Harmony in Bloom: Exploring Human-Plant Interaction for Musical Expression in the Internet of Plants Project

Author : SEGUI Matthieu
Contributors : STAS Nicolas, BOUFFARD-VERCELLI Diane

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ABSTRACT

This study explores human-plant interaction. This study has been conducted in order to understand what kind of interaction we have to detect in order to have the best and more natural kind of interaction with plants. The results will be applied in the Internet of Plants (IoP) project which is a project that intends to create a fully connected bio-organ system. The IoP is looking for reducing the gap between humans and plants by creating a symbiotic relationship between nature and technology and envision a world where our daily objects are responsive.

Plants represent a full ecosystem of evolution, adaptation and communication.

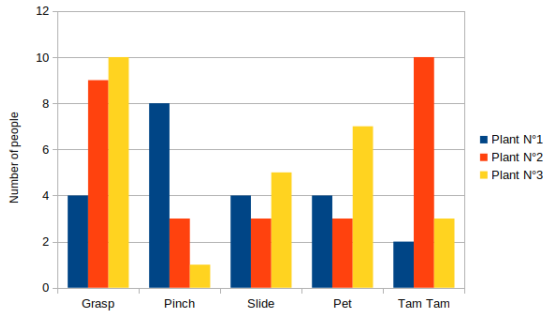

Fig. 1: Bar chart that is extracting the main types of interaction regarding each plants.

I. INTRODUCTION

In the context of the Internet of Plant (IoP) project, this study aims to extract the natural interaction between people and plants. This experiment explores the interactions the IoP device will have to detect to create a symbiotic relation between human and plants. The physical touch is the starting point of a sonification process. Sonification is "the use of non-speech audio to convey information or perceptualize data" [3]. Three distinct plant species—Dypsis lutescens, Pachira glabra, and Dracaena—are employed as subjects to extract user perceptions and interactions within this framework.

The methodology engage students from the engineering school and two researcher. Participants interact with the envisaged musical plants, employing tactile approaches, namely Grasp, Pinch, Slide, Pet, and Tam Tam. They imagine the interaction because the device is not yet ready.

The correlation between plant height and trunk interactions reveals environmental factors impacting human-plant dynamics. Additionally, interactions are categorized based on intensity, spatial displacement, and duration.

II. STATE OF THE ART

In the HCI world, the question of the human-plant interaction has already been asked. Seow and al. developed a framework that augment a *Mimosa Pudica* [7]. They designed and conducted a user study to test their framework Their user study is following a script of question that are based on the experience with the already built framework.

A more technical approach is explained by Poupyrev and al. with the *Botanicus Interacticus* framework [6]. The report does not present a user study but only the prototype for an art exhibition [2]. The information on the way to interpret the plant interaction is vague and only talk about machine learning.

R.F.M. worked on the interaction grade schoolers can develop with their plants [4]. The study tries to capture the human-plant link through sensors and also supervise the growing of the plants. Contrary to Seow and al. [7], he is only using non-intrusive ways to capture the interaction.

The human-plant interaction and collaboration is studied in different field of research. For example in the psychologic domain, Elings studied the benefits of horticultural therapy which includes the interaction between patient and pants during therapy [1].

This study will be conducted using the human centered paradigm in the human-plant interface. The reflection about the position of the plant or the human in the human-plant interaction is also a subject to be discuss. Indeed, Loh and al. studied and criticize the human centered HCI that is reducing the plant to an actuator [5].

III. METHODOLOGY

A. Participants

The study is conducted on 22 participants. Participants are mainly composed of engineering students. The participant set includes 15 males and 7 females. The age of the participants is between 19 and 22 years old. Only three participant are older than 22 years old.

B. Procedure

Upon welcoming each participant, we introduce the subject telling them : "We're in the very near future. You are looking at plants that make music when you physically interact with them (it is not actually the case, but imagine it). Explore their capabilities." Using this prompt, we tried not to bridle them to much but approach them to the physical interaction component. Subsequently, participants were given time to explore the potential musical capacities of the plants at their own pace. An important aspect of the procedure was our deliberate decision not to provide any guidance or answer questions during the exploration phase. In instances where participants encountered difficulty initiating exploration, the prompt was reiterated to encourage the participants to explore without the social boundaries (being judged by people for instance). This methodological approach was designed to capture the intuitive and natural human-plant interaction. Also, we avoided any kind of communication or talking between 2 participants to reduce the potential bias.

C. Materials/Tools

To proceed and conduct this user study, we choose 3 different plants from 3 different species.

1) Dracaena: It has long leaves and fragile perceived trunk but also flexible.

Fig. 2: The plant N°1 is a *Dracaena*. The plant is ... tall.

2) Pachira glabra: We chose to use this plant for its large leaves and its wide trunk. This *Pachira* is a bit taller than the *Dracaena* (figure 2).

Fig. 3: The plant N°2 is a *Pachira glabra*. The plant is ... tall.

3) Dypsis lutescens: The *Dypsis lutescens* is composed of many trunks and stems. On top of that, the leaves are numerous and tight.

Fig. 4: The plant N°3 is a *Dypsis lutescens*. The plant is ... tall.

4) The experimental space: The experimental space served as an open canvas for the exploration of human-plant interaction within the Internet of Plant project. While the configuration was not explicitly tailored to the plants, it provided a versatile environment that accommodated the envisioned musical flora. The space featured three distinct levels of height, each corresponding to one of the three plants introduced to participants.

Fig. 5: User study space setup. The set-up is built from our lab space.

IV. DATA COLLECTION

To capture the participant's interactions with the plants, a collaborative approach was adopted, involving two students linked to the project to provide dual perspectives. Throughout the exploration phase, both students took notes, documenting the diverse ways in which participants engaged with the three distinct plants. Each note explicitly specified the plant involved in the interaction in order to extract special features related to a specific plant.

The notes retrieved descriptions of participants' actions, movements and interactions. The dual-observer strategy facilitated tends to reduce the potential biased.

At the beginning of the experiment, the *Dypsis lutescens* was on the floor, the *Dracaena* was on a chair and the *Pachira Glabra* was on a table. At the middle of the experiment, we switched the *Dypsis lutescens* and the *Pachira Glabra* to see if the participants would interact differently with the plants. The set-up of the experiment is shown in Figure 6.

V. RESULTS

The data given by the user study allowed us to define 5 main types of interaction. Those interactions are defined by the way the user interacts with the plant. The 5 main types of interaction are :

- Grasp : user uses the whole hand to grab trunk or leaves.
- Pinch : user uses 2 to 3 digits to grab trunk or leaves.
- Slide : user uses his/her hand or finger to slide on the plant whether is on a leave or on the trunk. The action is continuous.
- Pet : user uses his/her hand to cuddle the plant or to pass through the leaves. The user is moving his/her hand in space. She/he is not staying still or staying on a particular object.
- Tam Tam : user taps on the plant mainly using the whole hand.

Looking at the results, we extracted the table I.

Plant/Interaction	Group 1		Group 2	Group 3	
	Grasp	Pinch	Slide	Pet	Tam Tam
Plant N°1	4	8	4	4	2
Plant N°2	9	3	3	3	10
Plant N°3	10	1	5	7	3
Total	23	12	12	14	15

TABLE I: Raw results extracted from the user study

Regarding the results we drew a graph.

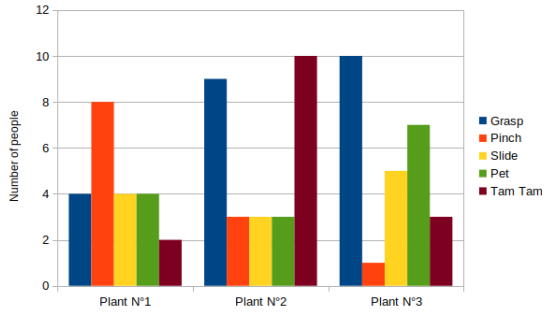

Fig. 6: Bar chart that is extracting the main types of interaction regarding each plants.

In the end, of the 22 participants, 15 were already familiar with the project and 7 were not.

VI. DISCUSSION

Looking at the results, the interaction were various depending on the plant. Thus, we can extract main interactions that are linked to the plant type. Looking at tab. I, people are more inclined to use their hands as tam tam or grasp the *Pachira glabra*. However, for the *Dracaena* people prefer to pinch the trunk or leave. People decided to grasp whether a pack of trunk or leaves when it came to *Dypsis lutescens*. This is induced by many factors including the leaves shape, the width of the trunk.

It was observed that when the plants were positioned at higher elevations on the table, individuals tended to engage more with the trunk of the plants.

Looking at table I, we decided to group interaction. This was done by grouping type of interaction depending on 3 main factors :

- The intensity factor : what is the intensity of the interaction (ex : pinch is lighter than grasp)
- The spatial factor : what is the interaction displacement.
- The duration factor : what is the interaction duration (ex : tam tam is instantaneous).

The ”Group 1” includes the pinch and grasp interaction. Indeed, looking at the 3 factors we defined, the pinch and grasp are high in intensity and long in duration but people stay still in space. This group of interaction can be defined as binary interaction. The user is either grasping or not.

The ”Group 2” includes the slide. The slide interaction is long in time, it moves in space but low in intensity. This group of interaction can be defined as continuous interaction.

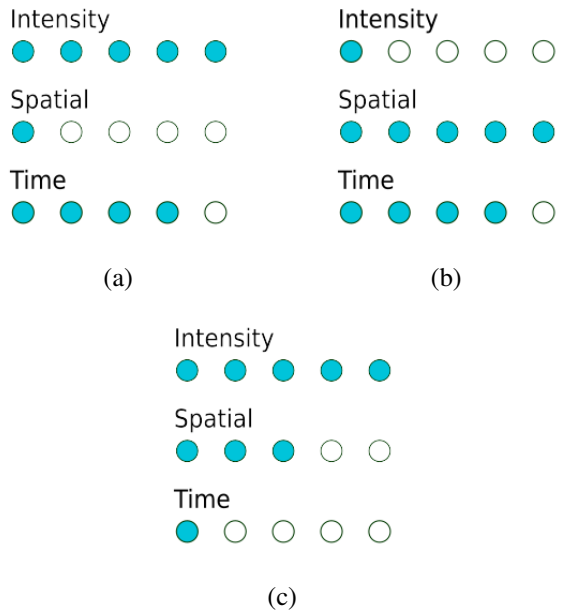

Fig. 7: Figure showing graphically the intensity of the 3 types of factors we defined. (a) Group 1 : pinch and grasp. (b) Group 2 : slide. (c) Group 3 : pet and tam tam.

Whereas, the ”Group 3” includes the pet and Tam Tam. These 2 interactions are really high in intensity, people usually tam tam and pet in different places but those interactions are short in time. This group is defined as repetitive interaction. The user is repeating the same action over and over again.

The participants we interviewed introduced a bias in the results. They were all students from the engineering school and thus, they all had a similar background. Some of them were already familiar with the project.

VII. CONCLUSION

During our study on the Internet of Plant project, we've captured insights into how people might interact with plants in a future where they make music through touch.

Our three chosen plants influenced how participants engaged with them. We observed everything from gentle petting to energetic drumming on the plants. Interestingly, we found that when the plants were higher up, participants tended to focus more on the trunk.

By grouping interactions based on factors like intensity and duration, we gained a clearer picture of how people approached these musical plants. It turns out that certain interactions, like grasping and pinching, were more common, while others, like sliding, had their own distinct appeal.

Regarding to the results we thought about what could be done with the defined interactions. For instance, the sound generated from the interaction could be linked to the kind of interaction. People doing Tam Tam on the plant will expect a drum sound. Whereas, people performing a slide will expect a sound closer to a continuous organ sound. The possibilities are endless and the only bride is the capabilities of the device capturing the interaction.

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