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ArsEmotica for arsmeteo.org: Emotion-Driven Exploration of Online Art Collections

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Abstract

In this paper, we present an application framework, ArsEmotica 2.0, where semantic technologies, linked data and natural language processing techniques are exploited for investigating the emotional aspects of cultural heritage artifacts, based on user generated contents collected in art social platforms. We rely on affective categorization models expressed by an ontology well grounded in psychology and encoded in W3C standard specification languages. We present the implementation and exploitation of the framework on a real dataset, the ArsMeteo online collection, aiming to adapt human access to cultural heritage collections by visualising emotions detected in artworks, and to let computer access by means of Linked Open Data. The use of semantic technologies enables both automatic reasoning on the elicited affective information, and interoperability or integration of tools developed within the Semantic Web and Linked Data Community.

Introduction

Humanities and arts are a rather fresh application area for Semantic Web technologies. Recently, many cultural heritage institutions opened their collections and archives for access on the web. The list includes several major art museums, such as the Guggenheim Museum, the Metropolitan Museum of Art, the San Francisco Museum of Modern Art, and the European Rijksmuseum. Initiatives like the Google *Art Project* to host the world's cultural treasures online, by enabling access to high-resolution images of artworks housed in the initiative's partner museums, can be also considered in this perspective. In this context, on the one hand there have been notable efforts to publish museum data to the Linked Open Data cloud (LOD): let us mention the Europeana project (Haslhofer and Isaac 2011), the CLAROS initiative (Kurtz et al. 2009), and other valuable efforts of single institutions such as the Amsterdam Museum (de Boer et al. 2013) and the Smithsonian American Art Museum (Szekely et al. 2013). On the other hand, there has been much interest in exploring the ways social technologies and principles of the Social Web can be applied in enhancing the exploration of cultural heritage objects, both on site, and on-line (Chae et al. 2012; Lin and Aroyo 2012; Baldoni et al. 2012). According to the new concept of *Participatory Museum* (Simon 2010), artworks can play an important role as "social objects", i.e. as a basis for an object-centered sociality.

The kind of work we are presenting here tackles with both the above mentioned research efforts, but the emotional dimension moves to the foreground. Recently, affective computing, and in particular sentiment analysis and emotion detection in user data collected by social platforms, are receiving increasing attention in many sectors (Cambria et al. 2013). Application of such techniques to the Cultural Heritage and Art domain, however, is quite at its beginning (Chae et al. 2012; Baldoni et al. 2012; Bertola and Patti 2013), in spite of the fact that a high interest in monitoring the sentiment of the visitors is recently raised among art practitioners, curators and cultural heritage stakeholders; think for instance about the work on the mechanics of emotions by the new-media artist Benayoun[1], or to the project "e-motion: Mapping Museum Experience" [2].

Contribution In this paper we describe the benefits and challenges raised by our experience in applying emotional tagging of artworks provided by the semantic web application ArsEmotica (Baldoni et al. 2012; Bertola and Patti 2013) to a real-world dataset of multimedia artworks from the ArsMeteo Italian social portal arsmeteo.org. Shortly, the ArsEmotica aim is to detect emotion evoked by artworks from online collections, by analyzing social tags intended as textual traces that visitors leave for commenting artworks on social platforms. The approach is *ontology-driven*: given a tagged resource, the relation with the evoked emotions is computed by referring to an ontology of emotional categories, developed within the project and inspired by the well-known Plutchik's model of human emotions (Plutchik 2001). Detected emotions are meant to be the ones which better capture the affective meaning that visitors, *collectively*, give to the artworks.

ArsEmotica provides a semantic tagging to ArsMeteo's artworks. Moreover, the ArsMeteo dataset includes "standard" collection structured metadata referring to artworks and unstructured information about artists who created

[1] http://www.benayoun.com/
[2] http://www.mapping-museum-experience.com

them, released by the artists themselves. Both emotional and ArsMeteo metadata have been represented into a unified semantic web representation, the ArsEmotica Ontology (AEO henceforth), which is an advancement w.r.t. to previous work on ArsEmotica. Encoded in OWL2 QL, AEO incorporates, in a unifying model, multiple ontologies which describe different aspects of the connections between media objects, persons and emotions. Such semantic representation of (also emotional) knowledge about artworks, allows us to enhance access to the ArsMeteo collection both along the human users dimension and and along the machines one, by obtaining two main results:

1. **Enrichment of user's experience by emotion-driven access to the artworks**

   An interactive user interface for visualizing the results of the emotion detection algorithm can give to the user a flavor about the emotional classification of the artwork in the context of the ontological knowledge model exploited.

2. **SPARQL endpoint to query the emotionally enriched ArsMeteo dataset** Access via SPARQL queries and connection of the ArsMeteo dataset to the linked open data cloud will foster interesting and unexpected possibility of reusing the data.

The use case on arsmeteo.org is a completely new contribution w.r.t. previous work, as well as the development of the unified AEO ontology and of a SPARQL endpoint.

Organization The rest of the paper is organized as follows. The first section describes the ArsMeteo dataset; followed by a section presenting the ArsEmotica's framework. The next section describes the ArsEmotica Ontology. Then, an interactive user interface to access the emotions evoked by artworks and the current stage of development of a SPARQL endpoint to automatically query the semantically enriched dataset are described. Final remarks end the paper.

The ArsMeteo Online Collection

ArsMeteo (Acotto et al. 2009) is an art portal for sharing artworks and their emerging, connective meanings. It is inspired by an idea of the Italian artist *Giorgio Vaccarino* and its development is leaded by a non-profit cultural organization called *Associazione Culturale ArsMeteo* (AMA), based in Turin, Italy. On-line since June 2007, the 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, pictures and music. Meanings are given by the tagging activity of the community. All contents are accessible as "digital commons". Currently, the portal collected over 350,000 visits and gathers a collection of over 10,000 artifacts produced by 307 artists; it has collected almost 38,000 tags (an average of about 10 tags per artwork).

For what concerns the *community aspects*, ArsMeteo started in a national context: most of the users are Italian, contemporary artists. For many of the ArsMeteo authors the portal was a first appealing opportunity for accessing and exploiting the new social potential of web-based technologies. Artists and visitors may express their own reception of the artworks by tagging them or by clicking on the plus and minus symbols next to tags to change tag weights. This is a form of spontaneous artwork's annotation produced by the members of the community.

The ArsMeteo Dataset

ArsMeteo's collection metadata are stored in a relational database, managed by the AMA. Structured metadata are released by authors themselves when they upload artworks into the portal, according to a metadata schema which includes information about *author* and *genre classification* according to a list of available labels, e.g. photography, music, performance.

Almost all such metadata already appears on the portal when a user accesses the preview of the uploaded artwork, together with the tags currently assigned. Moreover, unstructured information about artists who created them, can be released by the artists themselves in form of biographical sketches. Biographical information has been processed in order to extract, when present, geographical information about *place of birth* and *place of living* of the author. Related additional features have been included in the ArsEmotica semantic data model that will be introduced in the next sections, together with the features aimed at modeling the original items of the ArsMeteo metadata scheme.

ArsEmotica: a Semantic Framework for Emotion-driven Classification of Artworks

ArsEmotica is the application software that we developed for emotion detection. Details about the previous version can be found in (Baldoni et al. 2012; Bertola and Patti 2013). It is meant as a sort of "emotional engine", which can be interfaced with any resource sharing and tagging system which provides the data to be processed. Its pipeline includes four main steps in Fig. 1.

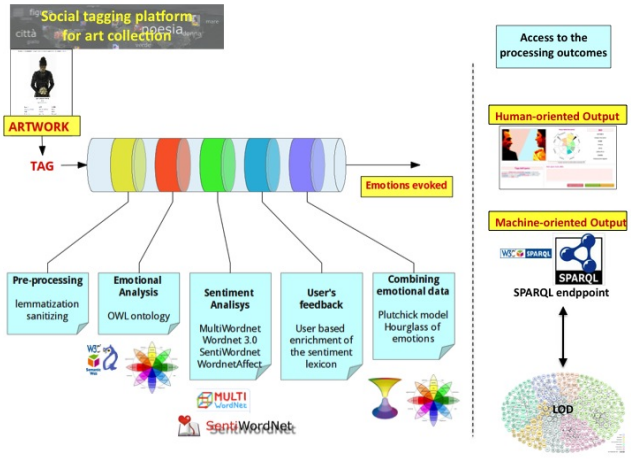

Figure 1: ArsEmotica overall architecture.

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.
2. **Checking tags against the ontology of emotions.** This step checks whether the tags of a given resource are "emotion-denoting" words directly referring to some emotional categories of the AEO ontology.
3. **Checking tags with SentiWordNet & user's feedback** Tags that are not recognized as "emotion-denoting" words in the ontology are further analyzed by means of *SentiWordNet* (Esuli, Baccianella, and Sebastiani 2010), in order to distinguish *objective* tags, which do not bear an emotional meaning, from *subjective* ones. The latter will be the only ones presented to the user in order to get a feedback about which emotional concept they deliver. The feedback is collected thanks to the interactive user interface described later in the paper, which has been designed in tune with the ontological model of emotions.
4. **Combining emotional data and output.** We have implemented a combination algorithm, that, on demand, elaborates on this results and allows to compare and combine emotions collected in the previous steps. This can be useful, in order to have a sort of synthesis which takes into account similarities among the detected emotions encoded in the affective model. We exploited such synthesis to offer human users with a more compact graphical "vision" of the output, but different possible uses of such further computation can be envisioned (see the right side of Fig. 1). The algorithm compares collected emotions, by exploiting the taxonomic structure of the ontology of emotions. Moreover, it combines them by referring to the Hourglass Model (Cambria, Livingstone, and Hussain 2012), a reinterpretation of the Plutchik's model.

Emotional Tagging of Artworks from the ArsMeteo Collection

Social tagging platforms for art collections, having active communities that visit and comment online the collections, are ideal data sources for applying the ArsEmotica analysis. The ArsMeteo collection, which is the focus of the current work, fits such characteristics. Emotions belonging to the ontology are detected in about 20 percent of the ArsMeteo dataset. 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.

The application of the ArsEmotica's emotional engine to the arsmeteo.org dataset provides new semantic metadata that can be used for classifying artworks according to emotional categories. The affective information is encoded in a semantic web ontology of emotions, which belongs to the AEO ontology we are going to describe.

The ArsEmotica Ontology

Written in OWL2 QL, the ArsEmotica Ontology (AEO) incorporates, in a unifying model, multiple ontologies which describe different aspects of the connections between *media objects* (e.g. the ArsMeteo artworks), *persons* and *emotions*.

In particular, it includes an *ontology of emotions* (details below). The represented emotions have been linked, via owl:sameAs, to the corresponding emotions in DBpedia[3]. Furthermore, it incorporates an *ontology of artifacts*, derived from the alignment of a domain ontology obtained from the DB of the ArsMeteo on line portal, with the *Ontology for Media Resources* (OMR)[4]. Such an alignment allows to express in a semantic unified framework the standard ontological features used for describing the artworks (e.g. the Media Resource type, the format, the creator of an artwork, and so forth). The OMR ontology is supposed to foster the interoperability among various kinds of metadata formats currently used to describe media resources on the Web. It offers a core vocabulary to describe media resources on the Web, introducing descriptors such as title, creator, publisher and createDate. The alignment between the artifact ontology and OMR is provided at the class level. For example, the ArsEmotica class containing all the artworks (Opera: http://arsemotica.di.unito.it/artifacts#Opera) has been declared as subclass of the MediaResource class from OMR (http://www.w3.org/ns/ma-ont#MediaResource).

Finally, in order to enable the representation of the potential networks among artists, the *FOAF model*[5] has been incorporated into AEO, and the information related to the geographical area where the artists operate have been included. As in the case of the emotions, the locations have been connected, in a Linked Data perspective, with the corresponding DBpedia URIs. This potentially enables a linkage to GeoNames Ontology. The adopted knowledge engineering approach, is grounded on the underlying rationale of the LOD framework, based on the assumption that the reuse and linkage to concepts represented in standard semantic resources (e.g. DBpedia) is one of the main features for preserving the quality of the linked data semantic ecosystem.

The Ontology of Emotions

The affective knowledge is encoded in an ontology of emotional categories based on Plutchik's circumplex model (Plutchik 2001), a well-founded psychological model of emotions, and includes also concepts from the Hourglass model in (Cambria, Livingstone, and Hussain 2012). The ontology has been developed in the context of the ArsEmotica project, and structures emotional categories in a taxonomy, which currently includes 32 emotional concepts.

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. Such model can be represented as a *wheel of emotions* and encodes the following elements:

[3] http://dbpedia.org/

[4] http://www.w3.org/TR/mediaont-10/

[5] http://xmlns.com/foaf/spec/

- **Basic or primary emotions**: *joy*, *trust*, *fear*, *surprise*, *sadness*, *disgust*, *anger*, *anticipation*; 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; looking at the Plutchik's wheel, the height 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 disjoint subclasses: $BasicEmotion$ and $ComplexEmotion$. Basic emotions of the Plutchik's model are direct sub-classes 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 sub-classes). Therefore, we have 24 emotional concepts subsumed by the $BasicEmotion$ concept.

Instead, the class $CompositeEmotion$ has 8 subclasses, corresponding to the primary dyads. Other relations in the Plutchik's model have been expressed in the ontology by means of *object properties*: the `hasOpposite` property encodes the notion of *polar opposites*; the `hasSibling` property encodes the notion of *similarity* and the `isComposedOf` property encodes the notion of *composition of basic emotions*. Moreover, a *data type property* `hasScore` was introduced to link each emotion with an *intensity* value i mapped into the Hourglass model ($i \in \mathbb{R}$).

We have chosen to encode the Plutchik's model in the ontology for several reasons. First, it is well-grounded in psychology and general enough to guarantee a wide coverage of emotions. This is important for implementing successful strategies aimed at mapping tags to the emotional concepts of the ontology. Second, the Plutchik's "wheel of emotions" allows us to link the ontology to an intuitive visual graphical presentation of the emotional space (see the next section). Most ontology-driven information retrieval systems cannot use ontologies this way because there is no proper presentation of them. Finally, it encodes interesting notions, e.g. emotional polar opposites, which can be exploited for finding new relations among artworks

Emotion Denoting Words in LEMON Due to the need of modeling the link among words in a language and the emotions they refer to, AEO has been also integrated with the ontology framework LExicon Model for ONtologies (LEMON) (McCrae, Spohr, and Cimiano 2011). In particular, as an advancement w.r.t. other approaches (Francisco, Gervas, and Peinado 2010), which inspired the previous version of ArsEmotica (Baldoni et al. 2012), such integration allowed us to explicitly differentiate between the *language level* (lexicon based) and the *conceptual* one representing the emotional concepts. Within this enriched framework, it is possible to associate a plethora of emotional words, with the encoding of language information, to the corresponding emotional concepts. In particular, emotion-denoting words are encoded in AEO as lexical entries (i.e. instances of `lemon:LexicalEntry`). They are linked to their corresponding *lexical sense* (for us the WordNet-Affect synset, denoted by WordNet ids) by means of the `lemon:sense` property. Finally, the lexical senses are related to the emotional concepts via the property `lemon:reference`. We semi-automatically populated the classes *LexicalEntry* and *LexicalSense* with synsets and lemmas from WordNet-Affect 1.1, an affective domain of the multilingual lexical database MultiWordNet[6], where the Italian WordNet is strictly aligned with Princeton WordNet 1.6[7]. Most of the synsets (about 780) have been automatically related to our emotional categories by exploiting information present in WordNet–Affect 1.1. The remaining ones (about 120), where manually annotated by two human raters in order to find an agreement, if possible, on their reference to our emotional categories. The result is an ontology including over 800 words Italian emotion-denoting words[8], with almost 900 WordNet-Affect 1.1 synsets classified under our emotional categories.

Access to the Semantic ArsMeteo Dataset Enriched with Emotions

The semantic representation of the ArsMeteo dataset within AEO ontology was, on the one hand, a stimulus for the design of a novel user interface to visualize the emotional tagging of artworks provided by ArsEmotica, and to offer a novel emotion-driven way to explore artworks to human users; on the other hand a basis for the development of a SPARQL endpoint to query semantically enriched data.

Access for Humans: Visualizing Detected Emotions

We have developed an interface linked to our ontology of emotions to present the outcomes of the emotional analysis for tagged artworks, and to collect the user's feedback. The Plutchik's model reflected in our ontology of emotions, in particular its graphical representation as a wheel, provides an intuitive metaphors to browse the emotional space, by offering a *spacial representation of emotions* and their relationships (similarities, intensities, oppositions). Such representation allows to convey to the user a rich information on

[6] http://multiwordnet.fbk.eu

[7] WordNet 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 (http://wndomains.fbk.eu/wnaffect.html).

[8] Not all the WordNet–Affect synsets, which refers to English based synsets in WordNet 1.6, have a corresponding Italian synset in MultiWordNet.

the emotional model, without referring to tree-like visualization of the ontology hierarchy. Moreover, the use of *colors* for denoting different emotions provides an 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.

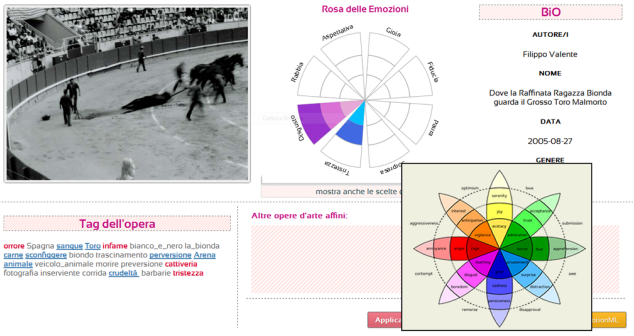

Figure 2: Graphical User Interface inspired to the Plutchik's wheel; showing the results of the emotional analysis.

The sequence of interactions offered to the user follows the flux of computation previously sketched. After the user selects an artwork from the ArsMeteo collection, the application applies the emotional analysis on the artwork's social tags. The result of this computation, i.e. the emotional tagging corresponding to the evoked emotions, is summarized to the user by a graphical representation which strongly recalls the Plutchik's color wheel. Let us consider, for instance, to run the ArsEmotica analysis to emotionally tag the artwork "Dove la Raffinata Ragazza Bionda guarda il Grosso Toro Malmorto" by Filippo Valente from the ArsMeteo dataset. The resulting window (Fig 2), 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 denote 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.

Art can affect people in different way, and History of Art presents many cases of controversial artworks that stirred mixed (also opposite) emotions. ArsEmotica detects and presents all the emotions related to the artwork's tags, which globally express the sentiment of ArsMeteo community about the artwork. Currently, we do not provide any ranking among the detected emotions. 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 they can select compound emotions (primary dyads). The tag evaluation is contextual to the vision of the artwork, which indeed remains visible in the background. After the feedback has been entered, detected and collected emotions are combined; the resulting emotional evaluation is presented again to the user by using the ArsEmotica's wheel.

Access to Machines: ArsMeteo in the LOD

For what concerns this aspect, our aim is to make possible to automatically query the ArsMeteo dataset by reasoning on semantic information about emotions persons and artifacts encoded in the AEO ontology. The AEO ontology enables classical reasoning e.g. by using domain/range restrictions. It also includes axioms from the externally imported ontologies (e.g. the author's homepage is obtained through the corresponding FOAF object property).

Recently, standards and tools for implementing the Semantic Web and the Web of Linked Data have evolved to a state of maturity, that allows to create applications combining independently developed data sources. Our starting point has been the development of a demo SPARQL endpoint, accessible at http://arsemotica.di.unito.it/arsemotica, relying on Hermit as a reasoner[9], where results to queries are returned in RDF format.

To test the potential of our semantic representation of ArsMeteo artworks, people and emotions we have encoded in SPARQL a number of queries such us:

"Give me the emotions stirred by ArsEmotica's artworks created by artists operating in the Turin area";

"Give me the artworks classified as sad and belonging to the *Music* genre";

"Give me artworks classified as joyful created by artists living in the Salento's Italian region";

"Given a specific author, count the occurrences of different emotions evoked by his/her artworks"; ...

Further reasoning is enabled by SWRL rules: if two artworks are tagged with opposite emotions, then the artworks are categorized as displaying opposite emotions. Sample queries at the demo SPARQL endpoint.

Concerning the scalability of the framework, the main issue is related to the ontological component. In particular, the computational complexity for query answering tasks depends on the computational properties of the underlying description logics providing the semantics for the adopted ontological language (OWL2 QL). Such complexity is well known (http://www.w3.org/TR/owl2-profiles/#OWL_2_QL), since OWL2 QL is the current standard in state-of-the-art semantic technologies handling huge amount of semantic data.

[9] http://hermit-reasoner.com/.

Conclusions and Future Work

In this paper we have described a novel unified semantic framework where artworks belonging to the real-world online collection arsmeteo.org can be semantically described by referring also to emotions. The framework allows to model relations among artworks, persons and emotions, by combining an ontology of emotions with available ontologies, such as FOAF and OMR. Moreover, where possible and relevant, we linked our data to external repositories of the LOD, e.g. DBpedia. We plan to develop the ontology and extend the coverage of our emotion lexicon, also in order to cope with multi-word expressions, that maybe don't explicitly convey emotions, but are related to concepts that do. To deal with such issue it will be convenient to rely on resources like EmoSenticNet (Poria et al. 2014a) and to adopt a concept-based approach, like the one described in (Poria et al. 2014b; 2012).

An interactive user interface to visualize to human users such affective information, in the context of the underlying ontological model, has been designed. The next step is to study innovative strategies to personalize navigation paths, by relying on semantic classification of the artworks in the emotional space, by exploiting the various dimensions suggested by the ontological model. Possible queries are: "show me sadder artworks" (intensity) or "show me something emotionally completely different" (polar opposites).

In (Baldoni et al. 2013) a user study about the first version ArsEmotica have been conducted, by involving about 100 users of the ArsMeteo community, providing some evidence for the core ArsEmotica's hypothesis that emotions evoked by artworks can be detected by analyzing social tags. Evaluation via user study of the current version is in progress.

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