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Logics and Symbolic AI
IA301

An Ontology-based guide for a sustainable home garden

Ontology Report

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1 Introduction

Home gardens are surely a good way to have instant access to fresh and chemical-free products, which especially proves useful during this particular time of lockdown. But promoting sustainable home gardens serves an even greater goal. In fact, the second SDG goal "Zero Hunger" includes to "ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems" and "that progressively improve land and soil quality". Our goal is to provide the necessary knowledge to guide individuals into creating and maintaining sustainable home gardens.

2 What problem does the ontology address?

There are many considerations that a person needs to take into account to create a suitable environment for the plants and to choose the right plants as well. In fact, sustainably managing a home garden has been considered as a knowledge problem since it is crucial to know the different parameters to have a healthy food source. From these parameters,we can mention: planting temperature, compatible crops,beneficial insects, suitable season, soil quality, most needed mineral, etc.

In this work, we present our sustainable garden ontology which provides a shared conceptualization with well-defined and understandable meaning. Actually, the ontology in the context of agriculture can an efficient method to compress and integrate many heterogeneous data sources in order to build a homogeneous knowledge source.

Thanks to our ontology, we focus on some of the most important parameters to build a sustainable management of a house garden. In particular, we pay a certain attention to companion planting. Finally, we check the consistency of our ontology based on our acquired knowledge.

3 How is our ontology designed?

3.1 Classes

Our ontology is created by using OWL and Protégé 5.5.0. It contains seven main classes which are *Crop*, *DomesticAnimal* , *Insect*, *NaturalFertilizer*, *Soil*, *Season* and *Mineral*.

Our principal class is *Crop* . It contains the most known crops that we can cultivate in France depending on the soil type, climatic conditions, culture, etc. This class has two subclasses : *Vegetable* and *Fruit*. The first subclass represents plants such as Lettuce , Onion and Pepper. Meanwhile, the other subclass contains for example Tomato and Strawberries.

Soil has not only the function of holding the plants tightly on the ground, but also the capability to provide all the essential nutrients (*Mineral*) to the plants to grow and thrive. For this reason, the *Soil*, depending on the crop needs, should have some fundamental characteristics.

Each vegetable or fruit class has the best time of year to be planted in order to get the best productivity. That's why knowing the right *Season* to plant is vital.

When the *Soil* lacks some essential minerals or has its texture to be improved, a fertilizer is needed. As our gardener should manage sustainaibly its garden, the synthetic fertilizers are not allowed. In this case, Natural organic fertilizer is used to boost plant growing and soil quality.

Having *Domestic animals* like chicken or rabbits around the garden, can be considered as an efficient way to have a sustainable fertilizer supply source.

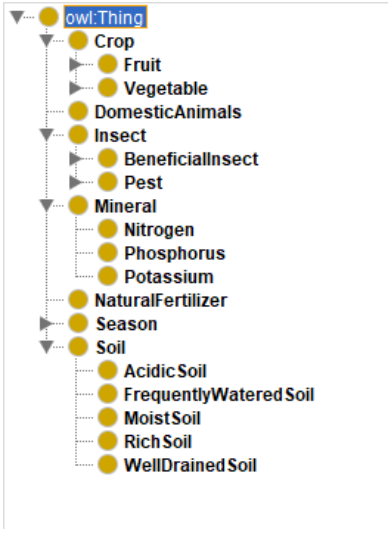

Figure 1: Classes

The next class is *Insect*. It contains two subclasses. The first subclass is *Pest*. Home garden owners are most of the time confronted to some type of insects that damage crops. These are pests. We can mention for instance *Aphids* and *Caterpillar*. In fact, the yield of the home garden is dramatically impacted by the presence of these pests. That's why a pest control must be done. But, since we are trying to build a chemical-free garden, the control process must not rely on pesticides. The most known eco-friendly method is to create a healthy natural environment by introducing or encourage the presence of some *BeneficialInsects*. This type of insects considered as natural predator of pests, helps creating a balanced ecosystem. Also, there is another benefit from the presence of *BeneficialInsects*. Actually, some insects like bees are considered as pollinators and they are crucial for the yield of the home garden.

Finally, it is worth to mention that our sustainable garden ontology is based on knowledge and expertise of domain experts , so that we can provide appropriate recommendations.

3.2 Object properties

From the previous paragraph, we can deduce some fundamental object properties. In figure 2, we have a Screenshot of our used object properties.

Object Property	Func	Sym	Inv Func	Trans	ASym	Refl	Irrefl	Domain	Range	Inverse
owl:topObjectProperty	☐	☐	☐	☐	☐	☐	☐			
requiresSoil	☐	☐	☐	☐	☑	☐	☑	Crop	Soil	
attacks	☐	☐	☐	☐	☑	☐	☑	Pest	Crop	isAttackedBy
eats	☐	☐	☐	☐	☑	☐	☑	BeneficialInsect	Pest	
pollinates	☐	☐	☐	☐	☑	☐	☑	BeneficialInsect	Crop	
requiresMineral	☐	☐	☐	☐	☑	☐	☑	Crop	Mineral	isEssentialFor
isEssentialFor	☐	☐	☐	☐	☑	☐	☑	Mineral	Crop	requiresMineral
improvesSoilQuality	☐	☐	☐	☐	☐	☐	☐	BeneficialInsect	Soil	
likes	☐	☑	☐	☐	☐	☐	☐	Crop	Crop	
produces	☐	☐	☐	☐	☑	☐	☐	DomesticAnim...	NaturalFertilizer	isProducedBy
isProducedBy	☐	☐	☑	☐	☑	☐	☑	NaturalFertilizer	DomesticAnim...	produces
isIncompatibleWith	☐	☑	☐	☐	☐	☐	☐	Crop	Crop	
growsInSeason	☑	☐	☐	☐	☑	☐	☑	Crop	Season	
requiresFertilizer	☐	☐	☐	☐	☑	☐	☑	Crop	NaturalFertilizer	
isAttackedBy	☐	☐	☐	☐	☑	☐	☑	Crop	Pest	attacks

Figure 2: Object properties

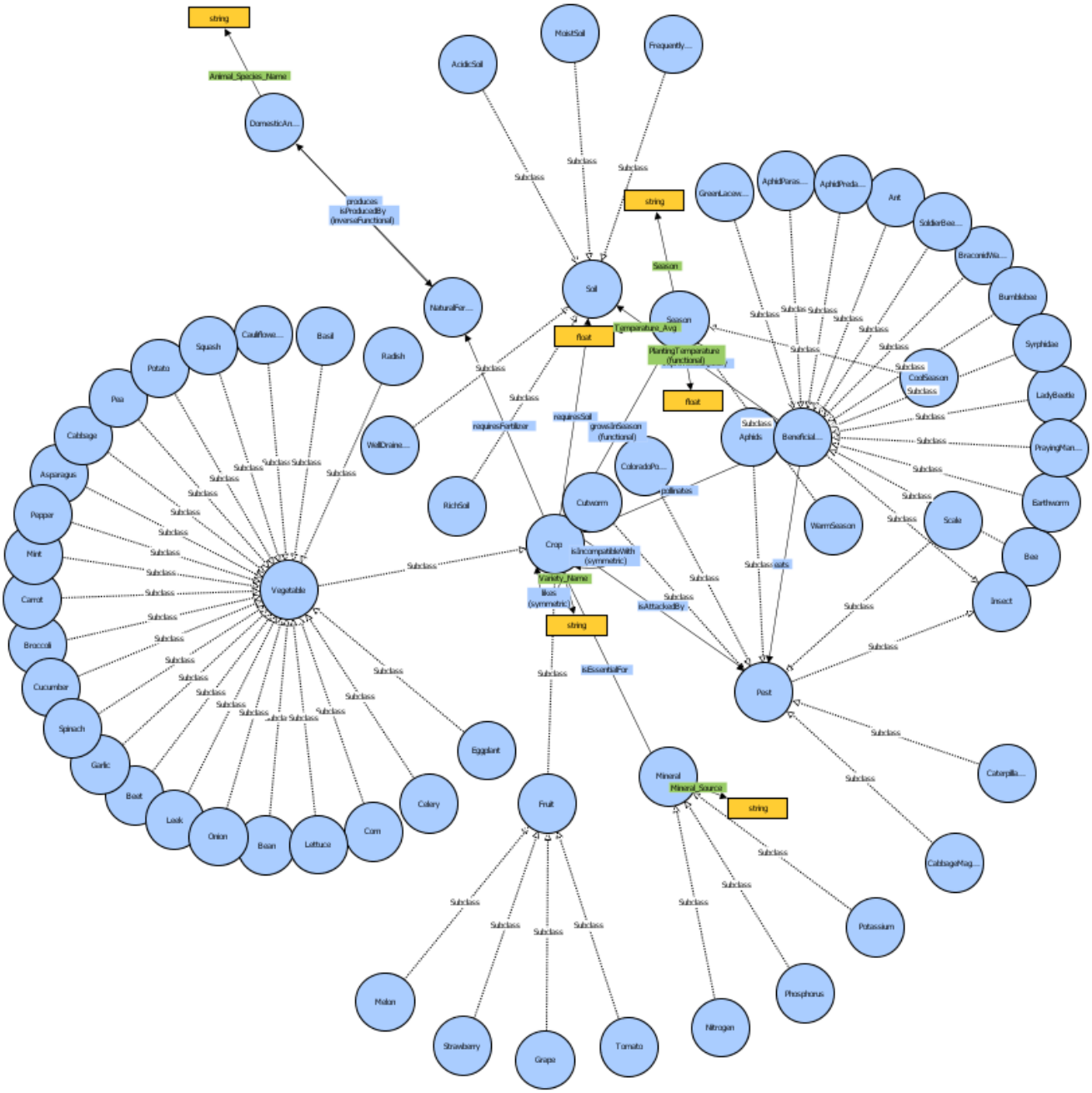

Figure 3: Representation of the knowledge (Using VOWL Plugin in Protegé) that will be covered by the object property "likes" between the different sub-classes of the class "Fruit" and "Vegetable"

First, we have two object properties (*likes* and *isIncompatibleWith*) that deal with the concept of companion planting. This means that we can plant two or more crop species together at the right time in order to achieve some benefits such as pest control and higher productivity. The property *likes* is defined between two crop species that benefit from being planted together. In the other side, there is the property *isIncompatibleWith* that describes the fact that two crop species should not be planted together for some reason (nutrient competition for instance).

We can see that the exported graph above represents the relationships between the different classes as well as object and data properties.

Moreover, we define the property *isEssentialFor* and its inverse *requiresMineral* in order to represent the fact that each plant needs a certain mineral more than other to grow. Also, we define the property *growsInSeason* to make clear the best season to grow a plant. The property *requiresSoil* gives a better understanding of the suitable soil for each plant.

To describe the relation between crops and insects, we define some properties: *attacks* and *IsAttackedBy* to draw attention to the potential damage done by pests,*pollinates* to describe the importance of some insects.
As we have mentioned in the previous part, there are some insect species considered as the natural predators of pests (described by the object property *eats*).

3.3 Data properties

We define the following data property *PlantingTemperature* to highlight the fact that each plant needs the right season planting temperature. For instance, *Lettuce* needs a cool planting temperature (between 5° and 10°C). Also we add other trivial data properties to enrich our ontology and to have better understanding of the data.

Data Property	Func	Domain	Range
owl:topDataProperty	☐		
Variety_Name	☐	Crop	xsd:string
Mineral_Source	☐	Mineral	xsd:string
Temperature_Avg	☐	Season	xsd:float
Product_name	☐	Mineral	xsd:string
PlantingTemperature	☑	Season	xsd:float
Animal_Species_Name	☐	DomesticAnimals	xsd:string

Figure 4: Data properties

3.4 Individuals

For Individuals, we decided to create ones from each class/subclass and introduce the relationships between them and define their data properties to experiment with the ontology and see the consistency of the different classes.

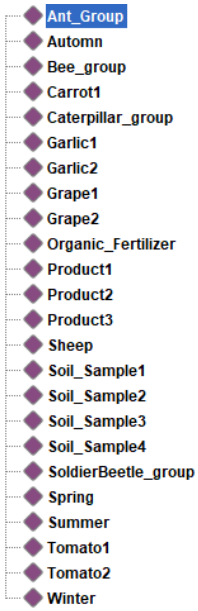

Figure 5: Created Individuals

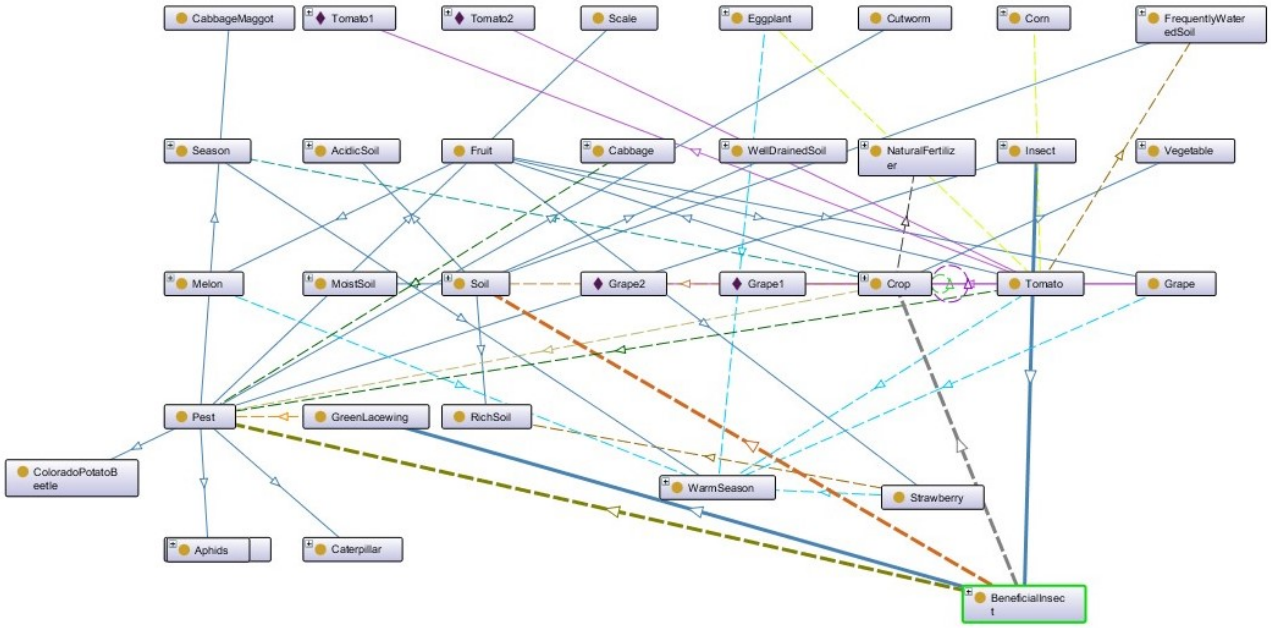

Figure 6: Graph describing the relationships between classes

Continuous lines define relationships between classes (descendants) and the discontinued ones define object properties.

These different links between the classes are the key elements that allow the ontology to model recommendation and consistency checks problems in sustainable gardening which at the end would have multiple advantages such as avoid usage of chemical pesticides and fertilizers, improve the soil's quality, better use limited gardening surface/area and plant as much as possible in an effective green way.

3.5 General design of the ontology with Protegé and running the reasoner

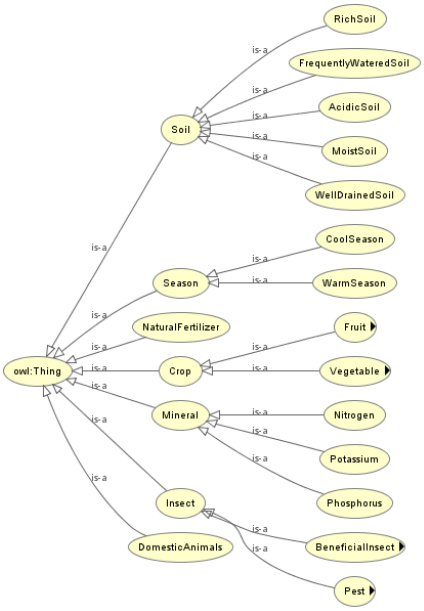

Figure 7: Design of the Ontology Using OWL Viz before inference

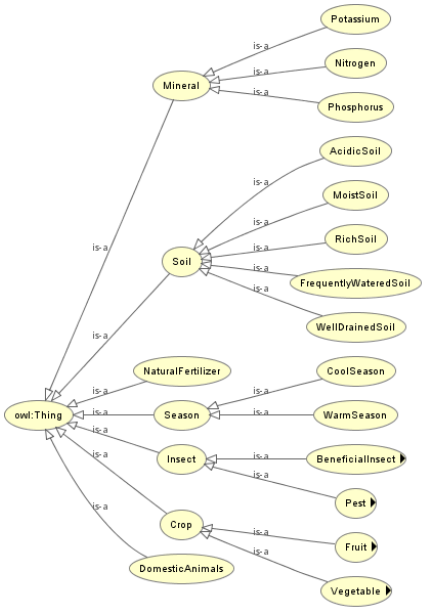

Figure 8: Design of the Ontology Using OWL Viz after inference

After creating our ontology using Protégé as shown in the previous parts, we invoke the reasoner. We used the reasoner by default : HermiT 1.4.3.456 The reasoner allows to check the consistency of our knowledge: We succeeded in avoiding inconsistencies and thus no alteration are suggested by the reasoner.

We notice that the general design of the ontology did not change after running the reasoner as shown in the above figure. This makes sense knowing the nature of our problem. However, we paid attention to not enumerating everything so that the reasoner makes inferences. Indeed, many inferences have been added : The domains and ranges of inverse classes have been inferred, also assertions have been inferred for individuals based on their relations to other individuals.

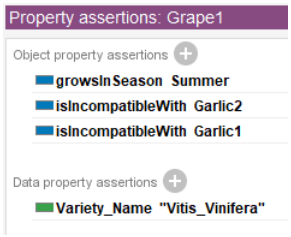

Figure 9: individual Grape1

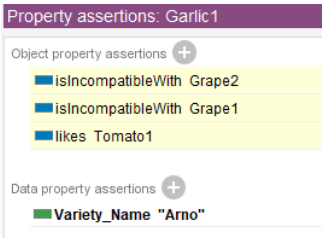

Figure 10: Added Inferences for individual Garlic 1

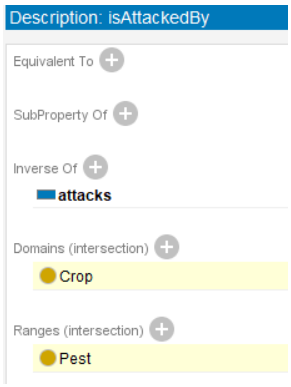

Figure 11: inferences for Object Property isAttackedBy

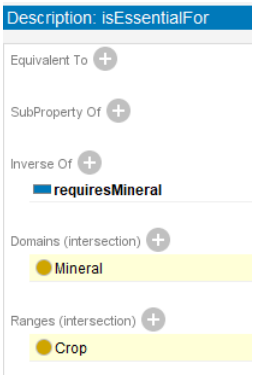

Figure 12: inferences for Object Property isEssentialFor

4 Conclusion

This is a small dive into the representation of sustainable gardening using protegé. Numerous classes, properties and individuals can be added to better model this subject and thus have a more generalized recommendation and consistency check model for an effective, sustainable and green way of creating a home garden.

5 References

These are the Articles that we used to build and design our ontology. Just click on the name of the article to get directed to the link:

Vergara-Lozano, Vanessa, et al. "An Ontology-Based Decision Support System for the Management of Home Gardens." International Conference on Technologies and Innovation. Springer, Cham, 2017.

Going green with a sustainable kitchen garden.

Sustainable vegetable gardening.

28 Easiest Types of Vegetables to Grow in Your Garden.

50 Essential Crops to Grow in Your Survival Garden.

How to Choose Fruit Plants for Your Home Garden.

The 6 most cost-effective vegetables to grow in your garden .

Companion Planting Guide: 10 Veggies That Should Grow Together .

Which Vegetables Grow Well Together.

Raising Animals as Gardening Allies.

23 Benefitial insects and crawlies that your garden will love .

10 Beneficial Insects That Will Actually Help Your Plants .

The 10 Most Destructive Garden Insects and How to Get Rid of Them.

8 Best Homemade Garden Fertilizers.