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(71) Applicant: **VALEO VISION** [FR/FR]; IP Department 34, Rue Saint André, 93012 BOBIGNY Cedex (FR).

(72) Inventors: **ALMEHIO, Yasser**; Valeo Vision - Service PI 34 rue Saint André, 93012 Bobigny - Cedex (FR). **EL IDRISSI, Hafid**; Valeo Vision - Service PI 34 Rue Saint André, 93012 Bobigny - Cedex (FR). **KARRAY, Marouene**; Valeo Vision - Service PI 34 Rue Saint André, 93012 Bobigny - Cedex (FR). **TALEB, Rabih**; Valeo Vision - Service PI 34 Rue Saint André, 93012 Bobigny - Cedex (FR).

(74) Agent: **VALEO VISIBILITY**; IP Department 34, rue Saint André, 93012 BOBIGNY Cedex (FR).

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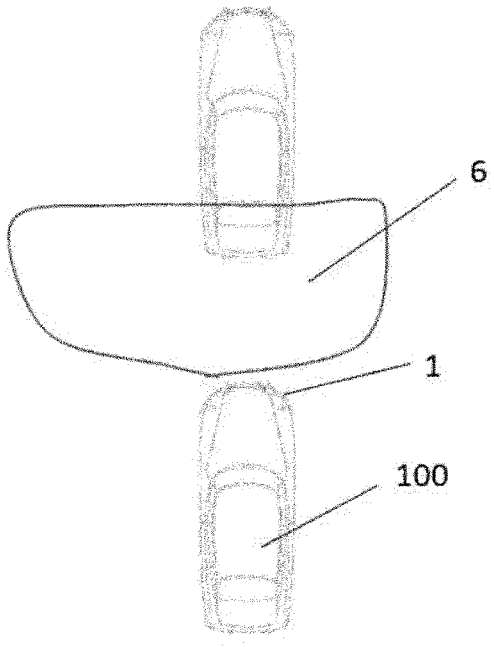
(54) **Title:** METHOD FOR OPERATING AN AUTOMOTIVE LIGHTING DEVICE AND AUTOMOTIVE LIGHTING DEVICE

fig 2b



(57) **Abstract:** This invention provides a method for operating an automotive lighting device (1) comprising a plurality of solid-state light sources (2). The method comprises predefining a plurality of use cases, each use case being associated to a case light pattern, providing the lighting device projecting a preliminary light pattern (5), providing a plurality of sensors (4), configured to sense some external data, processing the external data to classify the environment around the lighting device in one of the predefined use cases and projecting a new light pattern (6) corresponding to the case light pattern associated to the selected use case.

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Description

Title: Method for operating an automotive lighting device and automotive lighting device

This invention is related to the field of automotive lighting devices, and more particularly, to the management of the light patterns provided by these devices.

Digital lighting devices are being increasingly adopted by car makers for middle and high market products.

These digital lighting devices usually comprise solid-state light sources, the operation of which may involve a high power consume.

Temperature control in these elements is a very sensitive aspect, and is usually carried out by derating, which means decreasing the current value which feeds the light source so that the output flux and the operation temperature decreases accordingly. This causes that the performance of the light sources must be heavily oversized to face these overheating problems, so that the operation values may be decreased while still maintaining acceptable values.

This question is even more important in new electric vehicles, where energy saving is crucial, since it has a direct impact on the operation range of the vehicle and therefore on the CO2 emission values.

Further, there are some scenarios where a different light pattern is needed, to increase visual comfort if the surrounding environment allows it.

The invention provides an alternative solution for managing the optimal light pattern and for optimizing the lighting system energy consumption in an automotive lighting device by a method for operating an automotive lighting device according to the invention. Preferred embodiments of the invention are defined in dependent claims.

Unless otherwise defined, all terms (including technical and scientific terms) used herein are to be interpreted as is customary in the art. It will be further understood that terms in common usage should also be interpreted as is customary in the relevant art and not in an idealised or overly formal sense unless expressly so defined herein.

In this text, the term “comprises” and its derivations (such as “comprising”, etc.) should not be understood in an excluding sense, that is, these terms should not be interpreted as excluding the possibility that what is described and defined may include further elements, steps, etc.

In a first inventive aspect, the invention provides a method for operating an automotive lighting device comprising a matrix arrangement of light pixels, the method comprising the steps of:

- predefining a plurality of use cases, each use case being associated to a case light pattern;

- providing the lighting device projecting a preliminary light pattern;

- providing a plurality of sensors, configured to sense some external data;

- processing the external data to classify the environment around the lighting device in one of the predefined use cases; and

- projecting a new light pattern corresponding to the case light pattern associated to the selected use case.

The term "solid state" refers to light emitted by solid-state electroluminescence, which uses semiconductors to convert electricity into light. Compared to incandescent lighting, solid state lighting creates visible light with reduced heat generation and less energy dissipation. The typically small mass of a solid-state electronic lighting device provides for greater resistance to shock and vibration compared to brittle glass tubes/bulbs and long, thin filament wires. They also eliminate filament evaporation, potentially increasing the lifespan of the illumination device. Some examples of these types of lighting comprise semiconductor light-emitting diodes (LEDs), organic light-emitting diodes (OLED), or polymer light-emitting diodes (PLED) as sources of illumination rather than electrical filaments, plasma or gas.

This method is aimed to find the optimal light pattern to be projected by a lighting device. Predetermined use cases are defined and a corresponding light pattern is projected when the method identifies that the vehicle is under one of the predefined

use cases. An optimal light pattern is therefore found without an excessive computational cost, since there is a reasonable number of predefined use cases.

In some particular embodiments, the step of processing the external data to classify the environment in one predefined use case is performed periodically with a period lower than 2 seconds, and particularly lower than 0.5 seconds.

This feature involves a quick adaptation to changes in the environmental conditions of the vehicle.

In some particular embodiments, the step of processing the external data to classify the environment in one predefined use case is carried out by a control unit which is previously configured to classify the environment by means of:

- training the control unit to classify a situation into a predefined use case with a training dataset; and

- testing the control unit comparing the chosen predefined case with optimal expected results.

This way of training the control unit is useful since provides the control unit with the ability to classify a situation into a predefined use case in an improved way.

In some particular embodiments, the step of associating a case light pattern to each predefined case is carried out by a control unit which is previously configured to design a case light pattern by means of:

- training the control unit to design a case light pattern in response to a training dataset; and

- testing the control unit comparing the chosen case light pattern with optimal expected results.

This way of training the control unit is useful since provides the control unit with the ability to design the case light patterns in an improved way.

In some particular embodiments, the step of training the control unit comprises the use of a machine learning algorithm.

This machine learning algorithm may be used both in the design of the case light patterns and/or in the classification of each situation into a predefined use case. Each one of the two options follows its own machine learning algorithm. Once the corresponding results are validated, the values of the control unit are used to the corresponding steps of the method of the invention.

In some particular embodiments, the external data comprises information of at least one of outside luminous intensity, numbers of cars around and distance with respect to them, current vehicle speed, road type (city, highway), global positioning coordinates or presence and colour of surrounding traffic lights.

All of these features will influence in the particular use case to be selected. For example, the presence of a high number of vehicles and a traffic light in red will lead to “red traffic light”. But the same vehicles arrangement without a traffic light will led to “traffic jam”.

In some particular embodiments, the plurality of sensors comprise at least two of an external light sensor, a lighting functionality activation sensor, cameras, radar, lidar or infrared sensors.

These are examples of data which may be used by the machine learning algorithm to provide the new light pattern.

In a further inventive aspect, the invention provides a data processing element comprising means for carrying out the steps of a method according to the first inventive aspect and a computer program comprising instructions which, when the program is executed by a control unit, cause the control unit to carry out the steps of a method according to the first inventive aspect.

In a further inventive aspect, the invention provides an automotive lighting device comprising:

- a matrix arrangement of solid-state light sources;
- a plurality of sensors configured to provide some external data; and
- a control unit for performing the steps of the method according to the first inventive aspect.

This lighting device provides the advantageous functionality of efficiently managing the energy consumed by the light sources, by means of an accurate new light pattern provided by the control unit.

In some particular embodiments, the matrix arrangement comprises at least 2000 solid-state light sources.

A matrix arrangement is a typical example for this method. The rows may be grouped in projecting distance ranges and each column of each group represent an angle interval. This angle value depends on the resolution of the matrix arrangement, which is typically comprised between 0.01º per column and 0.5º per column. As a consequence, many light sources may be managed at the same time.

To complete the description and in order to provide for a better understanding of the invention, a set of drawings is provided. Said drawings form an integral part of the description and illustrate an embodiment of the invention, which should not be interpreted as restricting the scope of the invention, but just as an example of how the invention can be carried out. The drawings comprise the following figures:

fig 1shows a general perspective view of an automotive lighting device according to the invention.

fig 2a and fig 2b show the effect of two different light patterns involved in a method according to the invention.

In these figures, the following reference numbers have been used:

1 Headlamp

2 LED

3 Control unit

4 Sensors

5 Original light pattern

6 New light pattern

100 Automotive vehicle

The example embodiments are described in sufficient detail to enable those of ordinary skill in the art to embody and implement the systems and processes herein described. It is important to understand that embodiments can be provided in many alternate forms and should not be construed as limited to the examples set forth herein.

Accordingly, while embodiment can be modified in various ways and take on various alternative forms, specific embodiments thereof are shown in the drawings and described in detail below as examples. There is no intent to limit to the particular forms disclosed. On the contrary, all modifications, equivalents, and alternatives falling within the scope of the appended claims should be included.

fig 1 shows a general perspective view of an automotive lighting device according to the invention.

This headlamp 1 is installed in an automotive vehicle 100 and comprises

- a matrix arrangement of LEDs 2, intended to provide a light pattern;
- a control unit 3 to perform a control of the operation of the LEDs 2; and
- a plurality of sensors 4 intended to provide some external data.

This matrix configuration is a high-resolution module, having a resolution greater than 2000 pixels. However, no restriction is attached to the technology used for producing the projection modules.

The control unit, previously to its installation in the automotive headlamp, has undergone two training processes.

Both training processes comprise some machine learning steps, where the control unit is trained with training data provided by the plurality of sensors.

The first training process is concerning the design of different case light patterns, each one associated to a plurality of data values. This first training process comprises

- training the control unit to design a case light pattern in response to a training dataset; and

- testing the control unit comparing the chosen case light pattern with optimal expected results.

Different use cases are defined, and the optimal case light pattern is found for each use case, due to the aforementioned algorithm.

The second training process is concerning the classification of a situation into a predefined use case. This second training process comprises

- training the control unit to classify a situation into a predefined use case with a training dataset; and

- testing the control unit comparing the chosen predefined case with optimal expected results.

In this case, different situations are set, each one with different data obtained by the sensors. The control unit is trained to identify which of the use cases fits best the situation.

Once both training processes are finished, the control unit is installed in an automotive vehicle 100 of fig 1, to perform the luminous control of the headlamp 1.

The operation of this lighting device would be as follows: a preliminary light pattern is provided by the lighting device, according to the lighting functionality selected by the vehicle user.

Each 0.2 seconds, the control unit of the lighting device receives the data from the plurality of sensors. These data include external data of the vehicle (active lighting functionality, outside luminous intensity, numbers of cars around and distance with respect to them, current vehicle speed or presence and colour of traffic lights, etc). Due to its training, the control unit will classify the environment into one use case, and associate a case light pattern to this situation.

The headlamp will project the new light pattern, which provides an adequate lighting at the minimum power consumption.

This process is repeated each 0.2 seconds.

fig 2a shows an example of a first light pattern 5 projected by a lighting device according to the invention. This light pattern corresponds to a high beam pattern, which

is adequate to the environment conditions, since no other vehicle surrounds the lighting device.

fig 2b shows an example of a different environmental conditions. Since the vehicle 100 is approaching a traffic jam, and there is another vehicle in front of it, such light pattern is unnecessary. The control unit detects a vehicle in front of the lighting device, located just 1 or 2 m in front of it. The control unit does not detect any traffic light in front of the vehicle. The control unit detects, by the road signals, that the vehicle is in a highway. Hence, due to its training, the control unit considers that the use case is “traffic jam in a highway” and instructs the headlamp to project the corresponding light pattern. The resulting new light pattern 6 is enough to fulfil the lighting requirements in the particular circumstances of a traffic jam at the minimum power consumption possible.

Claims

1. Method for operating an automotive lighting device (1) comprising a matrix arrangement of light pixels (2), the method comprising the steps of:

- o predefining a plurality of use cases, each use case being associated to a case light pattern;
- o providing the lighting device projecting a preliminary light pattern (5);
- o providing a plurality of sensors (4), configured to sense some external data;
- o processing the external data to classify the environment around the lighting device in one of the predefined use cases; and
- o projecting a new light pattern (6) corresponding to the case light pattern associated to the selected use case.

2. Method according to claim 1, wherein the step of processing the external data to classify the environment in one predefined use case is performed periodically with a period lower than 2 seconds, and particularly lower than 0.5 seconds.

3. Method according to any of the preceding claims, wherein the step of processing the external data to classify the environment in one predefined use case is carried out by a control unit which is previously configured to classify the environment by means of:

- o training the control unit (3) to classify a situation into a predefined use case with a training dataset; and
- o testing the control unit (3) comparing the chosen predefined case with optimal expected results.

4. Method according to claim 3, wherein the step of training the control unit comprises the use of a machine learning algorithm.

5. Method according to any of the preceding claims, wherein the step of associating a case light pattern to each predefined case is carried out by a control unit which is previously configured to classify the environment by means of:

- training the control unit (3) to design a case light pattern in response to a training dataset; and

- testing the control unit (3) comparing the chosen case light pattern with optimal expected results.

6. Method according to claim 5, wherein the step of training the control unit comprises the use of a machine learning algorithm.

7. Method according to any of the preceding claims, wherein the external data comprises information of at least one of outside luminous intensity, numbers of cars around and distance with respect to them, current vehicle speed, road type (city, highway), global positioning coordinates or presence and colour of surrounding traffic lights.

8. Method according to any of the preceding claims, wherein the plurality of sensors comprises at least two of an external light sensor, a lighting functionality activation sensor, cameras, radar, lidar or infrared sensors.

9. Data processing element comprising means for carrying out the steps of a method according to any of the preceding claims.

10. Computer program comprising instructions which, when the program is executed by a control unit, cause the control unit to carry out the steps of a method according to any of claims 1 to 8.

11. Automotive lighting device comprising:

- a matrix arrangement of solid-state light sources (2);

- a plurality of sensors (4) configured to provide some external data; and

- a control unit (3) for performing the steps of the method according to any claims 1 to 8.

12. Automotive lighting device (1) according to claim 11, wherein the matrix arrangement comprises at least 2000 solid-state light sources (2).

fig 1

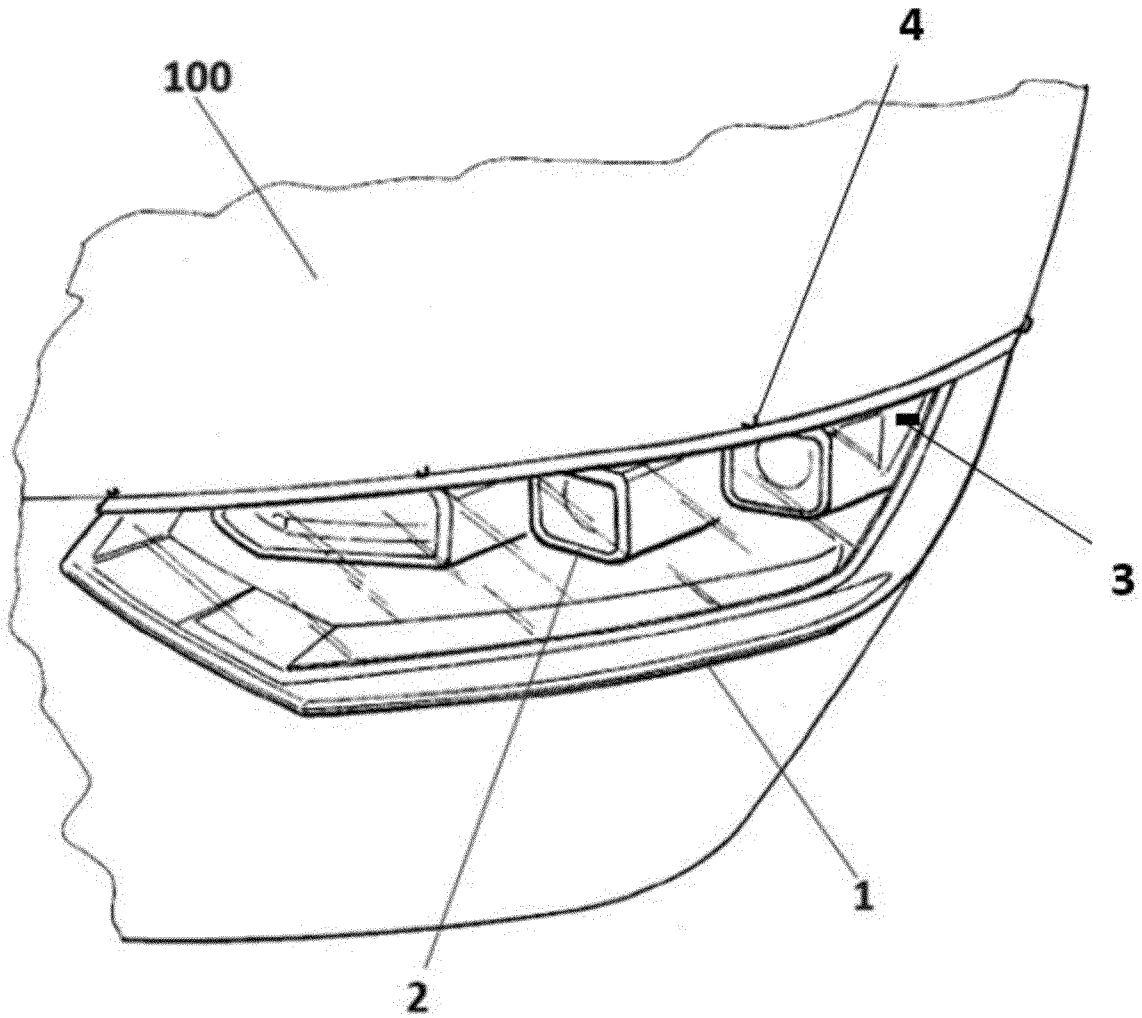


fig 2a

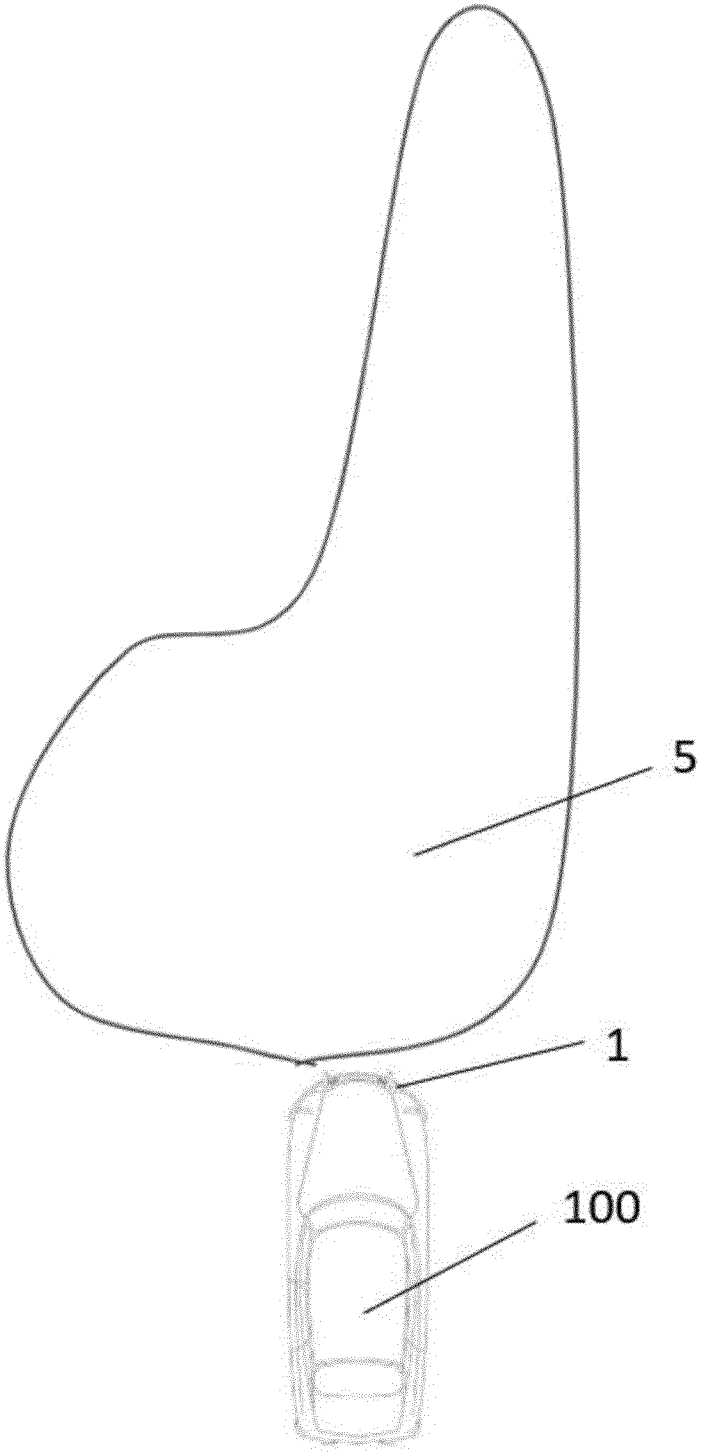
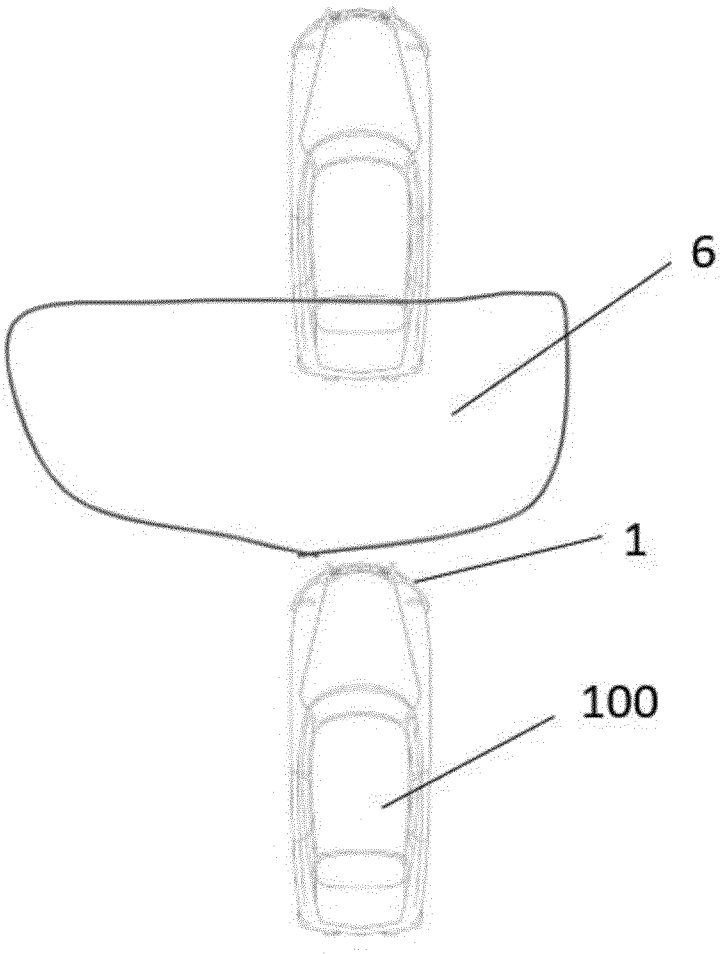


fig 2b



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2021/070179

A. CLASSIFICATION OF SUBJECT MATTER
INV. B60Q1/14 F21S41/153 F21S41/663 B60Q1/00 B60Q1/08
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)
B60Q F21S

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.
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X	CN 109 624 832 A (HOU LIYU) 16 April 2019 (2019-04-16) claims 1-7; figures 1,2	1-12
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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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Date of the actual completion of the international search	Date of mailing of the international search report
30 July 2021	10/08/2021

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	Carneiro, Joaquim

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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