9. Conclusions

9.1 Summary of the research

Broadly speaking, the research presented in this dissertation has examined the application of Semantic Web technologies to the field of e-learning. We concentrated the analysis on how such techniques could be applied to a less 'traditional' domain, such as philosophy.

In particular, we emphasized that the distinctive features of this and other humanities' domains (e.g., abstractness, subjectivity, historicity) require the investigation of novel approaches, which existing research fails to provide.

In order to address this issue, we created an innovative *philosophical* ontology, which is the most comprehensive attempt to date to deal with the complexity of the domain attempts to give justice to the well-known complexity of the domain.

Secondly, by taking inspiration from the field of *digital narratives,* we researched methods for the creation of ontology-driven philosophical narratives across Semantic Web resources. In particular, we have shown how these narratives could be used by learners for exploring the key dimensions in the philosophical discourse.

Let us recall the generic question that started our research path:

a) *"How can we better support the learning process, by making use of Semantic Web technologies?"*

Subsequently, with reference to the specific domain we have chosen to investigate (i.e., philosophy) and the specific technology we are benefiting from (i.e., ontological engineering), we rephrased the question above as follows:

b) *"How can we support learning about philosophy by means of an ontology-based application?*

Finally, in order to answer question b), five more specific research questions were formulated:

b1) What are the types of entities and relations which define a domain such as the philosophical one, which is normally considered hard to characterize using semantic technologies?

b2) How can we define an ontology for philosophy, so that it would support the integration of multiple data-sources in the emerging Semantic web?

b3) How feasible is to construct an ontology-based system, which supports the semantic navigation of philosophical resources?

b4) How should we structure a semantic navigation so that it could support the learning process, intended as a narrative-construction activity?

b5) What are the fundamental narratives capable of telling the 'story' of philosophy, and how can we represent them using a formal language?

The research questions have been addressed as follows. Chapters 2 and 3 dealt with the topics raised with questions a) and b) at a quite general level, in order to set the scene for the discussion of the other more specific research questions. More precisely, the literature reviewed in chapter 2 demonstrates the increasing importance and variety of Semantic Web approaches to e-learning. Moreover, we highlighted the pedagogical underpinnings and technical implications of one approach in particular, which aims at the construction of *ontology-driven* and *narrative-inspired* navigation mechanisms. The literature reviewed in chapter 3, instead, shows the lack of adequate formal models usable for implementing such approach in the specific field of philosophy.

In order to tackle this issue, we proposed a novel ontology for philosophy, which is, to our knowledge, the first and most comprehensible effort ever done in this direction (chapter 5). This section provides answers to the research questions b1) and b2).

Also, we created PhiloSurfical, a web-application aimed at showcasing the ontology capabilities. PhiloSurfical enables the dynamic exploration of philosophical resources by means of a number of ontology-driven navigational pathways (chapter 6). Research questions b3), b4) and b5) have been discussed in this section and a number of encouraging results presented.

Both the ontology and the software applications have been evaluated (chapters 7 and 8).

Our approach proved to be successful in carrying out the task of bringing the benefits of Semantic Web technologies to a humanities' domain. In particular, both the ontology and the navigation mechanisms created are a promising result which, in our opinion, can be inspirational to various other humanities' domains beyond philosophy.

9.2 Contributions

9.2.1 Contribution 1: philosophical ontology

Chapter 5 presented an extensive ontology which describes a number of aspects in the world of philosophy. The ontology is, to our knowledge, the first and most ambitious attempt to systematize the classification of philosophical knowledge ever created.

We have formalized knowledge regarding a variety of entities, ranging from physical objects, such as documents and people, to the more immaterial entities of philosophy, such as theories and concepts. In particular, we provided a novel formalization of the types of *philosophical-ideas* playing a role in the

construction of viewpoints, and, more broadly, having a recognizable function in modeling the interconnections between viewpoints within the history of thought.

Finally, it is important to remember that the ontology presented is an *integrated* model of various existing ontological representations. We made use of CIDOC-CRM (Crofts et al., 2005), an ISO standard created for facilitating information integration of museum-related data, as a foundation for a larger semantic model which integrates relevant ideas and classes from AKT (AKT, 2002), DOLCE (Gangemi et al., 2002) and FRBR (IFLA, 1998). As a result, our ontology has a high degree of interoperability with others used in semantic applications in this domain.

9.2.2 Contribution 2: KA experiment

The second contribution of this thesis work is the knowledge acquisition experiment carried out to validate the *philosophical-idea* branch of the ontology.

The experiment has been described in details in chapter 7. In brief, by using a knowledge acquisition technique (card sorting) we investigated a group of philosophers' implicit cognitive constructs *about* philosophy. As a result, we obtained a series of 'conceptual maps' that we compared to our ontological categories.

The experiment produced positive outcomes, both because of the confirmation of many of the classes in the ontology, and because it highlighted a number of unexplored territories which could open the way to future research.

In fact, it is important to stress that although the card sorting technique has been successfully used in many domains, there is no evidence of use of card-sorting (or any other knowledge acquisition technique) for investigating the type of abstract entities which are important in the philosophical domain. Thus we can say that our work has pioneered the use of these techniques in the philosophical domain.

9.2.3 Contribution 3: PhiloSurfical

The third contribution of our thesis is PhiloSurfical, an ontology-based web-application aimed at the navigation of the world of philosophy (chapter 6). In particular, PhiloSurfical lets users access philosophical resources starting from a specific text, the well-known Tractatus Logico-Philosophicus (Wittgenstein, 1921) by Ludwig Wittgenstein.

PhiloSurfical exemplifies the use of our ontology in a real-world application. By using a number of navigation mechanisms, philosophy learners can browse the Tractatus' text and related resources in a *dynamic* and *contextual* manner. That is, they can access relevant materials using mechanisms modeled on the underlying ontological representations.

As a result, this information can be presented to the user in the form of *maps* which mirror the *coherence relations* typical of the philosophical domain.

Furthermore, in order to facilitate the testing of PhiloSurfical we created a philosophical knowledge-base containing more than 20 thousand instances. The knowledge base can be either be accessed through the application or downloaded as a stand-alone resource.

9.2.4 Contribution 4: narrative pathways

The fourth contribution of our work is the formalization of a series of narrative pathways which can be used for navigating PhiloSurfical's knowledge base (cf. sections 6.5.4 and 6.6).

The narrative pathways are functions which make use of the ontological representations in various ways, to the aim of composing the information in the knowledge base according to some pre-defined *coherence criteria*.
With reference to the pedagogical approach described in chapter 4, we can say that in general *learners need structure*. More precisely, we have shown that philosophy learners can be supported using a number of *very specific* structures. Accordingly, we formalized the significant aspects of these structures by means of these ontology-based pathways.

In general, we see the pathways as the key-enablers for philosophy learners to grasp the typical structures of their domain. The contribution here is twofold:

one the one hand, the narrative pathways formalize a number of *coherence principles* which exist in the philosophical discourse. As such, they can be used by semantic applications for creating pedagogically-oriented browsing functionalities for philosophy.

Secondly, given that various dimensions of philosophy can also be found in other humanities' domains - e.g., history or literary studies - we believe that these pathways could be easily re-used or extended so to be employed in other applications too.

9.3 Open issues and future work

Although the PhiloSurfical application is providing the first ever tool aimed a supporting the interpretation of philosophical texts, in reality much more is needed before such a tool could be used in the daily practice by philosophers.

In particular, a number of issues need to be addressed, which are discussed in the next sections.

9.3.1 Availability of data

As the availability of structured resources on the web will increase, we reckon that systems such as PhiloSurfical will not need to rely on internal knowledge bases anymore. Instead, it will be possible to truly benefit from an extensive

semantic web, by means of automatic retrieval and interrogation of remote repositories.

For example, these could be made available by philosophy departments or institutions which carry out research in the field. Also, individual users may use tools for knowledge representation and decide to share these digital artifacts on the web, to the result that PhiloSurfical could benefit from these resources too.
At the time of writing, we can say that there are at least two major projects, one in America (Niepert et al., 2007) and one in Europe (Discovery, 2008), whose goal is to build a semantic repository of philosophical data.

In such a scenario, it is also likely that resource providers will promote different philosophical ontologies for the codification of their data. Consequently, more specialized tools for the integration of these models will be needed.

9.3.2 Cross domain learning-pathways

As the availability of humanities' data in the Semantic Web will increase, we also envisage a number of very interesting developments with regard to the *use* of learning pathways.

For example, in a scenario where multiple knowledge repositories could be queried with respect to the same issue (e.g., the description of a Wittgenstenian concept), we will need specialized mechanisms for letting users deal with these

(potentially competing) alternative resources. It is likely that the ontological representations gathered under the `interpretation` class (see section 5.3.5.4) will have to be extended, so to accommodate the specification of further constraints linked to characteristics such as a repository's trustworthiness, or the records of it previous usages.

Moreover, it is also interesting to think about the situation in which data providers from different humanities' domains would have become available. In such as case, we could start creating cross-domain 'semantic mash-ups': for example, in an ideal world information about Wittgentein's trips to Norway coming from our *philosophical* knowledge-base could be integrated with pictures about the village he lived in Norway, retrieved automatically from a *historical* repository maintained by the village's museum. Also, a *literary* semantic repository could be used so to gather data about other European writers who chose that specific village as a thinker's haven, etc.

A more realistic example of cross domain learning pathways can instead be conceived by looking at the recent developments of the Linking Open Data project (LODP) (LODP, 2008). People in this community work to the practical purpose of making available on the web a large set of interconnected *data-sets*, in a spirit very close to the Semantic Web initiative. At the moment, the project offers a number of different data-sets which could be linked to PhiloSurfical. One of these is DBpedia (Suchanek et al., 2007), a structured version of the Wikipedia; for example, we could build pathways which look up philosophers' information in the DBpedia, and present the results in a PhiloSurfical's map.

Another interesting resource in LODP are the BBC-programmes semantic repository (BBC, 2008): for example, learning pathways could provide links to relevant philosophical tv-programs.

In conclusion, we believe that despite the actual scarcity of philosophy-specific semantic repositories available, there are already many exciting possibilities for 'mashing-up' data from heterogeneous resources to the purpose of facilitating philosophers' encounter with the domain.

9.3.3 Extension of PhiloSurfical for the social web

An interesting research direction could develop PhiloSurfical further to make it into a fully-fledged *social* application, of the kind described by Gruber (Gruber, 2006).

Among other things, this would mean moving the focus to the user as the main resource producing the data needed by the system.

In more practical terms, it could be desirable to *extend the focus from navigation to annotation*: users should be able not only to browse philosophical resources, but to describe them using the ontology.

Another aspect which could be further developed is the provision of a stronger support for communities. For example, providing facilities for the creation and fostering of *groups of users* (e.g., chats, forums, shared workspaces) so that various aspects regarding PhiloSurfical's functionalities (i.e., which ontology/kb

to use, browsing or annotation preferences) could be selected/inferred using group-level information.

In general, this type of extensions will make PhiloSurfical a platform not only for learning about philosophy, but also for *knowing other philosophers*. Furthermore, this feature could also be improved by investigating how to transform the tool into a platform for *collaborative learning*.

9.3.3 PhiloSurfical as a shell

An interesting possible development of PhiloSurfical could be its evolution into a more general-purpose tool for the construction of Semantic Web applications in the humanities.

More precisely, it would be nice to provide users with means for autonomously selecting a text (e.g., another text among the ones freely distributed by the Project Gutenberg website (GutenbergFoundation, 2008)), parsing it, and importing it into the system according to a chosen semantic model. To this aim, we would like to provide PhiloSurfical with a number of functionalities typical of natural language processing technologies, e.g., by integrating the GATE application (Tablan et al., 2005).

Also, PhiloSurfical could combine mechanisms for the annotation/navigation of resources with facilities aimed at the creation and modification of the underlying

semantic model. In fact it is plausible that in the long run users may wish to extend the ontology or refine it according to specific contexts' of use.

Moreover, we expect users to be interested in accessing humanities-specific ontology repositories, browse the available ontologies and choose which ones to benefit from directly from the PhiloSurfical shell. In order to support these processes, we are investigating the integration of SW search tools such as Watson (d'Aquin, 2008).

Finally, a number of interesting developments could be carried out with respect to the narrative pathways. For example, we would like to provide more advanced interfaces so that users could *author* new pathways autonomously, *save* them in specialized repositories and *share* them with friends and colleagues.

By doing so, it will be possible to achieve a number of *personalization* mechanisms. For example, we would like to let philosophy teachers 'transpose' important characteristics of their philosophical approach to the pathways they are creating (e.g., a major or minor importance given to the historical perspective, or to the theoretical one). As a result, these *specialized* versions of PhiloSurfical could more easily find an application also in the classroom.

9.4 Conclusion

Traditionally, humanities have lagged behind the other scientific disciplines in the use of technologies to support their work practices. However, this is rapidly changing as more and more systems have been produced to support both scholars and members of the public in accessing and interpreting resources in the humanities.

PhiloSurfical is part of this trend and provides novel mechanisms for interpreting philosophical resources.

In particular, it is the first system that attempts to bridge the gap between the most recent advances in Semantic Web technologies and the philosophical discipline. An extensive ontology describing the various domain features and a number of narrative-inspired navigation mechanisms are two contributions of this research work that, we hope, will be the beginning of a renovated interest towards similar interdisciplinary enterprises.

Of course, this is just an initial piece of work bringing ontologies to support the analysis of philosophical texts - much more needs to be done to develop the larger scale philosophical resources which are needed to go beyond the relatively restricted support provided by PhiloSurfical and support users in analyzing a variety of philosophical works and making interesting connections between them.

In particular, we are hinting here at the development of an extensive web of data for the humanities; a network of interrelated databases, open repositories

and software systems geared towards the seamless exchange of information about philosophical, historical or literary subjects. But not only. We expect that the most challenging and exciting developments will happen once such infrastructure will have reached a critical mass, so to allow researchers to focus on the construction of the *semantic services* humanities scholars necessitate.
We envision tools for comparing literary sources, for interpreting multiple philosophical materials, or for helping navigating cleverly the sea of human knowledge in a way similar to what our PhiloSurfical has anticipated.

Clearly, compared to other areas such as bio-informatics, humanities computing is a research discipline whose journey still lies very much ahead. Accordingly, this work may also contribute to an understanding of the scope of humanities computing research.

Interestingly, the research issues raised by the development of PhiloSurfical outnumbered those addressed by PhiloSurfical itself. For these reasons we eagerly await further developments.