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(54) **TEMPERATURE MEASUREMENT FROM LUMINAIRE SENSORS**

TEMPERATURMESSUNG VON LICHTSENSOREN

MESURE DE TEMPÉRATURE À PARTIR DE CAPTEURS DE LUMINAIRE

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Description

TECHNICAL FIELD OF THE INVENTION

[0001] The invention relates to a luminaire and a method for estimating the ambient temperature of the luminaire.

BACKGROUND OF THE INVENTION

[0002] Temperature sensors integrated in luminaires can be used in order to estimate the ambient temperature of the luminaire. However, the temperature reading of the temperature sensor can be affected by any heat developed by the lighting means and the electronics of the luminaire itself.

[0003] Thus, the output value of the temperature sensor typically does not reflect the ambient temperature of the luminaire, but rather the combined effect of the ambient temperature and the heat developed by the luminaire components, such as LEDs, driver or other components.

[0004] Document WO 2019/020431 A1 discloses system, methods, and apparatuses for compensating sensor data from a luminaire based on ambient temperature estimate that is generated from operating characteristics of the luminaire.

[0005] Thus, it is an objective to provide an improved luminaire, which avoids the above-mentioned disadvantages.

SUMMARY OF THE INVENTION

[0006] The object of the present invention is achieved by the solution provided in the enclosed independent claims. Advantageous implementations of the present invention are further defined in the dependent claims.

[0007] According to a first aspect, the invention relates to a luminaire comprising lighting means, a control circuitry and an integrated temperature sensor functionally connected to the control circuitry, wherein the control circuitry is configured to compensate a temperature signal from the temperature sensor by a compensation value ΔT in order to obtain an estimate for an ambient temperature of the luminaire, wherein the control circuitry is configured to use at least one operating parameter of the lighting means of the luminaire to obtain the compensation value ΔT , in particular based on the current and historic state of the luminaire.

[0008] In particular, the control circuitry is not integrated in a housing of the luminaire, but is an external unit connected to the luminaire.

[0009] For instance, the control circuit can be integrated in an external device that has access to the current and historic states of the luminaire.

[0010] This provides the advantage that the ambient temperature of the luminaire can be estimated more precisely.

[0011] In an embodiment, the at least one operating parameter comprises a duration of operation of the luminaire, the temperature signal, or a dimming level of the luminaire.

[0012] This provides the advantage that the ambient temperature of the luminaire can be estimated more accurately taking into account the physical properties of the luminaire.

[0013] In a further embodiment, the control circuitry is further configured to use machine learning models such as random forest in order to obtain the compensation value ΔT .

[0014] This provides the advantage that the ambient temperature of the luminaire can be estimated on the basis of precise models.

[0015] In a further embodiment, the control circuitry is further configured to use the temperature signal or the dimming level of the luminaire in order to perform a training phase for the machine learning models.

[0016] This provides the advantage that the precision of the models used to estimate the ambient temperature of the luminaire is high.

[0017] In a further embodiment, the control circuitry is further configured to use a trained neural network in order to obtain the compensation value ΔT .

[0018] This provides the advantage that the ambient temperature of the luminaire can be estimated on the basis of precise models.

[0019] In a further embodiment, the control circuitry is further configured to use the temperature signal or the dimming level of the luminaire in order to perform a training phase for the trained neural network.

[0020] In a further embodiment, the luminaire is a free standing luminaire.

[0021] In a further embodiment, the training phase of the machine learning models is performed at a manufacturing stage of the luminaire.

[0022] In a further embodiment, the control circuitry is configured to correct air state parameters such as humidity and/or air quality on the basis of the compensation value ΔT .

[0023] In a further embodiment, the temperature sensor is configured to generate a voltage that varies linearly with temperature.

[0024] According to a second aspect, the invention relates to a method for estimating an ambient temperature of a luminaire, comprising: compensating a temperature signal from a temperature sensor by a compensation value ΔT in order to obtain an estimate for an ambient temperature of the luminaire, and using at least one operating parameter of lighting means of the luminaire to obtain the compensation value ΔT .

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] The invention will be explained in the followings together with the figures.

Fig. 1 shows a luminaire according to an embodiment; and

Fig. 2 shows a method for estimating an ambient temperature of a luminaire according to an embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0026] Aspects of the present invention are described herein in the context of a luminaire.

[0027] The present invention is described more fully hereinafter with reference to the accompanying drawings, in which various aspects of the present invention are shown. This invention however may be embodied in many different forms and should not be construed as limited to the various aspects of the present invention presented through this disclosure. Rather, these aspects are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the present invention to those skilled in the art. The various aspects of the present invention illustrated in the drawings may not be drawn to scale. Rather, the dimensions of the various features may be expanded or reduced for clarity. In addition, some of the drawings may be simplified for clarity. Thus, the drawings may not depict all of the components of a given apparatus.

[0028] Various aspects of a luminaire will be presented. However, as those skilled in the art will readily appreciate, these aspects may be extended to aspects of luminaire without departing from the invention.

[0029] It is further understood that the aspect of the present invention might contain integrated circuits that are readily manufacturable using conventional semiconductor technologies, such as complementary metal-oxide semiconductor technology, short "CMOS". In addition, the aspects of the present invention may be implemented with other manufacturing processes for making optical as well as electrical devices. Reference will now be made in detail to implementations of the exemplary aspects as illustrated in the accompanying drawings. The same reference signs will be used throughout the drawings and the following detailed descriptions to refer to the same or like parts.

[0030] Now referring to Fig. 1, a luminaire 100 is shown according to an embodiment.

[0031] The luminaire 100 comprises lighting means 102, a control circuitry 104 and an integrated temperature sensor 106 functionally connected to the control circuitry 104, wherein the control circuitry 104 is configured to compensate a temperature signal from the temperature sensor 106 by a compensation value ΔT in order to obtain an estimate for an ambient temperature of the luminaire 100, wherein the control circuitry 104 is configured to use at least one operating parameter of the lighting means 102 of the luminaire 100 to obtain the compensation value ΔT .

[0032] The temperature sensor 106 can be configured to generate a voltage which varies linearly with temperature. The temperature sensor 106 can internally be connected to an input channel which is configured to convert the output sensor voltage into a digital value.

[0033] The temperature sensor 106 can provide good linearity but it should be calibrated in order to obtain overall good accuracy of the temperature measurement. As the offset of the temperature sensor 106 varies from chip to chip due to process variation, the uncalibrated internal temperature sensor 106 can be suitable for applications that detect temperature changes only.

[0034] In order to be able to provide measurements with the necessary level of accuracy for the respective application, measurement distortions should be compensated for. Machine learning (ML) models, such as a 'random forest', can solve this compensation task, but require appropriate training data input. One way to generate this input can be to expose one instance of the luminaire 100 under consideration to varying environmental conditions (temperature, humidity, volatile organic compounds, CO₂, etc.), and measure the system response, while also collecting ground truth information within the lab, but outside the luminaire 100. Based on the data collected, and taking luminaire 100 state history into account, powerful, highly accurate models (± 0.5 degrees C in $>90\%$ of cases) can be trained and later applied. Both current temperature as observed within the luminaire 100 by the temperature sensor 106, and luminaire state (dim level) as observed in the past few hours, can be processed by ML model, e.g., a 'random forest', that has been trained on said two variables and actual temperature outside the luminaire 100 (ground truth).

[0035] This model can be implemented to run on a light-management system, on the temperature sensor 106, if computing capability is sufficient, or in the cloud, if that is more appropriate.

[0036] Embodiments of the invention provide the advantage that use is made of machine learning models to accurately approximate the physical characteristics of the luminaire 100, i.e., approximate the difference in temperature between inside and outside the luminaire 100.

[0037] Moreover, embodiments of the invention provide the advantage that, there is provision of accurate temperature, regardless of the fact that the temperature sensor 106 measurements can heavily be distorted by waste heat from the luminaire 100.

[0038] Moreover, the invention renders the installation of stand-alone temperature sensors 106, along with all the required wiring setup, redundant. It can also allow to integrate a temperature sensor 106 within any device that emits heat, while providing accurate temperature measurements.

[0039] Fig. 2 shows a method 200 for estimating an ambient temperature of a luminaire 100 according to an embodiment.

[0040] The method 200 comprises the steps of:

- compensating 201 a temperature signal from a temperature sensor 106 by a compensation value ΔT in order to obtain an estimate for an ambient temperature of the luminaire 100; and
- using 202 at least one operating parameter of lighting means 102 of the luminaire 100 to obtain the compensation value ΔT .

[0041] All features of all embodiments described, shown and/or claimed herein can be combined with each other.

[0042] While various embodiments of the present invention have been described above, it should be understood that they have been presented by way of example only and not limitation. Thus, the breadth and scope of the present invention should not be limited by any of the above-described embodiments. Rather, the scope of the invention should be defined in accordance with the following claims and their equivalence.

[0043] Although the invention has been illustrated and described with respect to one or more implementations, equivalent alternations and modifications will occur to those skilled in the art upon the reading of the understanding of the specification and the annexed drawings. In addition, while a particular feature of the invention may have been disclosed with respect to only of the several implementations, such features may be combined with one or more other features of the other implementations as may be desired and advantage for any given or particular application.

Claims

1. A luminaire (100) comprising lighting means (102), a control circuitry (104) and an integrated temperature sensor (106) functionally connected to the control circuitry (104), wherein the control circuitry (104) is configured to compensate a temperature signal from the temperature sensor (106) by a compensation value ΔT in order to obtain an estimate for an ambient temperature of the luminaire (100), wherein the control circuitry (104) is configured to use at least one operating parameter of the lighting means (102) of the luminaire (100) to obtain the compensation value ΔT ; **characterized in that** the control circuitry (104) is further configured to use machine learning models in order to obtain the compensation value ΔT .
2. The luminaire (100) of claim 1, wherein the at least one operating parameter comprises a duration of operation of the luminaire (100), or a dimming level of the luminaire (100).
3. The luminaire (100) of claim 1 or 2, wherein the machine learning models comprise a random forest.

4. The luminaire (100) of claim 3, wherein the control circuitry (104) is further configured to use the temperature signal or the dimming level of the luminaire (100) in order to perform a training phase for the machine learning models.

5. The luminaire (100) of claim 1 or 2, wherein the control circuitry (104) is further configured to use a trained neural network in order to obtain the compensation value ΔT .

6. The luminaire (100) of claim 5, wherein the control circuitry (104) is further configured to use the temperature signal or the dimming level of the luminaire (100) in order to perform a training phase for the trained neural network.

7. The luminaire (100) of any one of the preceding claims, wherein the luminaire (100) is a free standing luminaire.

8. The luminaire (100) of claim 4 and 7, wherein the training phase of the machine learning models is performed at a manufacturing stage of the luminaire (100).

9. The luminaire (100) of any one of the preceding claims, wherein the temperature sensor (106) is configured to generate a voltage that varies linearly with temperature.

10. A method (200) for estimating an ambient temperature of a luminaire (100), comprising:

- compensating (201) a temperature signal from a temperature sensor (106) by a compensation value ΔT in order to obtain an estimate for an ambient temperature of the luminaire (100); and
- using (202) at least one operating parameter of lighting means (102) of the luminaire (100) to obtain the compensation value ΔT ; **characterized by** further comprising:
 - using machine learning models in order to obtain the compensation value ΔT .

Patentansprüche

1. Leuchte (100), umfassend Leuchtmittel (102), eine Steuerschaltung (104) und einen integrierten Temperatursensor (106), der mit der Steuerschaltung (104) funktionell verbunden ist, wobei die Steuerschaltung (104) konfiguriert ist, um ein Temperatursignal von dem Temperatursensor (106) um einen Ausgleichswert ΔT zu kompensieren, um eine Schätzung für eine Umgebungstemperatur der Leuchte (100) zu erhalten, wobei die Steuerschaltung (104) konfiguriert ist, um mindestens einen Be-

triebsparameter der Leuchtmittel (102) der Leuchte (100) zu verwenden, um den Kompensationswert ΔT zu erhalten; **dadurch gekennzeichnet, dass** die Steuerschaltung (104) ferner konfiguriert ist, um Maschinenlernmodelle zu verwenden, um den Kompensationswert ΔT zu erhalten.

2. Leuchte (100) nach Anspruch 1, wobei der mindestens eine Betriebsparameter eine Betriebsdauer der Leuchte (100) oder einen Dimmpegel der Leuchte (100) umfasst. 10
3. Leuchte (100) nach Anspruch 1 oder 2, wobei die Maschinenlernmodelle einen Random Forest umfassen. 15
4. Leuchte (100) nach Anspruch 3, wobei die Steuerschaltung (104) ferner konfiguriert ist, um das Temperatursignal oder den Dimmpegel der Leuchte (100) zu verwenden, um eine Trainingsphase für die Maschinenlernmodelle durchzuführen. 20
5. Leuchte (100) nach Anspruch 1 oder 2, wobei die Steuerschaltung (104) ferner konfiguriert ist, um ein trainiertes neuronales Netzwerk zu verwenden, um den Kompensationswert ΔT zu erhalten. 25
6. Leuchte (100) nach Anspruch 5, wobei die Steuerschaltung (104) ferner konfiguriert ist, um das Temperatursignal oder den Dimmpegel der Leuchte (100) zu verwenden, um eine Trainingsphase für das trainierte neuronale Netzwerk durchzuführen. 30
7. Leuchte (100) nach einem der vorstehenden Ansprüche, wobei die Leuchte (100) eine frei stehende Leuchte ist. 35
8. Leuchte (100) nach Anspruch 4 und 7, wobei die Trainingsphase der Maschinenlernmodelle bei einer Herstellungsstufe der Leuchte (100) durchgeführt wird. 40
9. Leuchte (100) nach einem der vorstehenden Ansprüche, wobei der Temperatursensor (106) konfiguriert ist, um eine Spannung, die mit der Temperatur linear variiert, zu erzeugen. 45
10. Verfahren (200) zum Schätzen einer Umgebungstemperatur einer Leuchte (100), umfassend: 50
 - Kompensieren (201) eines Temperatursignals von einem Temperatursensor (106) um einen Kompensationswert ΔT , um eine Schätzung für eine Umgebungstemperatur der Leuchte (100) zu erhalten; und
 - Verwenden (202) mindestens eines Betriebsparameters von Leuchtmitteln (102) der Leuchte (100), um den Kompensationswert ΔT zu er-

halten; **gekennzeichnet dadurch, dass es** ferner umfasst:

- Verwenden von Maschinenlernmodellen, um den Kompensationswert ΔT zu erhalten.

Revendications

1. Luminaire (100) comprenant un moyen d'éclairage (102), un circuit de commande (104) et un capteur de température intégré (106) connecté fonctionnellement au circuit de commande (104), dans lequel le circuit de commande (104) est configuré pour compenser un signal de température provenant du capteur de température (106) par une valeur de compensation ΔT afin d'obtenir une estimation pour une température ambiante du luminaire (100), dans lequel le circuit de commande (104) est configuré pour utiliser au moins un paramètre de fonctionnement du moyen d'éclairage (102) du luminaire (100) pour obtenir la valeur de compensation ΔT ; **caractérisé en ce que** le circuit de commande (104) est en outre configuré pour utiliser des modèles d'apprentissage automatique afin d'obtenir la valeur de compensation ΔT .
2. Luminaire (100) selon la revendication 1, dans lequel l'au moins un paramètre de fonctionnement comprend une durée de fonctionnement du luminaire (100), ou un niveau de gradation du luminaire (100).
3. Luminaire (100) selon la revendication 1 ou 2, dans lequel les modèles d'apprentissage automatique comprennent une forêt aléatoire.
4. Luminaire (100) selon la revendication 3, dans lequel le circuit de commande (104) est en outre configuré pour utiliser le signal de température ou le niveau de gradation du luminaire (100) afin d'effectuer une phase d'apprentissage pour les modèles d'apprentissage automatique.
5. Luminaire (100) selon la revendication 1 ou 2, dans lequel le circuit de commande (104) est en outre configuré pour utiliser un réseau neuronal entraîné afin d'obtenir la valeur de compensation ΔT .
6. Luminaire (100) selon la revendication 5, dans lequel le circuit de commande (104) est en outre configuré pour utiliser le signal de température ou le niveau de gradation du luminaire (100) afin d'effectuer une phase d'apprentissage pour le réseau neuronal entraîné.
7. Luminaire (100) selon l'une quelconque des revendications précédentes, dans lequel le luminaire (100) est un luminaire autoportant.

8. Luminaire (100) selon les revendications 4 et 7, dans lequel la phase d'apprentissage des modèles d'apprentissage automatique est effectuée lors d'une étape de fabrication du luminaire (100). 5
9. Luminaire (100) selon l'une quelconque des revendications précédentes, dans lequel le capteur de température (106) est configuré pour générer une tension qui varie linéairement avec la température. 10
10. Procédé (200) d'estimation d'une température ambiante d'un luminaire (100), comprenant :
- la compensation (201) d'un signal de température provenant d'un capteur de température (106) par une valeur de compensation ΔT afin d'obtenir une estimation pour une température ambiante du luminaire (100) ; et 15
 - l'utilisation (202) d'au moins un paramètre de fonctionnement du moyen d'éclairage (102) du luminaire (100) pour obtenir la valeur de compensation ΔT ; **caractérisé en ce qu'il** comprend en outre : 20
 - l'utilisation de modèles d'apprentissage automatique afin d'obtenir la valeur de compensation ΔT . 25

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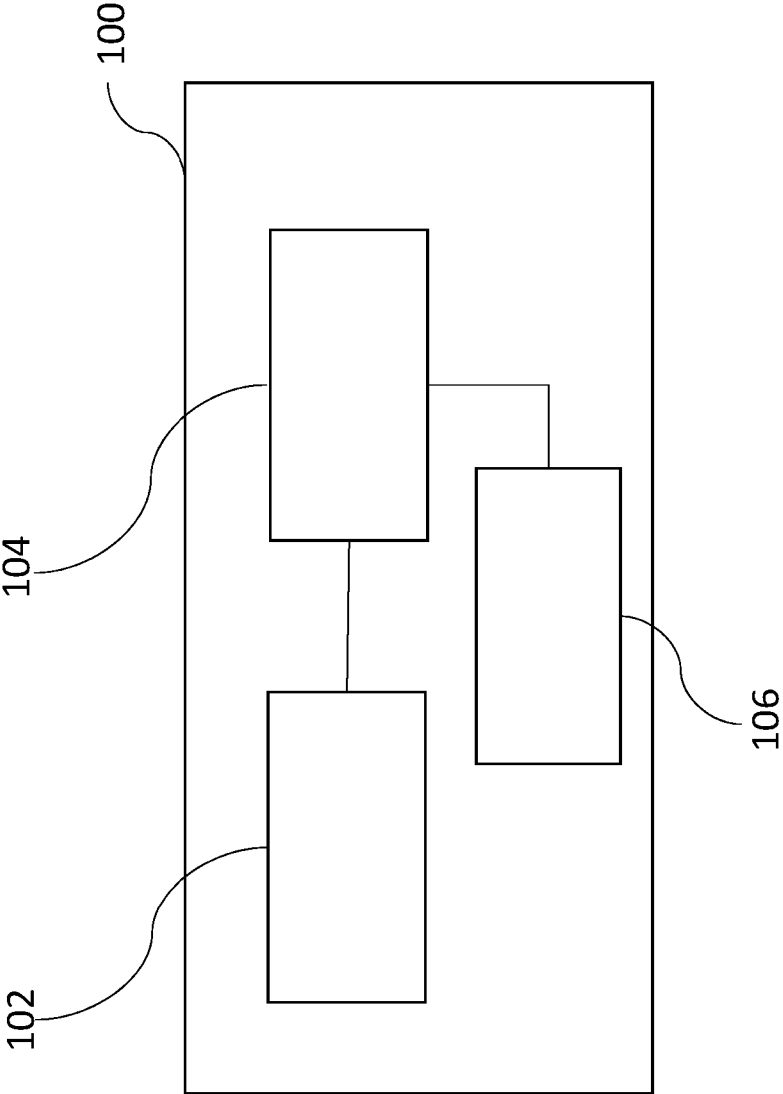


Fig. 1

200

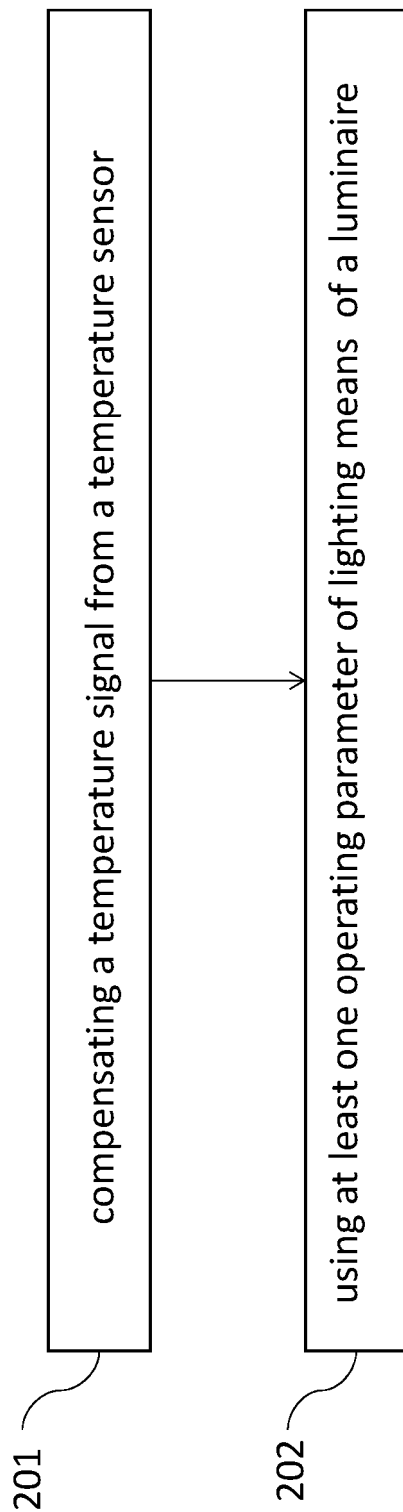


Fig. 2

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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