Growkit: Using Technology to Support People Growing Food at Home

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ABSTRACT

The rapid growth of urban populations creates challenges for food production. One solution that is potentially more sustainable than current methods is localized production, in particular food production by individuals at home. Growing food at home is possible, but it is a process that requires motivation, knowledge and skills. Here, we present the design of a sensor platform aimed at helping individuals in urban environments grow food at home by informing them about the needs of their plants and, based on urban farming practices, by connecting them with a network of growers to share knowledge and produce.

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Figure 1: Visit to a community garden in Amsterdam to gain insights into the organization of the garden, the types of plants that are grown there, and the community itself.

KEYWORDS

Community garden; Urban gardening; Vertical farming; Agriculture 4.0.

INTRODUCTION

The current food system feeds 7.3 billion people and very few of them are involved in food production, while more than half live in cities. By 2030 the world population living in cities will rise to 5 billion [10]. This creates a significant challenge in providing global urban populations with sufficient food in a sustainable way.

The next generation of food production, also known as the fourth agricultural revolution (i.e. agriculture 4.0), involves new ways of producing food in more efficient ways through the use of new technologies, such as the Internet of Things, robotics, and Artificial Intelligence, with the potential of radically changing farming practices [8].

One of the most well-known and promising example of agriculture 4.0 is vertical farming, which makes use of technology to create a controlled indoor environment with the goal of recreating the optimum conditions required for plants to grow. Vertical farming can involve aeroponics (using water vapor for moisture and nutrients), hydroponics, or drip irrigation to drastically reduces soil consumption, water consumption, and the need for space [3].

Vertical farming is typically deployed at a large scale but there are efforts to replicate the benefits of vertical farming for home use, with some success. A commercially available example is *Smart Garden* by the company Click and Grow which features automatic watering and ambient light adjustment [1]. Another example is Open AG Food Computer [5] which is an open-source desktop-size platform that measures and adjusts the environment within the enclosure to mimic a plant's native climate. The aim is to collectively share data and analyze plants' growth using "climate recipes"[5].

Despite these innovations people are not yet fully prepared to accept complex technological systems in their homes for the purposes of growing food [7]. Moreover, vertical farming systems, even for home use, still require a significant amount of space, which is scarce in urban living environments. What is more, the complexity of technological methods of food production, such as vertical farming, tends to make people skeptical about the "naturalness" of the cultivated food [7].

In order to address both these issues and to potentially pave the way for other, sophisticated home-based food production solutions like vertical farming, we present the initial design of a sensor system that helps people to more easily grow food at home and connecting them to a network of like-minded individuals to share knowledge and produce. This home system could work in conjunction with bigger vertical farms in the city and help people get used to the idea of the combination of nature and technology. We aim to recreate the values, human connections, and support of community gardens through digital technology.

Figure 2: The empathy map created based on interviews with members of the urban gardening community.

URBAN GARDENING COMMUNITIES

We decided to focus on already successful urban farming initiatives as a start to the project, namely, community gardens. Community gardens are areas in cities reserved for non-commercial horticulture where people meet multiple times each week to work together in all the processes involved in growing food, and then share the produce among members of the community.

Urban gardening communities have been shown to be successful in motivating people to be more involved in food production and sustainable ways of growing food, as well as providing benefits to food security, community development and human health [6]. Our aim was to take inspiration from urban gardening communities to see if we could replicate some elements of these communities in a distributed manner, aided by technology, in order for people to become small-scale urban gardeners at home.

To this end we scheduled multiple visits to 'Anna's Tuin en Ruigte' at Amsterdam Science Park within the city of Amsterdam, where permaculture methods are tested and applied to grow fruits and vegetables (Figure 1). We observed the organization of the garden, participated in maintaining the garden, talked to members of the community, and conducted 1-to-1 interviews.

Urban gardening community interviews

We interviewed 5 members of the community garden and used input from the interviews to draw an empathy map [4] (Figure 2). We asked each interviewee about their level of gardening expertise, what kind of plants they grow at home, and what their general challenges with growing plants to produce food are. Three respondents were young adults between 25 and 34 years old who recently got passionate about gardening, and were eager to learn more. The two other interviewees were gardening experts with a deep interest in gardening (also as part of their university education) and played a central role in the community garden. The novice gardeners remarked that they mainly grow herbs or small vegetable plants like radishes and carrots: "we plant it and just wait and see what happens. Sometimes we don't know what is going on with the plants so we just ask each other". The possibility to discuss with each other and with more expert gardeners was mentioned as a strong motivation for the novice gardeners to not give up and find answers when in doubt about their plants. The expert gardeners noted that they already use technology for specific technical tasks related to growing plants, such as measuring pH-levels, and did not necessarily need technology to improve their motivation for gardening.

Hardware iterations

During the process of gathering information from urban gardening communities, several hardware explorations were conducted. Input from the community was used in each hardware iteration. The first

Figure 3: A render showing what the Smart Ring prototype would look like in a home environment.

Figure 4: A user feedback sessions with the first Smart Ring prototype.

requirements that were obtained from the user research for the hardware itself were: 1) to accurately measure basic aspects of a plant's health in order to inform users about how best to treat their plants; 2) to design a hardware kit that could easily fit in a small urban house; 3) that is simple to understand and use; 4) and that connects a community of individual growers in a larger network.

The first prototype, called Smart Ring, is a ring containing sensors and lights that can be put in regular, round plant pots that people might already own (Figure 3). Multiple pots can be stacked one on top of the other so that a miniature vertical farm can be created. We evaluated this first prototype with 7 potential users (aged 23 - 36) and we found that they were fascinated by the possibility of measuring the condition of their plants (Figure 4). Regarding the sensors they remarked that they would like something that would not draw too much attention and that would only provide a limited number of notifications regarding their plants' health. Another aspect they underlined was that they would like to have something that takes up a minimal amount of space. The idea of stacking pots on top of each other was appreciated but it was mentioned that it would limit the possibilities of using already existing pots or growing different types of plants with different sizes. Furthermore, the structure with multiple pots was somewhat unstable, so we decided to explore other directions in the second prototype.

For the second prototype we deviated more strongly from the vertical farming concept on which the first prototype was based. We focused on designing a system that would be smaller, simpler and that could fit every possible pot the people could have in their homes. After an ideation phase we came up with the concept, made up of three parts: one or multiple sensor sticks directly connected to various plants, a central unit to display notifications, and a mobile application.

GROWKIT PROTOTYPE

For each of the components of the Growkit prototype several design iterations were created. Here, we focus on describing the latest designs of the components.

The sensors stick

The sensor stick (Catnip Electronics) measures the moisture of the soil, the amount of sunlight the plant receives and the room temperature (Figure 5). The stick can be put in a pot close to the plant that the user wants to monitor. The stick sends the measured data to the central unit, which will provide the user with feedback regarding their plant's health. On the first installation the user tells the stick, through the mobile application, the type of plant that it is going to monitor. The data received from the sensors are compared to the optimal conditions for that specific species of plant and feedback is given to the users through the central unit. Multiple sticks can be connected to a single central unit so that a user can monitor as many plants as they like.

Figure 5: The sensor stick detects moist, light and temperature.

Figure 6: The central unit lights up when a plant needs to be checked.

The central unit

All the sticks send the information obtained from the sensors to the central unit (Figure 6). The central unit displays the health of the plants to which each stick is connected to the user through lights and sounds. The central unit has a circular shape with three circles. The different circles represent the three different measurements of the plant (i.e. water, light and temperature) through an integrated LED strip. The LEDs light up depending on which measured aspect of the plant needs attention. For example, when any of the plants is subjected to an unfavorable room temperature for too long, the temperature ring will turn red indicating the user needs to address the ambient temperature of their plants. In case of multiple plants the user can check the app to which of plants might need special care (e.g. additional watering).

The app

The mobile application (Figure 7) receives all the data from the central unit and gives detailed information to the user about each plant that is being monitored. Thus, the app plays an important role in providing users with feedback about their plants.

Importantly, the app also serves as a way for individual users to connect with others around growing food at home. With this, our aim was to virtually recreate the community gardens' social aspect, that was considered to be a key component of the success of community gardens [9]. People feel more motivated when they can share knowledge and connect with other people with a similar interest [2]. The interviews with members of the community garden revealed some interesting social interactions that members engage in, such as showing their plants to friends, asking questions to more expert people when in doubt about how to best treat a specific plant, helping someone else by sharing personal knowledge, celebrating success and connecting with like-minded people, and sharing their harvest. Through the mobile application we wanted to connect individuals, not only in the same city, but also on a larger scale by giving them a platform where they can share the sensor data of their plants and get feedback on the growing process. Each user has a personal profile showing the plants they are growing and the milestones they want to reach. The community of users can interact and encourage each other by celebrating successes and giving advice through a forum section where everybody can share their knowledge and ask specific questions.

CONCLUSIONS AND DISCUSSION

The growth of urban populations in 2030 will lead to the need to investigate new ways of producing food in sustainable ways. Large scale solutions, such as vertical farms, are promising but part of the solution may involve individual citizens growing food locally, in their own homes. The aim of the current project was to design an easy-to-use, sensor-based, and app-supported prototype that helps

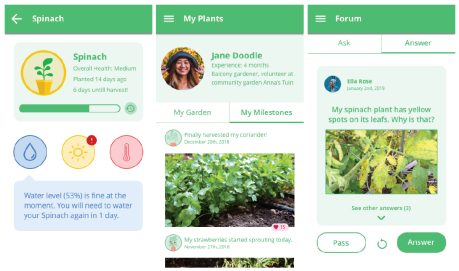

Figure 7: Screens of the app

novices to grow food at home. Importantly, the prototype connects growers in a network to share knowledge and produce in order to create a system of sustainable urban food production modelled after community gardens. The second prototype is still to be tested with users and plants, in order to gather feedback on both the sensing and the user interaction. We are currently planning a long-term evaluation with five prototypes of the second iteration in an office setting.

The main focus of future work will be on building up the virtual community aspects further. One idea is to integrate data obtained from home growers with data from vertical farming and urban gardens to obtain richer data sets regarding specific plants' growth conditions. An interesting, related question is whether food production at home can be integrated in a larger urban food growing system. Another aspect to be investigated more thoroughly is how to keep people involved in the virtual community and how to encourage them to share knowledge and produce with others. We continue to iterate on the current Growkit hardware as we continue to take inspiration from urban farming communities to build towards more sustainable urban food production.

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