

METHOD AND SYSTEM FOR AIRCRAFT TAXIING ASSISTANCE

The present invention relates to a method and system for aircraft taxiing assistance.

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Currently, the movement of an aircraft on the ground from its parking zone to its stationary point before take-off and its return to its parking zone following landing are handled by the pilot. The pilot has only
10 direct visual monitoring means for identifying the runway (edges and start of a runway) and any obstacles preventing access (vehicle for example).

Thus, a human error can cause certain failures during
15 this taxiing phase, which requires a good assessment of the terrain around the craft and which may prove hazardous. This is why pilots are requesting assistance in monitoring the runways at airports.

20 This is all the more important when the visibility conditions are poor (fog, rain, snow, etc.). Furthermore, these poor conditions usually impose a reduction in air traffic and the diversion of aircraft onto cleared runways.

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There is therefore a need for taxiing assistance in all weather conditions between the parking zone and the take-off runway.

30 Furthermore, military applications may be faced with similar issues.

Various methods and systems for taxiing assistance have already been developed.

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A first type of system employs cameras covering the visible range and is based on powerful additional lighting for nocturnal periods. However, this type of

system is ineffective when the weather conditions are unfavorable (fog, heavy rain, etc.).

A second type of known system comprises two sensors
5 placed on the aircraft that have different spectral
bands, for example an infrared sensor and a sensor in
the visible range. Two distinct images, of the runway
and of its environment, may thus be obtained. In order
to obtain a single image of the best possible quality
10 that can be seen by the pilot, this second type of
system provides for the selection of a first image as
background image then the overlaying on the latter of
the fragments (pixels) of the other image corresponding
to obstacles such as beacons. A single image is thus
15 obtained in which the obstacles are clearly visible,
although they would not have been sufficiently
distinguishable by the pilot with just the first image
that forms the background image. However, this second
type of system does not make it possible to obtain good
20 image quality for the pilot when the weather conditions
have greatly deteriorated.

The invention aims to provide a method and a system for
taxiing assistance which do not have the abovementioned
25 drawbacks of the prior art.

In particular, the invention relates to a method and a
system for taxiing assistance that makes it possible to
provide the pilot with a reliable image in all weather
30 conditions, in order to enable the pilot to move the
aircraft at low speed over the taxiways to its
stationary point or, after its landing, to its parking
zone.

35 To this end, and according to a first aspect, the
invention relates to a method for aircraft taxiing
assistance, which comprises the following steps:

- acquiring a first signal corresponding to the

runway and to its environment by first acquisition means placed on the aircraft and comprising a first sensor in a first spectral band;

5 - acquiring a second signal corresponding to the runway and to its environment by second acquisition means placed on the aircraft and comprising a second sensor in a second spectral band complementing the first spectral band;

10 - providing a database containing the signatures of elements which belong to the runway or are potentially located on the runway - such as beacons, vehicles, people - in the first and second spectral bands of the sensors, and a symbolic graphical representation of these elements;

15 - analyzing the first and second signals acquired and, based on the results of this analysis, generating, on a screen that can be seen by the pilot, a background image of optimum quality from one of said signals or from a combination of said signals, depending on the brightness and/or weather conditions;

20 - detecting the possible presence on the runway of one or more elements from the first and/or second signals and by correlation with the signatures contained in the database;

25 - overlaying on the background image, on the screen, the symbolic graphical representation of the detected element(s).

The expression "complementing" should be understood to mean that the second spectral band is distinct from the first and sufficiently distant from the latter for the two sensors to supply nonredundant information. Furthermore, it ensures that a sensor can give a signal that can be used satisfactorily if the other sensor cannot do so totally, given the weather conditions in particular, or the brightness conditions (day/night for example).

The method according to the invention therefore provides for a merging of the data from the (at least) two sensors. This merging makes it possible to enhance the image processing, reduce computation time, raise
5 the detection threshold and the probabilities of recognition, the quality, the speed of decision, and the identification capability. Furthermore, the merging avoids pilot fatigue and discomfort.

10 Thus, the invention makes it possible to display in the cockpit a quality image which is reliable for the pilot, supplying consolidated information on a single screen:

- about the position of the aircraft in the
15 taxiing zones (display of the runway, beacons, landscape); and

- about the possible presence of identified obstacles (vehicles, people);
hence a considerable reduction in the risks associated
20 with taxiing.

The expression "background image of optimum quality" should be understood to mean the image that provides the best possible display for the pilot. Depending on
25 the conditions, the optimum background image may be the image given by one or other of the two signals (possibly with optimization of certain parameters such as contrast, etc.), or an image given by a combination of these two signals. Generally, the optimum image is
30 obtained during the day via a signal in the visible or NIR (near-infrared) range and when the conditions have deteriorated (at night or in fog for example) via a signal in the IR range. Arbitration may be applied depending on the saturation. There may thus be a
35 priority signal (leading to the background image) and a complementary signal enriching the priority signal (by the overlaying of images).

The symbolic graphical representation overlaid on the background image may notably comprise a pictogram, a text making it clearer for the pilot to read the overall image, etc.

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According to one possible embodiment, the first spectral band is in the infrared range and the second spectral band is in the near-infrared and/or the visible range.

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For example, the first spectral band extends from 8 to 14 μm , and preferably from 8 to 12 μm , and/or the second spectral band extends from 0.4 to 3 μm , and preferably from 0.8 to 1.1 μm .

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Advantageously, the method may also comprise the step of acquiring at least a third signal corresponding to the runway and to its environment by at least third acquisition means placed on the aircraft and comprising a third sensor which complements the first and second sensors and which is able to supply information for determining the nature of a possible element detected from among various possibilities, on the basis of the signatures of elements which belong to the runway or are potentially located on the runway, in the range of the third sensor, and are contained in the database.

The third sensor, complementing the first and second sensors, supplies nonredundant and therefore useful information. The analysis of the signal supplied by the third signal, in conjunction with the corresponding signatures contained in the database, makes it possible to confirm the nature of the element detected or apply a discrimination relative to a number of possible elements.

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According to one possibility, at least third acquisition means are designed to acquire a signal

corresponding to the runway or to its environment through a cloud of suspended droplets.

According to one possible embodiment, the third
5 acquisition means comprise a radar and/or a third
sensor in the visible range. The radar may be used to
identify a vehicle whose engine has been stopped, and
which therefore has no heat signature; the spectral
band of the third sensor, in the visible range, can
10 extend from 0.440 μm to 0.740 μm . The presence of a
sensor handling the acquisition of data in the visible
range may prove useful when the visibility conditions
are satisfactory.

15 According to a second aspect, the invention relates to
a system for aircraft taxiing assistance intended to be
placed on an aircraft, which comprises:

- first acquisition means which comprise a first
sensor in a first spectral band and are able to supply
20 a first signal corresponding to the runway and to its
environment;

- second acquisition means which comprise a
second sensor in a second spectral band complementing
the first spectral band and are able to supply a second
25 signal corresponding to the runway and to its
environment;

- a database containing the signatures of
elements which belong to the runway or are potentially
located on the runway - such as beacons, vehicles,
30 people - in the first and second spectral bands of the
sensors, and a symbolic graphical representation of
these elements;

- a processing unit connected to the first and
second acquisition means and to the database and able
35 to:

- acquire the first and second signals;
- analyze the first and second signals acquired
and, based on the results of this analysis,

generate, on a screen that can be seen by the pilot, a background image of optimum quality from one of said signals or from a combination of said signals, depending on the brightness and/or weather conditions;

5 - detect the possible presence on the runway of one or more elements from the first and/or second signals and by correlation with the signatures contained in the database;

10 - inlay on the background image, on the screen, the symbolic graphical representation of the detected element(s).

Advantageously, the first and/or second acquisition means are equipped with a wide field optic of at least 80° in the horizontal direction and 60° in the vertical direction.

Furthermore, in order to enhance the dynamics of the image, the first and/or second acquisition means may comprise a shutter controlled by the processing unit.

The first and/or second acquisition means may also comprise a spectral filter placed upstream of the corresponding sensor in order to enable the acquisition of signals over the entire spectral band of said sensor or over a selected portion of said spectral band.

Advantageously, the system also comprises at least third acquisition means connected to the processing unit, comprising a third sensor which complements the first and second sensors and which is able to supply a third signal corresponding to the runway and to its environment and making it possible to determine the nature of a possible element detected from among various possibilities by virtue of the database which contains the signatures of elements which belong to the runway or are potentially located on the runway, in the

range of the third sensor.

The system may also comprise a device for aligning the sensors that makes it possible to obtain one and the
5 same frame of reference for all of said sensors.

Moreover, the processing unit may comprise:

- means for determining the properties of the detected element(s), such as the nature, the size, the
10 location and/or the speed of said element;
- and/or means of acquiring data specific to the aircraft, such as the speed, altitude and/or position;
- and/or means of enhancing the quality of the background image and/or of the symbolic graphical
15 representations of the detected element(s), such as the contrast, the brightness, the resolution and/or the contrast between said graphical representations and the background image.

20 There now follows a description, by way of nonlimiting examples, of a number of possible embodiments of the invention, with reference to the appended figures:

figure 1 is a diagrammatical representation of a taxiing assistance system according to a first
25 embodiment of the invention;

figure 2 is a diagrammatical representation of a taxiing assistance system according to a second embodiment of the invention; and

figure 3 is a diagrammatical representation of the
30 image that can be seen by the pilot, by virtue of the method and the system according to the invention.

Reference is first of all made to figure 1, which illustrates a first embodiment of the invention.

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The taxiing assistance system is partly housed in a module 1 interfaced on the skin of the aircraft, enabling:

- a flush-mounted installation, if necessary (to minimize drag);
 - sighting through de-iced portholes;
 - the installation of toughened portholes
- 5 resistant to abrasion and projectiles and having good optical properties;
- the installation of windows for any complementary sensors that have good characteristics in their respective bands;
- 10 - the addition of deflectors, if necessary, in order to prevent dirt, insects or particles in the air striking the portholes or being deposited thereon; and
- good conduction to mechanical ground (lightning).

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The system comprises first acquisition means 2 in a first spectral band 3 and second acquisition means 4 in a second spectral band 5.

- 20 The first acquisition means 2 comprise a first porthole 6 provided on the module 1, a spectral filter 7, a first sensor 8 and an associated first optical system 9. Similarly, the second acquisition means 4 comprise a second porthole 10 provided on the module 1, a spectral
- 25 filter 11, a second sensor 12 and an associated second optical system 13.

The first spectral band 3 is in this case in the IR range, for example with operation between 8 and 12 μm

30 by virtue of the spectral filter 7, and may especially be used to detect and measure beacon temperatures (between 680 and 1500°), particularly during the day; the second spectral band 5 is in this case in the NIR range, for example with operation between 0.8 and

35 1.1 μm by virtue of the spectral filter 11, and may especially be used to detect and measure runway temperatures and temperatures of vehicles on the runway (from a few degrees to several hundred degrees),

including at night or in fog.

In this case, the first porthole 6 is preferably made of germanium, and the second porthole 10 of sapphire.

5 The choice of the materials is guided by the required optical properties (transmission coefficient in the spectral band concerned), but also by the mechanical properties (impact strength, abrasion resistance) and thermal properties (conduction of the material for the
10 de-icing function).

The first sensor 8 is, for example, an uncooled bolometric sensor, the first optical system 9 preferably being a bolometric camera with wide field
15 (at least 40°), with germanium-type fixed aperture. The second sensor 12 is, for example, a CCD sensor. In order to maintain the resolution performance levels, the first sensor 8 and/or the second sensor 12 can comprise one or more detectors coupled to one and the
20 same optic.

The system also comprises a processing unit 14, comprising an image analysis unit 15 and a display unit 16, a mixer and a human-machine interface.

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The image analysis unit 15 is linked on the one hand to the first and second acquisition means 2, 4 and on the other hand to a database 17. This database 17 contains the signatures of elements which belong to the runway
30 or are potentially located on the runway - such as beacons, vehicles, people - in the first and second spectral bands 3, 5 of the sensors 8, 12, and a symbolic graphical representation of these elements.

35 The image analysis unit 15 is able to:

- acquire the signals from the sensors 8, 12;
- acquire the data from the aircraft (speed, altitude, etc.);

- merge the signals supplied by the sensors 8, 12;

- detect the elements of the scene;
- correlate the data deriving from the detection

5 with the data from the database 17;

- confirm the detection of elements of the scene;
- determine the attributes of the various elements of the scene (object location, object size, object type, object speed, etc.);

10 - analyze which of the sensors 8, 12 can be used according to the weather and/or brightness conditions to determine the optimum image background or an optimum combination of the images obtained from the various sensors.

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Furthermore, the image analysis unit 15 can use a motor to control a shutter provided in the optical system(s) 9, 13. The image analysis unit 15 can also control the spectral filter(s) 7, 11. With these filters containing

20 one or more wavelength ranges, it is thus possible to produce acquisitions in different sub-bands of the sensor concerned or, in a switched position, over the entire spectral band.

25 The display unit 16 is connected on the one hand to the first and second acquisition means 2, 4 and on the other hand to the image analysis unit 15. The display unit 16 is able to:

- acquire the attributes of the various elements

30 of the scene;

- acquire the aircraft data;
- acquire the choice of the background image to be displayed;

- enhance the background image (contrast,

35 brightness, resolution);

- enhance the image of the inlayed objects (contrast, brightness, resolution, both intrinsic and relative to the background image);

- if necessary, superpose symbols, text with which to clarify the reading of the images;
- if necessary, produce a dynamic analysis of the various elements of the scene and the associated display (hazard and nature of the hazard);
- transmit a signal that makes it possible to display, on a display means (existing or dedicated to the application), the duly constructed images.

Thus, to sum up, the image analysis unit 15 can be used to merge the signals obtained from the two acquisition means 2, 4 and the display unit 16 makes it possible to produce the best possible display for the pilot. Depending on the application, the image analysis 15 and display 16 units can be dissociated or incorporated within one and the same unit. Preferably, these units 15, 16 work in real time.

The system also comprises a power supply module 18, managing the BITE, de-icing and re-heating, and an equipment connector 19. An equipment health-checking device can also be provided with which to determine the defective elements.

Reference is now made to figure 2, which illustrates a second embodiment of the system according to the invention.

The module 1 contains, in addition to the components described in relation to figure 1, third acquisition means comprising a third sensor 20 able to detect a third type of information 21. It may, for example, be a radar connected via an antenna 22 to a spectral filter 23. As a variant, it may be an IR sensor with the associated optical system.

In this second embodiment, the image analysis unit 15 and the display unit 16 are also connected to the third

acquisition means, and the image analysis unit 15 is able to acquire the data obtained from the three sensors 8, 12, 20.

5 The merging and the enriching of the images are handled by the complementarity of the sensors 8, 12, 20, the separate and then combined processing of the signals in order to optimize restoration for the pilot.

10 The main steps in the processing of the signals and the automatic recognition are as follows:

- an upstream filtering stage (spatial, temporal, spectral);
- the detection and segmentation, in order to
- 15 extract objects such as closely related forms or more or less uniform regions, and the extraction of attributes to characterize the segmented objects;
- a phase for filtering and for confirming or rejecting beacons, supplying recognition probabilities;
- 20 - a human-machine interface management phase, with formation of the output image (which can be seen by the pilot), with management of the display dynamics in order to make the vision more comfortable for the pilot, and insertion of symbols.

25 Obtaining a good image for the eyes of the pilot involves a restoration step, the aim of which is to compensate the defects inherent in the sensor or in the photographing conditions and therefore to form an image

30 that is as faithful as possible to the signature of the observed object. The image enhancement processing operations make it possible to compensate the nonuniformities in gain and offset between the various pixels of a sensor, the noise from a detector and from

35 the analog electronics, the spatial transfer functions (optic, sensors).

Figure 3 diagrammatically represents the image 24 that

can be seen by the pilot on completion of the signal acquisition and process steps. The image 24 comprises:

- on the one hand a background image 25 corresponding to the best possible quality image and
5 obtained from one or the other of the signals obtained from the first and second sensors 8, 12 or from a combination of these signals, depending on the conditions;
- on the other hand, where appropriate, inlayed
10 on the background image 25, the symbolic graphical representation 26 of the element(s) which belong to the runway or are potentially located on the runway - such as beacons, vehicles, people, buildings, feeder lanes, etc. If appropriate, the symbolic graphical
15 representation 26 may include an explanatory text 27 making it easier for the pilot to interpret the image 24.

The performance levels of the system according to the
20 invention are as follows:

- range greater than 300 m;
- wide angular coverage (80° horizontal and 60°
vertical);
- real-time display (for example 30 images per
25 second);
- high contrast in the restoration of the objects relative to the runway, hence real comfort for the pilot (if necessary, with additional graphical help);
- excellent recognition of the beacons and of the
30 vehicles, regardless of the weather conditions.

The system and the method according to the invention do not require particular infrastructure on the runway and can therefore be used in all existing airports,
35 immediately and with no significant excess cost. Nor does installation on the aircraft demand complex provisions. It is, however, advantageous to mount the system aerodynamically on the fuselage of the aircraft,

in contrast to the known devices which generate significant drag and therefore increased consumption.

The other advantages of the invention include:

- a substantial gain in terms of air transport
5 safety, by the visual identification, in all weathers,
of feeder lanes, buildings and parking zones, and a
significant improvement in the safety of the hubs where
vehicle and foot traffic is heavy;
- a direct improvement in driving on the ground, and
10 the safeguarding of goods and people, hence an autonomy
in movement on the ground which is particularly
noticeable.

It should also be noted that the installation of the
15 system according to the invention can be incorporated
in the general architecture of an airplane without any
complex provisions.

It goes without saying that the invention is not
20 limited to the embodiments described hereinabove by way
of examples, but, on the contrary, encompasses all the
variant embodiments.

In particular, it will be noted that the method and the
25 system according to the invention can also be used to
provide assistance in any phase of use of an aircraft
and in particular the take-off and landing phases.

- 16 -

CLAIMS

1. A method for aircraft taxiing assistance, characterized in that it comprises the following steps:
- 5 - acquiring a first signal corresponding to the runway and to its environment, by first acquisition means (2) placed on the aircraft and comprising a first sensor (8) in a first spectral band;
- 10 - acquiring a second signal corresponding to the runway and to its environment, by second acquisition means (4) placed on the aircraft and comprising a second sensor (12) in a second spectral band complementing the first spectral band;
- 15 - providing a database (17) containing the signatures of elements which belong to the runway or are potentially located on the runway - such as beacons, vehicles, people - in the first and second spectral bands of the sensors (8, 12), and a symbolic graphical representation of these elements;
- 20 - analyzing the first and second signals acquired and, based on the results of this analysis, generating, on a screen that can be seen by the pilot, a background image (25) of optimum quality from one of said signals or from a combination of said signals, depending on the
- 25 brightness and/or weather conditions;
- detecting the possible presence on the runway of one or more elements from the first and/or second signals and by correlation with the signatures contained in the database (17);
- 30 - overlaying on the background image (25), on the screen, the symbolic graphical representation (26) of the detected element(s).

2. The method as claimed in claim 1, characterized in
- AMENDED SHEET (ARTICLE 19)

that the first spectral band is in the infrared range and the second spectral band is in the near-infrared and/or the visible range.

5 3. The method as claimed in claim 1 or 2, characterized in that the first spectral band extends from 8 to 14 μm .

10 4. The method as claimed in one of claims 1 to 3, characterized in that the second spectral band extends from 0.4 to 3 μm .

15 5. The method as claimed in one of claims 1 to 4, characterized in that it also comprises the step of acquiring at least one third signal corresponding to the runway and to its environment, by at least third acquisition means placed on the aircraft and comprising a third sensor (20) which complements the first and second sensors (8, 12) and which is able to supply
20 information for determining the nature of a possible element detected from among various possibilities, on the basis of the signatures of elements which belong to the runway or are potentially located on the runway, in the range of the third sensor (20), and are contained
25 in the database (17).

6. The method as claimed in claim 5, characterized in that the at least third acquisition means are designed to acquire a signal corresponding to the runway or to
30 its environment through a cloud of suspended droplets.

7. The method as claimed in claim 5 or claim 6, characterized in that the third acquisition means comprise a radar and/or a third sensor in the visible
35 range.

8. A system for aircraft taxiing assistance intended to be placed on an aircraft, characterized in that it

comprises:

5 - first acquisition means which comprise a first sensor (8) in a first spectral band and are able to supply a first signal corresponding to the runway and to its environment;

10 - second acquisition means which comprise a second sensor (12) in a second spectral band complementing the first spectral band able to supply a second signal corresponding to the runway and to its environment;

15 - a database (17) containing the signatures of elements which belong to the runway or are potentially located on the runway - such as beacons, vehicles, people - in the first and second spectral bands of the sensors (8, 12), and a symbolic graphical representation of these elements;

 - a processing unit (14) connected to the first and second acquisition means and to the database (17) and able to:

20 - acquire the first and second signals;
 - analyze the first and second signals acquired and, based on the results of this analysis, generate, on a screen that can be seen by the pilot, a background image (25) of optimum
25 quality from one of said signals or from a combination of said signals, depending on the brightness and/or weather conditions;
 - detect the possible presence on the runway of one or more elements from the first and/or
30 second signals and by correlation with the signatures contained in the database (17);
 - inlay on the background image (25), on the screen, the symbolic graphical representation (26) of the detected element(s).

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9. The system as claimed in claim 8, characterized in that the first and/or second acquisition means are equipped with a wide field optic of at least 80° in the

horizontal direction and 60° in the vertical direction.

10. The system as claimed in claim 8 or 9,
characterized in that the first and/or second
5 acquisition means comprise a shutter controlled by the
processing unit (14), in order to enhance the dynamics
of the image.

11. The system as claimed in one of claims 8 to 10,
10 characterized in that the first and/or second
acquisition means comprise a spectral filter (7, 11)
arranged upstream of the corresponding sensor (8, 12)
in order to enable the acquisition of signals over the
entire spectral band of said sensor or over a selected
15 portion of said spectral band.

12. The system as claimed in one of claims 8 to 11,
characterized in that it also comprises at least third
acquisition means connected to the processing unit,
20 comprising a third sensor (20) which complements the
first and second sensors (8, 12) and which is able to
supply a third signal corresponding to the runway and
to its environment and making it possible to determine
the nature of a possible element detected from among
25 various possibilities by virtue of the database (17)
which contains the signatures of elements which belong
to the runway or are potentially located on the runway,
in the range of the third sensor (20).

30 13. The system as claimed in one of claims 8 to 12,
characterized in that it comprises a device for
aligning the sensors (8, 12, 20) that makes it possible
to obtain one and the same frame of reference for all
of said sensors.

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14. The system as claimed in one of claims 8 to 13,
characterized in that the processing unit (14)
comprises an image analysis unit (15) and a

visualization unit (16).

15. The system as claimed in claim 14, characterized
in that the image analysis unit 15 and the
5 visualization unit 16 work in real time.

16. The system as claimed in one of claims 8 to 15,
characterized in that the processing unit (14)
comprises means for determining the properties of the
10 detected element(s), such as the nature, the size, the
location and/or the speed of said element.

17. The system as claimed in one of claims 8 to 16,
characterized in that the processing unit (14)
15 comprises means of acquiring data specific to the
aircraft, such as the speed, altitude and/or position.

18. The system as claimed in one of claims 8 to 17,
characterized in that the processing unit (14)
20 comprises means of enhancing the quality of the
background image (25) and/or of the symbolic graphical
representations (26) of the detected element(s), such
as the contrast, the brightness, the resolution and/or
the contrast between said graphical representations and
25 the background image.