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Harness Upstream Geophysical and Petrophysical Data with AI Workflows

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Module 11

Digital Twins: Upstream E&P

LEARNING OBJECTIVES

- ➢ GOAL01: Digital Twins Introduction
- ➢ GOAL02: Digital Twins in the O&G industry
- ➢ GOAL03: Case studies implementing Digital Twins in upstream
- ➢ GOAL04: Reinforcement Learning: A ML Technique for Digital Twins

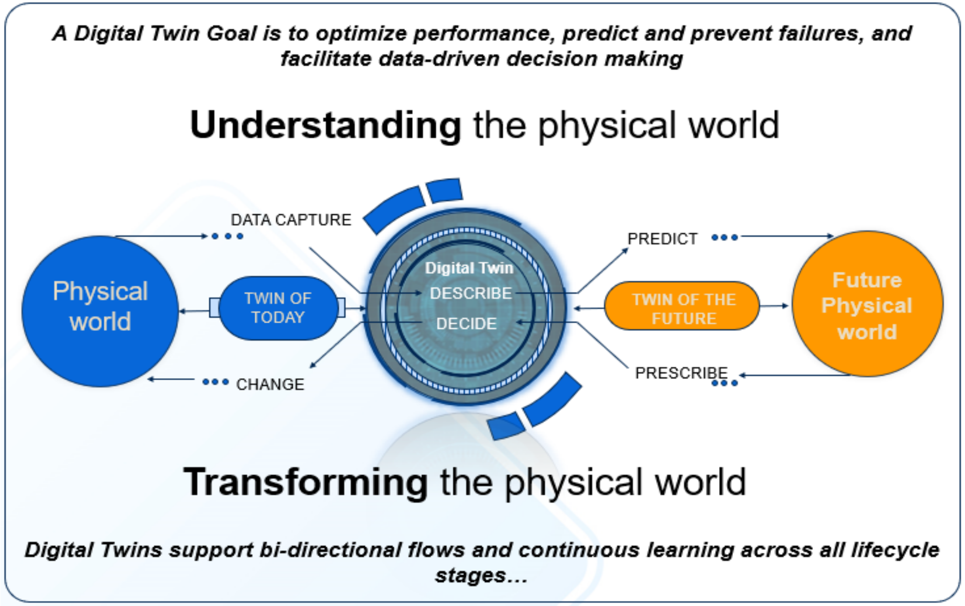
Digital Twins

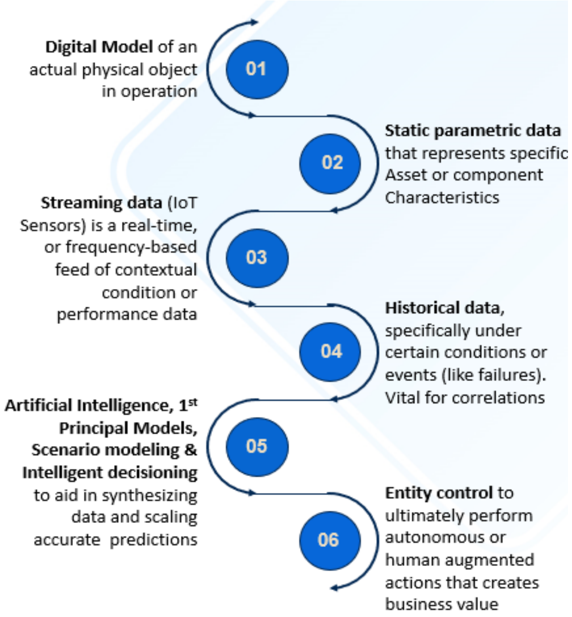
Digital Twins: Targeted Outcomes

1. Improved performance
2. Enhanced predictability (reduced downtime)
3. Increased innovation through virtual testing
4. Improved collaboration and decision-making
5. Reduced costs (Maintenance, Labor, Raw Materials)

Digital Twins

Digital Twins





Digital Twins

Digital Twins

Exploration and Drilling

- **Reservoir Simulation**: Digital twins can model underground reservoirs to predict how they'll behave. This aids in optimizing extraction techniques and maximizing the reservoir's yield.
- Drilling Optimization: By simulating the drilling process, companies can identify potential issues (like equipment failures or geological hazards) and adjust the drilling strategy accordingly.

Asset Performance Management

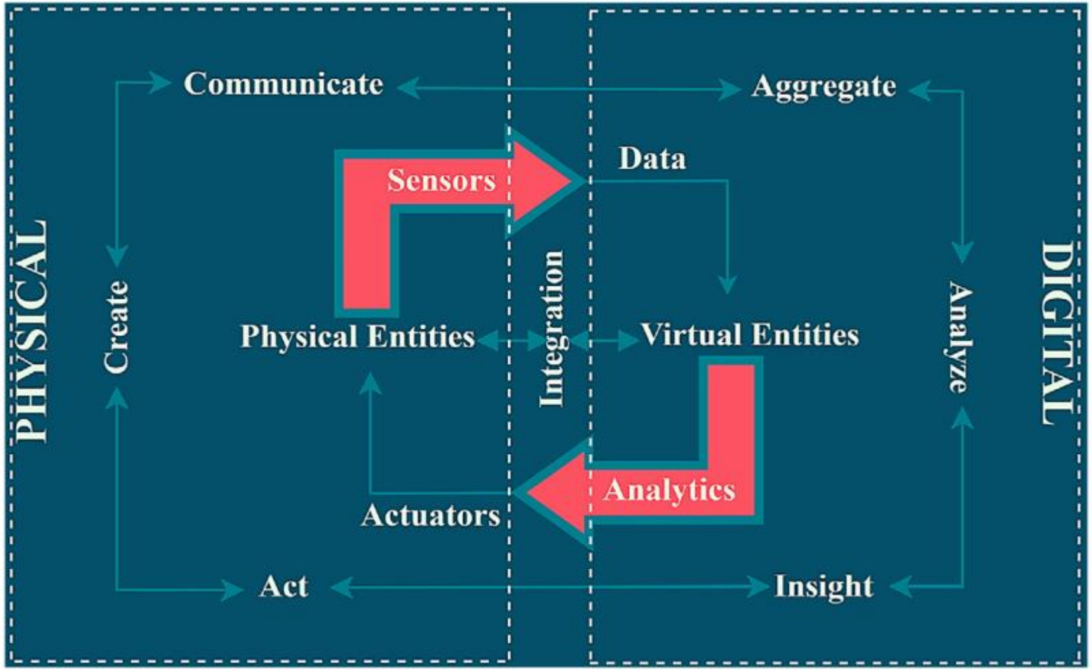
- Predictive Maintenance: Digital twins can predict when equipment might fail using sensors and real-time data. This helps companies fix problems before they happen, reducing downtime.
- Operational Optimization: Digital twins can model the entire operation of an asset (like an oil rig or refinery). Companies can find the most efficient way to run their operations by simulating different conditions.
- Production Optimization: Flow Simulation: Digital twins model the flow of oil and gas through pipelines and other infrastructure. This can help identify bottlenecks or inefficiencies in the system.

Real-time Monitoring and Control

- Remote Operations: Particularly useful in offshore or remote sites, digital twins allow operators in centralized control rooms to monitor and control equipment from a distance.
- System Performance: By continuously comparing the digital twin's performance with the real-world asset, discrepancies can be spotted immediately, leading to quick interventions.

Digital Twins

Digital Twin in the Hydrocarbon Industry

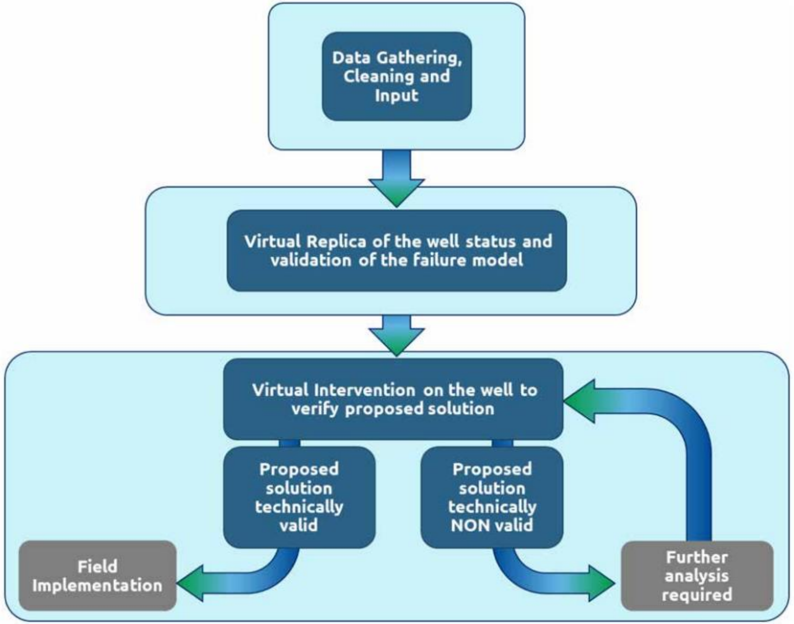


Digital Twin (DT) modeling is the foundation for the next generation of real-time production monitoring and optimization systems. It is a solution that boosts productivity by combining information, simulation, and visualization throughout the entire value chain of an operational firm, from subsurface equipment to central production plants.

Digital Twins

Digital Twin in the Risk Assessment Process

Generative AI – Digital Twin



Digital twin standard workflow

Risk Assessment Process

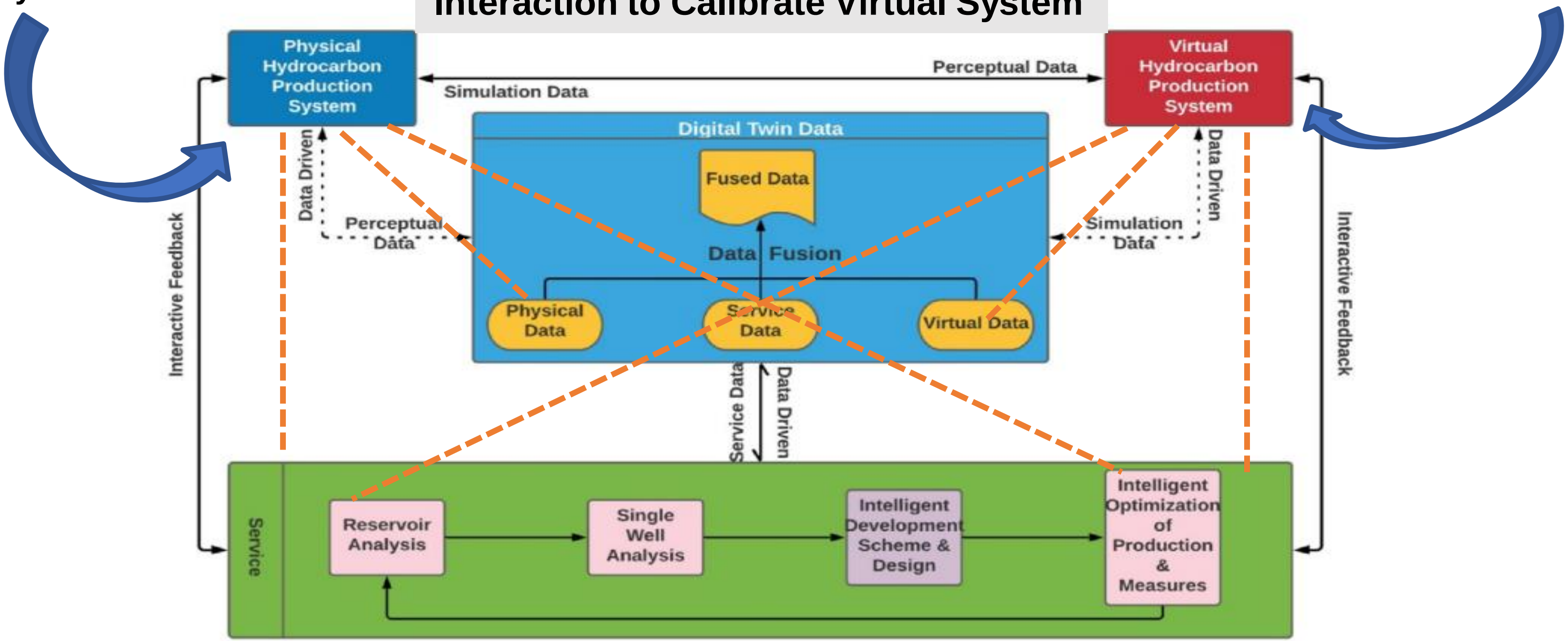
Digital Twins

Digital Twin Framework for O&G Production

Real System

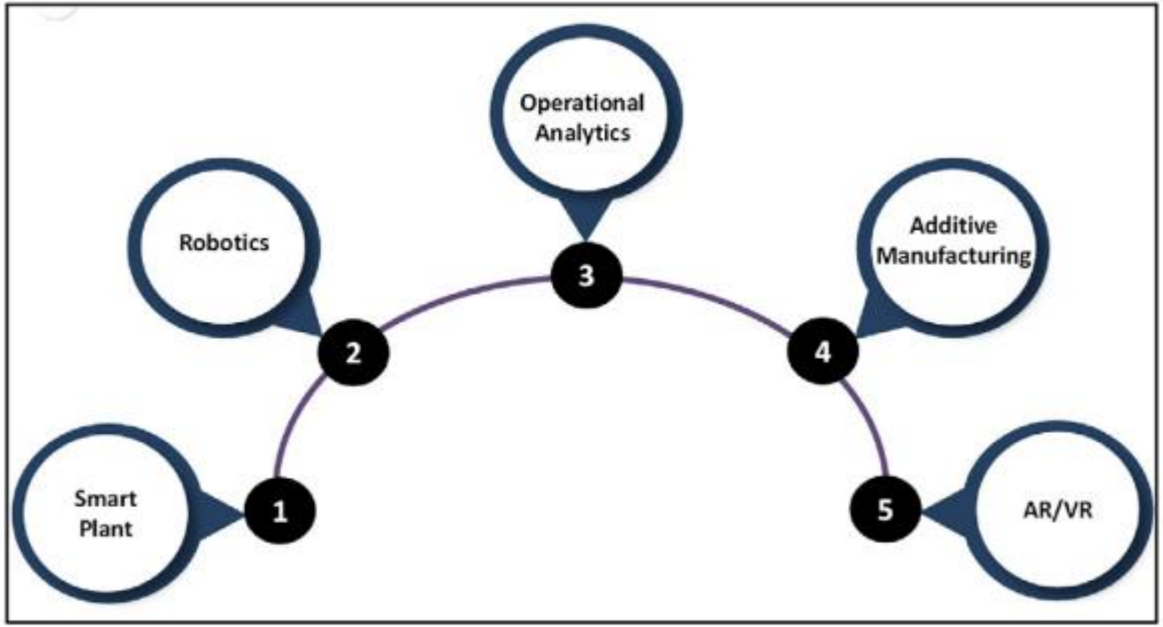
Digital System

Interaction to Calibrate Virtual System



Digital Twins

Strategies to Achieve a Digital Twin Model



Digital Twins

Digital Twin of a Well

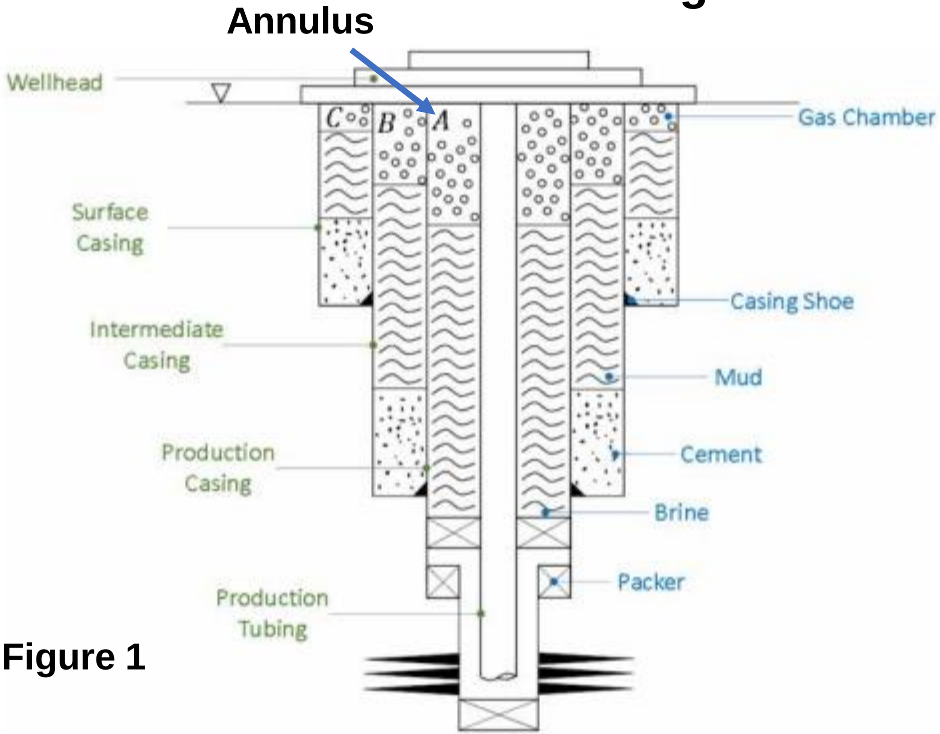


Figure 1

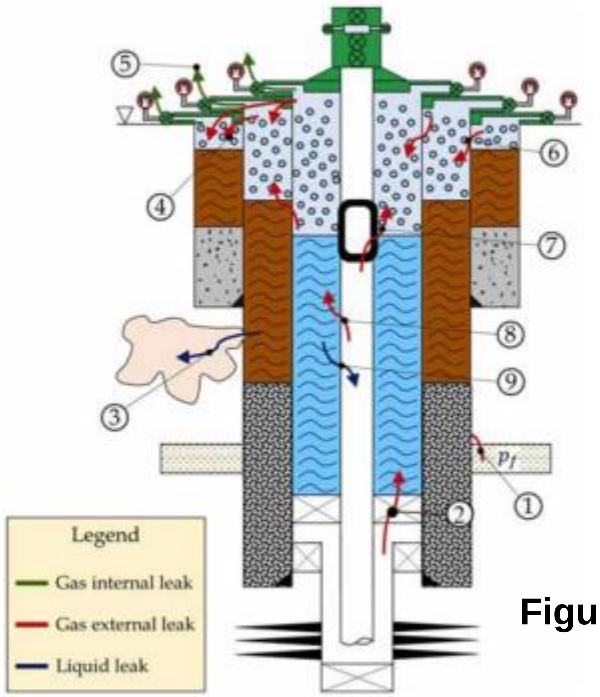


Figure 2

Digital Twins

Digital Twin – Smart Water Optimization Workflow

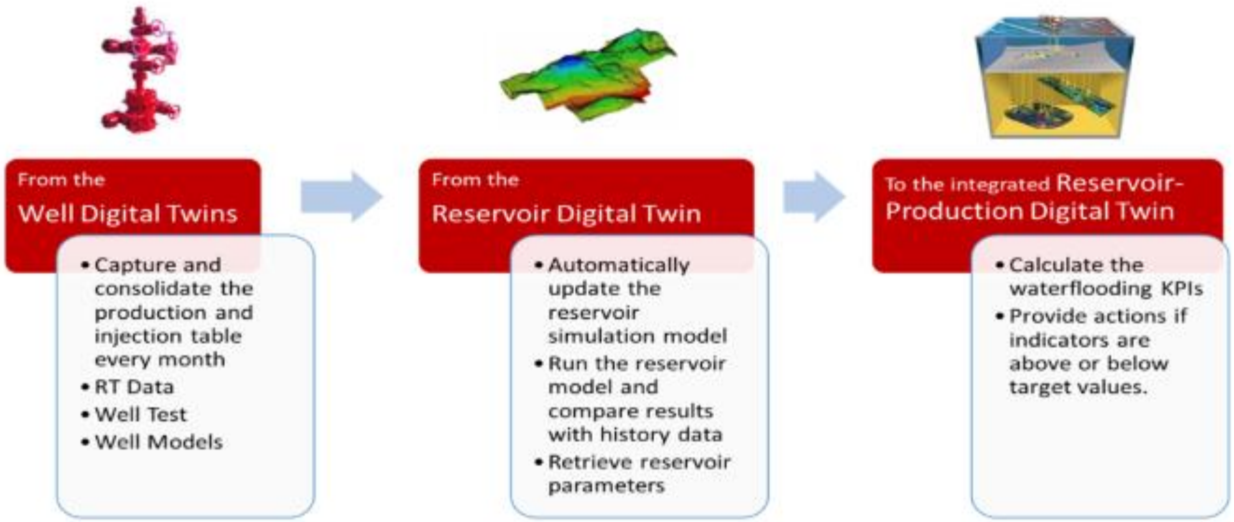
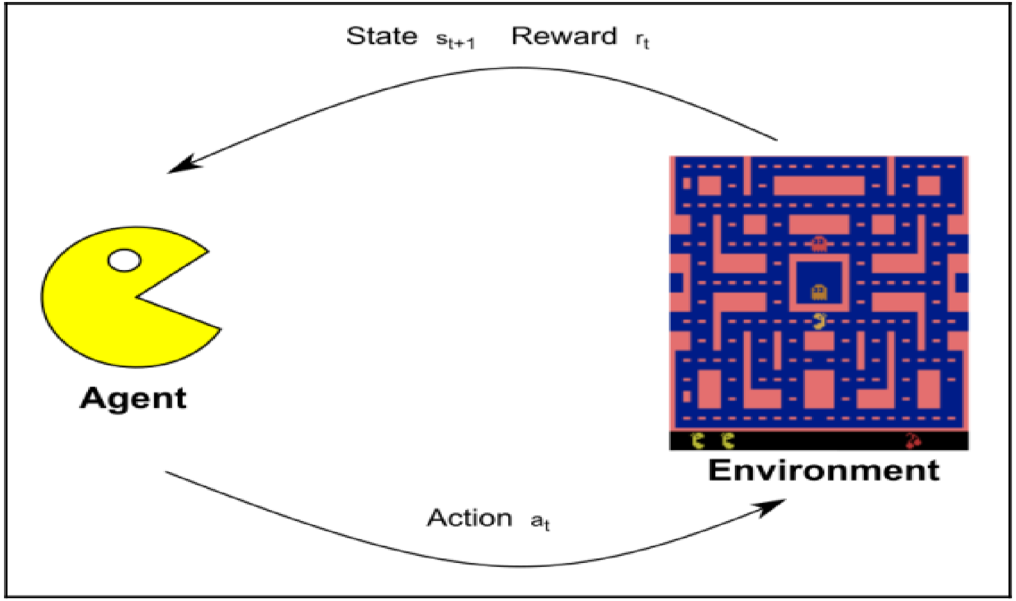


Figure 01

Digital Twins

What is Reinforcement Learning?



Reinforcement learning is learning what to do — how to map situations to actions — to maximize a numerical reward signal. The learner is not told which actions to take but must discover which ones yield the most reward by trying them. In the most interesting and challenging cases, actions may affect the immediate reward, the next situation, and all subsequent rewards. These two characteristics — trial-and-error search and delayed reward — are the two most important distinguishing features of reinforcement learning.

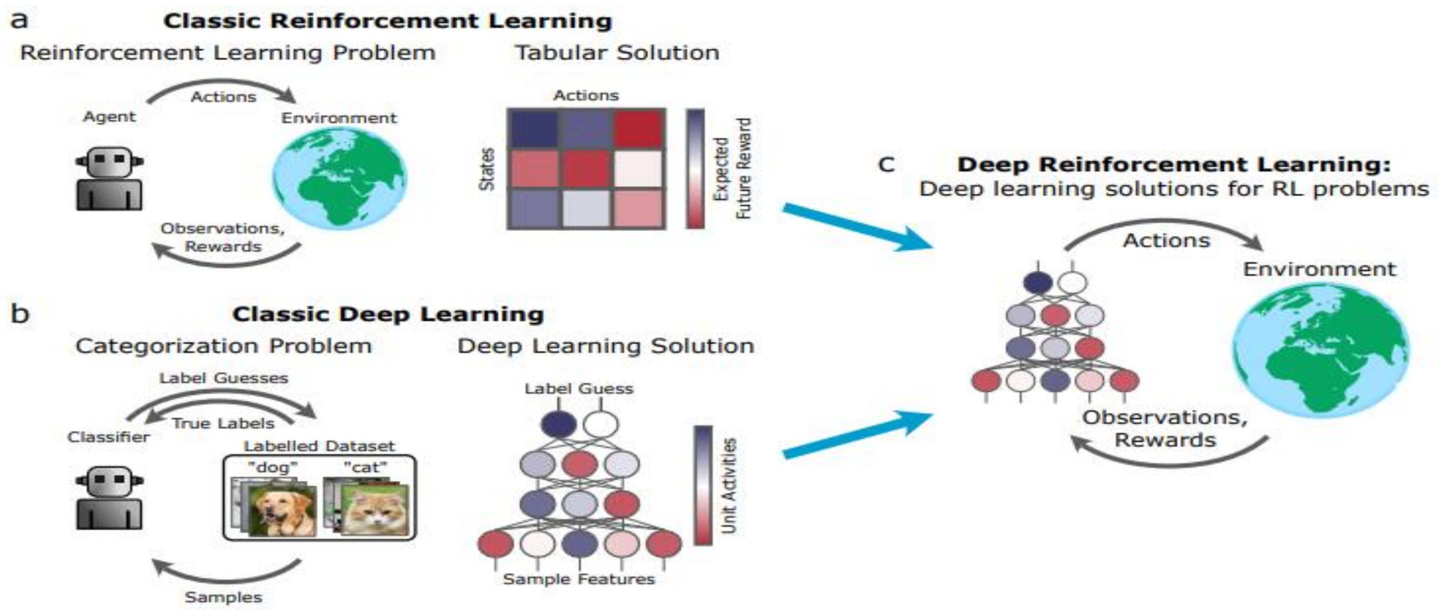
Digital Twins

Reinforcement vs. Supervised/Unsupervised

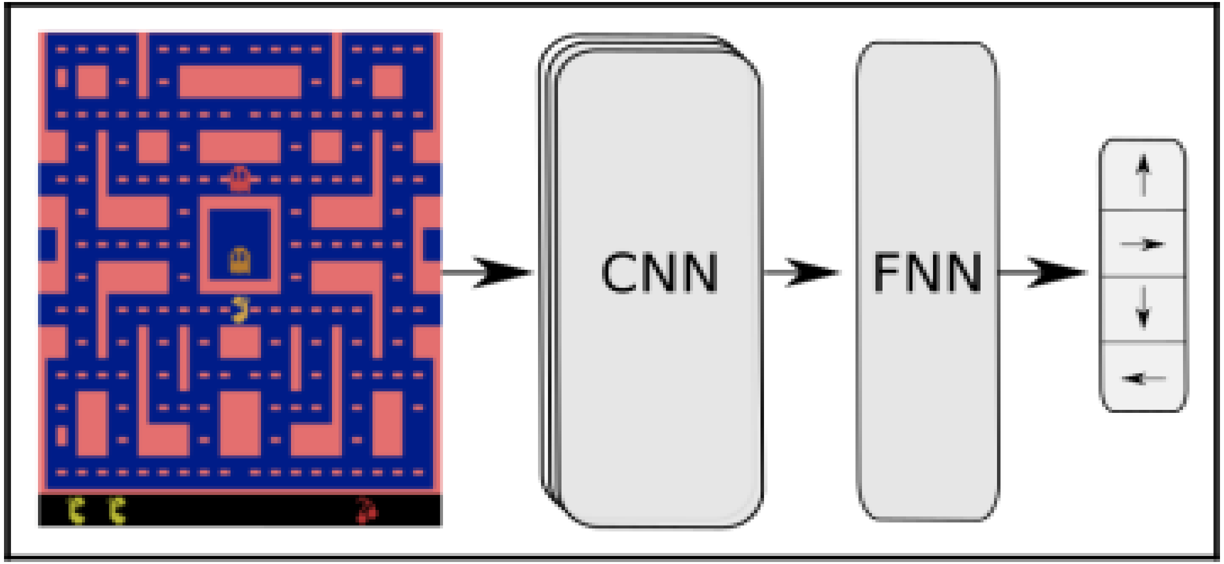
Reinforcement Learning	Supervised/Unsupervised Learning
Objective: choose "best" actions	Objective: Predict, classify or simplify
Environment is uncertain	Environment is known (x is known)
Training involves exploring the environment	Training involves finding patterns in data or is entirely absent
Training process involves determining the "best" policy	Training process involves fitting the "best" model
Explicit dependency of rewards on previous actions	Individual points are independent of each other

Digital Twins

Deep Reinforcement Learning (DRL)

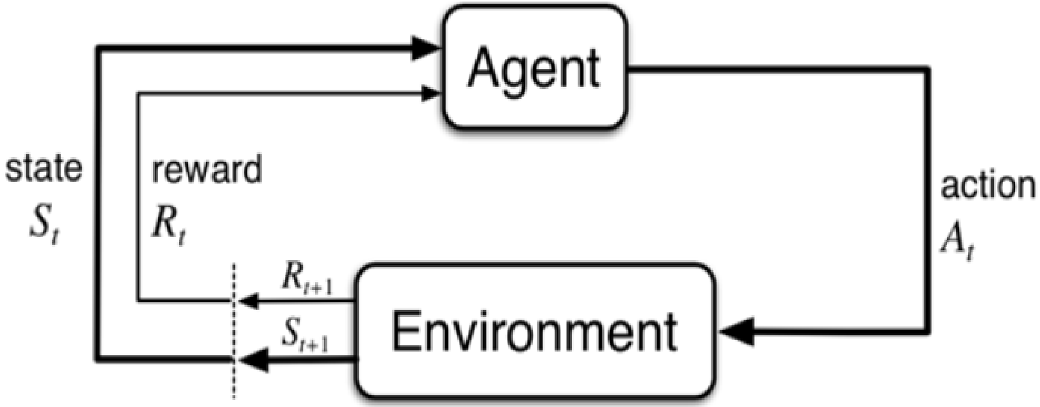


Digital Twins



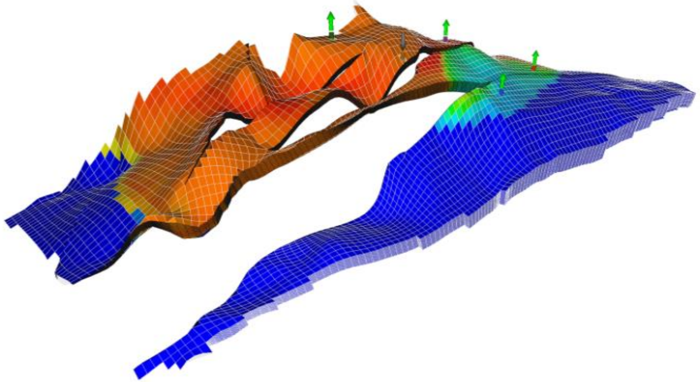
Deep Reinforcement Learning for Petroleum Reservoir Optimization

Digital Twins



Deep Reinforcement Learning for Petroleum Reservoir Optimization

Reservoir Simulation



Module 12

PINNs: Physics-Informed Neural Networks & Explainable AI and Generative AI

MODULE 12

This Module introduces PINNs, Physics-Based Neural Networks., recently proposed for solving partial differential equations. Unlike typical ML algorithms that require a large dataset for training, PINNs can train the network with unlabeled data. The applicability of this method has been explored for the flow and transportation of multiphase flow regimes in porous media.

We shall introduce a case study to manage reservoir pressure by implementing a PINN.

The module also details Explainable AI (XAI), a set of processes and methods that allow human users to comprehend and trust the results and output created by machine learning algorithms. Explainable AI describes an AI model, its expected impact, and potential biases.

We shall also explore Generative AI, discussing the Pros and Cons of these techniques in the oil and gas industry.

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