# AutoStress

## Interactive Stress Analysis for CAD Models via Machine Learning

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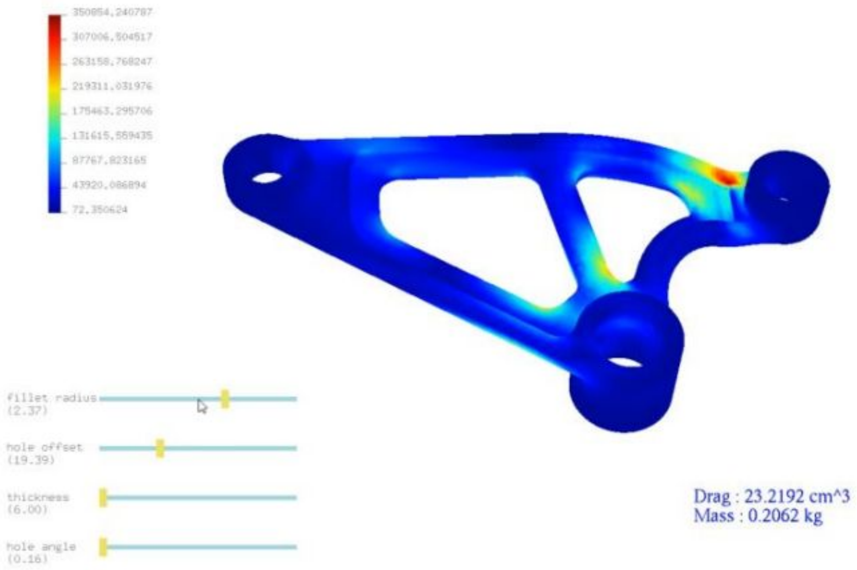
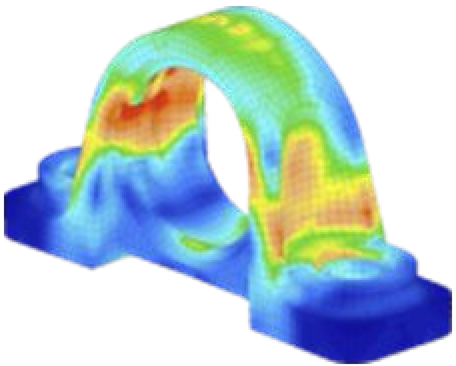
# Dream

- Interactively explore parametric design space of shapes.
- Real-time feedback about how shape will behave in real world.

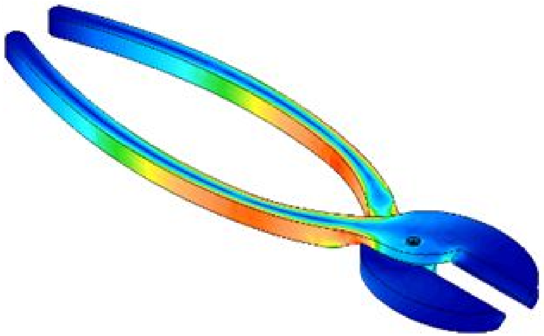



[A. Schulz et. al 2017]

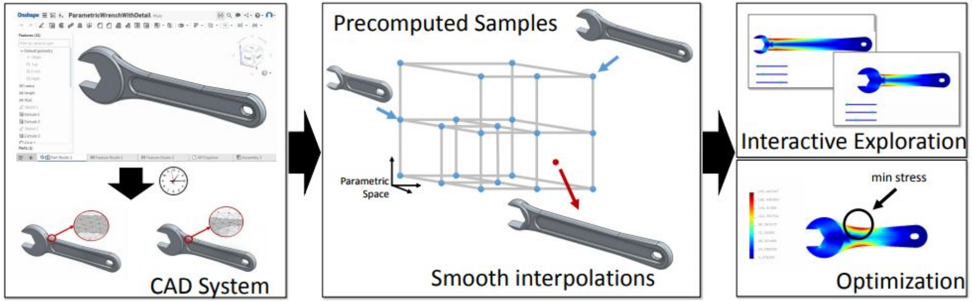
# Reality



- Simulation is slow!
- Stress analysis requires FEM on high-res tetrahedral mesh.
- Takes minutes for most applications.



# Previous Work




Two main approaches

Sample and interpolate

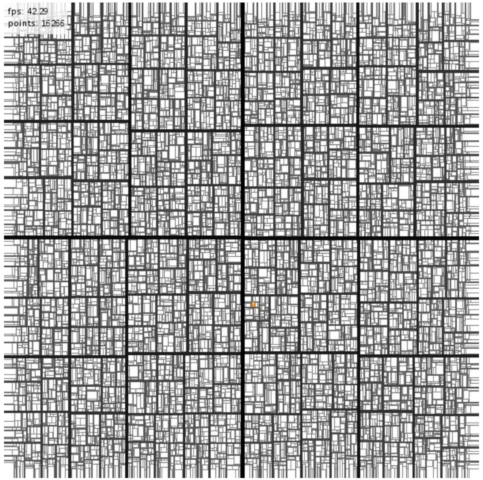
[Schulz 2017] Interactive Design Space Exploration and Optimization for CAD Models

Compute stress in reduced space

$$\sigma = Sr$$

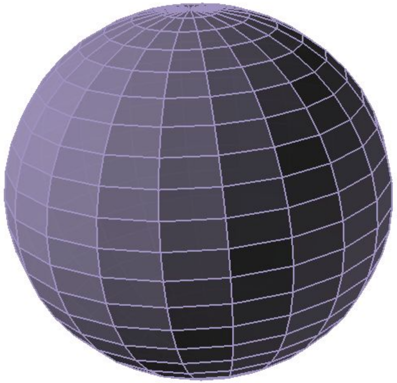
[Chen 2016] Example-Based Subspace Stress Analysis for Interactive Shape Design

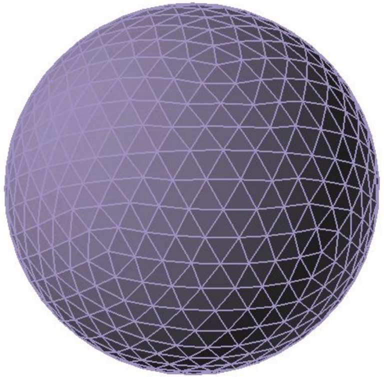
# Shortcomings



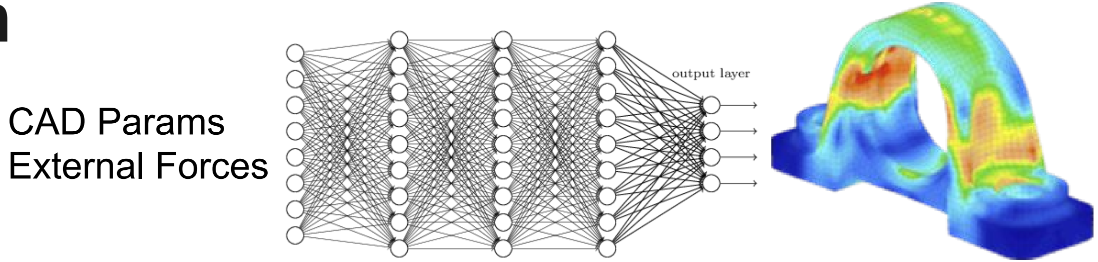

First approach
Interpolation requires storing 2^k meshes sampled using kd-tree
-> Huge memory requirements

Second approach
Requires mesh topology to remain constant
-> Not likely for CAD models





# Proposed Approach




Option 1:

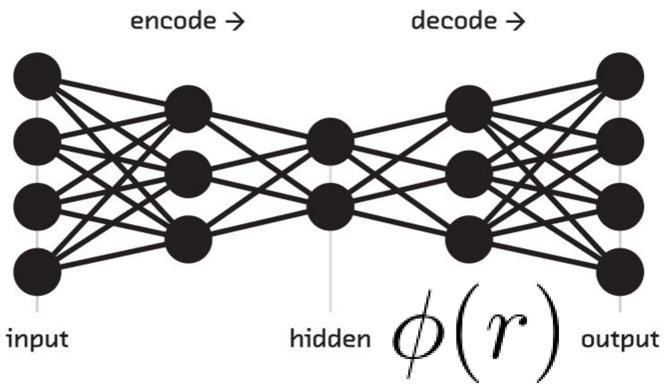
Learn a direct mapping using neural net
CAD model parameters and external forces -> stress field

Challenges

- Need a way of representing stress field on mesh independent of parameterization
    - Graph laplacian?
- How many points in the model space do we need to compute the stress field for?

# Proposed Approach

Option 2:




Use an autoencoder to learn a reduced representation of the space of stress fields.

$$\sigma = Sr \rightarrow \sigma = \phi(r)$$

Now reformulate stress field calculation using reduced degrees of freedom.

# Expected Results

Things get faster?!

Goal is to have realtime feedback of stress  while varying parametric shape parameters.

Hopefully this approach will be faster, or use less memory, or be more accurate, or all three!


Machine Learning (Credit: XKCD)