Correlation between upper and lower jaw of digital impressions

CAD	Computer Aided Design
CAM	Computer Aided Manufacturing
CEREC	Product name for the software for the dentist by SIRONA
inLab	Product name for the software for the dental labs by SIRONA
CEREC Connect	Product name for the software for dentist for sending cases digitally to the dental labs by SIRONA
CAD/CAM-Software	Umbrella term for the products CEREC, CEREC Connect and inLab by SIRONA

Capturing digital impressions from the upper jaw and lower jaw with dental scanning system is typically done separately. But for the design of a dental restoration or orthodontic treatment planning, upper and lower jaw must be correlated.

In order to correlate both jaws additional information is necessary. The information which provides the connection between upper and lower jaw can be provided by either the digital impression of a bite (patient bites on a silicone-like material that is applied on the preparation) or capturing optical impressions from the buccal view. The method by taking the optical impressions from the bite is well known and technically solved.

The correlation between upper and lower jaw by using buccal images can technically be calculated automatically by correlating corresponding areas on all images. But since the morphology details of teeth on the buccal surface are very similar among each other, it can be difficult for the software to calculate the correct correlation. Therefore the risk of mismatching models is increased. A solution can be a manual pre-correlation by the user combined with the final calculation done by the software.

As far as known all products in this field using the buccal method use an automatic correlation algorithm. In case that the software cannot correlate the buccal images with either the upper jaw or lower jaw, the user has to take additional images or remove not useful images until the software can calculate the correlation. It is not known if any product in this field uses a manual correlation method.

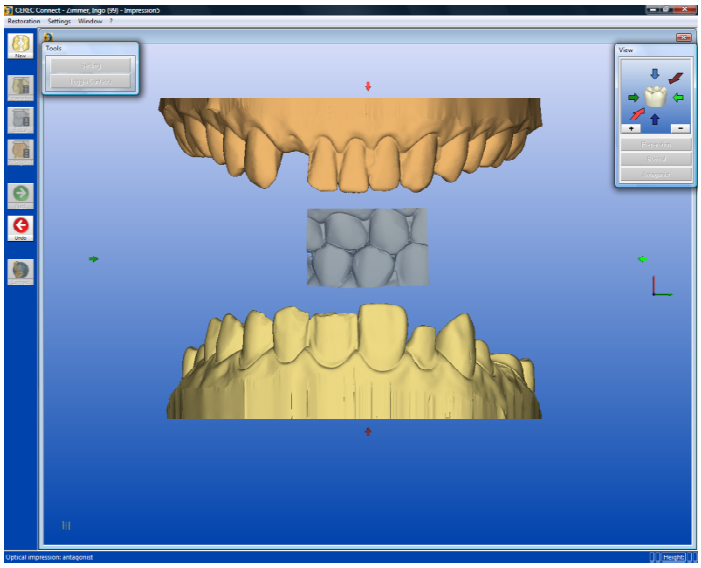
When using the correlation method of the bite registration it is also common technique to use a triple-point-matching method. The user defines corresponding areas on the model of upper and lower jaw (typically three dots on each jaw). Now the software knows the region of interest and can determine the correlation between both jaws.

In a user interaction step in the software the user drag&drops the 3D-model of the buccal over the corresponding area of the upper and the lower jaw. The software now has a well defined region of interest and is able to calculate the correct correlation. In addition the user gets an instant and visual feedback about the success of the correlation. This method also works when the model of the buccal is flipped by 180°.

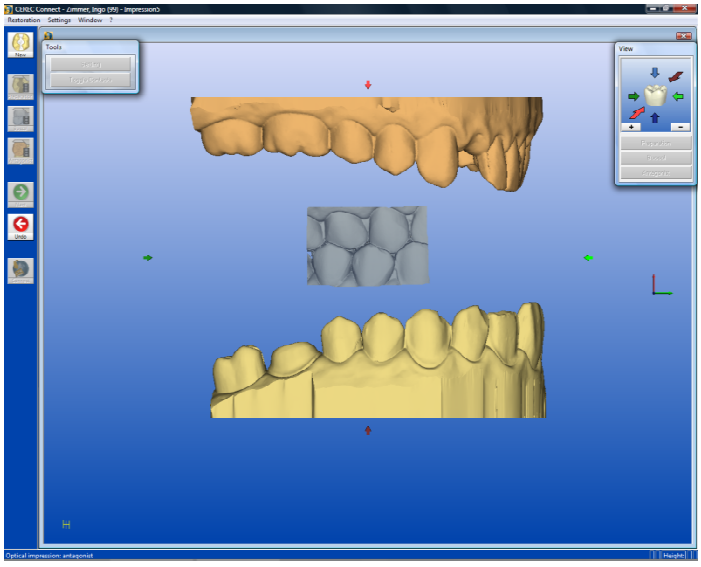
Tis concept is about the user interface and the method of moving all models interactively against each other and not just defining single dots on the tooth surface. The easiness of the user interaction and the direct visual feedback of the correct correlation of the models is also part of this concept. The algortithms correlating the models are well known ICP based algorithms.

User interface for buccal registration

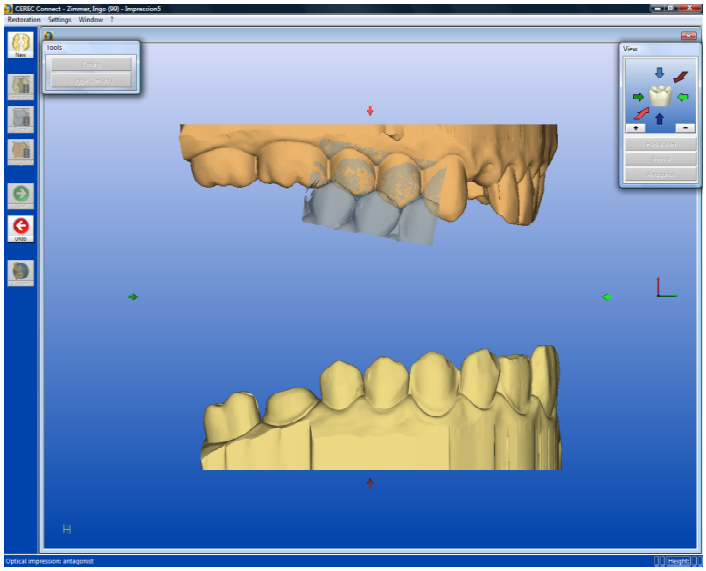
In the first step the 3D models of the preparation, the antagonist and the buccal are shown. The buccal model is placed in the middle between preparation and antagonist.



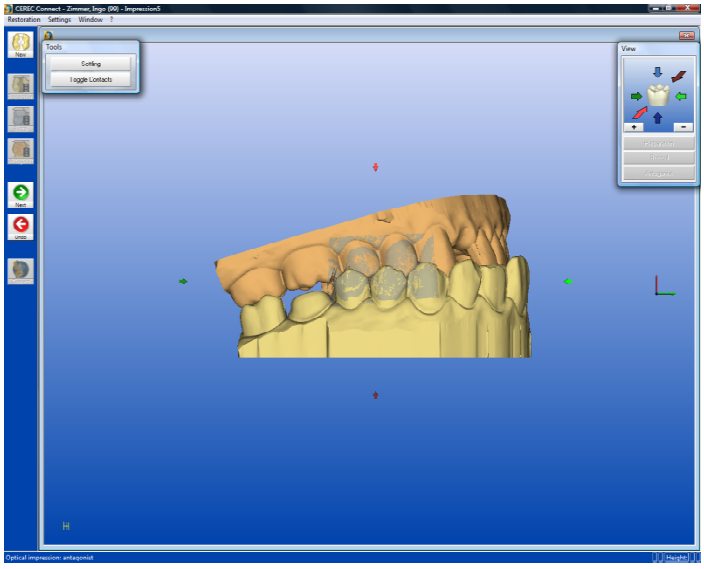
You can rotate both preparation and antagonist at the same time around one axis by clicking the left mouse button, holding and moving somewhere on the blue area. By clicking the left mouse button, holding and moving directly on the preparation or antagonist you can rotate each model individually.



Rotate both models preparation and antagonist in the way that you can see the matching parts between the buccal model and the preparation/antagonist model. Click and hold the buccal model and move it over the corresponding area on the preparation and drop it. The buccal model will be correlated to the preparation model automatically. If the correlation was successful the bucal model matches at the regarding position and you see the “leopard” pattern. If the correlation was not successful, the buccal model shakes for a moment and stays in the middle between the models. In this case redo this procedure and try to find a better matching area when doing the ‘Drag&Drop’ or add an additional buccal shot to enlarge the buccal model.

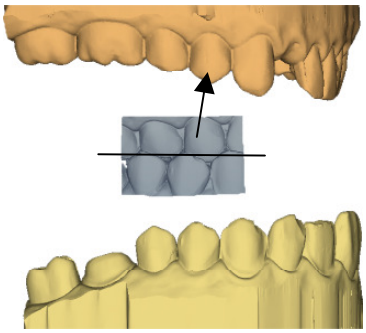


Now click and hold on the buccal model again and move it over the corresponding area of the antagonist and drop it. The buccal model (connected with the preparation model) will be correlated to the antagonist model automatically. If the correlation was successful the bucal model matches and you see the “leopard” pattern. If the correlation was not successful, the buccal model shakes for a moment. In this case redo this procedure and try to find a better matching area when doing the ‘Drag&Drop’ or add an additional buccal shot to enlarge the buccal model.

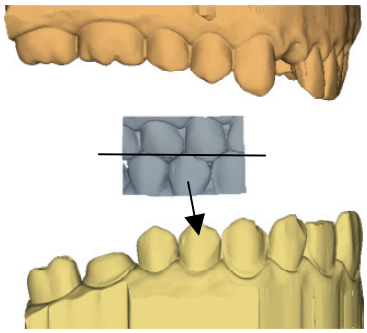


Depending on the quadrant where you have taken the buccal image it can happen that the buccal model seems to be rotated upside down. In this case simply click on the top spot of the buccal model and move it to the model that is underneath. The buccal model automatically rotates and you can use the above described ‘Drag&Drop’ technique. Also if you click on a lower spot of the buccal model and move it to the model that is on top the buccal model it will automatically rotate and you can use the ‘Drag&Drop’ technique.

The following graphics show this feature:

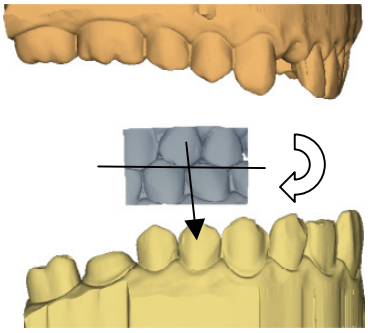


Click on top of the buccal model and move it up it stays as it is

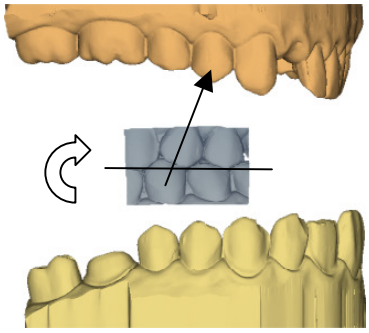


Click on bottom of the buccal model and move it down it stays as it is

In case that the buccal shot was taken in a different quadrant it will be visualized as if it was upside down. The software recognizes how you drag&drop the buccal model and rotates it automatically:



Click on top of the buccal model and move it down. The model rotates.



Click on bottom of the buccal model and move it up. The model rotates.

To improve the precision of the correlation between upper and lower jaw especially when doing full arches can be possibly improved by using more than one buccal image (e.g.one buccal image in each quadrant).

Technical information

Automatic orientation of upper and lower jaw model

After the 3D models of the upper jaw, lower jaw and the buccal image have been calculated by the software and automatic orientation algorithm comes into place. This algorithm determines the orientation of the models by calculation the main skeleton of the models. With this information the models can orientated in a way that both ends of the skeleton are opposed to the user´s view. Therefore models with a significant curvature are automatically orientated that the user sees the model from the buccal view.

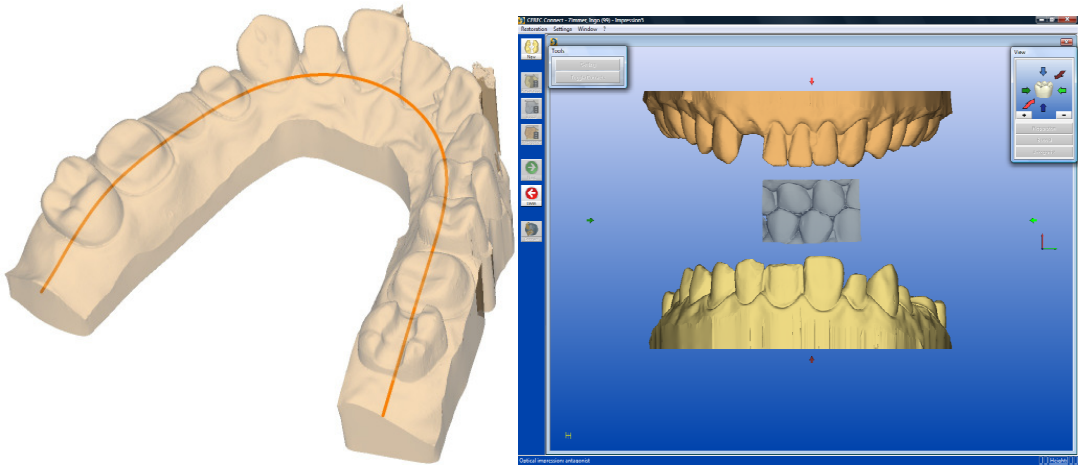


Fig.1 shows on the left the skeleton line of the model. The software calculates this skeleton to display the model to the user in the buccal orientation (right).

The user still has the option to rotate and translate the upper and lower jaw models in all three degrees of freedom.

Automatic orientation of the buccal model

The user drags the model of the buccal over the corresponding area of either the upper or lower jaw by single clicking and holding the left mouse button. The software detects the click position. If the click position is above the horizontal midline of the buccal model and the user moves it to the lower arch, the software automatically flips the buccal model in 180° and vice versa.

Correlation of upper jaw and lower jaw with the buccal model

The correlation of all models is not based on the triangulations (3D-models) but the points in the data cloud of the images. The software (in combination) with the Blucam can determine the quality for each pixel in an image and therefore the points in the datacloud that should be considered for correlating the models. Example: When a buccal shot is taken, at some areas the camera looks into the off. This typically happens at the interdental areas between the teeth or prepped areas. The pixels in that area will be marked as ‘bad pixels’ and will not be considered for the correaltion process. Using only valid pixels for correlating the models increases the quality of the process (Fig.2).

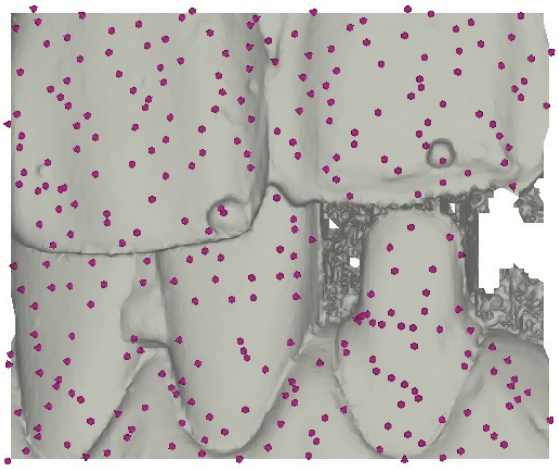


Fig.2 shows as a example that only valid data from the model is taken into conideration for the correlation process. Non valid data like dark areas at the prep for example cause artefacts and will not be considered for the correaltion.