Ontology 101: An Introduction

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AOPXplorer

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US Army Corps of Engineers

ERDC
Engineer Research and Development Center

If You Remember Nothing Else, Remember This:

- Ontologies are a way to represent our knowledge on a specific topic

If You Remember 2 Things, Remember:

- Ontologies are a way to represent our knowledge on a specific topic

- Ontologies allow us to share information using a common language

If You Remember 3 Things, Remember:

- Ontologies are a way to represent our knowledge on a specific topic
- Ontologies allow us to share information using a common language
- Ontologies help computers “understand” a subject and apply logic

Today's Goal

- To give you background on ontologies so that you can understand why you care about them, what they are, and how they are built

Are We Talking Philosophy or Computer Science?

- Strictly speaking, when we speak of ontologies here, I mean in the computer science sense
- Ontology is a core and critical area of philosophy
  - Specifically metaphysics (describing what exists and categories of existence)
- Computer science borrowed the concept of ontology from philosophy, but put its own spin on it
- In computer science, ontologies originated in the artificial intelligence community
  - Computers needed to understand human logic and decision-making

Let's Set The Stage

- Some of us have heard of the term "ontology"
- Most biologists who have heard of an ontology heard of the "Gene Ontology"
- Forget anything you know about ontologies – you are now a blank slate

So, What Is An Ontology?

- A representation of knowledge
  - A model of knowledge
- A means to describe concepts and their relationships in a way that a computer can use that information

How About Something More Concrete?

- I want to create a computer program that can order diet-appropriate pizzas for me
- To do that, the computer needs to know what a pizza is
- Think of the computer as a young child – how would you explain to them what a pizza is?

Pizza Defined

- Pizza
  - Has a base (we can argue about whether or not yeast-risen dough is a requirement another day)
  - May have sauce (sauce is optional)
  - Has at least one topping
    - Toppings may be cheese, fruits, vegetables, meats
  - Baked in an oven

A Pizza Ontology?

- We've defined a pizza
- But wait – there are lots of terms we didn't define
  - Base
  - Sauce
  - Toppings
  - Baked
  - Oven
- We go through the same process, defining each of these terms, and any other new terms

Wait, Wait!

- This sure looks like a rabbit hole…
- When/where do I stop defining and describing concepts? This could go on forever
- Toppings: how do I define spinach?
  - Is it enough to say it's a vegetable?
  - Do I need to specify that it's a flowering plant, it's an Amaranthaceae, or that it's native to Asia?
  - Do I need to include it's high in iron and calcium (although both may be difficult to absorb)?
  - What about the fact that Popeye seems to love it only when he or someone is in trouble (but can't be bothered to eat it otherwise)?

Fit for Purpose

- Question: When do you stop adding details?
- Answer: Only add in those details that are necessary for you to meet your goals

Example

- My program needs to understand pizza dietary restrictions
  - Vegan
  - Vegetarian
  - No dairy
  - No fish
  - No pork
  - No vegetables

- Fit For Purpose Ontology
  - Does knowing the anthropological history of spinach help the computer make informed decisions about dietary restrictions?

Let’s Talk Types of Pizzas

- We’ve defined a pizza:
  - Has a base
  - Optional sauce
  - Has at least one topping
  - Baked in an oven

- Types of pizzas
  - Vegetarian
  - Supreme
  - Meat lovers
  - Fungus delight
  - Margarita pizza

Let's Explore This Type/Subclass Thing Some More

- Vegetarian pizza
  - All qualities of a pizza
  - Toppings are of type vegetable, cheese is optional
  - Sauce is optional

- Sweet, this is our vegetarian pizza…

Is This A Vegetarian Pizza?

- The Supreme (sauce + cheese, too)

Topping	Type
Onion	Vegetable
Green Bell Pepper	Vegetable
Olive	Vegetable
Sausage	Meat
Pepperoni	Meat

Is This A Vegetarian Pizza?

- The Supreme (sauce + cheese)

Topping	Type
Onion	Vegetable
Green Bell Pepper	Vegetable
Sausage	Meat
Pepperoni	Meat

- Vegetarian Pizza Criteria

Criterion	Yes/No/Optional/ Silent
Vegetable	Yes
Cheese	Optional
Sauce	Optional
Meat	Silent

The Open World Assumption

- The Supreme (sauce + cheese)

Topping	Type
Onion	Vegetable
Green Bell Pepper	Vegetable
Sausage	Meat
Pepperoni	Meat

- Vegetarian Pizza Criteria

Criterion	Yes/No/Optional/ Silent
Vegetable	Yes
Cheese	Optional
Sauce	Optional
Meat	Silent

Closing the Loophole

- Vegetarian pizza
  - All qualities of a pizza
  - Toppings of type vegetable, cheese is optional
  - Toppings cannot be meat
  - Sauce is optional
  - Sauce cannot be a meat sauce

Is This A Vegetarian Pizza?

- The Supreme (sauce + cheese)

Topping	Type
Onion	Vegetable
Green Bell Pepper	Vegetable
Sausage	Meat
Pepperoni	Meat

- Vegetarian Pizza Criteria

Criterion	Yes/No/Optional/ Silent
Vegetable	Yes
Cheese	Optional
Sauce	Optional
Meat	**No**

Pizzas Are Great, But…

- Let's move to something a little more relevant to our topic at hand
- What this will be:
  - A means to explore the process I use when designing an ontology
- What this won't be:
  - A prescription for how to design an ontology for zebrafish, toxicology, developmental toxicology, etc…

Before We Begin

- I want you to think of the ontology we're going to start hashing out in the next several slides as a blueprint
- You are the architect!
  - That's actually what we call people who design high level blueprints like ontologies for large systems
- In computer speak, what we are doing is putting together the "classes" – or the blueprints – that model what things we need to understand, and how different parts relate to each other
  - Kind of like how a blueprint for a house shows you where the windows are in relationship to the kitchen, and where the sink is in relation to the shower, tub, and toilet

Design Step 1

- Ask what the purpose or goal of the ontology is
  - Is this ontology going to help computers perform an isolated, specific type of task? If so, what is the task?
  - Is this ontology going to be used by other ontologies as a source of expert information?

Design Step 2

- Start thinking about, and listing, all of the “nouns” in the field
- Don’t worry if you don’t get everything
- The next step will help you build out

Design Step 3

- One noun at a time, break down the important parts, and identify what makes that noun what it is, identify relationships between nouns

Step 4

- Repeat Steps 2 and 3

Exercise

- Step 1: Purpose – integrate behavioral data from zebrafish assays

Exercise

- Step 2: Think about and list the “nouns”
  - I’m looking at zebrafish behavioral assays, in males and females, following exposure, for some time, to some chemical (ignoring mixtures for now to keep it simple)

Exercise

- Step 2: Think about and list the “nouns”
  - I’m looking at zebrafish behavioral assays, in males and females, following exposure, for some time, to some chemical (ignoring mixtures for now to keep it simple)
- Some nouns
  - Zebrafish, tanks/chambers, chemical, sex, time, concentration, acclimation time, study site, IACUC approval number, optokinetic reflex, brain morphology, potentiated startle, impaired habituation

Exercise

- Step 3: Break down the important parts of each noun, identify what makes the noun what it is, identify relationships between nouns

- Zebrafish
  - Has_Sex {male, female, intersex}
  - Has_Age_At_Exposure {number greater than 0 in days}
  - Has_Exposure_Duration {number greater than 0 in hours}
  - Has_Pathology some pathologies {0 or more pathologies}

Exercise

- Pathology
  - Defined: some adverse event
  - Subclasses
    - Behavioral
      - Impaired habituation
      - Potentiated startle
      - Reduced locomotion
      - Memory deficit
      - Lack of optokinetic reflex
    - Morphological
      - Brain (has_organ {brain}, disjoint with all other organs)
        - Adverse morphology of amygdala
        - Adverse morphology of habenula

Exercise

- Sex
  - Male
    - Has_gonad {testes}, disjoint with has_gonad {ovary}
  - Female
    - Has_gonad {ovary}, disjoint with has_gonad {testes}
  - Intersex
    - Has_gonad {testes} and has_gonad {ovary}

Once We Have Our Ontology And All The Parts…

- We Test!
- Real fish with real data (or fake fish with fake data) are used to test out this ontology to see what we forgot, or what we might want to model a different way
- Our real/fake fish with real/fake data are called “individuals”

What If We Forgot Something?

- It's fairly common that I forget about an "-icity", some toxicity or pathology that I didn't think of
- That's okay – I just extend my ontology.
  - Add it and move on
- I've never built a perfect ontology in my life
  - It's not uncommon to go back to the drawing board and start from scratch
  - It's also not uncommon for this to take much longer than you ever imagined

So This Was All Abstract and Cool, But…

- You want to do this for real? So a computer can actually use it?
- I use Protégé (http://protege.stanford.edu/) to put together my ontologies
- I make my ontologies in a language called OWL (Web Ontology Language)

If You're Fired Up and Want To Participate…

- There are lots of ontology projects out there
  - ► And lots of philosophies on how to build an ontology

- AOP-Ontology project (https://github.com/DataSciBurgoon/aop-ontology)

- Make sure you talk with the ontology community coordinators for an ontology you would like to contribute to to find out their rules for engagement

Reasoning

- We did not discuss reasoning. That's coming up in a subsequent webinar
- That's where ontologies become really cool and useful and neat

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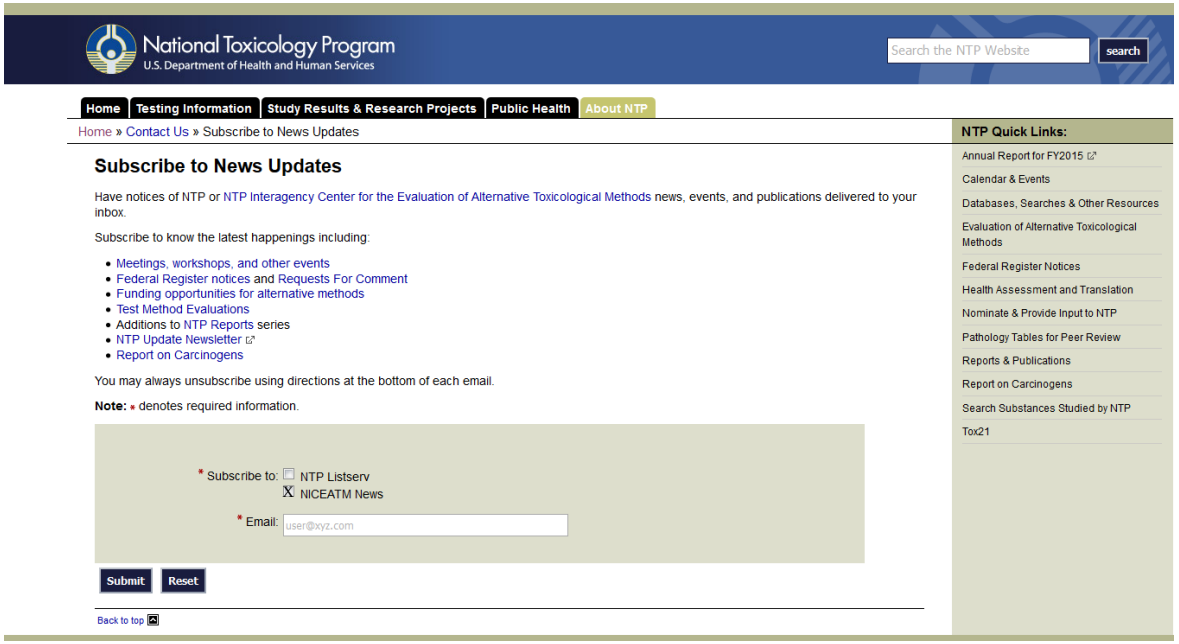

Thanks!

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