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Preparing anatomical scan data for sharing online

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PROFESSIONAL DEVELOPMENT

Preparing anatomical scan data for sharing online

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ABSTRACT

This paper gives an overview of working with anatomical scan data such as CT and surface scans. The various types of scans are discussed along with their pros and cons, before going on to provide a detailed guide as to how these can be further post-processed. A method for cleaning and enhancing scan data using the 3D modelling software ZBrush is outlined. Finally, a method for sharing the resulting scans online via Sketchfab is presented.

Introduction

In the UK, access to human remains is quite rightly limited to those institutions and individuals who have a specific need to work with this material. However, even groups such as anatomy and medical staff and students who have access through their place of work or study, do not have access out of hours. Indeed, as the COVID-19 pandemic has demonstrated that remote access to such resources is of paramount importance. Even as life in the UK slowly returns to its pre-pandemic state in many ways, it is likely that higher education has been changed forever, with many Universities planning to retain at least some degree of blended learning (Snelling, 2022). Scanning anatomical specimens therefore allows digital copies to be hosted online, thus widening out of hours access to these valuable resources.

There are various scanning modalities that can be used for capturing anatomical specimens in 3D. These include both clinical imaging techniques such as a CT and MRI, as well as commercial surface scanners and photogrammetry. This paper aims to give an overview of the different types of scan data available before going on to provide a method for post-processing such data using the 3D modelling software ZBrush. The principles described below could easily be applied to other 3D modelling packages however.

Access to and types of scan data

In terms of accessing scan data, you can either use that taken by others or create your own. There are a number of repositories that are worth noting if you do not have

access to scan specimens for yourself. Some publicly available sources of data include (please make sure you read the terms and conditions for each carefully):

- This Visible Human Project: https://www.nlm.nih.gov/research/visible/visible_human.html
- MorphoSource: https://www.morphosource.org
- 3D Slicer: https://www.slicer.org/wiki/SampleData

Alternatively, if you do have access to anatomical material through your place of work and have suitable permissions in place to create images of these, then you may choose to create your own scans. The most accessible means of creating your own scans is through photogrammetry, but 3D surface scanners, clinical CT and micro-CT scanners are also excellent options if you have access to them.

Before moving onto the method, it is useful to understand a little about the types of scan data that you might be working with and the advantages and disadvantages of each.

Photogrammetry is a technique where numerous 2D photographs of an object are taken from different viewpoints allowing the software to create a 3D reconstruction of the object. A major advantage is that it is very accessible and can be utilised with smartphones and free software if necessary. Photogrammetry also captures the colour of the object being scanned and generally results in high quality texture maps. Disadvantages include that it can struggle with accurately capturing transparent and shiny surfaces, as well as holes and undercuts.

Surface scanners come in a variety of shapes and sizes but are generally handheld laser or

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structured light scanners. Prices vary considerably from a few hundred to several thousands of pounds. Likewise, the quality of resulting scans can vary considerably. Advantages include that they are usually portable and generally quite fast to use, with the higher end scanners yielding highly accurate results both in terms of mesh accuracy and colour capture. Disadvantages include that they are restricted to capturing surface details (unlike CT scans which also capture internal information) and can struggle to capture certain surfaces such as those which are very dark, transparent, or shiny.

Clinical CT and MRI data are exported as image stacks using the DICOM (Digital Imaging and Communications in Medicine Standard) format, although they may be converted to other imaging formats such as TIFF, JPG, BMP, and PNG. Usually, this data will be collected by radiographers and will likely need segmenting and reconstructing to create a usable 3D model. An advantage of CT and MRI scans is that they capture internal as well as external details. Disadvantages include that manual segmentation can be time consuming and that no colour information is captured.

Micro-CT utilises much the same technology as clinical CT but for smaller objects and at a much higher resolution. Whereas clinical CT scanners tend to be located in hospitals, micro-CT scanners are often located in universities and may therefore be more accessible to researchers. Advantages include that the resulting scans are of a very high resolution. As above, disadvantages include that no colour information is captured.

For further details on each of the above please see *Interactive 3D Digital Models for Anatomy and Medical Education* (Erolin, 2019).

Once you have obtained your data (and reconstructed it, if necessary), you are ready to move onto the method outlined below to clean and enhance this data for further dissemination.

Method

It should be noted that this paper does not provide details on capturing and exporting the initial scan data as this varies considerably depending on the method and technology employed. Rather it focusses on the common steps in processing such data. These are *importing* scans, *cleaning* scans, *enhancing* scans, and finally *dissemination*. A basic understanding of ZBrush is required for the following method. When referring to the ZBrush interface the terms 'tray' and 'shelf' are often used. The following site can be used to check the ZBrush interface layout to see what these are referring to: http://docs.pixologic. com/user-guide/customizing-zbrush/interface-layout/ custom-interface/.

Importing scans

In order to import scans into ZBrush, they are best exported from the software used to create them as either STL or OBJ files. Files from photogrammetry and surface scanning software will usually have the option to also export a texture map.

Importing scans in to ZBrush is done through the 'Import' button in the tool menu, at the top of the right tray. You may need to left click and drag to load the scan into the workspace. Once loaded be sure to press the 'Edit' button (located next to 'Draw' on the top shelf of the standard interface) to make the scan fully 3D and editable. If a texture map is already available, this can be applied by going to 'Texture Map' in the right tray and clicking on the empty square seen there. This will bring up a texture menu from where you can select 'Import'. Navigate to the texture map file location and select the map to apply it. You may find it is applied in the wrong orientation. If that occurs, click on 'UV Map' (also found in the right tray), 'Adjust' and 'Flip V'. Finally, the default material in ZBrush is 'MatCap Red Wax'. If working with a texture map especially, this is best changed to 'SkinShade4' so as not to affect the colours of the texture map.

Cleaning scans

Regardless of where the initial data came from, once successfully imported into ZBrush to following processes are very similar.

Cleaning the mesh

The aim of 'cleaning' the mesh is to smooth out or delete any unnecessary data and artefacts as well as repairing and remodelling any missing data. Editing the scan is kept to a minimum so as not to alter the mesh significantly, ensuring it is an accurate representation of the scanned specimen. It should also be noted that where the scan has imported along with an existing texture map (as is often the case with photogrammetry and surface scans), effort should be made to avoid cutting or retopologising the mesh, as this will delete the UV map and thus the texture map along with it. If this is unavoidable, the texture map should first be converted to Polypaint (see *Repairing the texture map* below) and a new UV map created after the mesh has been altered (see *Vertex colour and texture maps* below).

The Smooth brush (accessed by holding down the 'Shift' key) can be useful for smoothing out any unwanted lumps and bumps on the surface of the mesh. This works particularly well for more minor imperfections that do not require cutting away. The smooth brush has its own intensity slider, allowing its effect to be more or less intense as required.

Using the smooth brush does not affect the UV/texture map.

To delete unnecessary data and artefacts, these first need to be selected. Holding down 'Ctrl' and 'Shift' (on PC) brings up the selection tool. Clicking on the 'SelectRect' brush that appears by default you can choose from a variety of selection brushes. The 'TrimLasso' brush can be used to select and delete areas of geometry, neatly closing any holes created (Figure 1). Selecting and deleting geometry that does not touch the main mesh will not affect the UV/texture map, however cutting and deleting geometry from the main mesh will. If you are working on a scan (such as CT data) that does not have an accompanying texture map this is not an issue. An alternative to the 'TrimLasso' is the 'SelectLasso' brush. The difference here being that the selected area is initially hidden but not deleted. This gives an opportunity to ensure the selection is correct before proceeding to the 'Geometry' menu, 'Modify Topology' and selecting 'Del Hidden'. Any resulting holes are then filled using the 'Close Holes' feature also within the 'Modify Geometry' sub-menu.

Sometimes (especially with CT data) there can be lots of very small artefacts around (and even within) the mesh. A simple way to delete these is to use polygroups. Turn on the 'Draw Polyframe' view (Shift + F) in the right shelf and deselect 'line' so that only the polygroup colour is visible. Open the 'Polygoups' menu in the right tray and select 'Auto Groups'. This will assign a different colour to each separate mesh. Hold down 'Ctrl' and 'Shift' and make sure 'SelectLasso' is selected. Next, click on each of the polygroups that you wish to retain (making sure

you click on a 'poly' or 'point' rather than 'edge' to select it). This will hide the selected mesh/s. Once all have been selected, simple left click and drag (while still holding down 'Ctrl' and Shift') on an empty region of background to invert the selection. You can then delete the hidden/unwanted geometry by going to 'Del Hidden' in the 'Geometry' menu.

In addition to deleting artefacts, there may also be areas in a scan that require filling. The 'fill holes' feature mentioned above will only work on holes that are *cut* into the mesh. However, on occasion a scan will import with what we would consider to be holes, these may be regions that haven't scanned properly (such as undercuts) or areas of lesser density on a CT scan. It's important to understand that these are not actually holes in the mesh, rather they are part of how the scan has been imported. Therefore, they need to be filled in a different way. The easiest way is to append a primitive shape such as 'Sphere 3D' via the 'Subtool' menu. This will first need resizing and repositioning using the transpose tools in the top shelf. Next, Using the 'Move' brush, tug the sphere until it fits snuggly in the hole (Figure 2). Once in position, the sphere can be merged with the scan. This should be repeated for all holes. At this stage, the filled hole will look quite crude and if an attempt is made to smooth the edges, it won't work very well. Looking at the 'Draw Polyframe' view, we can see why. Although the subtools have been merged, they have retained their own mesh density and structure. Zbrsuh contains a number of 'retopology' tools, and any of these can be used at this stage to retopologise the mesh. Once retopologised it will be possible to smooth out
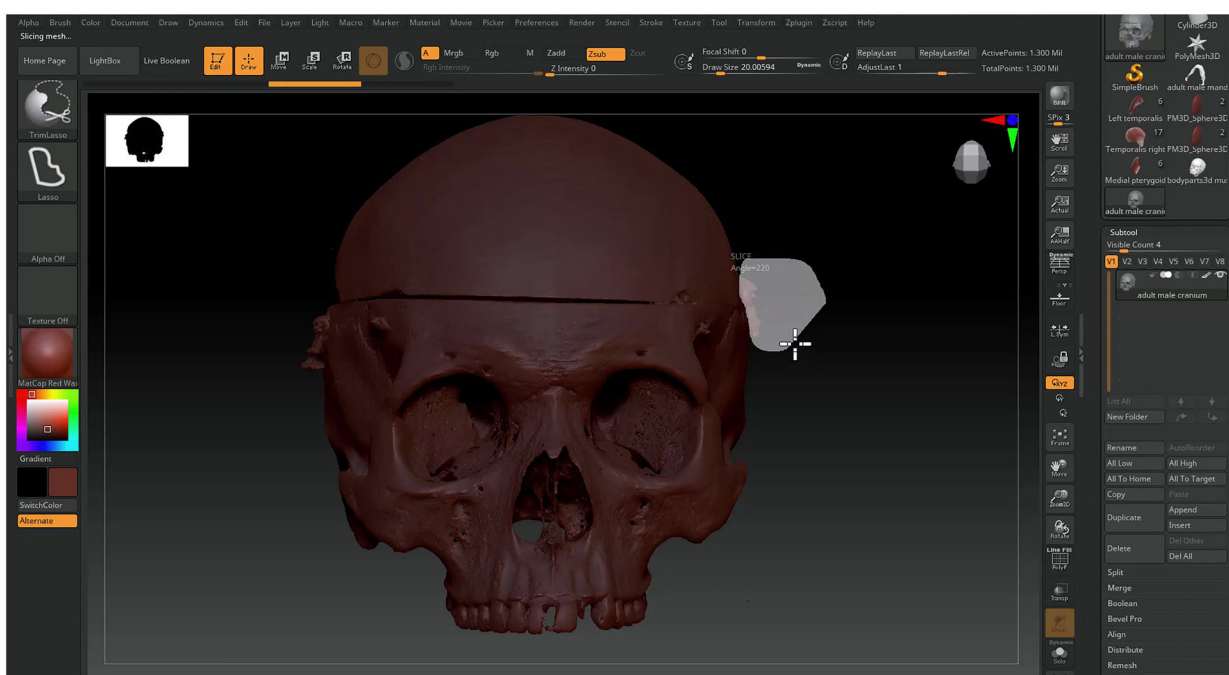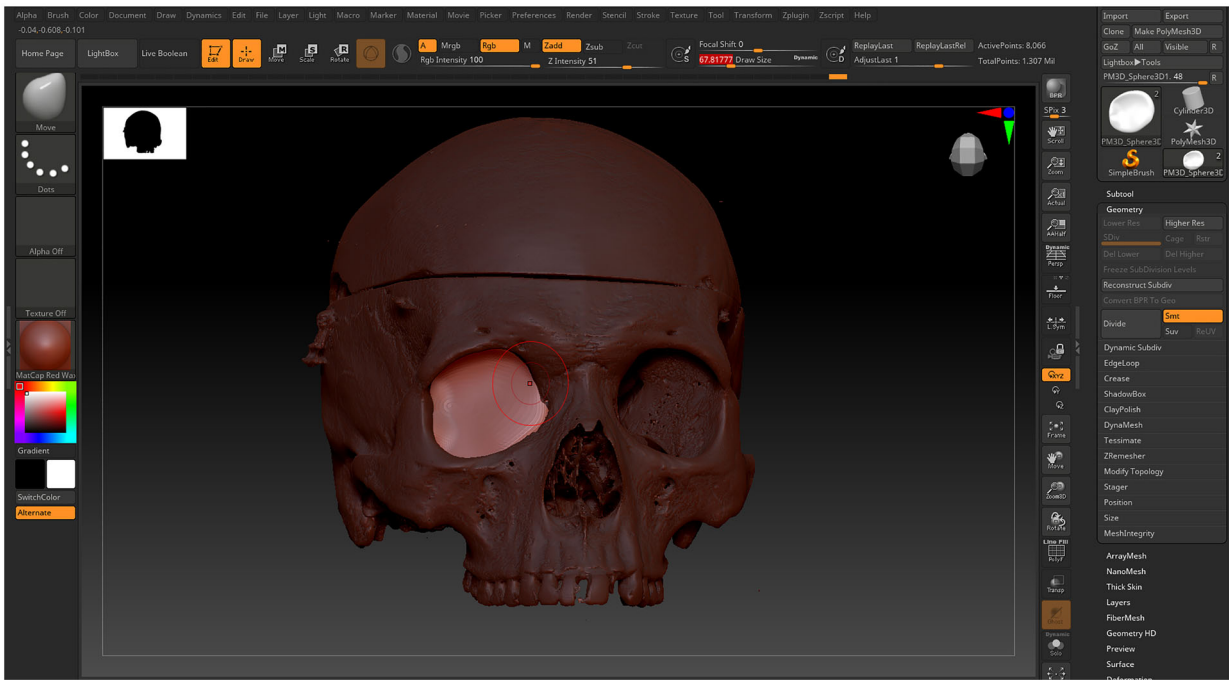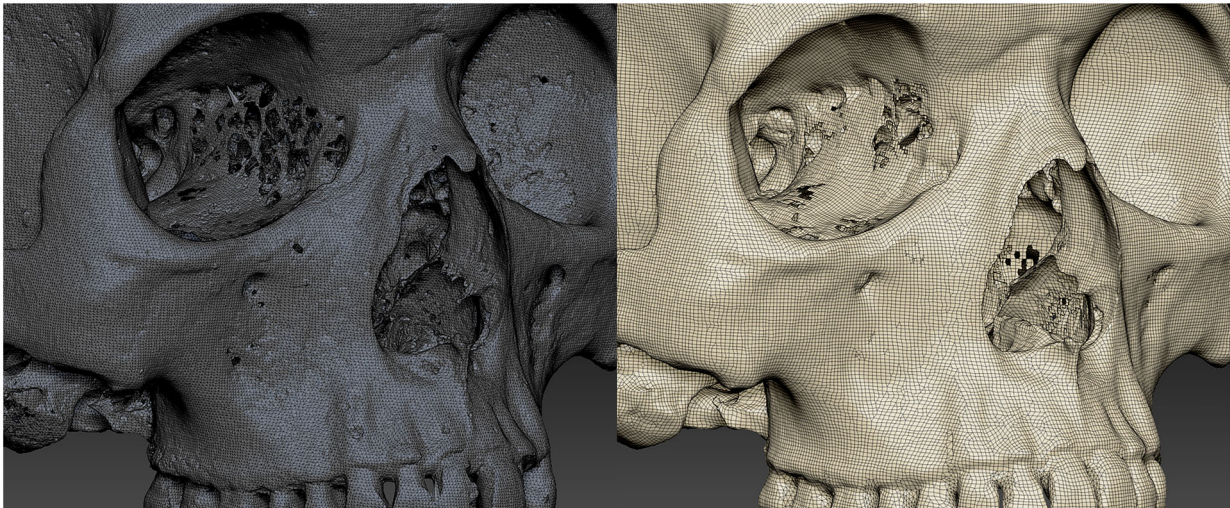

Figure 1. Using the 'TrimLasso' brush to select and delete areas of geometry on a micro-CT scan of a skull.

Figure 2. Filling holes with a primitive shape, the 'Move' brush can be used to tug the sphere until it fits snuggly in the hole.

Figure 3. A micro-CT scan of a skull before and after Dynameshing, with the 'Draw Polyframe' view switched on.

the filled holes. Retopology is a process of creating a new surface (or topology) for a mesh, making it cleaner and easier to work with (Figure 3). It should be noted that all of the following retopology tools will delete any existing UV maps, so make sure to take this into consideration. Some retopology tools to consider using are:

Dynamesh creates a topology that maintains a uniform resolution and polygon distribution for the mesh. Quick to use and useful in the earlier modelling stages especially if there are larger changes to the geometry. Any Polypaint information is retained.

ZRemesher will retopologise the entire mesh with a controlled flow of polygons and a global polycount value. It does tend to lose detail, however this can be sculpted or projected back later. Any Polypaint would also be lost and require projecting back onto the scan (see *Duplicating and Projecting Detail below*). Best used later in the modelling process as it creates a higher quality mesh for exporting and or adding detail to.

Decimation Master reduces the polygon count of models in an efficient way while maintaining detail. It is aimed at optimising the polycount to aid export to other 3D software packages and online. Any Polypaint is lost during the process however so would need adding later or projecting back (see *Duplicating and Projecting Detail below*).

Repairing the texture map

For scans that have imported along with a texture map, you may wish to edit this in addition to the mesh. If the texture map does not need editing, you can skip this step.

However, sometimes there will be minor errors on the texture map that you wish to correct. These might include glitches, unwanted shadows, or unwanted highlights. It's worth remembering that if the resulting model will be viewed through an interactive online environment that this will include real time lighting, which in turn will cast dynamic shadows and highlights.

In order to alter the texture map, it first needs to be converted to Polypaint. Before doing this however, it is usually worth increasing the resolution of the scan so as not too loose detail when converted. The easiest way to do this is to open the 'Geometry' menu in the right tray and select 'Divide'. Depending on the resulting resolution, you may wish to do this more than once. Once happy with the resolution, open the 'Polypaint' menu in the right tray and select 'Polypaint from texture' (you will need to have 'Mrgb' selected in the top shelf for this to work). The texture map will now be turned off with the resulting colour being the Polypaint. Turning off 'Mrgb', 'M', 'Zadd', and 'Zsub' in the top shelf and turning on only 'Rgb' will allow you paint over and modify this as you choose. Making sure the 'Standard' brush is selected, it is now possible to choose any colour and paint directly onto the scan. You can change the brush size and focal shift (how hard the edge of the brush is) in the top shelf. It is also possible to alter the Rgb intensity to allow for colour blending. Holding down the 'Shift' key will allow you to use the smooth brush (make sure only 'Rgb' is selected otherwise you will smooth the geometry along with the colour texture).

Once Polypainting is complete, you can overwrite the previous texture map with the new version. Simply open up the 'Texture Map' menu and select 'Create' – 'New from Polypaint'. As long as the mesh hasn't been cut or retopologised, this will create a new texture map. This should be done with the scan at its highest resolution (sub-division), although it may later be exported at a lower resolution if desired. If the scan has been cut or retopolgised, a new UV map will first need to be made (see *Vertex colour and texture maps* below).

Adding colour

Scan data that has been imported without a texture map (such as CT scans), can be painted directly in ZBrush. There are two main approaches to painting models in ZBrush, Polypaint and Spotlight.

Polypainting, as described above, allows you to paint directly onto the scan. Using the standard brush with only 'Rgb' selected you can paint with any colour you choose. The Rgb intensity can be altered to vary the brush opacity and the brush size and focal shift can also be changed. In addition, 'Alphas' can be used to add more detailed textures and patterns (Figure 4). Found in the left shelf, there is a wide variety of Alphas to choose from. Some such as Alpha 04 and 08 are useful for things like bone texture, while Alpha 62 can be useful for depicting muscle fibres, and Alpha 22 is useful for depicting veins. Alphas work best at higher resolutions, and like all Polypainting they can be smoothed by holding down 'Shift'.

The Spotlight function is a form of Polypainting that allows you paint with imported images including photographs. To create a Spotlight collection, first go to 'Texture' in the top menu and import the required images. Next, select each image in turn and click the 'Add to Spotlight' button below. Once all images are added to the Spotlight you can use the 'Tile Unified' option on the Spotlight dial to neatly stack the images to the left of the screen. At this stage it is often worth saving the Spotlight collection for future use. This can be done in the 'Texture' menu and loaded directly from here in the future. Selecting an image to work with, you can click and drag this over the scan (Figure 5). Making sure Rgb is selected, and the other buttons are turned off, press 'Z' to hide the Spotlight dial and paint over the image to transfer it to the scan below. The Spotlight feature can take a bit of getting used to but is a powerful tool once you do. You can read more on its various functions here: http://docs.pixologic.com/user-guide/3d-modelling/painting-your-model/spotlight/

Vertex colour and texture maps

Once Polypainting is complete, you can choose to either export the model as it is, or to first create an accompanying texture map. Polypaint (and Spotlight) are applied to the model as 'vertex colour'. Vertex colour applies the RGBA value directly to vertices on a mesh. This can be useful as it means files can be exported without the need for a texture map. The downside however, is that the resolution of the texture is directly related to that of the model. Not all file formats support vertex colour however so this needs to be considered when choosing how to export your final model. FBX, WRL, BLEND, and point cloud formats support vertex colour. Although not part of the default OBJ specification, ZBrush (and some other applications) does encode vertex colour into OBJ files exported from it.
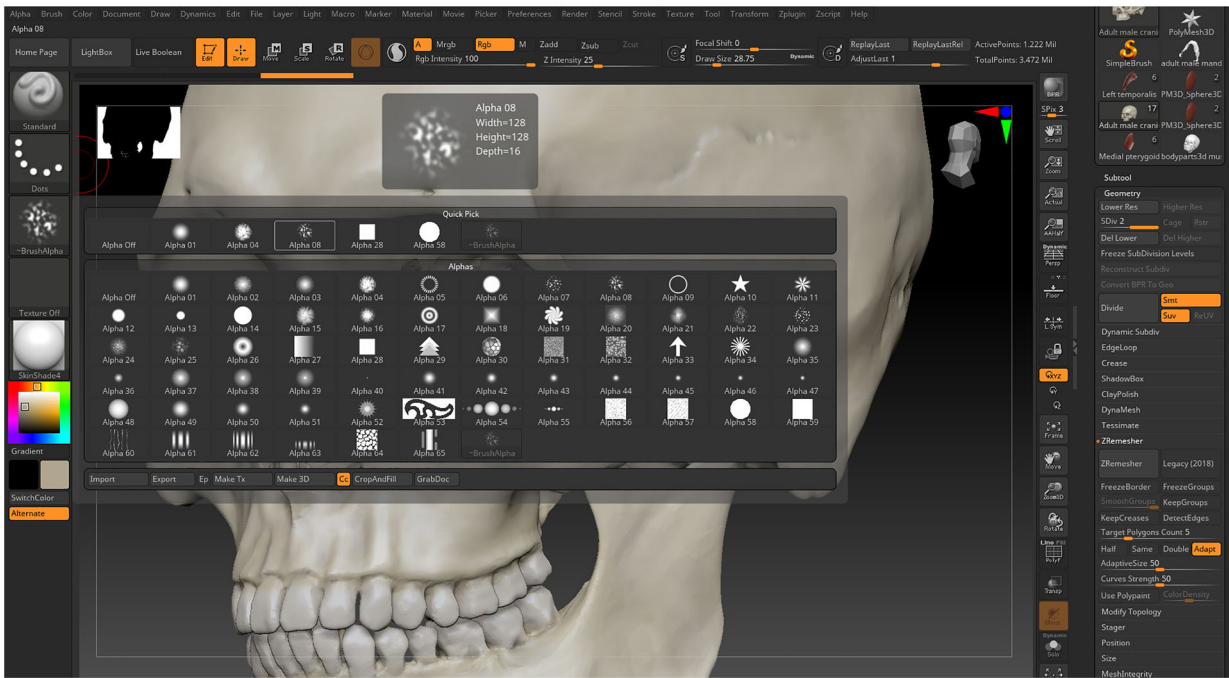
Figure 4. Found in the left shelf, there is a wide variety of Alphas to choose from. These can be useful for painting texture details.
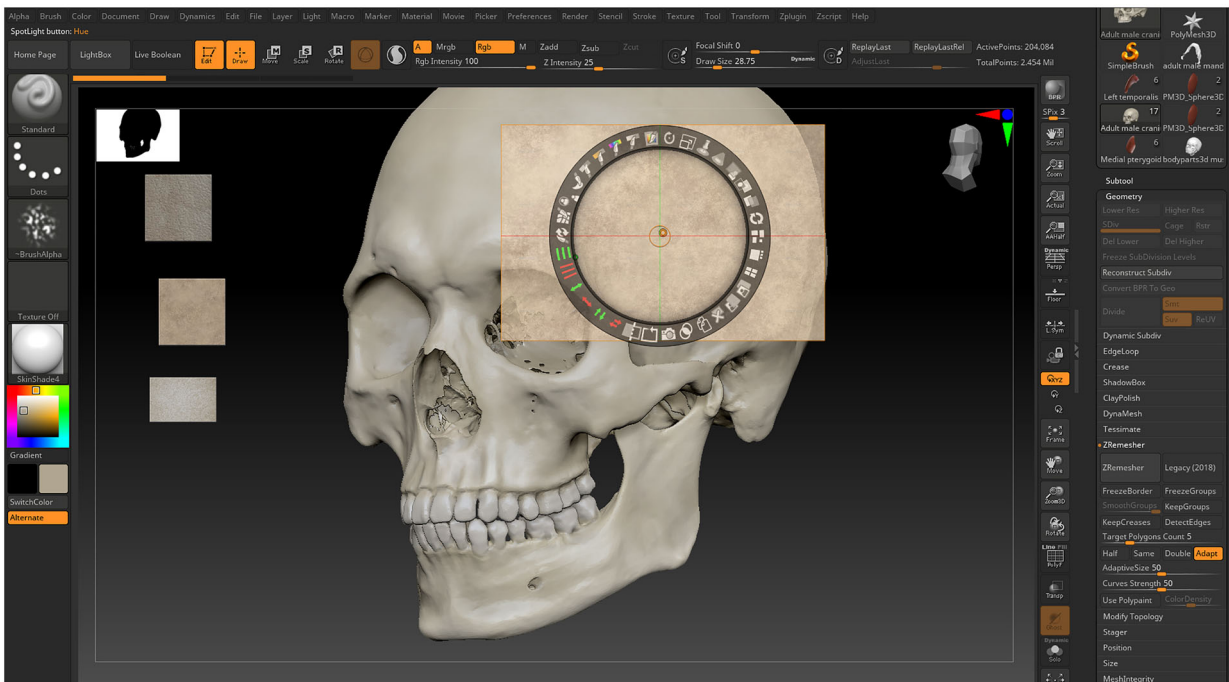
Figure 5. Setting up a texture to paint with using the Spotlight feature.

A major advantage of texture maps is that these can be created with the model at its highest resolution to create a high-quality texture. However, the model can then be exported at a lower resolution, meaning it will load quicker when viewed online. Wrapping the high-resolution texture map around a lower resolution model makes it appear better than it otherwise would. In order to create a texture map, the model first needs to be 'unwrapped' to create a UV map. UV mapping is the process of projecting a 2D image onto a 3D surface. The UV coordinates need to be assigned to a 3D model before the 2D texture map can be created. There are a number of ways of doing this in ZBrush but the easiest is to use the 'UV Master' function found within 'Zplugin' in the top menu. Make sure your model is set to its lowest subdivision level (resolution) and click 'Unwrap' (feel free to experiment with settings such as symmetry and control painting). All going well, after a few minutes you will have successfully created a UV map. Moving to the model's highest subdivision level (resolution), you can now open the

'Texture Map' menu and select 'Create' – 'New from Polypaint' to create a new texture map.

If working with complex shapes and especially CT (including micro-CT) or MRI data, you may find that the scan does not unwrap as easily as described above. This usually occurs due to the mesh being overly complex. For example, a CT scan that has captured the internal trabecular structure of bone will have an enormous and highly complex surface compared to a photogrammetry model of the same specimen. In this case you can either export the model without a texture map utilising vertex colour instead, or you can try the method described below for duplicating models and projecting detail.

Duplicating and projecting detail

The following technique is useful if you have a scan that it is difficult to create a UV map (and therefore texture map) for. The essence of this technique is that you duplicate the scan, retopologise the duplicate to a lower resolution, unwrap the UV map, and project detail and/or Polypaint information back from the original.

Before you duplicate your scan, go ahead and make any alterations that you need to make, such as tidying up the mesh to remove artefacts, etc. If you have one, you should also convert the texture map to Polypaint at this stage (as described above under *Repairing the Texture Map)* and make any required changes. Once complete, duplicate the scan via the 'Subtool' menu and rename. You can then retopologise the duplicate to a lower resolution. For complicated scans, especially those with internal structures such as CT data, you may need to retopologise to a very low resolution. Using 'UV Master' found within 'Zplugin' in the top menu, unwrap the duplicated scan. If it still doesn't unwrap, you may need to lower the resolution further. Once unwrapped, go back to the 'Subtool' menu and open up 'Project', choose whether you wish to project geometry and/or colour and press 'ProjectAll'. This will project the geometry and colour information from the original scan back onto the unwrapped duplicate. As the duplicated scan will be quite a low resolution, you will need to divide this (using 'Divide' found under the 'Geometry') to increase the resolution. Project all again and repeat dividing as projecting as many times as required. Finally, open up the 'Texture Map' menu and select 'Create' - 'New from Polypaint'. The texture map should be created at the highest resolution, although the scan can then be exported at a lower sub-division if required.

Enhancing scans

Enhancing scans is subtly different to cleaning them. With 'cleaning' the aim is to make the scan as close to the real specimen as possible by deleting artefacts, filling holes, and repairing the colour texture, and finally tidying the mesh structure ready for export.

Whether enhancement is appropriate depends on the intended outcome and use. A scan made for data collection in a research project may need to be minimally altered if at all to retain its integrity. Whereas a scan to be used for teaching or public outreach might benefit from 'enhancement' in order to improve the scans clarity. This could take the form of more extreme editing to the 3D mesh, such as neatening up tissue on a dissection scan, or defining the edges of structures more clearly, as well as changes to the scan colour such as colour coding and/or colour highlights. In addition, it is possible to combine scans with structures modelled from scratch in Zbrsuh, such as adding muscles over a bone scan (Figure 6).

Dissemination

Once your 3D model is complete, it's time to consider how and where to disseminate it. This paper focusses on sharing models online, but other options include; Interactive PDFs, e and iBook's, bespoke software applications, and 3D prints (Erolin, 2019).

The online platform Sketchfab is ideal for sharing for 3D models, including scans of anatomical material. It is the largest online platform for hosting and sharing interactive 3D models, supporting over 50 3D formats. Importantly for scans of anatomical specimens, it is possible to specify whether models are public or private, and whether they can be downloaded or viewed online only.

Importing models into Sketchfab

There are a variety of export options from ZBrush that will provide suitable files for upload to Sketchfab, these are summarised below:

- Where there is only one subtool (with or without a texture map), click on 'export' in the tool menu, at the top of the right tray and select OBJ. If there is no texture map, this will export a single OBJ file, including any Polypaint/vertex colour. If there is a texture map present, then three files will be exported: the OBJ, the texture map (as a 2D image), and an MTL (Material Template Library) file. These files should be zipped together ready to upload to Sketchfab.
- Where there are multiple subtools with texture maps, export via the 'Decimation Master' menu found under 'Zplugin' in the top menu. Click on 'Export All SubTools'. This will export a single OBJ file combining all subtools, along with multiple texture maps (one for each subtool) and a single MTL file. These files should be zipped together ready to upload to Sketchfab.
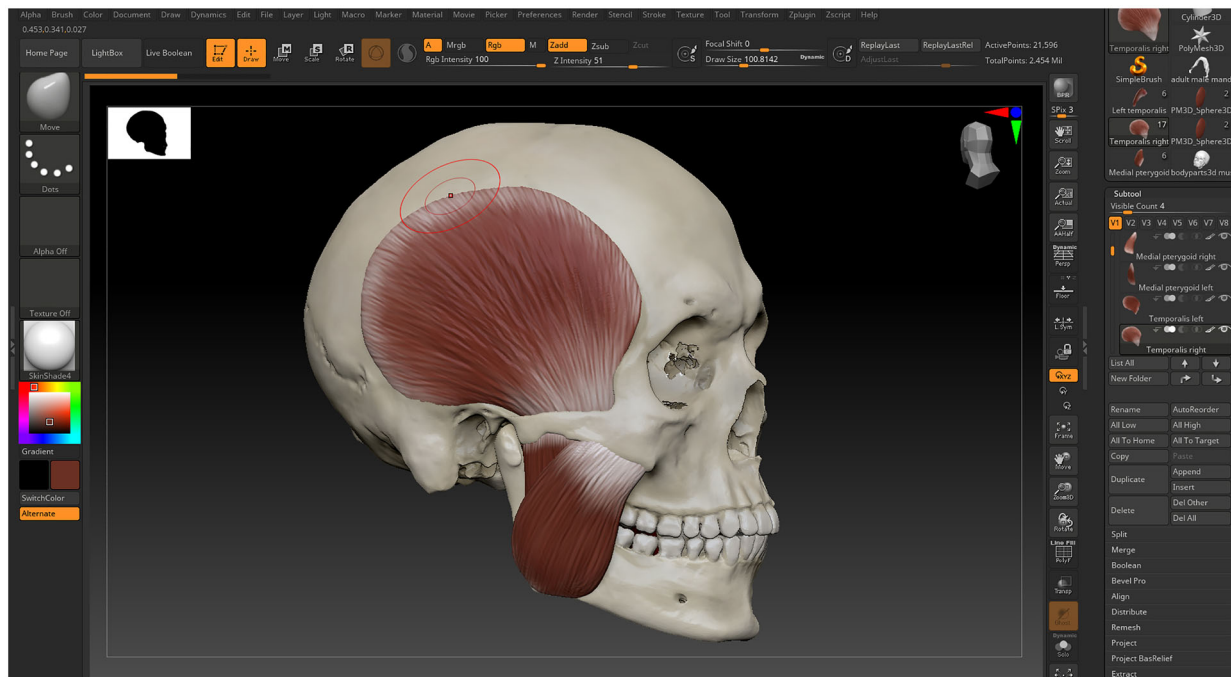
Figure 6. The muscles of mastication have been modelled over this cleaned up micro-CT skull scan.

- Where there are multiple subtools with vertex colour (and no texture maps), click on 'export' in the tool menu, at the top of the right tray and select FBX. This will export a single FBX file, which includes all subtools any Polypaint/vertex colour.

To import the above files into Sketchfab you will first need to create an account. Although a basic account is free, private models are only available with a paid subscription. Once logged into your account, click on the 'Upload' button usually found at the top right of the screen. Simply drag and drop the files in to the box to begin the upload. Single files can be dropped directly, whereas multiple files should be zipped together first. Whilst the file is uploading you can add a title and description. There is also the option to add it to a category such as 'Science and Technology' and to add tags to make it easier to find – however these options are only really for models that you want to be in the searchable and in the public domain. On the right there are options to make the model public or private and to set download options. If a model is public and downloadable there will also be the option to choose from a selection of Creative Commons licences. Once upload is complete and the above settings are saved, you can select 'Edit 3D Settings' to move onto the next section.

Sketchfab settings

Within the 3D Settings window you will find a wide range of settings including perspective, lighting, and material properties. These are each accessed from the tabs at the top left of the screen. Some of the most useful of these are described below.

Starting with the 'Scene' tab, it is possible to edit the 'Field of View' to determine how much perspective is applied to the scene. Don't worry if this also changes the size of the model, as this can be resized by zooming with the centre mouse button. It is also worth toggling on 'Show advanced rotation' and using the circular gizmo to re-position the model if necessary. If the model has no texture map, the 'Vertex Colour' option should be turned on, and if a texture map is present (even if yet to be applied), this should be set to off. Finally, custom backgrounds can be added under 'Background type' and 'Image'. Here you can upload an image perhaps including additional information and institutional logos etc. Alternatively, a simple colour background may be used.

Moving onto the lighting tab, by default, the Environment lighting will be applied. It's worth trying out a few different options here, but the studio lighting options are often best for controlled lighting. In addition, the 'Lights' option at the top of the menu can be toggled on for more options. Lighting presents such as 'Default 2x direction' can be useful, and it is even possible to edit the individual lights, altering their type, colour, and intensity. Finally, there is also the option for ground shadows which might be worth considering for some models.

The Materials tab is next, and this is where, if it wasn't zipped and already loaded with the model, you can add texture and other maps. If a model had more than one subtool, the very top drop-down menu will let you select from these so that you can alter their properties individually (Figure 7). If a

texture map does need manually adding, simply come down to 'Base colour' and click on the square below. Click on 'Texture' and 'Import textures' to load a texture map. There are also options below to add displacement, normal, and bump maps if desired. There are numerous other options worth exploring in this section, but a couple to pay particular attention to are the slider for the roughness/glossiness of a model (or model part), which can be useful in making a model look more wet/shiny, and the 'Opacity' option which can make a model (or model part) transparent. This is particularly useful where there is more than one subtool and you wish to see one through another. There are four options for rendering transparent objects in Sketchfab each with their own advantages and disadvantages and it's worth trying each out to see what works best.

The Post processing filters tab includes a variety of features, some of which are more useful than others in terms of presenting realistic anatomical models. 'Tone Mapping' and 'Colour Balance' are useful for making changes to overall brightness and contrast, and colour levels. 'Sharpness' can also be very useful in making models appear a little sharper than they otherwise would.

The Annotations tab is particularly useful for labelling anatomical models and allows for the addition of annotations with titles and descriptions. The number of annotations available will depend on your subscription level, ranging from 10 with a free account, 20 with a Pro, and up to 50 with a premium subscription.

Finally, the VR and AR tab allows you to prepare a model for viewing in virtual and/or augmented reality. It is possible to alter the model's scale here as well as it's height from the floor. Consider whether a model is best viewed at life size or bigger

(or smaller). The App free AR functionality is only available on premium and Enterprise subscriptions.

Sharing and embedding models

Now that your models are hosted online via Sketchfab and edited to look their best, you should consider how and where to share these. The two main options are to share links, either to individual models or collections of models on Sketchfab, or to embed the models directly on your own webpage or learning platform.

To share a link, simply click on the 'Share' button under the model and copy the url. To embed the model, click on the 'Embed' button, also found under the model to bring up the Embed Viewer window. There are various options here to check such as the size of the window that will be embedded and whether you want an animated entrance etc. Once you have selected the required options, simply copy the iframe code. This can then be embedded directly into various web platforms including virtual learning environments (VLE) such as Blackboard. For example, within Blackboard Collaborate, simply click on 'Add HTML' within a document and paste the code.

Finally, before sharing the final models it's worth considering who you wish to have access and at what level. Make sure that your Sketchfab settings reflect this – such as setting a model to private if you do not want it to come up in a Sketchfab search and disabling the download option where you don not want this to be possible. If embedding the model elsewhere be mindful who will have access to this site. Even if a model is set to private, if someone has access to the site where it is embedded, they will be able to see it. For this reason, when being used for university teaching, which is often the case for anatomy material, it is best to embed the models
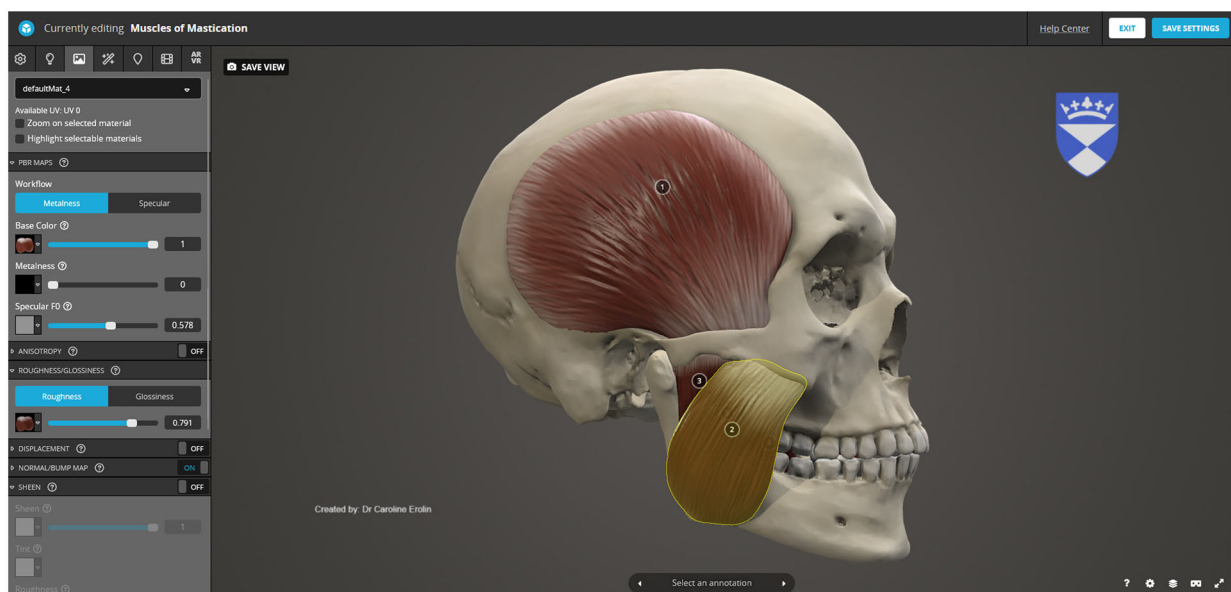

Figure 7. Editing material properties for individual structures in Sketchfab.

within a programmes VLE, so that only the enrolled students have access.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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