Digital Twins for plant life in an urban context

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Urban green spaces of a city are an important element not only for its citizen well-being but beneficial for the environment as well. However, green space planning is often based on purely aestethic and economic reasons. Reducing maintenance costs, including sophisticated biological expertise and integration in existing infrastructure is therefore a key aspect for modern green space planning. Digital Twins for plant life utilizing Knowledge Graphs are a promising solution.

Unlocking greening potential

Trees have a wide range of beneficial effects on urban spaces. They provide shade, purify the air and cool the microclimate by evaporating up to 400 liters of water during a hot summer day. Moreover, they have a beneficial aesthetical effect and increase biodiversity. A lot of greening potential is still unused and could be unlocked by new and innovative ideas. Places such as roofs, walls or parking spots are increasingly considered eligible greening areas. Improving these difficult-to-reach spaces with more vegetation requires new and innovative methods. A digital solution might just help foster more green in cities.

Digital Twin meets Knowledge Graph

Digital Twin is an emerging technology paradigm focusing on real-life entities and mirroring them to a virtual counterpart. At their core, they automate data gathering, facilitate live as-is insights and use actuators based on automated decision-making. They have been widely adopted in many fields of application, including car manufacturing, airplane construction, real estate management, etc. However, surprisingly few advances in agriculture, smart farming or forestry have been made toward Digital Twins. Implementing such a Digital Twin requires the integration of cross-domain data and a multitude of devices. These requirements pose technical challenges which Knowledge Graphs can manage. Knowledge Graphs can provide a machine-interpretable harmonization of heterogeneous data sources and are able to reflect complex relationships about relevant Digital Twin information. Software „reasoners“ can then scan through the Digital Twins system and infer new knowledge based on a proposed rule set. This reasoning enables tackling advanced technical challenges faced by Digital Twins and IoT.

Automated tree irrigation using Digital Twins

A Proof-of-Concept (PoC) implementation of a Digital Twin for smart tree irrigation in the city of Zurich has been implemented. Each tree is represented by its Digital Twin and the accumulated data is stored within a Knowledge Graph, giving it a small virtual presence. The Digital Twins contain advanced metainformation such as geolocation, type of tree, current health state and more. Digital Twins are automatically linked to another Knowledge Graph published by the Food and Agriculture Organization of the United Nations, making it possible to discover potential threats such as pests and diseases. This knowledge is then exploitable via API or user interface and offers advanced capabilities for data analysis. A small IoT testbed was created to assess the technical feasibility of automated decision-making based on a rule system. Machine-to-machine communication was accomplished by leveraging the new Web of Things (WoT) standard. The interplay between WoT and Knowledge Graphs enabled a more sophisticated way of defining rules for automated tree irrigation. Instead of conventionally defining actions in a rigid „chain-of-command“ style, it was possible to formulate a desirable state and the system itself matches appropriate actuations to achieve it. In this case, the goal was to keep the trees saturated under consideration of current root zone humidity, temperature and weather forecast. Such a system is still slightly futuristic but nonetheless draws a new perspective on autonomous systems.

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