Dialectical Ontology as a More Practical and More Natural Ontology Paradigm

Tim MUSGROVE [a,1]
[a] *Callisto Media Lab*

Abstract. A conventional method of ontology development starts with a foundational ontology (Aristotle's categories, Kant's categories, or some more modern alternative) and builds constraints for class membership, attributes, and relations around necessary and sufficient conditions. This tends to derive ontologies from well-formed taxonomies whereby both formal and material attribute inheritances are strictly enforced. This is really the most "foundational" assumption of most ontology building, and is often taken to be the obvious or the only approach. In stark contrast to all of this, it has been argued strongly and famously in intellectual history that a dialectical arrangement of entities and their relations is either more natural, more useful, more informative, or more practical than any purely taxonomical organization. This general trend of thought can be traced at least from Heraclitus and Socrates, through Hegel, Darwin, Marx, and others. But seldom has this approach been pursued in information sciences or tested with systems that operate on formal ontologies. We believe a dialectical ontology approach is actionable within working, software-based ontology frameworks. We give various examples, using the familiar thesis-antithesis-synthesis vocabulary, and discuss caveats of this approach, before recommending criteria for deciding when the dialectical structure is or is not more beneficial for an application, compared to the more common taxonomical structure. Also, we describe how the task of establishing a foundational ontology changes when taking the dialectical approach to ontology construction.

Keywords. Dialectics, ontological distance, pragmatism, natural kinds, ordinary language, Hegel, pragmatism, inheritance, dendrograms

1. Introduction

The following seeks to explain and defend the suitability of dialectical ontology for cognitive science, including but not limited to the building of machine-based ontology systems. It will be illustrated that dialectical ontology, despite marked differences with conventional ontology, bears features demanded by practitioners of the art such as universal applicability, ontological distance calculation, depth-first vs. breadth-first search, inheritance of properties, suitable answers to questions of monotonicity, and compatibility with description logics and ontology-based reasoners.

An example of this type of ontology is a dialectical structure of the artifacts of traffic intersection control. To use Hegel's familiar thesis-antithesis-synthesis vocabulary, a

[1] Timothy Musgrove, PhD., Research and Development, Callisto Media Publishing, 6005 Shellmound Sttreet, Suite 175, Emeryville, CA, USA. E-mail: tmusgrove@callistomedia.com.

stop sign can be seen to present a thesis (of controlling traffic at an intersection), the antithesis of which is the slowdown created by unnecessary stops, solvable by the synthesis offered us in a traffic light, which reduces the number of individual stops while still controlling traffic. That entity (the traffic light) then presents a new thesis which bears an antithesis of creating unnecessarily long vehicle pauses waiting for lights to change, solvable by a synthesis, afforded us by magnetic sensor loops to make the timing of the light more efficient. In this case the entities in question are both formally and materially at a great ontological distance from one another in any conventional, taxonomy-centric ontology (a wooden sign, an incandescent light, a wire loop with microprocessor). Yet these items can be related at a very close ontological distance to each other -- as common sense would seem to indicate they should be -- when an ontology is constructed in dialectic form.

1.1. Operational Definitions

By conventional ontology we mean the approach to ontology construction that centers on the establishment of a taxonomy of entity types, each type defined as a set of properties that are individually necessary and jointly sufficient for membership in the type, and where material and formal properties are taken as paradigmatic.

By dialectical ontology, we mean not the medieval sense of "dialectics" (Porphyrian trees), but the sense employed in Continental and especially German philosophical traditions, having roots in Kant and Hegel which were taken up by Fichte and Schelling [1]. The form of thesis-antithesis-synthesis is found in varying degrees in works or interpretations of Feuerbach, Freud, Marx, Nietzsche, and many others, and more recently, has been strongly criticized by Foucault, Derrida and others.

We are not concerned with the idealist vs. realist debate, nor the structuralist vs. post-structuralist debate, nor other debates that occupy some of these philosophers. Instead, we are concerned with the practical employment of the dialectic in its now-classic form of thesis-antithesis-synthesis, defined as follows:

- A thesis is exhibited by any entity possessing a function or purpose that has a positive utility (it achieves at least one positive outcome). The entity in question may be a natural kind, an artifact, a method, an idea, etc.
- An antithesis is exhibited by any entity having at least one outcome that has negative valence or negative utility in regards to the very same purpose or function as the thesis itself, which is to say, the entity in some regard impedes its own purpose.
- A synthesis is exhibited by any entity that retains the positive function or purpose found in some thesis, but now has at least one different characteristic, such that the entity now lacks a function or consequence that in the exhibited antithesis bears a negative value. Thus, the entity exhibiting a synthesis can be said to better serve the purpose of the entity exhibiting the foregoing thesis, at least in some respect. This may be achieved by a modification in the entity without changing its type, or may be such as to constitute a new type of entity.

We can now consider several comparisons of this foundation for ontology construction, in light of conventional ontology.

2. Foundation of the Structure, and Basic Operations

We can construct an acyclic graph such as a dendrogram for a dialectical ontology, and use it to understand inheritance of properties, so long as we realize there are now two kinds of inheritance: thesis-preservation and antithesis-negation. In conventional ontology we tend to use exclusively the preserving type of inheritance, not the negating.

In dialectical ontology, the preserving of essential attributes from thesis to synthesis is just like that of conventional ontology, whereby children inherit their parent's essential attributes. In dialectical ontology, however, the essential attributes all relate to the purpose(s) established for the entity in question, i.e. they are necessary (but possibly not sufficient) for pursuing said purpose(s). Moreover, we also have the negating of some non-essential attribute. This too, is inherited by all successive syntheses. If the synthesis did not negate something of the original thesis, it would not be able to resolve the antithesis. If a stop light did not negate the exceptionless ("always on") characteristic of a common stop sign, then it would not be what it is. It turns out that while making every car stop is essential to a stop sign being a stop sign, doing so is not essential to the *purpose* of a stop sign, which is to efficiently control traffic at an intersection. In creating a stop light as an improvement in traffic control, we learn that while making cars stop is essential, making all of them stop every time is not. This characteristic itself will be inherited by any successive synthesis, according to our dialectical approach.

But what differs markedly, is that the inherited attributes are neither material nor formal, but functional. We may deem that a stop sign must bear the word "stop," but a traffic light does not. From the dialectic point of view, we pay no regard to the failure of the synthesis to inherit all the essential formal properties of its preceding thesis.

Now given that the dialectical ontology framework being suggested here does rely on functional arguments, it therefore calls for an ontology of functions. A formalized dialectic ontology needs axioms describing the foundational dialectical relations ("if something exhibits a synthesis then it avoids an outcome that is antithetical to some thesis") as well as axioms defining the functions of the entities in the domain along with their purpose-related outcomes ("if something reduces vehicle speeds then it serves the purpose of traffic control", etc.). In this way, much of the work is similar in nature to conventional ontology construction, but with special emphasis on purposes.

This brings up the question of whether different modelers may see different purposes. The answer is inevitably yes. The teleological nature of dialectical ontology is at once its virtue and its weakness. But different modelers in conventional ontology frequently disagree on how best to construct taxonomies over the same domains. There is no reason to believe it must be any worse in dialectical ontology, because merely attending to purpose does not entail a subjectivist standpoint by modelers. For example, we can examine common use, which is publicly observable. That one considers the purpose of a chair to be primarily for sitting is not just "in the head." One can observe that the use most often made of a chair is to sit, notwithstanding its occasional use as a stepstool, magazine stand, or pet bed. Besides, debating whether the construed purposes in a dialectical ontology are correct or not, might itself be one of the rewards of the method.

2.1. Compatibility of Dialectical and Conventional Ontology

Dialectic and conventional ontologies can work together in the following manner. Dialectically related entities can be arranged in a way that is ostensibly taxonomical, but where each child inherits from its parent a purpose, rather than specific material or formal

properties. In this arrangement, the differentiae among various child types are the different antitheses which they variously negate, i.e. each child type avoids a different outcome that impedes one or more purpose(s) inherited by a parent (or grandparent, etc.).

The use of such an arrangement in one part of an ontology does not mean that the entire ontology must be dialectical. Instead, the dialectic structure can be used to supplement (rather than to supplant) conventional ontology. Dialectical axioms are added to a taxonomical ontology, and instantiated to the point that various theses, antitheses, and syntheses become manifest.

Here is a subset of axioms in a simple dialectical base model (for readability, presented here in Cognitum's Controlled English):

- `Every thing that has-outcome that serves-purpose that has-valence Positive has-dialectic-value Thesis-Preservation.`
- `Every outcome that impedes-purpose that has-valence Positive has-dialectic-value Antithetical.`
- `Every thing that has-purpose that has-valence Positive exhibits a thesis.`
- `Every thing that has-outcome that has-dialectic-value Antithetical exhibits an antithesis.`
- `Every thing that avoids-outcome that has-dialectic Antithetical has-dialectic Antithesis-Negation.`
- `Every thing that has-dialectic Thesis-Preservation and has-dialectic Antithesis-Negation exhibits a synthesis.`

After adding various additional axioms that are in keeping with the traffic control example described above, the associated ontological Reasoner can correctly answer questions such as:

- `Q: What exhibits a thesis?`
  `A: Stop-Sign, Timed-Light, Sensor-Driven-Light`
- `Q: What exhibits an antithesis?`
  `A: Stop-Sign, Timed-Light`
- `Q: What exhibits a synthesis?`
  `A: Timed-Light, Sensor-Driven-Light`

This does not mean that the stop sign, timed light, etc. cannot have been defined firstly by conventional ontology. Having a dialectic framework means it is not mandatory that they be conventionally defined, because they could merely be entered into their dialectic relationships with respect to various outcomes or purposes of traffic control – if that is all our application demands. But just the same, in applications demanding perspicuous formal and material properties, we could start by defining these things in the conventional way, then as an additional step, relate them to one another and to their various purposes and outcomes by means of a dialectical framework.

For those modelers who have already adopted and built upon a standard upper ontology (such as SUMO [2]) it would still be possible to add a dialectical layer, as it were. One would begin to give entities purposes, as well as outcomes that serve or impede their own purposes (or that avoid negative outcomes of other entities serving a shared purpose). This in turn would prompt thesis, antithesis, and synthesis relations to be instantiated accordingly.

2.2. Calculating Ontological Distance

It is commonplace to employ one or another measure of ontological distance when working with ontologies [3]. With a dialectical ontology, if we want to count only entities and the ontological distance between them, we can travel a dialectical ontology tree skipping over all the antitheses, and move from thesis to synthesis to subsequent synthesis, counting each such step. But if we wish to include problem phenomena, we need to move from a thesis to its synthesis only by way of its associated antithesis node. As long we are consistent in performing distance calculations one way or the other, we can perform ontological stepwise distance calculations easily.

Often with conventional ontologies we are dissatisfied with stepwise ontological distance, and so we modify the distance calculation based on, e.g. tree depth, to arrive at a reified distance metric. The intuitive example is that mammal and reptile are more different than are two particular species of snake. This type of observation is no less true in dialectical ontology, typically. The difference between a stop sign and traffic light seems "bigger" than the difference between a timer-based light and a sensor-based light. But this descending magnitude of distance is not always obvious. Consider a progression in erasable writing systems from the stylus and wax tablet, to the pencil and paper, on to the digital notepad. Is each step a larger or smaller difference than the one before? It can depend on the purposes at hand, and therefore there is not one right answer. Departing from simple stepwise distance seems to be debatable and possibly application-specific, just as it is in conventional ontology-based systems.

2.3. Branching Criteria

When one moves from conventional to dialectical ontology, the branching criteria change, because the structure is built by adding antithesis and synthesis, or problems and their solutions, or challenges and methods of their overcoming. The driving features (properties individually necessary and jointly sufficient) of each class describe not its material or formal constitution, but rather its purpose or its general point. To put it differently, dialectical ontology is always teleological, with successive structures expressing the evolution, development, or "unfolding" of the original *telos*. This will become more evident when discussing applications to a variety of domains, below.

Often times, dialectic ontologies are seen as enforcing a branching factor of two. For example, see the diagram below, popularly used to teach Marx's theory of history [4].

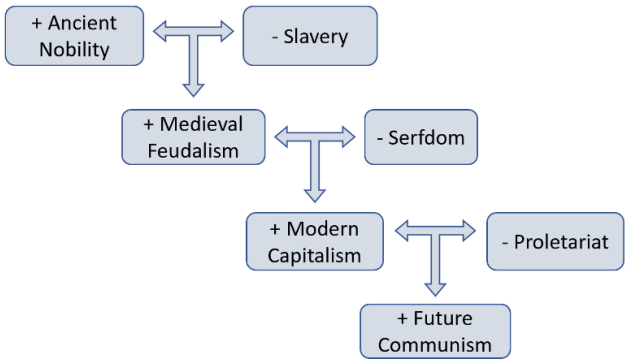

Figure 1. Example diagram of Marx's dialectical interpretation of political and economic systems in Europe.

This looks very linear or vertical, in that only two branches proceed from the starting node: the antithesis of slavery and the synthesis of feudalism. And only one of those, the synthesis, becomes the basis for additional child node concepts. There is a similar pattern for the rest of the diagram.

However, this pattern is not necessitated by the foundations of the dialectical method. Mostly "linear" diagrams of dialectical ontology like the one above are used pedagogically because they make subject matter easier to visualize. But in fact, because there can be more than one antithesis associated with a thesis, and more than one synthesis for each antithesis, the resulting diagrams can admit of any branching factor.

Let us take an example from food and nutrition. The highly nutritive cranberry is extremely tart (antithesis), and one solution is to add maple syrup to create a cranberry sauce (synthesis), but another solution is to dry the cranberries and roll them in powdered sugar (synthesis), in either case rendering the fruit more palatable while retaining its essential flavor and nutrients. This illustrates finding more than one possible synthesis of the same thesis-antithesis pair. We can re-purpose a typical dendrogram and make a different kind of diagram, annotating nodes with a "+" or "-" to indicate which is an antithesis and which is a (syn)thesis. When the dendrogram is evenly spaced, it yields alternating rows of antitheses and syntheses:

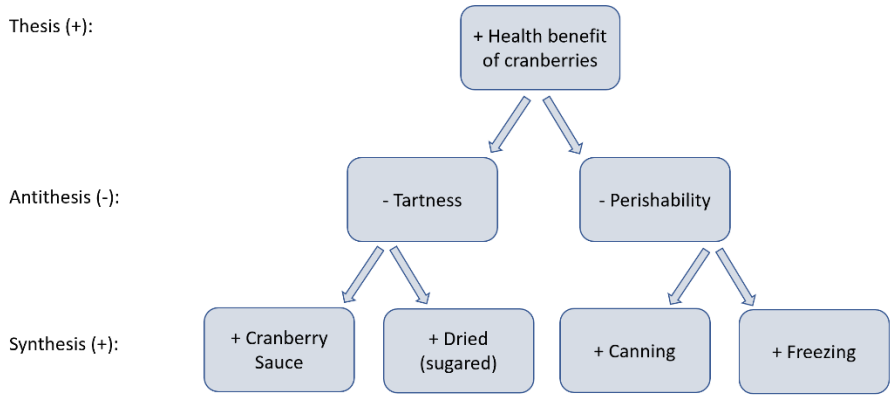

Figure 2. Dendrogram showing multiple antitheses for a thesis, and multiple syntheses for each antithesis.

In another example, consider disposable paper grocery bags. They have more than one drawback. While their purpose is to allow carrying of groceries at a negligible expense, they can be difficult to carry, they can rip, and actually their cost can be non-trivial. The cost problem works against the thesis because it costs money to buy groceries, and if money is going toward the bag itself, then the bag is taking the very resource that enables purchase of the groceries that go into the bag. Various syntheses are on offer, including the method of double-bagging, or making thicker bags, of adding handles to bags, or of making the bags of plastic instead of paper.

2.4. Breadth-first and depth-first search

A breadth-first search of a dialectical ontology is conducted by examining, under a given thesis, all of its antitheses in the current model, and then all possible synthesis of each of

them. Only then does the search continue to examine antitheses of the first occurring synthesis. By contrast, a depth-first search looks initially at just the first occurring antithesis, then just the first occurring synthesis derived from it, and then immediately to the first follow-on antitheses, and so on. Only when a leaf-node of the dendrogram is reached, does the search jump back to the second antithesis (if one exists) of the initial thesis that began the search.

For example, in Figure 2 (below), a breadth-first search goes from "paper grocery bag" to "ripping" to "difficulty carrying" to "cost," then to "double-bagging" (addressing ripping) to 'adding handles" (helping carry) to "plastic bags" (reducing cost). A depth first search would go first to "ripping," then to "double bagging," then to "doubling of cost", then to "50% thicker bags," then having reached a leaf node, would jump back up to "difficulty carrying," and so on.

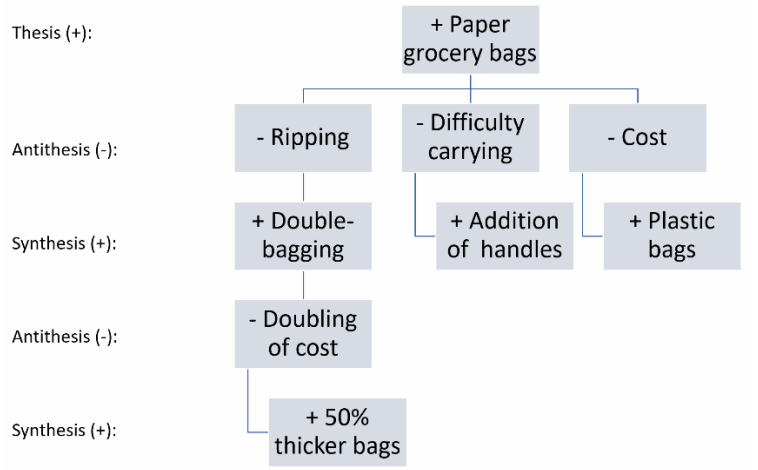

Figure 3. A dialectic dendrogram that may be searched either depth-first or breadth-first.

3. Applicability to a Wide Variety of Domains

To speak of purposes in constructing an ontology is intuitive enough with living organisms, the purposes of which can be construed as, for example, flourishing. Whether consciously or not, naturalists frequently have an implicit dialectical arrangement of entities in their taxonomies. Darwinian evolution lends itself to a dialectical arrangement, with almost every differentiating feature being an adaptation to a creature's environment, to overcome a challenge. This is true of bipedalism, the opposable thumb, and a larger brain. Marx in fact, observed the dialectic structure of Darwin's *Origin of Species* [5].

Dialectical ontology is very intuitive also for artifacts, the purpose of which is to have utility, i.e. to serve some need of the organism that contrived the artifact. It is not too difficult to carry this over to incorporeal entities like ideas and words, which can be taken as non-physical artifacts.

Dialectical construction becomes less intuitive in the realm of non-living natural kinds, like rocks, rivers, plateaus, and volcanoes. How can such things be said to have their own "purposes," except on pain of an anthropomorphic approach bordering on animism? It actually is not any more difficult here, for the dialectic can apply to

resolution of environmental interactions even of unconscious entities. As a body of water, a river creates tributaries to get around obstacles and continue downward to the sea. A volcano serves the "purpose" of venting subterranean pressures. This may seem like projecting conscious purpose onto unconscious entities, but one needn't become a Hegelian idealist just because of employing this technique. The non-living, naturally occurring physical entities are simply organized according to their function with respect to their environment, where the function can be interpreted by meaning-ascribing minds as serving purposes. It can be taken as merely a hermeneutic method of constructing an ontology, with no debate required over Idealism.

As an example, as of this writing, a few simple Google phrase-match searches [6] such as "volcanoes serve" and "volcanoes offer" readily yield numerous purpose-bearing statements by sincere and well-qualified writers, including:

- "in spite of their destructive power, volcanoes serve a vital purpose: they help release excess heat from the core and mantle of the planet, and they are the prime generators of Earth's crust"
- "volcanoes serve as a recharge area for [thermal mineral] springs"
- "volcanoes offer an insight into otherwise hidden deep structural and diagenetic processes"
- "volcanoes serve as powerful tourist magnets"

Indeed, there are plenty of "purposes" or "utility functions" of volcanoes, and really of any natural kinds. As human beings we tend to understand every kind of thing in view of a function or purpose it seems to have in relation to other things or to ourselves. The choice to build a dialectical ontology is a choice to take up purpose-serving as the fundamental construction principle for one's foundational ontology. One could view this as ascribing secondary rather than primary properties, or extrinsic rather than intrinsic properties, as a way of establishing each new category in the dialectical ontology.

This possibly "awkward" region of dialectical ontology, i.e., applying it to non-living natural kinds, perhaps best reveals the essential difference between dialectical and conventional ontology, and therefore provides a major clue to what applications dialectical ontology fits best, or when dialectical ontology is "the right tool for the job." A dialectical ontology becomes more appealing than a conventional ontology to the extent that the purposes, functions, or utility value of entities is most pertinent to the use case.

3.1. Literary Genres Construed Dialectically

Another domain requiring an adjustment of perspective in order to see the applicability of dialectical ontology is in literature. In order to demonstrate the universal applicability of the method, we can examine briefly two examples, one of contemporary literature and the other of very ancient literature.

For a recent example, we can take the emergence of "steampunk" as a sub-genre of science fiction literature [7]. In addition to being a sub-class of science fiction, it can be fruitful to see it has having also a dialectical relationship to its parent class. Mainstream science fiction tends to push things to another world or a future time, and leaves out a historical element other than specifically in "time travel" science fiction. Time travel science fiction is usually about issues such as changing (or trying not to change) the past without creating "time paradoxes", and thus these stories are still very materially about

a future far beyond the historical time period they describe. In contrast to this, steampunk invents an alternative way to cast science fiction into the past without need for time travel, and with no reference to contemporary or future time at all. This is by speculating that historical inventors had marvelous inventions beyond what we ordinarily suppose they had, specifically in the steam-powered 19th century. The "future-bias" of most science fiction can be understood as an antithesis to mainstream science fiction that is resolved by a "retrofuturistic" element in steampunk. Meanwhile the essential elements of science fiction, such as its containing alternative technologies that have a remarkable impact on human life, are preserved. By preserving the essential and negating something non-essential, steampunk exhibits a synthesis that shows another way in which science fiction can be instantiated. To leave aside this dialectic relation for a purely taxonomical classification would obscure the nature of the niche that steampunk fills.

Looking now to a very ancient example of a literary genre, the *midrash* was perhaps the earliest example of the dialectical function of speculative fiction [8]. *Midriashim* are Hebrew tales borne in the context of sacred literature that has been organized into a canon. The very essence of a canon is that it provides an authoritative body of literature to be shared among a literary community. This very act of establishing a canon creates, however, a vacuum of literature. Certain heroes, saints, prophets, etc. become the objects of great attention, even reverence, which creates a need or a desire for narrative answers to "what else" happened in their lives. The midrash tradition provides stories outside the canon that do not conflict with it, but that work to fill in the missing narrative gaps.

For example, we have numerous delightful *midrashim* of King Solomon's further (extra-biblical) exploits [9], chronicling his additional encounters with the Queen of Sheba, and how he came by his favorite ring, and many more adventures. These *midrashim* fit the dialectic especially well; they preserve everything canonical about the protagonist and his or her historical significance, while filling in "gaps" in the life-story of the same person. These stories, for example, build upon Solomon's fascination with wisdom, as well as his humility in confessing his insufficiency of wisdom, despite his being known as a prime exemplar of it.

We could ignore all of this and simply classify the *midrash* as a sub-class of "Extra-Canonical Ancient Hebrew Literature", alongside Jewish apocryphal and Talmudic literature, but this would seem to leave out its unique relation to the canon. The point is not that a conventional taxonomical classification is wrong, but that it doesn't get at the *raison d'être* of the genre as well as the dialectical construal does.

4. Deciding between Conventional and Dialectical Ontology for an Application

Dialectical ontology is especially appropriate in cases where strong emphasis is placed on the purposes, aims or uses of entities, rather than on their material or formal constitution. For example, consider consumer product audiences. Understood by sheer demographics, this does not seem a place where the dialectical approach yields many advantages. Marketers are interested in breaking down age groups, gender, race, geographical location, etc. These are the material properties of the entities in question.

However, if we change our focus from demographics to ethnographics or psychographics, we enter the realm of purpose and challenge, where dialectical ontology is well-suited. One such psychographic category is that of "empty-nesters", i.e. parents whose children have recently become adults and moved out of the home. Empty-nesters face the challenge of over-capacity on their housing, new mental health challenges, new

travel and communication demands, etc. Syntheses then arise to solve these antithetical challenges. Empty-nesters reconceptualize what their "nest" is; they list some of their rooms on Airbnb; they buy an RV or buy membership in a time-share network so they can have extended stays near their adult children. These all relate to the "home" or "domicile" referred to as "empty-nest". Each modified domicile arrangement is a synthesis of the original thesis, and one or more antitheses.

The conventional ontology would divide empty nesters into subclasses, perhaps early empty-nesters (those reaching the condition by age 40) and late empty nesters. Or we might construct a sibling category to empty-nesters such as "late-nesters" or "prolonged-nesters", i.e. those who have adult children older than 25 years still living with them.

By contrast, a dialectical ontology looks for the "empty nest" to be actually an antithesis to the nuclear family home; a benefit of the home is the environment for child-rearing, and an antithesis is the condition of that environment outliving its original purpose and becoming an "empty nest". Then various syntheses are possible.

This illustrates that the thematic occurrence in our application of a problem-solution dynamic is a clue that we should utilize the dialectic approach.

5. Questions of Monotonicity in Ontology Expansion

With a dialectical ontology, the question of whether ontological reasoning, with an ontology that undergoes expansion, is monotonic or non-monotonic is in some ways similar to the same question with conventional ontology. There is a familiar example of the class of "mammal" being defined to include having hair, producing milk and giving live birth, until the duck-billed platypus was encountered. Rather than create a new class, the requirement of giving live birth was ultimately removed from the mammal class, so that the platypus can count as a mammal. But this was settled upon only after much debate among anatomists.

> "In the taxonomy established for European species by European naturalists, it was axiomatic that all milk-producing animals give birth to live young, and so, by definition, are mammals. Warm-blooded egg-laying animals were birds. Cold-blooded egg-laying animals were reptiles. There was no place in this scheme for the platypus [10]."

Revising a classification schema in the face of an unexpected case is a familiar challenge to most working ontologists, and it raises the question of monotonicity (whether a system of logical deduction relying on the ontology "preserves truth"). Some statements that were true according to the ontology before it was modified, are no longer determined to be true afterwards. Generally speaking, a well-formed conventional ontology is monotonic when viewed synchronically, but when it is part of a developmental or adaptive system, it is rendered non-monotonic by some of its revisions, when viewed diachronically.

Overall, this is no different with dialectical ontology, though the reference of ontology revision is different. Since its architectonic is teleological, a dialectical ontology is revised when one discovers hitherto unknown (or previously misunderstood) purposes of entities. In the year 1915 one might have defined the purpose of a stop sign as that of stopping each vehicle. But upon the invention of the traffic light one realizes that stopping each car is not essential. In retrospect, the purpose of the stop sign might

have been misunderstood (over-specified) as stopping each and every car. Instead, it is to effectively control traffic flow.

This purpose could have been more properly construed, originally, just as the mammal class could have been understood originally as not precluding egg-laying. But in practice, it is the encounter with a previously unimagined case that enlightens the ontologist as to what the true definition "always was" of a long-standing class of entities. This was thought by Hegel to be the fundamental character of the dialectic, which he famously called the "unfolding of being" [11]. In less mystical-sounding terms, we can simply point out that no naturalist would deny that we now understand better what it means to be a mammal, after discovering and including the platypus. The forcing of a revision in order to accommodate new types of entities leads us to a better understanding of what already was defined.

So, we have a strong analogy between the two methods. In one case, we are revising material or formal attributes of entities in the face of exceptional cases; in the other case, we are revising our construals of their purposes or essential functions. Well-formed dialectical ontologies are therefore monotonic synchronically but non-monotonic diachronically, just like conventional ontologies are.

6. Naturalness and Practicality

Since it speaks more to the use, or usefulness, of entities, on a Wittgensteinian view of language [12], the dialectical ontology as outlined herein is arguably more "natural." This is because it is more like ordinary language, where the use of words in the context of life-situations is taken to be the main indicator of the meaning of those words. Analogously, the items in a dialectical ontology are given a context that describes a problem to be overcome within an environment. The very meaning of the item is its utility or applicability or value for overcoming a challenge or correcting a weakness.

Similarly, since the very definition of pragmatism is to focus on the capacity of entities for use in problem-solving, rather than to describe intrinsic properties of those entities [13], a dialectical ontology may be deemed more practical or more pragmatic in some cases. For example, in organizing a consumer retail store, a dialectical ontologist could place the emergency candles together with the battery-powered emergency night lights, next to the regular light bulbs. The logic could be that while shoppers are fulfilling the purpose of lighting their homes by shopping for light bulbs, they see the emergency candles and lights right next to them, and thus are reminded of an antithesis of the purpose of lighting one's home with light bulbs (residential power outages), whereupon the shoppers are presently offered a synthesis (stocking up on some back-up lighting sources). However, in a different store, the same emergency candles might be right next to the scented aromatherapy candles and the prayer candles, based on their shared material and structure (conventional ontology). But in such a case, the relevance of the items' adjacency, judged pragmatically, would be non-existent.

Likewise, a book that is a guide to backpacking deep into a particular wilderness region, say, the Sierra Nevada mountains, might have a Part 1 on survival skills, followed by a Part 2 describing flora and fauna of the region, probably organized into sections on plants, birds, reptiles, mammals, etc. However, if outlined from a dialectical point of view, it could group together just those plants and animals suitable for eating, versus those that are dangerous to humans, and those that are merely beautiful to look at. In turn, each of these could be grouped with the skills required to perform the associated

functions, based on overcoming challenges. In the chapter or rattlesnakes could be a section on what to do if bitten by one; in the chapter on steelhead bass could be tips on what bait to use for fishing them. Perhaps this organization would be deemed more practical or "pragmatic."

7. Areas for Further Research

There are at least two areas of development that are much needed, but go beyond the space of this article. The first matter relates to conceptual blending. Conceptual blending [14], or something akin to it, might be a promising way to build a system that can discover or devise new syntheses. More examination of this, especially of how coherence could encompass the negating of an antithesis, would be needed. Second, we only briefly touched upon the issue of whether a dialectical approach is fundamentally cognitivist, or even subjectivist -- or if it is, at any rate, much prone to subjectivism than conventional ontology. This question deserves to be treated at greater length.

8. Conclusions

A dialectical ontology shows not only what types of things exist and how they differ, but also *why* they exist and *why* they differ. It speaks not as much to the matter and form of items, as to their practical applications or purposes in the world, such as their use or their survival or flourishing. Conventional ontologies can do this as well, by means of relations and attributes added onto categories of entities; but a dialectical ontology does so in the very act of constructing a category within the dialectic framework.

Dialectical ontology meanwhile offers all the main features we need as computer scientists to manipulate ontologies: a tree structure with a concept of inheritance; a sensible way to speak of upper vs lower level ontology; a choice of depth-first or breadth-first search; a straightforward calculation of ontological distance, either stepwise or reified; and synchronic monotonicity with the potential for diachronic non-monotonicity. To a great extent, we can even use the same tools we use for other ontologies (e.g., dendrograms constructed with tree editors that allow labeling of edges, editors for making taxonomies and writing axioms and practicing with reasoners).

In short, the dialectical approach to ontology construction is well-grounded conceptually and is computationally operable, making it a viable alternative for practitioners who are building ontologies for working systems.

References

[1] Terry Pinkard, *German Philosophy 1760-1860: The Legacy of Idealism*, Cambridge University Press, 2002.

[2] Pease, A., Niles, I., Li, J., (2002), The Suggested Upper Merged Ontology, in Working Notes of the AAAI-2002 Workshop on Ontologies and the Semantic Web.

[3] Ranwez S., Ranwez V., Villerd J., Crampes M. (2006) Ontological Distance Measures for Information Visualisation on Conceptual Maps. In: Meersman R., Tari Z., Herrero P. (eds) *On the Move to Meaningful Internet Systems 2006: Lecture Notes in Computer Science, vol 4278*. Springer, Berlin, Heidelberg

[4] G.A. Cohen, *Karl Marx's Theory of History: A Defence*. Princeton University Press; 2000.

[5] Karl Marx, *Das Kapital.* Fowkes, trans. Penguin Books, 1992.

[6] Webpage: https://www.google.com/search?q=%22volcanoes+serve%22 Retrieved 07 July 2019.

[7] Rebecca Onion, Reclaiming the Machine: An Introductory Look at Steampunk in Everyday Practice. *Neo-Victorian Studies 1:1* (Autumn 2008) pp. 138-163.
[8] J. Rubenstein (1996). From Mythic Motifs to Sustained Myth: The Revision of Rabbinic Traditions in Medieval Midrashim. *Harvard Theological Review, 89*(2), 131-159. doi:10.1017/S0017816000031953
[9] Israel Drazin, King Solomon's Mighty Deeds in Midrashim, in *The Authentic King Solomon*. Gefen Publishing House, 2018.
[10] Brian K. Hall, The paradoxical platypus, *BioScience*, Volume 49, Issue 3, March 1999, Pages 211–218, https://doi.org/10.2307/1313511
[11] G.W.F. Hegel, *Introduction to the Philosophy of History.* Hackett Publishing Company, 1988.
[12] Ludwig Wittgenstein, *Philosophical Investigations.* Wiley-Blackwell; 4th edition 2009.
[13] William James, *Pragmatism and Other Writings*. Penguin, 2000.
[14] Confalonieri, Roberto and Kutz, Oliver. Blending under deconstruction: The roles of logic, ontology, and cognition in computational concept invention. Annals of Mathematics and Artificial Intelligence, 2019 July 25. https://link.springer.com/article/10.1007/s10472-019-09654-6