Hungry EcoCities
S+T+ARTS Residencies

Deliverable 1.2 – Contemporary agri-food AI urgencies framework

Version 1.0

Grant Agreement Number	101069990
Project title	AI enabled artistic solutions for sustainable food systems
Start date of the project	Sep 1st 2022
Duration of the project	42 months
Date of submission of the report	30.04.2023
Workpackage No.	1

Project coordinator: Brno University of Technology (BUoT)
WP leader: Aart van den Bos + Stichting NethWork / EatThis
Lead authors: Stephan Petermann (ET), Aart van den Bos (ET), Rodolfo Groenewoud (In4Art), Lija Groenewoud (In4Art), Pavel Chaloupsky (MENDEL), Robin de Croon (KUL)
Reviewers: Pavel Smrz (BUOT)

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History of changes

Date	Version	Author	Comment
28.03.23	0.0	All	Discussion on agri-food AI urgencies
05.04.23	0.1	All	structure
20.04.2023	0.2	Rodolfo Groenewoud (In4Art)	Draft
25.04.2023	0.3	Pavel Smrz (BUOT)	Review
30.04.2023	1.0	Rodolfo Groenewoud (In4Art)	Final version

*comment refers to draft/ update/ review etc

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1. Abstract

In this deliverable we bring together the outcomes of the preparational work in Work package 1. During the first eight months of the project, covering the period September 2022 until April 2023, the consortium members dedicated a lot of effort into setting the stage and preparing the ground to work on the expected outcomes of the project. This effort resulted in the following outcomes:

A/ the development of three knowledge hubs, consisting of consortium members and external experts / sources, around the three studios in Hungry EcoCities. The development and organization of these hubs is described in deliverable 1.1, which was delivered in December 2022 (M4).

B/ the development of the Directions Booklet, concluding the research and selection effort for the project content drivers of the studios, their knowledge hub members, and the consortium members. This booklet, published in designed form online and an integral part of the open call for artists, explores our topic in three main directions, each of which are broken down into three fields of investigation.

C/ the development of the AI technologies toolkit. The three technical universities in the consortium have led the identification and exploration into AI related technological fields of development which will influence the futures of food systems. Within these fields, the universities have identified specific tools/methods and areas of expertise to bring into the experiments throughout Hungry EcoCities. Already part of the open call documentation on an abstract level, this deliverable will describe the 11 AI related fields we have in our scope of expertise.

The purpose of this deliverable is to conclude our content preparational work before we enter the first set of residency experiments, the Humanizing Technology Experiments, by presenting the Hungry EcoCities Contemporary agri-food AI urgencies framework.

With this deliverable we complete the building blocks for the experimental residencies in the project. The ways in which the experiments work on challenges in this framework of investigation fields and technology tools will be further elaborated upon as part of deliverable D2.2, ‘HEC virtual fab lab framework architecture’, due in February 2024.

This deliverable is the result of partner efforts and an intense, one day, joint workshop during our consortium meeting in Berlin in March 2023. Even though we present our current work in this deliverable, we must stress the point that we are on an ongoing journey in this field and many new developments and insights are expected from the experiments and our continuous engagements with each other, the members from the knowledge hubs, and other experts and collaborators.

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2 – The AI related technologies toolbox of Hungry EcoCities

The technological university partners in this project have created a toolbox consisting of people (expert researchers), software (codes, algorithms, datasets) and hardware (labs, equipment) in 11 technological domains that are connected to artificial intelligence development. The toolbox is offered to the experiments to work with. Each experiment will work with one or more tools in the toolbox. At the moment of writing this deliverable, the first call for proposals is open for artists whom will relate their proposal to any of the tools in the toolbox.

The ways in which we, as a consortium, consider AI of relevance in the context of the future food system, is briefly and partially highlighted in the directions booklet. The text on the next page captures how the directions seemingly relate to AI at this moment.

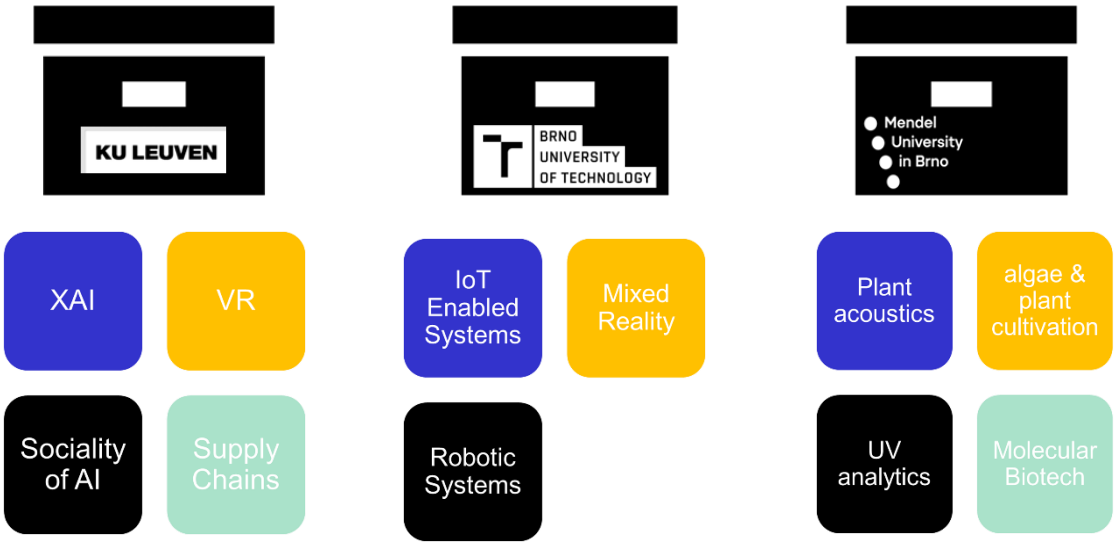

Figure 1: overview of the toolbox of Hungry EcoCities

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Overview of AI in Directions

Direction: LOCAL CONDITIONS
Studio Other Spaces Knowledge Hub Germany

Today, artificial intelligence (AI) is poised to radically transform not only our food cultures, but also our food systems. AI, and the neural networks behind it, will likely alter how food is grown and processed in many countries, in addition to how societies think about and talk about food. Just as established technologies already do, AI will further inform what, when, and where we eat, what we buy, and how we cook. AI also has the potential to offer new insights into and tools for producing and processing nutritious food for our growing global population, which currently exceeds 8 billion people. At larger scales, AI can be deployed in tandem with sustainability initiatives to help minimise food waste and increase food security in ecologically and socially responsible ways. Studies have shown promise that AI-powered optimisations may also be able to help minimise our dependence on fossil fuels, for example in the handling of food waste, and to increase local environmental health, and hence the well-being of the planet. At Studio Other Spaces, we want to engage projects in Hungry EcoCities that think critically about the potential of AI and take a holistic approach to assessing where AI can offer insights and solutions. We are also interested in exploring how AI and underlying neural networks can incorporate traditional knowledges – ways of farming, cooking, and working with the land that certain (industrialised) communities have lost touch with, and to which other contemporary communities, often indigenous, are already deeply committed.

Direction: CITY+FARMING SYNERGIES
Carlo Ratti Associati Knowledge Hub Italy

While rural areas might be ideal places to achieve exponential growth in yield rates, especially by leveraging Artificial Intelligence and other new tools, the roles of cities in future food scenarios will have to be multifaceted. How could AI support in the mission to create farmscrapers? Can AI align demand with supply to reduce energy and waste, and assist in the “traceability” of the food cycle?

Direction: MEGA SCALE
EatThis Knowledge Hub Netherlands

Could the Gigafactory be a public interface that encourages caring more about the production of our food? Can we think of the gigafactory as a city in a city? How can artificial, human and non-human intelligence have a place in this new typology of controlled environment agriculture? What are the conditions this would spatially require in a city? Would we be able to use satellite data and artificial intelligence to guide us through finding where we should grow? How would the AI models used in CEA respond to a poly-organized production area?

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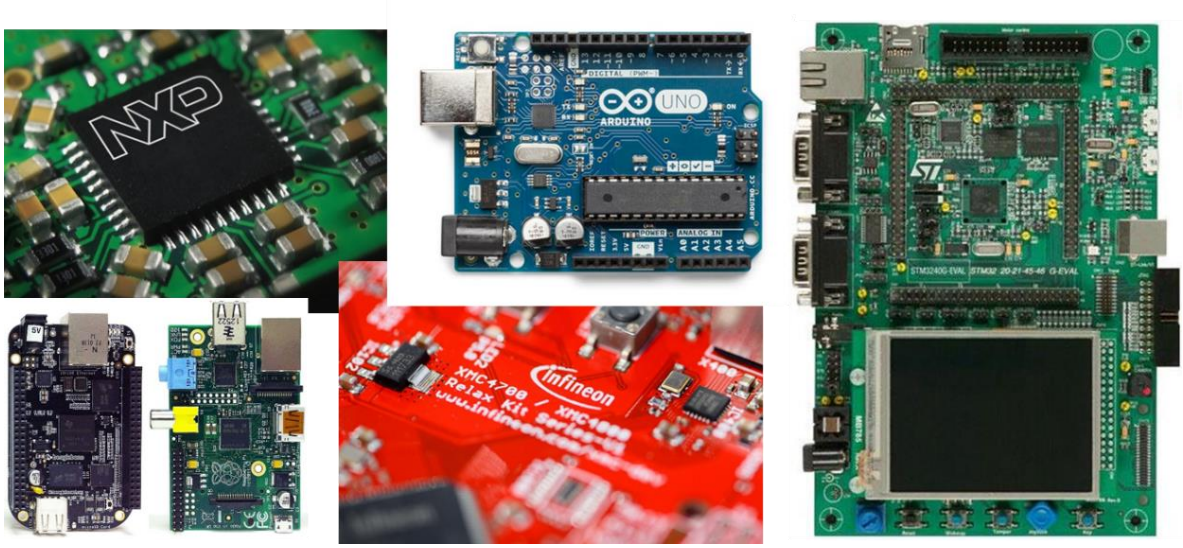
Tools: IOT Enabled Systems and agents

Tech experts: Brno University of Technology

Internet enabled devices and things are already all around us. Also in the food systems, IoT devices are present. Think of monitoring devices for growth operations, field operations, storage conditions. Or energy consumption regulators, stock management systems, logistic system optimizers, food quality sensors. In the food sectors there are many use cases known and unknown where sensorics can be of benefit for efficiency, optimization or otherwise.

In this toolset, we include all developments on IoT in the food system – embedded intelligence, edge computing, in-field data analysis, communication with the cloud, incremental learning environments.



There are many angles to consider when adding sensors and cameras into an operational environment, or a consuming environment. How is security assured? Privacy? Who has access to the systems and who has the knowledge to operate them? What happens with the data not strictly necessary for the purpose?

Because of these legit but complex questions, there is a notion in biological/regenerative farming practices that tech is bad. We do not think this is the case, IoT systems can support in coping with increasing complexity and making better informed decisions. The IoT enabled systems can provide insights from various sensors and hence, provide insight in the conditions in the field or supermarket, costs on the ground, scanning surfaces, human relation to the food, learn patterns, develop tools to do it better, simulation of biological processes. Efficiency, and consequently sustainability can be achieved efficiency through a higher degree of data usage in the right ways. In the visions, it can also contribute to upgrade the idea and perception of the biological farmer. AI future literacy topics for IoT Enabled Systems include Data Erasing (how to select for only that data which is required for the operation), Data Access (who gets access to what, when) and Data Control (who decides, and based on what?)

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Tools: Mixed reality / AI in Metaverse / Gamification and Storytelling

Tech experts: Brno University of Technology

The virtual reality can be seen as the extended media, a mixed reality that adds another layer over the physical world. It is another interface, an extension of the physical place. This leads to various formats of interaction with food, where experiments could indulge a more responsible choice (notion, that the responsible choice on itself should be investigated, what it is that makes it a responsible choice for whom and under which conditions). Food is something that grounds us to the physical. It is a reconnecting tool, the backbone of our life. Translated to the digital, we search or ways how to live in a digital world, while have the connection with food. It transcends from information to an experience, in which the following elements can be taken into account:

> storytelling
> stimulating senses
> reach places you wouldn't otherwise connect to
> insight in nutrients
> production costs
> physical grounding
> stimulating human-human interaction

When using this interface, there are also some conditions brought forward in the discussion, to make sure that the grounding with the physical is in place:

> explain how this tool is not disconnecting from the physical world?
> add different sensory impulses to stimulate and make clear the physical notion of food
> show the facts of where something comes from (origin) / transparency

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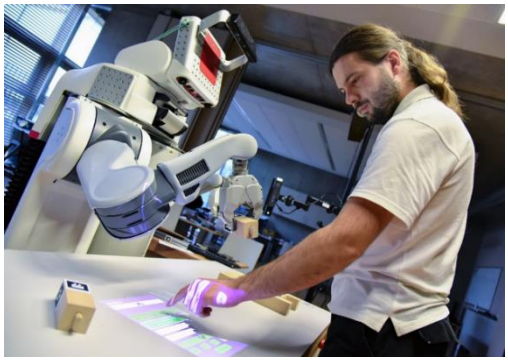
Tools: Robotic Systems and their natural programming

Tech experts: Brno University of Technology

The field of robotics can be analyzed in different ways, in this context we distinct between six main robotic system groups:
1/ Unmanned Aerial Vehicles (UAV), commonly known as drones
2/ Automated Guided Vehicles (AGV)
3/ Autonomous Mobile Robots (AMR)
4/ Humanoids
5/ Cobots
6/ Industrial Robotic Arm systems

Robotic systems are increasingly being integrated into food production practices, in use cases ranging from automating agricultural tasks, monitoring for precision farming, operations improvements, pest control and land monitoring. Also in processing parts of the value chain (selection, packaging, post processing) robotic systems are used increasingly. New use cases are being developed on a continuous basis, such as drone delivery systems or cultivation robots. In this toolset, primarily cobot applications and UAV applications are considered relevant for the Hungry EcoCities experiments.

The trigger point for discussions in this domain is that the robot is not a replacement, but a connection. It can stimulate interaction, even human- human interaction, like the cocktail Robot of CRA. An important element is the accessibility of these devices and the energy consumption. A change from vanity (the looks & feels) to the functional oriented achievements.



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Tools: Explainable AI

Tech experts: Leuven.AI

Explainable AI, also known as XAI, refers to a set of methods and techniques in artificial intelligence (AI) that aim to make the decision-making process of AI models transparent and understandable to humans. In other words, XAI is an approach to designing AI systems that allows humans to understand how the AI arrives at its decisions or recommendations.

Some of the techniques used in XAI include model interpretation, which involves analyzing the internal workings of an AI model to determine how it makes decisions, and model transparency, which involves designing AI models in such a way that their decision-making process can be easily understood and explained. Other techniques include generating human-understandable explanations of the AI's decisions, such as through the use of natural language generation or visualizations.

XAI can help to bridge the gap between technical AI experts and non-experts by providing understandable and interpretable explanations of how AI models make decisions. Doing so, it can play a crucial role in enhancing public trust in AI, as it can help to alleviate concerns around bias, accountability, and transparency in AI decision-making. By providing human-understandable explanations of AI models, XAI can also help to democratize access to AI, making it more accessible and understandable to a broader range of stakeholders. XAI can (1) help to promote AI literacy by enabling individuals to understand and interact with AI models more effectively; and (2) help to promote ethical considerations in AI design and development by highlighting potential biases or limitations in AI decision-making.

Organizations need to master the fundamentals of explainability through establishing a governance framework, putting in place the right practices and the right set of tools.
Different users/consumers of the AI systems data have different explainability needs. XAI is particularly important in situations where the decisions made by an AI system can have significant consequences, such as in precision agriculture or health/food recommendations. By providing explanations for the decisions made by an AI system, XAI can help to build trust and confidence in the technology, as well as identify potential biases or errors.

Hence, implications for AI Literacy, lead to:
> human control mechanism (what can/cannot be changed, learning what is of influence)
> transparency (of the source or the model)> perplexity and diversity (ensuring different perspectives)
> perpetuity (always changing conditions)
> prompt engineering (developing better questions)
> informed decision making through actionable insights (augmenting the intellect – tools that help deciding)

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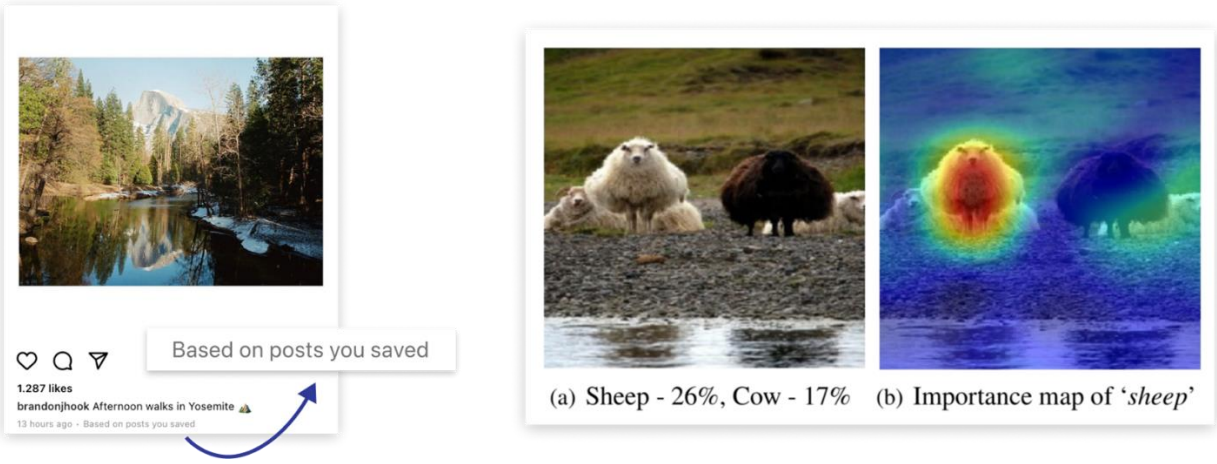
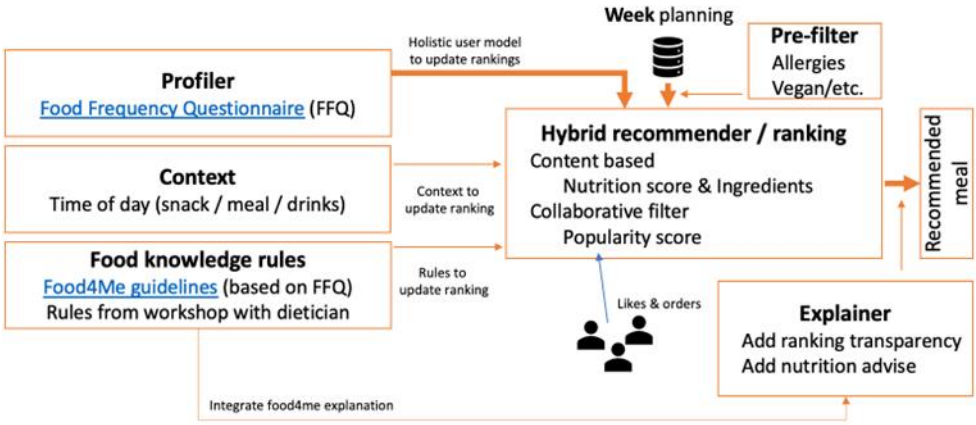
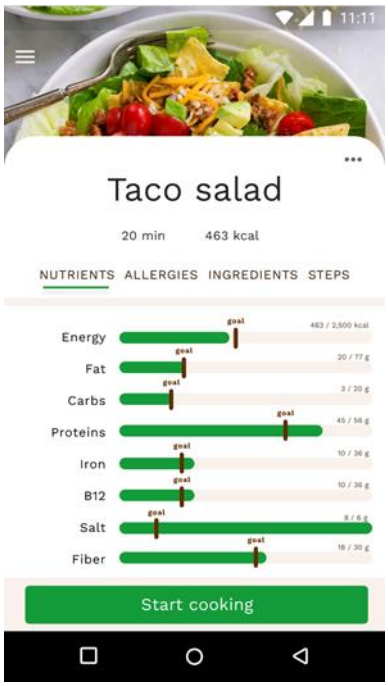


Example: textual explanations to complex visual maps



Example: Explanation interfaces development



Example: personalization interfaces

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Tools: Sociality of AI

Tech experts: Leuven.AI

Social effects of AI. Inequality in labor markets, social democracy in workplaces, job quality and wellbeing, new business models. Fairness of decision making. Rights of digital workers, rights of AI? Ability to exercise citizen rights. The broader issue of the sociality of AI, with specific interest in labor aspects of the green transition in relation to AI recommendations.

From a literacy aspect, it shows various aspects, relating to: equality, fairness, affordability, accessibility. Digitalization has an impact on all these layers and how it influence the people and the planet. It starts with discussing the type of society that a direction envisions, having the possibility also for utopian and dystopian thinking to understand what fits. It deals with creating an interface to understand what happens. This provides different directions for mapping the sociality:

- interface through which we have the interaction
- the different modes of interaction.

It is linked to getting a holistic overview that gives insight / input to:
- shared resources
- support learning
- support connection (among people, animals, plants)
- take into account criteria of:
> sustainability
> inclusivity
> beauty
> trust
> fair price/ true price (positive and negative costs production and health)

From the urgencies, a need to Reconnect & Engage, become a carrier, in which this tool, could be used to gain insight in the trade-offs, since the sociality enables possibilities for engagement:

- between humans
- between humans & animals
- between humans & plants
- between plants & animals

This topic is closely linked also to education, activating awareness to make a physical/ sensible connection by using ‘multiple knowledges'. It deals with activate to care, make aware and empower activation.

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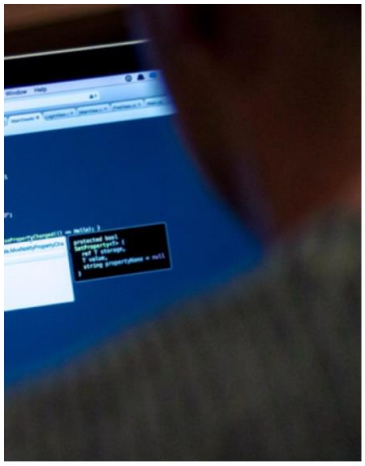
ABOUT RESEARCH TEAM



AI, Digitalization & Work

Recent research projects of the **Employment Relations & Labour Markets** group focus on digitalization and the emergence of digital work. These developments are likely to have a profound impact on existing labour market regulations, affecting industrial relations systems, the quality of work and the employment relationship.

Digitalization may also lead to social divisions in European labour markets. This is because new forms of work – often unregulated forms of work – are being created. This does not only pose a challenge to our regulatory framework, but also the very notion of work in contemporary societies. Since digital workers may not be entitled to social protection, they might suffer from precariousness.

Examples of Sociality of AI topics

Fairwork Belgium Ratings 2022: Labour Standards in the Platform Economy

SOCIAL GREEN DEAL

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Tools: Algorithmic Supply Chains

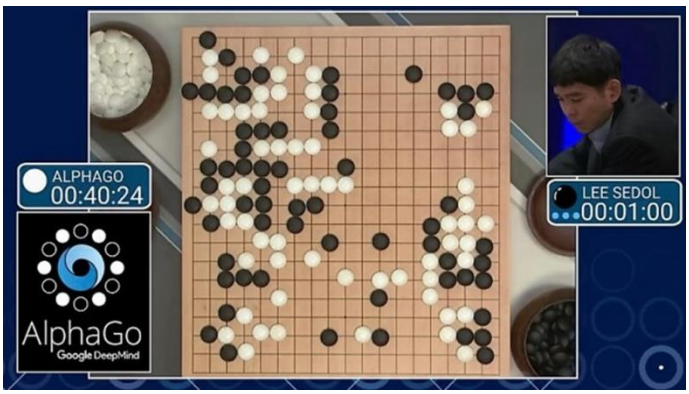
Tech experts: Leuven.AI

By leveraging the data insight in the processes of the supply chain, insights can be gathered on the efficiencies and costs, related to transport but also workforce. Hence, it related to connecting networks, smarter networks and resource optimization. It leads to optimization in inventory management, just-in-time delivery options and insight in the network and actors involved.

This approach can help our experiments to get insight in:

> FairPrice and sustainable options
> trust in the supply chain – e.g. is it really biological/sustainable?
> what is efficiency when approached from the basis of regeneration?
> opportunities for sharing services and recourses – linking to the urgency of creating a sense of collectiveness.
> opportunities to calculate logistics decarbonization
> pricing dynamic experiments : pricing on consumption date (close to end date)
> insights in the km2 travelled per product

The urgencies show us a need to make the supply chain more transparent to understand how the food gets to the table. This influences the way the public space can be used.



Using reinforcement learning algorithm also used by AlphaGo

Real-time visibility, alerts.
Intelligent Decision Support
Autonomous Decision making

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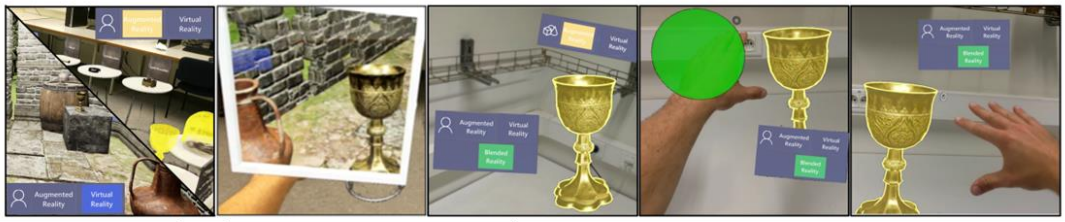
Tools: Virtual Reality

Tech experts: Leuven.AI

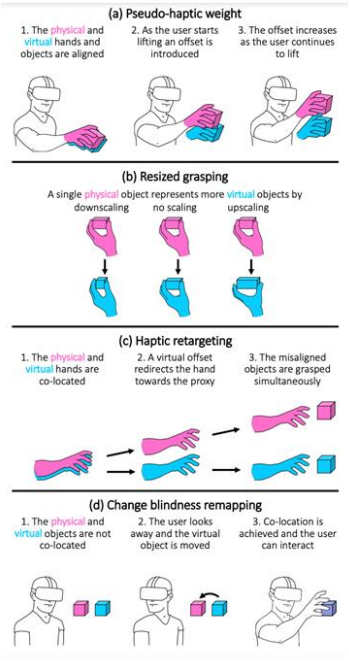
The Virtual Reality toolbox contains four elements which all relate in different ways to pushing the boundaries of VR experiences.

- Cross-reality interaction techniques use blended reality to combine physical and virtual elements in a single space of experience.
- Virtual Reality with Haptic Proxies add real-world constraints to virtual environments, such as gravity or air resistance.
- Natural walking in Virtual Reality allows for the folding and bending of virtual spaces to allow for natural movement experiences in virtual space.
- VR user studies consists of a set of hardware and software components which can be used to test use cases in VR.

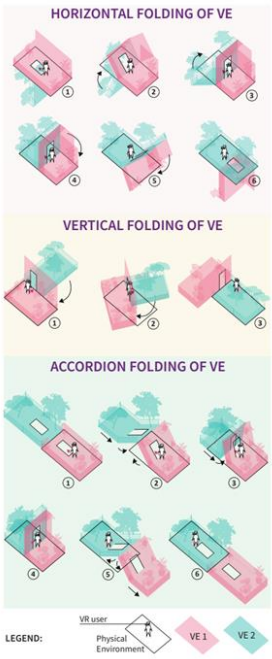
Dealing with the urban infrastructure, new public space uses are foreseen. The data from this direction can identify plots and dots, where options from the experiments might occur.



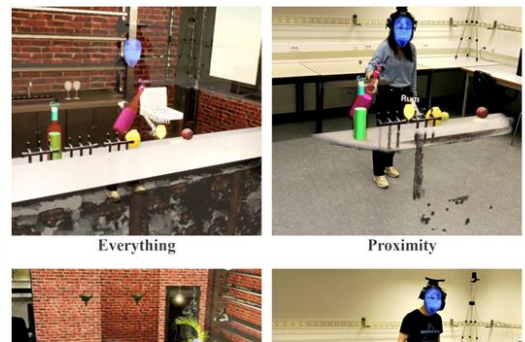
Cross-reality interactions



Haptic proxies in VR



Natural walking in VR



User studies in VR

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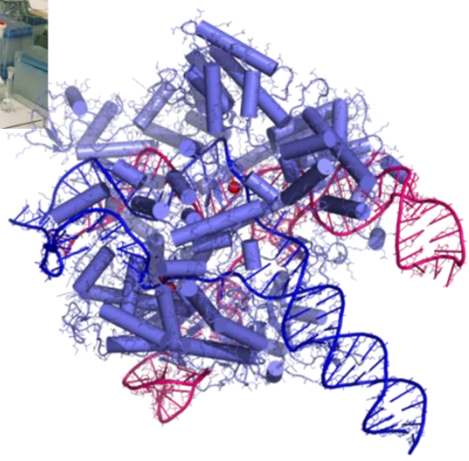
Tools: Molecular Biology

Tech experts: Mendel University

The skill to sequence the genomes of organisms on a molecular level is very new and in fast development. By learning about the molecular characteristics of organisms on all scales, from singular cell organisms to humans and animals, a new door has opened in the field of biological research and knowledge building. Molecular level differences and interactions between species are being discovered on a continuous basis, leading to insights into the effects of human activities over time and place on the evolution of many species.

Taking the holistic approach of the molecular data, requires us to analyze the input from an ecosystem perspective:

> what are we intervening with?
> what patterns evolve when using timelapses
> what networks & relationships are established/ assumed.
> genome engineering for crop modifications – when is it good and when is it bad?
> new, additional, layers of biodiversity are being exposed
> this allows the local to be very small – local on the level of the molecule.



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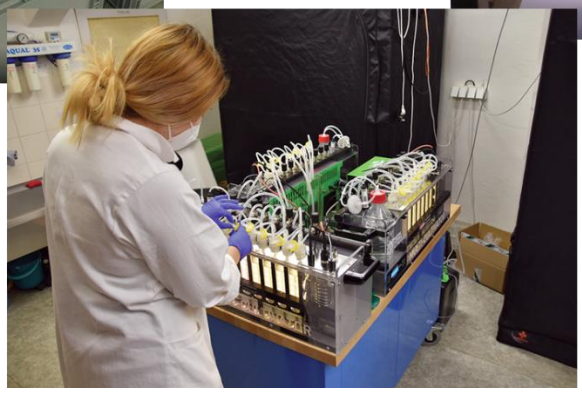
Tools: Algae / Plant Cultivation Systems

Tech experts: Mendel University

This topic deals with novel food and managing the conditions and nutrients for novel food materials. It is linked to changing the thinking of algae, not barely as a supplement, but as a separate food source. It leads to questions as how to consume this new food? How will the new food reach the customer? How to make it taste good? In which forms can it exist? How to make it beautiful? How to make it popular, and should it? How to inform on the value of it?

Algae can be linked to all three directions, through the bioreactors the scalability can be addressed, as part of a nutrient factory. Algae can contribute to the ambition of bringing nature back into the city, the algae making it a more-than-human city. At the same time, it is also be a local source (spirulina) and enthuse local customs and processing.

We see a clear link with sociality of AI, since it can be developed hand-in-hand with understanding cultivation and how this is fueled by culture. The AI literacy should provide insight in the intended and unintended consequences of an action.



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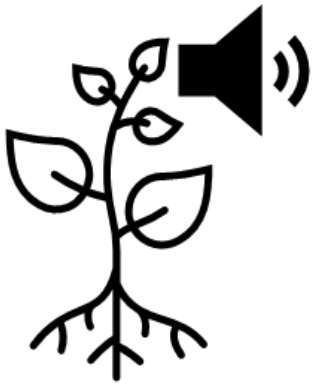
Tools: Plans Acoustics & UV Analytics

Tech experts: Mendel University

This category deals with giving the well-being of plants a face and voice. In essence, by doing so, it creates agency to the non-human species and by incorporating this in the AI literacy, it ensures that the data is already including this perspective as an input. However, it should be noted that these developments ae very new and are still in an experimental and research phase. These tools allow for the monitoring of plant stress, caused by toxicants, pollutants or other factors of influence. The effects of treatments can be measured, teaching us how species respond to certain treatments on shorter and longer terms (across generations). UV spectral analyses delivers plant specific, unique, insights into the metabolic compounds of a plant. These measurements are a sort of UV finger prints, raising the possibilities for specific, individualized analysis and treatment of plants. On larger surfaces, the same technology creates application maps which show soil health and plant compounds on a detailed level, supporting precision farming practices.

Nonetheless, taking these elements into account, it can support our future notion of AI literacy in the agri—food and support our thinking on dimensions like:

> what interfaces are needed to understand what it means to have the ‘voice / face’ of plants? Increasing complexity requires technology and ways to work with these technologies. Interfacing will be an important topic of future literacy.
> complexity is increased, if we know more about the plants, they are less anonymous, hence they get a portion.
> what are the crops rights in the ecosystem? How to use their data? Role for blockchain?
> potential to identify synergies and create awareness by taking out of the anonymity – which is the opposite of today's situation in food.
> the bottleneck lies not in the production of data, but in the capacities to analyze the data.
> tensions between individual plot level knowledge and scaling – we don't know how to scale yet



> probes, currently in early stages of development and cabelized, are a sub step to satellite remote sensing and individual crop treatment once they can be made wireless and scaled.
> mitigating parts of the risk of not selling by being able to analyze and plan on individual level
> building relationships with the origin – transparency on what something really is.
> healthy food starts with healthy diets for our food – diets for our plants.

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3 – Contemporary agri-food AI urgencies framework v1

Following the identification of the fields of investigation by the partner studios and the elements in the AI technology toolbox, we can create an initial mapping of the correlations between technology fields and investigation fields. The figure highlights in blue where technological developments and points of attention overlap with the fields of investigation. This initial mapping follows the workshop on this topic the consortium held in Berlin in March 2023. Once the Humanizing Technology Experiments are selected and ongoing, an updated map can be created highlighting where Hungry EcoCities focusses on in developing the experiments and spill-over activities.

		BRNO UNIVERSITY OF TECHNOLOGY			KU LEUVEN				Mendel University in Brno			
		IoT systems & agents	Mixed Reality	Robotic Systems	Explainable AI	Sociality of AI	Algorithmic Supply Chains	VR	Molecular Biology	Algae/Plant Cultivation	Plant Acoustics	UV Analytics
Studio Other Spaces	Explicit food cultures											
	Sustainable food education											
	Food aesthetics											
CARLO RATTI ASSOCIATI	Farmscraper											
	Urban planning toolbox											
	Supermarket of the future											
eat this.	Grow locations											
	Gigafactory for Food											
	Greenhouse of the future											

Figure: Hungry EcoCities Framework v1

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4 - Reflection and Lessons learned.

The EU has issued the AI Framework directive, in which it has written the following approach:

“The EU’s approach to artificial intelligence centers on excellence and trust, aiming to boost research and industrial capacity while ensuring safety and fundamental rights.” (A European approach to artificial intelligence | Shaping Europe’s digital future (europa.eu))

Within Hungry EcoCities, we want to contribute to this AI literacy. To do so, we will work throughout the project on several reports to inform agri-food AI literacy.

In this deliverable, we analyze the different tools that are used by the partners within the experiments and link them to the proposed vision. In deliverable D2.1, an AI literacy requirement framework will be created, to ultimately result in a HEClab: a digital environment, assessment & recommendations tool for AI usage in responsible food innovations.

The main question behind the AI literacy is how to use these type of tools in a responsible way. The developments are exponential, many AI tools are provided open and are available for all to use. However, there is a black box behind it, which needs to be addressed:

1) understanding of AI concepts & data selection & applications
2) ethical considerations
3) social implications

It questions on what database the AI and experiments are based:

1) who owns the data
2) who creates the data
3) fairness notions in data (verification of data biases/ data dependencies: needs of (non) humans – for what purpose is the data needed)

Hence, we see the work on AI literacy and AI usage in responding to urgencies in the food value chain a central element of Hungry EcoCities, on which we must reflect, from which we must learn, and what we should analyze and diffuse into the food domain throughout our project, in the experiments, around them and after them.

The description of the tools and the mapping against the fields of investigation in Hungry EcoCities must therefor be seen as nothing else than a first setup, which we intent to further explore and untangle as part of the residency experiments.

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Partners Hungry EcoCities

Horizon Europe Research and Innovation Action – This Hungry EcoCities project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement 101069990. It is part of the S+T+ARTS programme. S+T+ARTS is an initiative of the European Commission to bring out new forms of innovation at the nexus of arts, science and technology.

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