PLANTSENS

A rail-based multi-sensor imaging system for redundant water stress detection and automated irrigation in greenhouses

Bundesministerium für Ernährung und Landwirtschaft

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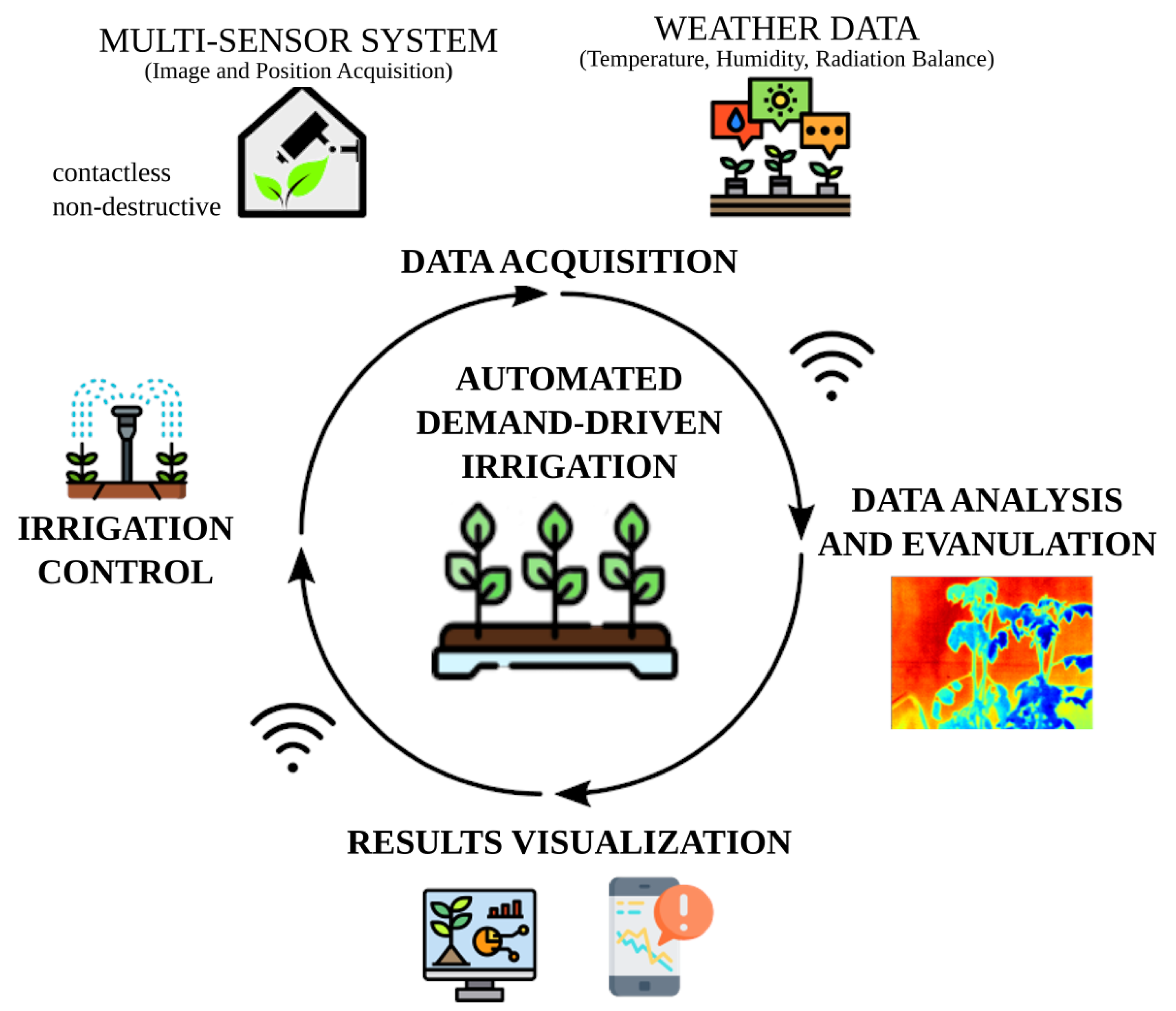
1. Motivation

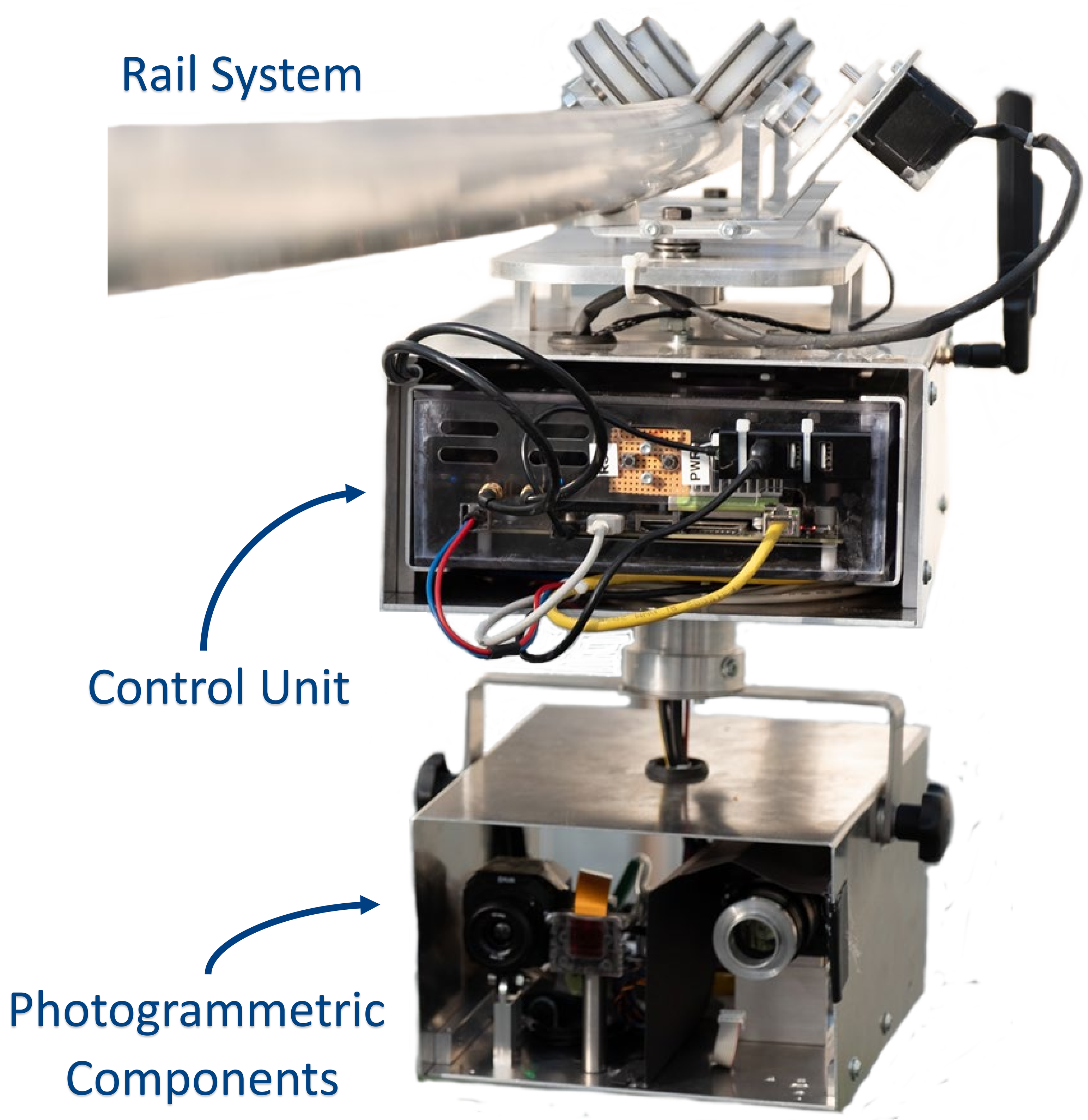
In recent years, the efficient and sustainable use of water in horticultural production systems has become increasingly important. The main goal of irrigation scheduling is to determine the correct time and amount of water to be applied to a crop to optimize production. Irrigating too early or too late cannot ensure the required plant water status throughout the growing cycle. Appropriately scheduled and precisely targeted irrigation concerning the actual water demand of the crop enables sustainable use of this limited resource.



To irrigate crops according to their current water needs, continuous monitoring of the plant conditions is essential. As part of the PLANTSENS project, a multi-sensor control system was developed for automated water status measurement by combining thermal and spectral imaging within near-infrared and short-wave infrared spectrum.

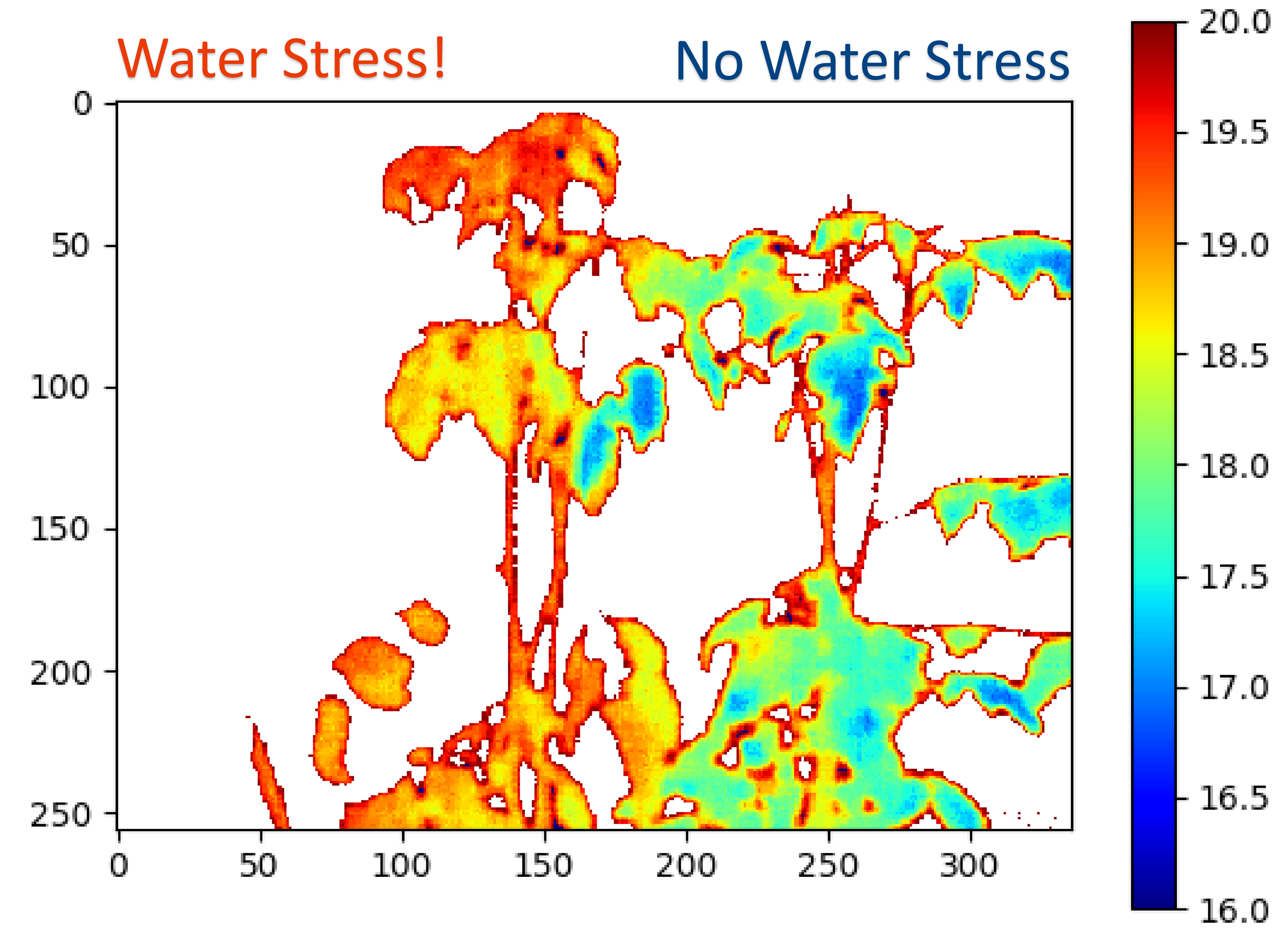
2. Measurement System

The measurement system consists of a control unit and photogrammetric components. To capture plants from different angles, the lower part of the system can rotate a full 360° horizontally.



3. Methodology

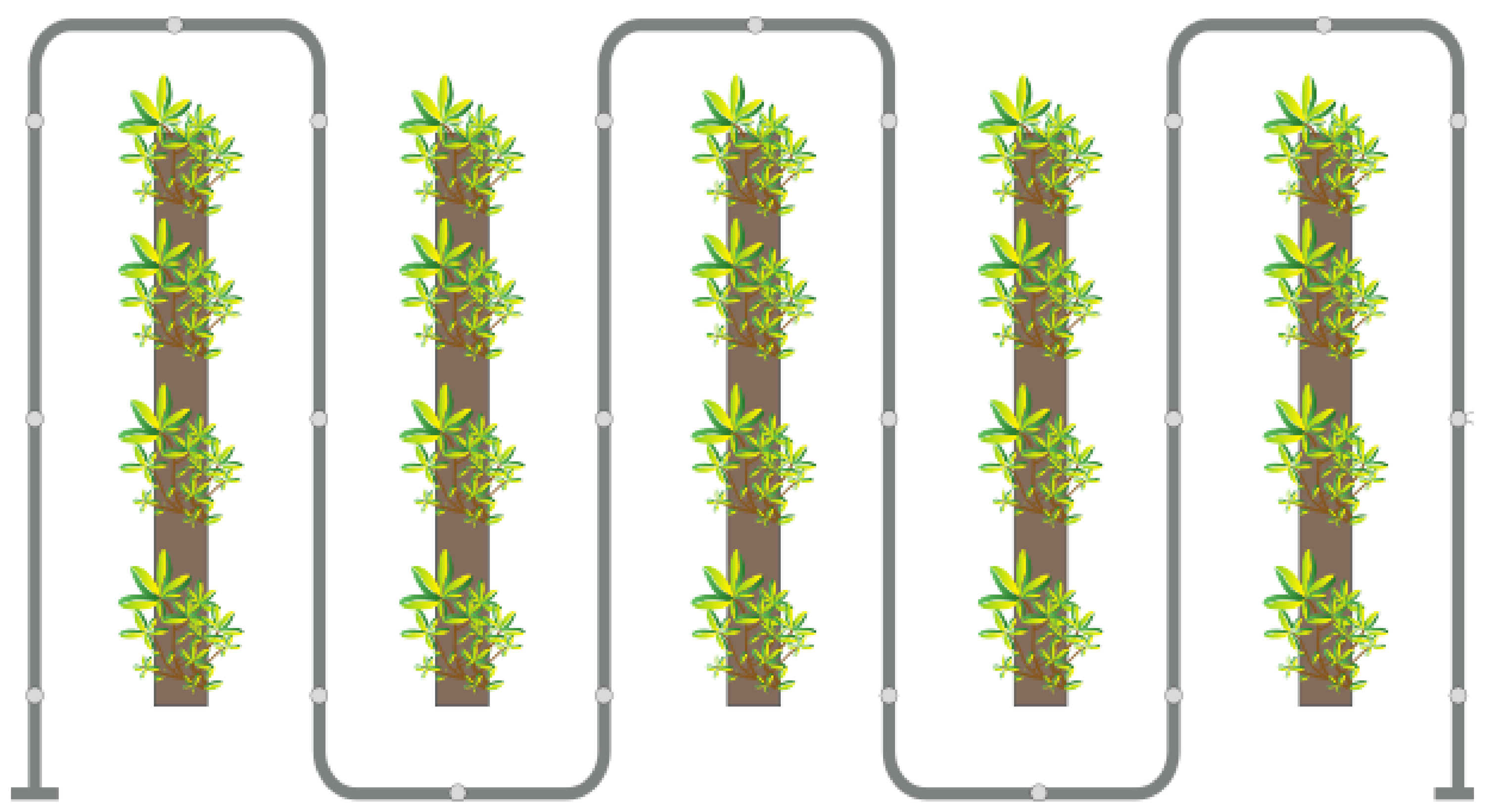
Plant stress, specifically water stress, is determined using two independent measurement methods. The first method calculates the water index by analysing the absorption of light in the short-wave infrared spectrum (SWIR). The second method determines the plant's water demand based on leaf temperature, which depends on transpiration efficiency and stomatal conductance.



4. Prototype

The prototype of the measurement system was tested in a greenhouse, where it was mounted on a rail system positioned directly above the plant culture. The plant leaves were captured at one-second intervals and from a short distance.

A stepper motor moves the camera system between the plant rows. The position is calculated by combining data from the IMU and the stepper motor. Additionally, the route is marked with NFC markers at both the start and end position, where the drive direction and acquisition angle change accordingly. The robot is controlled remotely by a dedicated software that uses real-time data from the sensors to mirror the status of the rover and the plants as closely as possible.



5. Outcome

The developed system integrates thermal and spectral imaging techniques with robotics and networking technologies to enable automated plant monitoring. The prototype has been introduced at numerous conferences, including INTERGEO, AGIT and IST, as well as in scientific journals. Current development focuses on modernizing and upgrading the system with improved sensors.

Further Information:
ROJEK, L., MÖLLER, M., RICHTER, M., BISCHOFF-SCHAEFER, M. & HEHL, K. (2023): Monitoring System for a Resource Efficient and Automated Irrigation of Tomato Crops Based on Water Stress Detection Using Short-Wave Infrared and Thermal Imagery. Elsevier: Smart Agricultural Technology, Vol. 4. https://doi.org/10.1016/j.atech.2023.100223.

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