AI4Water

PRIMA
PARTNERSHIP FOR RESEARCH AND INNOVATION IN THE MEDITERRANEAN AREA

This project is part of the PRIMA programme supported by the European Union

AI4Water

A framework for water optimization in irrigation

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What is a water optimization problem?

It is a **mathematical and engineering problem** aimed at finding the best way to manage, allocate, or use water resources, usually by maximizing benefits (like supply or profit) or minimizing costs (like energy or waste)

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What is a water optimization problem in irrigation?

It is a **mathematical and operational problem** aimed at determining the best possible way to allocate limited water resources to crops, maximizing agricultural productivity while minimizing waste and cost.

Decide

How much water to use
When to use it
Where to use it

Goals

Maximize yield of crops
Minimize water or cost
Satisfy constraints

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Water prediction … is it the same as water optimization?

Water prediction is about *forecasting* how much water will be needed or available in the future (e.g., future crop-water demand, soil moisture, water inflow, or rainfall/irrigation-water availability).

Generally speaking, we often use prediction (data-drive methods, ML) for those components of the problem where a physical model is unavailable, too uncertain or too computationally expensive to use in practice.

Water optimization (what to do)

Given the current and future state, what is the best irrigation schedule or allocation?

Objective function

Constraints:
- water-supply limits
- crop-specific rules

….

Optimizer:
- GA with simulation, RL
- searches for the best irrigation schedule (depths, timings), field allocations

Water prediction (what will happen)

How much water will the crop need, or how much water will be available, in the coming days/weeks?

What can be predicted?

- Crop evapotranspiration
- Soil moisture
- Rainfall
- Canal-release volumes
- Irrigation-water quality (salinization, contamination)
- Future demands

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Statement of the water optimization problem

Initially, we decided to:

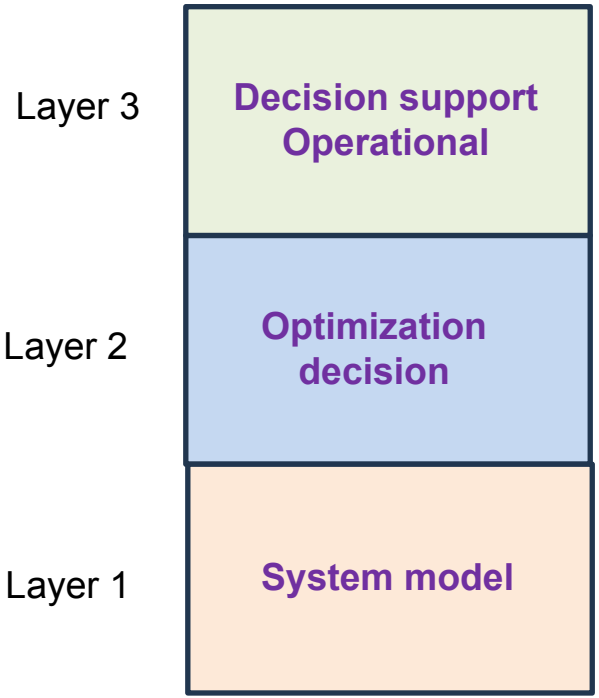
focus on irrigation schedule (e.g., day 10: 15mm, day 25: 20mm, …)

calculate how much water the crop will need

embedding a **physical crop–soil–water model** inside the optimization framework

Based on the published work: "***Optimization model of an irrigation reservoir for water allocation and crop planning under various weather conditions***" P. E. Georgiou, D. M. Papamichail, Irrigation Sciences, 2008.

Our view of the global picture: a three-layer framework design



Turn the solution returned by the optimization process into something usable by stakeholders

Solutions translated into calendar-like irrigation plan, including rules for specific and practical implementations. **GUI**.

Optimizer: Genetic Algorithm, Reinforcement Learning

Search for irrigation plans that the model layer can evaluate

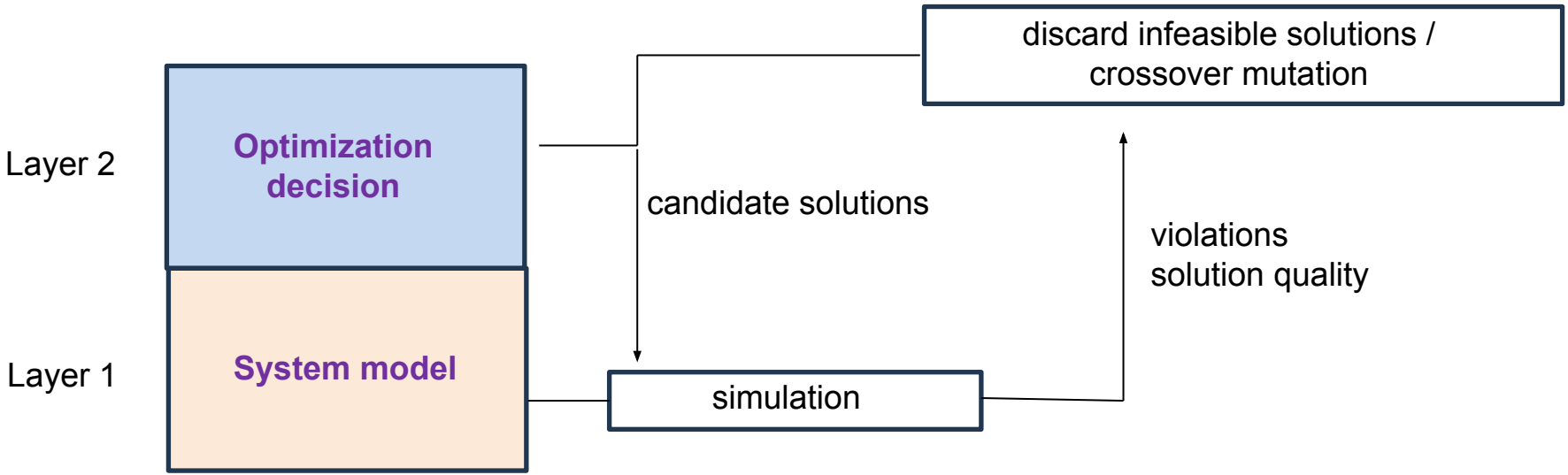
Objective and constraints

crop-soil-water model

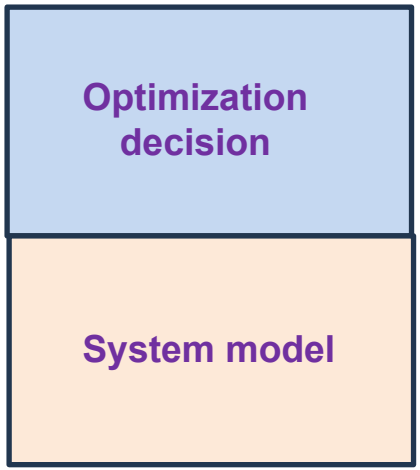
used as simulation model for optimization candidates

like a digital twin that mirrors the real-world behavior of the irrigation system

Genetic Algorithm loop



Constraints



simple constraints

simple, static bounds

- max 20 mm of water for crop C
- irrigation depth between 0 and 50 mm

hard constraints

complex
state-dependent rules

- water stress over time
- reservoir rules
- soil moisture cannot fall below SMmin

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Other constraints to consider

Scarse water to satisfy full crop yield

The drop in the yield keeps a non-linear relationship with the amount of water

→ **System model**

Waste water reuse for irrigation

Acceptable ranges of treated wastewater for crops

→ **Optimization decision**

Irrigation systems

Drip irrigation, Surface irrigation, Sprinkler irrigation
How much of the pumped water actually reaches the root zone

→ **System model**

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