# A pythonic journey from scientific data visualization to broadly data science

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Gastroenterology

BDSD 2020

# Outline

- Brief intro: → research route, applications showcase
  - Scientific modeling:  python for large-data visualization
  - Clinical data science: python for ML and DL

- Python → How to make it fast?
  - Efficient pipeline:
  - Python vs C (++)

- Python → Visualization analysis
  - Python vs javascript
  - Python way for ‘client-cloud’ visualization

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# Background: Esophageal transport

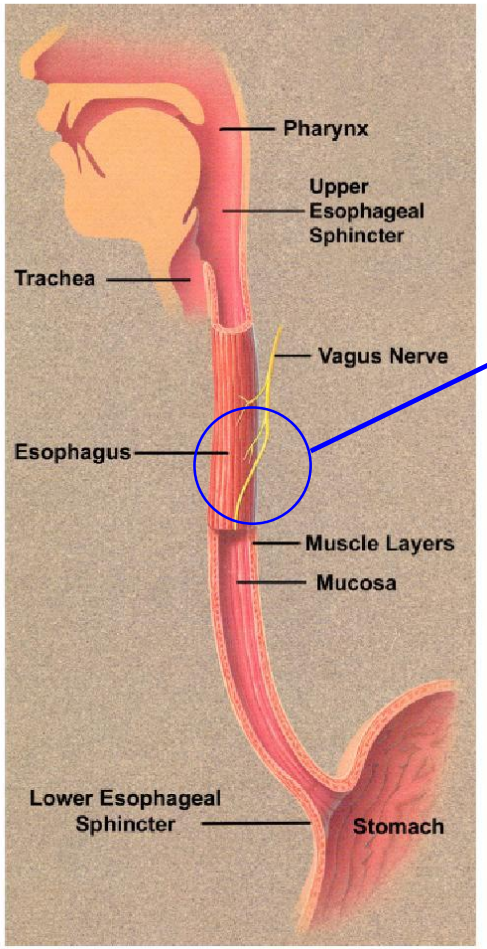
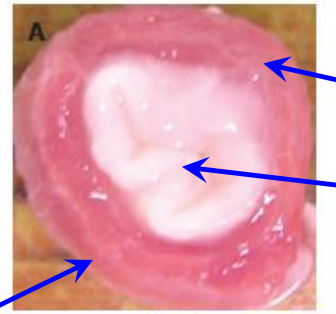


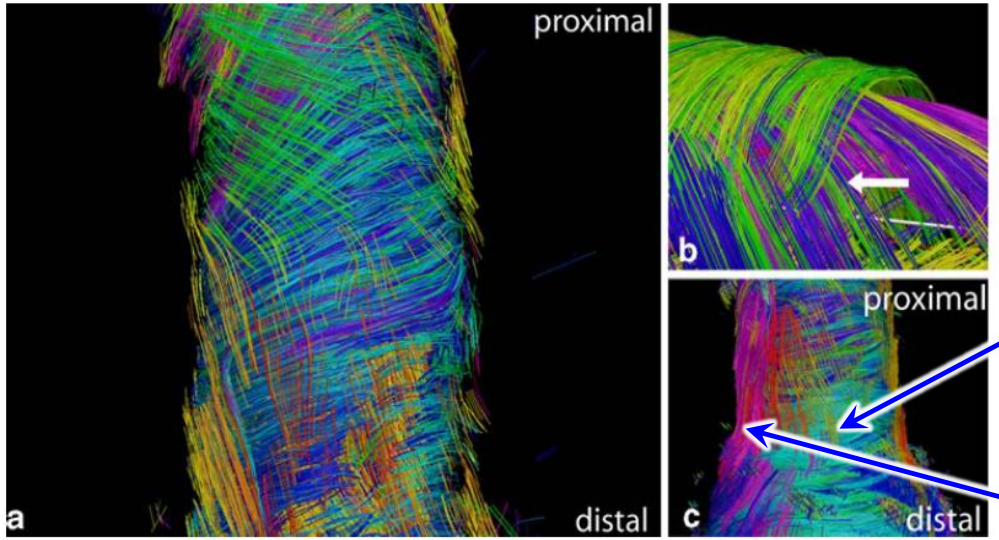

Fig.1. Esophagus
Ghosh SK. (PhD Thesis, 2005)




Muscle

Mucosa (folded)

Fig. 2. Esophagus cross-section
W Yang, et al. World J Gastroenterology 2007

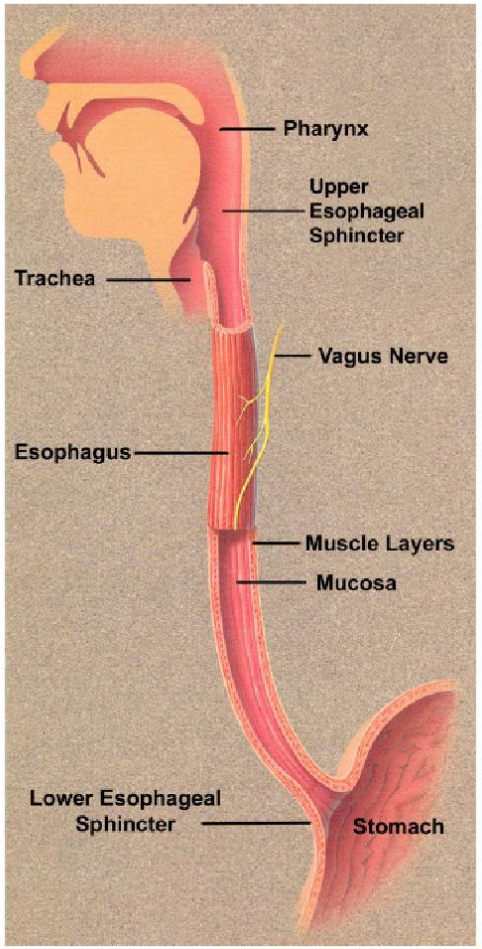


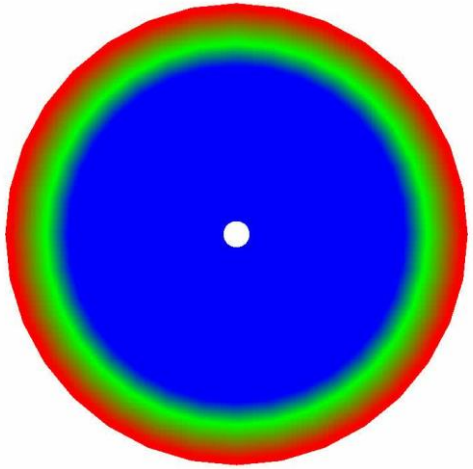

Circular muscle (CM)

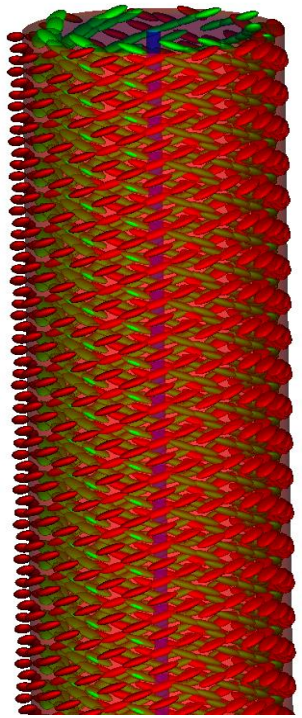
Longitudinal muscle (LM)

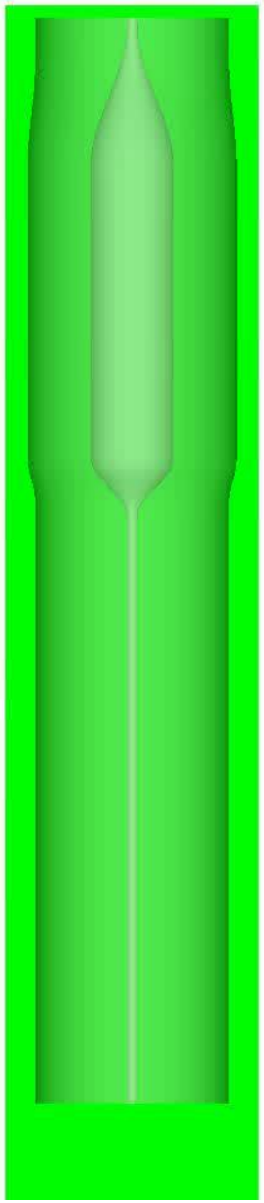
Fig. 3. Myoarchitecture of the esophagus
Richard J. Gilbert et. al, Cell Tissue Res 2008

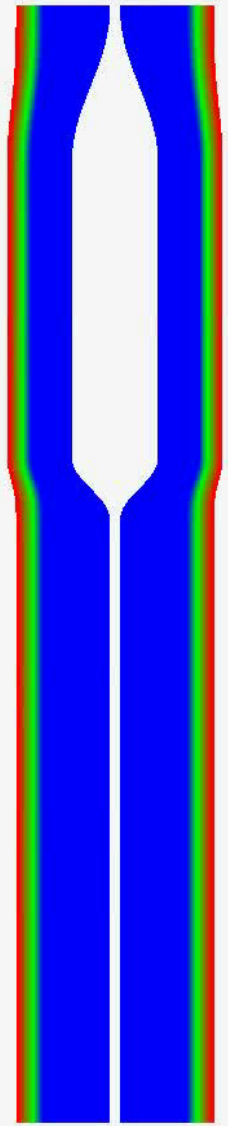
# Simulation model: Esophageal transport

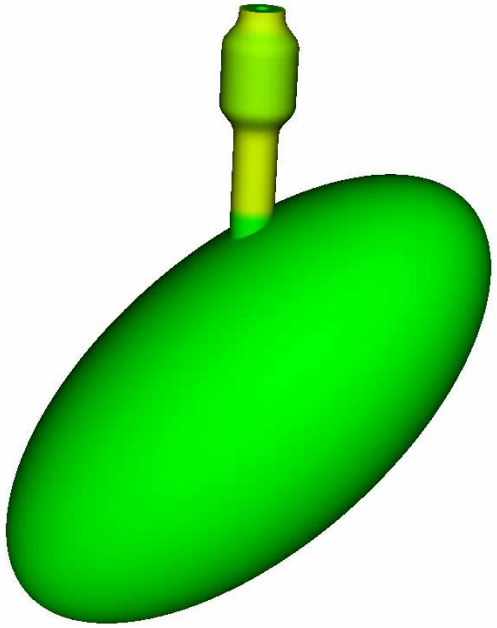


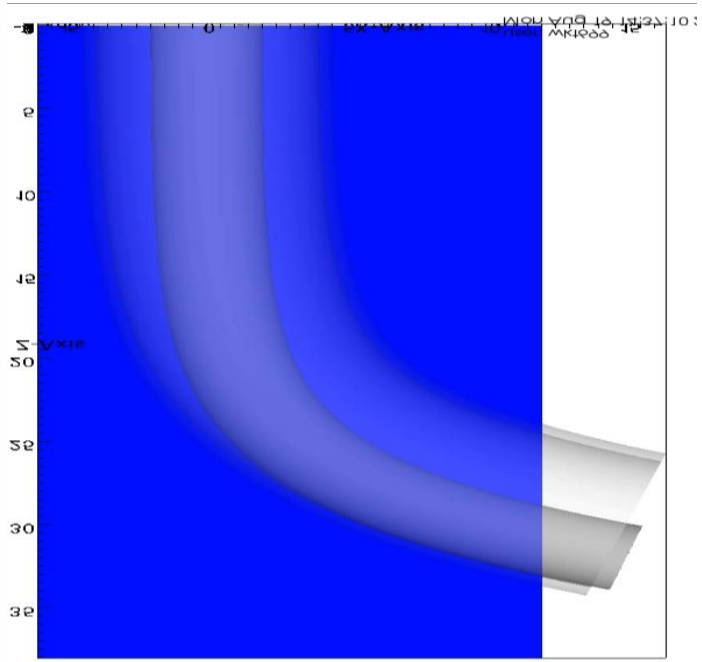









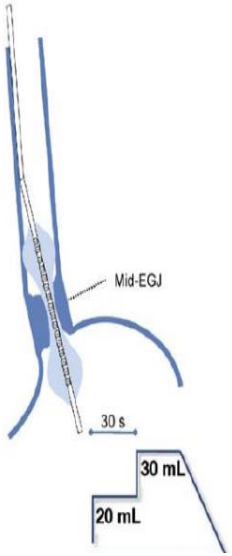




# Clinical device-based modeling → data + simulation

Clinical input: geometry of lumen

Outcome: pressure, velocity, wall stress, stiffness

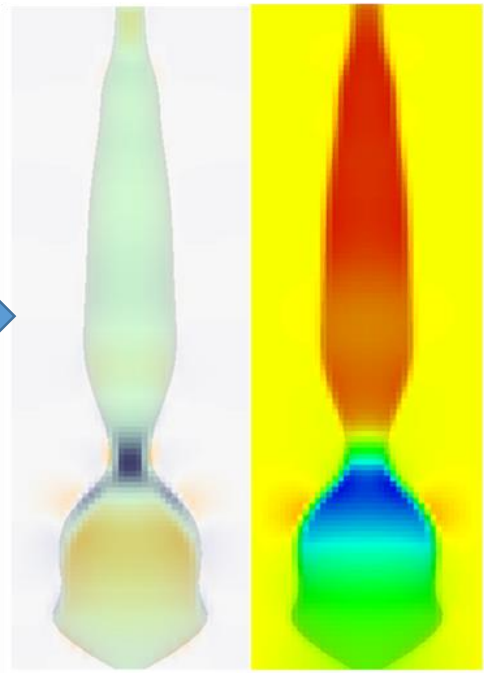


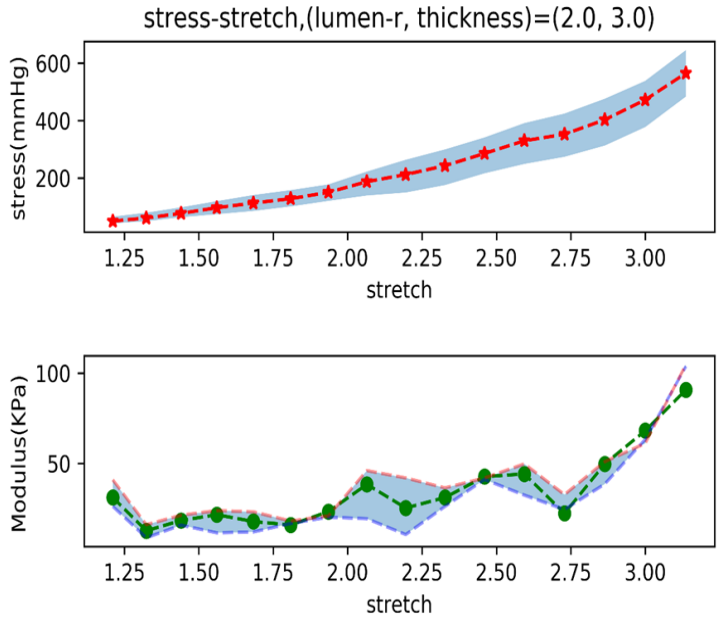


Endoflip



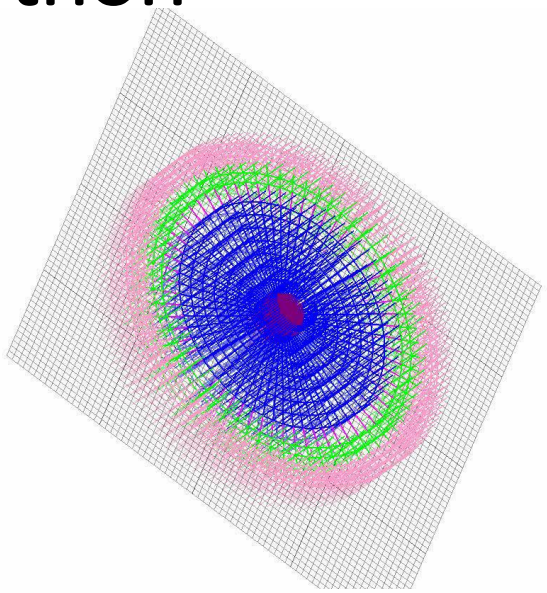
Demo case of axial velocity

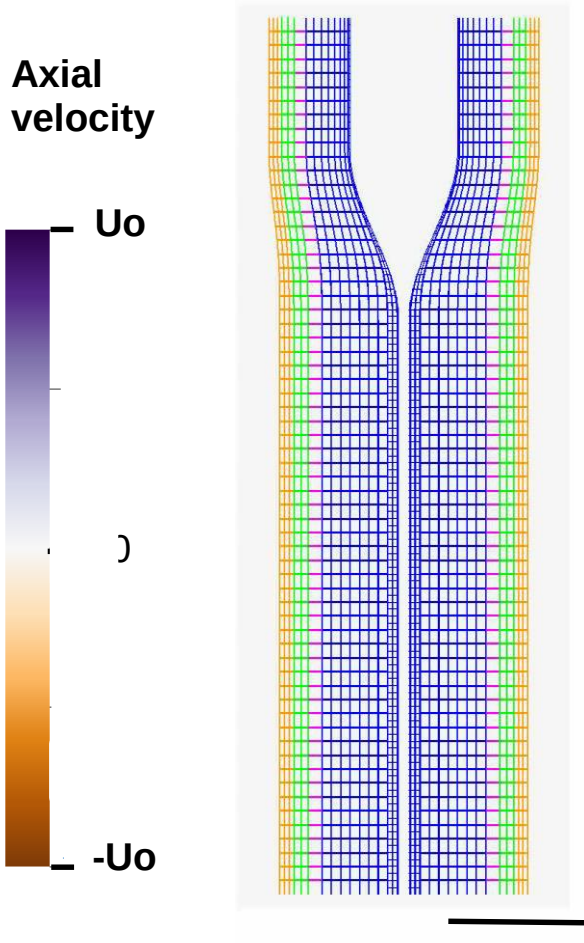


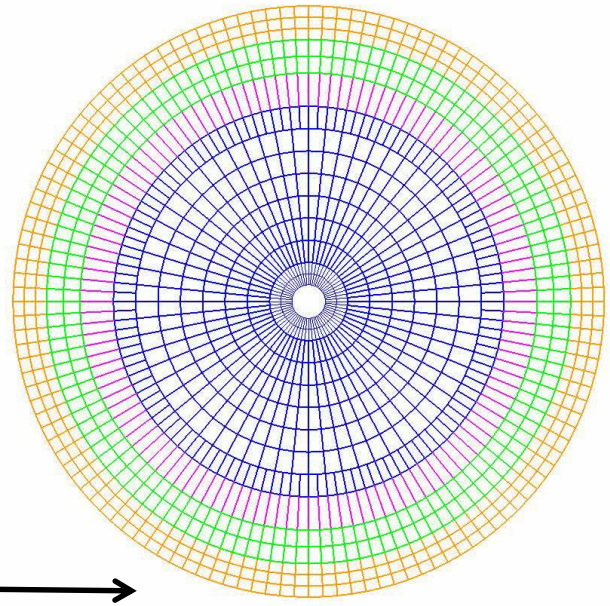



Demo outcomes

# Produce movies? Python





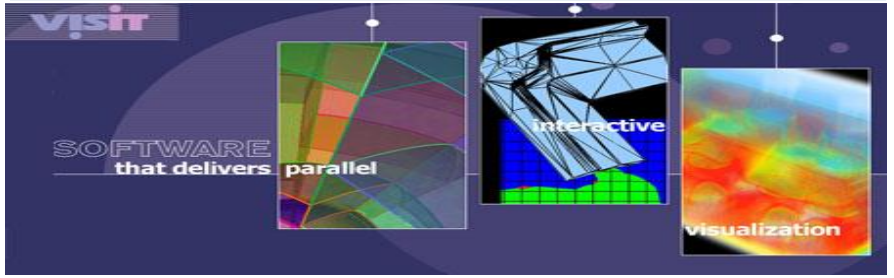



Cross-section view

Large-scale model → Data source

- C++ parallel library (IBAMR)
- Parallel computing on **NU Quest**
- ~5GB data per case

Data visualization: VisiT




ViSiT data on **NU Quest:**

Slow pipeline:

Download to local → open GUI → case by case:

- VERY SLOW FOR MANY CASES

Better pipeline: ?

- Python script + Bash run (templating)
- Generate image (not movies?) on Quest
- ffmpeg to merge image to movie
- Append to submitted job

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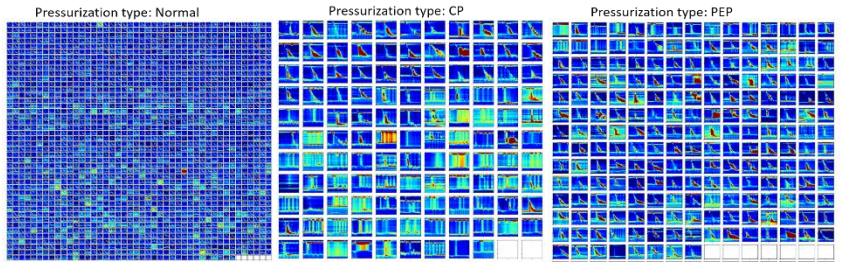
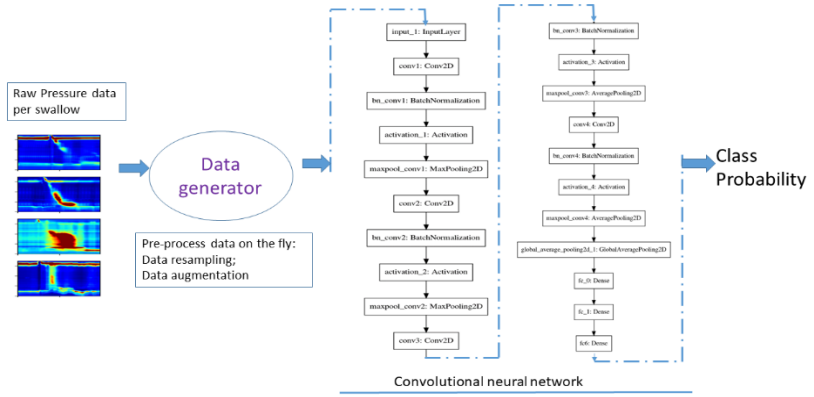
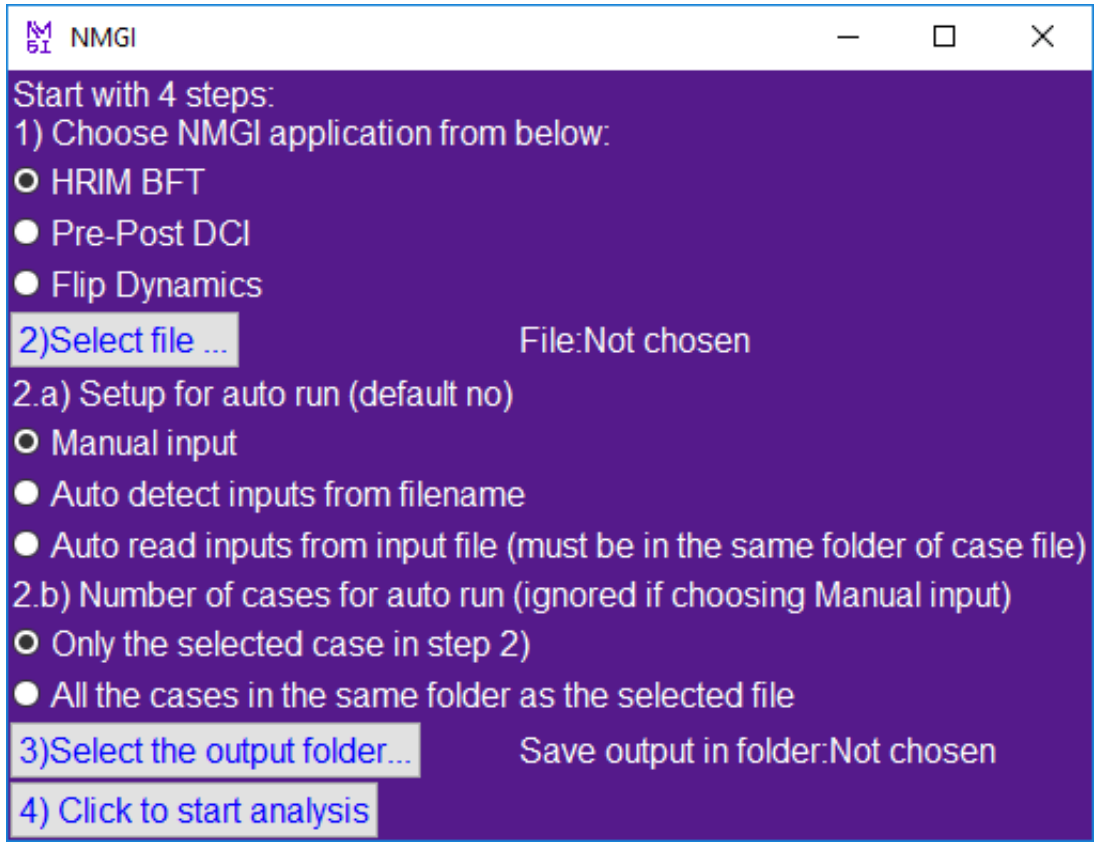
# Clinical Data Science: Analytics+DL

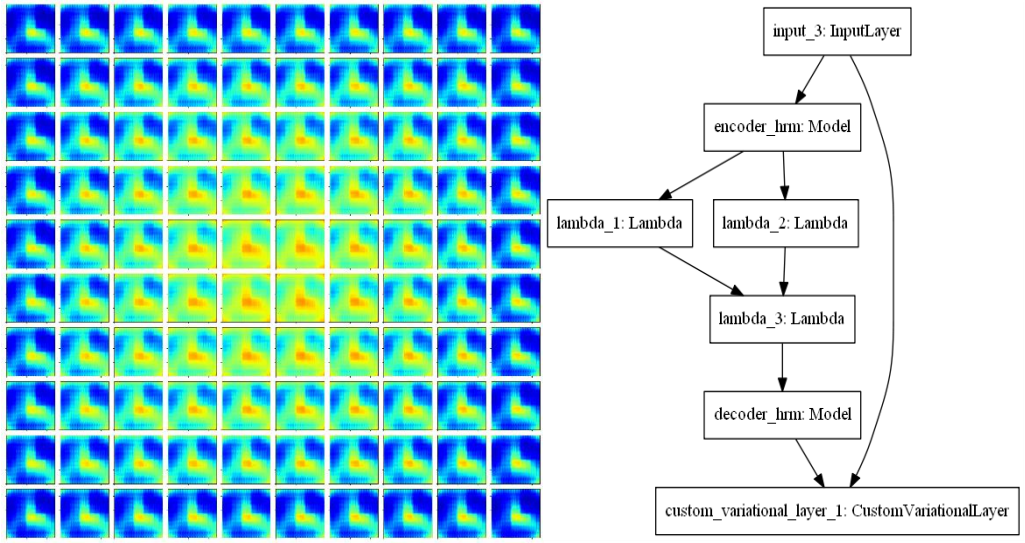


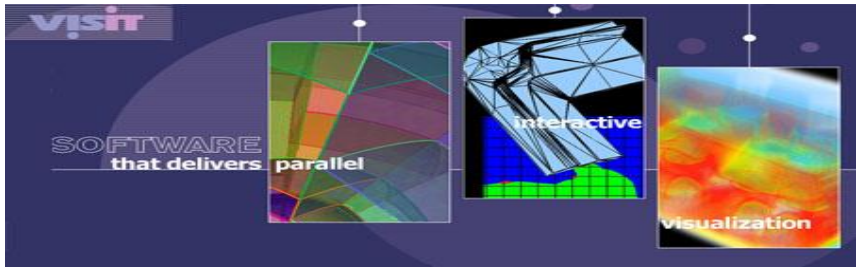

## NMGI: Analytics platform




## DL (Upper: CNN classifier; Lower: VAE)



# Python applications:




- Scientific large-scale application
  - Large-scale data visualization→ **ViSiT:** Client-server model + OpenGL
  - Biophysical modeling (PDE) → **FEniCS** support MPI run


- Data science stack:
  - Numpy + matplotlib:
  - Scipy
  - Pandas, Sklearn
  - Keras, Tensorflow

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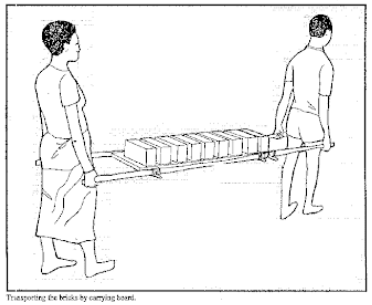
# How to run *things* efficiently?

Example: build a brick wall

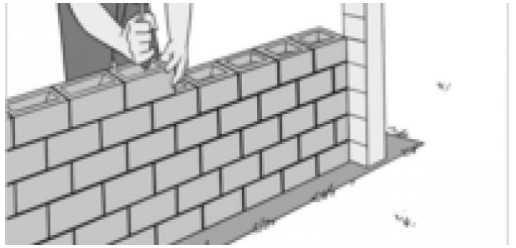
Source: storage



Transportation

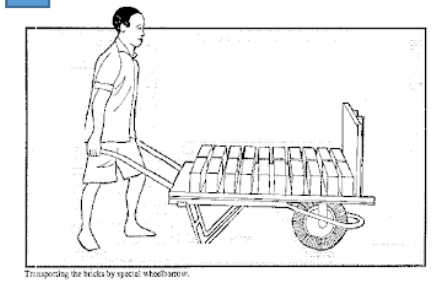
Overlapping
construction
& transportation

Construction

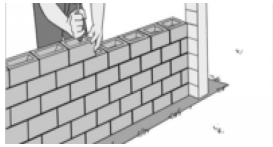


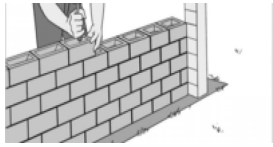
Overlapping
Memory-intensive
Computation-intensive

Vectorization
(transport more
per time)



Multiple
processing





https://www.tensorflow.org/guide/data_performance

Numpy, Tensorflow, matlab

Multi-thread, multi-process

# How to run *things* efficiently?

## Python

Scripting: interpreter

Data type:

- Variable type: (implicit)
- Run-time changeable

  a =1; a =‘a’;

Memory:

- Automatic memory management:

  Garbage collection (reference counts)

Efficiency: native python is slow

- Difficult to multi-thread
- No vectorization (numpy is from C)

## C++

Programing: compiler + linker

Data type:

- Variable type: explicit, compiled-time assigned.

  int a =1; str str_a =‘a’;

Memory:

- User-controlled (malloc):
- Create, release (stack overflow!!)

Efficiency: fast

- Vectorization (Array)
- MPI, threading is easy

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# Visualization analysis: comparison

## Pythonic way

Pos:

- Developer-friendly (debug)
- Efficiency tools (numpy, tensorflow)
- Stack for DS, ML (data slicing, ML)
- data local: data security & privacy
- Computation local: no server burnout

Neg:

- Less user-friendly (installation)
- Visualization interactivity
  Bokeh, Plotly (js for interactiby)

## Javascript (client-server model)

Pos:

- Developer control (server-side control)
- User-friendly (zero installation)
- Cross-platform

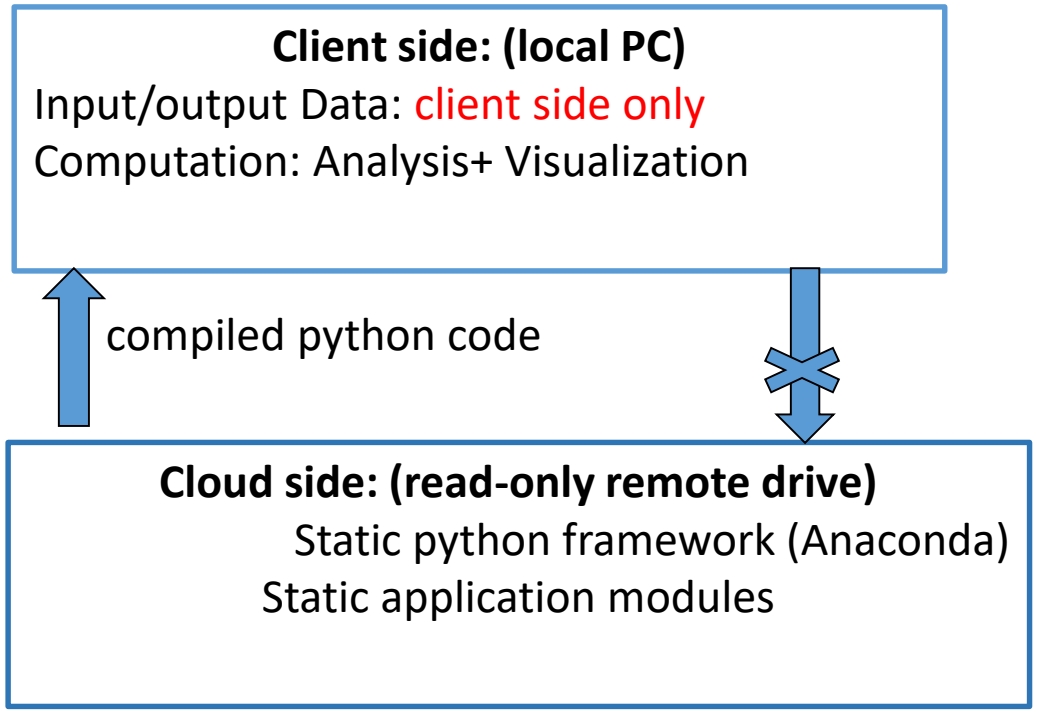
Neg:

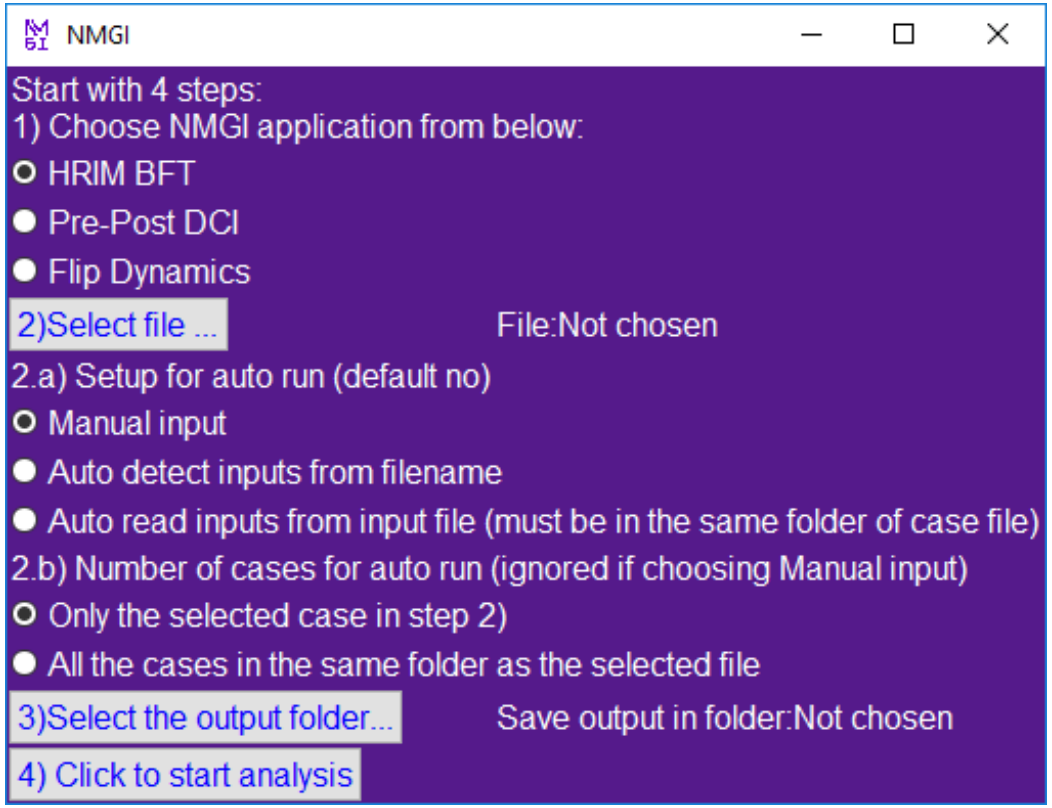
- Non-blocking computing in server + client side (ajax)
  - Multiple clients' request
  - Multiple servers' response
- Server burden:
  - Computation: server or client?
- Javascript: slow for data science

# New Pythonic way: client-cloud model

Goal: user-friendly → zero installation + double-click to run

one-way traffic → no data flowout



# New JS way: client-only analysis – single webpage

Step 1: upload local file with HTIM5 file reader

Step 2: plug in plotting module: plotly.js, or even tensorflow.js

**Efficiency → speed up**

- Memory intensive data operation: data slicing (Tips from tensorflow.js)
- Overlapping consumer and producer: callback function, asynchrony
- Computation intensive operation:  WebGL (use gpu)

# Thanks, Happy programming!!

Acknowledge:

- Northwestern Quest (for both parallel simulation + tensorflow DL)
- NIH grant support!