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| **Title:** | An In Situ Electrical Impedance Tomography Sensor System for Biomass Estimation of Tap Roots | | | |
| **Author(s) Name:** | **Basak, R.**; Wahid, K.A. | | | |
| **Contact Email(s):** | rinku@aiub.edu | | | |
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| **Abstract:** |  |
| Root biomass is one of the most relevant root parameters for studies of plant response to environmental change. In this work, a dynamic and adjustable electrode array sensor system is designed for developing a cost-effective, high-speed data acquisition system based on electrical impedance tomography (EIT). The developed EIT system is found to be suitable for in situ measurements and capable of monitoring the changes in root growth and development with three-dimensional imaging by measuring impedances in multiple frequencies with the help of an EIT sensor. The designed EIT sensor system is assessed and calibrated by the inhomogeneities in both water and soil media. The impedances are measured for multiple tap roots using an electrical impedance spectroscopy (EIS) tool connected to the sensor at frequencies ranging from 1 kHz to 100 kHz. The changes in conductivity are calculated by obtaining the boundary voltages from the measured impedances for a given stimulation current. A non-invasive imaging method is utilized, and the spectral changes are observed accordingly to evaluate the growth of the roots. A further root analysis helps us estimate the root biomass non-destructively in real-time. The root size (such as, weight, length) is correlated with the measured impedances. A regression analysis is performed using the least square method, and more than 97% correlation is found for the biomass estimation of carrot roots with an RMSE of 4.516. The obtained models are later validated using a new and separate set of carrot root samples and the accuracy of the predicted models is found to be 93% or above. A complete electrode model is utilized, and the reconstruction analysis is performed and optimized by utilizing the impedance imaging technique in difference method. The tomography of the root is reconstructed with finite element method (FEM) modeling considering one-step Gauss–Newton (GN) algorithm which is carried out using an open source software known as electrical impedance and diffuse optical tomography reconstruction software (EIDORS). | |