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Development of a generic aquaponic model using object oriented programming to study the systems at the individuals level

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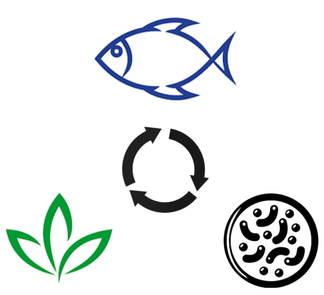
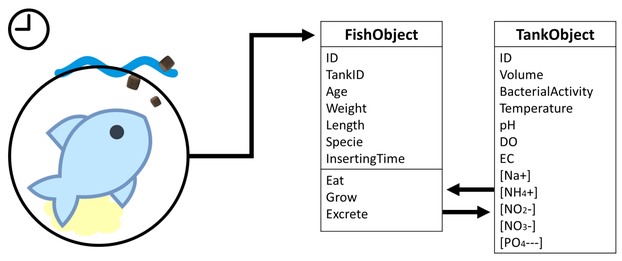
Introduction



Aquaponics is the association of fish and plant farming, exploiting the natural phenomenon observed in aquatic ecosystems. The microbiota transforms the fish waste into different bio-chemical that are less toxic for fish and very suited for hydroponic plants culture.

Even though fish and plant models are common in the literature, few have been developed for aquaponics. The aim of this study is to build a generalist model suitable for a wide range of aquaponic systems. Once completed, the latter will be implemented in an user-friendly application as part of the Smart Aquaponics project, an European Interreg.

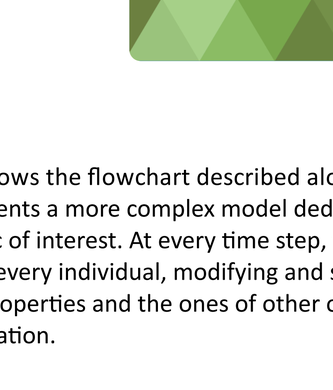


The model is being developed using object-oriented programming. The OOP provides the sought modularity by providing a variety of customizable objects. Using this tool, the user describes the studied system as closely as possible before running the computation.

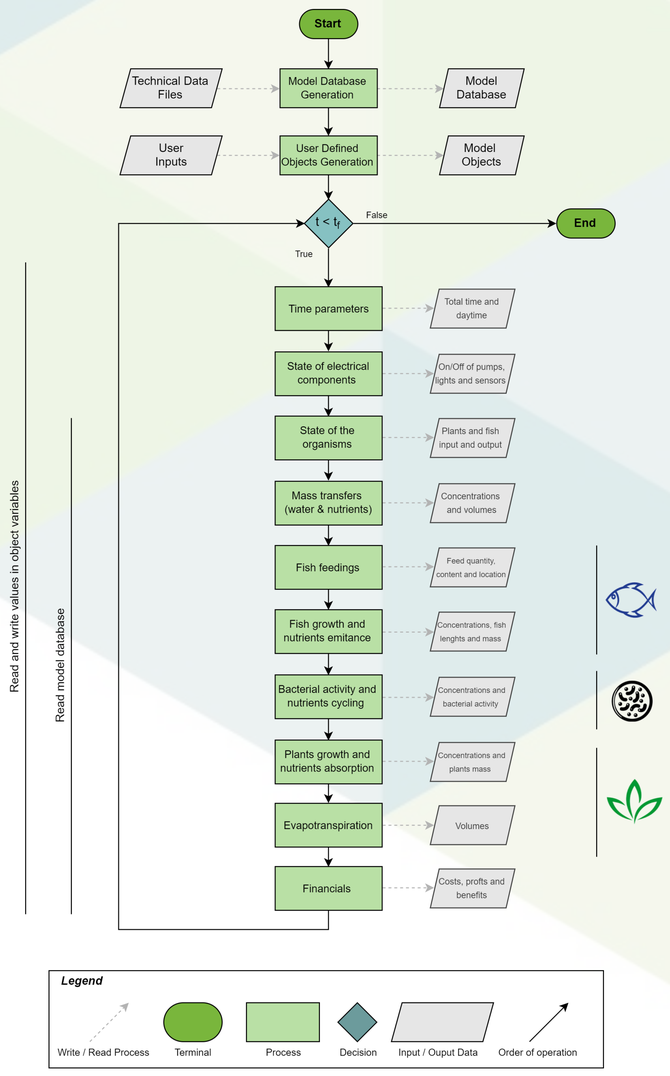
Model

The model follows the flowchart described alongside. Each process represents a more complex model dedicated to one particular topic of interest. At every time step, the processes are applied to every individual, modifying and saving their own current properties and the ones of other objects affected by the operation.

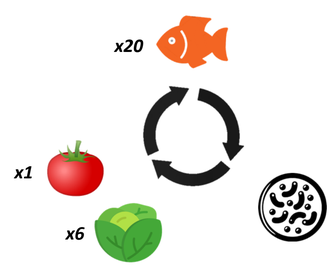
Every sub-model is used as a black box taking inputs and giving outputs. Therefore, they can easily be replaced. At the end, it is a very complex set of interactions that is set up to predict the evolution of several parameters of interest for aquaponics.



Detailed fish growth process - the fish follow a Von Bertallanfy growth curve parametrized for each specie and the environmental parameters influence the growth through limiting functions

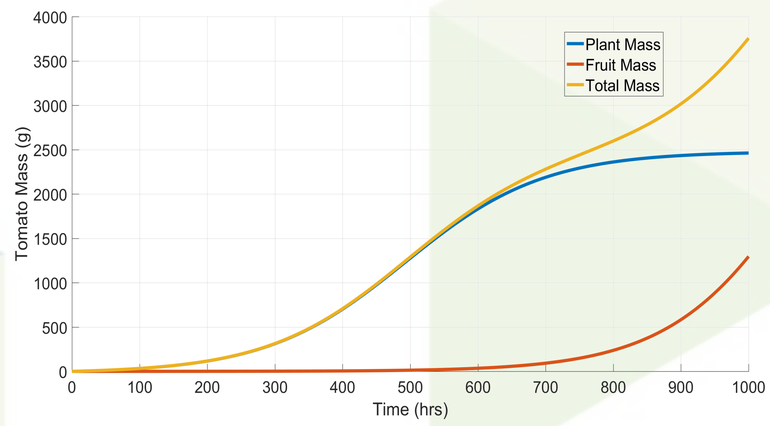


Results

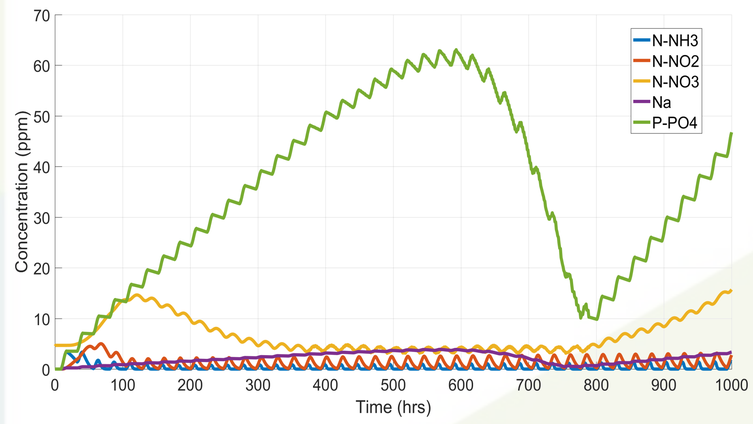


To generate the following results, the parameters of a simple coupled aquaponic system have been introduced in the model. In this hypothetical installation, 20 goldfish evolved in the presence of 6 lettuces and 1 tomato plant through a classic biofilter.

The computed outputs are various (cf. flowchart) and new ones are regularly added to keep pace with the continuous development of aquaponics. Two example of results are given below to illustrate the dynamical behaviour of a few variables of interest.



Theoretical growth curve of a tomato plant for a non-limited modelled growth during a production cycle of 40 days



Theoretical concentrations in the fish tank for different nutrients in the fish tank during a production cycle of 40 days

Prospects

The results of the model are very logical and plausible. However, the sub-models were built using values found on studies specialized in the different fields addressed by aquaponics such as aquaculture, hydroponics or microbiology but they have not been validated yet.

The coming step is to equip a variety of aquaponics installations with sensors in the context of the Smart Aquaponics project, in order to generate a strong aquaponics database that will be used for model calibration and validation.

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