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(54) **Title:** MODELING DENTAL STRUCTURES FROM DENTAL SCAN

(57) **Abstract:** A method for updating a three-dimensional (3D) dental model of at least one tooth, comprising: (a) providing at least one 2D dental image including the at least one tooth; (b) running a trained visual filter neural network on the 2D dental image to identify the tooth number of the at least one tooth; (c) providing a baseline 3D dental model that includes the at least one tooth; (d) generating a 2D capture of the baseline 3D dental model; (e) updating the 2D capture of the 3D dental model to include the identified tooth number obtained from the 2D dental image; and (f) using the updated 2D capture to update the 3D dental to include the identified tooth number obtained from the 2D dental image.

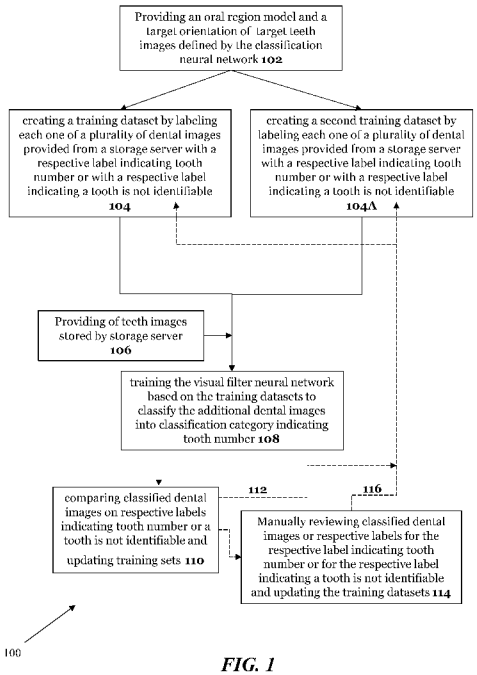

FIG. 1

[Continued on next page]

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Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US22/38943

A. CLASSIFICATION OF SUBJECT MATTER

IPC - INV. G06N 3/02; G06T 7/60; G06T 7/70; G16H 30/40 (2022.01)
ADD.

CPC - INV. G06N 3/02; G06T 7/0012; G06T 7/60; G06T 7/70; G16H 30/40

ADD. G06T 2207/30036; G06V 2201/03

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
See Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
See Search History document

Electronic database consulted during the international search (name of database and, where practicable, search terms used)
See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 2020/0305808 A1 (DIAGNOCAT, INC.) 01 October 2020; abstract; paragraphs [0045, 0046, 0050, 0095, 0096, 0100, 0101, 0102, 0109, 0113, 0114, 0124]; claim 2	1, 2, 4-5, 7-22 --- 3, 6
Y	KATTAN ET AL. "A New Horizontal Plane of the Head" pp 1-5. Open Access Macedonian Journal of Medical Sciences; 6(5):767-771.. Online. 20 May 2018; [retrieved 11 January 2022]. Retrieved from the Internet: <URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5985866/>;; DOI: 10.3889/oamjms.2018.172	3, 6
P,Y	WO 2022/020267 A1 (GET-GRIN INC.) 27 January 2022; entire document.	1-22
P,Y	PRADOS-PRIVADO ET AL. "A Convolutional Neural Network for Automatic Tooth Numbering in Panoramic Images" pp 1-7. BioMed Research International. Online. 14 December 2021; [retrieved 11 January 2023] Retrieved from the Internet: <URL: https://www.hindawi.com/journals/bmri/2021/3625386/>; DOI: 10.1155/2021/3625386	1-22

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 January 2023 (11.01.2023)	FEB 16 2023
Name and mailing address of the ISA/ Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer Shane Thomas Telephone No. PCT Helpdesk: 571-272-4300

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US22/38943

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
-***-Please See Supplemental Page-***-

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-22

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US22/38943

-***-Continued From Box No. III: Observations where unity of invention is lacking-***-

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fee must be paid.

Group I: Claims 1-22 are directed towards a method for training a visual filter neural network to identify one or more tooth numbers.
Group II: Claims 20-45 are directed towards a method for updating a three-dimensional (3D) dental model of at least one tooth.

The inventions listed as Groups I-II do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

The special technical features of Group I include at least (b) providing orientation data, wherein the orientation data correlates a spatial location of the one or more model teeth with the corresponding tooth number of the one or more model teeth; (c) providing a plurality of training dental images, wherein each training dental image of the plurality of training dental images comprises one or more teeth; (d) creating a plurality of training datasets by using the visual information corresponding to the one or more model teeth to label the one or more teeth in each one of the plurality of training dental images with a respective label, wherein the respective label indicates either a tooth number or a tooth number is not identifiable; and (e) training the visual filter neural network based on the plurality of training datasets to identify a tooth within a dental image of a subject and label the tooth with a corresponding tooth number, which are not present in Group II.

The special technical features of Group II include at least providing the initial 3D dental model of the dental structure of the subject; and updating the 3D dental model, which are not present in Group I.

The common technical features shared by Groups I-II are training a visual filter neural network to identify one or more tooth numbers of one or more teeth from one or more dental images; and one or more model teeth.

However, these common features are previously disclosed by US 2008/0172386 A1 to Ammar et al. (hereinafter "AMMAR"). AMMAR discloses training a visual filter neural network to identify one or more tooth numbers of one or more teeth from one or more dental images (using dental images in a special neural network algorithm to assign each tooth a number corresponding to its location in the dental chart; Figs. 1-5; para [0052], [0065], [0067]); and one or more model teeth (establishing and enhancing raw subject dental records and extracting high level features; para [0032]).

Since the common technical features are previously disclosed by AMMAR, these common features are not special and so Groups I-II lack unity.