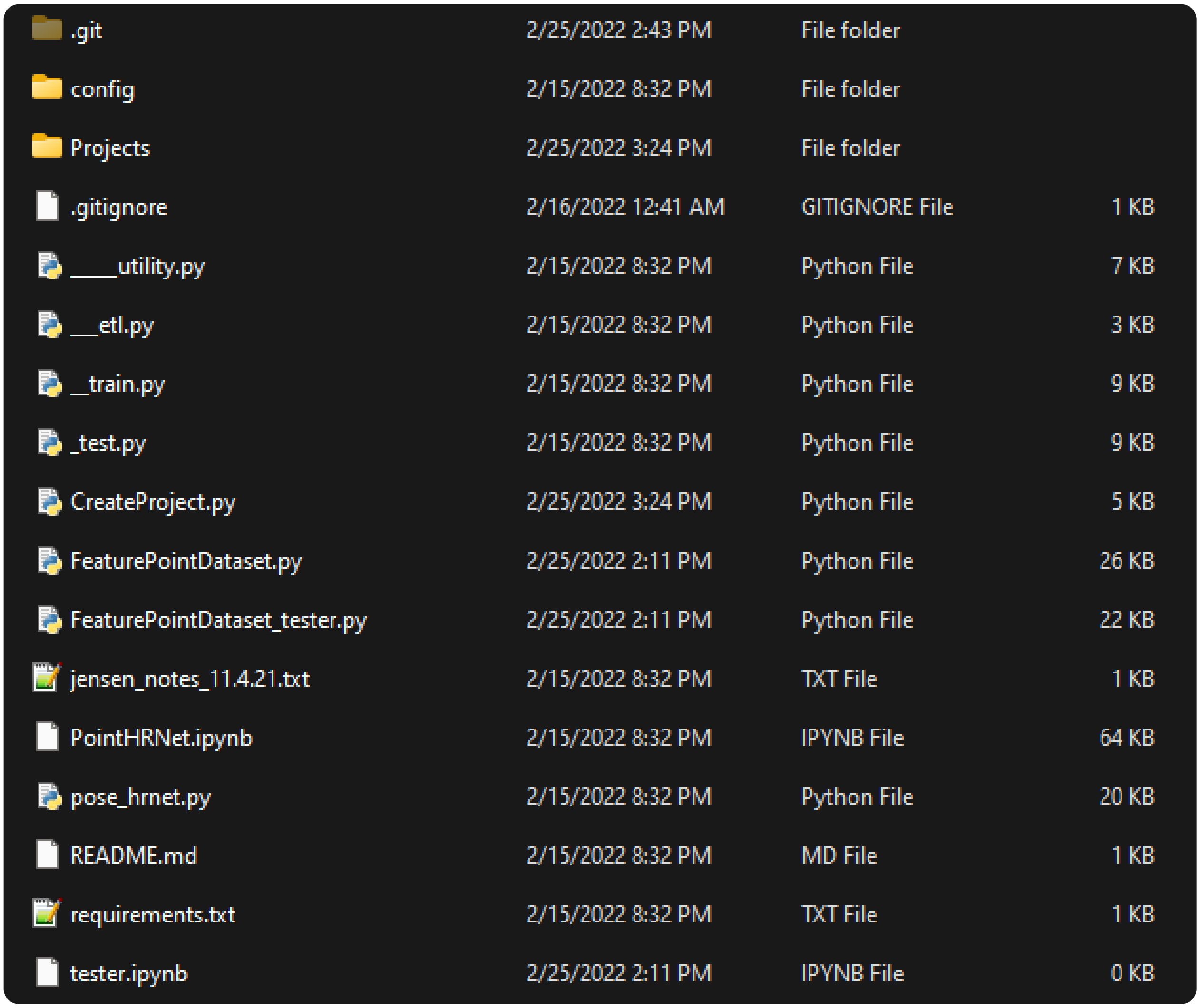
ShapeWorks Workflow

Section 1: Installation

- To get ShapeWorks, first install miniconda if you don't already have it.
- Visit ShapeWorks's GitHub and download the latest stable release.
- Install ShapeWorks using the installer you downloaded
- Open a miniconda terminal and navigate to the ShapeWorks folder
  - Default location is C:\Program Files\ShapeWorks
- Run install_shapeworks in the miniconda terminal
  - NOTE: If this step takes a while to complete, try deleting the shapeworks folder and updating your miniconda
- Once that is complete, navigate to C:\Program Files\ShapeWorks\bin and run ShapeWorksStudio.exe

Section 2: Importing a dataset

- For our purposes, we are using ShapeWorks to analyze .stl files.
- Download our shoulder dataset from here
- Once it is downloaded, clone the nick-dev branch from the Shoulder-Keypoint repo on GitHub and create a folder named "Projects" in the root of that folder



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config	2/15/2022 8:32 PM	File folder	
Projects	2/25/2022 3:24 PM	File folder	
.gitignore	2/16/2022 12:41 AM	GITIGNORE File	1 KB
____utility.py	2/15/2022 8:32 PM	Python File	7 KB
___etl.py	2/15/2022 8:32 PM	Python File	3 KB
__train.py	2/15/2022 8:32 PM	Python File	9 KB
_test.py	2/15/2022 8:32 PM	Python File	9 KB
CreateProject.py	2/25/2022 3:24 PM	Python File	5 KB
FeaturePointDataset.py	2/25/2022 2:11 PM	Python File	26 KB
FeaturePointDataset_tester.py	2/25/2022 2:11 PM	Python File	22 KB
jensen_notes_11.4.21.txt	2/15/2022 8:32 PM	TXT File	1 KB
PointHRNet.ipynb	2/15/2022 8:32 PM	IPYNB File	64 KB
pose_hrnet.py	2/15/2022 8:32 PM	Python File	20 KB
README.md	2/15/2022 8:32 PM	MD File	1 KB
requirements.txt	2/15/2022 8:32 PM	TXT File	1 KB
tester.ipynb	2/25/2022 2:11 PM	IPYNB File	0 KB

- Open the repo in VSCode and run the file "CreateProject.py"
  - The program will prompt you first for a name for the project file.
  - Next, get the path to the shoulder data you downloaded earlier and paste it into the program. It should be that path to a folder that contains the two datasets, "Akira_Organized" and "Keisuke_Organized"
  - Next, choose which bones to import. Type 1 for scapula, 2 for humerus, or 3 for clavicle.
  - Lastly, choose the amount of bones to import. I would recommend 9 at most if you're just trying to get optimization to work correctly and mess around with parameters.
  - If you're trying to generate data for the whole dataset, however, type "all"
  - The project file will be saved in the Projects folder you created earlier
- Open ShapeWorks and click "Open Existing Project", then navigate to the Projects folder and select the file you created above to import your desired .stl files.

Section 3: Using ShapeWorks to create point clouds

- ShapeWorks uses three steps in order to generate a point cloud:
  - *Groom*, which smooths out the models and makes them easier for the program to process
  - *Optimize*, which is what we use to actually generate the points on each mesh
  - *Analyze*, which we can use to visualize the different point clouds for each individual mesh and see how well our optimization parameters did

Section 3a: Grooming

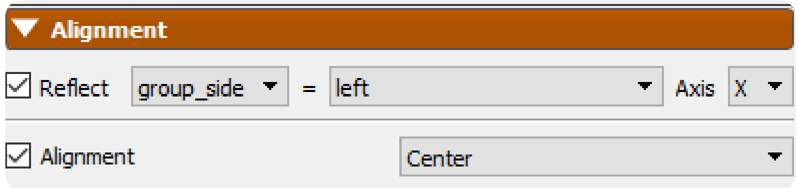
Mesh Grooming

- Mesh Grooming has three main options:
  - Fill Holes
  - Smooth
  - Remesh
- Fill holes should always be selected for our purposes, as many of the scapula meshes have...you guessed it: holes!
  - NOTE: If the grooming step is taking a long time for Scapulae, de select this option. Not recommended, but it was not completing on some computers so do this if needed.
- Smoothing is prety self explanatory: it smoothes out the mesh. This *can* be useful, but if you enable it be sure to keep iteration amounts between 1 and 3, as going higher loses the surface detail that we need to generate accurate clouds.
- Remesh modifies the mesh so that the triangles that make it up have more similar areas. This is very useful, but keep it at default.

Alignment

- This section allows you to modify the alignment and the reflections of meshes
- For our purposes, the *CreateProject.py* file mentioned above assigns the "right" group to any bone that contains "Raxes" in its name. Otherwise, it assigns the "left" group
  - This is done because the Keisuke dataset is the only one with meshes from both sides of the body - Akira has only the left. The Keisuke dataset names corresponding meshes "Raxes" for the right side, and "Laxes" for the left, resulting in the above logic for the script.
- Select the "Reflect" option to reflect the meshes so that they all have the same orientation.

- Change the "shape_file" option to "group_side" to enable this feature



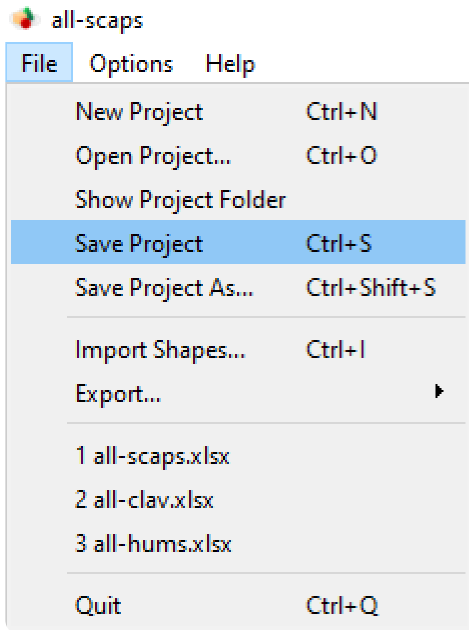
Section 3b: Optimizing

- There are a lot of options to choose from here, and they all have different effects. Here is what I have found through trial and error, and the page on what the parameters mean and some quick tips on optimization from ShapeWorks:
  - Number of particles
    - The amount of particles the program generates
    - Keep this number low while fine-tuning your parameters (x<64) but increase and decrease by factors of x*2 if you need to.
    - Increasing it provides a mesh with higher detail at the end, but takes much longer
  - Initial Relative Weighting
    - How the initial correspondence is weighted
    - Increase this number (by a factor of 0.01) in order to make particles correspond better
  - Relative Weighting
    - Relative weighting of correspondence during optimization
    - Decrease this number (by a factor of 1) to help particles spread more evenly across the mesh
  - Starting Regularization & Ending Regularization
    - Don't worry about modifying these(?)
  - Iterations Per Split
    - How many times the optimization occurrs per split of points
    - Keep this around 1000, increase it to help get particles to be in the "right places" but there are diminishing returns on increasing it.
    - This affects processing time quite a lot, especially with higher amounts of particles
  - Optimization Iterations
    - How many times the program will optimize point location per iteration. Keep this around 1000.
  - Geodesic Distance

        - Don't enable this. Increases computing time by a factor of 10x and is not useful for our application.
    - Normals
        - Tells the algorithm whether to consider surface normals and the xyz of a particle in correspondence
        - Should be enabled to avoid particles flipping sides on thin structures
        - Seems like it may be needed in order to get particles to place correctly on most smaller structures
    - Normals Strength
        - How much the algorithm ascribes strength of surface normals relative to position.
    - Procrustes
        - These options provide minimal changes and have little documentation. Would recommend to just avoid for now.
    - Multiscale Mode
        - No documentation on this option and it hasn't provided meaningful improvements. Would recommend avoiding this.
    - Multiscale Start
        - After how many particles should multiscale mode begin.
    - Narrow Band
        - Doesn't affect optimization. Don't worry about this.

Section 3c: Exporting Data

- To export the key point data, just save the project! This will save all of the current particles in a folder with the same name as the project, just with "_particles" appended.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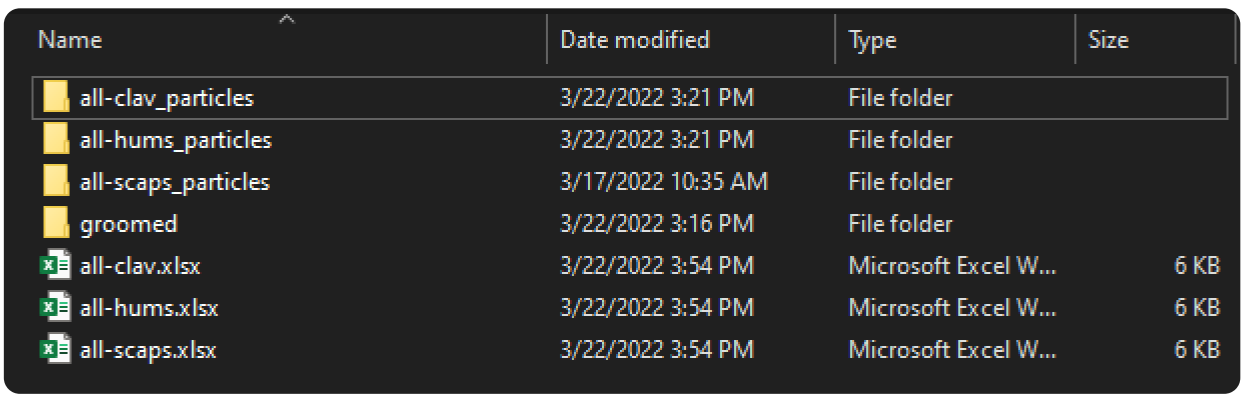
3 all-hums.xlsx
Quit Ctrl+Q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