
THINKING ABOUT MODELS: CT (Computed Tomography) Exploration of the Human Heart

Brian K. Penney, Virginia Lauzon, Abigail Borroto, and Caroline Cardoso
Saint Anselm College, Biological Sciences, Manchester, NH

DISCUSSION QUESTIONS

Questions and Rubrics

We have run this exercise for volunteers, high school students, biology majors, and science non-majors. While the protocol stays the same in each case, the way we discuss the material obviously differs. Here are two examples.

Example 1. For a 45-minute class, sophomore level majors. Higher order thinking questions are about the use of models. Some vocabulary and technical questions are included to potentially prepare students for work in this field. I typically give students these questions ahead of class to guide in-class discussion.

A. Definitions (*=items not from your text: look up in dictionary and discuss in class)

- *Stack *a three-dimensional block of grayscale values, obtained from a CT scan or other 3D representation of an object*
- *Slice *a 2D section of grayscale values, one voxel thick*
- *Voxel *a three-dimensional equivalent of a pixel*
- *Radiodense *relatively impenetrable to Xrays, and therefore looking light on a radiograph*
- *Segmentation *the process by which a user delimits a section of voxels as a separate unit, or segment*
- *Look up table *a table that tells a program to change one grayscale value to a different value or color*

B. Concepts

B1. Explain why a CT scan is considered a model of a body.

A CT scan is simpler than an actual body. Whereas real bodies have infinitely microscopic detail—organs are made of cells, which are made of organelles which are made of molecules—the CT scan is made of voxels that contain no smaller units.

Each voxel only has a grayscale value as a property. Components of real bodies have texture, alignment (e.g. fiber direction), moisture content, etc.

C. Understandings

C1. Describe how a program generates an image from a 3D stack via cropping and a look up table vs from segmentation.

In cropping/LUTs, the organ is made visible by highlighting some voxels with colors, and then turning others invisible, transparent or otherwise less visible.

In segmentation, the user tells the program that certain voxels are part of an object (a "segment"). This segment can then be displayed independently as a set of voxels, or converted to a series of equations describing a shape.

C2. Explain the statement, "All models are wrong, some are useful" using examples from the CT scan exercise.

Models are simplifications and omit features found in real bodies; this allows us to focus on particular parts for medical decisions, but limits models' utility in other applications

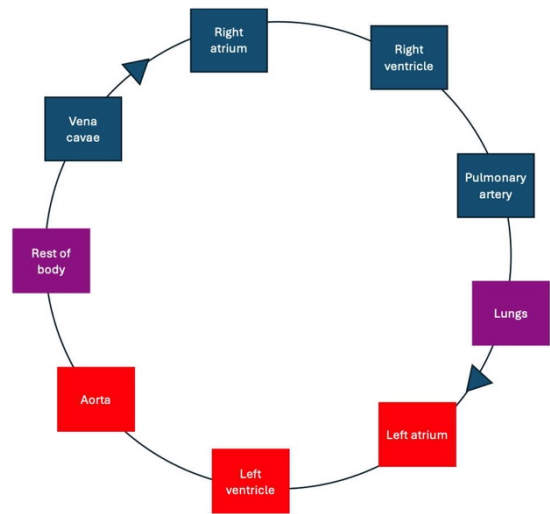
Medical imaging represents one kind of model; the image is not the body!

Science is a process of creating models of the natural world in order to make the world comprehensible and/or predictable, and then testing/refining those models based on real world data.

Because of these simplifications, no model is absolutely correct.

Different models may be used in different circumstances, depending on the need. ("All models are wrong. Some models are useful")

3. Contrast the segmentation and 3D crop box models with a flow chart model of the heart as seen to the right.



Part 2- Investigating Detail

1. Find and list three features of a real heart that cannot be found in your Slicer models.

2. Can the crop box model or the segmentation model distinguish between two tissues of the same density? Explain why the models can or cannot.

3. Would a proposed new tissue type be investigated using a model or the real thing? Argue why you made your decision.

Part 3- Application

1. What level of detail would be needed to explain the path of circulation in the heart to a grade schooler? Which model corresponds to this level of detail, if any?
 - a. Pick one model that would not work in this scenario and explain why.

2. What level of detail would be needed to 3D print a model so that an actual heart could be recognized by its shape? Which model corresponds to this level of detail, if any?
 - a. Pick one model that would not work in this scenario and explain why.

3. What level of detail would be needed for a surgeon to see the difference between a patient's muscle and connective tissue? Which model corresponds to this level of detail, if any?

a. Pick one model that would not work in this scenario and explain why.

4. Research scientists suspect that there is a new undetected structure in the heart, what level of detail would be needed to determine this new structure? Which model corresponds to this level of detail, if any?

a. Pick one model that would not work in this scenario and explain why.

Part 4-Reflection

1. After completing this lab, what is your opinion about how scientists use models?

Lab Questions Rubric

Content Rubric (for Questions in Parts 1-3)

Level	Not Yet Proficient (1)	Proficient (3)	Exceeds Proficiency (5)
Development	The arguments, and rationale are lacking development.	The arguments are developed, substance and rationale are occasionally used.	The arguments are developed, evidence, and/or rationale are clearly used throughout.
Engagement/ Participation	Explores a topic at a surface level, providing little insight and/or information beyond the very basic facts indicating low interest in the subject.	Explores a topic with some evidence of depth, providing occasional insight and/or information indicating mild interest.	Explores a topic in depth, yielding a rich awareness and/or little-known information indicating intense interest in the subject.

Reflection Rubric (for Part 4)

Level	Not Yet Proficient (1)	Proficient (3)	Exceeds Proficiency (5)
Depth of Reflection	Simplistic observations provide little or no insight, comment or analysis, answers are more descriptive than reflective.	Adequate degree of observations provides some insight and analysis, reflections and outcomes are considered but there is a lack of depth.	Sophisticated and thoughtful observations, high degree of insight and analysis, evidence and outcomes have been processed and reflected upon.

Use of Textual Evidence	Very few or no examples from the text are used and claims made in reflection are unsupported and irrelevant to the topic.	Use some examples from the text to support most claims in reflection and there are some connections made.	Use specific and convincing examples from the models and texts studied during this lab to support claims in reflection, making insightful connections.
--------------------------------	---	---	--