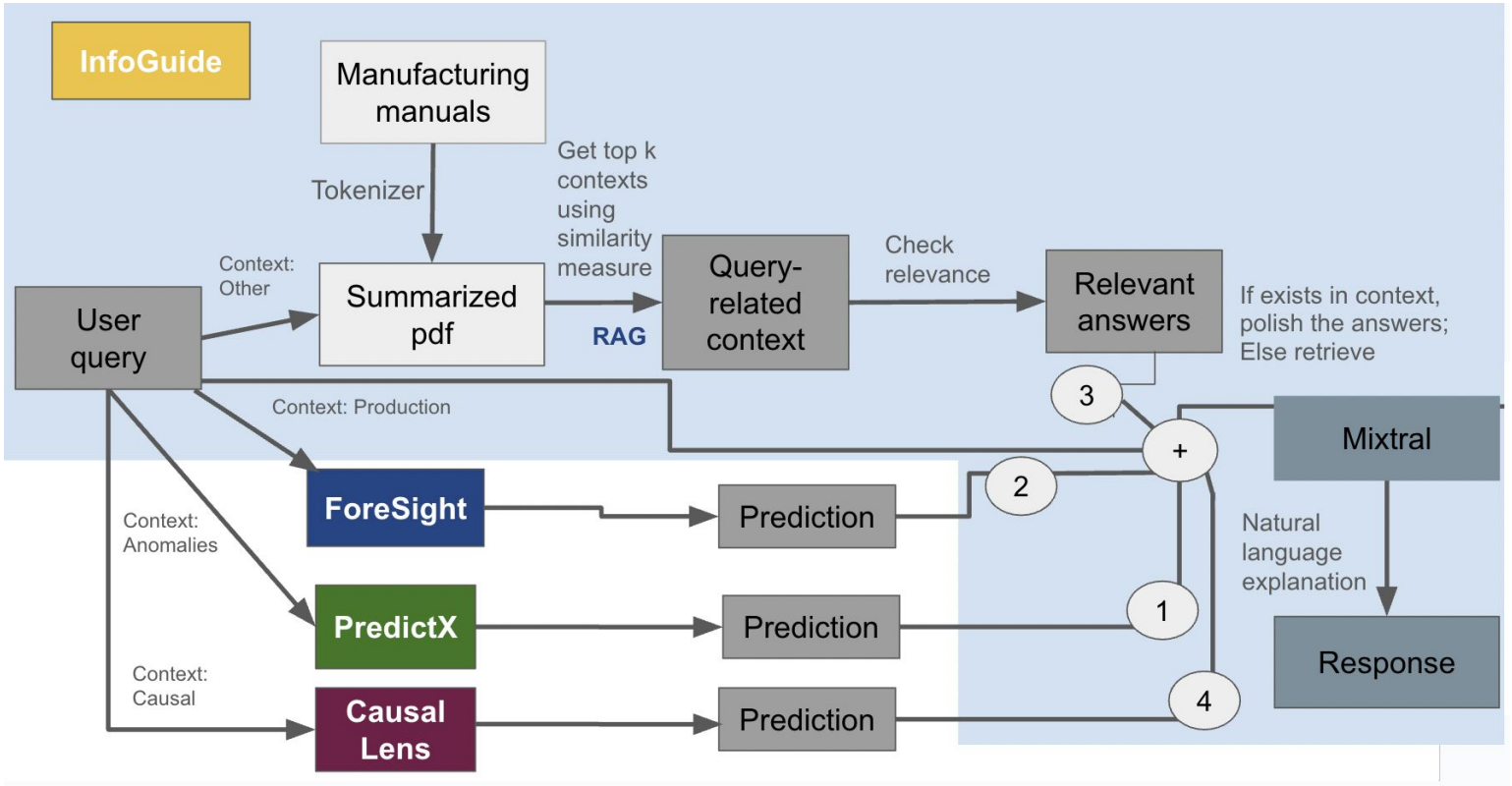


Vegemite yeast evaporation process

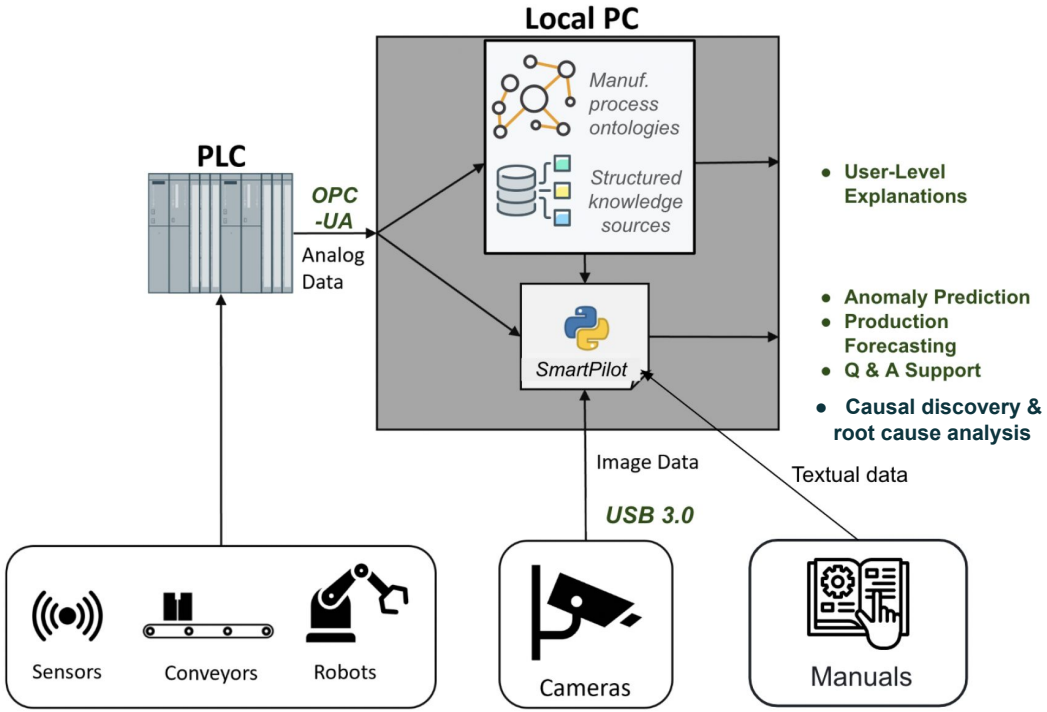

```
{"Status": "Incomplete",
  "Part": "Yeast - FMX",
  "Process": "Veg - AV16",
  "Employee": "Laurie Jenkins",
  "Date": "12/10/20",
  "Time": "2:19:39 PM",
  "AV Wash": "Yes",
  "VYA - Batch": "24",
  "VFX - Yeast Vat": "1",
  "Code": "Silo 1",
  "VFX - Feed TS": "",
  "VFX - Feed SS": "",
  "VFX - Feed IS": "",
  "VFX - Feed Setting": "",
  "VFX - Beer Recycle Setting": "",
  "VFX - Water Setting": "",
  "VFX - Cream TS": "21.41",
  "VFX - Cream SS": "0.91",
  "VFX - Cream IS": "20.5",
  "VYA - Papain Batch": "200402",
  "VYA - Papain added": "4",
  "VYA - Clerol batch": "200722",
  "VYA - Vacuum Salt Added": "123",
  "VYA - Bag Salt Batch": "0",
  "VYA - Bag Salt Added": "0",
  "VYA - 1st pH": "",
  "VYA - Post heat duration": "7",
  "VYA - Final Volume": "",
  "VMBX - Auto TS": "",
  "VMBX - Auto SS": "",
.....
}
```


Time series data

Architecture of InfoGuide Agent



DEPLOYMENT SETUP OF SMARTPILOT



DEMONSTRATION OF SMARTPILOT

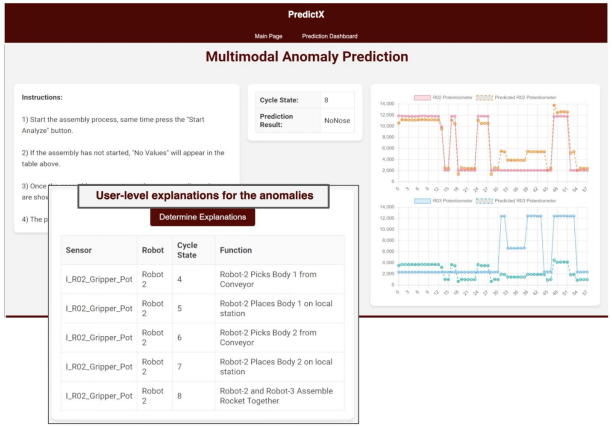


Fig: Real-time anomaly prediction and user-level explanations given by ***PredictX***

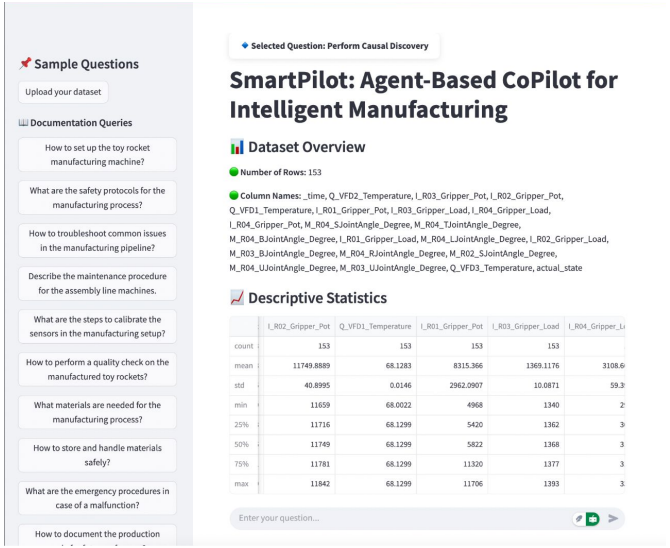


Fig: ***InfoGuide*** agent, upload dataset feature and sample questions in the left panel

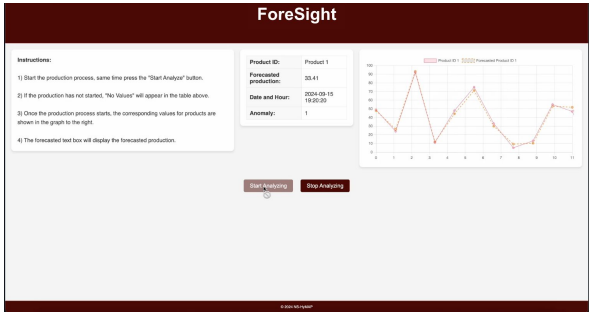


Fig: Production forecasting capability of ***ForeSight*** agent

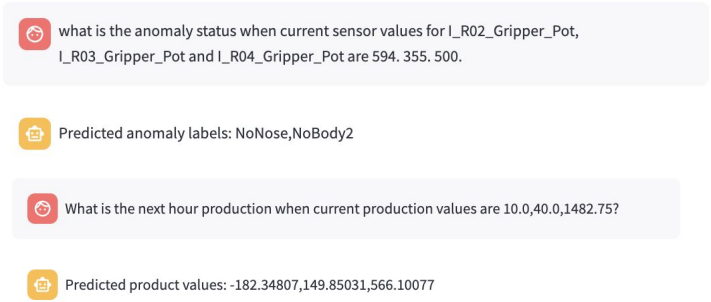


Fig: ***InfoGuide*** agent providing real-time responses to user queries

RESULTS AND EVALUATION

- Accuracy: 92%+ in anomaly prediction
- Latency: Real-time (<1s) agent response
- Human feedback: >80% agreement with InfoGuide outputs
- Explainability: Rated 4.5/5 by domain experts

CONCLUSION AND FUTURE WORK

- SmartPilot = foundational layer for vertical AI in manufacturing
- Future work: add active learning, edge-agent deployment, and human-in-the-loop workflows
- Goal: A fully adaptive CoPilot that evolves with the factory

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For more information, visit:

Demo Video

SmartPilot GitHub Repository

AIISC Smart Manufacturing Wiki Page

THANK YOU