Crop Water Ontology (CWO) Report

1. Initial information

This document consists of a practical work done for the training CES IA of the school Telecom Evoution (Telecom Paris) for the module Symbolic IA. The person in charge for its evaluation and correction is Dr. Natalia Diaz Rodriguez (natalia.diaz@ensta-paris.fr)

It has been designed by: Francisco Romero (francisco.rs00@gmail.com) and Javier Castells Alvarez-Ossorio (castells.javier@gmail.com)

In the next URL (Github repository) you can find the OWL file created by Protégé application (V.5.5.0):

https://github.com/javiercastells/CES-IA-Telecom-Paris-/tree/main/Module%205%20-%20Symbolic%20IA/TP/Report

2. Ontology Description

This section describes the designed ontology and what daily problem solves.

As an introduction, due to the problems concerning the famine in Malagascar with big droughts and seeing similar situations in other parts of the world, we see a need for the creation of an ontology to help all these communities in general to effectively manage their water resources for crops. (http://www.fao.org/news/story/es/item/1398817/icode/)

Therefore, in order to solve part of the above problem, we have aimed at solving one of the United Nations Sustainable Development Goals (SDG), specifically on Goal 15: Life on Land, we chose to work on the following topic:

***R15.3 - AI to optimize water consumption in crops**: AI, together with the use of sensors, would allow making predictions that can improve real water needs, by assessing evaporation, allowing a reduction in its use without harming crops.*

The main objective is to be able to save water, by making the water supply process for crops more efficient. This can be achieved with the help of an Artificial Intelligence, that gathers information from different sensors, and is able to predict the amount of water that the crop well need. In this way, the water supply can be more properly tuned. For example, if the Artificial Intelligence is able to predict potentially dry periods, the water supply could be temporarily increased. Inversely, if the AI predicts a potential excess of water in the crop, the supply can be reduced, to avoid needless use of water.

With that problem in mind, we made the following considerations in order to build our ontology.

3. Ontology design decisions

We have based this Ontology on one of the SDG requirements, more specifically R15.3 on AI to optimize water consumption in crops.

In order to control the water needs of a crop, we start by deducing the different elements that make up a crop and those elements that imply the loss of water from the crop. As we progress in this ontology, we deduce 4 main general elements for all crops:

- **Water Suppliers**: Entities that provide water to the crop.
- **Water Consumers**: Entities that remove water from the crop (e.g. evaporation).
- **Water Quantity**: Entities that indicate the amount of water in the crop (humidity in the crop).
- **Water Regulator**: Entity in charge of controlling the amount of water in the crop by providing or not water (through water suppliers) depending on the water consumed by water consumers.

As we go deeper into these 4 entities and their relationships, we see that to evaluate whether or not we have enough water for a crop depends entirely on the type of crop and the ground on which it is cultivated, so this information is necessary in our study. Following this new idea we see that what is important does not depend on the consumers (external or internal) but on whether we have the necessary water at any given moment for the crop cultivated. This makes us rethink the previous entities and regenerate a new approach to our ontology in which we will define 6 fundamental elements:

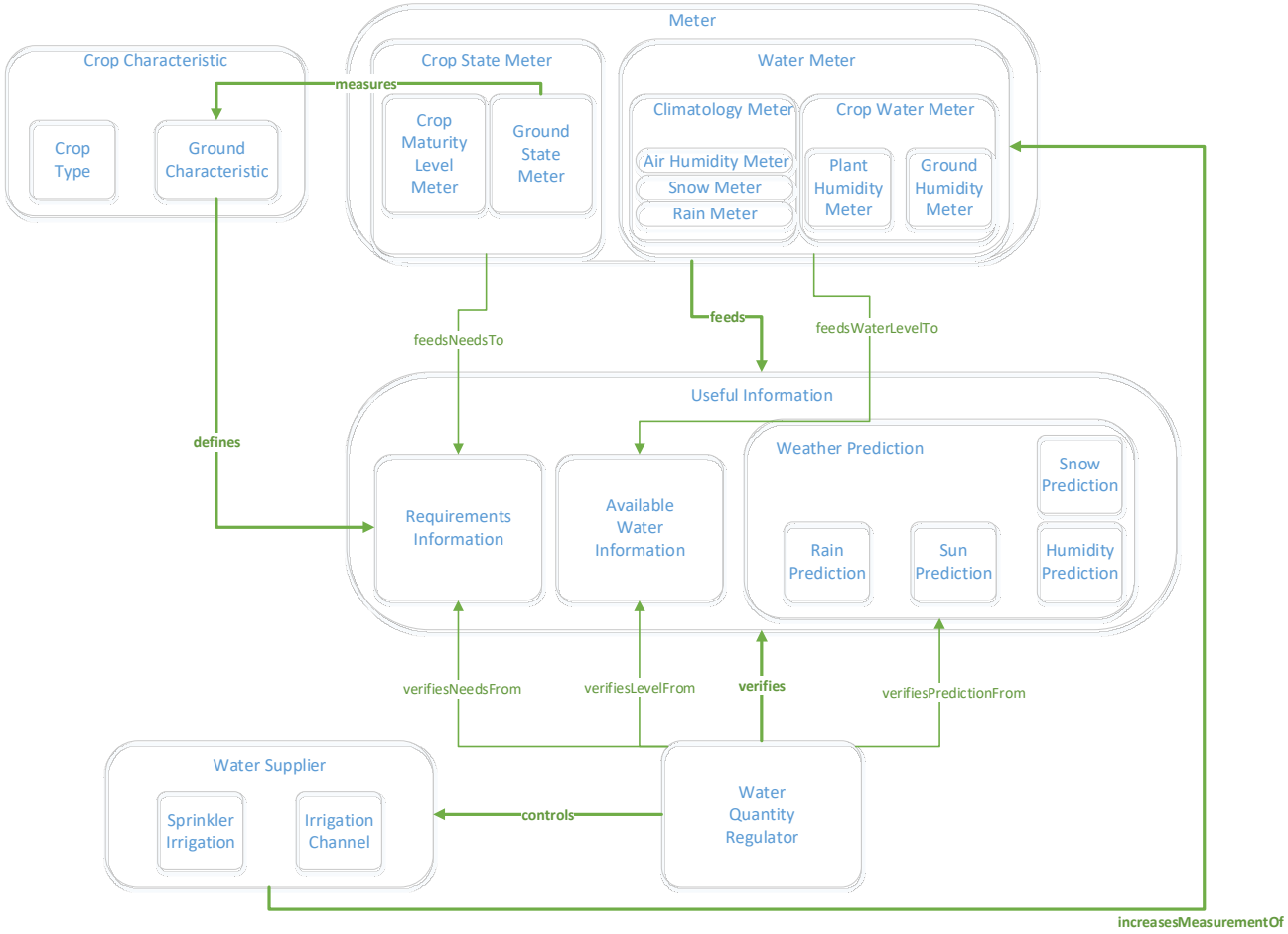
1. **Characteristics of the crop** (CropCharacteristic entity): This gives an idea of the type of crop that has been used and the physical and mineral characteristics of the ground on which it has been cultivated, so we will know the water needs it requires. This information is known from the agricultural and mineralogical point of view and does not depend on any external factor.
2. **The state of external and internal elements** that directly influence the crop.
    A. State of the climate (climatologyState entity)
    B. State of the crop (cropStateMeter entity): e.g. state of growth of the crop, soil condition
3. **Elements measuring** the different states above (Meter entity):
    A. **Crop Water Meter:** These are meters (sensors) that take measurements concerning how much water is available in the crop (for instance, how humid is the soil and the plants themselves).
    B. **Climatology Water Meter:** This is another kind of meters focusing on meteorological aspects, such as the quantity of rainwater, snow or even the perceived sun heat.
    C. **Crop State Meter:** A third kind of meters provide information about maturity of the plants, or even some of the land's intrinsic characteristics (for instance, the structure and texture of the soil), that might also change in time.
4. **Useful information to know the water needs** (UsefulInformation entity): it will determine the amount of water available and needed from the previous meters and the characteristics of the crop:
    A. **Requirements Information**: It represents information about the water requirements of the crop. These requirements will be defined by the crop's intrinsic characteristics, such as: Crop Type, Ground Size, Soil Structure and Soil Texture. Additionally, this information is updated with measurements coming from the Crop State Meters.
    B. **Available Water Information:** It represents real time information about the available water in the crop. It is obtained thanks to the Crop Water Meters.

C. **Weather Prediction:** This is dynamic information about natural phenomena that affects the crop and that come from Climatology Water Meters.

5. **Water Regulator** (WaterQuantityRegulator entity): In charge of, knowing the useful information on water availability and needs, making water supply to the crop or not.
6. **Water Suppliers** (WaterSupplier entity): it will supply water to the crop, based on that the Water Regulator demands. In our ontology on a created two types of water suppliers:
   A. Irrigation Channel
   B. Sprinkler Irrigation

With these elements we create a closed system in which, knowing the needs of the crop and the soil, theirs states at any given moment and the climatic factors (at any given moment and their prediction), we generate sufficient information to be able to generate a decision to provide water or not by the regulator.

4. Visual Representation Ontology

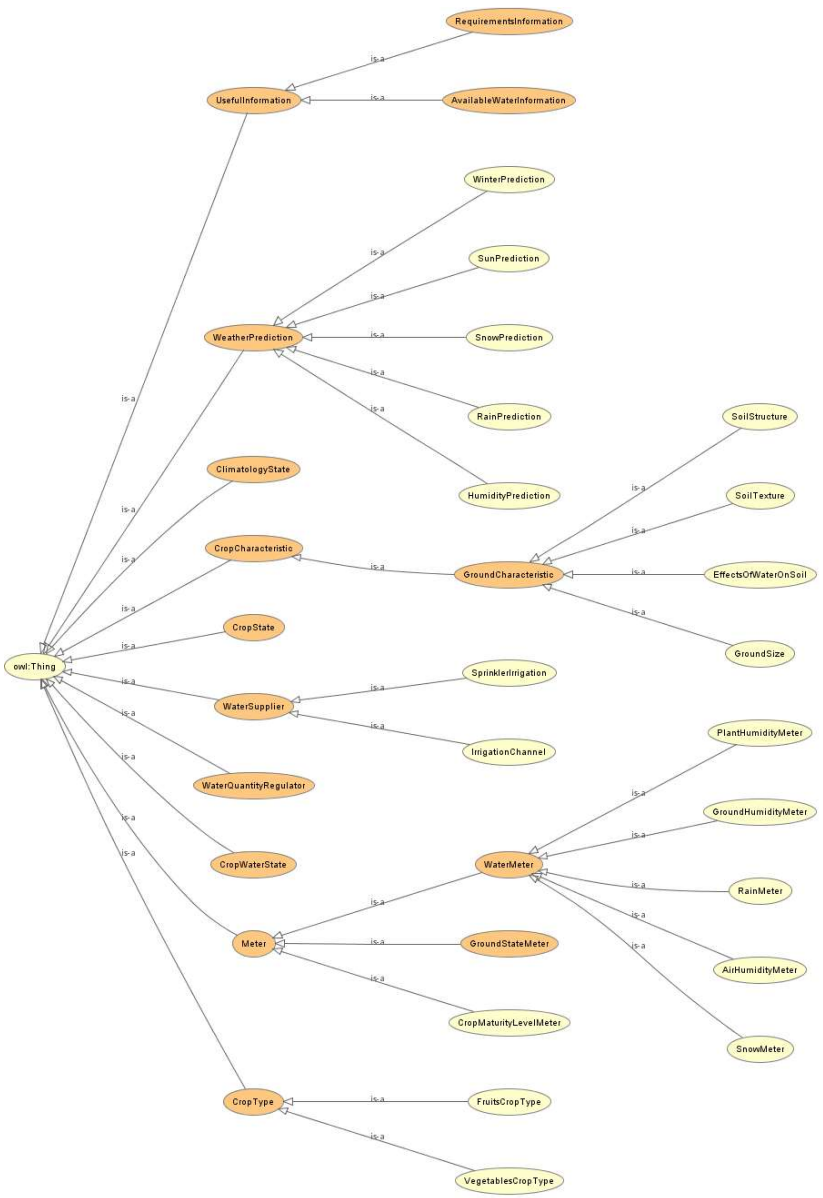


5. References

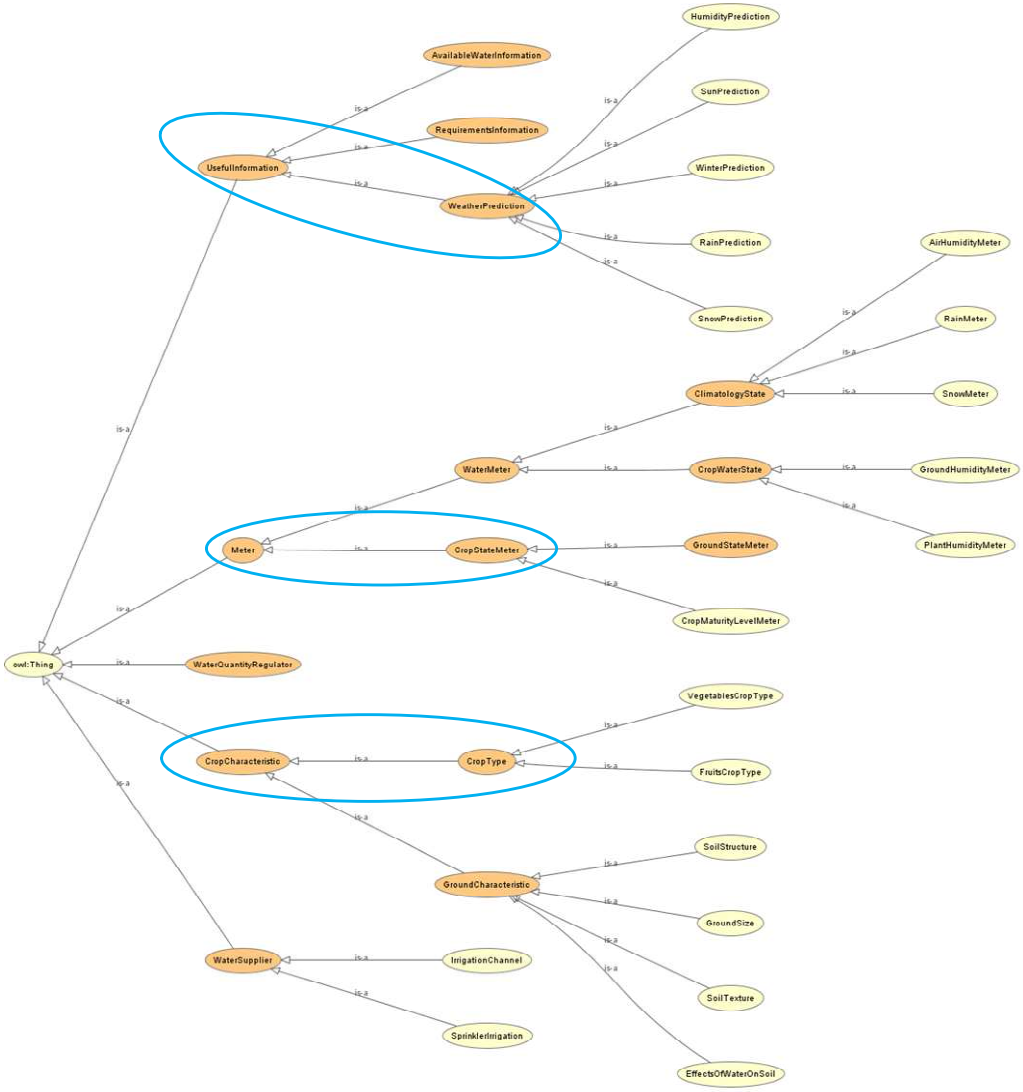
- Sustainable Development Goals (UN) - https://www.un.org/sustainabledevelopment/biodiversity/
- AI for Good - https://ai4good.org/what-we-do/sdg-data-catalog/
- AI Love SDGs - https://dasci.es/ia4ods/inner-ods-15.html

6. Protégé screenshots

Full ontology graph (asserted)

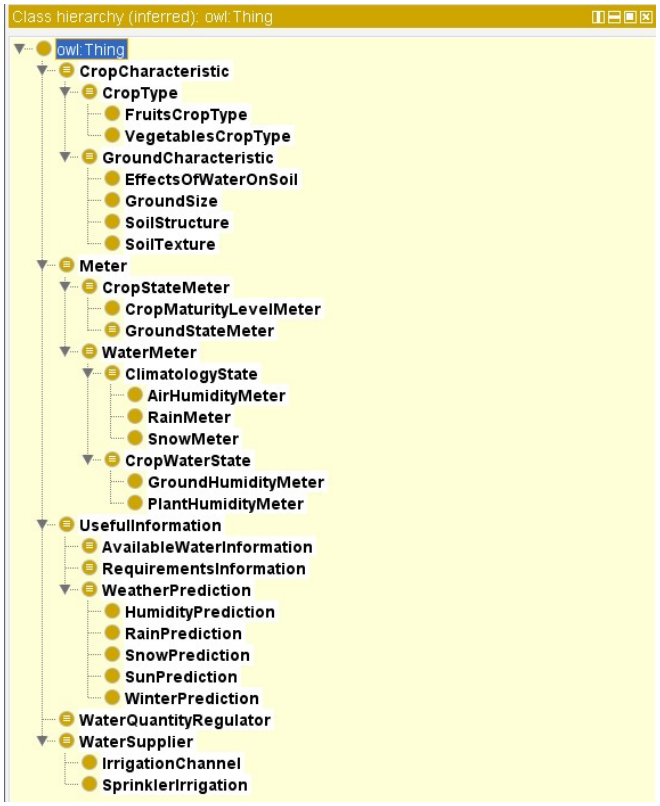


*Full ontology graph (inferred) (in **blue** some of the inferences)*

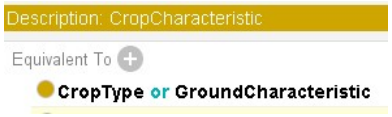


Class Hierarchy (asserted)

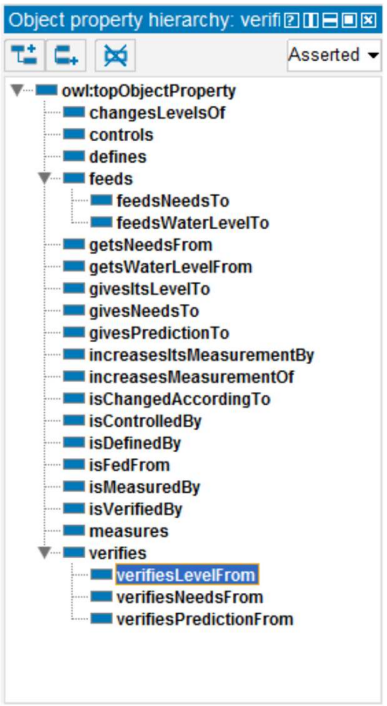
Class Hierarchy (inferred)



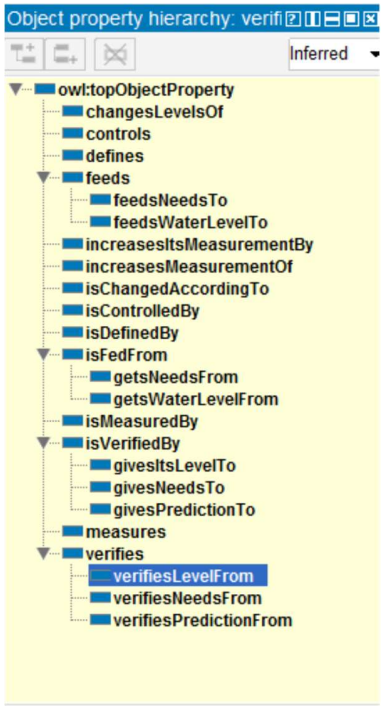
Most of the classifications that are observable on the inferred hierarchy are possible thanks to the Value partitions that we've defined. For instance, for the Crop Characteristic class, we defined a **covering axiom** stating that this class can only be either a CropType or GroundCharacteristic. In this manner, these sub classes are automatically classified by the reasoner:



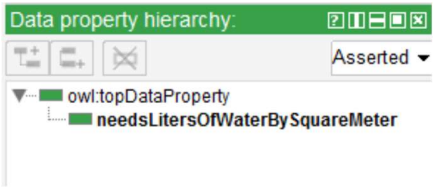
Object property hierarchy (asserted)



Object property hierarchy (inferred)

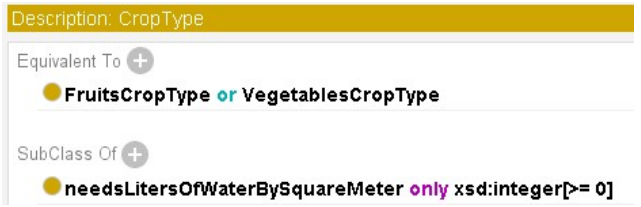


Data property hierarchy (assert, same as inferred)



This property allows us to define different water requirements according to the type of crop we are dealing with. The figure below shows how the Crop Type has a data property and that it should be an integer greater than zero:

Assignation of the Data property of the CropType class



We have created some individuals for FruitsCropType class and VefetablesCropType: