Undergraduate Research at Estrella Mountain Community College with Mayo Clinic on Creating Patient-specific Models for Fluoroscopy Skin Dose Estimation

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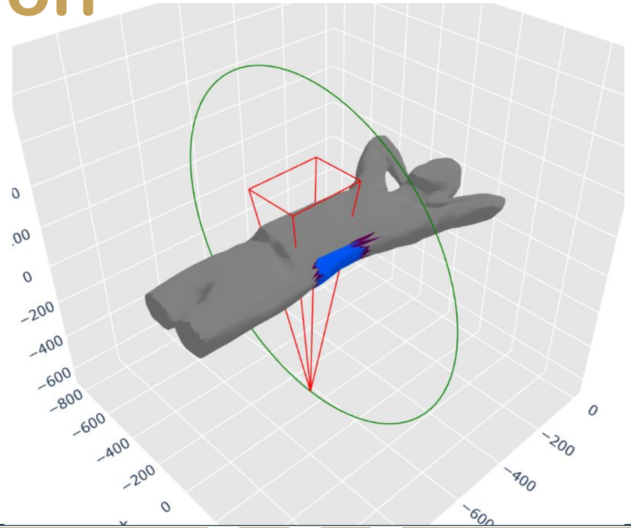
Estrella Mountain Community College
A Maricopa Community College

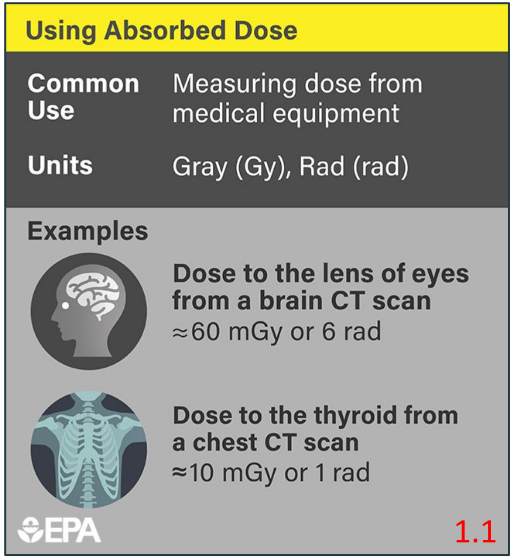
Mayo Clinic



Importance of URE at EMCC

- Part of High Impact Teaching practices
- Develop STEM identity
- Early exposure to research process first hand
- Community College students are capable of rigorous research

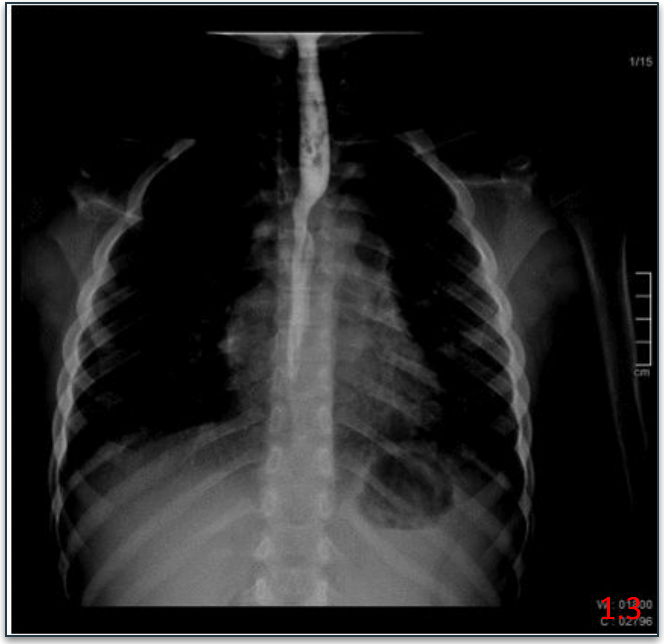
Introduction to Fluoroscopic Procedures



- Absorbed dose is measured in Gray Units (Gy) and it is important in fluoroscopic procedures to assess the risk of skin damage
- Patients are exposed to radiation for extended periods of time. Peak Skin Dose (PSD) is used to find the maximum dosage of radiation to a small area of the skin during the procedure

X-ray vs Fluoroscopy

1.2

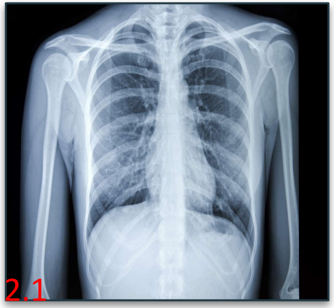


1.3

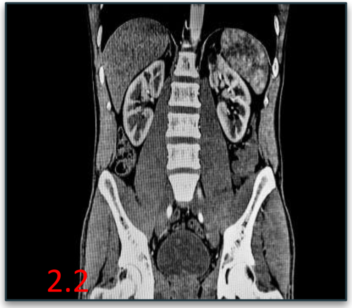
- What are the differences between an X-Ray and a Fluoroscopy?
- What are cases that would require a fluoroscopy?

- How does a fluoroscopy work?
- Why is this important in the medical field?

How big is a Gy?



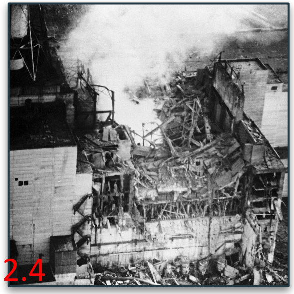
Chest X-Ray
Equivalent of 10 days of background radiation



CT Scan
Roughly several months to a years worth of background radiation

Fluoroscopy Procedure
Most procedures are .01 Gy of radiation but is dependent on the length of the procedure

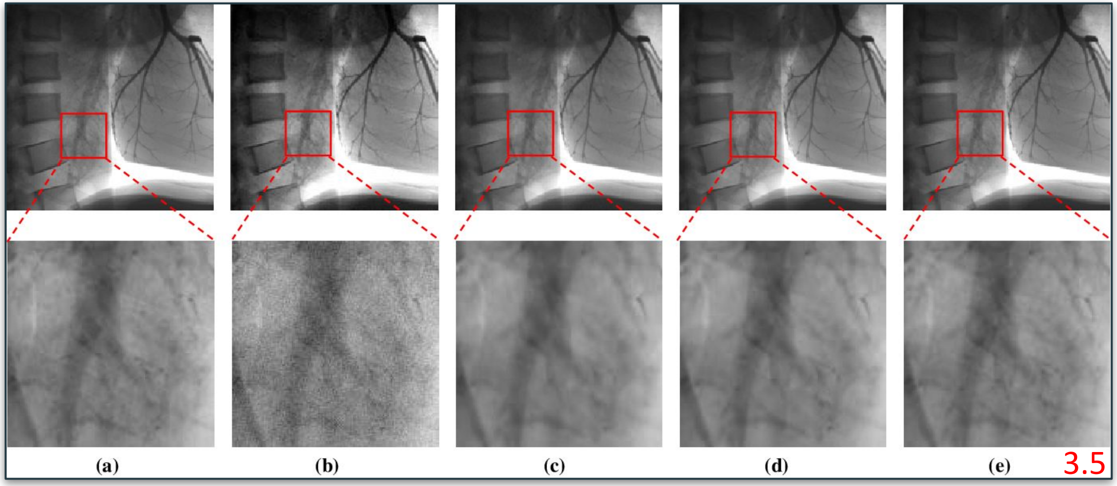
Atomic Bomb Exposure
Civilians 1-2 km away from the impact would experience radiation burns, radiation sickness, and long term risk of cancer



Chernobyl Incident
Workers experienced acute radiation sickness, long term risks of cancer, and death

0.0001 Gy | 0.001 - 0.02 Gy | 0.001 - 0.1 Gy | 1-10 Gy | 10+ Gy

Gys in a Focused Area



- A PSD of 2 Gy is generally all that is needed to cause erythema in most radiosensitive individuals. 5 Gy or more may be needed for a typical individual.
- As the skin dose increases so does the severity of the skin damage.

PSD Range & Related Skin Injury

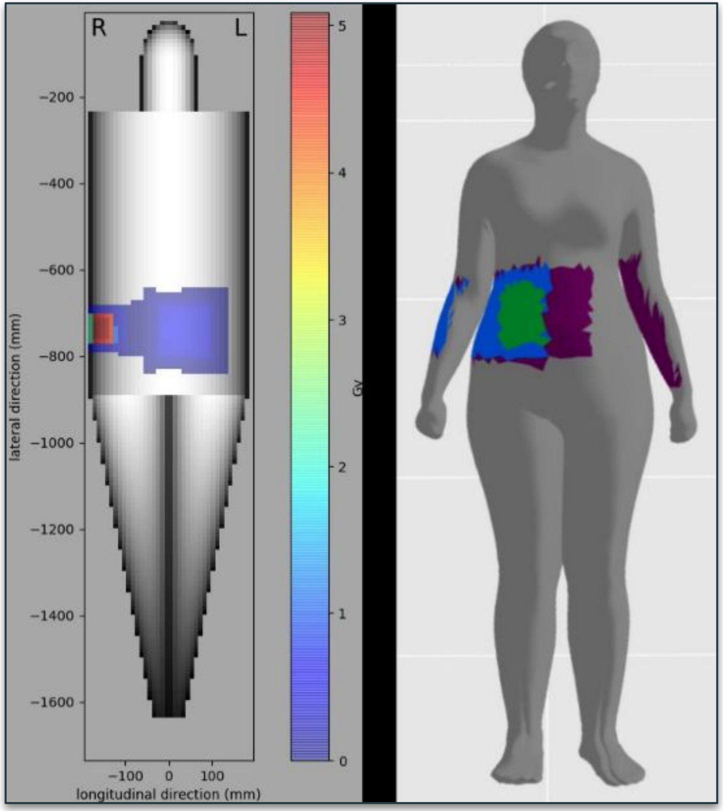
2-5 Gy

5-10 Gy

10-15 Gy

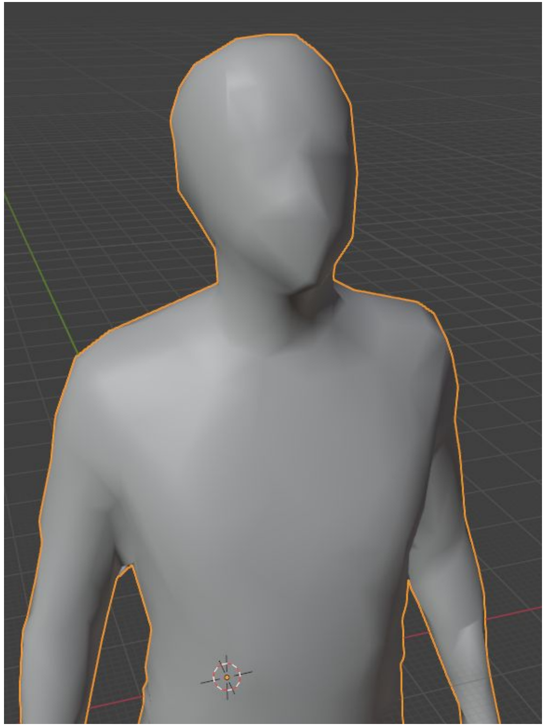
15+ Gy

Previous Groups Question?

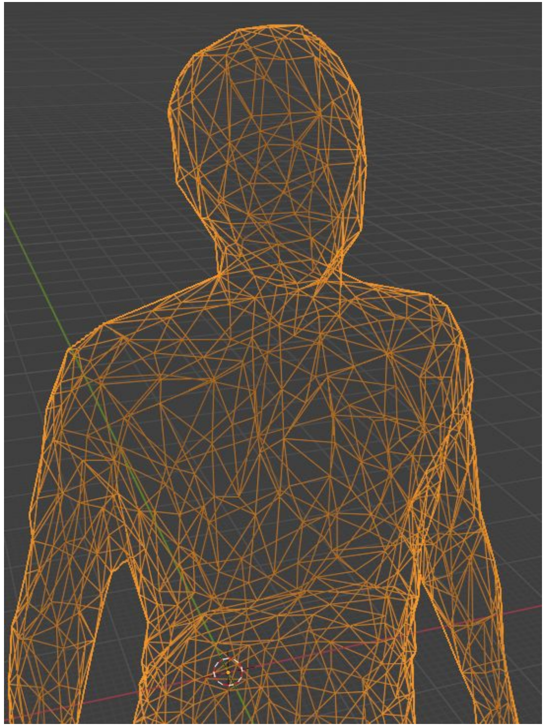


- What can be done to improve the accuracy of PSD calculations?
- How do peak skin dose calculations compare between cylindrical and anthropomorphic models?

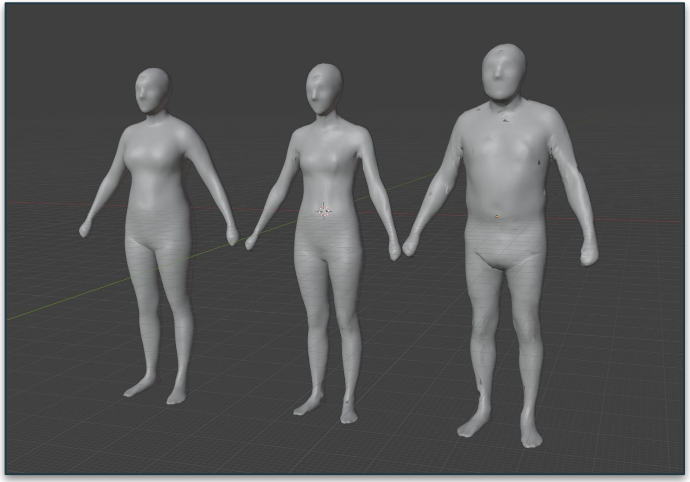
Triangulation



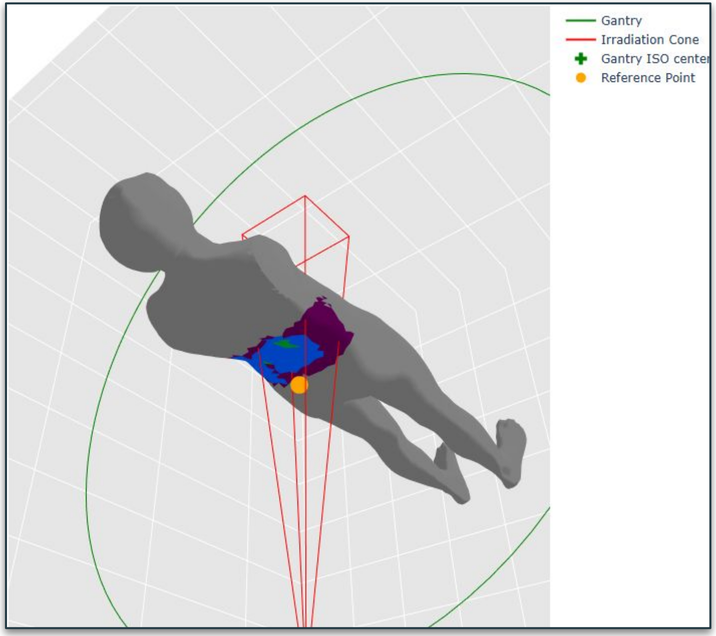
- How we represent 3d models digitally (Computers don’t really make round things)
- The more triangles the smoother the surface looks



Tools provided by Mayo



- PSD calculator and past fluoroscopy data and meshes were provided by Mayo clinic
- 110 cases were provided to calculate the PSD.



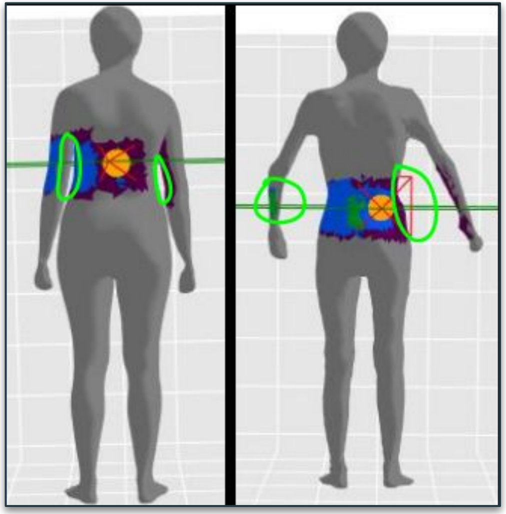
- 22 models (11 male, and 11 female) chosen from a public database, based on estimated height and weight percentile combinations.

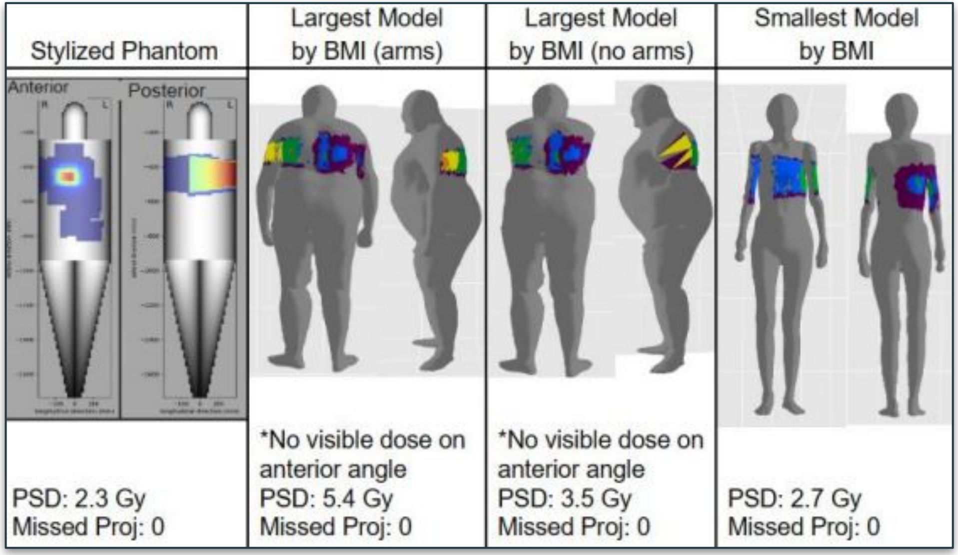
Previous Group's Research Results

- Anthropomorphic Models PSD Vs. Cylindrical Models W/ Missed projections

  - Arms down: (4.7% ± 2.1%)

  - Arms removed: (0.0% ± 15.1%)



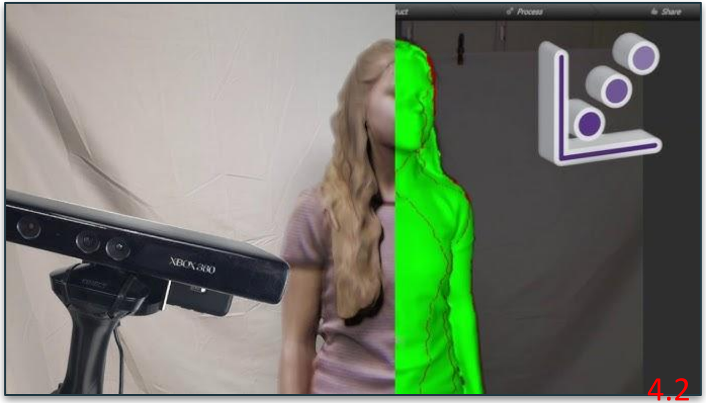


- Dose estimation software should be implemented using individualized patient models to better approximate PSD

Our Question & Purpose

- Could we use a depth camera to create an efficient system to construct individualized patient models and run them through a PSD calculator?

4.1

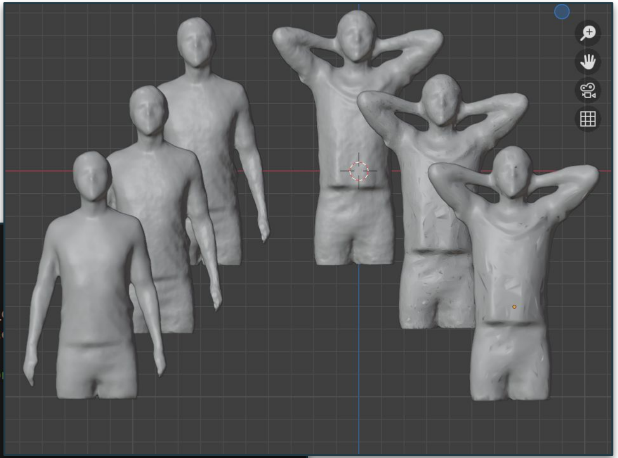


4.2

Klepel, Chris. *Turable Motor*. 2021.

Overview

- Make meshes
- Polish meshes in Blender
- Calculations & Data Collection
- Data analysis

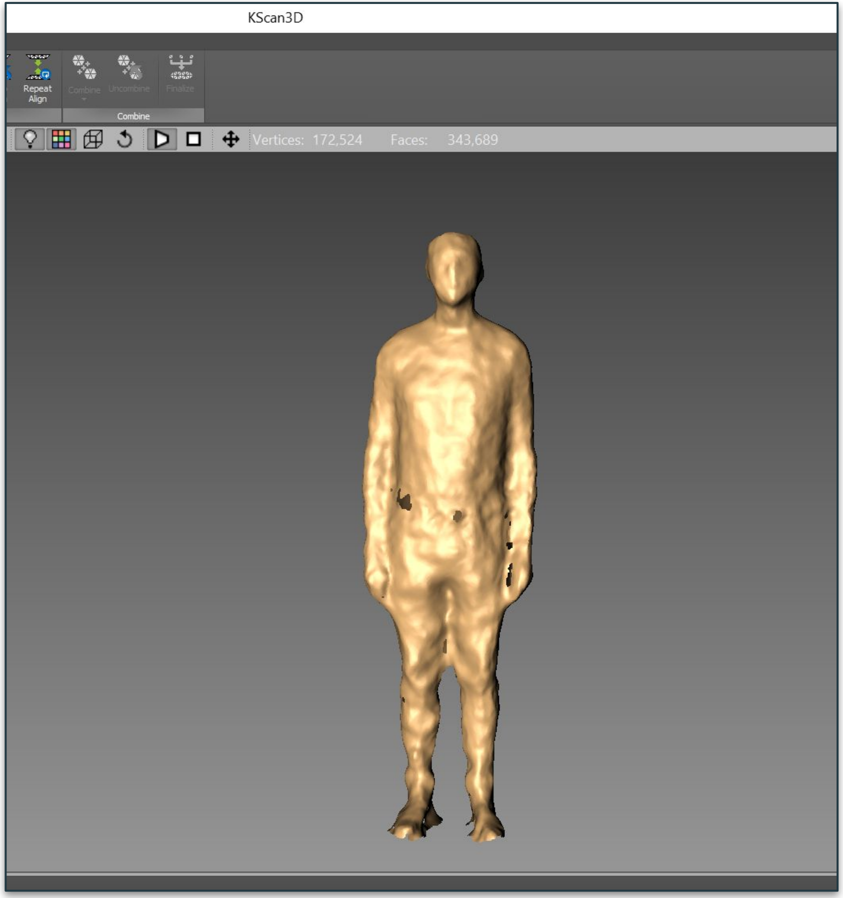


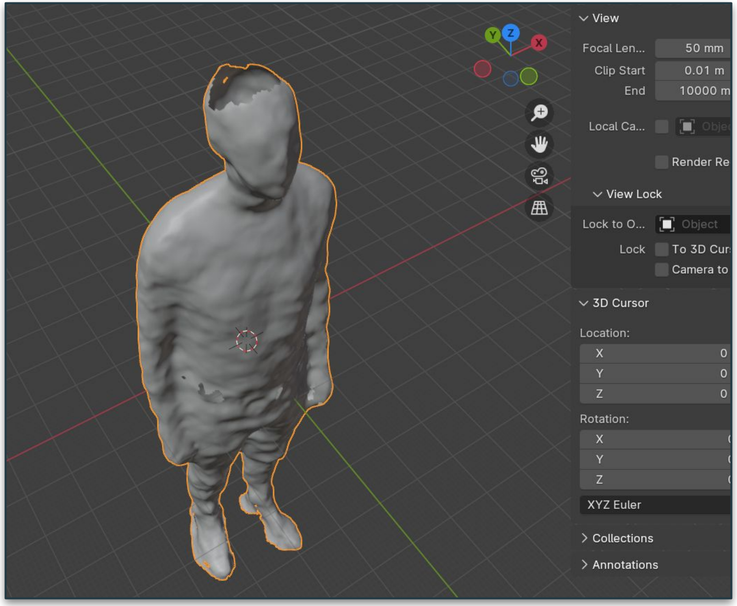
```
    parameters = device_parameters_dict[station_name]

    parameters['phantom_translation_lateral'] = 0
    parameters['phantom_translation_longitudinal'] = 0
    parameters['patient_orientation'] = data['structured_report_
    parameters['patient_orientation'] =  parameters['patient_ori
    # parameters['patient_orientation'] = 'hfs'
    parameters['phantom_translation_height'] = -50      # cushio


    res = calculate_skin_dose(
        study_dict = data['study_dict'],
        structured_report_dict =  data['structured_report_dict'],
        patient_orientation = parameters.get('patient_orientation'),
        table_attenuation = parameters.get('table_attenuation'),
        back_scatter = parameters.get('back_scatter'),
        stationary_acquisition_correction = parameters.get('stationary_acquisition_correction'),
        fluoroscopy_correction = parameters.get('fluoroscopy_correction'),
        phantom_translation_longitudinal = parameters.get('phantom_translation_longitudinal', 0),
        phantom_translation_lateral = parameters.get('phantom_translation_lateral', 0),
        phantom_translation_height = parameters.get('phantom_translation_height', 0),
        geometry_transform = GeometryFromTemplateInstance(device_geometry_instance),
        patient_model = M1,
        patient_z_auto_translation = True
        )
    return res

run_data = (M1, data, device_geometry_dict, device_parameters_dict)
res = run_patient_model(run_data)
print(f"{res['result']['max_skin_dose']}") # Peak skin dose
#print(f"{res['result']['missed_projections']}") # Missed projections
```

Creating Meshes

- Learning K-Scan Software
- What are the capabilities of the kinect?
- How many attempts did it take to get a mesh?

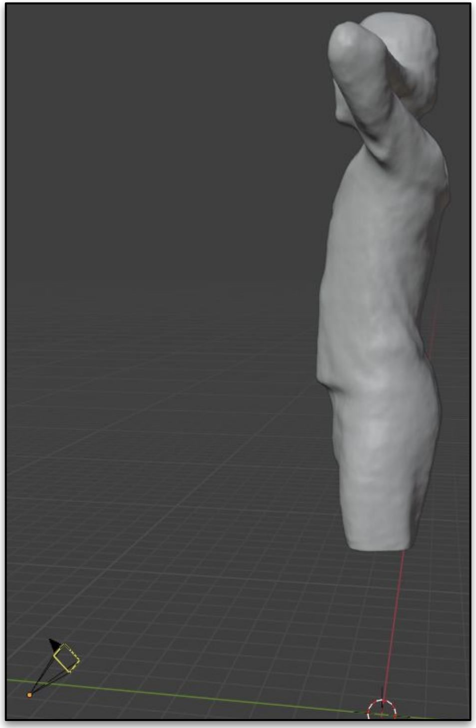
1st Attempt

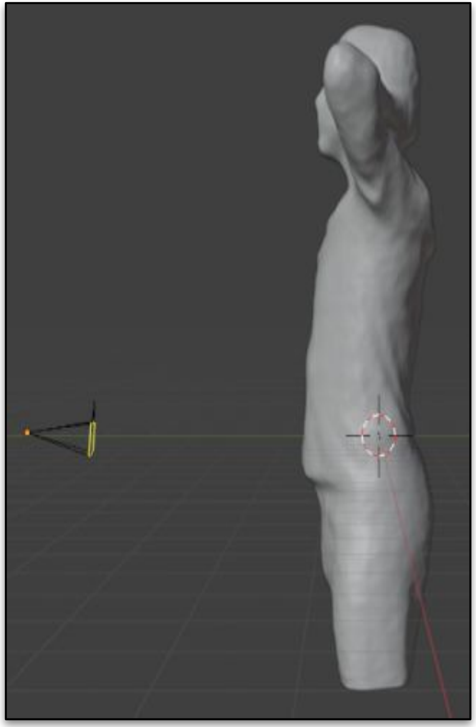


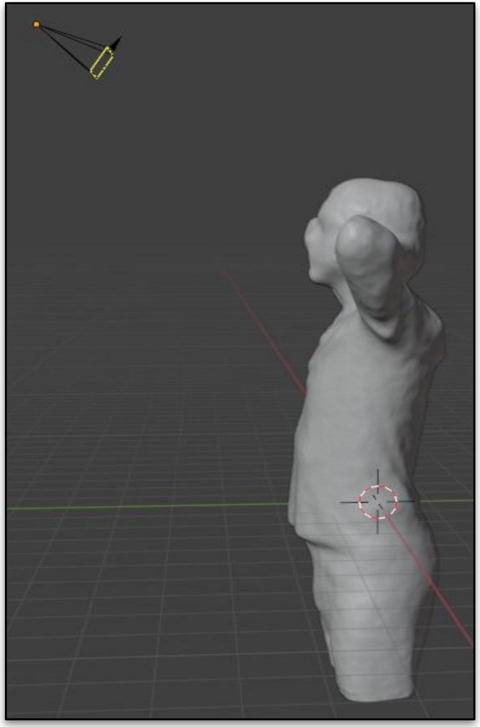


- Xbox Kinect
- K-Scan Software

Refined Scanning Process



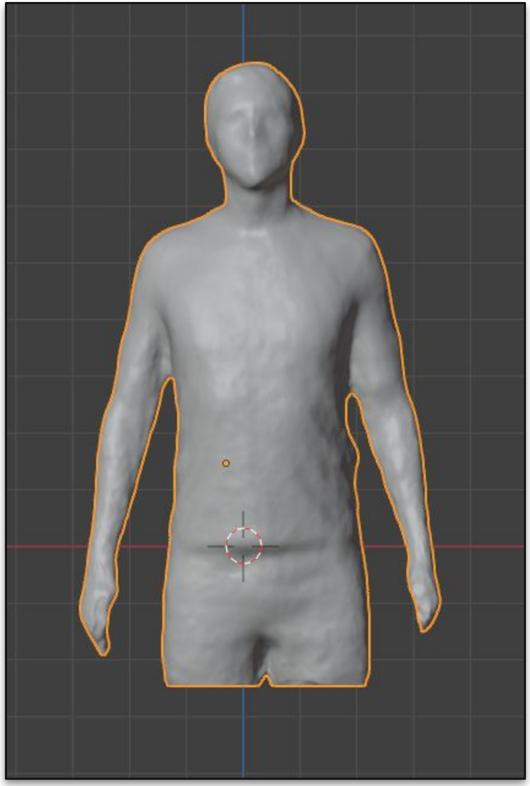


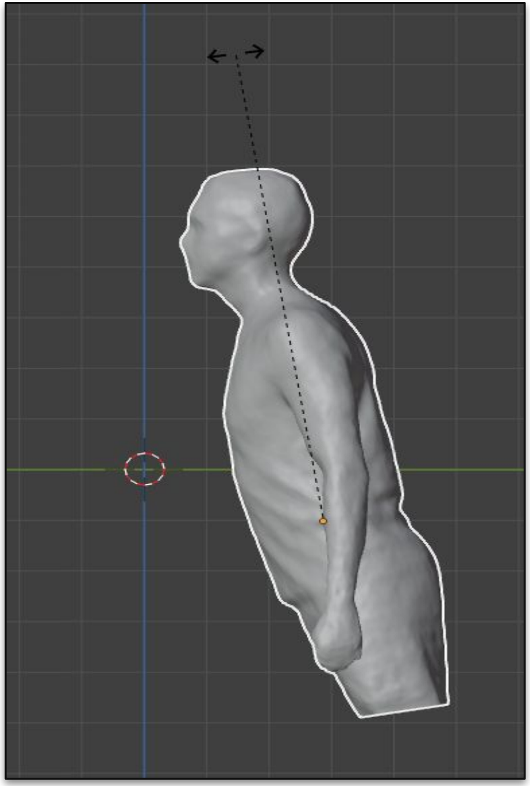


- Angle x 3 ≈ 90 snapshots total

Blender Work

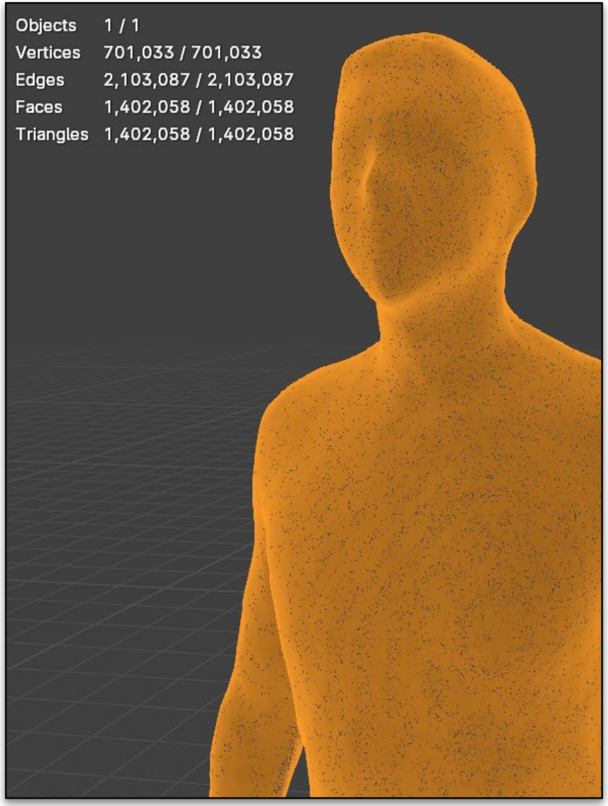
- Up-Scaled Meshes
- Positionioned Meshes
- Bisected Limbs
- Interested in Torso

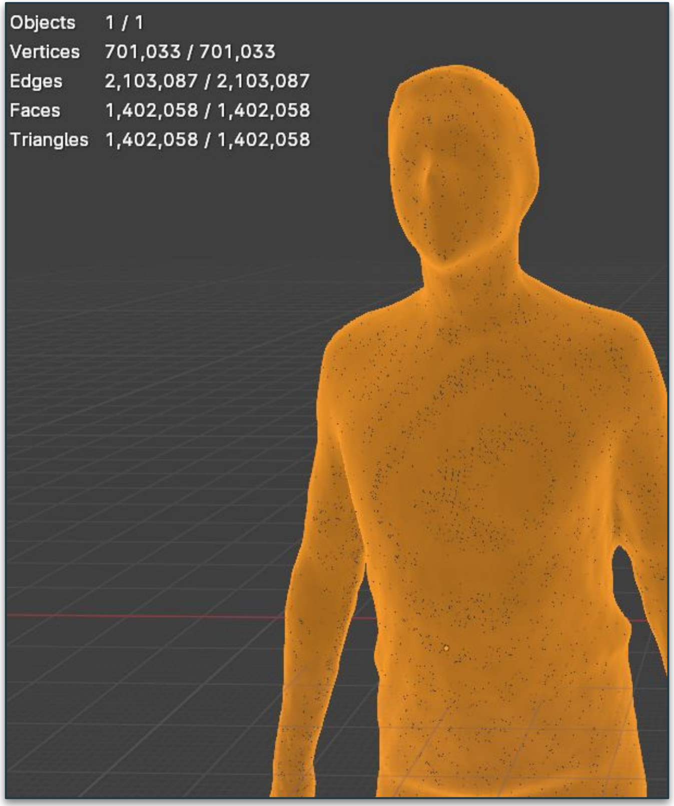




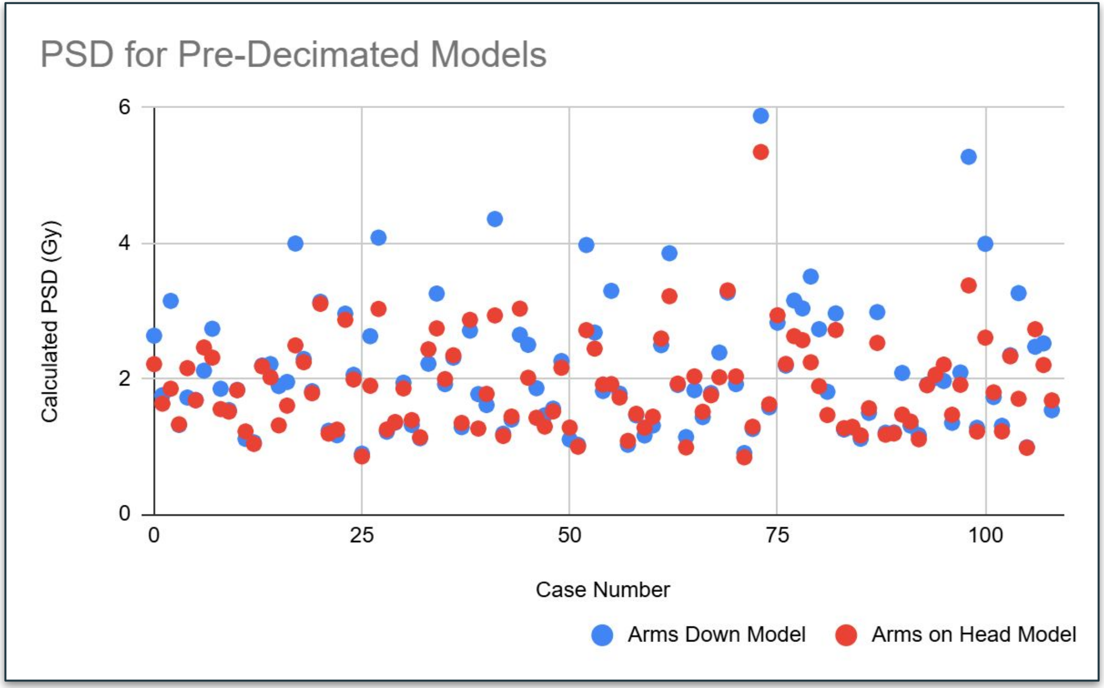
Models Used for First Round of Calculations

- Stepping Stone (We were able to create very accurate personalized meshes with kinect)
- Wouldn't be large expenditure for clinical use





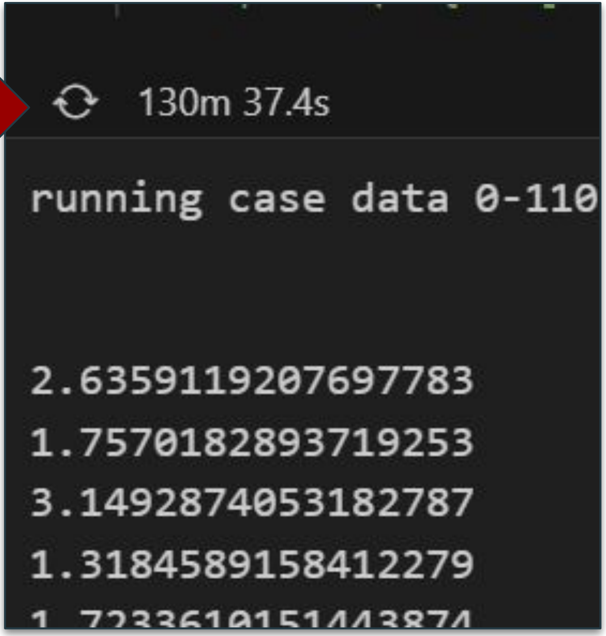
Data for first Round of Calculations



- Calculating the PSD for the Decimated and scaled models
- Used 110 real cases to calculate the PSD
- Gathered data on the amount of triangles and vertices on each mesh.

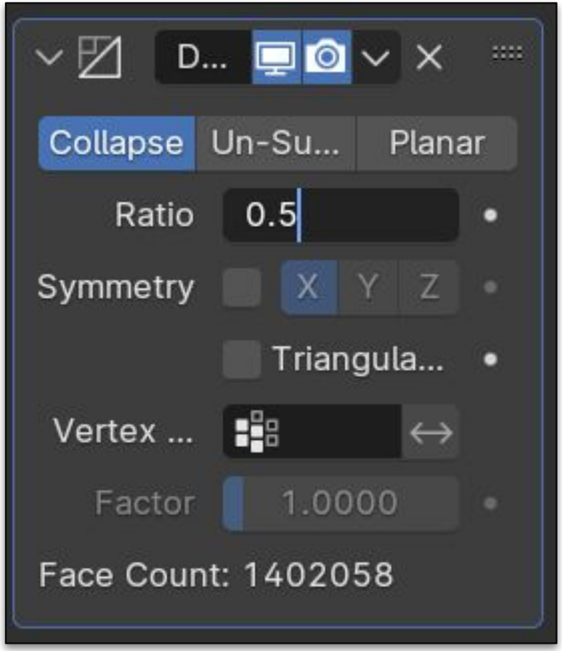
Long Calculation Times

- Not practical for collecting data
- Lots of triangles (Loss of efficiency compared to anthropomorphic models)
- How much longer was it taking for undecimated models compared to decimated models?



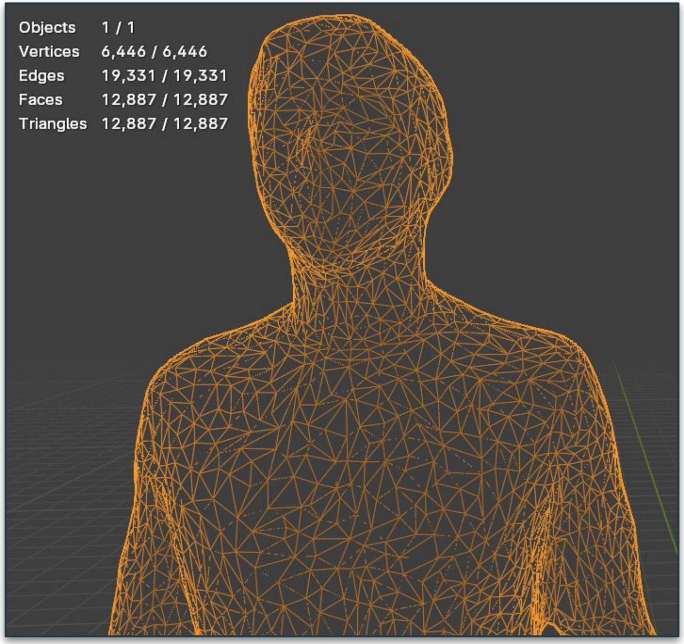
Looked Into Decimation

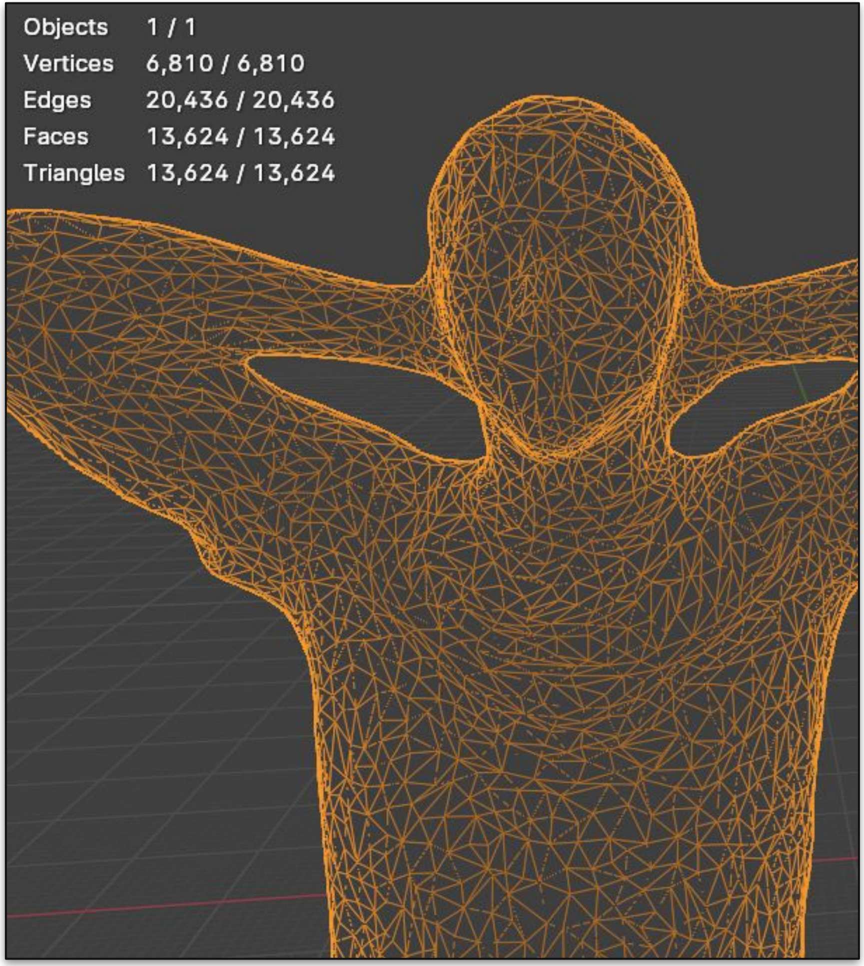
- Blender function
- Reduced ratio
- Ex. 1.5mil triangles to 750k triangles (0.5 ratio)



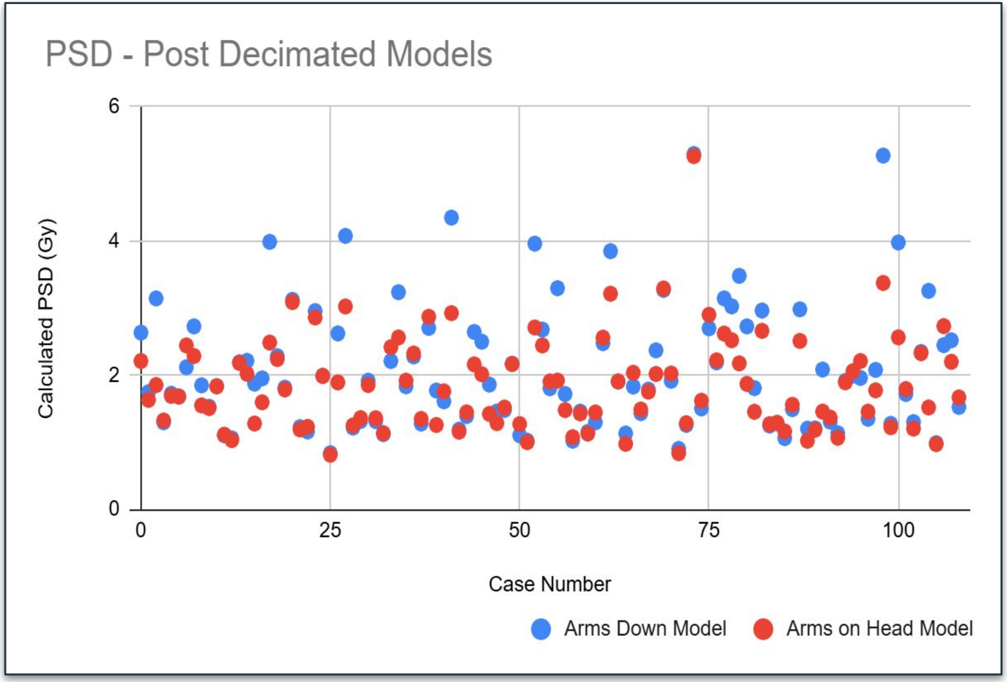
Decimated Models

- Models stats consistent after decimation with undecimated
- Stats matched models



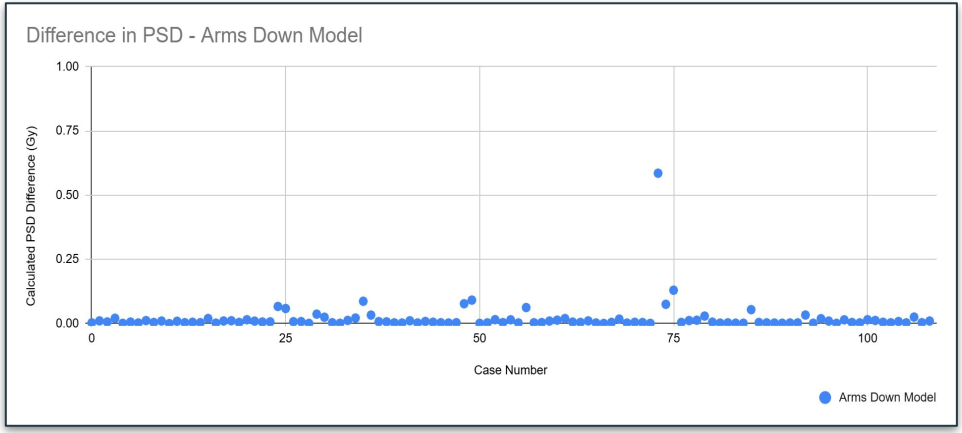


Calculations for Decimated Models



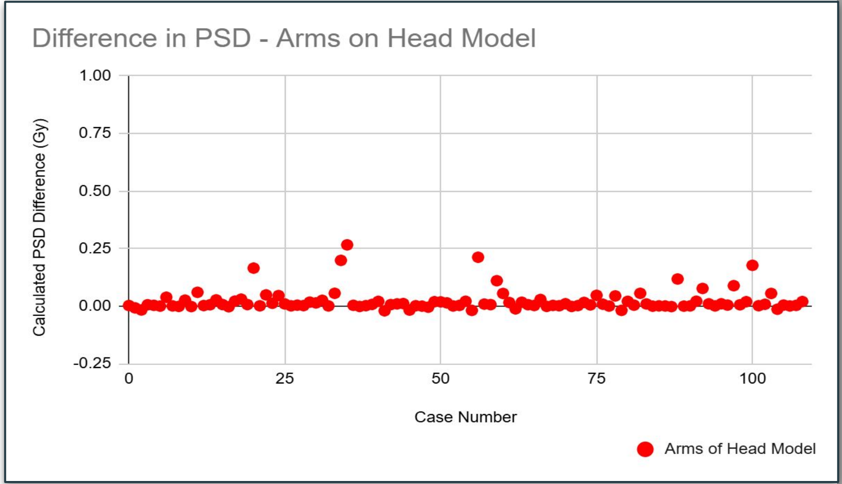
- No surprise, shorter run times which was goal of decimation
- Used same 110 cases used for 1st round of meshes & compared data
- How much did decimation effect PSD

Data Analysis



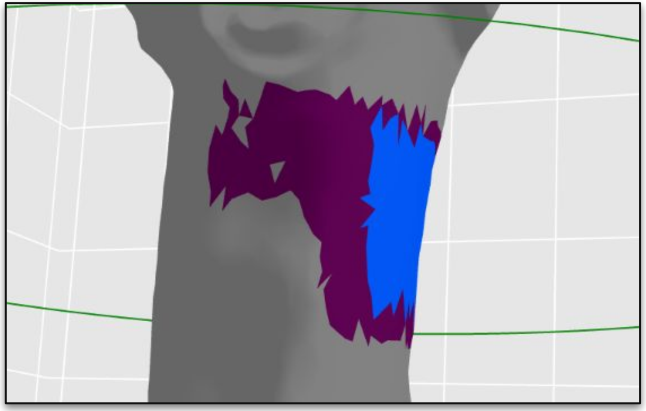
- Arms Down had an average difference of 0.8%

- Arms Up had 1.26% difference between undecimated & decimated

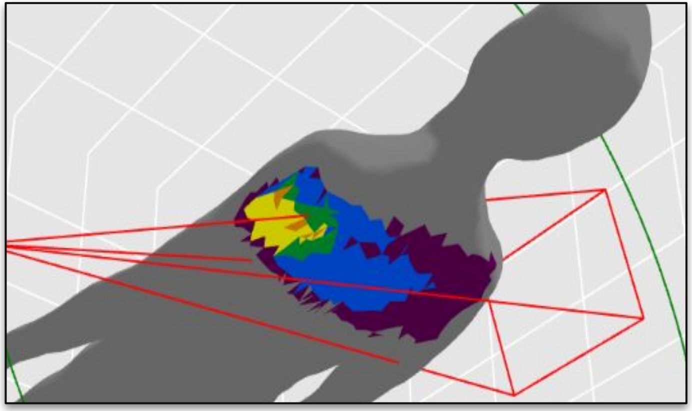


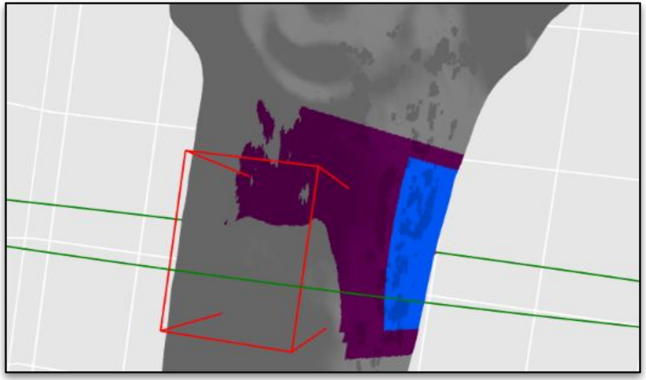
Outliers

Arms Up Decimated Case #35

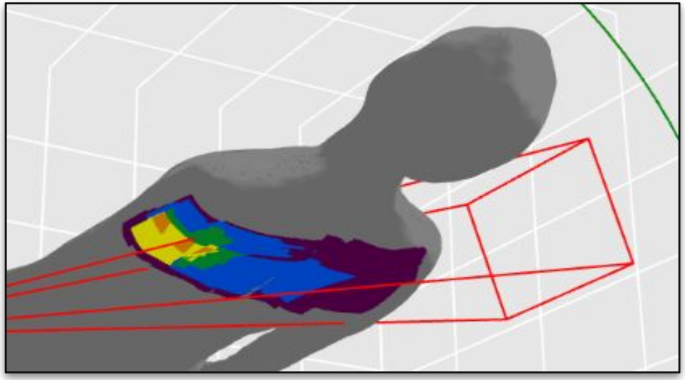


Arms Down Decimated Case #73





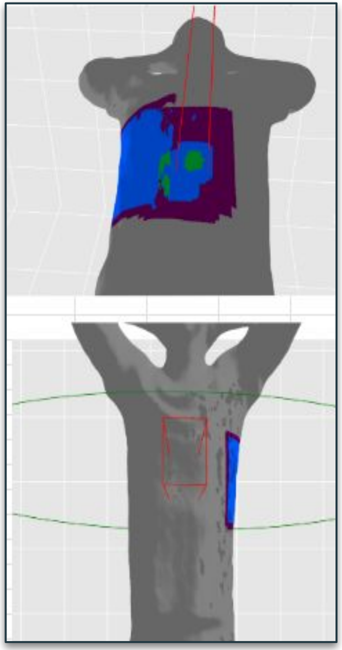
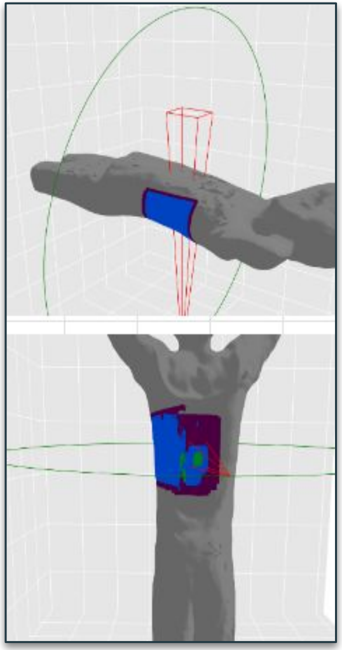
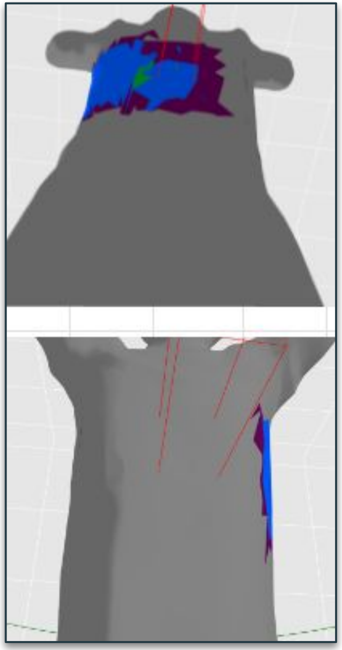
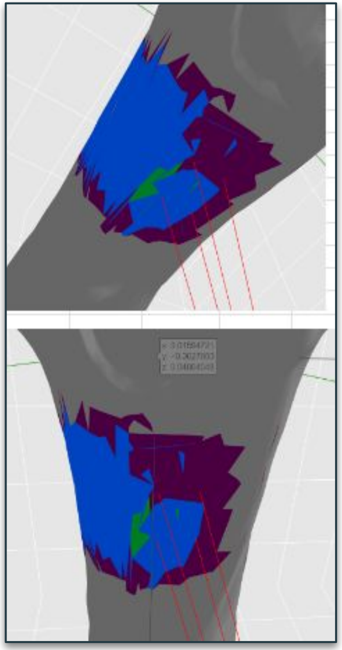
Arms Up Undecimated Case #35



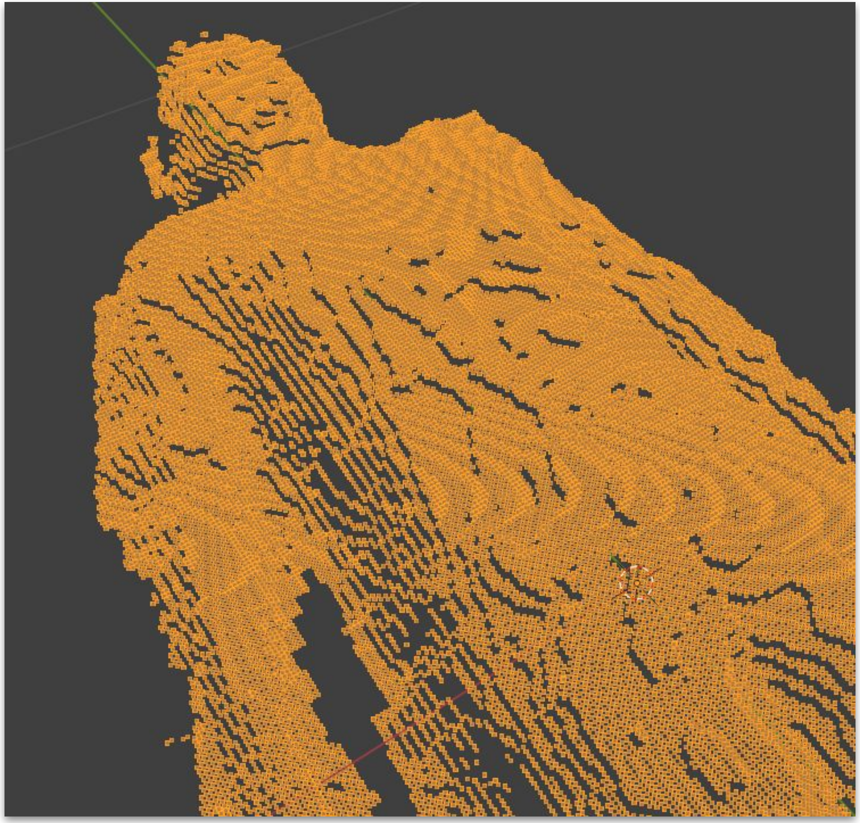
Arms Down
Undecimated #73

Conclusions & New Questions

- Decimation had benefits and drawbacks
- Research leads to a positive outlook that there is a method that can be efficient to use in a clinical setting and produce accurate PSD readings.

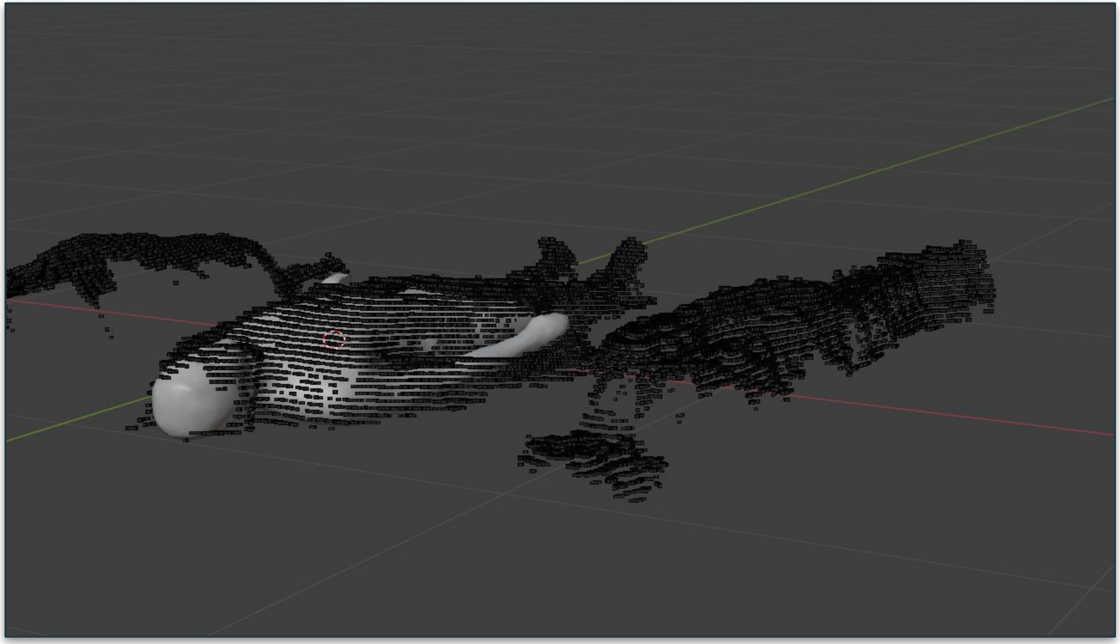





What is a Point Cloud



- Point Cloud - Made up of many individual points located using a 3d coordinate system
- All the points together make up what is seen in the image

Plans for the Future



- Make patient model fit into their point cloud to improve accuracy further
- Implement 3rd party software to rig a pre-existing mesh

Plans for the Future

- Collect PSD data from real procedures using phantom
- Create mesh of Mayo Clinic phantom
- Put mesh through dose calculator program
- Collect data
- Compare accuracy between them

Our Experiences & Reflections

Images

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- Wolfgang Stefan (Mayo Clinic, Phoenix, AZ)
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RSNA (Radiology Society of North America)

ANAS (Arizona Nevada Academy of Science)

Thank You for Your Time!

Q & A Session