Organizing Artworks in an Ontology-based Semantic Affective Space

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Abstract. In this paper, we focus on applying sentiment analysis to resources from online collections, by exploiting, as information source, tags intended as textual traces that visitors leave for commenting artworks on social platforms. Our aim is to create a semantic social space where artworks can be dynamically organized according to an ontology of emotions. We propose to tackle this issue in a semantic web setting, through the development of an ontology of emotional categories based on Plutchik's circumplex model, a well-founded psychological model of human emotions. The ontology has been conceived for categorizing emotion-denoting words and has been populated with Italian terms. The capability of detecting emotions in artworks can foster the development of emotion-aware search engines, emotional tag clouds or interactive map of emotions, which could enable new ways of accessing and exploring art collections. First experiments on tags and artworks from the ArsMeteo Italian web portal are discussed.

Keywords: Ontology of emotions, emotion visualization, affective computing

1 Introduction

The development on the web and the advent of social media has brought about new paradigms of interactions that foster first-person engagement and crowd-sourcing content creation. In this context the subjective and expressive dimensions move to the foreground, opening the way to the emergence of an affective component within a dynamic corpus of digitized contents, which advocate new techniques for automatic processing, indexing and retrieval of the affective information present. Therefore, recently a high interest raised among researchers in developing approaches and tools for sentiment analysis and emotion detection, aimed at automatic analyzing and processing the affective information conveyed by social media [16, 7]. In addition, the need to support users in accessing and exploring the outcomes of the emotion detection and sentiment analysis algorithms has fueled interest on research of solutions that address the *sentiment summarization and visualization problem*. Organization and manipulation of social media contents, for categorization, browsing, or visualization purpose, often

need to encompass a semantic model of their affective qualities (or of their reception by the users). In particular, a key role to bring advancements in this area can be played by ontologies and cognitive models of emotions [5], to be defined and integrated into traditional information processing techniques.

In this paper we address the above issues in the context of the ArsEmotica project [2–4][1]. ArsEmotica is an application software that detects emotions evoked by resources (artworks) from online collections, by exploiting, as information source, tags intended as textual traces that visitors leave for commenting artworks on social platforms. The final aim is to create a *semantic social space* where artworks can be dynamically organized according to an ontology of emotions. Detected emotions are meant to be the ones which better capture the affective meaning that visitors, *collectively*, give to the artworks. We propose to tackle this issue in a semantic web setting, through the development of an ontology of emotional categories based on Plutchik's circumplex model [15], a well-founded psychological model of human emotions. The approach to the sentiment analysis task is, indeed, *ontology-driven*. Shortly, given a tagged resource, the correlation between tags and emotions is computed by referring to the ontology of emotional categories, by relying on the combined use of Semantic Web technologies, NLP and lexical resources.

In the last years, many cultural heritage institutions opened their collections for access on the web (think for instance to the Google Art project[2]). User data collected by art social platforms are a precious information source about trends and emotions. Therefore, a growing interest in monitoring the sentiment of the visitors in virtual environments can be observed among art practitioners, curators and cultural heritage stakeholders, as discussed in [4].

In the following, we will describe the most recent achievements within the ArsEmotica project, with a special focus on the development of the ontology of emotions. The ontology inspired an interactive user interface for visualizing and summarizing the results of our emotion detection algorithm; detected emotional responses to artworks are represented by means of a graphical representation inspired to the Plutchik's *emotion wheel*. Moreover, we will present first results of the ongoing experiments of running the ArsEmotica emotion detection engine on a real dataset of artworks and tags from the ArsMeteo web portal [1]. The paper is organized as follows. Section 2 recalls the ArsEmotica's architecture. Section 3 focusses on the ontology of emotions. Section 4 describes the first experiments on the ArsMeteo dataset. Section 5 discusses the ArsEmotica's interactive user interface. Final remarks end the paper.

2 The ArsEmotica Framework

In this section, we briefly recall the characteristics and the main components of ArsEmotica 2.0, the application software that we developed for testing our ideas. Details can be found in [4, 2]. ArsEmotica is meant as a sort of "emotional

[1] `http://di.unito.it/arsemotica`
[2] `http://www.googleartproject.com/`

engine", which can be interfaced with any resource sharing and tagging system which provides the data to be processed, i.e. digital artworks and their tags. Social tagging platforms for art collections, having active communities that visit and comment online the collections, would be ideal data sources.

The pipeline of ArsEmotica includes four main steps.

1. **Pre-processing: Lemmatization and String sanitizing.** In this step tags associated with a given artworks are filtered so as to eliminate flaws like spelling mistakes, badly accented characters, and so forth. Then, tags are converted into lemmas by applying a lemmatization algorithm, which builds upon *Morph-It!*, a corpus-based morphological resource for the Italian language [18].
2. **Checking tags against the ontology of emotions.** This step checks whether a tag belongs to the ontology of emotions. In other words, it checks if the tags of a given resource are "emotion-denoting" words directly referring to some emotional categories of the ontology. Tags belonging to the ontology are immediately classified as "emotional".
3. **Checking tags with SentiWordNet.** Tags that do not correspond to terms in the ontology are further analyzed by means of *SentiWordNet* [8], in order to distinguish *objective* tags, which do not bear an emotional meaning, from *subjective* and, therefore, affective tags. The latter will be the only ones presented to the user in order to get a feedback on which emotional concept they deliver. The feedback is collected thanks to the interactive user interface described in Sec. 5, which has been designed in tune with the ontological model of emotion presented below.

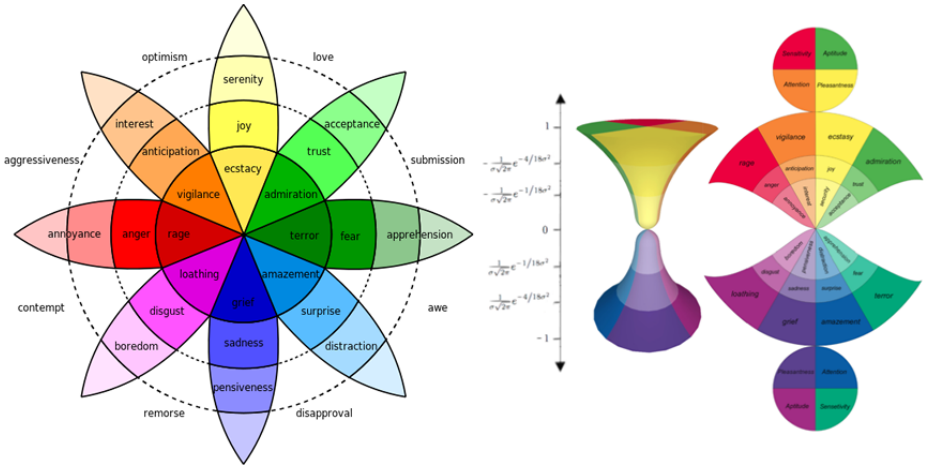

Fig. 1. Plutchik's circumplex model [15] (left); Hourglass model [6] (right).

4. **Combining emotional data and output.** Based on data collected in the previous steps, the tool computes and offers as output a set of emotions associated to the resource. We have implemented a new algorithm for accomplishing this task, where emotions collected in the previous steps are not simply ranked as in [2] but compared and combined. The algorithm compare collected emotions, by exploiting ontological reasoning on the taxonomic structure of the ontology of emotions. Moreover, it combines them by referring to the Hourglass Model [6], a reinterpretation of the Plutchik's model, where primary emotions are further organized around four independent but concomitant dimensions (*Pleasantness*, *Attention*, *Sensitivity* and *Aptitude*), whose different levels of activation can give birth to very wide space of different emotions. Shortly, in this model different emotions (basic or compound), result from different combinations of activation levels for the four dimensions. Dimensions are characterized by six levels of activation, which determine the intensity of the expressed/perceived emotion as a float $\in [-1, +1]$ (Figure 1, right side). This allows to classify affective information both in a categorical way (according to a number of emotion categories) and in a dimensional format (which facilitates comparison and aggregation), and provided us a powerful inspiration in implementing a new algorithm for combining emotional data in a final output.
   The resulting output can be produced in different modalities. Emotions evoked by artworks are visualized by a sort of *emotion wheel*, graphically inspired to the color wheel used by Plutchik for offering a bi-dimensional representation of his circumplex model of emotions [14] (Sec. 5). Moreover, the application encodes the output in a machine-readable format, by relying on W3C standards: RDF and EmotionML, an emerging standard for emotion annotation[3].

3 An Ontology for ArsEmotica

In this section we describe the ontology, which plays a key role in all steps of ArsEmotica computation. It is an ontology of emotional categories based on Plutchik's circumplex model [15, 14], a well-founded psychological model of emotions, and includes also concepts from the Hourglass model in [6]. The ontology is written in OWL. It can be released on demand for academic purposes.

3.1 Classes, Hierarchy and Properties

The ontology structures emotional categories in a taxonomy, which includes 32 emotional concepts. Due to its role within the ArsEmotica architecture, the ontology has been conceived for categorizing emotion-denoting words, as the one used in the previous version of the application. It, includes two root concepts: *Emotion* and *Word*.

[3] `http://www.w3.org/TR/emotionml/`

Class Emotion For what concerns the class *Emotion*, the design of the emotional categories taxonomic structure, of the disjunction axioms and of the object and data properties mirrors the main features of Plutchik's circumplex model, (see Fig 1, left side). Such model can be represented as a *wheel of emotions* and encodes the following elements and concepts:

- **Basic or primary emotions**: *joy*, *trust*, *fear*, *surprise*, *sadness*, *disgust*, *anger*, *anticipation* (i.e. *expectancy*); in the color wheel this is represented by differently colored sectors.
- **Opposites**: basic emotions can be conceptualized in terms of polar opposites: *joy* versus *sadness*, *anger* versus *fear*, *trust* versus *disgust*, *surprise* versus *anticipation*.
- **Intensity**: each emotion can exist in varying degrees of intensity; in the wheel this is represented by the vertical dimension.
- **Similarity**: emotions vary in their degree of similarity to one another; in the wheel this is represented by the radial dimension.
- **Complex emotions**: complex emotions are a mixtures of the primary emotions; in the model in Fig 1 emotions in the blank spaces are compositions of basic emotions called *primary dyads*.

Emotion is the root for all the emotional concepts. The *Emotion*'s hierarchy includes all the 32 emotional categories presented as distinguished labels in the model. In particular, the *Emotion* class has two sub-classes: $BasicEmotion$ and $ComplexEmotion$. $BasicEmotion$ and $CompositeEmotion$ are disjoint classes.

Basic emotions of the Plutchik's model (*Disgust, Trust, Sadness, Joy, Anticipation, Surprise, Anger* and Fear) are direct subclasses of $BasicEmotion$. Each of them is specialized again into two subclasses representing the same emotion with weaker or the stronger intensity (e.g. the basic emotion *Joy* has *Ecstasy* and *Serenity* as subclasses). Therefore, we have 24 emotional concepts subsumed by the $BasicEmotion$ concept. Instead, the class $CompositeEmotion$ has 8 subclasses, corresponding to the primary dyads in the Plutchik's model.

Other relations proposed in the Plutchik's model have been expressed in the ontology by means of the following *object properties*, where $Arch$ is the set of the basic emotions and $Comp$ the set of the complex emotions:

- **hasOpposite**: $(f : Arch \longrightarrow Arch)$, encodes the notion of *polar opposites*;
- **hasSibling**: $(f : Arch \longrightarrow Arch)$ encodes the notion of *similarity*;
- **isComposedOf**: $(f : Comp \longrightarrow Arch)$ encodes the notion of *composition of basic emotions*.

The *data type property* **hasScore:**$(f : Arch \longrightarrow \mathbb{R})$ was introduced to link each emotion with an intensity value mapped into the hourglass model.

Class Word *Word* is the root for the emotion-denoting words, i.e. those words which each language provides for denoting emotions, in line with related and previous work [10, 2]. Since we currently applied our application to use cases where tagging involved Italian communities, we defined and populated the subclass

ItalianWord[4]. Intuitively, each instance of the *Word* and *Emotion* concepts, e.g. *felicità* has two parents: one is a concept from the *Emotion* hierarchy (the emotion denoted by the word, e.g. *Joy*), while the other is a concept from the *Word* hierarchy (e.g. Italian, the language the word belongs to).

3.2 Individuals and Ontology Population

We semi-automatically populated the ontology with Italian words by following the same methodology described in [2] for populating OntoEmotion, the ontology used in the previous version of the ArsEmotica prototype. Shortly, we relied on the multilingual lexical database MultiWordNet [13] and its affective domain WordNet-Affect[5], a well-known lexical resource that contains information about the emotions that the words convey, that was developed starting from WordNet [17]. WordNet [9] is a lexical database, in which nouns, verbs, adjectives and adverbs (lemmas) are organized into sets of synonyms (synsets), representing lexical concepts. The WordNet-Affect resource was developed through the selection and labeling of the synsets representing affective concepts.

Our population process started by manually selecting a set of representative Italian emotional words, at least one word for each concept. This initial set was including less than 90 words classified under our 32 emotional concepts, but they were only *nouns*. In order to expand with *adjectives* the set of Italian words representative of emotional concepts, we included and classified according to the ontology[6] the list of 32 emotion terms in [11]: *addolorato, allegro, angosciato, annoiato, ansioso, arrabbiato, contento, depresso, disgustato, disperato, divertito, entusiasta, euforico, felice, gioioso, imbarazzato, impaurito, indignato, infelice, irritato, malinconico, meravigliato, preoccupato, risentito, sbalordito, scontento, sconvolto, sereno, sorpreso, spaventato, stupito, triste*.

In a second phase we automatically expanded the set of individuals (emotion denoting words) belonging to the emotional concepts by exploiting MultiWordNet and the WordNet-Affect. All manually classified words and adjectives were used as *entry lemmas* for querying the lexical database. The result for each word was a synset, representing the "senses" of that word, labeled by MultiWordNet unique synset identifiers. Each synset was then processed by using WordNet-Affect [17]: when a synset is annotated as representing affective information, then, *all the synonyms belonging to that synset* are imported in the ontology as relevant Italian emotion-denoting words for the same concept of the entry lemmas. In other words, we automatically enriched the ontology with synonyms of the representative emotional words, but also filter out synsets which do not convey affective information. As a final step, we further expanded the set of emotion denoting words with further *adjectives, verbs* and *adverbs*, by exploiting the

[4] The ontology is already designed to be extended with further subclasses of *Word*, for representing emotion-denoting words in different languages.

[5] `http://wndomains.fbk.eu/wnaffect.html`

[6] This process has been carried on manually, by relying on morpho-semantic relations between nouns already classified in the ontology and adjectives specified in the Treccani dictionary (`http://www.treccani.it`).

WordNet relation `derived-from`, for which can be assumed that the affective meaning is preserved. Therefore, all synsets obtained by an application of the `derived-from` relation (and not yet classified in our ontology) were included as individuals of the proper emotional concept. At the end of the process a human expert checked the identified terms. The resulting ontology contains about 700 Italian words referring to the 32 emotional categories of the ontology.

4 First Experiments on the ArsMeteo Dataset

We are currently testing the version 2.0 of the ArsEmotica prototype against a dataset of tagged multimedia artworks from the *ArsMeteo* art portal (`http://www.arsmeteo.org` [1]). According to the ArsEmotica emotional analysis, 1705 out of the 9171 artworks in the dataset bear an emotional meaning encoded in the ontology.

4.1 The ArsMeteo Dataset

Our dataset *ArsM* is a significant set of tagged artworks from the ArsMeteo web portal. It consists of 9171 artworks with the associated tags[7]. The ArsMeteo

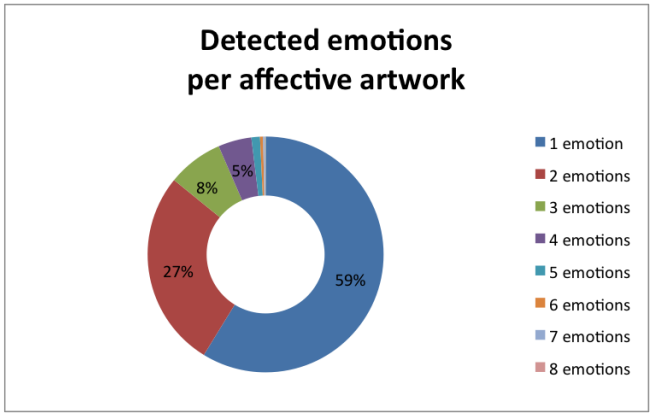

Fig. 2. Detected emotions per artwork in $AffectiveArsM$

web platform combines social tagging and tag-based browsing technology with functionalities for collecting, accessing and presenting works of art together with their meanings. It enables the collection of digital (or digitalized) artworks and performances, belonging to a variety of artistic forms including poems, videos,

[7] Specifically, *ArsM* includes comments associated to the artworks from Arsmeteo users until December 2010.

pictures and musical compositions. Meanings are given by the tagging activity of the community. Currently, the portal collected over 10,000 artworks created by about 300 different artists; his community has produced over 37,000 tags (an average of 10 tags per artwork).

4.2 Emotional Analysis

Emotions belonging to the ontology are detected in about 20 percent of our dataset[8]. Let us denote with $AffectiveArsM$ the set of artworks classified according to some emotions of our ontology after the emotional analysis performed by ArsEmotica.

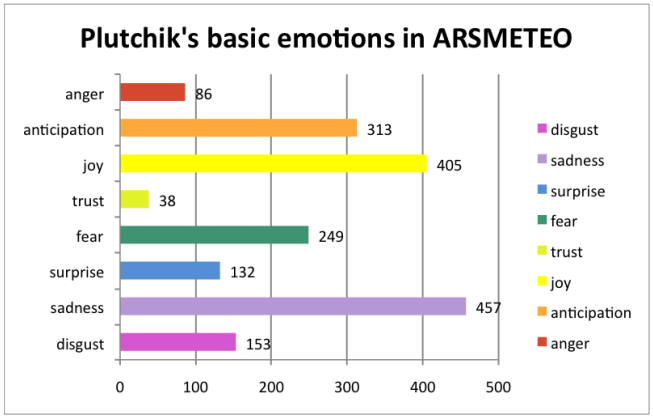

Fig. 3. Distribution of emotional labels in ArsMeteo: basic emotions.

In ArsMeteo, artworks usually have many tags, expressing a variety of meanings, thus supporting the emergence of different emotional potentials. This is consistent with the idea that art can emotionally affect people in different ways. When this happens, the analysis performed by ArsEmotica provides multiple emotional classifications. Fig 2 shows results on number of emotions detected for each artworks in $AffectiveArsM$. About 40% of the artworks received multiple classification, i.e. ArsEmotica detected more than one emotion associated to the artwork.

For what concerns the emotion distribution in $AffectiveArsM$, when we consider basic emotions in their varying degree of intensities, the most common emotions were the ones belonging to the *sadness* (457 artworks) and *joy* family (405 artworks), followed by *anticipation*, *fear*, *disgust* and *surprise*. *Anger* was

[8] Notice that the tagging activity, monitored in ArsMeteo since 2006, was not performed with the aim of later applying some kind of Sentiment Analysis, but as a form of spontaneous annotation produced by the members of the community.

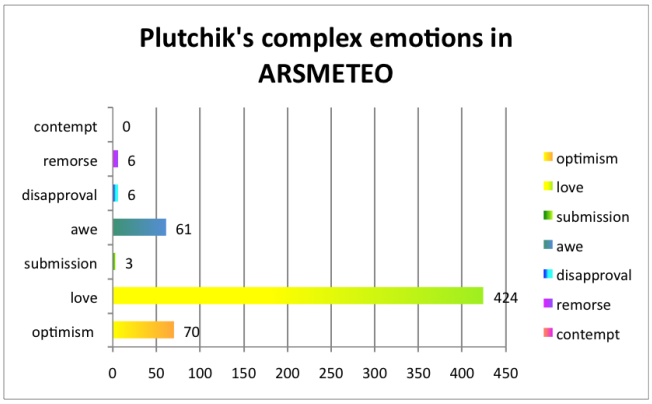

Fig. 4. Distribution of emotional labels in ArsMeteo: complex emotions.

rarer, and *trust* was almost nonexistent (see Fig. 3); when we consider complex emotions, results are summarized in Fig. 4: *love* is very common (424 artworks), *optimism* and *awe* are rare, and the other complex emotions are almost nonexistent.

5 Visualizing and Summarizing Detected Emotions

We have developed an interface linked to our ontology of emotions, which have as main aims: a) to present the outcomes of the emotional analysis for tagged artworks, b) to propose to the user intuitive metaphors to browse the emotional space, and c) to ease the task of emotionally classifying tags having indirect emotional meanings, by means of emotional concepts from the ontology. On this perspective, the Plutchik's model is very attractive for three main reasons. First, the reference to a graphical wheel is very intuitive and offers a *spacial representation of emotions* and their different relations (similarities, intensities, polar oppositions). Such kind of representation allows to convey to the user a rich information on the emotional model, without referring to tree-like visualization of the ontology hierarchy. Second, the use of *colors* for denoting different emotions provides a very intuitive communication code. Different color nuances for different emotions, transmit naturally the idea that primary emotions can blend to form a variety of compound emotions, analogous to the way colors combine to generate different color graduations. Third, the number of emotional categories distinguished in the wheel is *limited*. This aspect facilitates the user that is involved in an emotional evaluation.

The Interface The sequence of interactions offered to the user follows the flux of computation sketched in Section 2. After the user selects an artwork from the collection (Fig. 5, top-left window), the application applies the emotional analysis on the artwork tags. The result of this computation, i.e. the *evoked emotions*,

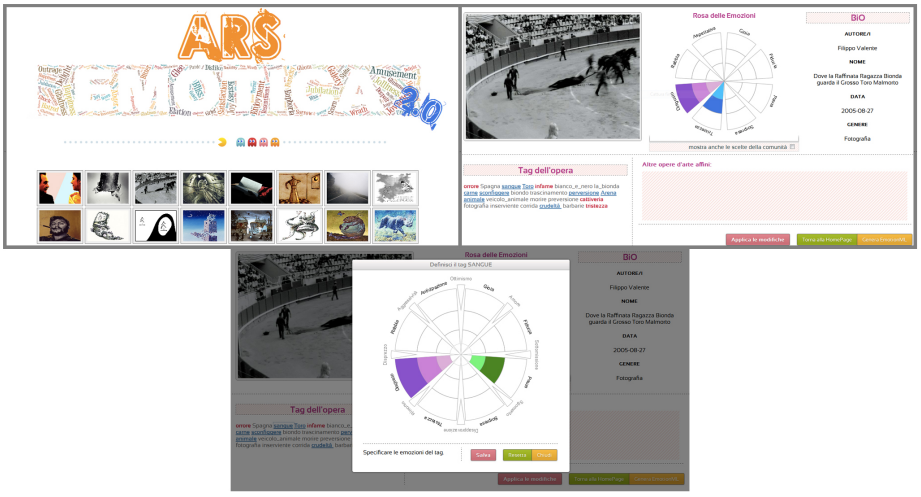

Fig. 5. The ArsEmotica Interface. Top-left: homepage and selection of the artwork; top-right: summarization of results of the automatic emotional analysis of the selected artwork; bottom-center: collection of the tag-mediated user feedback

is summarized to the user by a graphical representation (obtained by adapting the RGraph tool[9]) called "La rosa delle emozioni" which strongly recalls the Plutchik's color wheel. Let us consider, for instance, to run the emotional analysis to the artwork"Dove la Raffinata Ragazza Bionda guarda il Grosso Toro Malmorto" by Filippo Valente, belonging to our *ArsM* dataset. The resulting window (Fig 5, top-left window), includes a preview of the artwork and a summary of related metadata (e.g. title and author of the selected artwork); below, the four red colored tags are identified as emotional according to the emotional ontology: 'orrore', 'infamia', 'cattiveria', 'tristezza'; the presence of emotional responses related to *Sadness* and a strong disgust (*Loathing*) is highlighted by coloring the sectors of the emotion wheel corresponding to those emotions. Internal sectors of the ArsEmotica's wheel are intended as representing light intensity of emotions, while the external ones as representing high intensity. Underlined blue colored tags denotes tags that have been recognized by the sentiment analysis stage as possibly conveying some affective meaning. Then, they appear as active links for the user's emotional feedback: see e.g. 'sangue', 'sconfiggere', and so on.

Indeed, a user which is not satisfied with the outcome can select a tag to evaluate among the active ones. Then, the application activates a pop-up window, where an uncolored emotional wheel is shown. Users can express the emotional evaluation in terms of basic emotions with different intensities, and color the wheel accordingly, by clicking on one of the 24 sectors of the wheel; otherwise

[9] `http://www.rgraph.net/`

they can select compound emotions, by selecting the wedge-shaped triangles inserted between the basic emotions. In our example (Figure 5, bottom-center) the user associated to the tag 'sangue' (blood) the emotions *Fear* and *Disgust* (with high intensity, which corresponds to *Loathing*). Notice that the tag evaluation is contextual to the vision of the artwork, which indeed remains visible in the background. After user expressed her feedback, detected and collected emotions are combined and the resulting emotional evaluation is again presented to the user by using the ArsEmotica's wheel.

6 Conclusion and Future Work

In this paper we have described the OWL ontology of emotions used in the ArsEmotica 2.0 prototype, which refers to a state-of-the-art cognitive model of emotions and inspired an interactive user interface for visualizing and summarizing the results of the emotion detection algorithm.

Recently, many researchers are devoting efforts in developing ontology of emotions in the Semantic Web context [5, 12, 10], and some of them addressed the issue from a foundational point of view. In particular, the Human Emotion Ontology (HEO) developed in OWL [12], was introduced with the explicit aim to standardize the knowledge about emotions and to support very broad semantic interoperability among affective computing applications. It will be interesting to study how to link the ArsEmotica's ontology of emotions with HEO, which could play for us the role of "upper ontology" for emotions, by providing an ontological definition of the general concept of emotion. In fact, in our ontology the root concept of the *Emotion* hierarchy is treated as primitive (it is not semantically described in terms of characterizing properties).

The Hourglass Model we refer to in order to combine detected and collected emotions in ArsEmotica allows us to design a fluid and continuous emotional space, where artworks (but also possibly user's tag) can be positioned. The actual ArsEmotica interface provide our users with the possibility to access the outcomes of a the emotional analysis. On this line, the next step is to study innovative strategies to *browse* the artworks, by relying on their semantic organization in the ArsEmotica emotional space. The aim is to provide users with the possibility to explore the resources by exploiting the various dimensions suggested by the ontological model. Possible queries to deal with could be: "show me sadder artworks" (intensity relation); "show me something emotionally completely different" (polar opposites); "show me artworks conveying similar emotions" (similarity relation).

For what concerns sentiment visualization, designing engaging interfaces that allow an appropriate granularity of expression is not an easy task. We plan to evaluate soon the new prototype and its interface, by carrying on a user test where users of the ArsMeteo community, which in the past have already actively participated to a user study on the first version of our prototype [3], will be involved.

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