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Study of Botanical Music Integration using the Touché method

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Abstract

This study explores the integration of Touché's Swept Frequency Capacitive sensing technique with plant biology to understand plant responses to touch and to generate music from these interactions. The research involves the collection of various indoor plants such as Money Plant, Bamboo Plant, Oyster Plant, and Philodendron Plant, each with unique properties and benefits. Capacitive sensors are integrated with the plants, and Arduino boards are utilized to measure changes in capacitance upon touch. The electrical signals from plants are converted into musical notes using Max8 software, providing a dynamic interface for plant interaction. Results indicate that plants with thicker stems, such as bamboo and oyster plants, exhibit heightened sensitivity, potentially due to their higher water content and conductivity. The study also suggests succulent plants show promise in this regard. Through this interdisciplinary approach, insights are gained into plant sensory mechanisms and adaptive responses, bridging the gap between technology, biology, and music. Further investigations could delve into the specific mechanisms underlying plant sensitivity and explore the impact of music on plant growth and behaviour, offering new perspectives on plant communication and environmental responsiveness. Ultimately, this integration of technology with nature aims to promote growth without negative environmental impact.

Keywords: Touché, Plants, Subliminal music, capacitive sensing, Touch integration, Arduino Uno

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1. Introduction

Touché proposes a novel Swept Frequency Capacitive Sensing technique that can detect touch events as well as recognize complex hand and body configurations. Such contextual information improves touch interaction in a wide range of applications. For example, in our explorations, we include touch and gesture sensitivity for the human body and Plants [9]. Plants can detect subtle stimuli such as 'touch' and unexpected 'sound', in addition to a wide range of stimuli. Plant roots are extremely touch-sensitive, and when they encounter a soil barrier, they can effectively redirect their growth to overcome it. Similarly, tendrils in climbing plants are extremely sensitive to touch, allowing them to detect and grab a support in close proximity. The outcomes from one of the research papers, demand questions about the nature of touch sensing in roots, where the sensors are located, and how these sensory systems work together to avoid obstacles [10]. Plant electrical signals, which occur early in the plant-stimulus interaction, rapidly transmit stimulus-generated information to other organs, and even the entire plant, promoting the appropriate response and initiating a regulatory cascade. Plant electrical activity is analyzed at various scales, including ion channels, cells, tissues, organs, and the whole plant level.

The new theory of plant neurobiology based on integrated electrical signals of plant stimulus perception may be supported by the visualization of the synchronous propagation of plant electrical signals [7]. Plants use sound vibrations caused by chewing herbivores as a general cue to activate their defence machinery, implying the existence of other ecological sound cues. Plant species, like animals, can operate within specific frequency and sound intensity ranges. Sound frequencies and intensities outside of this range may have a negative impact on plants. Although they lack specialized sense organs and cells, plants do have long-range plant electrical impulses that can reliably transmit information to other electrical pulses acting as organs when they are stimulated outside. This allows plants to integrate their growth or coordinate with their environment [4]. Plants also have green colour which can be used for relaxation as well. There is a significant decrease in oxy-Hb concentration in the frontal lobe after viewing green and green-white plants. The findings show that looking at these plant colors has a positive association with relaxation [8].

Using this ability of plants, we will integrate the Touché method in order to produce music and study the responses of various plants to touch. In this research, we will use Money Plant, Bamboo Plant, Oyster Plant, and Philodendron Plant and apply various types of touch to record readings. The flow diagram is shown in Figure 1. It depicts that Capacitive Sensing which is integrated with different plants like Oyster Plants, Money Plants etc. When the volunteer physically touches any part of the plant, there is a capacitance change within the plant itself.

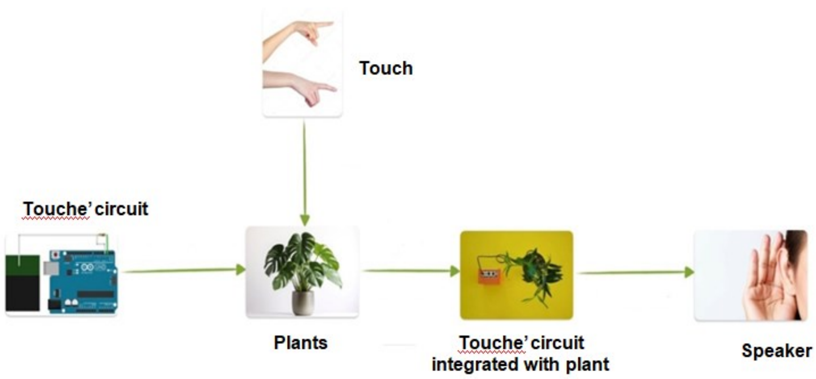

Figure 1. Flow Diagram of the Plants Integrated with the Touché Method

An electrical output is then produced by the Arduino. Hence, the changes occur in capacitance values. This then converts the digital data of FARADS into music. This Capacitive Sensing [14] helps in measuring the resonant frequency and its resistance value in the circuit based on the plant and the capacitance between the gripping hand, and the body resistance. The resonant frequency measurement provides a high sensitivity that enables the estimation of the distance to the approaching hand and the gripping area of hand. [12][3]. Therefore, the output of the Arduino is then fed into the input of MAX8 software, and the music is produced from the speaker.

2. Materials and Methodology

2.1 Plant Data

The Money Plant, Bamboo Plant, Oyster Plant and Philodendron Plant were collected and studied for the present study. Money Plant (Epipremnum Aureum) has been associated with various health benefits. They release oxygen at night, making them excellent plants to keep in bedrooms as they can improve sleep quality. Additionally, they help reduce stress, enhance focus and productivity, and promote a sense of well-being. Observing a money plant for five minutes leads to lower systolic blood pressure, higher alpha and beta brainwaves, and lower anxiety scores compared to the control condition [5].Indoor plants such as Bamboo (Bamboos vulgarise) are known to purify the air at home. Bamboo plants also have the properties of being a natural disinfectant. Thus, it helps in keeping the environment of the house clean and in pristine condition. Every part of the bamboo plant, including the rhizome, Culm shavings, leaves, roots, shoots, and seeds, has potential medicinal applications [2].

The Oyster Plant (Tradescantia Spathacea) is a succulent perennial herb that is found in many tropical countries. The oyster plant's bioactive compounds are also being explored to combat infectious diseases or even play a role in cancer prevention. The oyster plant is also known as common falsify. The common name Oyster Plant refers to the flavour of the roots that supposedly taste like oysters. The plant is used for colds, sore throat, whooping cough, nasal bleeding, and is also used as an anti- inflammatory [13]. Philodendron Plants are known for improving air quality, reducing stress, and being low maintenance. They release moisture into the air through transpiration, which can boost humidity levels. Porous oxygenating leaves brighten and freshen the room visually and atmospherically.

2.2 Circuit Design

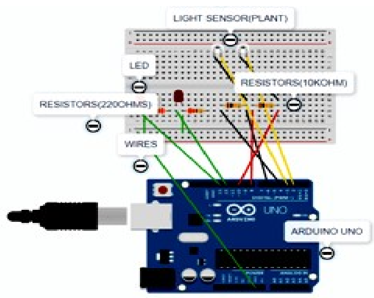

Figure 2. Touché Circuit Design using Arduino Uno Board

The circuit shown in Figure 2. consists of passive components like two 10KΩ resistors, two 220Ω resistor and two LEDs along with an Arduino Uno board, Bread Board and a set of jumper wires. The code is uploaded to the Arduino Uno board using IDE software [15]. Arduino code snippet utilizes the Capacitive Sensor library to measure capacitance on two pins, presumably connected to capacitive touch sensors. The flow of the software is explained below.

1. Library Inclusion: The code includes the Capacitive Sensor library to interface with capacitive touch sensors.

2. Sensor Initialization: Two capacitive sensors are instantiated, one connected to pins 4 and 6 (Sensor1) and the other to pins 8 and 10 (Sensor2).

3. Global Variables: Variables `val1` and `val2` are declared to store the capacitance values measured by Sensor1 and Sensor2, respectively.`pos` and `pos2` are threshold values used to trigger LED outputs.

4. Setup: Serial communication is initialized at a baud rate of 9600.Pin 13 (led) is configured as an output pin to control an LED.

5. Main Loop: The loop continuously reads capacitance values from Sensor1 and Sensor2 every 1000 milliseconds. The measured values are printed to the serial monitor. If the capacitance value from Sensor1 exceeds the threshold (`pos`), the LED connected to pin 13 (led) is turned on; otherwise, it's turned off. Similarly, if the capacitance value from Sensor2 exceeds `pos2`, the LED connected to pin 12 (led2) is turned on or off accordingly.

6. Delay: A short delay of 10 milliseconds is applied at the end of each loop iteration.

This code essentially reads capacitance values from two capacitive sensors, prints them to the serial monitor, and controls LEDs based on the measured values. Here, the input is the Touch and the output is the change is capacitance value of plants which is visualized by the LEDs that glows at different pressure points.

2.3 Integration of Circuit with Plants

The two capacitive sensor's electrodes are inserted into the stems/branches of the plants used for the study. The code is uploaded to the Arduino Uno. Now there is a flow of electricity in closed manner. When the plant is touched, it induces a change in the capacitance which changes the flow of electricity. This is measured in Farads. The output of the Arduino Uno (change in capacitance) is given as the input to the MAX8 software. The code in MAX8 sets up a range switch which will be triggered as per the changes from the Arduino due to touches.

When the value is in the specified range, it triggers the music to be played. The music that is integrated is a subliminal tone.

In this method, we utilize passive components to enhance touch sensitivity in conductive materials and employ Arduino as a crucial component in our experiment. The Swift Frequency Capacitive Sensing technique [6] is employed to convert electrical signals from plants into musical notes, enabling the generation of nuanced musical gestures. The setup involves two capacitance plates: one connected to the human hand (capacitance plate 1) and the other in contact with the plant's body (capacitance plate 2), where jumper wires are inserted. When the human hand makes contact with the plant, the distance between the two plates changes, inducing a current. This change in current is detected by the Arduino Uno board.

The MAX 8 software is then integrated with this signal. In MAX 8, sounds are designed specifically for various plant touches, allowing for a diverse range of musical responses [11]. By analyzing the impedance levels of each plant, the device can distinguish between different plants and their respective touches. Once the signal is processed in MAX 8, the resulting sound is sent to an output device, such as a speaker, for auditory feedback. Simultaneously, readings are taken and compared to analyze the sensitivity and responsiveness of different plants to touch stimuli.

This setup enables the generation of music through interactions between humans and plants, providing a unique sensory experience and opening avenues for artistic expression and scientific exploration. By combining technology with botanical research, we can delve deeper into the intricate mechanisms of plant communication and responsiveness while creating captivating musical compositions.

3. Results and Discussion

3.1 Plant Data Collection

The plants used for this study is collected from the institute premises during the period 10th January 2024 – 1st February 2024, Figure 3. shows the different plants collected namely the a) Money Plant, b) Bamboo Plant, c) Oyster Plant and d) Philodendron Plant. The chosen plants are all Indoor Plants which has its own advantages.

(a) (b) (c) (d)

Figure 3. Plants used for the Study, (a) Money Plant, (b) Bamboo Plant, (c) Oyster Plant, and (d) Philodendron Plant

The plants are integrated with the touché circuit and the different touches like tap, tip, high pressure, squeeze etc are studied. The experimental setup of the study is shown in Figure 4.a. – 4.d.The Oyster plant is connected to the Touché circuit as shown in Figure 4.a. and 4.b. and the output capacitance are read as 0. After touching the plant stem with two fingers the LED glows and the change is capacitance is noted. Similarly, Fig 4.c. and 4.d. represents the change in capacitance before and after touching the money plant. The capacitance values are tabulated in Table 1.

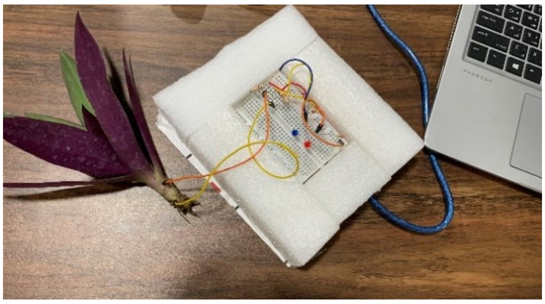

Figure 4.a. Before Touching the Oyster Plant

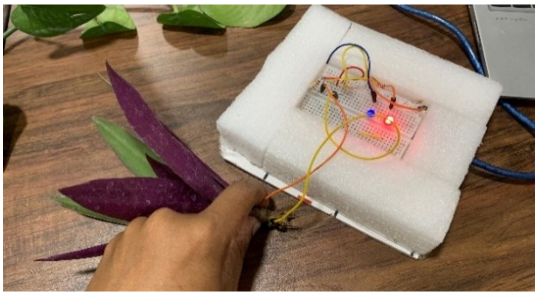

Figure 4.b. After Touching the Oyster Plant

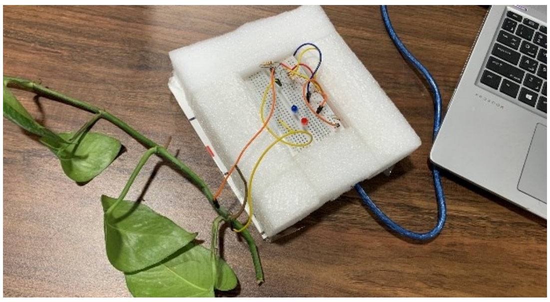

Figure 4.c. Before Touching the Money Plant

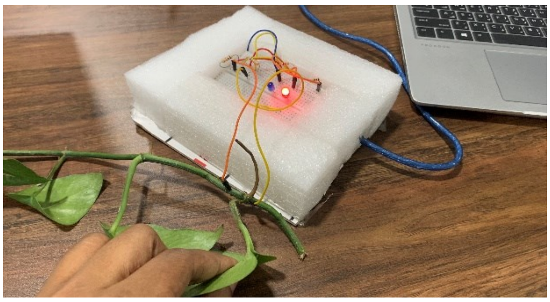

Figure 4.d. After Touching the Money Plant

Table1. Capacitance Values for Different Types of Touches and Plants

Type of Touch	Money plant Capacitance in Farads (Soil)	Bamboo plant Capacitance in Farads (Soil)	Oyster plant Capacitance in Farads (Water Root)	Philodendron plant Capacitance in Farads (Cutting)
(Tap)	0	5	4	1
(Tips)	0	7	23	0
(H.Pressure)	116	29	32	27
(Squeeze)	59	30	52	29
(Middle Part)	16	67	32	29
(Press All Parts)	60	147	60	30
(Lower Stem)	35	230	28	1

From the Table 1, the different forms of touch were to tabulate the readings in Farads. Money plants and bamboo plants used for this research were all in soil, while the oyster plants were grown in water. Philodendron plant was cut from the middle to perform this experiment. When these plants were slightly tapped, Bamboo plant showed greater capacitance value. When the tips of the plant leaves were touched, Oyster plant showed more response compared to the other plants. For high pressure and squeeze, each having different pressures, Money plant was quick to show higher response. When the middle part of the plant was touched, the bamboo plant had good readings. While the rest of the parts and the last steam part, when touched, bamboo plant had the highest response than the rest. So, we know that moisture content in tree trunks and plants increases exponentially with capacitance [1].

The output from Arduino Uno is given as the input in the MAX8 software. This acts as an integration of digital data to musical switch. As the volunteer touches the plant, the digital data is received via the serial port of MAX8 software. We have setup a threshold for Two Touch Factors (TTF) namely, High pressure and Squeeze. Once the Input data is in the specified range it triggers the integrated music for each touch to be played.

3.2 Inference

From the results we can infer those plants with thicker stems gives more sensitive readings, due to ample amount of water content stored. Also, succulent plants have a better conductivity. Preferred plants can be oyster plants and bamboo plants as of now. Capacitance of the Bamboo plant is comparatively higher which is observed to have all the factors like thick stem system, good contact with soil, high formation of roots. These factors have appeared to affect their sensitivity directly. Using Max8 software, we are installing subliminal music to different plants. This software uses the output of Arduino as its own input, where the capacitance produced by touch is limited as a Threshold value. When the capacitance surpasses the given Threshold, it acts as a switch to activate the Music. Threshold is directly proportional to Pressure applied to produce the capacitance value.

4. Conclusion

In conclusion, the integration of Touché's Swept Frequency Capacitive Sensing technique with plant biology offers intriguing possibilities for understanding plant responses to touch and generating music from these interactions. Through this research, we have explored the sensitivity of various plants to touch and their capacity to produce electrical signals in response to stimuli.

Our findings suggest that plants with thicker stems, such as bamboo and oyster plants, exhibit heightened sensitivity, likely due to their higher water content and conductivity. Succulent plants also show promise in this regard. The capacitance of bamboo plants, in particular, stands out as being comparatively higher, likely influenced by factors such as stem thickness, root formation, and soil contact. By employing Max8 software, we have devised a method to translate plant capacitance into musical output. This setup utilizes Arduino's output as input for Max8, where the capacitance generated by touch serves as a threshold for activating music. The threshold is directly linked to the pressure applied, thus providing a dynamic interface for plant interaction.

Through this research, we not only explore the sensory capabilities of plants but also tap into their potential for artistic expression. By studying how different plants respond to touch and sound stimuli, we gain insights into their sensory mechanisms and adaptive responses. This interdisciplinary approach bridges the gap between technology, biology, and music, opening avenues for creative exploration and scientific inquiry.

In the future, further investigations could delve into the specific mechanisms underlying plant sensitivity and electrical signalling. Additionally, exploring the impact of music on plant growth and behaviour could unveil novel insights into plant communication and environmental responsiveness. Overall, this research highlights the fascinating interplay between technology and nature, offering new perspectives on the complexity of plant life and its interactions with the world around us.

References

[1] Ali, A., Ali, A., Abaluof, H., Al-Sharu, W. N., Saraereh, O. A., & Ware, A. (2023). Moisture Detection in Tree Trunks in Semiarid Lands Using Low-Cost Non-Invasive Capacitive Sensors with Statistical Based Anomaly Detection Approach. Sensors, 23(4),2023: 2100.

[2] Akhtar, J., & Patowary, L. (2022). Bambusa vulgaris: A comprehensive review of its traditional uses, phytochemicals and pharmacological activities. Sciences of Phytochemistry, 1(2), 11-21.

[3] Bian, S., Liu, M., Zhou, B., & Lukowicz, P. (2022). The state-of-the-art sensing techniques in human activity recognition: A survey. Sensors, 22(12), 4596.

[4] Demey, M. L., Mishra, R. C., & Van Der Straeten, D. (2023). Sound perception in plants: from ecological significance to molecular understanding. Trends in Plant Science.

[5] Hassan, A., Qibing, C., Yinggao, L., Tao, J., Li, G., Jiang, M., ... & Bing-Yang, L. (2019). Psychological and physiological effects of viewing a money plant by older adults. Brain and Behavior, 9(8), e01359.

[6] Honigman, C., Hochenbaum, J., & Kapur, A. (2014). Techniques in Swept Frequency Capacitive Sensing: An Open Source Approach. In Nime (pp. 74-77).

[7] Li, J. H., Fan, L. F., Zhao, D. J., Zhou, Q., Yao, J. P., Wang, Z. Y., & Huang, L. (2021). Plant electrical signals: A multidisciplinary challenge. Journal of Plant Physiology, 261, 153418.

[8] Kexiu, L., Elsadek, M., Liu, B., & Fujii, E. (2021). Foliage colors improve relaxation and emotional status of university students from different countries. Heliyon, 7(1).

[9] Sato, M., Poupyrev, I., & Harrison, C. (2012, May). Touché: enhancing touch interaction on humans, screens, liquids, and everyday objects. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 483-492).

[10] Mishra, R. C., & Bae, H. (2019). Plant cognition: ability to perceive 'Touch'and 'Sound'. Sensory Biology of Plants, 137-162.

[11] Mokhtar, M. H., & Chan, C. S. C. (2023). Max as a Digital Platform for Noise Music Performance. Harmonia: Journal of Arts Research and Education, 23(2), 246-253.

[12] Ono, Y., Morimoto, Y., Hattori, R., Watanabe, M., Michida, N., & Nishikawa, K. (2017). Smart steering wheel with swept frequency capacitive sensing. IEICE Transactions on Electronics, 100(11), 972-977.

[13] Prajapati, T., Shukla, A., & Modi, N. (2020). Tradescantia spathacea Sw.: a review of its pharmacological and ethnopharmacological properties. Int J Res Cult Soc, 4, 52-56.

[14] Shadwani, M., Sachan, S., & Sachan, P. (2016). Capacitive sensing & its applications. Int. J. Eng. Res. General Sci, 4(3).

[15] Zlatanov, N. (2016). Arduino and open source computer hardware and software. J. Water, Sanit. Hyg. Dev, 10(11), 1-8.