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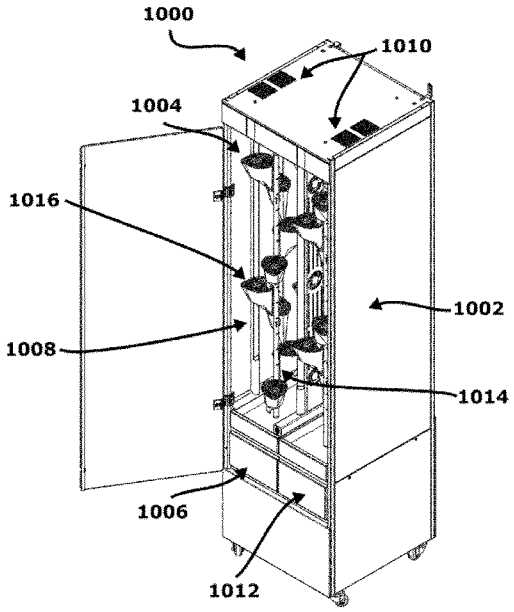


Fig. 1

(57) Abstract: The present invention relates to a method for controlling a plant growth device (1000), the method comprising acquiring sensor data via at least one sensor component (102) processing the sensor data via at least one data processing component (104) to generate at least one processed data set and predicting plant growth based on the processed data set. The present invention also relates to a corresponding system configured for controlling at least one plant growth device (1000), the system comprising at least one sensor component (102) configured to obtain sensor data associated with the plant growth device (1000) at least one communication component configured to transfer data from and to the plant growth device (1000) at least one data processing component (104) configured to process sensor data from the plant growth device (1000); at least one server (106) configured to generate a controlling hypothesis; at least one user interface (2000) configured to display information to at least one user and to receive input information from at least one user.

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Intelligent Plant Growth System and Method

The invention lies in the field of plant growing and particularly in the field of hydroponic germination of plants. More particularly, the present invention relates to an intelligent hydroponic system, a method performed in such a system and corresponding use of the system.

Recently, plant growing systems have been increasingly used in many areas. In particular, hydroponic plant growing systems have encountered vast application for indoor gardening and it has been rapidly developing due to increasing demand. Indoor plant growing devices and system cab used by businesses such as restaurants or by individuals for private use.

EP 3251499 A1 relates to a hydroponic plant grow cabinet, comprising a housing, said housing comprising main plant growing chamber and a pre-growing chamber for seeds/seedlings, main tank and auxiliary tanks for a nutrient solution and pH level regulating solutions, pumps and tubing, lighting means, ventilating means, control means, sensors, display means, loudspeaker and user input means, network communication means, connection to electric main, connections to water mains and sewage characterized in that said cabinet comprises connections to water mains and sewage, inside said housing cabinet comprises a module of a refill cartridge system for cartridges with nutrients and chemicals for regulating pH level, in the main chamber at least one module of plant growing pod stands, said module being slidable in and out of the main chamber, where each stand comprises in vertical direction multitude of plant grow pods one above the other, and in the pre-growing chamber at least one holder module for receiving several seed/seedling growing cups, said cup holder module being slidable in and out of the chamber.

EP 3138386 A1 refers to a plant breeding cabinet with a cabinet body and at least one cabinet door and an illumination arranged in the cabinet body, a light screen being arranged in the cabinet body between the illumination and the at least one cabinet door.

US 2014/0026474 A1 refers to embodiments generally related to a system for growing plants or other living organisms. A container is used that includes sensors for sensing conditions of the plant. Dispensers, such as emitters, provide away to dispense materials such as water, nutrients, insecticides, herbicides, etc. under human or machine control. A network connection allows monitoring and control of the container from a remote site. Management of plant growth can be local or remote, or a combination of the two. Control expertise can be selected by a user who is local to the container from a website. Control

expertise can also be provided by a human expert who is remote from the container. Other features are described.

EP 3087831 A1 discloses to a system for indoor plant cultivation. The system is low cost, simple system that may be used for example at homes, in restaurants, and in schools to grow vegetables, flowers and other plants. Short summarized, what is claims is a system for indoor plant cultivation comprising a frame having at least on first lifting means and at least one second lifting means; at least one lighting system comprising a light panel, multiple grow lights, and at least one sensor block; at least one growth rack comprising water inlet, one or more cells for plant capsules and a control system comprising a main water inlet, a pump/valve, water pipes and flow sensors for each growth rack, a control center, an analytic center and control device.

US 2009/0031622 A1 refers to a plant growing environment control terminal comprising an image data receiving section for receiving image data on the image of a plant from a plant growing facility, an image display section for displaying the plant image according to the received image data, a growing environment data receiving section for receiving growing environment data, and a growing environment data transmitting section for transmitting the received growing environment data to the plant growing facility. The end user can grow the plant in his (her) own way while checking the growth progress on the image even from a remote place. Therefore, a plant growing environment control terminal effectively producing generally called healing effect is provided.

In light of the above, it is therefore an object of the present invention to overcome or at least to alleviated the shortcomings and disadvantages of the prior art. More particularly, it is an object of the present invention to provide a method and a corresponding system for controlling a plant growth device providing an optimized and user-oriented plant growth management.

These objects are met by the present invention.

In a first embodiment the invention relates to a method for controlling a plant growth device, the method comprising: acquiring sensor data via at least one sensor component, processing the sensor data via at least one data processing component to generate at least one processed data set and predicting plant growth based on the processed data set.

In one embodiment, the plant growth device may be a hydroponic system.

In another embodiment, the plant growth device may be an aeroponic system.

In one embodiment, the plant growth device may be an autonomous system.

In one embodiment, the plant growth device may be a manually controlled system.

In one embodiment, the plant growth device may be a semi-autonomous system.

The method may further comprise monitoring growth of plants via comparing a first processed data set with a second processed data set to generate a compared data set. Monitoring plant growth via comparison of a first, i.e. initial, stage of the plant growth with a second, i.e. a subsequent, stage of the plant growth may allow to have a more detailed understanding of the development of a given plant under supplied conditions in the plant growth device, which may be advantageous, as it may allow to further alter the settings of the plant growth device to optimize conditions for plant growth.

The method may comprise matching the sensor data, the processed data set and the compared data sets to at least one user profile to generate a profile matching data set. Generating a profile matching data set may facilitate to supply a user-oriented approach, as it may allow the method to meet requirements, needs and/or preferred results of a given user. Furthermore, it may allow the method to achieve personalized results, i.e. a profile matching data set may supply information to reach individual goals of a plurality of users.

The method may comprise generating a controlling hypothesis of the plant growth device, wherein the controlling hypothesis may be based on profile matching data set.

In one embodiment, the sensor component may comprise at least one of pH sensors, water level sensor, humidity sensors, temperature sensors, optical sensors, and/or image sensors. It will be understood that the sensor component may be allocated at different locations in the plant growth device, e.g. the water level sensor may be located in a central water tank, the humidity sensor may probably be set in the enclosure of the plant growth device for measuring air relative humidity. In some instances, the sensor component may also represent a remote sensor component. Furthermore, it will be understood that the pH sensor may comprise different types of electrode and/or sensors, which may further be configured to measure additional parameter to pH levels, such as, conductivity, dissolved oxygen, etc. For instance, in one embodiment, the pH sensor may comprise an electrode comprising a glass membrane or a porous ceramic membrane. Therefore, the said pH sensor may be used to determine the acidity or alkalinity of the a medium in the plant growth device, such as, for example, water. However, the pH sensor may further be

configured to measure a plurality of parameters related to the environment of the plant growth device. For example, the pH sensor may also be configured to measure, in addition to pH level, conductivity, specific conductance, salinity, resistivity, oxidation-reduction potentials (ORP), total dissolved solids (TDS), dissolved oxygen (DO), temperature, and electrolytes such as ammonium, nitrates, chloride, etc. Furthermore, it will be understood that the optical sensors may comprise a plurality of sensors and combinations thereof, such as, inter alia, photoconductive devices, photovoltaics, photodiodes, phototransistors, etc. In some instances, the optical sensors may further comprise optical switches, which may be advantageous as it may allow to activate or deactivate a given component, e.g. light supply, according to sensor data collected via the optical sensor. It will also be understood that the image sensor may comprise a plurality of sensors configured to detect and/or capture information required to generate image data. Such image sensors may comprise light-detection based sensors but may also comprise sensors using other types of electromagnetic radiation. In simple terms, the image sensors may comprise, for example, cameras, camera modules, thermal imaging devices, radars, sonar sensors, night vision devices, etc. Furthermore, the image sensor may be a semiconductor charge-coupled device (CCD), or a complementary metal-oxide-semiconductor (CMOS), or a N-type metal-oxide-semiconductor (NMOS), etc.

In another embodiment, sensor data may further comprise at least one of pH level, electroconductivity, water temperature, water level, air temperature, air humidity, pressure, nutrient and supplement levels, and image data.

In one embodiment, the sensor data may comprise sensor data as a function of time. In simple words, the sensor data may sense a plurality of parameters of the plant growth device on the time domain, i.e. over time, which may, for example, be based on intermittent measurements and/or continuous measurements. It will be understood that whether a measurement is continuous or not shall depend on the type of parameter being measured and that there may be periods or phases in which a given parameter is measured continuously but later only within intervals. For example, when a batch of a new nutrient composition is supplied to a plant growth device, the pH, water conductivity and temperature may be measured continuously, for instance, for two hours. However, after the batch of the new nutrient composition is fully supplied to the plant growth device, the same parameter might only be monitored every, for example, two hours. Such configuration may be advantageous, as it may allow to maximize the utilization of components, such as internal memories of the data processing component, etc.

In one embodiment, the data processing component may perform at least one step of: processing sensor data, comparing processed sensor data set, matching sensor data set,

generating profile matching data set, and generating control hypothesis. It will be understood that the control hypothesis may also be used for further machine learning methods, such as, it may be used in reinforcement learning, for example, in combination with a reward function.

In one embodiment, the data processing component may be in-built in the plant growth device, which may be advantageous, as it may allow to process and/or pre-process the sensor data before and/or in order to transmit the (pre)(processed) sensor data to another component.

In one embodiment, the data processing component may be a remote component, which may be advantageous, as it may allow to implement more powerful data processing components with the further advantage of an increased computing capacity.

In another embodiment, the plant growth device may comprise at least two data processing components and wherein the at least one data processing component may be one of: a data processing component in-built in the plant growth device, and a remote data processing component. Such configuration may provide the advantage of allowing a combination of the described above components, i.e. the sensor data may be (partially) preprocessed in the in-built data processing component and then the preprocessed sensor data may be transmitted to a remote data processing component, where further computation of data may be performed, such as, for example, via the remote data processing component, which may be a (integrated) module of a server and/or a neural network.

The data processing component may comprise a server.

The data processing component may be a remote server.

In one embodiment, the first processed data set may comprise a data set of a first time-dependent sensor data, and the second processed data set may comprise a data set of a second time-dependent sensor data, wherein the second time-dependent sensor data may be acquired at a time t_2 being different from a time t_1 of the first time-dependent sensor data.

The steps described in embodiments of the present invention may be iteratively performed, such that for each natural number $n \leq m$, where m denotes the number of iterations, the n-th sensor data may be acquired via at least one sensor component, the n-th sensor data may be processed via at least one data processing component to generate the n-th

processed data set, and the n-th plant growth prediction may be performed based on the processed data set. Furthermore, the first processed data set may be compared with the n-th processed data set to generate the n-th compared data set, and the n-th profile matching data set may be generated based on the n-th sensor data, the n-th processed data set and the n-th compared data set.

Moreover, in one embodiment, the n-th controlling hypothesis of the plant growth device may be generated, and wherein the n-th controlling hypothesis may comprise at least one controlling settings for controlling the plant growth device to (n+1)th steps described above, and wherein the n-th controlling hypothesis depends on the n-th profile matching data set.

The number of iterations may comprise iterations with initiation intervals of 30 min, preferably 15 min, most preferably 5 min.

The method may further comprise triggering data transmission from the in-built data processing component to the remote data processing component at least every 30 min, preferably every 15 min, most preferably every 5 min.

In one embodiment, the step of triggering data transmission may comprise sensor data.

In another embodiment, the step of triggering data transmission may comprise transmitting processed data set.

In one embodiment, the step of triggering data transmission may comprise transmitting compared data set.

In another embodiment, the step of triggering data transmission may comprise transmitting profile matching data set.

In one embodiment, the step of triggering data transmission may comprise transmitting controlling hypothesis.

The controlling hypothesis may comprise at least one of: plant growth prediction, stock of plant in the plant growth device, plant consumption schedule, malfunction data, plant growth environment data, plant health status prediction, and user usage patterns analytics. In some instances, this may be advantageous, as it may allow to implement and/or suggest mitigation options. For instance, the plant health status prediction may comprise determining whether the color of a given plant is "correct" or denotates "good

health". If said color is "off", i.e. if the color indicates that the plant is unhealthy, a mitigation action may be suggested and/or implemented. Subsequently, in an update, for example, a second sensor data, the controlling hypothesis may be updated including an interpretation of whether the mitigation has "fixed" the problem, i.e. if plant is now exhibiting a "healthy" color, and such result may be served as input for training of the neural network.

In one embodiment, the malfunction data may comprise a hypothesis for a cause of malfunction and/or action propositions for malfunction mitigation.

In one embodiment, the image sensor may be a camera configured to capture image data. In some instances, image data may be advantageous, as it may be used, for example, to analyze plant health, performance and yield. Furthermore, image data may be used to analyze plant health and performance by comparing changes in leaf shape, elongation of stems, leaf coloration, plant size as estimated yield, growth rate, root size, root size, etc. Moreover, image data may further be advantageous, as in some instance may be used to analyze users' machine usage patterns, for instance, which plants are placed into the machine, the consumption rates i.e. how fast are plants consumed, etc.

In one embodiment, the image data may be time-lapsed image data.

In one embodiment, the image data may be continuous image data.

In one embodiment, the at least one user profile may comprise at least one of user's plant consumption preferences, user's plant consumption requirements, and user's plant consumption goals.

The method may further comprise at least one of the steps of transferring sensor data to at least one server, granting access to the least one server to a neural network, training the neural network via using the sensor data in the at least one server, and using the neural network for improving the controlling of the plant growth device and/or the controlling settings of the controlling hypothesis.

In one embodiment, the method may further comprise using the sensor data for generating signals for processing and/or methods of machine learning and artificial intelligence (AI) to derive information related to the at least one user profile and/or the controlling hypothesis.

The controlling hypothesis may be based on at least one analytical approach. For instance, the controlling hypothesis may be based on at least one of: signal filter processing, pattern recognition, probabilistic modeling, Bayesian schemes, machine learning, supervised learning, unsupervised learning, reinforcement learning, statistical analytics, statistical models, principle component analysis, independent component analysis (ICA), dynamic time warping, maximum likelihood estimates, modeling, estimating, neural network, convolutional network, deep convolutional network, adversarial neural network, deep learning, ultra-deep learning, genetic algorithms, Markov models, and/or hidden Markov models.

The data processing component may be external to the plant growth device.

The plant growth device may comprise the data processing component.

The image data may be used to support computer vision.

The image data may be used for plant recognition, plant tracking and plant growth monitoring.

The at least one analytical approach may be used to analyze biological, environmental and/or human-machine interactions.

The at least one server may comprise a synthetic dataset of plants to bootstrap models for machine vision, machine cognition, etc. according to any of the preceding embodiments.

In another embodiment, the method may further comprise digital simulation of plants and/or models of growth.

The digital simulation of plants and/or models of growth may further comprise using at least one generative adversarial network (GAN).

The method may comprise using at least one of 3D rendering technologies, L-systems, and parametric modelling to output the digital simulation of plants and/or models of growth.

The output may be used to bootstrap at least one synthetic dataset for GANs.

The method may further comprise using at one convolutional neural network to process 2D image data of plants.

The step of predicting plant growth may comprise using plant genome sequence data as input for GANs.

The step of predicting plant growth may further comprise creating a plurality of digital replicas of plants, and wherein replica plants may be used to simulate and predict real life plant environment reactions.

In one embodiment, the prediction of plant replicas may be transferred to the server, and wherein the server introduces said predictions to the controlling hypothesis.

In another embodiment, the prediction may be used as input data to forecast and create new nutritional compositions in laboratory experimental conditions, and wherein the new nutritional composition can be generated via a mixture of main supplements mixture available in the plant growth device.

In one embodiment, the method may further comprise using a user interface, wherein the user interface may be configured to grant access to at least one user to an intelligent machine. It will be understood that in some embodiments the term intelligent machine may be intended to refer to a plant growth device, and/or a system for controlling the plant growth device.

In another embodiment, the method may further comprise using the user interface to allow the at least one user to input and/or modify user profile information.

The user interface may further comprise at least one of receiving any data according to any of the steps described above, displaying any of the data to the at least one user, displaying a recommendation for plants or sets of plants to grow according to any of the data described above, displaying a recommendation for nutrients or supplements to introduce into the plant growth device generated based on any of the data described above, and displaying a recommendation for recipes according to according to any of the data described above.

In one embodiment, the method may further comprise using at least one optical sensor for reading a marking comprising a unique identifier (UID) for a seed.

The step of reading a marking may further comprise at least one of: identifying the seed in accordance with at least one authentication scheme, generating a hash value for the seed via application of at least one cryptographic hash function, and tracking the seed based on said generated hash value.

The marking may be machine-readable representation of data.

The marking further may also comprise a human-readable representation of data.

In a second aspect the present invention relates to a system configured for controlling a plant growth device that may be particularly configured to conduct a method according to any of the above explained method embodiments.

The system may comprise: at least one communication component configured to transfer data from and to the plant growth device, at least one data processing component configured to process sensor data from the plant growth device, and at least one server.

In one embodiment, the system may be configured to control at least two plant growth devices.

The plant growth device may be a hydroponic system, which may be advantageous, as it may provide means for a less complex system due to the lack of need, for example, of soil, and a better use of space. Furthermore, it may provide a more environmentally-friendly option as it may allow reducing water consumption as well as providing a greater control over the internal environment and conditions of the plant growth device such as control over lighting, pH, water level, temperature, etc., which may on the one hand facilitate selectively tuning priority growth of plants, and on the other hand, it may provide a better plant growth rate.

The plant growth device may be an aeroponic system, which in some instances may be advantageous, as it may allow a faster plant growth based of a constant and tunable oxygen supply. Furthermore, it may allow reducing needs of nutrients and water as well as a providing an easy to maintain system due to comprising a less complex system.

The system may be an autonomous system, which in some instances may be advantageous, as it may allow the system to operate without a direct involvement of a user.

The system may be a manually controlled control system, which may be desired, as a user may have control over the system to better adapt the operation of the system to specific needs, requirements and/or wishes regarding, for instance, characteristics growth of plants.

The system may be a semi-autonomous system.

The at least one data processing component may be in-built in the plant growth device.

The at least one data processing component may be a remote data processing component.

The at least one server may be a remote server.

The at least one plant growth device may comprise at least one sensor component.

The at least one sensor component of may comprise at least one of pH sensors, water level sensors, humidity sensors, temperature sensors, optical sensors and/or image sensors.

The image sensor may be a camera configured to capture time-lapsed image data.

The image sensor may be a camera configured to capture continuous image data.

In one embodiment, the system comprising at least one neural network.

The at least one server may be configured to grant access to the at least one neural network to the sensor data of the at least one plant growth device and wherein said sensor data may be used to train the neural network.

In one embodiment, the training of the neural network may comprise using at least one of: plant growth rate and plant color.

In another embodiment, the training of the neural network may further comprise using feedback provided by at least one user comprising at least one of: plant taste and consumption date.

The neural network may be configured to improve the controlling of the plant growth device and/or the controlling settings of the controlling hypothesis.

The data processing component may be non-transient computer-readable media comprising instructions which, when executed by the plant growth device, may cause the plant growth device to carry out the corresponding steps as recited herein.

In one embodiment, the at least one neural network may comprise a generative adversarial network.

In another embodiment, the at least one neural network may comprise a convolutional neural network.

The system may further comprise a user interface configured to grant access to at least one user to an intelligent machine.

The user interface may further be configured to allow the at least one user to input and/or modify user profile information.

In one embodiment, the user interface may further comprise at least one of: a receiving component configured to receive data related to the plant growth device, and a displaying component configured to: display any of the data related to the plant growth device to the at least one user, to display a recommendation for plants or sets of plants to grow according to any of the data related to the plant growth device, to display a recommendation for nutrients or supplements to introduce into the plant growth device generated based on any of the data related to the plant growth device, and to display a recommendation for recipes according to according to any of the data related to the plant growth device.

The present invention also relates to a use of the system to carry out the method as recited herein.

The present technology is also defined by the following numbered embodiments.

Below, method embodiments will be discussed. These embodiments are abbreviated by the letter "M" followed by a number. When reference is herein made to a method embodiment, those embodiments are meant.

M1. A method for controlling a plant growth device (1000), the method comprising

acquiring sensor data via at least one sensor component (102);

processing the sensor data via at least one data processing component (104) to generate at least one processed data set;

predicting plant growth based on the processed data set.

M2. The method according to the preceding embodiment, wherein the plant growth device (1000) is a hydroponic system.

M3. The method according to embodiment M1, wherein the plant growth device (1000) is an aeroponic system.

M4. The method according to any of the preceding embodiments, wherein the plant growth device (1000) is an autonomous system.

M5. The method according to any of embodiments M1 to M3, where in the plant growth device (1000) is a manually controlled system.

M6. The method according to any of embodiments M1 to M3, wherein the plant growth device (1000) is a semi-autonomous system.

M7. The method according to any of the preceding embodiments, wherein the method further comprises monitoring growth of plants via comparing a first processed data set with a second processed data set to generate a compared data set.

M8. The method according to any of the preceding embodiments, wherein the method comprises matching the sensor data, the processed data set and the compared data sets to at least one user profile to generate a profile matching data set.

M9. The method according to any of the preceding embodiments, wherein the method comprises generating a controlling hypothesis of the plant growth device (1000), wherein the controlling hypothesis is based on profile matching data set.

M10. The method according to any of the preceding embodiments, wherein the sensor component (102) comprises at least one of

pH sensors;
water level sensors;
humidity sensors;
temperature sensors;
optical sensors; an
image sensors.

M11. The method according to the preceding embodiment, the sensor data comprising at least one of

pH level;
electroconductivity;
water temperature;
water level;
air temperature;
air humidity;

pressure;

nutrient and supplement levels; and

image data.

M12. The method according to any of the preceding embodiments, wherein the sensor data comprises sensor data as a function of time.

M13. The method according to any of the preceding embodiments, wherein the data processing component (104) performs at least one step of

processing sensor data;

comparing processed sensor data set;

matching sensor data set;

generating profile matching data set; and

generating control hypothesis.

M14. The method according to the preceding embodiment, wherein the data processing component (104) is in-built in the plant growth device (1000).

M15. The method according to embodiment M13, wherein the data processing component (104) is a remote component.

M16. The method according to embodiment M13, wherein the plant growth device (1000) comprises at least two data processing components (104) and wherein the at least one data processing component (104) is one of

a data processing component (104) in-built in the plant growth device (1000); and

a remote data processing component (104).

M17. The method according to any of the preceding claims and with features of embodiment M13, wherein the data processing component (104) comprises a server (106).

M18. The method according to any of the preceding claims and with features of embodiment M13, wherein the data processing component (104) is a remote server (106).

M19. The method according to any of the preceding embodiments, wherein

the first processed data set comprises a data set of a first time-dependent sensor data, and

the second processed data set comprises a data set of a second time-dependent sensor data, wherein the second time-dependent sensor data is acquired at a time t_2 being different from a time t_1 of the first time-dependent sensor data.

M20. The method according to any of the preceding embodiments, wherein the steps of embodiment M1 are iteratively performed, such that for each natural number $n \leq m$, where m denotes the number of iterations;

the n-th sensor data is acquired via at least one sensor component (102);

the n-th sensor data is processed via at least one data processing component (104) to generate the n-th processed data set;

the n-th plant growth prediction is performed based on the processed data set.

M21. The method according to the preceding embodiment, wherein the steps of embodiment M7 are iteratively performed, such that for each natural number $n \leq m$, where m denotes the number of iterations;

the first processed data set is compared with the n-th processed data set to generate the n-th compared data set.

M22. The method according to any of the two preceding embodiments, wherein the steps of embodiment M8 are iteratively performed, such that for each natural number $n \leq m$, where m denotes the number of iterations;

the n-th profile matching data set is generated based on the n-th sensor data, the n-th processed data set and the n-th compared data set.

M23. The method according to any of the three preceding embodiments, wherein the steps of embodiment M9 are iteratively performed, such that for each natural number $n \leq m$, where m denotes the number of iterations;

the n-th controlling hypothesis of the plant growth device (1000) is generated, and wherein the n-th controlling hypothesis comprises at least one controlling settings for controlling the plant growth device (1000) to (n+1)th steps of M1, M7 and/or M8, and wherein the n-th controlling hypothesis depends on the n-th profile matching data set.

M24. The method according to the preceding embodiment, wherein the number of iterations comprises iterations with initiation intervals of 30 min, preferably 15 min, most preferably 5 min.

M25. The method according to any of the preceding embodiments, wherein the method further comprises triggering data transmission from the in-built data processing component (104) to the remote data processing component (104) at least every 30 min, preferably every 15 min, most preferably every 5 min.

M26. The method according to the preceding embodiment, wherein the step of triggering data transmission comprises sensor data.

M27. The method according to any of the preceding embodiments and with features of embodiment M25, wherein the step of triggering data transmission comprises transmitting processed data set.

M28. The method according to any of the preceding embodiments and with features of embodiment M25, wherein the step of triggering data transmission comprises transmitting compared data set.

M29. The method according to any of the preceding embodiments and with features of embodiment M25, wherein the step of triggering data transmission comprises transmitting profile matching data set.

M30. The method according to any of the preceding embodiments and with features of embodiment M25, wherein the step of triggering data transmission comprises transmitting controlling hypothesis.

M31. The method according to any of the preceding embodiments, wherein the controlling hypothesis comprises at least one of:

plant growth prediction;
stock of plant in the plant growth device (1000);
plant consumption schedule;
malfunction data;
plant growth environment data;
plant health status prediction; and
user usage patterns analytics.

M32. The method according to the preceding embodiment and with features of embodiment M11, wherein the malfunction data comprises a hypothesis for a cause of malfunction and/or action propositions for malfunction mitigation.

M33. The method according to any of the preceding embodiments and with features of embodiment M10, wherein the image sensor is a camera configured to capture image data.

M34. The method according to the preceding embodiment, wherein the image data is time-lapsed image data.

M35. The method according to the preceding embodiment, wherein the image data is continuous image data.

M36. The method according to any of the preceding embodiments and with features of embodiment M8, wherein the at least one user profile comprises at least one of

user's plant consumption preferences;

user's plant consumption requirements;

user's plant consumption goals.

M37. The method according to the preceding embodiment, wherein the method comprises at least one of the steps of

transferring sensor data to at least one server (106);

granting access to the least one server (106) to a neural network;

training the neural network via using the sensor data in the at least one server (106); and

using the neural network for improving the controlling of the plant growth device (1000) and/or the controlling settings of the controlling hypothesis.

M38. The method according to any of the preceding embodiments, wherein the method further comprises using the sensor data for generating signals for processing and/or methods of machine learning and artificial intelligence (AI) to derive information related to the at least one user profile and/or the controlling hypothesis.

M39. The method according to any of the preceding embodiments and with features of embodiment M9, wherein the controlling hypothesis is based on at least one analytical approach.

M40. The method according to any of the preceding embodiments, wherein the data processing component (104) is external to the plant growth device (1000).

M41. The method according to any of the embodiments M1 to M37, wherein the plant growth device (1000) comprises the data processing component (104).

M42. The method according to any of the preceding embodiments and with features of embodiment M10 and M33, wherein the image data is used to support computer vision.

M43. The method according to the preceding embodiment, wherein the image data is used for plant recognition, plant tracking and plant growth monitoring.

M44. The method according to any of the preceding embodiments and with features of embodiment M40, wherein the at least one analytical approach is used to analyze biological, environmental and/or human-machine interactions.

M45. The method according to any of the preceding embodiments and with features of embodiment M37, wherein the at least one server (106) comprises a synthetic dataset of plants to bootstrap models for machine vision, machine cognition, etc. according to any of the preceding embodiments.

M46. The method according to any of the preceding embodiments, wherein the method further comprises digital simulation of plants and/or models of growth.

M47. The method according to the preceding embodiment, wherein the digital simulation of plants and/or models of growth further comprises using at least one generative adversarial network (GAN).

M48. The method according to the preceding embodiment, wherein the method comprises using at least one of

3D rendering technologies;

L-systems; and

parametric modelling,

to output the digital simulation of plants and/or models of growth.

M49. The method according to the preceding embodiment, wherein the output is used to bootstrap at least one synthetic dataset for GANs.

M50. The method according to embodiment M47, wherein the method further comprises using at one convolutional neural network to process 2D image data of plants.

M51. The method according to any of the preceding embodiments and with features of embodiment M1, wherein the step of predicting plant growth comprises using plant genome sequence data as input for GANs.

M52. The method according to any of the embodiments M47 to M51 and with features of embodiment M1, wherein the step of predicting plant growth further comprises creating a plurality of digital replicas of plants, and wherein replica plants are used to simulate and predict real life plant environment reactions.

M53. The method according to the preceding embodiment, wherein the prediction of plant replicas is transferred to the server (106), and wherein the server (106) introduces said predictions to the controlling hypothesis.

M54. The method according to the preceding embodiment, wherein the prediction is used as input data to forecast and create new nutritional compositions in laboratory experimental conditions, and wherein the new nutritional composition can be generated via a mixture of main supplements mixture available in the plant growth device (1000).

M55. The method according to any of the preceding embodiments, wherein the method further comprises using a user interface (2000), wherein the user interface (2000) is configured to grant access to at least one user to an intelligent machine.

M56. The method according to the preceding embodiment, wherein the method further comprises using the user interface (2000) to allow the at least one user to input and/or modify user profile information.

M57. The method according to the preceding embodiment, wherein using the user interface (2000) comprises at least one of

receiving any data according to embodiments M1 to M43;

displaying any of the data related to the plant growth device (1000) according to embodiments M1 to M21 to the at least one user;

displaying a recommendation for plants or sets of plants to grow according to any of the data related to the plant growth device (1000) according to embodiments M1 to M43;

displaying a recommendation for nutrients or supplements to introduce into the plant growth device (1000) generated based on any of the data related to the plant growth device (1000) according to embodiments M1 to M43; and

displaying a recommendation for recipes according to according to any of the data related to the plant growth device (1000) according to embodiments M1 to M43.

M58. The method according to any of the preceding embodiments, wherein the method further comprises using at least one optical sensor for reading a marking comprising a unique identifier (UID) for a seed.

M59. The method according to the preceding embodiment, wherein the step of reading a marking further comprises at least one of

identifying the seed in accordance with at least one authentication scheme;

generating a hash value for the seed via application of at least one cryptographic hash function; and

tracking the seed based on said generated hash value.

M60. The method according to any of the two preceding embodiments, wherein the marking is machine-readable representation of data.

M61. The method according to any of the three preceding embodiments, wherein the marking further comprises a human-readable representation of data.

Below, system embodiments will be discussed. These embodiments are abbreviated by the letter "S" followed by a number. When reference is herein made to a system embodiment, those embodiments are meant.

S1. A system configured for controlling a plant growth device (1000) that is particularly configured to conduct a method according to any of the preceding method embodiments.

S2. The system according to the preceding embodiment, wherein the system comprises

at least one communication component configured to transfer data from and to the plant growth device (1000);

at least one data processing component (104) configured to process sensor data from the plant growth device (1000);

at least one server (106).

S3. The system according to any of the two preceding embodiments, wherein the system is configured to control at least two plant growth devices (1000).

S4. The system according to any of the preceding system embodiment, wherein the plant growth device (1000) is a hydroponic system.

S5. The system according to any of the preceding system embodiment, wherein the plant growth device (1000) is an aeroponic system.

S6. The system according to any of the preceding system embodiments wherein the system is an autonomous system.

S7. The system according to any of the embodiments S1 to S5, wherein the system is a manually controlled control system.

S8. The system according to any of the embodiments S1 to S5, wherein the system is a semi-autonomous system.

S9. The system according to any of the preceding system embodiments, the at least one data processing component (104) is in-built in the plant growth device (1000).

S10. The system according to any of the embodiments S1 to S5, wherein the at least one data processing component (104) is a remote data processing component (104).

S11. The system according to any of the preceding system embodiments, wherein the at least one server (106) is a local server (106).

S12. The system according to any of the preceding system embodiments, wherein the at least one server (106) is a remote server (106).

S13. The system according to any of the preceding system embodiments, wherein the at least one plant growth device (1000) comprises at least one sensor component (102).

S14. The system according to the preceding embodiment, wherein the at least one sensor component (102) of comprises at least one of

pH sensors;
water level sensor;
humidity sensors;
temperature sensors;
optical sensors; and
image sensors.

S15. The system according to the preceding embodiment, wherein the image sensor is a camera configured to capture image data.

S16. The system according to the preceding embodiment, wherein the image data is time-lapsed image data.

S17. The system according to embodiment S15, wherein the image data is continuous image data.

S18. The system according to any of the preceding system embodiments, the system comprising at least one neural network.

S19. The system according to the preceding embodiment and with features of embodiment S2, wherein the at least one server (106) is configured to grant access to the at least one neural network to the sensor data of the at least one plant growth device (1000) and wherein said sensor data is used to train the neural network.

S20. The system according to the preceding embodiment, wherein the training of the neural network comprises using at least one of:

plant growth rate; and

plant color.

S21. The system according to the preceding embodiment, wherein the training of the neural network further comprises using feedback provided by at least one user comprising at least one of

plant taste; and

consumption date.

S22. The system according to the preceding embodiment, wherein the neural network is configured to improve the controlling of the plant growth device (1000) and/or the controlling settings of the controlling hypothesis.

S23. The system according to any of the preceding system embodiments, wherein the data processing component (104) is non-transient computer-readable media comprising instructions which, when executed by the plant growth device (1000), causes the plant growth device (1000) to carry out the corresponding steps according to any of the preceding method embodiments.

S24. The system according to any of the preceding system embodiments and with features of embodiments S16, wherein the at least one neural network comprises a generative adversarial network.

S25. The system according to any of the preceding embodiments and with features of embodiments S16, wherein the at least one neural network comprises a convolutional neural network.

S26. The system according to any of the preceding system embodiments, wherein the system further comprises a user interface (2000) configured to grant access to at least one user to an intelligent machine.

S27. The system according to the preceding embodiment, wherein the user interface (2000) is further configured to allow the at least one user to input and/or modify user profile information.

S28. The system according to the preceding embodiment, wherein the user interface (2000) further comprises at least one of

a receiving component configured to receive data related to the plant growth device; and

a displaying component configured to

display any of the data related to the plant growth device (1000) to the at least one user;

display a recommendation for plants or sets of plants to grow according to any of the data related to the plant growth device (1000);

display a recommendation for nutrients or supplements to introduce into the plant growth device (1000) generated based on any of the data related to the plant growth device (1000); and

display a recommendation for recipes according to according to any of the data related to the plant growth device (1000).

Below, use embodiments will be discussed. These embodiments are abbreviated by the letter "U" followed by a number. When reference is herein made to a system embodiment, those embodiments are meant.

U1. Use of the system according to any of the preceding system embodiments for carrying out the method according to any of the preceding method embodiments.

The present invention will now be described with reference to the accompanying drawings which illustrate embodiments of the invention. These embodiments should only exemplify, but not limit, the present invention.

Fig. 1 schematically depicts a plant growth device according to embodiments of the present invention;
Fig. 2 schematically depicts a system for controlling a plant growth device according to embodiments of the present invention;
Fig. 3 schematically depicts an intelligent plant growth system according to embodiments of the present invention.

It is noted that not all the drawings carry all the reference signs. Instead, in some of the drawings, some of the reference signs have been omitted for sake of brevity and simplicity of illustration. Embodiments of the present invention will now be described with reference to the accompanying drawings.

Fig. 1 schematically depicts an embodiment of a plant growth device 1000 according to embodiments of the present invention. In simple terms, the plant growth system may comprise a grow cabinet 1002, which may also be referred to as grow enclosure 1002 or simply as cabinet 1002 or enclosure 1002. Furthermore, the plant growth device 1000 may also comprise a plurality of sensors, for instance, but not limited to, pH sensors such as conventional glass electrodes, e.g. silver-silver chloride membrane probes, pH-meter based on solid state electrodes, telemetry, colorimetry, Clark electrodes, etc.; water level sensors, humidity sensors, temperature sensors, optical sensors, image sensors.

In one embodiment, the image sensor may be at least one camera configured to capture image data. In one embodiment, the image data may be time-elapsed image data. In another embodiment, the image data may be a continuous image data.

The enclosure 1002 may, for instance, comprise a chamber 1004 and a pre-growing chamber for seed/seedlings 1006, main tank and auxiliary tanks for a nutrient solution and pH level regulating solutions, pumps and tubing, lighting means 1008, ventilating means 1010, control means, sensors, display means, loudspeaker and user input means, network communication means and connection to electric main. Furthermore, the plant growth device 1000 may comprise a plurality of connections to water mains and sewage and inside the plant growth device 1000 it may further comprise a module of a refill cartridge system 1012 for cartridges with nutrients and chemicals for regulating pH level.

In one embodiment, the enclosure 1002 may comprise at least one module of plant growing pod stands 1014, which may be configured to be slidable in and out of the enclosure 1002. Moreover, the plant growth device 1000 may be configured to receive a plurality of seeds 1016 and/or seedling growing cups 1016, which may also be referred to as pods 1016.

In another embodiment, the sensors may measure data relating, for example, to nutrient solutions and pH level, which may be advantageous, as it may allow to collect sensor data regarding the environmental conditions inside the plant growth device 1000, information relating to maintenance, refill, exchange of nutrient solutions, etc.

In another embodiment, the plant growth device 1000 may also comprise sanitation components configured to avoid, reduce or eliminate bacterial growth via, for example, UV-light.

In one embodiment, the plant growth device 1000 may also comprise at least one display component (not shown), for example, screen or touch screen and loudspeaker, which may be configured to output data to at least one user. In another embodiment, the plant growth device 1000 may further comprise at least one input component, such as, for example, keypads or touch screen.

The plant growth device 1000 may comprise at least one network communication component (not shown) configured to establish bidirectional communication with a controlling system 100. The plant growth device 1000 may further comprise a user interface 2000, which may be configured to grant access to at least one user to at least one user profile to input commands for controlling various environmental functions, such as plant watering, temperature, humidity, air circulation and lighting, etc.

The plant growth device 1000 may further comprise other components such as a computer network configured to establish connection for data exchange between a plurality of components, and may, inter alia, comprise LAN connections, wireless networks such as wireless LAN, Wi-Fi, wireless sensor networks, mobile networks, etc. In one embodiment the plant growth device 1000 may be (semi) automatically controlled.

Fig. 2 schematically depicts a system 100 according to embodiments of the present invention. In simple terms, the system 100 may comprise a sensor component 102, a processing component 104 and a server 106.

It will be understood that in some embodiments, the sensor component 102 may be intended to refer to a plurality of sensors of the plant growth device 1000, and therefore,

the sensor component 102 may also be referred to as sensors 102 or sensor 102. In one embodiment, the sensors 102 may be configured to measure a plurality of parameters, such as, temperature, humidity, water level, etc.

In a further embodiment, the sensors 102 may also comprise optical and/or image sensors such as cameras, which may be configured to acquire image data at different times. Said image data may then be linked to a plurality of growth stages of plants in the plant growth device 1000 and such image, may be used, for example, to forecast, predict and/or simulate plant growth. Furthermore, the image data may also be used to evaluate impact of settings of the plant growth device 1000 on the growth of a plurality of plants. The term simulate may be intended to refer to the generation and/or reproduction of representative models of plants subjected to "hypothetical" conditions, which may allow to better understand optimal growth conditions of plants. It may also be intended to refer to approximate imitations of plants, plant growths, performance of the plant growth device, etc.

In simple words, the image sensors 102 may, for example, capture a first image of pods containing seeds, which may be used as initial image data. Subsequently, the image sensor 102 may capture a plurality of images at different times. The interval between one image and another may differ from plant to plant and such information may, for example, be based on a seed-provider database, where an expected plant growth under optimal conditions may be detailed. In even more simple words, the sensors 102 may acquire image data at different times at different interval of time. For example, in the case of a given plant, such as, *Ocimum basilicum* i.e. basils, the image data may be captured every 120 min after inserting a pod containing basils seeds in the plant growth device 1000. However, for another plant, for example, *Petroselinum crispum* i.e. parsley, the image data may be captured at different time intervals, such as, every 100 min or every 150 min. Such different time intervals may be related to different time required for different plants to exhibit a significant change in their growth stage.

Moreover, such settings for the image sensor 102 to acquire image data at different intervals may be advantageous, as it may allow a fine degree of control over the acquisition of data. For instance, the sensors 102 may even be configured to acquire data at different times for variants of the same plant. Taking the case of basil as an example, it may be required to acquire image data every 120 min for a variant of basil, e.g. for *Ocimum tenuiflorum*. However, for another variant of basil, e.g. for *Ocimum gratissimum*, acquiring image data every 200 min may be sufficient. Such differentiation in acquiring data via the sensor component 102 may be advantageous, as it may also allow to have a more precise and/or exact monitoring, prediction and/or simulation of plant growth. Moreover, it may

also be advantageous, as it may allow to adequate the generation of data according to the technological availability, such as, data transmission technology, processing technology, etc.

Data acquired and/or generated by the sensor component 102 may also be referred to as sensor data and may, inter alia, comprise a plurality of data related to the performance of the plant growth device 1000, e.g. humidity, water level, lighting status, etc., as well as data related to the plants such plant growth, impact of the environment of the plant growth device 1000 on the plants, etc.

In one embodiment of the present invention, the sensor component 102 may be configured to be in bidirectional communication with the processing component 104, which may be advantageous, as it may allow the sensor component 102 to transfer sensor data to the processing component 104 as well as receiving information from the processing component 104, such as, settings information required to alter settings of the internal environment of the plant growth device 1000. It will be understood that the sensors may not necessarily have a direct control over the settings, but only implement instructions received, for example, from the data processing component 104.

In one embodiment, the sensor component 102 may be part of the plant growth device 1000. In other words, in one embodiment, the sensor component 102 may be in-built in the plant growth device 1000, such as a camera built inside the plant growth device 1000 and/or a humidity sensor built inside the enclosure of the plant growth device 1000.

In another embodiment, the sensor component 102 may be a remote component. In other words, in one embodiment the sensor component 102 may not be in-built in the plant growth device 1000 but a remote component in communication with the plant growth device 1000, for example, a remote camera and/or a remote barcode scanner. In one embodiment, the communication of the remote sensor component 102 with the plant growth device 1000 may be a wired connection. In another embodiment, the communication of the remote sensor component 102 with the plant growth device 1000 may be a wireless connection, such as, a Wi-Fi connection.

In one embodiment, the processing component 104 may be part of the plant growth device 1000. In more simple words, in one embodiment the processing component 104 in-built in the plant growth device 1000, which may be advantageous, as it may allow the plant growth device 1000 to (partially) operate independent from having a connection to a server component 106 or not.

In another embodiment, the processing component 104 may be a component remote to the growth device 1000. In more simple words, in one embodiment the processing component may not be integrated into the plant growth device 1000.

In one embodiment, the processing component 104 may be a component comprising a plurality of modules, wherein some modules are part of the plant growth device 1000 and some modules are remote to the plant growth device 1000, which may be advantageous, as it may allow the plant growth device 1000 to operate (partially) independent from either the (main) processing component 104 and/or the server component 106. Furthermore, such configuration may allow the plant growth device 1000 to pre-process sensor data before transmitting to a server 106.

In one embodiment, the processing component 104 may be integrated in a server component 106. In some embodiments, the processing component 104 integrated in a server component 106 may be a module component part of the processing component 104 in-built in the plant growth device 102.

In one embodiment, the system 100 may also comprise a server component 106, which may comprise a plurality of servers 106, therefore it may also be referred to as server components 106, or simply as servers 106 or server 106.

In one embodiment, the server 106 may be configured to be in bidirectional communication with the processing component 104 and/or the sensor component 102. Such configuration may be advantageous, as it may allow the server 106 to receive and send data from and to the processing component 104 and/or the sensor component 102. In embodiment, the server 106 may receive and transfer a plurality of type of data, e.g. image data, via a plurality of transfer protocols, e.g. via JSON API, via direct HTTPS, etc. In another embodiment, such data may be encrypted.

In one embodiment, the server 106 may be configured to provide a plurality of different access levels, such as, for example, it may be configured to provide access to an authorized agent to a given information, such as, plant growth status, user profile, etc.

In one embodiment, the server 106 may be configured to request an authentication to an authorized agent before granted access to the requested data. In another embodiments, a given authorized agent may be denied access to data not listed in their access entitlements.

It will be understood that even though examples are given (mostly) in terms of image data, any sensor data of the plant growth device 1000 may be used to monitor, predict and/or

simulate plant growth. The step of simulating plant growth may be intended to refer to the simulation of plants, e.g. replicas, which may allow to analyze a "simulated" plant growth in order to generate models/replicas with characteristics closer to that of a given "real" plant. Moreover, it will also be understood that embodiments of the present invention may also refer to other aspects of the performance of the plant growth device 1000 such as, but not limited to, malfunction of components of the plant growth device 1000, parameters of the internal environment of the plant growth device 1000, etc.

In one embodiment, the processing component 104 and/or the server 106 may subject the sensor to at least one analytical approach. Based on the processed sensor data, a hypothesis may be generated, which may also be referred to as controlling hypothesis, as it may include, inter alia, information that may be used to set, correct and/or optimize the performance of the plant growth device 1000, and may, therefore, also contain settings for altering the performance of the plant growth device 1000. Furthermore, the controlling hypothesis may also comprise hypothesis for users, such as, most probably date of availability of a given plant, matching of plant growth to consumption goals of a user, etc.

Moreover, the controlling hypothesis may also comprise hypothesis regarding the functioning of the plant growth device 1000, therefore, it may also be referred to as comprising causes of the deviations from an expected performance and/or an action proposition for reducing the deviations. In simple words, the controlling hypothesis may also comprise malfunction hypothesis and it may be output to the user (i.e., the hypothesis or the action proposition) and/or (in case of the action proposition) automatically implemented by the system.

Furthermore, in another embodiment, it may possible to clearly differentiate and infer the prevalent root cause for data. For instance, in case of a delayed plant growth, it may be possible to differentiate between germination failure and/or delayed growth due to suboptimal conditions inside the plant growth device 1000. Such hypothesis may take into consideration a plurality of practical applications such as action propositions to improve the conditions inside the plant growth device 1000, an alert to remove and/or replace the pod with germination failure. In one embodiment, the optimization of conditions inside the plant growth device 1000 may automatically be implemented by the system 100.

In one embodiment, the server 102 may further comprise at least one neural network configured to implement machine learning via using the sensor data obtained from the plant growth device 1000. Such neural network may be able to analyze patterns of the sensor data, including their deviations and may thus further interpret the sensor data in order to implement any of the features mentioned in the numbered embodiments.

That is, in general words, embodiments of the present invention acquire data, e.g. a signal, from a plant growth device 1000 via a sensor component 102 and generate sensor data. In other words, embodiments of the present invention describe a system 100 sensing a plant growth device 1000 via a sensor component 102 to generate sensor data, which comprises a plurality of types of data providing information about the status of the plant growth device 1000, e.g. the temperature inside the enclosure 1002. The sensor data is then processed via a process component 104 and transferred to a server 106. The processed sensor data is compared to an initial sensor data and the system then generates a controlling hypothesis based on the analysis of the sensor data. It will be understood that the initial sensor data may refer to a first acquired sensor data, but it may also refer to a reference sensor data stored in the server 106. Such reference sensor data may comprise historical sensor data acquired via the sensor component 102 and/or sensor data provided by, for example, seeds producers, scientific database, etc.

It will be understood that the herein described technology is typically computer implemented, i.e., performed by a data processing component 104.

Fig. 3 schematically depicts an embodiment according to the present invention. In simple terms, Fig. 3 depicts a system 200 comprising a plant growth device 1000, a controlling system 100 and a user environment 2000. The user environment 2000 may also be referred to as user interface 2000, or simple as interface 2000.

In one the user environment 2000 may comprise the operating system of the plant growth device 1000, which may, for example, be output to at least one user as a graphical user interface. The operating system of the plant growth device 1000 may only be accessible to an authorized user, such as, for example a software engineer, a neural network, etc.

In one embodiment, the user environment 2000 may be output on a display built on the plant growth device 1000.

In simple terms, the plant growth device 1000 may allocate a plurality of seeds, which may be individually identified using a marking, e.g. a barcode, associated with a unique identifier (UID). Furthermore, the plant growth device 1000 may comprise a least one optical sensor, e.g. a charge-coupled device (CCD), that may be used for reading the marking of the seeds, such as device may, for example, be a barcode scanner or barcode reader. One the seed has been correctly identified, the system 100 may retrieve that information from the plant growth device 1000. Such information may be used, for example, to establish the first setting of the plant growth system 1000 for an optimal plant

growth. Furthermore, the system 100 may process a plurality of sensor data measured by the plant growth device 1000 and use the processed data to predict, inter alia, plant growth, display recommendations for consumption of plants to at least one user, etc. Furthermore, image data may be used for plant recognition, i.e. the image data capture via, for example, a camera, may be used for recognition of plants by the plant growth device 1000 and/or the controlling system 100.

Furthermore, a user may also be granted access at the user interface 2000 to data input options, which may, for instance, allow the user to provide preferred settings such as plant consumption priority, plant consumption goals, manual control of the conditions inside the plant growth device 1000, etc.

It also be understood that different users may be granted different level of access according their user profile. For instance, a software engineer may only access to data relevant to the performance of the plant growth device 1000 such as malfunction of sensors, while data relating to user of the plant growth device 1000 are not accessible, such as health profile of a given user, etc.

In one embodiment, the system 100 may be responsible for granting access to different users.

In one embodiment the system 100 may be (partially) in- built in the plant growth device 1000.

Furthermore, the system 100 may also comprise using a blockchain. In simple terms, the system 100 may use a method that may comprise using the at least one optical sensor for reading the marking that contains the UID for a seed. Such method may, inter alia, comprise the steps of identifying the seed in accordance with at least one authentication scheme, generating a hash value for the seed via application of at least one cryptographic hash function and tracking the seed based on said generated hash value.

In one embodiment, the marking may be a machine-readable representation of data such as an optical machine-readable representation, e.g. barcodes. The use of a marking may be particularly advantageous, as it may allow to track all changes to a given seed, such as, for example, introduction into the plant growth device 1000, growth profile, prediction and/or estimation of growth and readiness for consumption, germination failure, etc.

In another embodiment, the marking may further comprise a human-readable representation of data, which may advantageous, as it may allow a user to identify the

seed with the plant growth device 1000. Such function may particularly be useful for the user to select a seed that has to be introduced in the plant growth device 1000, for example, from a storage containing a plurality of different seeds.

In one embodiment, the plant growth device 1000, the controlling system 100 and the user interface 2000 may be in bidirectional communication.

While in the above, a preferred embodiment has been described with reference to the accompanying drawings, the skilled person will understand that this embodiment was provided for illustrative purpose only and should by no means be construed to limit the scope of the present invention, which is defined by the claims.

Whenever a relative term, such as "about", "substantially" or "approximately" is used in this specification, such a term should also be construed to also include the exact term. That is, e.g., "substantially straight" should be construed to also include "(exactly) straight".

Whenever steps were recited in the above or also in the appended claims, it should be noted that the order in which the steps are recited in this text may be accidental. That is, unless otherwise specified or unless clear to the skilled person, the order in which steps are recited may be accidental. That is, when the present document states, e.g., that a method comprises steps (A) and (B), this does not necessarily mean that step (A) precedes step (B), but it is also possible that step (A) is performed (at least partly) simultaneously with step (B) or that step (B) precedes step (A). Furthermore, when a step (X) is said to precede another step (Z), this does not imply that there is no step between steps (X) and (Z). That is, step (X) preceding step (Z) encompasses the situation that step (X) is performed directly before step (Z), but also the situation that (X) is performed before one or more steps (Y1), …, followed by step (Z). Corresponding considerations apply when terms like "after" or "before" are used.

Claims

1. A method for controlling a plant growth device (1000), the method comprising
acquiring sensor data via at least one sensor component (102);
processing the sensor data via at least one data processing component (104) to generate at least one processed data set;
predicting plant growth based on the processed data set.

2. The method according to the preceding claim, wherein the method further comprises
monitoring growth of plants via comparing a first processed data set with a second processed data set to generate a compared data set;
matching the sensor data, the processed data set and the compared data sets to at least one user profile to generate a profile matching data set; and
generating a controlling hypothesis of the plant growth device (1000) based on profile matching data set.

3. The method according to any of the preceding claims, wherein the sensor data comprises at least one of
pH level;
electroconductivity;
water temperature;
water level;
air temperature;
air humidity;
pressure;
nutrient and supplement levels; and
image data;
wherein the sensor data comprises sensor data as a function of time.

4. The method according to any of the preceding claims, wherein
the first processed data set comprises a data set of a first time-dependent sensor data, and
the second processed data set comprises a data set of a second time-dependent sensor data, wherein the second time-dependent sensor data is acquired at a time t_2 being different from a time t_1 of the first time-dependent sensor data.

5. The method according to any of the preceding claims, wherein the steps of claims 1 and 2 are iteratively performed, such that for each natural number $n \leq m$, where m denotes the number of iterations;

the n-th sensor data is acquired via at least one sensor component (102);

the n-th sensor data is processed via at least one data processing component (104) to generate the n-th processed data set;

the n-th plant growth prediction is performed based on the processed data set.

the first processed data set is compared with the n-th processed data set to generate the n-th compared data set.

the n-th profile matching data set is generated based on the n-th sensor data, the n-th processed data set and the n-th compared data set.

the n-th controlling hypothesis of the plant growth device (1000) is generated, and

wherein the n-th controlling hypothesis comprises at least one controlling settings for controlling the plant growth device (1000) to (n+1)th steps, and wherein the n-th controlling hypothesis depends on the n-th profile matching data set.

6. The method according to any of the preceding claims, wherein the controlling hypothesis comprises at least one of:

plant growth prediction;

stock of plant in the plant growth device (1000);

plant consumption schedule;

malfunction data comprising a cause of malfunction and/or action propositions for malfunction mitigation;

plant growth environment data;

plant health status prediction; and

user usage patterns analytics.

7. The method according to any of the preceding claims, wherein the at least one user profile comprises at least one of

user's plant consumption preferences;

user's plant consumption requirements; and

user's plant consumption goals.

8. The method according to the preceding claim, wherein the method comprises at least one of the steps of

transferring sensor data to at least one server (106);

granting access to the least one server (106) to a neural network;

training the neural network via using the sensor data in the at least one server (106); and

using the neural network for improving the controlling of the plant growth device (1000) and/or the controlling settings of the controlling hypothesis.

9. The method according to any of the preceding claims, wherein the method further comprises using the sensor data for generating signals for processing and/or methods of machine learning and artificial intelligence (AI) to derive information related to the at least one user profile and/or the controlling hypothesis, and wherein the controlling hypothesis is based on at least one analytical approach and wherein the at least one analytical approach is used to analyze biological, environmental and/or human-machine interactions.

10. The method according to any of the preceding claims, wherein the at least one image sensor is configured to capture image data, and wherein the image data is used for at least one of:

supporting computer vision;

plant recognition;

plant tracking; and

plant growth monitoring.

11. The method according to any of the preceding claims, wherein the method further comprises digital simulation of plants and/or models of growth comprising at least one of

a generative adversarial network (GAN); and

a convolutional neural network.

12. The method according to any of the preceding claims, wherein the step of predicting plant growth comprises at least one of

using plant genome sequence data as input for a generative adversarial network (GAN); and

creating a plurality of digital replicas of plants, wherein replica plants are used to simulate and predict real life plant environment reactions.

13. The method according to any of the preceding claims, wherein the method further comprises using a user interface (2000) comprising at least one of

receiving any data related to the plant growth device (1000) according to any of the preceding method claims;

displaying any of the data related to the plant growth device (1000) according to any of the preceding method claims to the at least one user;

displaying a recommendation for plants or sets of plants to grow according to any of the data related to the plant growth device (1000) according to any of the preceding method claims;

displaying a recommendation for nutrients or supplements to introduce into the plant growth device (1000) generated based on any of the data related to the plant growth device (1000) according to any of the preceding method claims; and

displaying a recommendation for recipes according to according to any of the data related to the plant growth device (1000) according to any of the preceding method claims.

14. The method according to any of the claims the preceding claims, wherein the sensor component (102) comprises at least one optical sensor, and wherein the method further comprises using the optical sensor for reading a marking comprising a unique identifier (UID) for a seed, and wherein the step of reading a marking further comprises at least one of

identifying the seed in accordance with at least one authentication scheme;

generating a hash value for the seed via application of at least one cryptographic hash function; and

tracking the seed based on said generated hash value,

wherein said marking is at least one of

a machine-readable representation of data; and

a human-readable representation of data.

15. A system configured for controlling at least one plant growth device (1000), the system comprising:

at least one sensor component (102) configured to obtain sensor data associated with the plant growth device (1000);

at least one communication component configured to transfer data from and to the plant growth device (1000);

at least one data processing component (104) configured to process sensor data from the plant growth device (1000);

at least one server (106) configured to generate a controlling hypothesis;

at least one user interface (2000) configured to display information to at least one user and to receive input information from at least one user.

16. The system according to the preceding claim, wherein the system comprises at least one of a hydroponic system; and

an aeroponic system.

17. The system according to any of the preceding two claims, wherein the at least one data processing component (104) comprises at least one of:

an in-built data processing component in the plant growth device (1000); and

a remote data processing component,

and wherein the at least one server (106) is at least one of:

a local server; and

a remote server,

and wherein the at least one server comprises at least one neural network.

18. The system according to the preceding claim, wherein the at least one sensor component (102) of comprises at least one of

pH sensors;

water level sensor;

humidity sensors;

temperature sensors;

optical sensors; and

image sensors.

19. The system according to any of the claims 15 to 18, wherein the at least one server (106) is configured to grant access to the at least one neural network to the sensor data of the at least one plant growth device (1000) and wherein said sensor data is used to train the neural network and wherein the neural network is configured to improve the controlling of the plant growth device (1000) and/or the controlling settings of the controlling hypothesis.

20. The system according to any of the claims 15 to 19, wherein the data processing component (104) is non-transient computer-readable media comprising instructions which, when executed by the plant growth device (1000), causes the plant growth device (1000) to carry out the corresponding steps according to any of the claims.

21. The system according to any of the claims 15 to 20 and with features of claim 17, wherein the at least one neural network comprises at least one of

a generative adversarial network; and

a convolutional neural network.

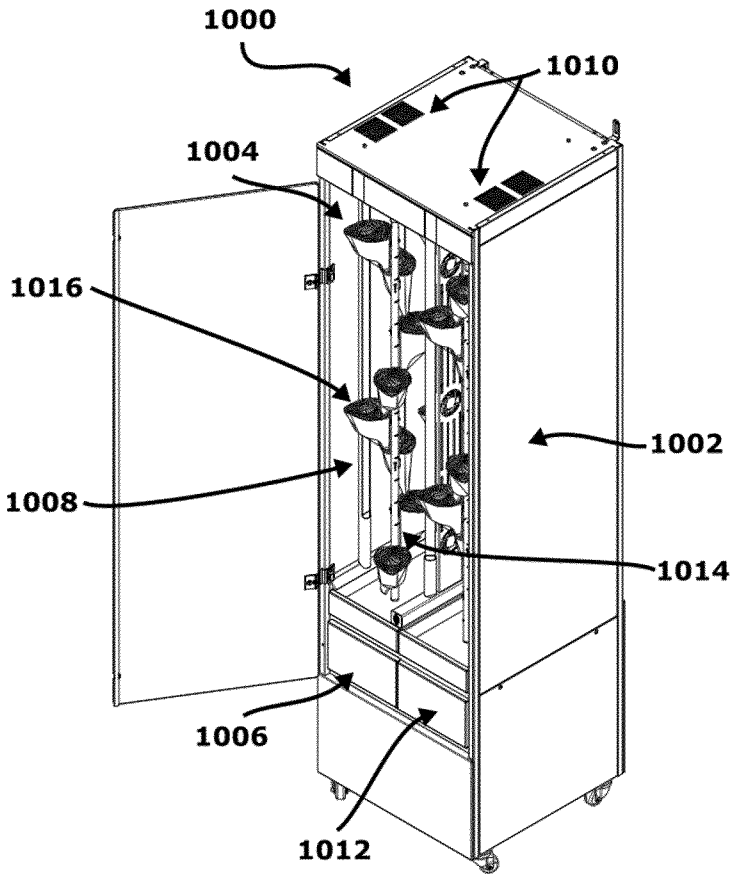


Fig. 1

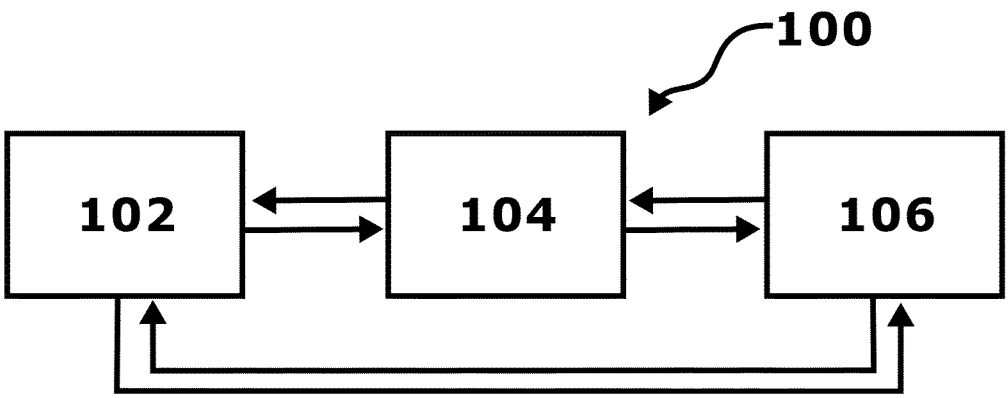


Fig. 2

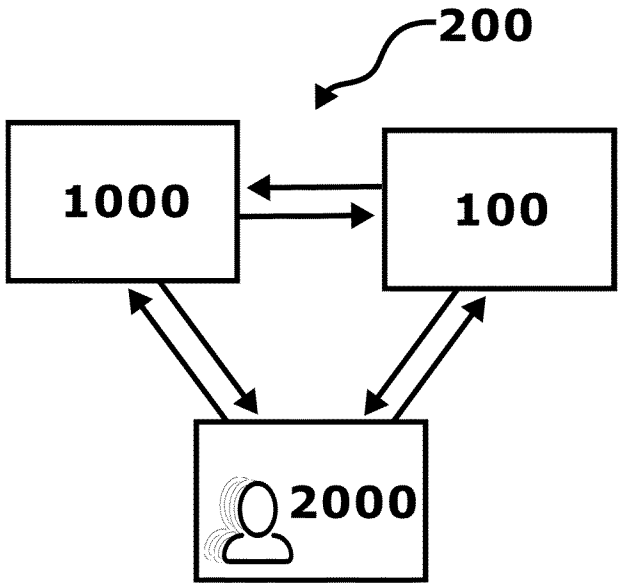


Fig. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2020/058959

A. CLASSIFICATION OF SUBJECT MATTER
INV. A01G31/06
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A01G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 2018/359955 A1 (MILLAR GARY BRET [US]) 20 December 2018 (2018-12-20) abstract figures 1-6 paragraphs [0015] - [0048] -----	1-13, 15-21 14
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 May 2020	28/05/2020

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Benedetti, Arnaud

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Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2020/058959

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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