A versatile deep-learning model for accurate prediction of plant growth

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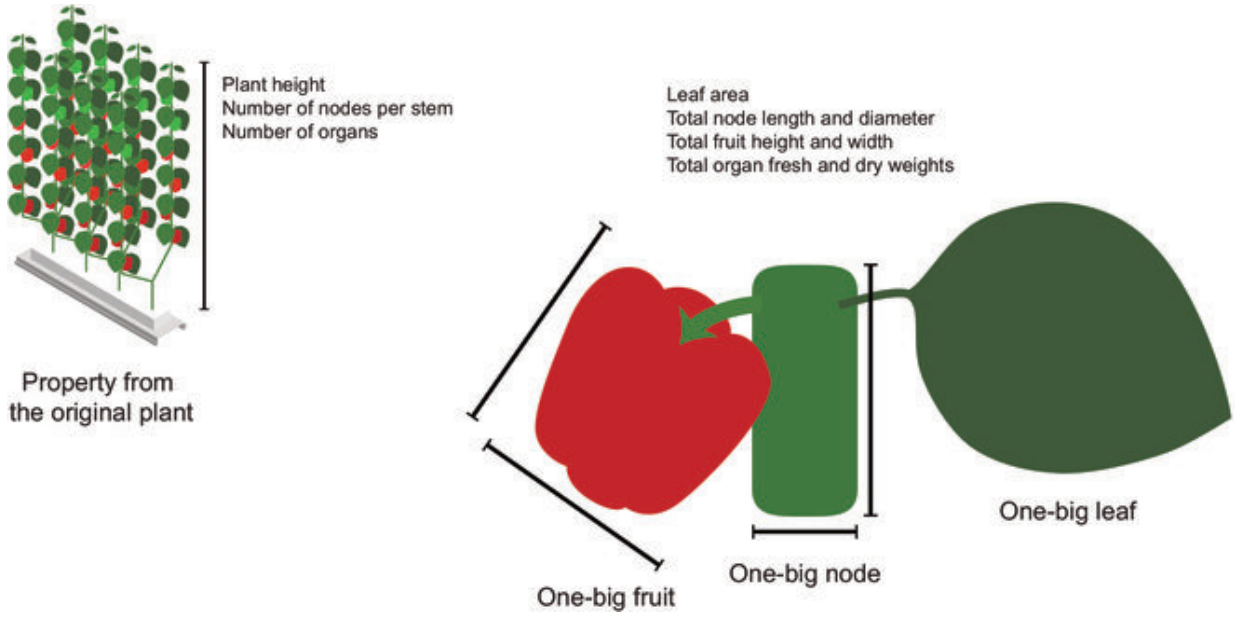

Target crop growth and morphology were abstracted as one-big organs. Averages can be calculated with total values and the number of organs. Credit: *Plant Phenomics*

Crop yield can be maximized when the best genetic variety and most effective crop management practices are used for cultivation. Scientists have developed various machine learning models to predict the factors that produce the greatest yield in specific crop plants. However, traditional models cannot accommodate high levels of variation in

parameters or large data inputs.

This can lead to the failure of models under certain circumstances. Also, since crop models are restricted to the types of input they can accommodate, improvements to one model may not apply to other models.

To overcome this limitation, researchers from Korea led by Professor Jung Eok Son from Seoul National University have created a novel deep-learning based crop model known as "DeepCrop", for hydroponic sweet peppers. The model can accommodate several input variables and has fewer limitations on the amount of data it can process.

Hence, it can be employed in most settings and can be extended to similar applications. The researchers tested the predictions of DeepCrop by cultivating the crop twice a year for two years in greenhouses. Their results were published in *Plant Phenomics* on March 1, 2023.

"We selected deep-learning algorithms as a potential solution to mitigate fragmentation and redundancy. Deep learning has high applicability to broad target tasks as well as remarkable abstraction ability for enormous sets of data," explains Prof. Son.

DeepCrop is a process-based model that can simulate crop growth in response to various factors and environmental conditions. It can be scaled up to include many input types or greater amount of data. One reason for the high versatility of DeepCrop is that it is constructed exclusively with neural networks. Neural networks are combinations of algorithms that process the interactions between input data to make useful predictions.

Since simulations are created on a computer-based platform, DeepCrop requires minimal infrastructure. "With its applicability, a complicated

task conducted at the enterprise became accessible with a personal computer," says Prof. Son.

Deep-learning algorithms must be fed data before they can make any predictions. DeepCrop algorithms on plant growth simulation were trained in a similar manner. However, it did not need the programming of sophisticated concepts in plant physiology or crop modeling to produce useful predictions. "DeepCrop simulation adequately followed the growing tendency from scratch according to the scores, but the model should be inspected because it has potential to be improved," Prof. Son notes.

To validate the predictions of DeepCrop, the team cultivated sweet peppers in preset greenhouse conditions. A comparison of predicted and actual plant growth patterns suggested that DeepCrop outperformed other existing process-based crop models, as indicated by its modeling efficiency. The model was also the least likely to make prediction errors.

The capacity of DeepCrop to produce useful predictions even with varying inputs and parameters suggests that it can determine relationships between input data regardless of data type. The results of this study also suggest that deep-learning models can be useful for a wide range of applications in crop science. "We expect that the developed DeepCrop can improve the accessibility of crop models and mitigate fragmentation problems in crop model studies," concludes Prof. Son.

More information: Taewon Moon et al, Process-Based Crop Modeling for High Applicability with Attention Mechanism and Multitask Decoders, *Plant Phenomics* (2023). DOI: 10.34133/plantphenomics.0035

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