Title: METHOD AND SYSTEM OF ILLUMINATING PLANTS

Abstract: A system of illuminating at least one plant. The system comprises a plurality of controllable illumination sources each emit light having at least one controllable illumination parameter toward at least one plant, a memory of hosting an illumination plan adapted for inducing at least one cultivation target from the at least one plant during a period, a processing unit which computes at least one adjustment for the at least one controllable illumination parameter of each the controllable illumination source according to the illumination plan during the period, and at least one controller which operates each the controllable illumination source according to respective the at least one adjustment during the period.
FIELD AND BACKGROUND OF THE INVENTION

The present invention, in some embodiments thereof, relates to methods and systems of plant illumination and, more particularly, but not exclusively, to methods and systems of plant illumination in greenhouses.

The way in which to obtain and to maintain favorable cultivation conditions in a greenhouse has been the object of a great number of studies and experiments. Many of the studies focus on attempts to automate the control of the greenhouse environment, for example provide solutions for cooling down of the greenhouse when the temperature threatens to rise above a limit value while others.

For example, International Patent Application No. WO/1997/012511, filed in October 3, 1995, describes a system for establishing and maintaining a favorable environment for cultivation of plants that comprises an enclosure, such as a greenhouse, defining a cultivation space for receiving plants to be cultivated. An electrical consuming device is associated with the enclosure for establishing or maintaining favorable conditions for photosynthesis in the enclosure. A furnace receives a hydrocarbon fuel and burns the fuel to generate a hot combustion gas that contains water vapor and carbon dioxide. Thermal energy is recovered from the hot combustion gas and converted at least partially to mechanical energy. Cooled combustion gas is supplied to the cultivation space, and a generator is coupled to convert mechanical energy to electrical energy. The generator is coupled to the electrical consuming device for supplying electrical energy thereto.

Today, advances in sensors, actuators and microprocessor technology, both on hardware and software level, have enabled distributed implementation of sensor and control actions over sensor/actuators networks. If we connect such local sensor/actuators, private networks to global network (Internet) additional features could be exhibit. The monitored and controlled system could become accessible from almost anywhere. The process parameters data display, remote control, system testing and system reconfiguration could be done using standard browsers on workstation computers, allowing the control by large screens, menus, buttons, on-line helps. This technology allows establishing a greenhouse which is monitored and controlled

SUMMARY OF THE INVENTION

According to some embodiments of the present invention there is provided a system of illuminating at least one plant. The system comprises a plurality of controllable illumination sources each emitting light having at least one controllable illumination parameter toward at least one plant, a memory of hosting an illumination plan adapted for inducing at least one cultivation target from the at least one plant during a period, a processing unit which computes at least one adjustment for the at least one controllable illumination parameter of each the controllable illumination source according to the illumination plan during the period, and at least one controller which operates each the controllable illumination source according to respective the at least one adjustment during the period.

Optional, the system further comprises at least one sensor which measures at least one cultivation parameter pertaining to the at least one plant, the processing unit computing the adjustment according to the at least one cultivation parameter.

More optionally, the plant parameter includes a member of a group consisting of: a tilt, a height, a blooming state, a color, fructification morphology, a fructification level, a number of branches, a height, and a width of the branches of the at least one plant.

More optionally, the at least one sensor includes a member of a group consisting of: an image sensor, a thermometer, a hygrometer, an aerometer, a pyranometer and a solar radiation sensor.

More optionally, the processing unit computes the adjustment according to a combination of a plurality of cultivation parameters.

More optionally, the illumination plan define at least one illumination rule for at least one value of the at least one cultivation parameter, the processing unit computes the adjustment according to the illumination rule in light of the at least one cultivation parameter.
More optionally, the processing unit computes the adjustment according to a combination of a trend of the at least one cultivation parameter.

Optionally, the at least one controller operates at least one reflector of at least one of the plurality of controllable illumination sources to change its illumination angle according to respective the at least one adjustment.

Optionally, the at least one controller operates at least one dimming element of at least one of the plurality of controllable illumination sources to change its illumination intensity according to respective the at least one adjustment.

Optionally, the plurality of controllable illumination source are divided among a plurality of greenhouses, the processing unit computes the adjustment for each the greenhouse, the at least controller operating at least one respective the controllable illumination source accordingly.

According to some embodiments of the present invention there is provided a method of illuminating at least one plant. The method comprises placing at least one controllable illumination source having at least one controllable illumination parameter for illuminating at least one plant, providing an illumination plan adapted for inducing at least one cultivation target from the at least one plant during a period, computing at least one adjustment of at least one controllable illumination parameter of the at least one controllable illumination source according to the illumination plan during the period, and operating the at least one controllable illumination source according to the at least one adjustment.

Optionally, the adjusting comprises adjusting a photometric curve of the light according to the at least one adjustment.

Optionally, the adjusting comprises changing intensity of the light according to the illumination plan at least one adjustment.

Optionally, the providing comprises receiving the at least one cultivation target from a user and automatically selecting the illumination plan accordingly.

Optionally, the method further comprises measuring at least one cultivation parameter of the at least one plant; the adjusting being performed according to the at least one cultivation parameter.
More optionally, the measuring comprises measuring a trend of the at least one cultivation parameter during a period and adjusting the at least one controllable illumination parameter according to the trend.

Optionally, the method further comprises measuring a combination of a plurality of cultivation parameters and adjusting the at least one controllable illumination parameter according to the combination.

According to some embodiments of the present invention there is provided a system of illuminating at least one plant. The system comprises a plurality of controllable illumination sources each emitting light having at least one controllable illumination parameter toward at least one plant, at least one sensor which measures at least one cultivation parameter of at least one of a local climate condition and at least one plant parameter, a processing unit which identifies, according to the at least one cultivation parameter, a deviation from an illumination plan selected for the at least one plant and computes at least one adjustment for the at least one controllable illumination parameter of each the controllable illumination source, and at least one controller which operates each the controllable illumination source according to respective the at least one adjustment.

According to some embodiments of the present invention there is provided an illumination device of illuminating at least one plant. The illumination device comprises an illuminator and at least one dimming element of changing illumination intensity of the illuminator, at least one reflector and at least one actuator which maneuvers the at least one reflector, a communication interface receives at least one illumination instruction, and a controller which operates the at least one dimmer and the at least one actuator according to the at least one illumination instruction.

Optionally, the at least one reflector having plurality of reflection states, each define a different reflection angle for light emitted from the illuminator.

According to some embodiments of the present invention there is provided a method of illuminating at least one plant. The method comprises illuminating at least one plant according to an illumination plan with light having at least one controllable illumination parameter, measuring at least one cultivation parameter of the at least one
plant, detecting a deviation from the illumination plan by the measuring, and adjusting
the at least one controllable illumination parameter according to the detecting.

Unless otherwise defined, all technical and/or scientific terms used herein have
the same meaning as commonly understood by one of ordinary skill in the art to which
the invention pertains. Although methods and materials similar or equivalent to those
described herein can be used in the practice or testing of embodiments of the invention,
exemplary methods and/or materials are described below. In case of conflict, the patent
specification, including definitions, will control. In addition, the materials, methods, and
examples are illustrative only and are not intended to be necessarily limiting.

Implementation of the method and/or system of embodiments of the invention
can involve performing or completing selected tasks manually, automatically, or a
combination thereof. Moreover, according to actual instrumentation and equipment of
embodiments of the method and/or system of the invention, several selected tasks could
be implemented by hardware, by software or by firmware or by a combination thereof
using an operating system.

For example, hardware for performing selected tasks according to embodiments
of the invention could be implemented as a chip or a circuit. As software, selected tasks
according to embodiments of the invention could be implemented as a plurality of
software instructions being executed by a computer using any suitable operating system.

In an exemplary embodiment of the invention, one or more tasks according to exemplary
embodiments of method and/or system as described herein are performed by a data
processor, such as a computing platform for executing a plurality of instructions.
Optionally, the data processor includes a volatile memory for storing instructions and/or
data and/or a non-volatile storage, for example, a magnetic hard-disk and/or removable
media, for storing instructions and/or data. Optionally, a network connection is provided
as well. A display and/or a user input device such as a keyboard or mouse are optionally
provided as well.

BRIEF DESCRIPTION OF THE DRAWINGS

Some embodiments of the invention are herein described, by way of example
only, with reference to the accompanying drawings. With specific reference now to the
drawings in detail, it is stressed that the particulars shown are by way of example and for
purposes of illustrative discussion of embodiments of the invention. In this regard, the
description taken with the drawings makes apparent to those skilled in the art how
embodiments of the invention may be practiced.

In the drawings:

FIG. 1 is a schematic illustration of a system of controlling the illumination of
plants according to an illumination plan in light of real time data, according to some
embodiments of the present invention;

FIG. 2 is a schematic illustration of a system of controlling the illumination of
plants in a plurality of different cultivation areas, according to some embodiments of the
present invention;

FIG. 3 is a schematic illustration of an exemplary controllable illumination
source, according to some embodiments of the present invention;

FIGs. 4A-4E are schematic illustrations of reflectors of an exemplary
controllable illumination source having a single lamp in various tilting angles, according
to some embodiments of the present invention;

FIG. 5 is a flowchart of a method of sequentially controlling light illuminating
one or more plants, according to some embodiments of the present invention; and

FIG. 6 is a flowchart of another method of controlling light illuminating one or
more plants, according to some embodiments of the present invention.

DESCRIPTION OF EMBODIMENTS OF THE INVENTION

The present invention, in some embodiments thereof, relates to methods and
systems of plant illumination and, more particularly, but not exclusively, to methods and
systems of plant illumination in greenhouses.

According to some embodiments of the present invention there are provided
systems and methods of controllably illuminating plants according to an illumination
plan by changing and/or adjusting parameters of illuminating light, for example
intensity, angle and/or spectral characteristics. The illumination plan is optionally
adapted for the illuminated plants and/or for selected cultivation targets, such as
economic efficiency and number of cultivation cycles. Optionally, the selected
cultivation targets are adapted for the illuminated plants. Optionally, the systems and
methods dynamically adjust or change the illumination according to real time local data,
such as local climate conditions and/or plant parameters. For brevity adjusting and changing may be referred to herein interchangeably. This allows proving a controlled illumination environment that adapts the illumination according to real time measurements of cultivation parameters, such as the solar radiation changes, blooming status, fructification morphology, plant growth and the like. Optionally, the cultivation parameters are monitored during a period of hours, days, weeks, and/or months, allowing the detection of cultivation trends. In such embodiments, the illumination may be adjusted to a detected trend.

Optionally, the system is based on a plurality of controllable illumination sources which emit light toward the plants and optionally on one or more sensors which measures related cultivation parameters, such as climate condition and plant parameters in real time. The system optionally includes a processing unit, such as a device with a central processing unit (CPU), a digital signal processor (DSP), or a coprocessor for a CPU or DSP which is programmed to compute adjustments for the controllable illumination parameters of each controllable illumination sources according to an illumination plan that is selected for inducing one or more cultivation targets from the illuminated plants during a period of hours, days, weeks, and/or months. Optionally, the processing unit identifies, according to the cultivation parameters, a deviation from the illumination plan. The processing unit may compute an adjustment for one or more of the controllable illumination parameters of some or all of the controllable illumination sources. The adjustment is used for instructing controllers which operate the controllable illumination sources to change the controllable illumination parameters.

According to some embodiments of the present invention there is provided a method of illuminating plants according to a targeted illumination plan. The method is based on locating controllable illumination sources each having controllable illumination parameters for illuminating one or more plants. An illumination plan adapted for inducing one or more cultivation targets from the plants during a period is selected. This allows adjusting the controllable illumination parameters of one or more of the controllable illumination sources according to an illumination plan during a cultivation period.

Before explaining at least one embodiment of the invention in detail, it is to be understood that the invention is not necessarily limited in its application to the details of
construction and the arrangement of the components and/or methods set forth in the following description and/or illustrated in the drawings and/or the Examples. The invention is capable of other embodiments or of being practiced or carried out in various ways.

Reference is now made to FIG. 1, which is a schematic illustration of a system 100 of controlling the illumination of plants according to an illumination plan, optionally in light of real time data, according to some embodiments of the present invention. The system 100 includes a plurality of controllable illumination sources 102 each having controllable illumination parameters. These parameters may be changed and/or adjusted according to an illumination plan selected for inducing one or more cultivation targets in a certain period from the illuminated plants. The illumination plan may define fixed controllable illumination parameters, dynamic controllable illumination parameters, and/or controllable illumination parameters which are adapted according to climate condition and/or plant parameters scenarios, as further described below. The illumination plan defines controllable illumination parameters which are set to illuminate plants in different cultivation stages.

As outlined above, each one of the controllable illumination sources 102 is a dynamic controllable illumination source having variable controllable illumination parameters. As used herein, a controllable illumination parameter means an intensity of illuminating light, a spectral characteristic of the illuminating light, for example the center frequency, span and resolution bandwidth, an illumination angle, a reflection angle, and/or any combination thereof. These parameters may be changed according to real time data such as climate conditions and/or cultivation parameters, for example as described below. As used herein, real time data means data that is measured or acquired at some point in time during a computational process without introducing a delay of more than few seconds to the computational process.

Each controllable illumination source 102 is connected to a controller 105 which operates it according to received instructions. The controller 105 may be connected to dimming element(s) which change the voltage that feeds the one or more illuminators of the controllable illumination source 102, such as lamps, and/or to actuator(s) that maneuver supporting elements, such as reflectors and/or filters, which are mounted to divert and/or to filter light emitted from the lamp(s) of the controllable illumination
source 102. The dimming element(s) and/or actuator(s) allow changing the controllable illumination parameters of the controllable illumination source 102. Optionally, the dimming element(s) are operated according to the digital addressing lighting interface (DALI) protocol, which is incorporated herein by reference.

Optionally, the controllable illumination source 102 includes a number of illuminators, such as lamps. Optionally, different illuminators emit light with different illumination parameters, for example different spectral characteristics and/or intensity. In such embodiments different lamps may be powered to provide different illuminations according to the illumination plan and/or the real time data pertaining to the plant. Additionally or alternatively, the number of powered lamps is changed according to the illumination plan and/or the real time data pertaining to the plant so that a common illumination source is used to sequentially provide different illumination intensities in different stages of the cultivation period.

The system 100 further includes a processing unit 104 which instructs the controllers 105 according to the illumination plan. The instructions are optionally provided during a cultivation period of a number of hours, days, weeks, and/or months.

Optionally, the processing unit 104 includes and/or connected to a database 107 that hosts one or more illumination plans, each define a desired level of illumination for each of a plurality of stages of each of a plurality of plant illumination plans. The desired level of illumination may be set to achieve one or more cultivation targets, for example a certain economic efficiency level, a desired number of cultivation cycles, an increased yield, a desired energy consumption level, a desired fructification, a desired fructification date, a desired fructification morphology, and any combination thereof. Optionally, different illumination plans may have different cultivation targets and/or different combinations of cultivation targets. In use, the operator may use a man machine interface (MMI) 106 that is connected to the processing unit 104 for selecting plant illumination plan, for example of a certain plant, and one or more cultivation targets. In such an embodiment, the processing unit 104 receives the operator selections and computes or selects a matching illumination plan. Optionally, the illumination plan defines the desired illumination level in different hours of the day during each stage. For example, the illumination plan defines a desired solar radiation flux density per hour of the day during each one of the stages of plant illumination, optionally in watts per square
meter. For clarity, the desired illumination level may be defined for any time unit, for example per minute, per hour, per day, and/or any intermediate or larger time unit.

Optionally, the system 100 includes one or more sensors 103 which are set to measure variable cultivation parameters, such as climate conditions and/or plant parameters of the illuminated plants.

Optionally, the sensors 103 include sensors which measure climate conditions inside and/or outside of a cultivation area, such as a greenhouse, wherein the plants are illuminated. Optionally, the sensors 103 include a thermometer which measures temperature inside and/or outside of the greenhouse. Optionally, the sensors 103 include a hygrometer which measures humidity levels inside and/or outside of the greenhouse. Optionally, the sensors 103 include an aerometer which measures density of air and/or other gases inside and/or outside of the greenhouse. Optionally, the sensors 103 include an actinometer which measures radiation inside and/or outside of the greenhouse. For example, the actinometer is a pyranometer that measures the solar radiation flux density, for example in watts per meter square from a field of view of 180 degrees. Optionally, the sensors 103 include a solar radiation sensor which measures the solar radiation zenith angle or angle of incidence.

Optionally, the sensors 103 include plant sensors which measure plant parameters, such as the tilt of the plant, the height of the plant, the blooming state of the plant, the color of the blooming, the fructification morphology, the fructification level, the number of branches, the height and/or width of the branches. Optionally, the plant sensors are image sensors which image the illuminated plant. The captured image allows analyzing plant parameters of the illuminated plant, for example using known image processing techniques. For example, the image is matched with a previously captured image and/or a reference map to detect a change in the height, width, tilt, branches characteristics, fructification morphology, the fructification level, and/or blooming state.

Optionally, the processing unit 104 detects one or more changes in the cultivation parameters according to the outputs of the sensors 102. The processing unit 104 may now instruct the controller 105 to change the controllable illumination parameters of one or more of the controllable illumination sources 102 according to the detected changes, in light of the illumination plan.
For example, the controller 105 may change the angle of the reflector(s) so that light illuminates only areas in which the plants are found. In such a manner, uncultivated areas are not illuminated and energy consumption can be reduced as the workload of the controllable illumination source 102 may be reduced.

Optionally, the illumination plan defines a desired illumination and/or a desired illumination change, for example light intensifying and/or light dimming percentages, in response to a scenario, such as a cultivation parameter value and/or a combination of cultivation parameters as measured by the sensors 103. Optionally each scenario is defined as a set of rules which link between different measurements of climate conditions and/or plant parameters and a desired illumination level and/or change. For example, the set of rules defines responses of the controllable illumination sources to scenarios such as predefined changes in the temperature, predefined changes in the humidly level, predefined changes in the CO₂ concentrations and the like. The response may be dimming, shutting off, and/or intensifying the light emitted, changing the luminous intensity distribution, which may be referred to as the photometric curve of the controllable illumination source 102, diverting the light be changing the tilting of the reflectors and the like, mounting or dismounting a filter and the like. Optionally, a number of filters are used where each filter filters light in a different frequency range. Optionally, the rules define when the desired controllable illumination parameters are affected by non illumination characteristics, for example temperature, blooming state and the like. Optionally, the illumination plan is selected and/or set according to the plant illuminated by the system. Optionally, the illumination plan may be manually adjusted and/or selected by the user, for example using the MMI 106 that is connected to the processing unit 104. Optionally, the illumination plan is selected according to the type of plants illuminated by the system. In such an embodiment, the database may include a plurality of plans, each for a different plant, a combination of plants and/or a group of plants having common characteristics. In use, the user may select one or more plants and a respective illumination plan is selected by the processing unit 104 accordingly. Optionally, a number of illumination plans may be set simultaneously where each illumination plan is set for a different group of controllable illumination sources 102. In such a manner, the system may illuminate each one of a plurality of different plants according a different illumination plan that is adapted thereto.
Optionally, the illumination plan is computed according to the desired level of illumination of a number of plants. For example, an average level of illumination is set for a combination of a plurality of plants. In such a manner, the desired illumination level may be set to provide a relatively high cumulative gain from the illumination process.

Optionally, the system 100 includes a plurality of groups 212 of controllable illumination sources 102 and one or more of sensors 102, each associated with a certain greenhouse or another cultivation area, for example as shown at FIG. 2. In such an embodiment, each group 212 is connected to a local exchange node 201 that manages the communication of the sensors and/or the controllable illumination sources 102 with the processing unit 104. In such embodiments, the processing unit 104 manages the illumination in a plurality of cultivation areas, optionally remote and separate. Optionally, each group is set in one or more rows above one or more rows of plants.

Optionally, the communication between the local exchange nodes 201 and the processing unit 104 is wireless, for example based on communication protocols such as Wi-Fi™, WiMax™, 3GPP long term evolution (LTE) and the like.

Optionally, the processing unit 104 includes a communication module that allows communicating with remote client terminals 213, such as laptops, cell phones, personal computers and the like, via a network 214. In such embodiments, the remote client terminals 213 may present the alarms which are described below and/or allows operators to use the remote client terminals 213 as the aforementioned MMIs.

Reference is now made to FIG. 3, which is a schematic illustration of an exemplary controllable illumination source 102 having a lamp 302, such as a high pressure sodium lamp and high-intensity discharge lamp, for example hydrargyrum quartz iodide (HQI) lamp, and a pair of adjustable reflectors 301, and a dimming element (not shown), according to some embodiments of the present invention. The lamps optionally have a workload of between about 400W and about 1000W. Optionally, the controllable illumination source 102 is operated according to the instructions received from the processing unit 104 so that it illuminates one or more plants in selected controllable illumination parameters. The reflectors 301 may be tilted or otherwise maneuvered to change the illuminated area and/or location. The tilting of the reflectors changes the photometric curve of the controllable illumination source 102. This is
expressed, *inter alia*, in the reflection angle in which light is reflected from the controllable illumination source 102 toward the plants, for example as shown at FIGs. 4A-4E. The reflectors may be tilted together, optionally simultaneously, for example as shown at FIGs. 4A-4D or separately, for example as shown at FIG. 4E.

Optionally, the exemplary controllable illumination source 102 includes a communication interface to communicate with the processing unit 102 and/or the local exchange node 201, for example a Wi-Fi™ communication unit, a Bluetooth™ communication unit and the like. Optionally, the communication interface is used to provide a feedback pertaining to the angles of the reflectors and/or the intensity of the illumination to the processing unit 104. This feedback allows calculating a change and/or estimating the current status of the exemplary controllable illumination source 102.

Optionally, the exemplary controllable illumination source 102 includes status sensors, such as heat sensors and/or current sensors which monitor the normal functioning of the lamp 302, for example its temperature. The status of the functioning of the controllable illumination source 102 may be forwarded to the processing unit 104, allowing it to generate an alarm and/or otherwise notify an operator about a malfunction.

Reference is now also made to FIG. 5, which is a flowchart of a method of sequentially controlling light illuminating one or more plants, according to some embodiments of the present invention.

First, as shown at 501, one or more illuminations sources 102 are placed to illuminate plants in one or more cultivation areas, such as greenhouses, a growth chamber, a shaded piece of land and the like. The illuminations sources 102 are optionally placed in one or more rows above the plants, for example as described above.

As shown at 502, one or more illumination plans which are adapted for inducing one or more cultivation targets from the illuminated plants during a cultivation period are provided. Each illumination plan may be received and/or selected according to the illuminated plants and/or their illumination requirements, for example as described above.

Now, as shown at 503, one or more adjustments for one or more controllable illumination parameters are computed according to the selected illumination plan during the cultivation period. For brevity, an adjustment may also mean a change in the
illumination, an illumination according to a certain set of instructions, and/or an adjustment or a change to the light exposure of one or more plants. This allows, as shown at 504, operating the controllable illumination sources according to the illumination plan. For example, the angle of the reflectors may be adjusted to direct light toward a segment which does not receive a sufficient amount of solar radiation. In another example, the intensity of the light source 102 is dimmed as the solar radiation which impinges one of the sensors increases about a certain threshold.

This process is iteratively repeated, as shown at 505, providing a controlled illumination during the entire cultivation process or any portion thereof. By automatically adjusting the illumination in real time, according to the illumination plan, a controlled illumination environment is provided. This allows illuminating plants with optimal illumination, as defined in the illumination plan.

Reference is now made to FIG. 6, which is a flowchart of another method of controlling light illuminating one or more plants, according to some embodiments of the present invention. Blocks 501-502 and 504 are as depicted in FIG. 5, however FIG. 6 further depicts blocks pertaining to a real time adaptation of the illumination according to cultivation parameters. As shown at 601, one or more cultivation parameters of the illuminated plants are measured, for example using the sensors. Optionally, the measuring is performed during a cultivation period that lasts hours, days, weeks, months, and/or years. Optionally, the measuring is performed using the sensors 103. Optionally, the measurements are recorded in a monitoring database. The measurements are optionally analyzed to detect trends and/or changes of cultivation parameters during the cultivation period. For example, trends of local weather, trends of solar radiation intensity and and/or angle, local climate condition trends and/or plant parameter trends during different parts of a cultivation period, for example a day, at each cultivation area, for example the angle of incidence of solar radiation, the composition of the impinging light, the temperature, the specific point at a blooming cycle and the like. Optionally, trends and/or changes of a number of measurements are matched to detect correlation and/or difference. Optionally, the recorded measurements may be used to produce reports.

Optionally, an alarm is generated if one or more of the measured climate conditions and/or cultivation parameters exceed or drop below a certain threshold. The
alarm may be a message sent to an operator or any other designated address. The alarm may be indicative of a malfunction in one or more of the controllable illumination sources.

Now, as shown at 602, the measurements are matched with the provided illumination plan. The match allows identifying a deviation from the illumination plan, for example a deviation between the current illumination of the plants and a desired illumination value, for example the intensity or angle of the illuminating light. Optionally, as described above, the illumination plan includes a set of rules which define various scenarios and a desired illumination response or a desired illumination change response. If a match between the measurements and one or more of the scenarios is found, the desired illumination response or the desired illumination change response is selected.

Now, as shown at 603, an adjustment for one or more of the controllable illumination parameters of the light sources 102 is computed according to the deviation or response. This allows, as shown at 504 and described above, operating the illuminations sources 102 to illuminate the plants so that they receive the desired level of illumination as defined in the related illumination plan.

Optionally, this process is iteratively repeated, as shown at 505 and similarly to the described above, providing a controlled illumination during the entire cultivation process or any portion thereof. By automatically adjusting the illumination in real time, according to changing climate conditions and/or cultivation parameters, a controlled illumination environment is provided. This allows illuminating plants with optimal illumination, as defined in the illumination plan, regardless of temporary climate changes, such as solar radiation changes, optionally while taking into account the cultivation stage and the actual growing stage of the plant.

It is expected that during the life of a patent maturing from this application many relevant systems and methods will be developed and the scope of the term a sensor, a processing unit, a controllable illumination source, and an exchange node is intended to include all such new technologies *apriori*.

As used herein the term "about" refers to ± 10%.
The terms "comprises", "comprising", "includes", "including", "having" and their conjugates mean "including but not limited to". This term encompasses the terms "consisting of" and "consisting essentially of.

The phrase "consisting essentially of" means that the composition or method may include additional ingredients and/or steps, but only if the additional ingredients and/or steps do not materially alter the basic and novel characteristics of the claimed composition or method.

As used herein, the singular form "a", "an" and "the" include plural references unless the context clearly dictates otherwise. For example, the term "a compound" or "at least one compound" may include a plurality of compounds, including mixtures thereof.

The word "exemplary" is used herein to mean "serving as an example, instance or illustration". Any embodiment described as "exemplary" is not necessarily to be construed as preferred or advantageous over other embodiments and/or to exclude the incorporation of features from other embodiments.

The word "optionally" is used herein to mean "is provided in some embodiments and not provided in other embodiments". Any particular embodiment of the invention may include a plurality of "optional" features unless such features conflict.

Throughout this application, various embodiments of this invention may be presented in a range format. It should be understood that the description in range format is merely for convenience and brevity and should not be construed as an inflexible limitation on the scope of the invention. Accordingly, the description of a range should be considered to have specifically disclosed all the possible subranges as well as individual numerical values within that range. For example, description of a range such as from 1 to 6 should be considered to have specifically disclosed subranges such as from 1 to 3, from 1 to 4, from 1 to 5, from 2 to 4, from 2 to 6, from 3 to 6 etc., as well as individual numbers within that range, for example, 1, 2, 3, 4, 5, and 6. This applies regardless of the breadth of the range.

Whenever a numerical range is indicated herein, it is meant to include any cited numeral (fractional or integral) within the indicated range. The phrases "ranging/ranges between" a first indicate number and a second indicate number and "ranging/ranges from" a first indicate number "to" a second indicate number are used herein
interchangeably and are meant to include the first and second indicated numbers and all the fractional and integral numerals therebetween.

It is appreciated that certain features of the invention, which are, for clarity, described in the context of separate embodiments, may also be provided in combination in a single embodiment. Conversely, various features of the invention, which are, for brevity, described in the context of a single embodiment, may also be provided separately or in any suitable subcombination or as suitable in any other described embodiment of the invention. Certain features described in the context of various embodiments are not to be considered essential features of those embodiments, unless the embodiment is inoperative without those elements.

Although the invention has been described in conjunction with specific embodiments thereof, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art. Accordingly, it is intended to embrace all such alternatives, modifications and variations that fall within the spirit and broad scope of the appended claims.

All publications, patents and patent applications mentioned in this specification are herein incorporated in their entirety by reference into the specification, to the same extent as if each individual publication, patent or patent application was specifically and individually indicated to be incorporated herein by reference. In addition, citation or identification of any reference in this application shall not be construed as an admission that such reference is available as prior art to the present invention. To the extent that section headings are used, they should not be construed as necessarily limiting.
WHAT IS CLAIMED IS:

1. A system of illuminating at least one plant, comprising:
   a plurality of controllable illumination sources each emitting light having at least one controllable illumination parameter toward at least one plant;
   a memory of hosting an illumination plan adapted for inducing at least one cultivation target from said at least one plant during a period;
   a processing unit which computes at least one adjustment for said at least one controllable illumination parameter of each said controllable illumination source according to said illumination plan during said period; and
   at least one controller which operates each said controllable illumination source according to respective said at least one adjustment during said period.

2. The system of claim 1, further comprising at least one sensor which measures at least one cultivation parameter pertaining to said at least one plant, said processing unit computing said adjustment according to said at least one cultivation parameter.

3. The system of any of claims 1-2, wherein said plant parameter includes a member of a group consisting of: a tilt, a height, a blooming state, a color, fructification morphology, a fructification level, a number of branches, a height, and a width of the branches of said at least one plant.

4. The system of any of claims 1-3, wherein said at least one sensor includes a member of a group consisting of: an image sensor, a thermometer, a hygrometer, an aerometer, a pyranometer and a solar radiation sensor.

5. The system of any of claims 1-4, wherein said processing unit computes said adjustment according to a combination of a plurality of cultivation parameters.

6. The system of any of claims 1-5, wherein said illumination plan define at least one illumination rule for at least one value of said at least one cultivation parameter, said processing unit computes said adjustment according to said illumination rule in light of said at least one cultivation parameter.
7. The system of any of claims 1-6, wherein said processing unit computes said adjustment according to a combination of a trend of said at least one cultivation parameter.

8. The system of any of claims 1-7, wherein said at least one controller operates at least one reflector of at least one of said plurality of controllable illumination sources to change its illumination angle according to respective said at least one adjustment.

9. The system of any of claims 1-8, wherein said at least one controller operates at least one dimming element of at least one of said plurality of controllable illumination sources to change its illumination intensity according to respective said at least one adjustment.

10. The system of any of claims 1-9, wherein said plurality of controllable illumination source are divided among a plurality of greenhouses, said processing unit computes said adjustment for each said greenhouse, said at least controller operating at least one respective said controllable illumination source accordingly.

11. A method of illuminating at least one plant, comprising:
   placing at least one controllable illumination source having at least one controllable illumination parameter for illuminating at least one plant;
   providing an illumination plan adapted for inducing at least one cultivation target from said at least one plant during a period;
   computing at least one adjustment of at least one controllable illumination parameter of said at least one controllable illumination source according to said illumination plan during said period; and
   operating said at least one controllable illumination source according to said at least one adjustment.

12. The method of claim 11, wherein said adjusting comprises adjusting a photometric curve of said light according to said at least one adjustment.
13. The method of any of claims 11-12, wherein said adjusting comprises changing intensity of said light according to said illumination plan at least one adjustment.

14. The method of any of claims 11-13, wherein said providing comprises receiving said at least one cultivation target from a user and automatically selecting said illumination plan accordingly.

15. The method of any of claims 11-14, further comprising measuring at least one cultivation parameter of said at least one plant; said adjusting being performed according to said at least one cultivation parameter.

16. The method of claim 15, wherein said measuring comprises measuring a trend of said at least one cultivation parameter during a period and adjusting said at least one controllable illumination parameter according to said trend.

17. The method of any of claims 11-16, further comprising measuring a combination of a plurality of cultivation parameters and adjusting said at least one controllable illumination parameter according to said combination.

18. A system of illuminating at least one plant, comprising:
   a plurality of controllable illumination sources each emitting light having at least one controllable illumination parameter toward at least one plant;
   at least one sensor which measures at least one cultivation parameter of at least one of a local climate condition and at least one plant parameter;
   a processing unit which identifies, according to said at least one cultivation parameter, a deviation from an illumination plan selected for the at least one plant and computes at least one adjustment for said at least one controllable illumination parameter of each said controllable illumination source; and
   at least one controller which operates each said controllable illumination source according to respective said at least one adjustment.
19. An illumination device of illuminating at least one plant, comprising:
   an illuminator and at least one dimming element of changing illumination
   intensity of said illuminator;
   at least one reflector and at least one actuator which maneuvers said at least one
   reflector;
   a communication interface receives at least one illumination instruction; and
   a controller which operates said at least one dimmer and said at least one actuator
   according to said at least one illumination instruction.

20. The illumination device of claim 19, wherein said at least one reflector having
   plurality of reflection states, each define a different reflection angle for light emitted
   from said illuminator.

21. A method of illuminating at least one plant, comprising:
   illuminating at least one plant according to an illumination plan with light having
   at least one controllable illumination parameter;
   measuring at least one cultivation parameter of said at least one plant;
   detecting a deviation from said illumination plan by said measuring; and
   adjusting said at least one controllable illumination parameter according to said
   detecting.
FIG. 5

501 Providing illumination sources
502 Providing illumination plan(s)
503 Computing adjustment(s)
504 Operating illumination source(s)
505