

FIELD OF INVENTION

5 [001] The present disclosure relates to a computing platform for determining the fit of a dental aligner.

BACKGROUND

10 [002] The conventional method of how to monitor aligner treatment in the orthodontist's office is simply to visually examine how well or closely the aligner fits with the patient's teeth. The position of the interior aligner surfaces relative to the tooth surfaces of various aligners in a series of aligners is observed by a trained orthodontist to assess progression with a series of aligners.

[003] This monitoring is done to determine whether the patient can proceed to a next aligner in the series, since the movement of teeth and the duration of aligner wear depends on the individual. A
15 duration of wear for each aligner originally scheduled at the start of the aligner treatment may not be suitable for every patient. Having the patient consult the orthodontist for periodic assessments is inconvenient for the patient.

[004] Remote assessment is possible. In one known approach, a box is provided to slot a smartphone with its lens facing the patient's naked teeth (i.e. without wearing the aligner) that allows the patient to
20 scan an image of their teeth and send to the practitioner's office for analysis to track progress with the aligner. While remote assessment is convenient for the patient, it is time consuming and tedious for the receiver, especially when it receives many images to analyse for dental aligner fit.

[005] An object of the present invention is to provide a solution that addresses the above shortcomings.

25 **SUMMARY OF THE INVENTION**

[006] According to a first aspect of the present invention, there is provided a computing platform that receives dental images, the computing platform configured to: analyse each dental image with an algorithm trained to recognise teeth wearing dental aligners within the dental image and identify one or
30 more teeth with an unacceptable gap between its top and a facing inner surface of the dental aligner, the gap being empty and transparent; and harness an output of the algorithm to provide a recommendation on a next course of action with respect to a dental aligner application strategy.

[007] The recommendation on the next course of action may be decided on the output of the algorithm having complied with one or more conditions.

35 [008] The output of the algorithm may comprise an indication of a number of identified teeth with the unacceptable gap, whereby the recommendation on the next course of action is based on the number of identified teeth with the unacceptable gap.

[009] The recommendation on the next course of action may include one or more of a duration to extend wear of a current dental aligner, use of a chewing device, progressing to a next dental aligner and directing for a new set of dental aligners to be made.

[010] The duration to extend wear of the current dental aligner may increase with the number of
5 identified teeth with the unacceptable gap.

[011] The recommendation to progress to the next dental aligner may be provided when the number of identified teeth with the unacceptable gap is below a threshold value.

[012] The received dental images may include those of patients after having worn their dental aligners over a prescribed duration.

10 [013] The recommendation on the next course of action for a patient may be based on a plurality of the dental images for that patient after having worn their dental aligner over the prescribed duration.

[014] Each of the plurality of dental images may be taken at a different angle, wherein the number of identified teeth with the unacceptable gap is a total from the plurality of dental images.

[015] Prior to the receipt of the dental images for analysis, the algorithm may be trained on dental
15 images having labels of teeth wearing dental aligners.

[016] The labels may indicate the teeth which have an unacceptable gap between its top and a facing inner surface of the dental aligner and the teeth which have an acceptable gap between its top and a facing inner surface of the dental aligner.

[017] The labels may include use of a bounding box having a boundary spanning from middle of the
20 tooth to a corresponding segment of the dental aligner.

[018] The output of the algorithm may further include a confidence score for each tooth having an acceptable or unacceptable gap in each dental image.

[019] The recommendation on the next course of action may use an artificial intelligence engine.

[020] According to a second aspect of the present invention, there is provided a method for
25 determining dental aligner fit, the method comprising: analysing each received dental image with an algorithm trained to recognise teeth wearing dental aligners within the dental image; identifying one or more teeth with an unacceptable gap between its top and a facing inner surface of the dental aligner, the gap being empty and transparent; and harnessing an output of the algorithm to provide a recommendation on a next course of action with respect to a dental aligner application strategy.

30

BRIEF DESCRIPTION OF THE DRAWINGS

[021] Representative embodiments of the present invention are herein described, by way of example only, with reference to the accompanying drawings, wherein:

35 [022] Figure 1A shows a schematic of a system using a computing platform that hosts an algorithm to analyse dental images showing worn dental aligners for their fit.

[023] Figure 1B shows dental images, taken at different angles, which are received by the computing platform of Figure 1A.

[024] Figure 2A shows an operation flow diagram for the computing platform of Figure 1A.

[025] Figure 2B shows a sample original dental image and annotated version, both output by the computing platform of Figure 1A.

[026] Figures 3 and 4 show sample raw images used to train the algorithm used by the computing platform of Figure 1A.

[027] Figure 5 shows the labelling of received images, following the training of Figures 3 and 4.

[028] Figure 6 shows a flow chart used by the computing platform of Figure 1A for determining dental aligner fit.

DETAILED DESCRIPTION

[029] In the following description, various embodiments are described with reference to the drawings, where like reference characters generally refer to the same parts throughout the different views.

[030] The present application falls within the field of orthodontics, in particular the delivery of a dental treatment plan which uses clear aligners to treat malocclusions that include overcrowding, overjet, underbite, crossbite, open bite and teeth spacing.

[031] A clear aligner treatment plan involves wearing a series of clear aligners, which are removable transparent trays (typically made of plastic) shaped like teeth and used as an alternative to metal braces. These clear aligner trays are made of a semi-rigid material that moves teeth from an undesirable state to a more desirable (medically and aesthetically) position by applying gentle, consistent pressure to a patient's teeth, which stimulates osteoclastic & osteoblastic activity. The wearing of an aligner follows a schedule, e.g. wear daily for 10 hours for 15 days, before progressing to a next aligner in the series.

Each of the aligners in the series defines a corresponding series of tooth positions that work towards a final desired tooth alignment. The patient is considered ready to progress to a next aligner in the series, from determining the progress made by a currently worn aligner through assessing a degree of fitness of the current aligner. On the other hand, if the patient is considered not ready to progress to a next aligner and has to continue wearing their current aligner, the treatment plan may direct for a further duration to wear the current aligner paired with additional remedies, such as a "chewie" (a device, typically in the shape of a cylinder, for chewing on to better seat the aligner onto teeth).

[032] One known approach for assessing the progress made by a currently worn aligner through the degree of its fitness has the patient schedule a review appointment or send pictures of their teeth with the aligner worn for review by an orthodontist or a qualified person. Scheduling a review appointment takes time, while remote review (from the received pictures) is similarly time consuming and labour intensive.

[033] Herein disclosed is an approach that seeks to address the above shortcomings using an algorithm, hosted in a computing platform, to analyse received images of teeth with dental aligners worn. The algorithm is trained to recognise teeth wearing dental aligners within the image and identify one or more teeth with an unacceptable gap between the top of these one or more teeth and a facing inner surface of the dental aligner. A gap, if present, refers to a space between a chewing surface of a tooth and a facing inner surface of the worn dental aligner. This space is empty (i.e. devoid of any filler) and transparent, wherein the gap is considered unacceptable when it exceeds a height determined from the training of the algorithm.

[034] The presence of teeth with an unacceptable gap, wherein this number of teeth exceeds a threshold, signifies that the current worn aligner within its series is not sitting well. The threshold is in the millimetre range and deduced by the algorithm after being trained by a sufficiently large number of sample images of teeth wearing dental aligners. Having the algorithm configured to analyse the fit of a current aligner by sending images of it being simply worn is advantageous since the patient does not need to undertake any special preparation for this analysis.

[035] In one implementation, an object detection algorithm is used, such as a convolution neural network like YOLO (You Only Look Once). The algorithm is trained on dental images having labels of teeth wearing dental aligners. The labelling achieves two purposes. Firstly, they tell the algorithm whether each tooth is fit (has an acceptable gap between its top and a facing inner surface of the dental aligner) or unfit (has an unacceptable gap between its top and a facing inner surface of the dental aligner). Secondly, these labels cause the algorithm to measure a range of unacceptable gap heights. In one approach all sample images used to train the algorithm are labelled by the same party, so as to reduce discrepancy in the labelling of fit or unfit teeth. The algorithm then automatically deduces or solves for the threshold of an unacceptable gap from being trained with a sufficiently large dataset of such dental images. The deduced unacceptable gap is then used to assess whether gaps detected in subsequently received dental images (i.e. those for analysis) are acceptable or not. In one approach, a uniform unacceptable gap is adopted, i.e. the threshold above which a gap is considered unacceptable is the same. One implementation has a uniform unacceptable gap within the same tooth category (e.g a first for canines; a second for incisors; and a third for molars), while another implementation has a uniform unacceptable gap across all teeth categories.

[036] The output of the algorithm, following the analysis of received dental images of teeth wearing dental aligners, is then processed to provide a recommendation on a next course of action with respect to the dental aligner application strategy, i.e. the manner in which an overall dental aligner treatment plan may have to be adjusted. Broadly, the recommendation relates to whether the current aligner should continue to be worn or whether another aligner should be worn (such as progressing to a next aligner in the series or a new series of dental aligners need to be fabricated). The recommendation may be formulated from a library of actions, with each being based on one that an orthodontist would prescribe from patient review of the fit of their current aligner. The selected recommendation depends

on the output of the algorithm following the analysis of the received dental images. In one approach, each course of action requires one or more criteria to be met before being dispensed, with the criteria being coded in the form of conditional statements. The output of the algorithm is assessed against one or more of these conditional statements. A course of action where the output of the algorithm complies with its one or more conditions is then returned as the provided recommendation. Examples of a recommended next course of action includes a duration to extend wear of a current dental aligner, use of a chewing device, progressing to a next dental aligner and directing for a new set of dental aligners to be made. Having a computer platform host such an algorithm and provide a recommendation on the next course of action allows the patient to remotely track their progress of the effectiveness of their dental aligner treatment plan without having to arrange for a physical consultation at each point.

[037] The present invention is described in greater detail below in conjunction with Figures 1A, 1B, 2A, 2B, 3 to 6.

[038] Figure 1A shows a schematic of a system 100 with a computing platform 101, configured in accordance with the present invention, to analyse dental images showing worn dental aligners for unacceptable gaps. The computing platform 101 hosts an algorithm 104 and a recommendation engine 114.

[039] The computing platform 101 may be implemented as a single computer server or several computer servers having at least one memory 106 to store programming code for the algorithm 104 and the recommendation engine 114; and one or more processors 108 to execute instructions to run the algorithm 104 and the recommendation engine 114. The memory 106 includes read-only memory (ROM), writable memory, random-access memory (RAM) or other type of dynamic storage device that stores information and instructions for the one or more processors. The computing platform 101 includes input/output (I/O) interfaces (not shown) to interface the computing platform 101 with peripheral and input devices, such as a keyboard, mouse and a display. Example implementations of the computing platform 101 include: a personal computer (PC); workstation; laptop; a network or internet-computer; and a tablet computer.

[040] The operation of the computing platform 101 is explained with reference to the flow diagram 200 of Figure 2A, used by the computing platform 101 to monitor a patient's dental treatment plan.

[041] During a dental treatment plan involving the use of clear dental aligners, a patient progresses through a series of dental aligners according to an initial schedule prescribed at the start. On or around the end of an interval to wear a current aligner, an assessment needs to be done to determine whether the current aligner has moved the patient's teeth to a position where a next aligner in the series may be worn. Alternatively, the patient may want to conduct interim progress checks during this interval.

[042] To assess progress, a patient takes pictures of themselves in step 202 wearing their current dental aligner. In one approach, the patient is requested not to bite on their dental aligner and six pictures, each taken at a different angle, are submitted. With reference to Figure 1B, these six different angles are: i) front view with open teeth 152; ii) front view with teeth closed 154; iii) left view with

teeth closed 156; iv) right view with teeth closed 158; v) front view of upper teeth with the mouth open 160; and vi) front view of lower teeth with the mouth open 162. The patient is not required to send dental images of their naked teeth, i.e. without wearing the dental aligner.

[043] The computing platform 101 receives these dental images 102 from a patient device 110, such as a smart phone, a tablet or a PC, over a secure communication channel. These dental images 102 may be “selfies” taken by their patient of themselves using their device 110 without the use of a box to hold their device 110 in alignment with their teeth, in contrast to known approaches where a box is provided to spread the lips apart and a slot to hold a mobile phone. The received dental images 102 may be those of patients after having worn their current dental aligners over a duration prescribed by a schedule of the patient’s aligner treatment plan. Alternatively, the received dental images 102 may also be those of patients wishing to conduct an interim progress check of their current worn dental aligner. In one approach, a dedicated app installed in the patient device 110 may be used to take the dental image 102 for seamless transmission to the computing platform 101. In another approach, the patient device 110 does so through a secure portal.

[044] In step 204, the algorithm 104 hosted in the computing platform 101 analyses each of the received dental images 102. As mentioned above, the algorithm 104 is trained to recognise teeth wearing dental aligners within the dental images 102. That is, the dental images 102 may also show other features irrelevant for the analysis, such as the patient’s lips, but the trained algorithm 104 locates the portion 112 in each of the received dental images 102 where the dental aligners are worn. The ability to locate these portions 112 is advantageous because of the unsupervised taking of the dental images 102 resulting in their nonuniform capture and therefore presence of irrelevant features.

[045] The trained algorithm 104 evaluates the gap (refer reference numerals 308 and 408 in Figures 3 and 4 respectively) between a chewing surface of each tooth and a facing inner surface of the dental aligner, which is used to assess the degree of unseat of the current worn dental aligner. The evaluation of whether the gap between the top (or chewing surface) of each tooth and a facing inner surface of the current worn dental aligner is unacceptable, and the identification of the number of teeth with such an unacceptable gap, is done with the gap being empty and therefore transparent. There is no requirement to use a coloured filler therebetween to facilitate identification of the gap by the algorithm 104.

[046] In one implementation, the trained algorithm 104 returns a result that the current aligner is not sitting well if it identifies that the number of teeth with an unacceptable gap is above a threshold number. The magnitude of the unacceptable gap is learnt by the algorithm 104 during training. In one approach, each tooth category may have its own unacceptable gap threshold which is determined from a subset of the pictures used for training, the pictures being taken at different angles as mentioned above. For example, the threshold for canine and incisor teeth may be determined from pictures of: a front view with the teeth closed (see reference numeral 154 of Figure 1B); a front view of the upper teeth with the mouth open (see reference numeral 152 of Figure 1B); a front view of the lower teeth with the mouth open (see reference numeral 162 of Figure 1B); and left and right views with the teeth closed (see

reference numerals 156 and 158 respectively of Figure 1B), which serves to establish a first unacceptable gap distance. The threshold for molar and premolar teeth may be determined from pictures of: a front view of the upper teeth with the mouth open (see reference numeral 160 of Figure 1B); a front view of the lower teeth with the mouth open (see reference numeral 162 of Figure 1B); and
5 left and right views with the teeth closed (see reference numerals 156 and 158 respectively of Figure 1B), which serves to establish a second unacceptable gap distance.

[047] The trained algorithm 104 identifies, for each tooth, whether the dental aligner is seating well or not by measuring the distance of aligner unseat based on a percentage fit. This percentage fit is a confidence score representing the confidence level that the trained algorithm 104 has on the fitness of
10 each tooth. The dental aligner is considered well seated for a tooth if the trained algorithm 104 returns a value that is above a certain percentage, signifying that the trained algorithm 104 is confident that the gap is acceptable for this tooth. Vice versa, the dental aligner is considered poorly seated for a tooth if the trained algorithm 104 returns a value that is below a certain percentage, signifying that the trained algorithm 104 is not confident that the gap is acceptable for this tooth, i.e. the gap is unacceptable. The
15 algorithm 104 saves into a database the original images, along with annotated images of the fitness of each tooth; and a confidence score assessment for each tooth (i.e. how confident the algorithm 104 is whether the tooth is fit or unfit) in each of the dental images 102 (such as a spreadsheet) in step 206, along with a cumulative number of fit and unfit teeth.

[048] The approach of identifying a cumulative number of teeth with an unacceptable gap has the
20 possibility of one tooth being identified to have an unacceptable gap in one of the several dental images 102, yet identified to have an acceptable gap in another of the several dental images 102. Such occurrences would apply mainly to teeth where the gap measured by the trained algorithm 104 in each of the several dental images 102 is at a borderline of an acceptable percentage fit. The cumulative result returned by the trained algorithm 104 may be an indication that the current aligner fits poorly for these
25 teeth if one is identified as having an unacceptable gap in any one of the analysed several dental images 102. On the other hand, if the trained algorithm is confident that the same teeth in all the analysed several dental images 102 have a good percentage fit, the cumulative result returned by the trained algorithm 104 would be an indication that the current aligner fits well for these teeth since it is expected that they are identified to have an acceptable gap in all the analysed several dental images 102. That is,
30 performing an assessment on the progress of the current worn aligner using several dental images 202 seeks to have the algorithm reach an overall conclusion on whether the current aligner can be concluded to have a good fit in the presence of several teeth where it lacks confidence in identifying a good percentage fit. If enough of these teeth are considered by the trained algorithm 104 to have an unacceptable gap, this contributes to a conclusion that the patient is not ready to progress to the next
35 dental aligner in the series.

[049] The saved output in the step 206 can be processed by the recommendation engine 114 to provide a recommendation on a next course of action with respect to the dental aligner application strategy. The

recommended next course of action serves to inform the patient on whether their dental aligner treatment plan is on track through reference to the progress made using the current worn dental aligner, e.g. whether the current aligner should continue to be worn or whether another aligner should be worn (such as progressing to a next aligner in the series or a new series of dental aligners need to be fabricated).

5 Each course of action is based on a library of actions that an orthodontist would prescribe depending on the progress the teeth has made from wearing the current dental aligner. For the sake of simplicity, only a selection of recommendations is shown and discussed with respect to Figure 2A. The recommendation engine 114 generates accompanying instructions 116 to the recommended next course of action decided by the recommendation engine 114. The computing platform 101 transmits 118 the

10 instructions 116 to the patient device 110. The recommended next course of action is also patient specific in that it is based on dental images 102 provided by the patient after having worn their current dental aligners over a prescribed duration.

[050] In step 208, the output from the trained algorithm 104 (i.e. a cumulative number of fit and unfit teeth with respective confidence score) is retrieved. This output can then be tested for whether one or

15 more conditions of steps 210, 214, 218 and 222 are complied with to provide a recommendation on the next course of action. Steps 210 and 214 respectively test whether all the teeth are fit or unfit. If all the teeth are identified to be fit, step 212 occurs where the computing platform 101 transmits 118 a message to the patient device 110 that the patient may progress to the next dental aligner in the series. If all the teeth are identified to be unfit, step 216 occurs where the computing platform 101 transmits

20 118 a message to the patient device 110 recommending that the patient extend wear of the current dental aligner for 20 more days with the use of a “chewie” (a device for chewing on to better seat the aligner onto teeth, as mentioned above) 3 to 5 times daily during this period.

[051] Step 218 tests whether the number of unfit teeth is between 15 and 25. If so, step 220 occurs where the computing platform 101 transmits 118 a message to the patient device 110 recommending

25 that the patient extend wear of the current dental aligner for 10 days and use the “chewie” 3 to 5 times daily during this period.

[052] Step 222 tests whether the number of unfit teeth is more than 25. If so, step 224 occurs where the computing platform 101 transmits 118 a message to the patient device 110 recommending that the patient extend wear of the current dental aligner for a longer period, 20 days, and use the “chewie” 3 to

30 5 times daily during this longer period. If the number of unfit teeth is less than 25, this would mean there is less than 15 unfit teeth. Step 226 then occurs where the computing platform 101 transmits 118 a message to the patient device 110 that the patient may progress to the next dental aligner in the series.

[053] It can be seen from the output of the steps 212, 216, 220, 224 and 226, that if the computing platform 101 identifies that the number of identified teeth with the unacceptable gap is below a threshold

35 value, the computing platform 101 transmits 118 a message to the patient device 110 that the patient may progress to the next dental aligner in the series. On the other hand, if the computing platform 101 identifies that the number of identified teeth with the unacceptable gap is above the threshold, the

recommendation would be to extend a duration of wear of the current dental aligner or extend a duration of wear of the current dental aligner with the use of a “chewie”. The extent to which the duration of wear is extended, along with the use of the “chewie”, depends on the number of identified teeth with the unacceptable gap. They also show that the duration to extend wear of the current dental aligner increases with the number of identified teeth with an unacceptable gap between the chewing surface of a tooth and a facing inner surface of the worn dental aligner.

[054] It will be appreciated that the recommendations listed above are only examples, whereby the duration to extend wear of the current dental aligner, along with the use of the “chewie” during this duration, may vary in accordance with orthodontist prescription stored in the above-mentioned library of actions. For example, the recommendation may also include for the patient to arrange for a replacement of the dental aligner (not shown in Figure 2A).

[055] Returning to the step 208, step 228 occurs if the computing platform 102 receives a request to retrieve the original dental images, along with their annotated versions showing the fitness of each tooth. Figure 2B shows a sample original dental image 240, along with its annotated version 242, which will be output in step 230 in response to the request made in the step 228. The annotated version 242 shows that all of the teeth are identified to be fit. These images 240 and 242 may be requested, for example, if there is a need to conduct a visual inspection to verify the detection of fit and unfit teeth by the trained algorithm 104.

[056] It is possible for the flow chart 200 of Figure 2 to determine the recommendation on the next course of action with respect to the patient’s dental aligner application strategy through only using one dental image, rather than a plurality of dental images taken at different angles. In addition, instead of using the number of fit/unfit teeth with specific confidence score, the recommendation on the next course of action may be determined based on the measured magnitude of the teeth with the unacceptable gap.

[057] From the above, Figure 2A shows that the recommendation on the next course of action with respect to the patient’s dental aligner application strategy includes one or more of a duration to extend wear of a current dental aligner; use of a chewing device; and progressing to a next dental aligner in the series. The recommended next course of action may also include directing for a new set of dental aligners to be made, for example, if the number of identified teeth with the unacceptable gap is beyond a predetermined number. The flow chart 200 may be implemented by, but not necessarily limited to, if, else and for loops. Alternatively, the recommendation on the next course of action uses an artificial intelligence engine.

[058] Prior to the receipt of the dental images 102 for analysis, the algorithm 104 needs to be trained to address the problem in computer vision to recognise an object, namely a worn dental aligner, and its location in a dental image. Raw dental images from different patients’ teeth wearing an aligner from a series of their dental aligners are used as the training dataset. They may undergo one or more of the following processes: resizing, saturation adjustment and auto-orientation. The raw dental images are

then manually labelled to indicate which of the teeth are fit or unfit. These labelled dental images are used to train the algorithm 104, the labels teaching the algorithm 104 to detect the location of teeth in subsequently received dental images 102, draw bounding boxes around each tooth and annotate each tooth as either being fit or unfit.

5 [059] The labelling of raw dental images is described with reference to Figures 3 and 4, which shows only a few samples for the sake of simplicity.

[060] Figure 3 shows a raw dental image 302 of a worn dental aligner. The first step is to define an annotation group for all the teeth captured in the dental image 302. Bounding boxes 304 associated with the annotation group are then drawn for each tooth. Each tooth is visually assessed to determine
10 whether a gap 308 between a chewing surface of a tooth and a facing inner surface of the dental aligner is acceptable or not. Each bounding box 304 is then labelled 306 “fit” or “unfit”, as shown in labelled image 310. The algorithm 104 is then configured to treat bounding boxes that are labelled as “fit” as teeth that have an acceptable gap while bounding boxes that are labelled as “unfit” as teeth that have an unacceptable gap. Accordingly, the bounding box 304 and its label tells the algorithm 104 the location
15 of the object of a specific class in the image 302 for future detection purpose. The labelled bounding boxes in the image 310 show that all teeth have been visually assessed to have an unacceptable gap.

[061] Figure 4 shows another raw dental image 402 of a worn dental aligner. Like Figure 3, the first step is to define an annotation group for all the teeth captured in the dental image 402. Bounding boxes 404 associated with the annotation group are then drawn for each tooth. Each tooth is visually assessed
20 to determine whether a gap 408 between a chewing surface of a tooth and a facing inner surface of the dental aligner is acceptable or not. Each bounding box 404 is then labelled 406 “fit” or “unfit”, as shown in labelled image 410. The algorithm 104 is then configured to treat bounding boxes that are labelled as “fit” as teeth that have an acceptable gap while bounding boxes that are labelled as “unfit” as teeth that have an unacceptable gap. The labelled bounding boxes in the image 410 show that all
25 teeth have been visually assessed to have an acceptable gap, which is expected since the gap 408 is smaller than the gap 308 of Figure 3.

[062] From the above description for Figures 3 and 4, the labels 306 and 406 indicate the teeth which have an unacceptable gap between its top (or chewing surface) and a facing inner surface of the dental aligner and the teeth which have an acceptable gap between its top (or chewing surface) and a facing
30 inner surface of the dental aligner. Through exposure to a sufficiently large database of these labels 306 and 406, the algorithm 104 learns dimensions for an acceptable gap which is used to automatically classify each tooth as being “fit” or “unfit”. It was also found, with reference to Figures 3 and 4, that where the bounding box 304 and 404 has a boundary spanning from middle of the tooth to a corresponding segment of the dental aligner, this resulted in possible better detection of “fit” and “unfit”
35 teeth. However, having the bounding box cover the length of a tooth (not shown) still resulted in training the algorithm 104 to perform this detection. Figure 5 shows the output of the trained algorithm

104 used on a received dental image 502, where the trained algorithm 104 labels which of the teeth are fit 504 or unfit 506.

[063] Returning to Figure 1A, the memory 106 of the computing platform 101 may store a history of patient wear of past and/or current dental aligners for the recommendation engine 114 to determine a next course of action. This stored history may include the duration of wear of each aligner in the patient's series of aligners, dental images uploaded during this wear and the assessment of the number of fit or unfit teeth in each of these images. For example, if the memory 106 records that a patient is still being recommended to wear the same aligner over the most past assessment points, this could be an indication of that aligner having lost elasticity. The recommendation engine 114 may then recommend for a replacement to be made, with appropriate instructions 116 transmitted 118 to the patient device 110. The patient may then arrange for delivery of a replacement set of dental aligners.

[064] Figure 6 shows a flow chart used by the computing platform 102 of Figure 1A for determining dental aligner fit.

[065] In step 602, each dental image received by the computing platform 102 is analysed with its algorithm 104 trained to recognise teeth wearing dental aligners within the dental image.

[066] In step 604, one or more teeth with an unacceptable gap between its top and a facing inner surface of the dental aligner is identified. The gap is recognised from the presence of an empty and transparent space in the biting surface of the tooth and a facing surface of a corresponding segment of the dental aligner.

[067] In step 606, an output of the algorithm 104 is harnessed to provide a recommendation on a next course of action with respect to a dental aligner application strategy.

[068] In the application, unless specified otherwise, the terms "comprising", "comprise", and grammatical variants thereof, intended to represent "open" or "inclusive" language such that they include recited elements but also permit inclusion of additional, non-explicitly recited elements.

[069] While this invention has been described with reference to exemplary embodiments, it will be understood by those skilled in the art that various changes can be made and equivalents may be substituted for elements thereof, without departing from the spirit and scope of the invention. In addition, modification may be made to adapt the teachings of the invention, without departing from the essential scope of the invention. Thus, the invention is not limited to the examples that are disclosed in this specification, but encompasses all embodiments falling within the scope of the appended claims.

CLAIMS

1. A computing platform that receives dental images, the computing platform configured to:
analyse each dental image with an algorithm trained to recognise teeth wearing dental aligners
5 within the dental image and identify one or more teeth with an unacceptable gap between its top and a facing inner surface of the dental aligner, the gap being empty and transparent; and
harness an output of the algorithm to provide a recommendation on a next course of action with respect to a dental aligner application strategy.
- 10 2. The recommendation on the next course of action is decided on the output of the algorithm having complied with one or more conditions.
3. The computing platform of claim 1 or 2, wherein the output of the algorithm comprises an indication of a number of identified teeth with the unacceptable gap, whereby the recommendation on
15 the next course of action is based on the number of identified teeth with the unacceptable gap.
4. The computing platform of claim 3, wherein the recommendation on the next course of action comprises one or more of a duration to extend wear of a current dental aligner, use of a chewing device, progressing to a next dental aligner and directing for a new set of dental aligners to be made.
20
5. The computing platform of claim 4, wherein the duration to extend wear of the current dental aligner increases with the number of identified teeth with the unacceptable gap.
6. The computing platform of claim 4 or 5, wherein the recommendation to progress to the next
25 dental aligner is provided when the number of identified teeth with the unacceptable gap is below a threshold value.
7. The computing platform of any one of the preceding claims, wherein the received dental images comprise those of patients after having worn their dental aligners over a prescribed duration.
30
8. The computing platform of claim 7, wherein the recommendation on the next course of action for a patient is based on a plurality of the dental images for that patient after having worn their dental aligner over the prescribed duration.
- 35 9. The computing platform of claim 8, wherein each of the plurality of dental images is taken at a different angle, wherein the number of identified teeth with the unacceptable gap is a total from the plurality of dental images.

10. The computing platform of any one of the preceding claims, wherein prior to the receipt of the dental images for analysis, the algorithm is trained on dental images having labels of teeth wearing dental aligners.
- 5
- 11 The computing platform of claim 10, wherein the labels indicate the teeth which have an unacceptable gap between its top and a facing inner surface of the dental aligner and the teeth which have an acceptable gap between its top and a facing inner surface of the dental aligner.
- 10 12. The computing platform of claim 10 or 11, wherein the labels comprise use of a bounding box having a boundary spanning from middle of the tooth to a corresponding segment of the dental aligner.
13. The computing platform of any one of the preceding claims, wherein the output of the algorithm further comprises a confidence score for each tooth having an acceptable or unacceptable gap in each dental image.
- 15
14. The computing platform of claim 1, wherein the recommendation on the next course of action uses an artificial intelligence engine.
- 20 15. A method for determining dental aligner fit, the method comprising:
analysing each received dental image with an algorithm trained to recognise teeth wearing dental aligners within the dental image;
identifying one or more teeth with an unacceptable gap between its top and a facing inner surface of the dental aligner, the gap being empty and transparent; and
25 harnessing an output of the algorithm to provide a recommendation on a next course of action with respect to a dental aligner application strategy.