Europäisches Patentamt
European Patent Office
Office européen des brevets

Antrag auf Erteilung eines europäischen Patents
Request for grant of a European patent
Requête en délivrance d'un brevet européen

☐ Nachreichung von Form 1001 zu einer früher eingereichten Anmeldung nach Regel 40 (1) vom
Form 1001 filed further to a previous application under Rule 40(1) on
Dépôt du formulaire 1001 pour une demande déposée antérieurement au titre de la règle 40(1) en date du

☐ Bestätigung einer bereits durch Fax eingereichten Anmeldung vom
Confirmation of an application already filed by fax on
Confirmation d'une demande déjà déposée par téléfax le
bei
with
auprès de

Nur für amtlichen Gebrauch / For official use only / Cadre réservé à l'administration		
1 Anmeldenummer / Application No. / N° de la demande	MKEY	
2 Tag des Eingangs (Regel 35 (2)) / Date of receipt (Rule 35(2)) / Date de réception (règle 35(2))	DREC	
3 Tag des Eingangs beim EPA (Regel 35 (4)) / Date of receipt at EPO (Rule 35(4)) / Date de réception à l'OEB (règle 35(4))	RENA	
4 Anmeldetag / Date of filing / Date de dépôt		

5 Es wird die Erteilung eines europäischen Patents und gemäß Artikel 94 die Prüfung der Anmeldung beantragt. /
Grant of a European patent, and examination of the application under Article 94, are hereby requested. /
Il est demandé la délivrance d'un brevet européen et, conformément à l'article 94, l'examen de la demande.

☒ EXAM 4

Prüfungsantrag in einer zugelassenen Nichtamtssprache /
Request for examination in an admissible non-EPO language /
Requête en examen dans une langue non officielle autorisée

5.1 Der Anmelder verzichtet auf die Aufforderung nach Regel 70 (2), zu erklären, ob die Anmeldung aufrechterhalten wird. /
The applicant waives his right to be asked whether he wishes to proceed further with the application (Rule 70(2)). /
Le demandeur renonce à être invité, conformément à la règle 70(2), à déclarer s'il souhaite maintenir sa demande.

☐ MEPA

AREF

6 Zeichen des Anmelders oder Vertreters (max. 15 Positionen) /
Applicant's or representative's reference (max. 15 keystrokes) /
Référence du demandeur ou du mandataire (max. 15 caractères ou espaces)

EP21/02/2011

Anmelder / Applicant / Demandeur

APPR

7 Name /
Nom

8 Anschrift /
Address /
Adresse

UNIVERSITAT POLITÈCNICA DE CATALUNYA
Jordi Girona, 31
08034 Barcelona
Spain

9 Zustellanschrift /
Address for correspondence /
Adresse pour la correspondance

UNIVERSITAT POLITÈCNICA DE CATALUNYA
Jordi Girona, 29 Planta Baja, NEXUSII
08034 Barcelona (SPAIN)

TRAN | FILL

Zeichen des Anmelders / Applicant's reference / Référence du demandeur: EP21/02/2011

10 Staat des Wohnsitzes oder Sitzes /
State of residence or of principal place of business /
Etat du domicile ou du siège

ES

11 Staatsangehörigkeit /
Nationality /
Nationalité

ES

12 Telefon /
Telephone /
Téléphone

+34 93 413 40 70

13 Fax /
Téléfax

+34 93 413 76 31

14 Weitere(r) Anmelder auf Zusatzblatt /
Additional applicant(s) on additional sheet /
Autre(s) demandeur(s) sur feuille supplémentaire

☐

Vertreter / Representative / Mandataire

FREP

15 Name / Nom
(**Nur einen** Vertreter oder den Namen des Zusammenschlusses angeben, der in das Europäische Patentregister einzutragen ist und an den zugestellt wird) /
(Name **only one** representative or association of representatives, to be listed in the Register of European Patents and to whom communications are to be notified) /
(N'indiquer qu'**un seul** mandataire ou le nom du groupement de mandataires qui sera inscrit au Registre européen des brevets et auquelles les significations seront faites)

et al ☐

16 Geschäftsanschrift /
Address of place of business /
Adresse professionnelle

17 Telefon /
Telephone /
Téléphone

18 Fax /
Téléfax

19 Weitere(r) Vertreter auf Zusatzblatt /
Additional representative(s) on additional sheet /
Autre(s) mandataire(s) sur feuille supplémentaire

☐

Vollmacht / Authorisation / Pouvoir

GENA

20 ist beigefügt / is enclosed / joint

☐

21 Allgemeine Vollmacht ist registriert unter Nummer /
General authorisation has been registered under No. /
Un pouvoir général a été enregistré sous le numéro

Erfinder / Inventor / Inventeur

INVT 20

22 Der (die) Anmelder ist (sind) alleinige(r) Erfinder. /
The applicant(s) is (are) the sole inventor(s). /
Le(s) demandeur(s) est (sont) le(s) seul(s) inventeur(s).

☐

23 Erfindernennung in beigefügtem Schriftstück /
Designation of inventor attached /
Voir la désignation de l'inventeur ci-jointe

☒

24 **Bezeichnung der Erfindung / Title of invention / Titre de l'invention**

TIDE TIEN TIFR

SYSTEM, METHOD AND COMPUTER PROGRAM FOR RECEIVING A LIGHT BEAM

Zeichen des Anmelders /
Applicant's reference /
Référence du demandeur EP21/02/2011

25 Prioritätserklärung (Regel 52) und Recherchenergebnisse nach Regel 141(1) / Declaration of priority (Rule 52) and search results under Rule 141(1) / Déclaration de priorité (règle 52) et résultats de la recherche conformément à la règle 141 (1)

PRIO

Eine Prioritätserklärung wird für die folgenden Anmeldungen abgegeben: /
A declaration of priority is hereby made for the following applications: /
Une déclaration de priorité est produite pour les demandes suivantes :

Nur für amtlichen Gebrauch / For official use only / Cadre réservé à l'administration			
01			
02			
03			
04			

Die Recherchenergebnisse nach Regel 141(1) sind beigefügt. /
Search results under Rule 141(1) are attached /
Les résultats de la recherche selon la règle 141(1) sont joints

	Staat / State / Etat	*Anmeldetag / Date of filing / Date de dépôt*	*Aktenzeichen / File No. / N° de dépôt*	
01				☐
02				☐
03				☐
04				☐

25.1 Auf einem Zusatzblatt ist angegeben, dass weitere Prioritäten beansprucht werden und die entsprechenden Recherchenergebnisse nach Regel 141 (1) beigefügt sind. / Additional declaration(s) of priority and indication(s) of the attachment of corresponding search results (Rule 141(1)) on additional sheet. / Il est indiqué sur une feuille supplémentaire que d'autres priorités sont revendiquées et que les résultats correspondants de la recherche selon la règle 141(1) sont joints. ☐

25.2 Diese Anmeldung ist eine vollständige Übersetzung der früheren Anmeldung. / This application is a complete translation of the previous application. / La présente demande est une traduction intégrale de la demande antérieure. ☐ *01* ☐ *02* ☐ *03* ☐ *04* ☐ *andere / other / autres*

25.3 Es ist nicht beabsichtigt, eine (weitere) Prioritätserklärung einzureichen. / It is not intended to file a (further) declaration of priority. / Il n'est pas envisagé de produire une (autre) déclaration de priorité. ☐

26 Bezugnahme auf eine früher eingereichte Anmeldung / Reference to a previously filed application / Renvoi à une demande déposée antérieurement

EAPP

26.1 Es wird auf eine früher eingereichte Anmeldung Bezug genommen. Die Bezugnahme **ersetzt die Beschreibung und etwaige Zeichnungen** (Regel 40 (1) c), (2)). Die Anmeldung, auf die Bezug genommen wird, ist: / Reference is made to a previously filed application. That reference **replaces the description and any drawings** (Rule 40(1)(c), (2)). The application to which reference is made is the following: / Il est fait référence à une demande déposée antérieurement. Ce renvoi **remplace la description et, le cas échéant, les dessins** (règle 40(1)c), (2)). La demande à laquelle il est fait référence est la suivante : ☐

Nur für amtlichen Gebrauch / For official use only / Cadre réservé à l'administration		

Staat / State / Etat	*Anmeldetag / Date of filing / Date de dépôt*	*Aktenzeichen / File No. / N° de dépôt*

26.2 Die Bezugnahme auf die früher eingereichte Anmeldung **ersetzt auch** die **Patentansprüche** (Regel 57 c)). / The reference to the previously filed application **also replaces** the **claims** (Rule 57(c)). / Le renvoi à la demande déposée antérieurement **remplace également les revendications** (règle 57c)). ☐

26.3 Eine **beglaubigte Abschrift** der früher eingereichten Anmeldung (Regel 40 (3)) / A **certified copy** of the previously filed application (Rule 40(3)) / Une **copie certifiée** conforme de la demande déposée antérieurement (règle 40(3)) ☐ ist beigefügt. / is attached. / est jointe. ☐ wird nachgereicht. / will be supplied later. / sera produite ultérieurement.

26.4 Eine **Übersetzung** der früher eingereichten Anmeldung (Regel 40 (3)) / A **translation** of the previously filed application (Rule 40(3)) / Une **traduction** de la demande déposée antérieurement (règle 40(3)) ☐ ist beigefügt. / is attached. / est jointe. ☐ wird nachgereicht. / will be supplied later. / sera produite ultérieurement.

27 Teilanmeldung / Divisional application / Demande divisionnaire

PANR

Die Anmeldung ist eine Teilanmeldung, die aus der folgenden früheren Anmeldung hervorgeht: / The application is a divisional application based on the following earlier application: / La présente demande constitue une demande divisionnaire relative à la demande antérieure suivante :

DFIL

Nummer der früheren Anmeldung / Number of earlier application / Numéro de la demande antérieure

Zeichen des Anmelders / Applicant's reference / Référence du demandeur: EP21/02/2011

27.1 Datum des ersten Bescheids der Prüfungsabteilung zu der frühesten Anmeldung, zu der ein Bescheid ergangen ist (Regel 36 (1) a)): / Date of Examining Division's first communication in respect of the earliest application for which a communication has been issued (Rule 36(1)(a)): / Date de la première notification de la division d'examen relative à la demande la plus ancienne pour laquelle une notification a été émise (règle 36(1)a)) :

Datum / Date

Bei Abweichung von der in Feld 27 angegebenen Anmeldung ist die betreffende früheste Anmeldung: / If different from the application mentioned in Section 27, the relevant earliest application is: / Si la demande la plus ancienne concernée diffère de celle mentionnée à la rubrique 27, veuillez indiquer son numéro :

Nummer der betreffenden frühesten Anmeldung / Number of the relevant earliest application / Numéro de la demande la plus ancienne concernée

27.2 Datum des Bescheids, in dem die Prüfungsabteilung zum ersten Mal eingewandt hat, dass die frühere Anmeldung nicht den Erfordernissen des Artikels 82 genügt (Regel 36 (1) b)): / Date of communication in which the Examining Division has objected for the first time that the earlier application does not meet the requirements of Article 82 (Rule 36(1)(b)): / Date de la notification dans laquelle la division d'examen a objecté pour la première fois que la demande antérieure ne satisfait pas aux exigences de l'article 82 (règle 36(1)b)) :

Datum / Date

28 Anmeldung nach Artikel 61 (1) b) / Article 61(1)(b) application / Demande selon l'article 61(1)b)

☐ EANR

Es handelt sich um eine Anmeldung nach Artikel 61 (1) b). / The application is an Article 61(1)(b) application. / La présente demande constitue une demande selon l'article 61(1)b).

Nummer der früheren Anmeldung / Number of earlier application / Numéro de la demande initiale

29 Patentansprüche / Claims / Revendications

CLMS

Zahl der Patentansprüche / Number of claims / Nombre de revendications: 17

29.1 ☒ wie beigefügt / as attached / telles que jointes en annexe

29.2 ☐ wie in der früher eingereichten Anmeldung (siehe Feld 26.2) / as in the previously filed application (see Section 26.2) / telles que figurant dans la demande déposée antérieurement (voir rubrique 26.2)

29.3 ☐ Die Patentansprüche werden nachgereicht. / The claims will be filed later. / Les revendications seront produites ultérieurement.

30 Abbildungen / Figures / Figures

DRAW 2

Zur Veröffentlichung mit der Zusammenfassung wird vorgeschlagen Abbildung Nr. / It is proposed that the abstract be published together with figure No. / Il est proposé de publier avec l'abrégé la figure n°

31 Benennung von Vertragsstaaten / Designation of contracting states / Désignation d'Etats contractants

DEST

Alle Vertragsstaaten die dem EPÜ **bei Einreichung** der europäischen Patentanmeldung angehören, gelten als benannt (Artikel 79 (1)). / All the contracting states party to the EPC **at the time of filing** of the European patent application are deemed to be designated (Article 79(1)). / Tous les Etats contractants qui sont parties à la CBE **lors du dépôt** de la demande de brevet européen sont réputés désignés (Article 79(1)).

Zeichen des Anmelders / Applicant's reference / Référence du demandeur: EP21/02/2011

32 Verschiedene Anmelder für verschiedene Vertragsstaaten / Different applicants for different contracting states / Différents demandeurs pour différents Etats contractants

APPR02

Name(n) des (der) Anmelder(s) und benannte Vertragsstaaten: /
Name(s) of applicant(s) and designated contracting states: /
Nom(s) du (des) demandeur(s) et des Etats contractants désignés :

33 Erstreckung des europäischen Patents / Extension of the European patent / Extension des effets du brevet européen

EXPT

Diese Anmeldung gilt als Antrag, die europäische Patentanmeldung und das darauf erteilte europäische Patent auf alle Nichtvertragsstaaten des EPÜ zu erstrecken, mit denen am Tag der Einreichung der Anmeldung Erstreckungsabkommen in Kraft sind. Der Antrag gilt jedoch **als zurückgenommen**, wenn die Erstreckungsgebühr nicht fristgerecht entrichtet wird. /
This application is deemed to be a request to extend the European patent application and the European patent granted in respect of it to all non-contracting states to the EPC with which extension agreements are in force on the date on which the application is filed. However, the request **is deemed withdrawn** if the extension fee is not paid within the prescribed time limit. /
La présente demande est réputée constituer une requête en extension des effets de la demande de brevet européen et du brevet européen délivré sur la base de cette demande à tous les Etats non parties à la CBE avec lesquels des accords d'extension sont en vigueur à la date du dépôt de la demande. Cette requête est toutefois **réputée retirée** si la taxe d'extension n'est pas acquittée en temps utile.

33.1 Es ist derzeit beabsichtigt, die Erstreckungsgebühr(en) für die nebenstehend angekreuzten Staaten zu entrichten. /
It is currently intended to pay the extension fee(s) for the states marked opposite with a cross. /
Il est actuellement envisagé de payer la (les) taxe(s) d'extension pour les Etats dont le nom est coché ci-contre.

Hinweis: Im automatischen Abbuchungsverfahren werden nur für die hier angekreuzten Staaten Erstreckungsgebühren abgebucht, sofern dem EPA nicht vor Ablauf der Zahlungsfrist ein anderslautender Auftrag zugeht.

Note: Under the automatic debiting procedure, extension fees will only be debited for states indicated here, unless the EPO is instructed otherwise before expiry of the period for payment.

Veuillez noter que dans le cadre de la procédure de prélèvement automatique des taxes d'extension, le compte est débité du montant dû seulement pour les Etats cochés ici, sauf instruction contraire reçue avant l'expiration du délai de paiement.

☐ **BA** Bosnien und Herzegowina / Bosnia and Herzegovina / Bosnie-Herzégovine

☐ **ME** Montenegro / Montenegro / Monténégro

☐ | |

☐ | |

(Platz für Staaten, mit denen nach Drucklegung dieses Formblatts Erstreckungsabkommen in Kraft treten oder für die am Anmeldetag der früheren Anmeldung Erstreckungsabkommen in Kraft waren (Artikel 76 (1)) / Space for states with which extension agreements enter into force after this form has been printed or for which extension agreements existed on the date of filing of the earlier application (Article 76(1)) / Espace prévu pour des Etats à l'égard desquels des accords d'extension entreront en vigueur après l'impression du présent formulaire ou étaient en vigueur à la date de dépôt de la demande antérieure (article 76(1)))

34 Biologisches Material / Biological material / Matière biologique

☐ BIOM 1

34.1 Die Erfindung verwendet und/oder bezieht sich auf biologisches Material, das nach Regel 31 hinterlegt worden ist. /
The invention uses and/or relates to biological material deposited under Rule 31. /
L'invention utilise et/ou concerne de la matière biologique déposée conformément à la règle 31.

a Die nach Regel 31 (1) c) erforderlichen Angaben, d. h. die Hinterlegungsstelle und die Eingangsnummer, sind in den technischen Anmeldungsunterlagen enthalten auf /
The information required under Rule 31(1)(c), i.e. depositary institution and accession number, is given in the application's technical documents on /
Les indications visées à la règle 31(1)c), à savoir l'autorité de dépôt et le numéro d'ordre, figurent dans les pièces techniques de la demande à la / aux

Seite(n) / page(s)	*Zeile(n) / line(s) / ligne(s)*

b Ist die Eingangsnummer am Anmeldetag noch nicht bekannt, so sind die Hinterlegungsstelle und das (die) Bezugszeichen (Nummer, Symbole usw.) des Hinterlegers in den technischen Anmeldungsunterlagen zu entnehmen auf /
If the accession number is not yet known on the date of filing, for the depositary institution and the depositor's identification reference(s) (number, symbols, etc.) see the application's technical documents on /
Si le numéro d'ordre n'est pas encore connu à la date de dépôt, l'autorité de depôt et la (les) référence(s) d'identification (numéro ou symboles etc.) du déposant figurent dans les pièces techniques de la demande, à la/aux

Seite(n) / page(s)	*Zeile(n) / line(s) / ligne(s)*

☐ Die Angaben werden später mitgeteilt /
The information will be submitted later /
Les indications visées seront communiquées ultérieurement

34.2 Die Empfangsbescheinigung(en) der Hinterlegungsstelle /
The receipt(s) of deposit issued by the depositary institution /
Le(s) récépissé(s) de dépôt délivré(s) par l'autorité de dépôt

☐ ist (sind) beigefügt. / is (are) enclosed. / est (sont) joint(s).

☐ wird (werden) nachgereicht. / will be filed later. / sera (seront) produit(s) ultérieurement.

Zeichen des Anmelders / Applicant's reference / Référence du demandeur: EP21/02/2011

35 Falls das biologische Material nicht vom Anmelder, sondern von einem Dritten hinterlegt wurde /
If the biological material was deposited by a person other than the applicant /
Lorsque la matière biologique a été déposée par une personne autre que le demandeur

Name und Anschrift des Hinterlegers / Name and address of depositor / Nom et adresse du déposant

35.1 Ermächtigung nach Regel 31 (1) d) /
Authorisation under Rule 31(1)(d) /
L'autorisation prévue à la règle 31(1)d)

☐ ist beigefügt / is attached / est jointe

☐ wird nachgereicht / will be supplied later / sera produite ultérieurement

36 Verzicht auf die Verpflichtung des Antragstellers nach Regel 33 (2) in gesondertem Schriftstück /
Waiver of the right to an undertaking from the requester pursuant to Rule 33(2) attached /
Renonciation, sur document distinct, à l'engagement du requérant au titre de la règle 33(2)

☐

37 Gemäß Regel 32 (1) erklärt der Anmelder hiermit, dass der Zugang zu dem in den Feldern 34 und 35 genannten biologischen Material nur durch Herausgabe einer Probe an einen Sachverständigen hergestellt wird. /
The applicant hereby declares under Rule 32(1) that the biological material referred to in Sections 34 and 35 is to be made available only by the issue of a sample to an expert. /
Conformément à la règle 32(1), le demandeur déclare par la présente que l'accessibilité à la matière biologique mentionnée aux rubriques 34 et 35 ne peut être réalisée que par la remise d'un échantillon à un expert.

☐ BIOM 3

38 **Nucleotid- und Aminosäuresequenzen /**
Nucleotide and amino acid sequences /
Séquences de nucléotides et d'acides aminés

SEQL 1

38.1 Die Beschreibung enthält ein Sequenzprotokoll auf Papier nach Regel 30 (1). /
The description contains a sequence listing on paper in accordance with Rule 30(1). /
La description contient un listage de séquences sur papier conformément à la règle 30(1).

☐ ☐ wird nachgereicht / will be supplied later / sera produite ultérieurement

38.2 Eine Kopie des in Feld 38.1 genannten Sequenzprotokolls auf einem elektronischen Datenträger ist beigefügt. /
A copy of the sequence listing referred to in Section 38.1 on an electronic data carrier is enclosed. /
Une copie du listage de séquences mentionné à la rubrique 38.1 est jointe sur un support électronique de données.

☐

38.3 Der Anmelder erklärt hiermit, dass die auf dem elektronischen Datenträger gespeicherte Information mit dem auf Papier eingereichten Sequenzprotokoll übereinstimmt. /
The applicant hereby states that the information recorded on the electronic data carrier is identical to the sequence listing filed on paper. /
Il est déclaré par la présente que l'information figurant sur le support électronique de données est identique à celle que contient le listage de séquences déposée sur papier.

☐

Sonstige Angaben / Further indications /
Indications supplémentaires

39 Zusätzliche Abschriften der im europäischen Recherchenbericht angeführten Schriftstücke werden beantragt. /
Additional copies of the documents cited in the European search report are requested. /
Prière de fournir des copies supplémentaires des documents cités dans le rapport de recherche européenne.

*Anzahl der **zusätzlichen** Sätze von Abschriften /*
*Number of **additional** sets of copies /*
*Nombre de jeux **supplémentaires** de copies*

ASOC

☐

40 Die Rückerstattung der Recherchengebühr gemäß Artikel 9 (2) Gebührenordnung wird beantragt. /
Refund of the search fee under Article 9(2) of the Rules relating to Fees is requested. /
Le remboursement de la taxe de recherche est demandé en vertu de l'article 9(2) du règlement relatif aux taxes.

☐

41 gestrichen / deleted / supprimé

Zeichen des Anmelders / Applicant's reference / Référence du demandeur: EP21/02/2011

Europäisches Patentamt
European Patent Office
Office européen des brevets

Empfangsbescheinigung
Receipt for documents
Récépissé de documents

Liste der diesem Antrag beigefügten Unterlagen – Hiermit wird der Empfang der unten bezeichneten Dokumente bescheinigt. Wird im Falle der Einreichung der europäischen Patentanmeldung bei einer nationalen Behörde diese Empfangsbescheinigung vom Europäischen Patentamt übersandt, so ist sie als Mitteilung gemäß Regel 35 (4) anzusehen (siehe Feld RENA).

Checklist of enclosed documents – Receipt of the documents indicated below is hereby acknowledged. If this receipt is issued by the European Patent Office and the European patent application was filed with a national authority, it serves as a communication under Rule 35(4) (see Section RENA).

Liste des documents annexés à la présente requête – Nous attestons le dépôt des documents désignés ci-dessous. Si, en cas de dépôt de la demande de brevet européen auprès d'un service national, l'Office européen des brevets délivre le présent récépissé de documents, ce récépissé est réputé être la notification visée à la règle 35(4) (cf. rubrique RENA).

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Amtsstempel / Official stamp / Cachet officiel

Tag des Eingangs (Regel 35 (2)) / Date of receipt (Rule 35(2)) / Date de réception (règle 35(2)) DREC	
Anmeldenummer für den Schriftverkehr mit dem EPA; *Aktenzeichen für Prioritätserklärungen* / Application No. to be used in correspondence with the EPO; *file No. to be used for priority declarations* / N° de la demande à utiliser dans la correspondance avec l'OEB; *n° de dépôt à utiliser pour la déclaration de priorité*	
Tag des Eingangs beim EPA (Regel 35 (4)) / Date of receipt at EPO (Rule 35(4)) / Date de réception à l'OEB (règle 35(4)) RENA	

47 A. Anmeldungsunterlagen und Prioritätsbeleg(e) / Application and priority documents / Pièces de la demande et document(s) de priorité

Blattzahl / Number of sheets* / Nombre de feuilles**

1.	Beschreibung (ohne Sequenzprotokollteil) / Description (excluding sequence listing part) / Description (sauf partie réservée au listage des séquences)	☒	22
2.	Patentansprüche / Claims / Revendications	☒	17
3.	Zeichnung(en) / Drawing(s) / Dessin(s)	☒	3
4.	Sequenzprotokollteil der Beschreibung / Sequence listing part of description / Partie de la description réservée au listage des séquences	☐	
5.	Zusammenfassung / Abstract / Abrégé	☒	
6.	Früher eingereichte Anmeldung / Previously filed application / Demande déposée antérieurement	☐	
7.	Übersetzung der Anmeldungsunterlagen / Translation of the application documents / Traduction des pièces de la demande	☐	
8.	Übersetzung der früher eingereichten Anmeldung / Translation of the previously filed application / Traduction de la demande déposée antérieurement	☐	
9.	Prioritätsbeleg(e) / Priority document(s) / Document(s) de priorité	☐	
10.	Übersetzung des (der) Prioritätsbelegs(belege) / Translation of priority document(s) / Traduction du (des) document(s) de priorité	☐	

Gesamtzahl der Abbildungen / Total number of figures* / Nombre total de figures**: 3

*Anzahl / Number / Nombre**

* Die Richtigkeit der Blattzahl und der Gesamtzahl der Abbildungen wurde bei Eingang nicht geprüft. / * No check was made on receipt that the number of sheets and the total number of figures indicated were correct. / * L'exactitude du nombre de feuilles et du nombre total de figures n'a pas été contrôlée lors du dépôt.

AREF

Zeichen des Anmelders / Applicant's reference / Référence du demandeur

EP21/02/2011

48 B. Der Anmeldung in der eingereichten Fassung liegen folgende Unterlagen bei: / This application as filed is accompanied by the items below: / Les pièces ci-après sont annexées à la présente demande :

1.	Vollmacht / Authorisation / Pouvoir	☐
2.	Allgemeine Vollmacht / General authorisation / Pouvoir général	☐
3.	Erfindernennung / Designation of inventor / Désignation de l'inventeur	☐
4.	Recherchenergebnisse nach Regel 141 (1) / Search results under Rule 141(1) / Résultats de la recherche conformément à la règle 141(1)	☐
5.	Gebührenzahlungsvordruck (EPA Form 1010) / Voucher for the settlement of fees (EPO Form 1010) / Bordereau de règlement de taxes (OEB Form 1010)	☐
6.	Elektronischer Datenträger für Sequenzprotokoll / Electronic data carrier for sequence listing / Support électronique de données pour listage des séquences	☐
7.	Zusatzblatt / Additional sheet / Feuille supplémentaire	☐
8.	Sonstige Unterlagen (bitte hier spezifizieren) / Other documents (please specify here) / Autres documents (veuillez préciser)	☐

49 C. Exemplare dieser Empfangsbescheinigung (bitte zutreffende Zahl ankreuzen) / **Copies of this receipt for documents** (please mark appropriate number with a cross) / **Exemplaires du présent récépissé de documents** (veuillez cocher la chiffre correspondant)

☒ 3 Einreichung direkt beim EPA / Direct filing with the EPO / Dépôt direct auprès de l'OEB

☐ 4 Einreichung bei einer nationalen Behörde / Filing with a national authority / Dépôt auprès d'un service national

42 **Automatischer Abbuchungsauftrag /**
Automatic debit order /
Ordre de prélèvement automatique
(nur möglich für Inhaber von beim EPA geführten laufenden Konten) /
(for EPO deposit account holders only) / (possibilité offerte uniquement aux titulaires de comptes courants ouverts auprès de l'OEB)

DECA

Das EPA wird hiermit beauftragt, fällig werdende Gebühren und Auslagen nach Maßgabe der Vorschriften über das automatische Abbuchungsverfahren vom nebenstehenden laufenden Konto abzubuchen. /
The EPO is hereby authorised, under the Arrangements for the automatic debiting procedure, to debit from the deposit account opposite any fees and costs falling due. /
Par la présente, il est demandé à l'OEB de prélever du compte courant ci-contre les taxes et frais venant à échéance, conformément à la réglementation relative à la procédure de prélèvement automatique.

Nummer des laufenden Kontos / Deposit account number / Numéro du compte courant

Name des Kontoinhabers / Account holder's name / Nom du titulaire du compte

43 Etwaige **Rückzahlungen** sollen auf das nebenstehende beim EPA geführte laufende Konto erfolgen. /
Any **refunds** should be made to the EPO deposit account opposite. /
Les **remboursements** éventuels doivent être effectués sur le compte courant ci-contre ouvert auprès de l'OEB.

DEPA

Nummer des laufenden Kontos / Deposit account number / Numéro du compte courant

Name des Kontoinhabers / Account holder's name / Nom du titulaire du compte

44 Die vorgeschriebene Liste über die diesem Antrag beigefügten Unterlagen ergibt sich aus der vorbereiteten Empfangsbescheinigung (Seite 8 dieses Antrags). /
The prescribed list of documents enclosed with this request is shown on the prepared receipt (page 8 of this request). /
La liste prescrite des documents joints à la présente requête figure sur le récépissé préétabli (page 8 de la présente requête).

☒

45 Für Angestellte nach Artikel 133 (3) Satz 1 mit allgemeiner Vollmacht /
For employees under Article 133(3), first sentence, having a general authorisation /
Pour les employés mentionnés à l'article 133(3), 1ère phrase, munis d'un pouvoir général

Nummer / Number / Numéro

46 **Unterschrift(en) des (der) Anmelder(s) oder Vertreter(s)**
Name des (der) Unterzeichneten bitte in Druckschrift wiederholen und bei juristischen Personen die Stellung des (der) Unterzeichneten innerhalb der Gesellschaft angeben. /
Signature(s) of applicant(s) or representative(s)
Under signature please print name and, in the case of legal persons, position within the company. /
Signature(s) du (des) demandeur(s) ou du (des) mandataire(s)
Prière d'indiquer en caractères d'imprimerie le ou les noms des signataires ainsi que, s'il s'agit d'une personne morale, la position occupée au sein de celle-ci par le ou les signataires.

Ort / Place / Lieu

BARCELONA

Datum / Date

21/02/2011

Unterschrift(en) / Signature(s)

Xavier Gil Mur
Vicerrector de Política Científica

Zeichen des Anmelders / Applicant's reference / Référence du demandeur: EP21/02/2011

Europäisches Patentamt
European Patent Office
Office européen des brevets

Erfindernennung
Designation of inventor
Désignation de l'inventeur

(falls Anmelder nicht oder nicht allein der Erfinder ist) /
(where the applicant is not the inventor or is not the sole inventor) /
(si le demandeur n'est pas l'inventeur ou l'unique inventeur)

Zeichen des Anmelders / Applicant's reference /
Référence du demandeur
(max. 15 Positionen / max. 15 spaces / 15 caractères au maximum)

EP21/02/2011

Anmeldenummer oder, falls noch nicht bekannt, Bezeichnung der Erfindung: /
Application No. or, if not yet known, title of the invention: /
N° de la demande ou, s'il n'est pas encore connu, titre de l'invention :

SYSTEM, METHOD AND COMPUTER PROGRAM FOR RECEIVING A LIGHT BEAM

In Sachen der oben bezeichneten europäischen Patentanmeldung nennt (nennen) der (die) Unterzeichnete(n)[1] / In respect of the above European patent application I (we), the undersigned[1] / En ce qui concerne la demande de brevet européen susmentionnée, le(s) soussigné(s)[1]

UNIVERSITAT POLITÈCNICA DE CATALUNYA

als Erfinder[2]: / do hereby designate as inventor(s)[2]: / désigne(nt) en tant qu'inventeur(s)[2] :

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C/. Jordi Girona, 31 Barcelona 08034 (SPAIN)

☐ Weitere Erfinder sind auf einem gesonderten Blatt angegeben. / Additional inventors are indicated on a supplementary sheet. /
D'autres inventeurs sont mentionnés sur une feuille supplémentaire.

Der (Die) Anmelder hat (haben) das Recht auf das europäische Patent erlangt[3] / The applicant(s) has (have) acquired the right to the European patent[3] /
Le(s) demandeur(s) a (ont) acquis le droit au brevet européen[3]

☐ gemäß Vertrag vom / by an agreement dated / en vertu du contrat passé le

☒ als Arbeitgeber / as employer(s) / en qualité d'employeur(s)

☐ durch Erbfolge / as successor(s) in title / par succession

Ort / Place / Lieu: Barcelona

Datum / Date: 21/02/2011

Unterschrift(en) des (der) Anmelder(s) oder Vertreter(s): /
Signature(s) of applicant(s) or representative(s): /
Signature(s) du (des) demandeur(s) ou du (des) mandataire(s) :

Xavier Gil Mur
Vice-Rector
Universitat Politècnica de Catalunya

Name des (der) Unterzeichneten bitte in Druckschrift wiederholen. Bei juristischen Personen bitte die Stellung des (der) Unterzeichneten innerhalb der Gesellschaft in Druckschrift angeben. / Please print name(s) under signature(s). In the case of legal persons, the position of the signatory within the company should also be printed. / Le ou les noms des signataires doivent être indiqués en caractères d'imprimerie. S'il s'agit d'une personne morale, la position occupée au sein de celle-ci par le ou les signataires doit également être indiquée en caractères d'imprimerie.

System, method and computer program for receiving a light beam

The present invention relates to a method for receiving a light beam. More specifically, the invention relates to a method for receiving a light beam that, for example, may be a part of a method for scanning a surface, the received light beam being a light beam reflected in the surface to be scanned.

The invention also relates to a system and a computer program for receiving a light beam, suitable for carrying out such a method.

BACKGROUND ART

Nowadays, there is a wide range of fields in which 3D mapping and information is applied to enhance different technologies: being video generation techniques including depth information, guiding of vehicles through mapping of the surface where the vehicle stands, object location, quality control in a manufacturing process, etc.

One of such 3D mapping used in said fields is the scanning of surfaces by means of systems based on Time of Flight measuring techniques (known as TOF), which have been widely used in the past for obtaining images with depth information.

Said systems based on TOF techniques commonly involve the implementation of a system for transmitting and receiving a light beam, in order to measure distances from a surface. The first imaging systems based on TOF used mechanical scanning techniques and comprised a mechanical system responsible for managing the transmission and reception of the light beam in a determined direction. In any case, the measure was based on a single point with a single sensor and the image was formed from a mechanical scanning and the correlation of "measurement" and "trigger point" of the light beam. Furthermore, the mechanical scanning involved problems

relating to the vibration of the components of the system, their lower durability and big size.

As opposed to the systems for receiving a light beam used in the described mechanical systems, there also exist systems for receiving a light beam based on arrays of light sensors.

Basically, there are scanning systems that comprise an array of light sensors of a specific size (n columns by m rows), which may receive and detect the reflection of the light beam on the surface all at once. These systems, known as Flash Ladars, use modulated and/or pulsed TOF measuring techniques, which are widely known. Furthermore, by using these systems to obtain a digital image, there is no need to perform a mechanical scanning of a surface in two dimensions, since the array itself defines a two-dimensional surface, which in the end will define the image size.

More specifically, as can be seen in Figure 1, a system for scanning a surface usually used nowadays (in this example, a system using pulsed TOF techniques, although modulated ones are also used) comprises a laser or LED beam transmitter 1 that transmits a light beam 2 to the surface 3 to be scanned, this light beam being reflected on the surface and being received by the array of light sensors 4 acting as a receiving system and acting as a detector for determining the moment of receiving each portion of the light beam 2. Further, the system comprises a beam splitter 5 which directs a portion of the light beam to a detector 9 for determining the moment of starting the transmission of the light beam, the required optical elements 6,7, and a device 8 for counting the TOF values (taking into account the moment in which the detector 9 detects the portion of the light beam split by the beam splitter 5) for each portion of the light beam received by the array of light sensors 4 and for determining the distance between the transmitter 1 and the surface 3 taking into account the corresponding TOF value. This way, the system enables to obtain a 3D digital image of the scanned surface.

An example of a system using a pulsed TOF technique device developed by MIT is described in "*Real-Time 3D Ladar Imaging*" (Cho, Anderson, et.al., LINCOLN LABORATORY JOURNAL, volume 16, no.1, 2006). Such a TOF device comprises an array of light sensors, and it uses pulsed signals. More specifically, a 32x32 pixel sensor is used, which is able to perform measurements at a frequency of up to 16KHz, using a signal with a wavelength of 532nm and a pulse width of 250ps.

Other few examples of manufacturers or development teams which have worked with this technology in the past and/or are still developing it, but in the field of the modulated techniques are *Mesa Imaging* (a *Centre Suisse d'Electronique et de Microtechnique* (CSEM) spin-off), which have designed and commercialized a TOF imaging camera; *PMD Technologies* (a *Zentrum für Sensorsysteme* (ZESS) spin-off) from the Siegen University in Germany, which, similarly to CSEM, have developed an array-based TOF imaging camera; Optrima (an ETRO (*Department of Electronics and Informatics*) and VUB (*Vrije Universiteit Brussel*) spin-off), which have also developed a further TOF array-based imaging camera; and *Canesta Inc.*, a company which, since 2004, has developed sensing devices used in TOF imaging cameras such as the previously described.

However, these imaging systems have limitations related to their receiving system, where the size of the light sensors comprised in the array of light sensors affects the resolution of the image of the scanned surface. Basically, given that the overall size of the light sensors (since it is difficult to integrate a sensor and its circuitry in one silicon chip using normal microelectronic schemes) is large, the number of portions of the light beam detectable by the scanning system is low (i.e. fewer portions can be distinguished), and therefore the spatial resolution of the scanned image is low. Since said spatial resolution of the digital image may be crucial when using the device in fields such as video generation techniques involving depth information in video

images, guidance of vehicles or robots by means of 3D vision, quality control in manufacturing processes, etc..., the existing systems, with lower spatial resolutions, may not be suitable to be used in said applications, if a high spatial resolution or performance of an existing device is required.

In summary, the known receiving systems have the drawback that the number of portions of the light beam received by the array of light sensors is too small, that is, from a given light beam and due to the size of the elements in the array, the amount of portions of the light beam that the systems can receive is too small (given that only one portion of the light beam is received by each light sensor), so spatial resolution of the scanned image is low. This way, the use of these receiving systems is limited to certain applications and even for these applications the results are not as good as one would wish.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a system for receiving a light beam that receives a higher number of portions of the light beam than the known receiving systems previously described.

To achieve the above, according to a first aspect, the invention provides a system for receiving a light beam comprising a pixelated light switch array, in which each switch is adapted to receive at least one portion of the light beam and direct it to the array of light sensors, and in that the pixelated light switch array comprises a higher number of switches than the number of light sensors comprised in the array of light sensors.

The provision of the pixelated light switch array with a higher number of switches than the number of light sensors comprised in the array of light sensors allows receiving a higher number of portions of the light beam. However, at the same time, when combining the pixelated light switch with a system for receiving a light beam, the reception of said light beam becomes

very delicate since the usual size of a pixel an array may normally be aproximately 10um (depending on the type of array), which means that the received light by a single pixel is very low, and the device will have to use sensors with a proper sensitivity, to be able to detect a light beam with a size corresponding to the size of the pixel.

An alternative or addition to the system would be to, when in use, assure that the system for receiving a light beam is used in combination with a more powerful light source than the ones used in the prior art.

It is important to highlight that the array of light sensors may be understood as an array of any size, including an array with a single light sensor, that is, an array of 1x1 light sensor.

According to another aspect of the invention, it is provided a method for receiving a light beam, the method comprising, for each switch of a pixelated light switch array:

- receiving at least one portion of the light beam;
- directing (for example, deflecting the received portion) the received portion of the light beam to an array of light sensors;

the pixelated light switch array comprising a higher number of switches than the number of light sensors comprised in the array of light sensors.

By performing said method and using said system for receiving a light beam, a higher number of portions of reflected light beam can be received according to a reflected surface, in comparison with previous systems which used an array of light sensors with no pixelated light switch array. More specifically, when a light beam is transmitted and reflected to a surface, a higher number of reflected portions of the light beam can be received, thus obtaining more information about the reflected surface which may be used in several applications, such as the obtaining of an image corresponding to the shape, speed, type of movement, or other characteristics of said surface.

Also, according to another aspect, the invention provides a computer program product comprising program instructions for causing a computer system to perform the method for receiving a light beam described before.

Said computer program may be embodied on storing means (for example, on a record medium, on a computer memory or on a read-only memory) or carried on a carrier signal to be, for example, downloaded from a computer or sent by an email (for example, on an electrical or optical carrier signal).

According to a preferred embodiment of the invention, the invention provides a system for scanning a surface comprising:

- a light source for transmitting a light beam to the surface to be scanned;
- the system for receiving a light beam as described before, for receiving the light beam reflected on the surface;
- a first computer system for determining the time of flight value of each received portion of the light beam;
- a second computer system for determining a parameter related to the distance travelled by each received portion of the light beam taking into account its time of flight value determined by the first computer system;

wherein the determined parameter related to the distance of each portion of the light beam is indicative of a spatial point of the scanned surface.

By using this scanning system, a digital image may be obtained which comprises a bidimensional set of information, defined by the number of switches of the pixelated light switch array, and a third dimension which is the corresponding parameter related to the distance determined for each value of the bidimensional set of points defined by the pixelated light switch array. Said parameter related to the distance may be a parameter used to obtain said distance, a parameter calculated out of distance, or the distance value itself.

Said digital image may have, consequently, a higher number of points (a higher spatial resolution) than a digital image obtained by methods and systems of the prior art, therefore making it useful for applications which demand a higher level of precision, such as quality control in a manufacturing process, movement guided by 3D vision, etc.

On the other hand, the first computer system and the second computer system may be part of a single computer system. Further, the scanning system may comprise a third computer system for controlling the pixelated light switch array. This third computer system may also be part of the single computer system that may include the first and/or second computer systems.

Also, the determination of the time of flight value of each received portion of the light beam may be performed by using TOF calculations. One such calculation typically used involves using the formula:

d = (c / 2f) * (phase / 2*pi)
c = speed of light;
f = modulation frequency of the light (a typical case is a value of 20MHz);
phase = phase of the received signal.

The above formula is a general one which may be modified depending on the modulation techniques used for the calculation. For example, if a pulsed technique is used, the formula is:

d = c * t;
when the time of displacement of a light pulse is counted and "c" is the speed of light.

The light sensors comprised in the array of light sensors may be any one of the following list: photodiode sensors, APDs (Avalanche photodiodes) type sensors, SPADs (Single photon avalanche photodiodes) type sensors, SiPM

(Silicon photomultipliers) type sensors or MPPC (Multipixel photon counter), and PMT (photomultiplier tube) type sensors, or any other type of suitable or similar light detecting device.

Also, for an optimum performance of the overall system, it may have to be assured that the sensors are properly isolated from external lights, since the light beams redirected by the pixelated light switch array have very low power and their detection can easily distorted by a normal ambient light. Furthermore, the sensors would have to be implemented in such a way that its signal-noise ratio is optimized, taking into account their low power.

Furthermore, for a proper performance of the system and avoiding measurements distorted by other signals, the computer systems and the overall system may have to be able to process signals with a wide bandwith, thus minimizing the effect from the parasite capacities, to be able to avoid them and any other jitter effect.

An example of such an effect would be that a typical signal to be detected by the light sensors would be signals with delays in the order of 30ps, thus making it important to use electronics which do not distort such a precise signal.

According to a preferred embodiment, the light source is adapted to generate a pulsed light beam for pulsed TOF calculation techniques. More specifically, by using a pulsed light beam, the time when the pulsed light beam is transmitted, and the moment of starting the transmission of the light beam, used for determining the time of flight values, may be set using any feature related to the shape of the signal, such as a first rise of the pulse when it is first transmitted, or a first fall of the pulse when it is first transmitted. Furthermore, the moment of receiving a portion of the light beam by means of the array of the light sensors (or by means of the pixelated light switch array) may be obtained by means of a corresponding feature related to the shape of

the signal, in an analogue way to the one used for obtaining the moment of transmission.

An alternative to said detection of the rise or fall of a pulse may be the use of a Constant Fraction Discriminator (CFD) circuit, which takes into account the whole duration of a pulse instead of the rise or fall. These type of circuits may be more efficient since they avoid the problems generated by the need of maintaining a constant and optimum level of threshold when detecting risings or falls, required when using other detecting techniques.

Alternatively, the light source may be adapted to generate a modulated light beam for modulated TOF calculation techniques. Therefore, a simple detection of a predetermined phase of the received portion of light beam is enough to detect the time of flight value of the corresponding portion of the light beam.

According to a further embodiment, the light source comprises a first element for adapting and widening the range of the light beam in order to reach a wider area. Said element may be an optical element such as an optical lens or a set of optical lenses, disposed in front of the light source's output in such a way that it widens the range of the output light beam transmitted towards a surface, thus enabling the light beam to reach a wider area and not a small area or a single point. This is useful since, if a digital image of a surface may be obtained, the reflected portions of a light beam may be reflected on several different points of said surface for the image to be correspondant to the surface.

Furthermore, the optical element may be important when using light sources which output narrow light beams, such as lasers, which otherwise would only reach a very small area of the surface to be imaged.

Also, the optical elements may be movable in such a way that they may be able to direct the light source output towards different zones, thus enabling to

perform scanning of wider surfaces by moving the light source several times and making the light beam to reflect in different areas of a surface (e.g. the lenses may rotate horizontally, vertically, etc).

According to yet another embodiment, the scanning system further comprises a second element for generating an image of the surface on the pixelated light switch array. Further, the scanning system may comprise a third element for focusing each portion of the light beam received on the pixelated light switch array, on the array of light sensors.

For an optimum performance, the third lens has to be very accurate when focusing each portion of light beam on the pixelated light switch array, because of the small size of the pixels of the array, an also it may have to be able to focus properly for light coming from a wide range of distances.

In an analogue way as in the case of the optical element previously described, the second and third element may be an optical element (such as a lens or a set of lenses) which, in the case of the second one, directs the incoming portions of the light beam reflected on the surface, towards the pixelated light switch array, and in the case of the third one, it focuses each portion of light beam reflected by the pixelated light switch array towards the array of light sensors.

Furthermore, said second element may be embodied in a similar way as the zoom devices found in any analog or digital camera, thus enabling to focus and zooming in or out to determine which part of the surface is wished to obtain a digital image from. Also, this second element may have, as in the previous case, a movable part to direct the element towards a surface.

According to a preferred embodiment of the invention, the pixelated light switch array comprises a MEMS type device, which more specifically may be a Digital Micromirror Device (DMD). The DMD component is part of the technology known as DLP (Digital Light Projection) which has been developed

by Texas Instruments since the late 1980s. A DMD comprises a set or array of micromirrors which may be deflected electrically by a programmed device (for example, the third computer system described before) connected to the DMD. Said DMD has been previously used in the field of projection of digital images, deflecting a source of light to project it on a screen.

By the use of a DMD, a much higher resolution is achieved when attempting to determine a plurality of TOFs from a surface, to obtain a 3D image of said reflecting surface. Furthermore, by using a DMD, the system may be more reliable in front of possible malfunctions and may have a higher durability, since the micromirrors comprised in it are electronically driven, and have a higher endurance than mechanical scanning devices.

Alternatively, the pixelated light switch array may comprise a liquid crystal display or deformable mirrors. In the case of a liquid crystal display, an option may be a screen such as an LCOS screen.

An LCOS™ or LCoS™ (Liquid crystal on silicon) screen comprises a "micro-projection" or "micro-display" reflective technology similar to DLP projectors technology. However, it uses liquid crystals instead of individual mirrors, the pixels being able to deflect, transmit or absorb incoming light in a given direction. Thus, such a device enables to selectively illuminate at least one pixel of the screen and direct the light arriving to the pixel, to a given direction, such control being performed electronically.

By way of comparison, LCD projectors use transmissive LCD chips, allowing light to pass through the liquid crystal. In LCoS, liquid crystals are applied directly to the surface of a silicon chip coated with an aluminized layer, with some type of passivation layer, which is highly reflective (being defined as reflective LCs type of liquid crystals). Depending on the specific LCoS chip, it may be preferable to use it instead of a device comprising micromirrors.

Other type of liquid crystal displays may be suitable to be used, such as the transmissive ones (for example, the Twisted nematic liquid crystals), or the ferroelectric ones (for example, the Ferroelectric liquid crystals (FLC), the Surface stabilized FLCs, and one of the most widely used nowadays, the FLCOS (Ferroelectric LC on silicon)) which are all suitable to be used in the invention.

On the other hand, a set of deformable mirrors based on MEMS technologies may be used. The Microelectromechanical systems or MEMS use a technology of very small mechanical devices driven by electricity, which are made up of components between 1 to 100 micrometres in size. The advantage of using MEMS devices derives in that the only driving to be done is an electrical one, and the scale of the MEMS devices enables to perform a determination of a time of flight with higher detail or spatial resolution, determining smaller portions of light beam reflected on to the surface, which may be useful for applications such as, for example, the obtaining of digital images of the reflecting surface.

According to another embodiment of the invention, a method for scanning a surface is provided, the method comprising:

- transmitting a light beam to the surface to be scanned;
- executing the method of receiving a light beam, for receiving the light beam reflected on the surface;
- determining the time of flight value of each received portion of the light beam;
- determining the distance-related parameter for each received portion of the light beam taking into account its determined time of flight value;

wherein the determined distance-related parameter of each portion of the light beam is indicative of a spatial point of the scanned surface.

The distance-related parameter may be a parameter which is used to obtain the real distance (such as speed), a parameter calculated out of distance or,

for example, the value of the distance itself.

According to an embodiment of the invention, it is provided a computer program product comprising program instructions for causing a computer system to perform the method for scanning a surface described before.

According to another aspect, the invention provides a use of a pixelated light switch array, in which each switch is adapted for receiving at least one portion of a light beam and for deflecting it to an array of light sensors, in a system for scanning a surface or in a method for scanning a surface, described before.

BRIEF DESCRIPTION OF THE DRAWINGS

Particular embodiments of the present invention will be described in the following by way of non-limiting examples, with reference to the appended drawings, in which:

Figure 1, is a schematic representation of a system for scanning a surface, according to the state of the art;
Figure 2, is a schematic representation of a system for scanning a surface, according to the invention; and
Figure 3, is a flowchart of a method for scanning a surface, according to the invention.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

According to a preferred embodiment of the invention, a system 20 for scanning a surface 28 and obtaining a digital image of said surface will be described by means of the accompanying figures, wherein figure 2 depicts the system 20 for scanning a surface 28, which comprises a light source in the form of a pulsed laser beam transmitter 22 such as a Nd:YAG pulsed laser.

The laser transmitter 22 comprises a first set of lenses 23, which is displayed in such a way that, when the laser 22 transmits a laser pulsed light beam signal, the lenses widen the range of the laser beam, thus reaching a wide surface instead of a focalised point, as lasers usually do.

Furthermore, the system comprises a system for receiving a light beam 21 comprising a pixelated light switch array, which, in this case, is a DMD™ device 24 (Digital micromirror device), as the ones manufactured by Texas Instruments; an array of avalanche photodiode sensors in Geiger mode 26 for detecting light beams; and a second set of lenses 25 displayed before the DMD 24 surface. Said elements are displayed pursuing the generation of an image of the observed surface of the DMD.

Said first and second set of lenses 23 and 25 further comprises means to open and close its optical range, and therefore being able to direct more or less upcoming light beams into the device, towards the switches of the DMD 24, in such a way as a photographic or video camera's objective works. This way, an image is created on the DMD's surface, which is to be used to obtain an image of the observed surface of the DMD (which may be, for example, a topography image or a 3D image).

Said DMD comprises a plurality of 'pixels' defined by a plurality of electronically controlled micromirrors which are suitable for receiving the reflected portions of light beams on their surface and deflect a receiving light beam by rotating certain degrees; the relative position of the DMD and the array of photodiodes is such that, when a micromirror of the DMD is deflected, it conducts its corresponding portion of light beam towards one of the photodiodes of said array.

More precisely, the micromirrors have at least two deflecting positions, each having an angle such that the first one deflects the incoming light beam towards at least one of the avalanche photodiode sensors comprised in the

array of photodiodes 26, and a second angle which deflects an incoming light beam towards a dump position, assuring that it is not directed to any of the photodiodes.

Furthermore, a third set of lenses 29 is arranged between the DMD 24 and the array of avalanche photodiode sensors 26, which is adjusted in such a way that, when any micromirror is deflected towards the array 26, the incoming light beam is directed correctly towards a photodiode of the array 26.

Also, the DMD device 24 comprises a number of micromirrors which is higher than the number of photodiodes of the array of photodiodes.

Furthermore, different DMD type devices exist in the market which may be suitable to be used with the present invention, each varying several features, which affect their spatial resolution, which may vary between 0.7 to 2 Megapixels. Therefore, an image obtained by using a DMD type device may have a resolution of up to 1920x1080 points, in front of a typical array of 176x144 points (that is, an image with 25344 pixels) normally found in the market.

Other features are fairly similar: for example, a large amount of DMD devices have a standard frame rate of 32.552Hz and a micromirror inclination of up to +/- 12º.

A further important feature is the "fill factor", which relates to the space between micromirrors, which, in this embodiment, is approximately 91%, corresponding to a space of 10.8um or more between micromirrors.

Also, a dump element 27 is displayed in such a way that, when a switch of the DMD is not in use, it deflects its corresponding incoming portion of light beam towards said Dump, which avoids the interference with the portion of light

beam which is being directed towards the light sensors by another switch of the DMD.

The system also comprises a computer controller 30 such as an FPGA device, which comprises several modules used to obtain the digital image of the surface where the light beam has been reflected.

The FPGA 30 performs the overall control of the system, coordinating all the different parts of it, such as the transmission of the laser, and the functioning of the reception part of the system, controlling the different elements such as the DMD and the array of photodiodes, and the signals sent and received from them, by means of different modules comprised in the FPGA itself.

A computer module of the FPGA is the Reception control module 31, which is connected to the DMD and the array of photodiodes, to electronically control their movements, obtaining signals from them, etc. For example, the deflection of the micromirrors and the obtaining of the detection signal from the array of photodiodes when the deflected light beam hits one photodiode, is performed by means of said Reception control module 31. It is important to highlight that the array of photodiodes may or may not be directly connected to the FPGA. For example, a pulse detection analog electronics may be provided between the FPGA and the array of photodiodes to adapt the signals sent between them.

A second computer module is the TOF (Time of flight) calculator module 32, which determines the Time of Flight value of each portion of light beam that arrives to each micromirror of the DMD, by detecting it through one photodiode of the array of photodiodes 26 using a widely known technique involving calculating the instant time when the laser pulse signal beam is transmitted and the arrival of the corresponding portion of the light beam which has been reflected on the surface, detecting the rise of one or several pulses of the received laser pulsed signal.

A further computer module comprised in the FPGA is the Imaging module 33, which, based on the calculated TOF of each point of the DMD (that is, of each portion of light beam received in its corresponding micromirror), calculates the distance travelled by each portion of light beam and uses it to determine the Z axis of a digital image.

Said digital image of the reflected surface is obtained by gathering the information corresponding to an X and Y axis, determined by the surface size of the DMD and the amount of micromirrors it comprises, thus obtaining a bidimensional digital image of the surface, and adding the third component, on the Z axis, by using the different distances travelled by the different portions of light beam reflected by the surface, which have arrived to the system through the DMD and the array of photodiodes, obtaining, at the end, a three-dimensional digital image of the reflected surface with components X, Y and Z.

According to the invention, as illustrated in figure 3, the previously described system is able to perform the method for scanning a surface, which comprises:

- (101) Selecting a first micromirror of the DMD;
- (102) Transmitting, by means of the laser transmitter 22, a pulsed laser signal to the surface to be scanned;
- (103) Receiving portions of the light beam at the DMD device 24, through the second set of lenses 25, the portions of the light beam reflected by the surface to be scanned;
- (104) Deflecting a portion of the light beam towards the array of photodiodes 26, by deflecting the selected micromirror of the DMD device 24;
- (105) Calculating the Time of Flight value of the deflected portion of the light beam, the portion of the light beam being detected by a photodiode of the array of photodiodes 26;

- (106) Determining, from the calculated time of flight, a Z value for a pixel of a scan pattern corresponding to the deflected micromirror;
- (107) Verifying if all the micromirrors of the DMD have been deflected;
in case of negative result, selecting a further micromirror of the DMD device 24 and returning to step (102);
- (108) Obtaining a digital image from the X, Y and Z values comprised in the scan pattern.

In step (102), the Laser transmits a pulsed signal of hundreds or thousands of picoseconds and a peak power of some kW, which is adapted and its range widened by the set lenses 23 disposed in front of the Laser's output, to reach a further area of the surface to be scanned.

An example of such a Laser may be a compact laser source that generates radiation of the eyesafe wavelength region near 1.55 μm, such as the one described in "Eyesafe microchip laser for laser range finder application" by *Do-Hyun Park et. al.* Such a laser source may be useful in several applications involving the scanning of a person or an animal, since it can avoid any physical injure on the person's or animals eyes, typically done by a normal Laser.

Then, when the light beam is reflected on the surface and arrives to the receiver, in step (103), the second set of lenses 25 redirects the incoming portions of light beam towards the DMD 24 surface, which, as described in step (104), sequentially and individually deflects its micromirrors, redirecting the incoming portions of light beam towards the array of photodiodes 26, for each micromirror of the DMD.

In this example, only one photodiode is used to detect each deflected portion of light beams, but other alternatives may occur. For example, more than one photodiode can be used to detect the deflected portions of light beam. In such a case, the fact that there is a higher number of micromirrors than

photodiodes enables the system, when sequentially redirecting the portions of light beam from the micromirrors to the photodiodes, to redirect the light beams to each photodiode, obtaining a higher spatial resolution (a higher number of micromirrors) using less photodiodes to detect all the incoming light beams.

A further alternative may be that more than one photodiode is used and they can detect portions of light beam in parallel. This enables to deflect a subset of micromirrors of the DMD device at once, thus using the photodiodes in parallel, each photodiode detecting a portion of light beam reflected by each deflected micromirror.

Therefore, to obtain the same spatial resolution without the DMD, that is, using a device with direct detection of the portions of light beam by means of the array of photodiodes, a higher number of photodiodes would have to be used, making the size of the device larger than the device of the present invention is (which comprises the DMD and less photodiodes).

Afterwards, each sensor detects the deflected light beam, producing a signal which is transmitted to the FPGA, where, based on the instant when the light beam was transmitted, and its arrival instant, determines the TOF value of each corresponding portion of light beam.

More precisely, according to the present embodiment of the invention, the FPGA has previously stored (at the time of the transmission) the instant when the pulsed laser signal has been transmitted, being said instant the time when the rise of the first pulse has been transmitted. Then, a time counter has been started at the instant of said rise, and when the arrival of the reflected light beam is detected, by means of the time counter, the time lapse between said transmission instant and the arrival instant of the corresponding pulse is determined.

Regarding the speed of the calculation of the TOFs, the high frame rate of the described DMD devices implies that the system has an approximate calculation velocity of 32KHz, which enables to perform up to 32K measurements per second, with a spatial resolution of up to 2 Megapixels, as it has been previously described. However, if more than one light sensor is used in parallel to detect incoming light beams, more measures can be performed in less time (for example, if 4 sensors are used in parallel, it enables to perform 128K measurements per second).

Then, using common techniques of distance calculation based on Time of Flight calculations, a distance value Z_i is determined for each calculated TOF value, corresponding to each portion of light beam reflected by each micromirror of the DMD.

When obtaining the digital image from one or more scan patterns, the image comprising X, Y and Z values, these values may be represented related or not to physical values (meters, feet, etc.).

The X and Y values may be represented in such a manner that, taking into account the first and/or second sets of lenses 23 and 25, a real value in meters/feet/other between pixels of the digital image may be determined, but in some cases, only the 'real' value of the Z axis may be needed, thus making unnecessary any calculation to determine the scale of the image corresponding to real lengths.

Furthermore, the real Z axis values of the images may be determined by the normal calculation of the time of flight plus further calculations, but sometimes, depending on the application, only the differences between values may be needed, thus not determining the real values of distances between the system and each point of the image, but the relationship between each point of the digital image.

Although only a number of particular embodiments and examples of the invention have been disclosed herein, it will be understood by those skilled in the art that other alternative embodiments and/or uses of the invention and obvious modifications and equivalents thereof are possible. Furthermore, the present invention covers all possible combinations of the particular embodiments described. Reference signs related to drawings and placed in parentheses in a claim, are solely for attempting to increase the intelligibility of the claim, and shall not be construed as limiting the scope of the claim. Thus, the scope of the present invention should not be limited by particular embodiments, but should be determined only by a fair reading of the claims that follow.

For example, in the description of the preferred embodiment, a specific implementation of the invention has been described which uses a pulsed light signal transmission and reception, but an alternative implementation can also comprise a modulated light signal transmission and reception.

In that case, the transmission and reception, as it has been described in the summary of the invention, would be different, in order to detect a modulated signal (for example, by detecting the reception of a specific phase of the signal, instead of, for example, the detection of a rise or fall of the pulsed signal performed in the preferred embodiment previously described).

Aside from said transmission and detection, the device could function in the same way as the described embodiment comprising a modulated signal transmission and reception, since the time-of-flights, distances and X, Y and Z values necessary to obtain an image, can be obtained by using the corresponding calculations in both cases.

Further, although the embodiments of the invention described with reference to the drawings comprise computer apparatus and processes performed in computer apparatus, the invention also extends to computer programs,

particularly computer programs on or in a carrier, adapted for putting the invention into practice. The program may be in the form of source code, object code, a code intermediate source and object code such as in partially compiled form, or in any other form suitable for use in the implementation of the processes according to the invention. The carrier may be any entity or device capable of carrying the program.

For example, the carrier may comprise a storage medium, such as a ROM, for example a CD ROM or a semiconductor ROM, or a magnetic recording medium, for example a floppy disc or hard disk. Further, the carrier may be a transmissible carrier such as an electrical or optical signal, which may be conveyed via electrical or optical cable or by radio or other means.

When the program is embodied in a signal that may be conveyed directly by a cable or other device or means, the carrier may be constituted by such cable or other device or means.

Alternatively, the carrier may be an integrated circuit in which the program is embedded, the integrated circuit being adapted for performing, or for use in the performance of, the relevant processes.

CLAIMS

1. A system (21) for receiving a light beam, comprising an array of light sensors (26), **characterized** in that it also comprises a pixelated light switch array (24), in which each switch is adapted to receive at least one portion of the light beam and direct it to the array of light sensors (26), and in that the pixelated light switch array (24) comprises a higher number of switches than the number of light sensors comprised in the array of light sensors (26).

2. A method of receiving a light beam, comprising, for each switch of a pixelated light switch array:

- receiving at least one portion of the light beam;
- directing the received portion of the light beam to an array of light sensors;

the pixelated light switch array comprising a higher number of switches than the number of light sensors comprised in the array of light sensors.

3. A computer program product comprising program instructions for causing a computer system to perform the method for receiving a light beam, according to claim 2.

4. A computer program product according to claim 3, embodied on a storage medium.

5. A computer program product according to claim 3, carried on a carrier signal.

6. A system (20) for scanning a surface (28), comprising:

- a light source (22) for transmitting a light beam to the surface (28) to be scanned;
- the system (21) for receiving a light beam according to claim 1, for receiving the light beam reflected on the surface (28);

- a first computer system (32) for determining the time of flight value of each received portion of the light beam;
- a second computer system (33) for determining a parameter related to the distance travelled by each received portion of the light beam taking into account its time of flight value determined by the first computer system;

wherein the determined parameter related to the distance of each portion of the light beam is indicative of a spatial point of the scanned surface (28).

7. The system according to claim 6, wherein the light source (22) is adapted to generate a pulsed light beam.

8. The system according to claim 6, wherein the light source (22) is adapted to generate a modulated light beam.

9. The system according to any of claims 6 to 8, wherein the light source (22) comprises a first element (23) for widening the range of the light beam.

10. The system according to any of claims 6 to 9, further comprising a second element (25) for generating an image of the surface (28) on the pixelated light switch array (24).

11. The system according to claim 10, further comprising a third element (29) for focusing each portion of the light beam received on the pixelated light switch array (24), on the array of light sensors (26).

12. The system according to any of claims 6 to 11, wherein the pixelated light switch array (24) comprises a Digital Micromirror Device (DMD).

13. The system according to any of claims 6 to 11, wherein the pixelated light switch array (24) comprises a liquid crystal display.

14. The system according to any of claims 6 to 11, wherein the pixelated light switch array (24) comprises deformable mirrors.

15. A method of scanning a surface (28), comprising:

- transmitting a light beam to the surface to be scanned;
- executing the method of receiving a light beam according to claim 2, for receiving the light beam reflected on the surface;
- determining the time of flight value of each received portion of the light beam;
- determining a distance-related parameter for each received portion of the light beam taking into account its determined time of flight value;

wherein the determined distance-related parameter of each portion of the light beam is indicative of a spatial point of the scanned surface.

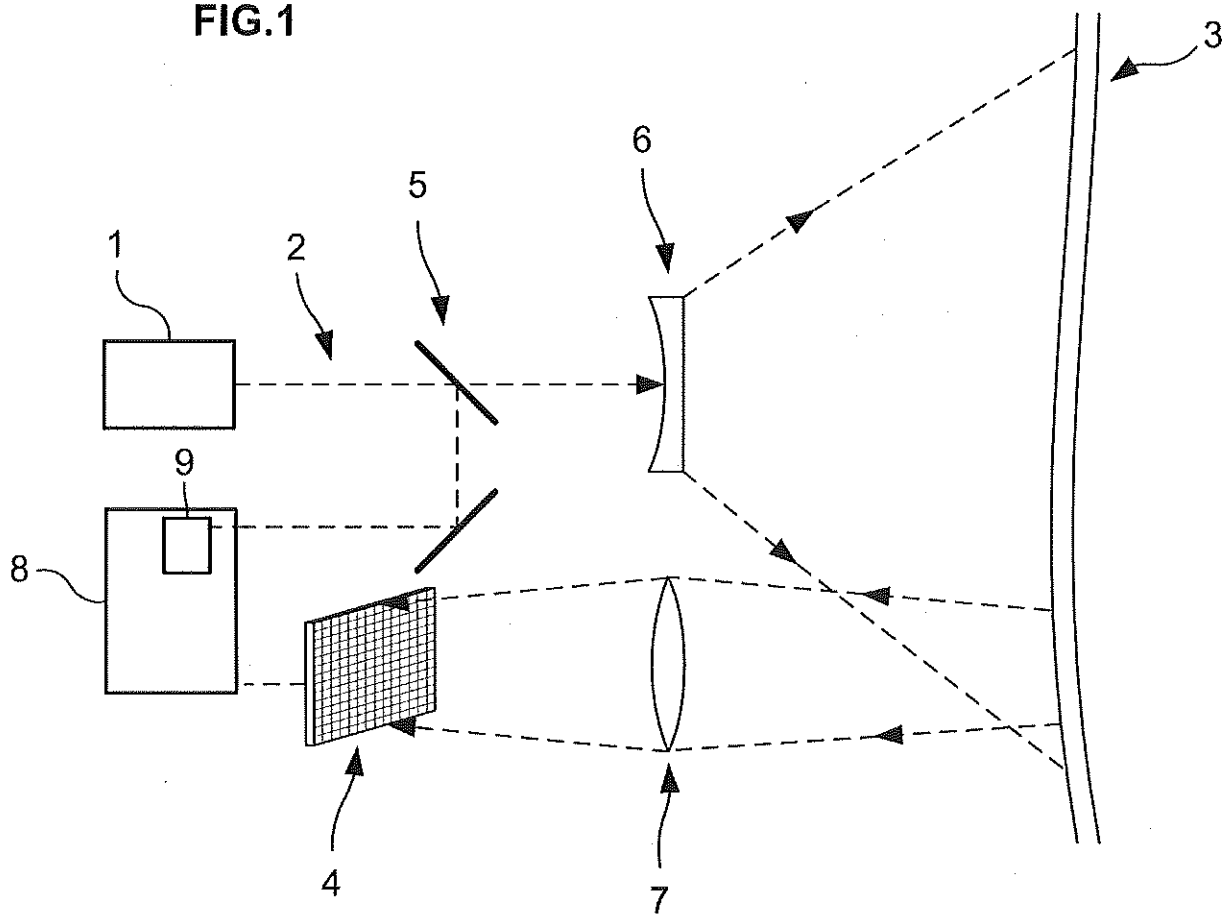
16. A computer program product comprising program instructions for causing a computer system to perform the method for scanning a surface, according to claim 15.

17. Use of a pixelated light switch array (24), in which each switch is adapted for receiving at least one portion of a light beam and for directing it to an array of light sensors (26), in a system (20) for scanning a surface (28) according to any of claims 6 to 14 or in a method for scanning a surface (28) according to claim 15.

ABSTRACT

The invention relates to a system (21) for receiving a light beam, comprising an array of light sensors (26). The system also comprises a pixelated light switch array (24), in which each switch is adapted to receive at least one portion of the light beam and direct it to the array of light sensors (26), and the pixelated light switch array (24) comprises a higher number of switches than the number of light sensors comprised in the array of light sensors (26).

FIG.1



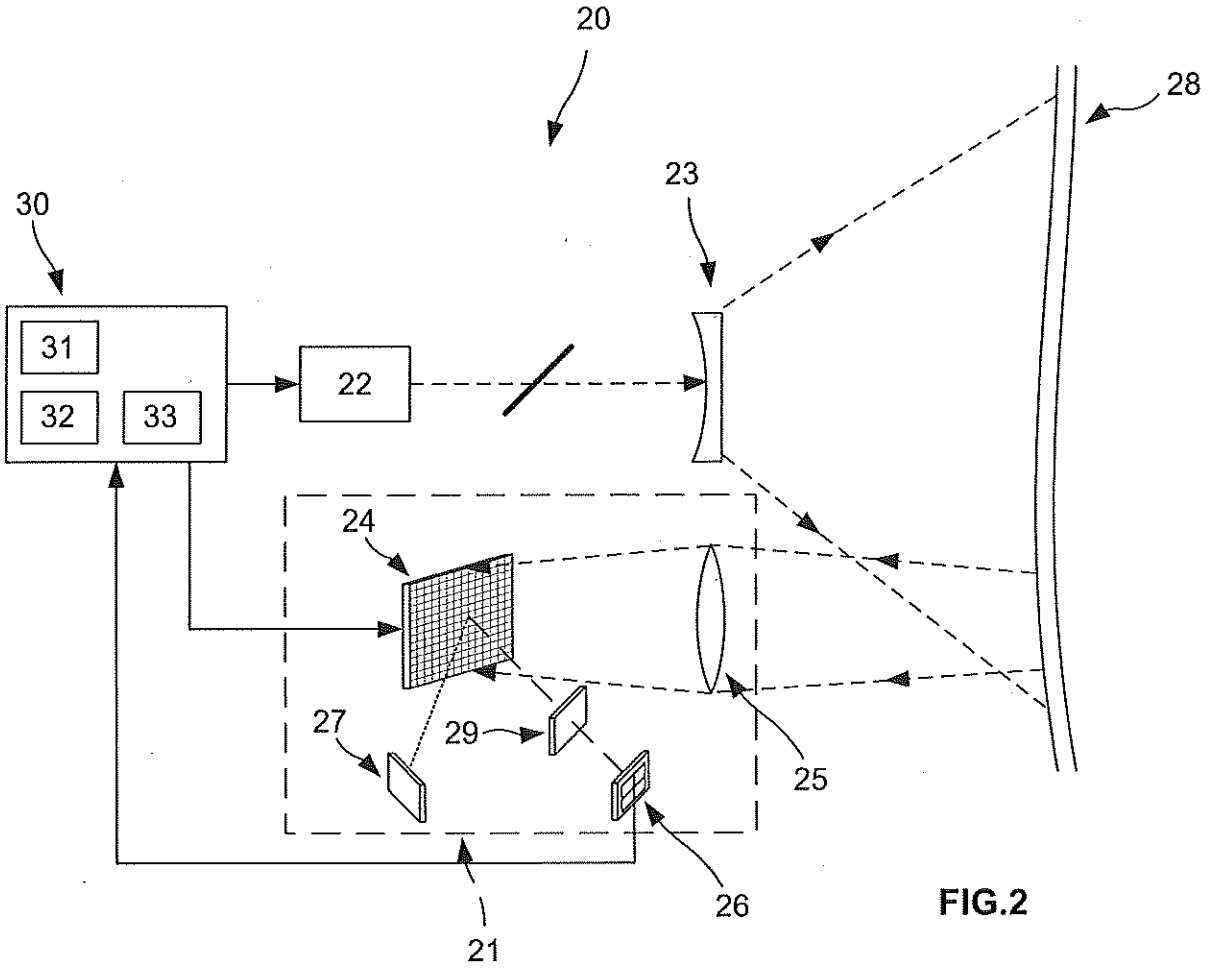


FIG.2

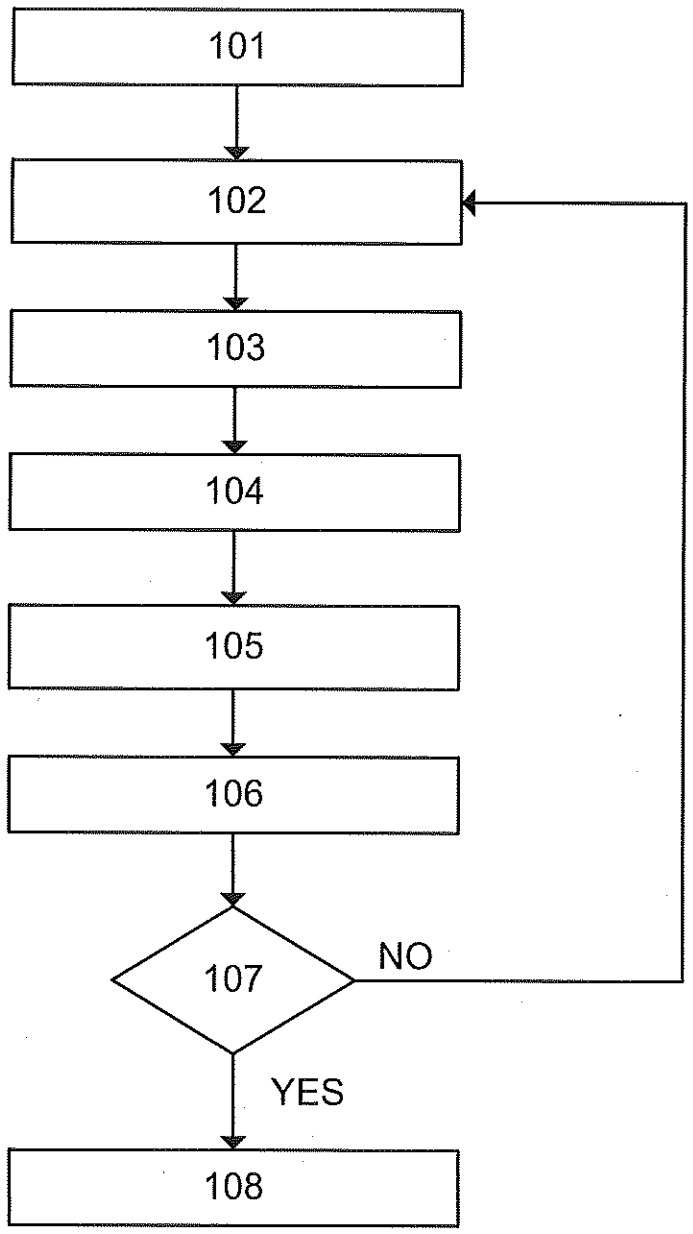


FIG.3