


Analysis of Electric Voltage Signals Produced by Plants Using Matlab

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Abstract—Some plant species can move rapidly in response to various stimuli (e.g. touch). Some of these plant species are *Mimosa Pudica* L (Putri Ashamed) and the Venus Fly Trap plant. Previous electrophysiological studies have shown that electrical signals travel long distances and quickly through the *Mimosa pudica* plant (Putri Malu). Thigmotactic or seismonastic movements in *Mimosa pudica*, such as responses to touch, *Mimosa pudica* are electrically and mechanically analyzed using matlab software, i.e. if the voltage of the electric signal the output is 506mV-800mV or higher. Venus Fly Trap plant in response to mechanical stimulation. Electrical signaling and rapid closing of the Venus flytrap plant that electrically stimulated between the sheath and lobe closes the Venus flytrap leaf by activating a mechanically stimulated motor call from the trigger hair. Biologically closed electrical circuits operating over long distances in biological networks are electrically and mechanically analyzed using matlab software i.e. the generated electrical voltage signal is 512mV-555mV or higher. Activation of such a circuit can cause various physiological and biophysical responses. Here, we analyze the biologically open and closed electrical circuits of sensitive plants Venus's fly trap and shy daughter by data acquisition with the measurements taken on this assay taking a time duration of approximately 9 s per test.

Keywords— Electrical Signals, Plants, *Mimosa Pudica*, Venus Fly Trap, MatLab.

I. INTRODUCTION

Plants process solar energy through photosynthesis. The process produces various materials needed to support plant development. The resulting material is partly used by plants and partly excreted through the roots. Microorganisms around the plant root zone process these wastes. The process is a series of biochemical reactions that result in the release of electrons. The electrons released during the reaction can be captured by electrodes placed around plant roots to generate an electrical signal.(Muladi et al. 2021)

Currently, a tool has been developed that functions to detect electrical signals generated by plants. Using a silver wire electrode soldered to a copper wire. Silver wire is then attached to the body of the plant with gel electrodes.

In plants, electrical signals are considered as changes in electric potential (EP). EP in plants is produced in response to various stimuli, such as injury, chemicals (eg herbicides, plant growth stimulants and salt), heat, water and electric shock. The plant EP is recorded using electrodes attached to the plant surface or inserted into the plant tissue. Surface electrodes are non-invasive and can be attached to the surface of plant parts (eg stems and leaves).

In analyzing the activity of electrical signals generated by plants in real timehow is EP in plants *Mimosa Pudica* (embarrassed daughter) and plants *Dionaea Muscipula*.(venus plant)to detect electrical signals from these plants and will be processed using Matlab for analysis and visualization. The resulting data can be used to study the resulting signal wave pattern.

By using electrodes with Matlab, monitoring the activity of plant electrical signal waves can become easier and more effective. This can open up opportunities for the development of more sophisticated technologies. (Senavirathna and Muhetaer 2020)

II. LITERATURE REVIEW

A. Electric Voltage Plants

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B. *Mimosa Pudica*

Some plant species can move quickly in response to various stimuli (eg touch). One such plant species, *Mimosa pudica*L, has a pulvinus motor organ at the junction of the leaflet-rachilla, rachilla-petiole, and petiole, and with mechanical stimulation, this organ immediately closes the leaflet and moves the petiole. (Hagihara and Toyota 2020). The *Mimosa Pudica* plant is a thigmonastic or seismonastic plant whose leaves close and the petiole hangs down in response to certain stressors such as injury, wind, vibration, touch, stimulation. (Volkov, Foster, and Markin 2010). Thigmonastic or seismonastic movements, such as responses to touch, appear to be governed by the transduction of electrical and chemical signals, spreading the stimulus throughout the plant.(Kagawa and Saito 2000). One such hypothesis states that the thigmonastic movements of *Mimosa pudica* are powered by a sudden loss of turgor pressure in the pulvinus motor cells at the base of each leaf or leaflet. (Temmei et al. 2005).

C. *Venus Fly Trap*

This Venus fly trap plant consists of 5–7 leaves; each leaf is divided into two parts. The upper leaf has a pair of trapezoidal lobes joined by a blade or midrib. The center of each lobe contains three or more sensitive trigger hairs with a red anthocyanin pigment that attracts insects. The edges of each lobe are lined with hairlike projections or cilia. The underside of the leaf is sometimes referred to as the footstalk. 5 The six trigger hairs that project from the upper leaf epidermis of the Venus flytrap act as mechanical sensors. When the insect touches the trigger hairs, these mechanical sensors generate an electrical signal that acts as an action potential, which activates the motor cells. Macfarlane6 found that the two mechanical stimuli required for trap closure must be applied in intervals of 0.75–20 seconds. Brown and Sharp found that at high temperatures of 35–40°C usually only a single

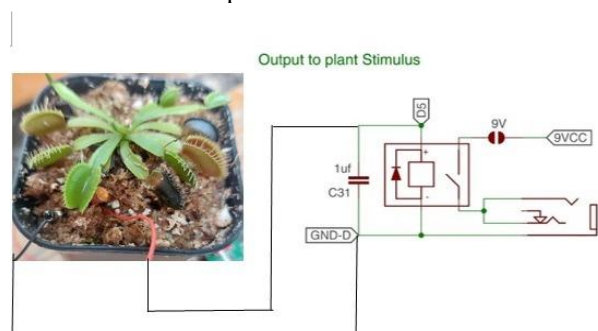
mechanical stimulus is needed (Volkov, Adesina, and Jovanov 2007). Thigmonastic or seismonastic movements, such as responses to touch, appear to be governed by the transduction of electrical and chemical signals, spreading the stimulus throughout the plant (Kagawa & Saito, 2000). The movement of plants or plant parts occurs in various sizes and time scales. Plants show motion at all scales from opening and closing. (Forterre 2013). The action potential is recorded by connecting an electrode to one of the metal lever arms of the shutter force sensor and inserting a reference electrode into the ground. For AP measurement one electrode is connected to a metal lever and the other electrode is inserted into the soil (Burri et al. n.d.). There are significant differences between the nature of the electrical signal generated in the Venus flytrap described in the literature. The amplitude of the action potential varies from 14 mV to 200 mV with a signal duration from 2 ms to 10 s. potentials between Ag/AgCl electrodes inserted into traps, leaf stalks, and soil or external ECG electrodes attached to the surface of the Venus flytrap. Different types of electrodes with different positions in plant tissue or in soil exhibit different amplitudes and durations of electrical signals because the potentials are measured in different electrochemical circuits (Volkov 2018)

D. *MatLab*

The MATLAB working environment. This is the set of tools and facilities that you work with as the MATLAB user or programmer. It includes facilities for managing the variables in your workspace and importing and exporting data. Handle Graphics. Matlab graphics system. It includes high-level commands for two-dimensional and three-dimensional data visualization, image processing, animation, and presentation graphics(News group 1984)

III. RESEARCH METHODS

Picture 1 shows a control experiment we recorded electrical signals induced by mechanical stimulation of the Venus and *Mimosa Pudica* plants using a data acquisition system with a 1uf charged capacitor, Positive and negative voltage +2.5 -2.5, 9V battery, ATMEGA32U4, InAmp AD8226, OpAmp LMV321ILT, Ag Electrode /AgCl for electrical stimulation of Venus and *Mimosa Pudica* plants.



Picture 1. Output To Plant Stimulus

Measurements were made at room temperature. Ag/AgCl electrodes were made from silver wire which was wrapped around then the electrodes were attached using an electrode gel to the lobe/stem/petiole. then sends a signal through the tool *plant spikerbox* shown on the chart *software matlab*, in monitoring the voltage signal generated by plants with matlab as a whole starting from the beginning to the end of the system. If the electric voltage signal on the plant has been detected by plant stimulation, this stimulation produces a signal that is converted into digital data. The electric voltage signal data generated by the plant is sent to *software matlab* which is where data processing occurs in graphical form for analysis.

IV. RESULTS AND DISCUSSION

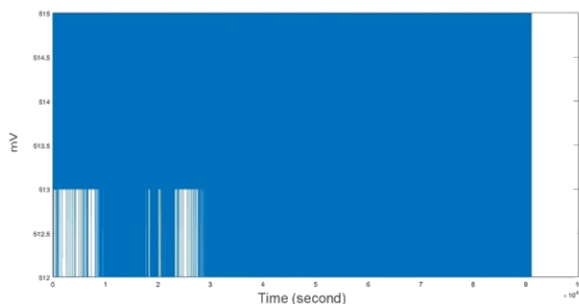
A. The First Test Was Carried Out On Venus Plant Subjects When They Were Open And Closed When Given A Stimulus To The Trigger Hairs

1. Testing The Electric Voltage Signal On The Venus Plant *Fly Trap* When It Is Open

In this test, Picture 2 and 3 they show, the first recorded the electrical signals induced by mechanical stimulation of trigger hairs in venus plants in the open/unstimulated state of the plant. Then, we tested the electrical signaling by generating an electrical signal using *software MatLab*, data graph of the signal that a venus plant generates when open plants are detected shows a graph. This is the resting membrane potential, typically with values between 512mV–515 mV taken over 9 seconds.



Picture 2. The First Test on Venus Plant Subjects in an Open State



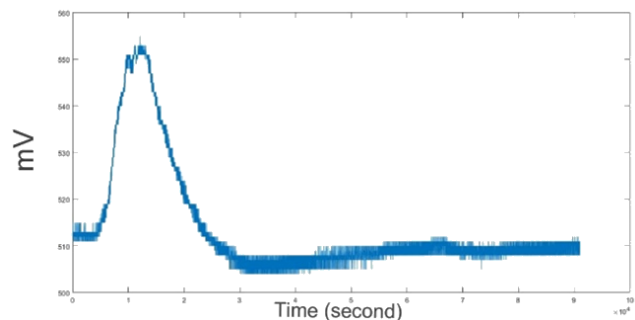
Picture 3. Graph of Electrical Voltage Signals in Venus Plants When Open

2. Testing The Electric Voltage Signal On The Venus Plant *Fly Trap* when The Condition Is Given A Stimulus To The Trigger Hair

In this test, Picture 5 and 6 show, the first recorded electrical signals induced by mechanical stimulation of trigger hairs in venus plants *fly trap* when the state of the plant is given a stimulus to the trigger hair and closes. Then, we tested the electrical signaling by generating an electrical signal using *software MatLab*, data graph of the signal generated by the venus plant when the plant is stimulated and then closed is detected showing a graph, This is the membrane potential value when stimulated, starting with an initial value of 512mV then reaching a peak value when given a stimulus of 555mV and then closing with a value of 512mV, taken within 9 seconds.



Picture 4. The venus fly trap plant when stimulated triggers the hair and closes



Picture 5. Graph of Electrical Voltage Signals in Plants Venus fly trap when stimulated the hairs trigger and close

B. The Second Test Was Carried Out On The *Mimosa Pudica* Plant Subject When It Was Open And Closed When Given A Stimulus

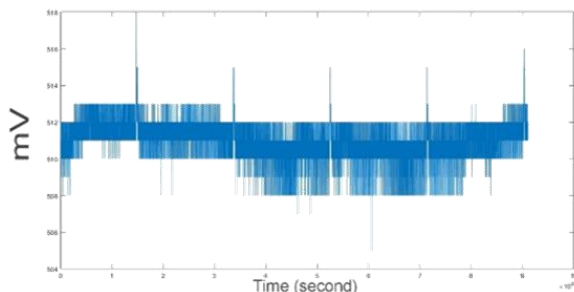
1. Testing the electric voltage signal on the *Mimosa Pudica* plant when it is open

In this test, Picture 6 and 7 show, the recorded the electrical signal induced by mechanical stimulation of the shy daughter plant when the plant was open/not exposed to stimulation. Then, we tested the electrical signaling by generating an electrical signal using *software MatLab*, data graph of the signal generated by the shy daughter when open plants are detected shows the graph. This is

the resting membrane potential, usually with values between 506mV–518 mV taken in 9 seconds.



Picture 6. Mimosa Pudica plant when open



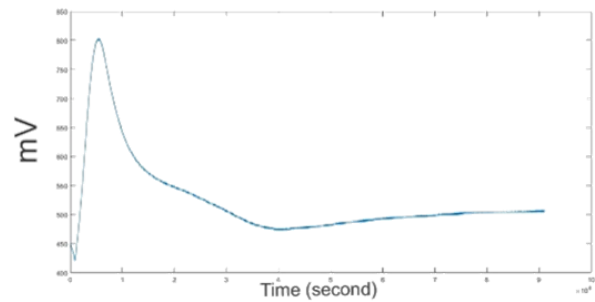
Picture 7. The First Test on the Subject of Mimosa Pudica Plants in an Open Condition

2. Testing the electric voltage signal on the Mimosa Pudica plant when given a stimulus

In this assay, Picture 8 and 9 show, the recorded the electrical signal induced by mechanical stimulation of the shy daughter plant when the state of the plant is given a stimulus on and closes. Then, we tested the electrical signaling by generating an electrical signal using software MatLab, data graph of the signal produced by the shy daughter plant when the plant is stimulated and then closed is detected showing a graph, This is the value of the membrane potential when stimulated, starting with an initial value of 450mV then reaching a peak value when given a stimulus of 800mV and then closing with a value of 550mV, taken in 9 seconds.



Picture 8. Mimosa Pudica plant when it gets stimulated and closes



Picture 9. Graph of Electrical Voltage Signals in Mimosa Pudica Plants When stimulated and closed

V. CONCLUSION

The electrical signal data generated on the Venus plant Fly Trap when the state is not stimulated, starting from 512mV-515mV and when the plants are stimulated on the trigger hairs, the resulting electrical signal data is with an initial value exposed to a stimulus of 512mV, then reaches a peak value of 555 mV and then closes with the state of the plant closing with a value 512mV. Meanwhile, in the Putri Malu plant, the electrical signal data generated by the Putri Malu plant when conditions were not given stimulation was between 506mV-518mV. And for the electrical signal data generated in the shy daughter plant when stimulated, starting with an initial value of 450mV then reaching a peak value when given a stimulus of 800mV and then closing with a value of 550mV, and all the results of the electrical signal value data are taken on the Venus plantfly trap and shy daughter that is all within 9 seconds.

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