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Building a Smart Dendrometer: Calibration and Field Deployment of a linear magnetic driven IoT Sensor for Real-Time Radial Growth Assessment

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Technological advancements in forest digitization have revolutionized real-time monitoring of tree ecophysiological processes. Direct measurement sensors, such as dendrometers, sap flow sensors, and spectrometers, enable high-resolution insights into tree function and growth. Here, we present a novel dendrometer designed to monitor radial stem increment using a Hall effect-based linear magnetic encoder system integrated into an IoT-enabled platform.

The dendrometer employs a commercially available linear magnetic encoder chip (AMS OSRAM GmbH) that operates without physical contact, ensuring low power consumption and long-term monitoring suitability. Key design components include a linear arm, sensor housing, rail, magnetic tape, and chip braces. Calibration was conducted using a stepper motor for linear movements at 0.1 mm increments, capturing 100 data points per step in four replicates. Regression analysis demonstrated high accuracy, with an R^2 of 0.99 and an RMSE of 0.05 mm. Temperature sensitivity tests (0–40°C) revealed minimal impact on sensor performance.

Field tests over one growing season involved four dendrometers installed on specimens of spruce (Picea abies (L.) H.Karst)) and silver fir (Abies alba Mill.). Seasonal radial growth patterns captured by the devices aligned closely with established static UMS D1 diameter belt measurements, demonstrating their capacity to detect both long-term trends and short-term diel stem oscillations.

This study highlights the potential of an IoT-driven dendrometer for capturing high-resolution radial growth data, offering insights into tree physiology and forest responses to environmental changes. Future development should focus on enhancing measurement precision through design optimization and improved access to power width modulation components in the AS3511 chip. This dendrometer represents a promising tool for advancing forest monitoring and understanding the impacts of climate change on tree growth dynamics.