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Social cohesion, Participation, and Inclusion through Cultural Engagement

D6.3 Prototype of Knowledge based Support

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4	AAU	AALBORG UNIVERSITET	Denmark
5	OU	THE OPEN UNIVERSITY	United Kingdom
6	IMMA	IRISH MUSEUM OF MODERN ART COMPANY	Ireland
7	GVAM	GVAM GUIAS INTERACTIVAS SL	Spain
8	PG	PADAONE GAMES SL	Spain
9	UCM	UNIVERSIDAD COMPLUTENSE DE MADRID	Spain
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11	FTM	FONDAZIONE TORINO MUSEI	Italy
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Executive summary

This document describes three prototypes of Knowledge-based sensemaking tools namely DEGARI, Thematic Reasoner and Value Reasoner. Such tools are the fundamental building blocks of the Intelligence Layer envisioned in the Deliverable D4.1 and an important technical asset for supporting of the interpretation-reflection loop (Deliverables D2.1 and D2.2). Such prototypes provide reasoning capabilities over the Emotional, Narrative and User Modelling Knowledge Areas of the SPICE Ontology Network (cf. Deliverable D6.2). Finally, this document reports on the preliminary adoption of such reasoners in the case studies. The experimentation with the case studies has been supported by the technical research infrastructure (cf. Deliverable D6.1).

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Introduction

This deliverable provides preliminary description for the prototypes of the knowledge-based sensemaking tools developed in SPICE. The current prototypes rely on the SPICE Ontology Network (SON, described in the Deliverable D6.2) concerning the following knowledge areas: Emotion, Narrative, Values, and User and Community modelling. The output of these sensemaking tools enables the enrichment of contents (user-generated or coming from museum catalogues) associated with cultural items, by suggesting new forms of semantic aggregation and connections among users (e.g., citizens or museum curators), artworks, artifacts and the corresponding interpretations and reflections generated from them. From a technical perspective, these reasoning systems rely on the tools for textual annotation and recommendation developed in the Work Package 3 and build upon the storage capabilities provided by the Linked Data Hub (cf. Deliverable D4.1) and technical research infrastructure (cf. Deliverable D6.1). Overall, the reasoning systems described here go beyond the current state of the art of ontology-based engines (they are already used and available to the SPICE consortium via the research infrastructure described in Deliverable 6.1) and enrich the spectrum of intelligent services that can be used in SPICE. These tools have been preliminarily tested on data coming from three case studies: the GAM, the IMMA, and the Hecht Museums.

The document is organized as follows: we first review the main related knowledge-based sensemaking tools developed in the context of cultural heritage applications and covering the same knowledge areas that are of interest for the SPICE project, then we describe the prototypes of DEGARI (the emotion reasoning tool), the Thematic Reasoner and the Value Reasoner by outlining the current state of development, their current applications and results in the context of the SPICE case studies. Finally, we provide an outlook about the future development of such prototypes and the integration with the other software components of the project.

Data and Knowledge driven Sensemaking Tools for Emotion, Narratives and Values

The application of knowledge and data driven methods used to make sense of cultural data and to organize and semantically guide the exploration of cultural archives has been explored in literature. In the following, we highlight some relevant contributions and contextualize them with respect to the main areas of interest of SPICE concerning the Emotional, Narrative and Value Knowledge areas.

For what concerns the Emotional Knowledge-Area: it is well acknowledged that emotions are a key part of the aesthetic experience throughout the ages and across cultures. Despite the importance of the emotional stance, there are few works and resources specifically developed to address emotion detection in the art and media domain. These include the work by Mohammad and Kiritchenko (2018), where the authors describe the WikiArt Emotions Dataset, which includes emotion annotations for thousands of pieces of art from the WikiArt.org collection (here each piece of art is annotated for one or more of 20 emotion categories and annotations were obtained via crowdsourcing) and the work by Patti et al. (2015), where the ArsEmotica framework is proposed, which relies on the combined use of NLP affect resources and an ontology of emotions to enable an emotion-driven exploration of online art collections. In general, an overall trend is represented by diversity of the methods and tools used to extract and make sense of the emotional responses to art (or evoked by art), ranging from the use of deep learning techniques to more structured, symbolic based, approaches. In particular, depending on the specific research goals, one could be interested in issuing a discrete label describing the affective state expressed in a cultural item (frustration, anger, joy, etc.) to address different contexts of interaction and tasks. In this case, both basic emotion theories, in the Ekman (1993) tradition, and dimensional models of emotions, have provided a precious theoretical grounding for the development of lexical resources (Strapparava and Valituti, 2004; Mohammad and Turney, 2013) and computational models for emotion extraction (Cambria et al. 2020). In parallel, there is a general tendency to move towards richer, finer-grained models, possibly including complex emotions, especially in the context of data-driven and task-driven approaches, where restricting the automatic detection to a small set of basic emotions would fall short to achieve the objective of characterizing the influence of the emotional aspect in the overall context of the conceptualization of cultural items. This is also the perspective that we have chosen in SPICE for the development of its emotion reasoning engine. As we will show in the following, the sensemaking tool developed to deal with emotion reasoning and classification has been based on the Plutchik's theory of emotion. The choice of this model is based on the fact that, besides its previous applications in the cultural heritage domain, it provides a recipe for the generation of compound emotions that is compliant with the commonsense reasoning framework of the probabilistic non monotonic Description Logics known as T^{CL} (Typicality-based Compositional Logic, Lieto & Pozzato 2020) underlying DEGARI. We will describe the emotion-based sensemaking tool and its functioning in the section "DEGARI prototype".

The second area of interest for the development of sensemaking tools in SPICE is the Narrative Knowledge-Area. In this respect, the use of structured (namely, symbolic-based) approaches for the knowledge elicitation of the narrative components of cultural items has been investigated in a variety of projects for more than a decade. A pioneering contribution in the use of ontologies to provide online access and interpretation to cultural heritage is given by the CultureSampo project (Hyvönen et al. 2009). This project encompasses a set of domain ontologies, which provide the

background against which cultural objects, encoded in different media formats, can be explored by tracking the connections among them in terms of geographical and chronological relations, authorships, processes, etc. Similarly, the DECHO system (Aliaga et al. 2011) relies on a conceptual model of the archaeological domain to support the exploration of cultural heritage objects. Narrative is also the focus of the Bletchley Park Text system (Mulholland and Collins, 2002), a semantic system designed with the goal of supporting the users in the exploration of online museum collections. Designed with the notion of the "guided visit" in mind, the system relies on an ontology of story, taken from the Story Fountain project (Mulholland et al. 2004). The stories represented in the system are exploited to create relations between the entities contained in online collections, allowing the user to query the system for a semantic path between entities. Similarly, the Storyspace project (Wolff et al. 2012), a web-based environment for authoring stories about cultural artifacts, relies on an ontology for describing curatorial narratives. The Labyrinth project (Damiano and Lieto, 2013; Damiano et al. 2015 and 2016) has also shown how to exploit an ontology of narrative concepts connecting characters, roles, archetypes and stories that work as a *fil rouge* to link different multimedia artifacts, in the spirit of the archetypal thematic cores encoded in Warburg's Mnemosyne project (Warburg and Birnk 2008). More recently, Meghini et al's Narrative Ontology (NOnt), developed within the EU Mingei project, provides a Description Logics formalization of narratives, implemented as an extension of standard vocabularies such as CIDOC CRM[1] - specific to the cultural heritage domain -, FRBRoo[2], and OWL Time[3], and suitable to describe temporal processes (such as the intangible knowledge about Craft Heritage) through narratives. In SPICE, we have focused our attention on the importance of the narrative aspects to contextualize the interpretation and reflection on cultural artifacts. In line with the notion of inspirational juxtaposition of themes advocated by the Labyrinth project, but differently from most of the mentioned case studies, the sensemaking tool that we have developed aims at extracting the thematic subjects underlying a cultural item (or a collection of items) via the exploitation of the DBpedia links referring to the descriptions of cultural items. We will describe the prototype of the narrative-based sensemaking tool in the section "Thematic Reasoner prototype".

Finally, for what concerns the Value-Knowledge Area: notwithstanding the relevance of values in cultural contexts, there are no available resources and tools for dealing with this aspect from the perspective of automated reasoning. In the cultural heritage context, the role of values has been mostly investigated in relation with narrative contents, where conflicts of values usually play the role of providing the propulsive force to the story. According to Bruner (1991), "stories achieve their meanings by explicating deviations from the ordinary in a comprehensible form", thus contributing to reassert the canonicity of a culture's values. However, also thanks to the pervasiveness of narrative elements in cultural heritage, values extend their influence from the narrative domain to cultural artefacts in general, as well exemplified by the iconological subjects indexed in Iconclass (Van de Wall 1974). The latter in fact are often posited at the junction between values and emotions, such as "the peace", "the justice", or "the truth". A notable exception to the lack of dedicated tools for the analysis of values is provided by the approach described by Hopp et al. (2021) to detect and characterise value conflicts in media. Drawing from Tamborini's Model of Intuitive Morality and Exemplars (MIME, Tamborini 2011, 2013), which applies Haidt's socio-intuitionist model of moral judgment to the analysis of narrative media (see Deliverable 6.2), Hopp and colleagues have

[1]http://www.cidoc-crm.org/
[2] http://www.cidoc-crm.org/frbroo/
[3]https://www.w3.org/TR/owl-time/

analysed moral conflict in a corpus of movie scripts; their methodology allows detecting and measuring value conflicts in movie scenes based on the changes in the connectivity patterns of the networks. Although effective, this method only indirectly encodes the appraisal of media contents in the MIME model, according to which appraisal is driven by the five universal and innate moral foundations stated by Haidt and Greene (care/harm, fairness/cheating, loyalty/betrayal, authority/subversion, and sanctity/degradation). By adopting a similar perspective, in the section "Value Reasoner" we will present the ideas behind the development of the value-based sensemaking tool, which takes as input the values identified in cultural aspects through textual descriptions.

DEGARI Prototype

In this section, we present the SPICE tool dealing with Emotion-based reasoning: **DEGARI** (**D**ynamic **E**motion **G**enerator **A**nd **R**eclass**I**fier), an explainable AI system for emotion attribution and recommendation. This system relies on a recently introduced commonsense reasoning framework, the T^{CL} logic (the details of the logic are in Lieto & Pozzato 2018 and 2020), which is based on a human-like procedure for the automatic generation of novel concepts in a Description Logics knowledge base.
In particular, starting from an ontological formalization of emotions based on the Plutchik's model developed in the SON (see Deliverable 6.2), the DEGARI system exploits the T^{CL} logic to automatically generate novel commonsense semantic representations of compound emotions (e.g., Love as derived from the combination of Joy and Trust according to Plutchik's theory).
The generated emotions correspond to prototypes, i.e., commonsense representations of given concepts and, in the context of SPICE, they have been used to reclassify emotion-related contents in the museum datasets made available by the GAM gallery museum (Galleria d'arte Moderna di Torino, the IMMA Museum as well as the Hecht musem.

The use of the Plutchik's emotional classification (and, in particular, the spatial configuration that this emotional model embeds by including notions of similarity and opposition between different emotional concepts), allowed us to group together (both *within* the same museum collections and *between* the collections of the different museums involved in SPICE) cultural objects evoking: i) the same emotions or ii) similar emotions or iii) opposite emotions. Before summarizing the technical elements of the system, we present some example scenarios concerning its usage in SPICE.

Usage Scenarios

Scenario 1: a Museum Curator wants to design a novel museum itinerary for the visitors. By using the results of DEGARI she/he can design a novel curatorial narrative where cultural items evoking similar, opposite or the same emotion are suggested to the curator. Such suggestions can then be physically arranged and organized by the curator in different parts of the museum sharing the same emotion-driven grouping suggested by the system.

Scenario 2: a Museum Visitor uses her/his app to tag a certain cultural item with an emotional label. The APP, by communicating with the DEGARI reasoning system, can suggest cultural items (within the museum or available in other museums) that share the same kind of emotions. This association can rely on the previous visitor's provided tags. Alternatively, in order to foster the Interpretation-Reflection loop, it can also suggest cultural items that evoke the opposite emotion (with respect to the one associated by the user).

Goal

As mentioned, DEGARI has the goal of automatically assigning emotional labels to cultural items. Such assignment is currently mainly based on the textual information available in the museum catalogues, but the system is also able to process textual information coming from user-generated content.

The assignment of the emotional labels provided by DEGARI is not the usual one provided in classical emotion-classification systems. In fact, the use made by DEGARI of the Plutchik's ontology allows the assignment of fine-grained emotional labels to the museum items (in particular: DEGARI allows the assignment of secondary emotions in the Plutchik's wheel) that go well beyond the classical

basic emotions provided by models like the one of Ekman (see, again, Deliverable 6.2), mostly used in computer vision applications.

As mentioned, the secondary emotions used to classify cultural items are automatically generated by DEGARI by exploiting the above mentioned T^{CL} logic. The approach used by this logic, and its contextualization in the context of the DEGARI application, is synthesized in the following section (a detailed description is available in the recent publication Lieto et al. 2021).

Approach

The T^{CL} reasoning component employed in DEGARI allows to generate a prototypical (i.e. commonsense) representation of the compound emotions (also called "complex" or "secondary" emotions) described in the Plutchik's ontology. Within this latter model, compound emotions are assumed to be generated (i.e. "derived") by combining basic emotions.

The combination mechanisms used by DEGARI, in particular by its T^{CL} component, rely on the coupling of different ingredients: a non-monotonic Description Logics of typicality, a probabilistic semantics coming from Logic Programming and the HEAD-MODIFIER heuristics coming from the field of cognitive semantics. This coupling allows to generate human-like conceptual combinations, as shown in a number of papers employing this formalism in different applications, ranging from cognitive modelling (Lieto and Pozzato, 2018; Lieto et al. 2019; Chiodino et al. 2020), to computational creativity (Lieto and Pozzato 2019), to serendipity-based multimedia recommender systems (Chiodino et al. 2020).

In order to generate the prototypical representations of the compound emotions by starting from the basic one (as described in the Plutchik's ontology), DEGARI resorts to the NRC Emotion Intensity Lexicon (Mohammad S. and Kirilenko, 2018): an affective lexicon that associates, in descending order of frequency, words to emotional concepts, https://saifmohammad.com/WebPages/NRC-Emotion-Lexicon.htm). This lexicon allows to encode the features associated to the basic emotions that need to be combined together. In particular, it provides a list of English words, each with real-values representing intensity scores for the eight basic emotions of Plutchik's theory. The lexicon includes close to 10,000 words including terms already known to be associated with emotions as well as terms that co-occur in Twitter posts that convey emotions. The intensity scores were obtained via crowdsourcing, using best-worst scaling annotation scheme. For our purposes, we considered the most frequent terms available in such lexicon (and associated to the basic emotions of the Plutchik's wheel) as typical features of such emotions.

As a result of the employment of the NRC lexicon, DEGARI results to be equipped with a form of lexical-based emotion representation expressed in a T^{CL} knowledge base (KB). This KB contains a TBox with both *rigid inclusions* (of the form **Joy ⊑ PositiveEmotion,** in order to express essential constraints that do not have any exception) as well as *probabilistic prototypical inclusions* of the form **0.72:: T(Surprise) ⊑ Delight** representing the fact that the lexical word "Surprise" (coming from the NRC lexicon) is *typically* associated with a frequency/probability/degree of belief of 72% to the emotional concept Delight. In this way, once the prototypes of the basic emotional concepts were formed, the probabilistic T^{CL} reasoning framework used by DEGARI is used to generate the compound emotions. The software modules involved in the processes of (basic) emotion formation and (compound) generation of prototypical emotions corresponds to the **Modules 2** and **3** of the overall system architecture depicted in Figure 1.

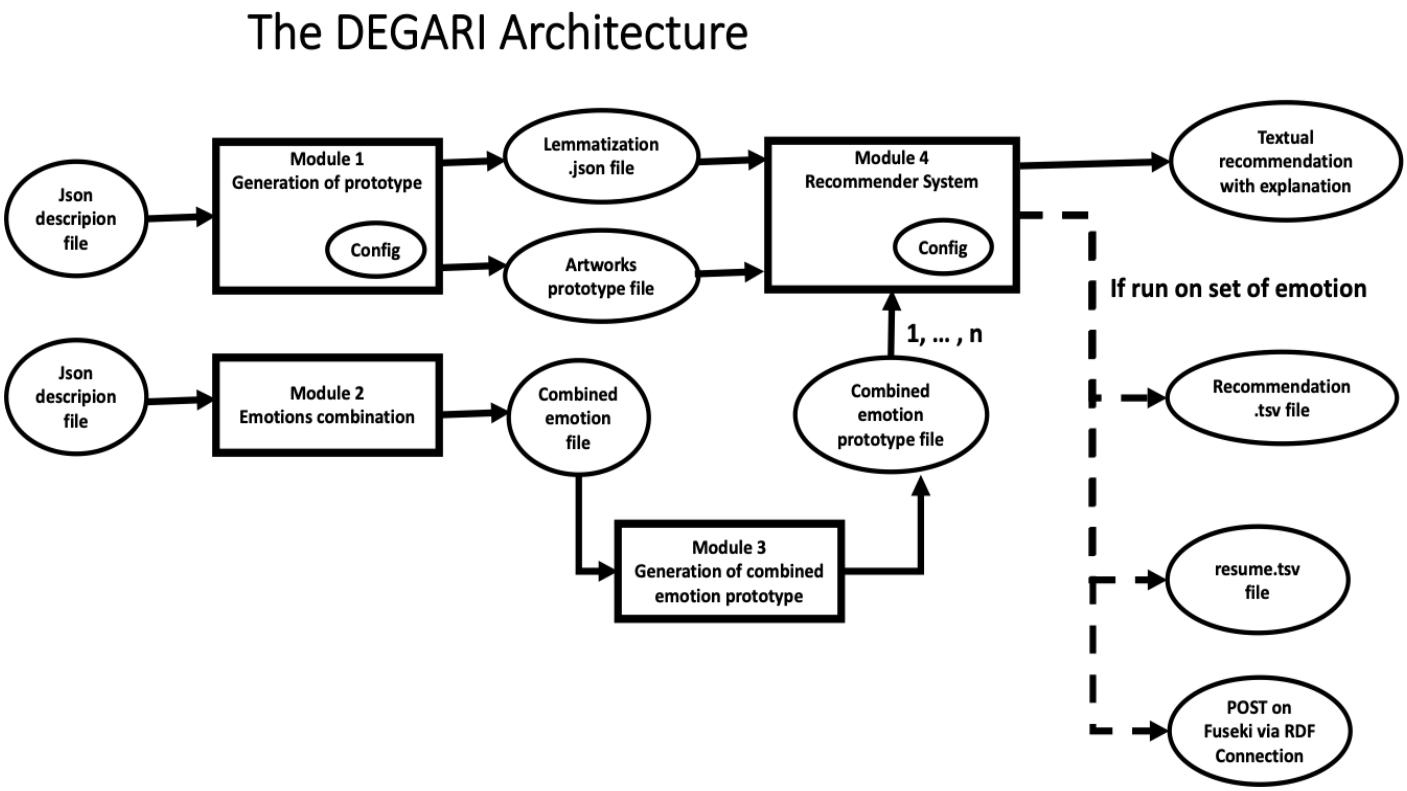
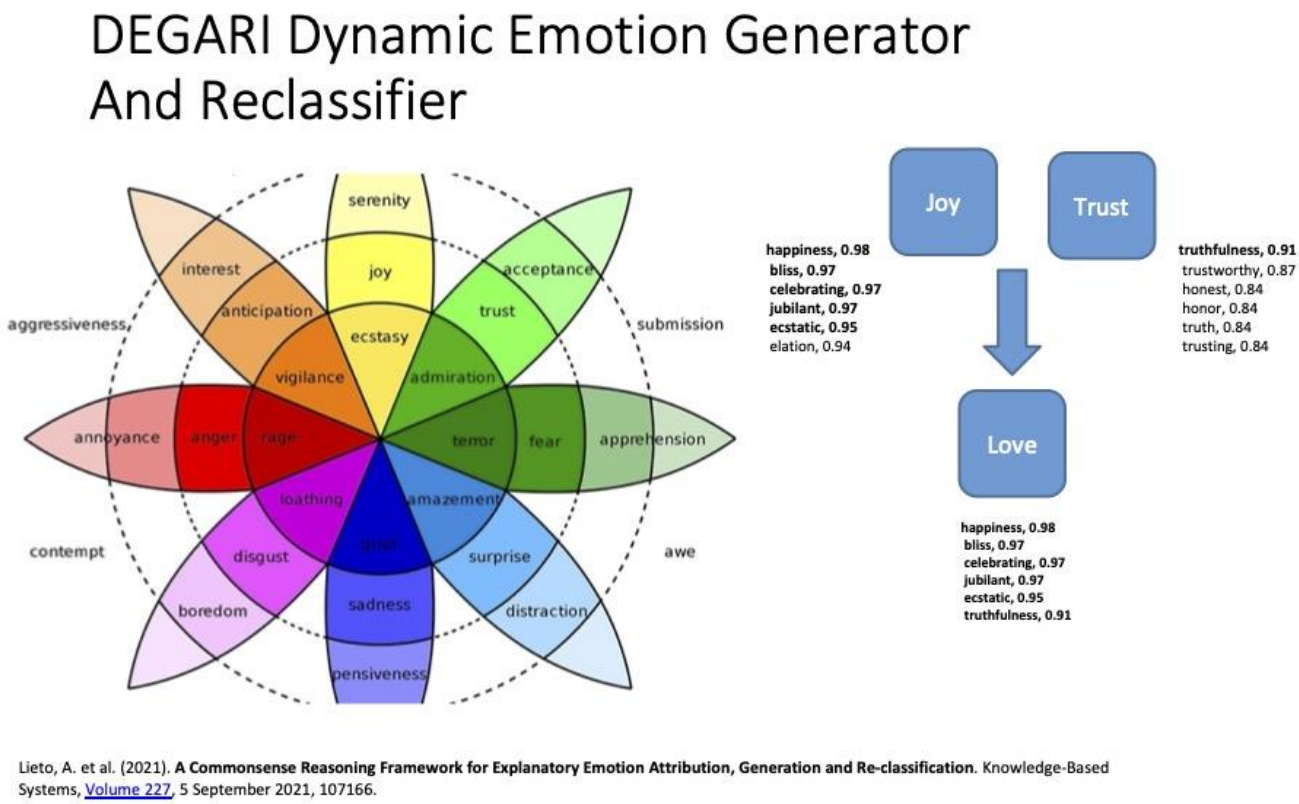


Figure 1. The overall software architecture of DEGARI. Module 1 represents the entry point of the system. It accepts JSON files containing a textual description of the cultural items (coming from user comments or from the museum catalogues) and performs an automatic information extraction step generating a lemmatized version of the JSON descriptions and a frequentist-based extraction of the typical terms associated to the cultural item. Modules 2 and 3 are devoted respectively i) to the acquisition of the basic Emotions to combine (Module 2) and ii) to the generation of the compound Emotions (Module 3). Module 4 is the one classifying, grouping and recommending the cultural item according to the novel generated emotions.

An illustrative example showing the rationale used by DEGARI to generate the compound emotions (in this case the emotion Love as composed by the basic emotions Joy and Trust according to the Plutchik's theory) is reported in Figure 2. The lexical features associated to each basic emotion (and the corresponding probabilities) comes from the NRC lexicon mentioned above.

Once the prototypes of the compound emotions are generated, DEGARI is also able to reclassify the museum items taking the new, derived emotions into account. As a consequence, such a reclassification allows the system to group and recommend museum items based on the novel assigned labels (**Module 4** in the overall architecture depicted in Figure 1).



Lieto, A. et al. (2021). **A Commonsense Reasoning Framework for Explanatory Emotion Attribution, Generation and Re-classification**. Knowledge-Based Systems, Volume 227, 5 September 2021, 107166.

Figure 2 Generation of Novel Compound Emotions with DEGARI by exploiting the Plutchik's ontology. The features and the probabilities of each basic emotions are obtained from the NRC lexicon

In particular, the reclassification step requires matching the extracted metadata of each museum item (or the user-generated texts associated with it) with the ones characterizing the compound emotions generated by DEGARI. The extraction of the metadata from the museum items is done on the JSON file taken as input and is used, in **Module 1** of the system, to generate i) a lemmatized version of the JSON description of the cultural item ii) the extraction of a typical characterization of the museum items obtained via the computation of the most frequent terms retrieved in their textual description (the assumption is that the most frequently used terms to describe an item are also the ones that are more typically associated to them). The frequencies are computed as the proportion of each term with respect to the set of all terms characterizing the item, in order to compare. Once this pre-processing step is automatically done, the final representation of the cultural item is compared with the representation of the typical compound emotions obtained in **Module 3**. This comparison, and the corresponding classification, is done in **Module 4** that implements the following categorization heuristics: if the cultural item contains all the rigid properties and at least the 30% of the typical properties of the compound emotion under consideration, then the item is classified as belonging to it. The 30% threshold was empirically determined: i.e., it is the percentage that provides the better trade-off between overcategorization and missed categorizations.

Once the categorization has taken place, DEGARI is eventually able to classify and group together the items evoking the same emotions (e.g., Despair in the Figure 3) or, as will be shown in the examples from the case studies, items having opposite or similar emotions.

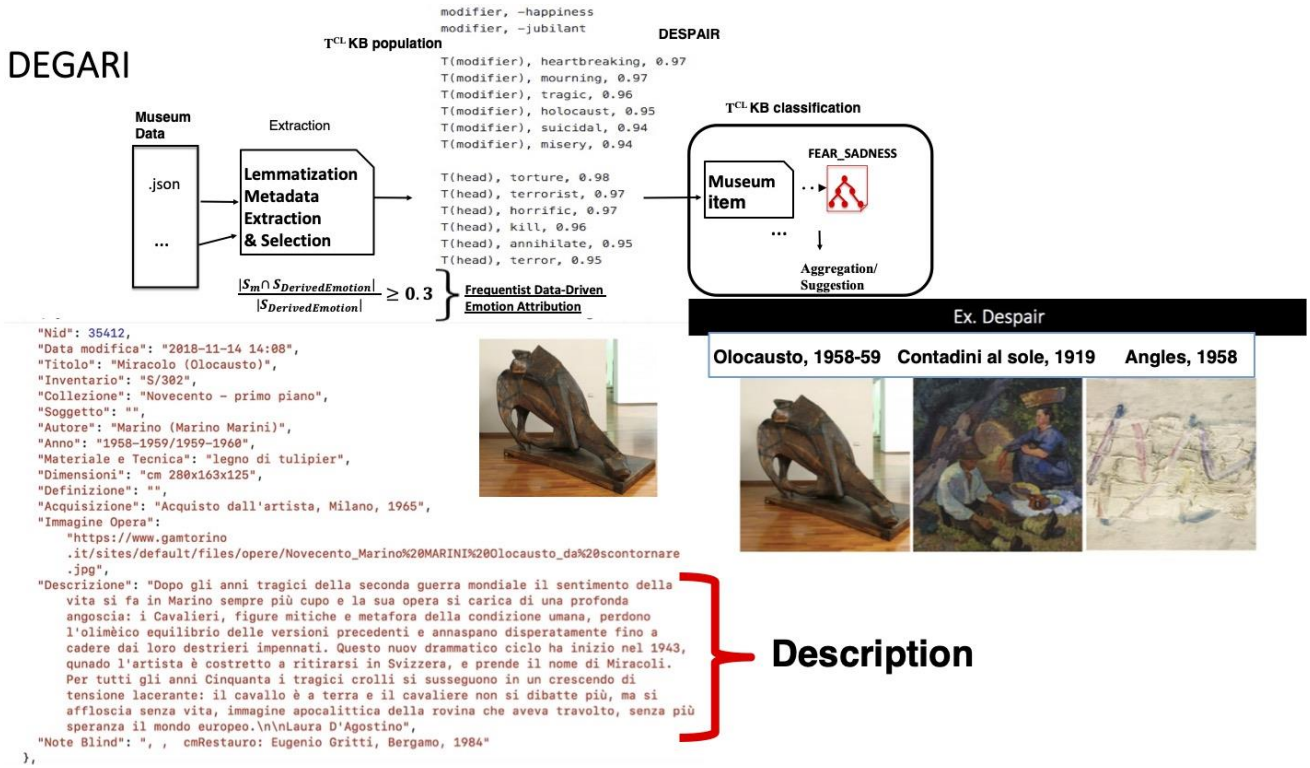


Figure 3 A pictorial example of the categorization pipeline used by DEGARI for emotion attribution and content aggregation/suggestion based on the artwork "Miracolo Olocausto", from the GAM collection, that has been coupled with other artworks like "Contadini al Sole" based on the fact that these items have been classified as evoking the same emotion (Despair).

A final crucial feature of the DEGARI classification system is represented by the fact that the rationales of its classifications are entirely transparent and explainable.

In the Figure 4 below, an example of explanation provided by the system showing why this collection of artifacts from Hecht about the Bar Kochva Rebellion is classified with the label "Awe" (generated by combining the basic emotions of "Fear" and "Surprise"). In particular, the system shows how the lexical triggers of this classification have been the words "surprise", "torture", "kill" that are also included in the prototypical description of the generated compound emotion "Awe".

```
Recommendation for category: awe-fear_surprise

Category prototype:

[('surprise', 0.93, False),
 ('torture', 0.98, True),
 ('terrorist', 0.97, True),
 ('horrific', 0.97, True),
 ('kill', 0.96, True),
 ('terror', 0.95, True)]
['anticipation']

Recommended artworks:


spiceartefactBarKochvaRebellion-0.6
        spiceartefactBarKochvaRebellion - Bar Kochva Rebellion
        \-> matches: ['surprise', 'torture', 'kill']

Classified 1 of 1 contents (100.0%)
```

Figure 4 An example of the DEGARI explanations provided for each emotional classification.

Current status

The original prototype (i.e. the standalone version) of this reasoner is available at **http://www.di.unito.it/~lieto/DEGARI/** and is described in the paper (Lieto et al. 2021). In the context of SPICE, however, DEGARI has been additionally made available as a web service that that can be invoked via standard HTTP requests and whose reasoning output is made automatically available to the SPARQL endpoint and accessible by other software components via the SPARQL APIs made available in the technical infrastructure described in the Deliverable 6.1.

The whole pipeline of the DEGARI service made available for SPICE is implemented in Python. This architecture is shown in Figure 5 and works with the following workflows without any manual intervention:

1. Users/clients can send a JSON file artefact by using POST method. This JSON file contains the description of a particular artefact (i.e., "*The Scream of Munch*"). An example of JSON format is described in Figure 6.
2. JSON file with ID and its description is stored into the file system of DEGARI-REST server
3. DEGARI-REST server executes reclassification of the JSON artefact and once the connection to Fuseki is established, it is possible to use RDF connection to provide SPARQL update queries and model updates on Fuseki server (http://130.192.212.225/fuseki/)
4. DEGARI executes a SPARQL update query to Fuseki server via RDF connection. In this way, the corresponding ontology-model that we want to update is automatically updated.

Finally, in this step of the DEGARI pipeline, given an IP address, a post method (e.g., POST/SPARQL INSERT/UPDATE) and a data format (e.g., JSON), it is possible to update multiple SPARQL end-points simultaneously.

5. After the SPARQL update query, Fuseki server sends to DEGARI-REST server an ACK response
6. DEGARI-REST is sent back to the client an XML file containing URLs to JSON and its recommendation. An excerpt of the XML file is shown in Figure 7.
7. In the last step, the user is able to execute a SPARQL query to Fuseki in order to get the classification results for its JSON artefact (send at step 1).

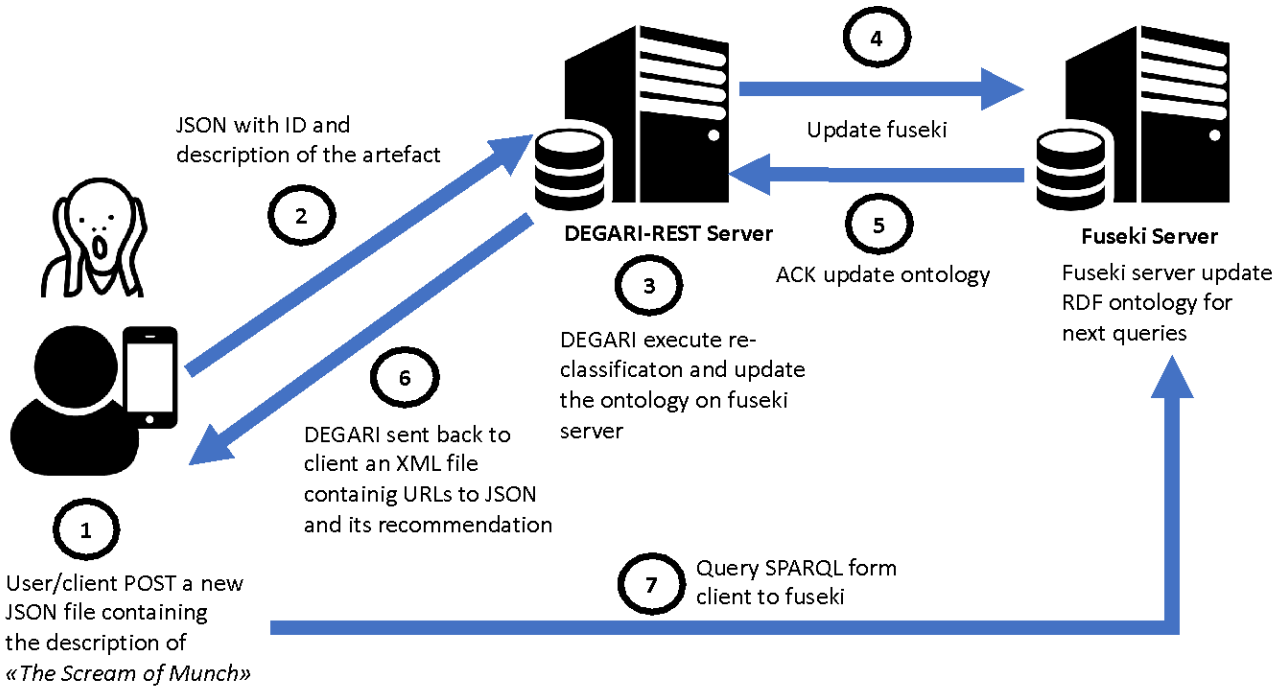


Figure 5 DEGARI-POST - pipeline architecture

```
[
    {
        "@id":      "spice:artefact/137-5",
        "@type":  "schema:CreativeWork",
        "dc:description":  "Description of the artefact… "
        "caption":          " Collection Irish Museum of Modern Art,
                              Purchase, 2010 »
    }
]
```

Figure 6 Example of the JSON structure of the artifacts taken in input by DEGARI – Steps #1 and #2

```
<?xml version=\"1.0\
<DegariArtwork>
    <artwork TimeStamp="2021-09-07-09-47-19">
        <URLToYourJSON>ClientArtWork_2021-09-07-09-47-19.json </ URLToYourJSON >
        <URLToFuseki>http://130.192.212.225/fuseki/</URLToFuseki >
    </artwork>
</DegariArtwork>
```

Figure 7 Example of the XML-Response to client – Step #6

DEGARI graphical interface and authentication

A second way of use DEGARI us via a login interface available here http://130.192.212.225:8090/DegariLogin/index.php.

Users and/or developers who wish to authenticate themselves, are asked to send an email to manuel.striani@unito.it and antonio.lieto@unito.it in order to be included in the database of DEGARI users. Figure 8 shows the graphical interface of DEGARI system login authentication.

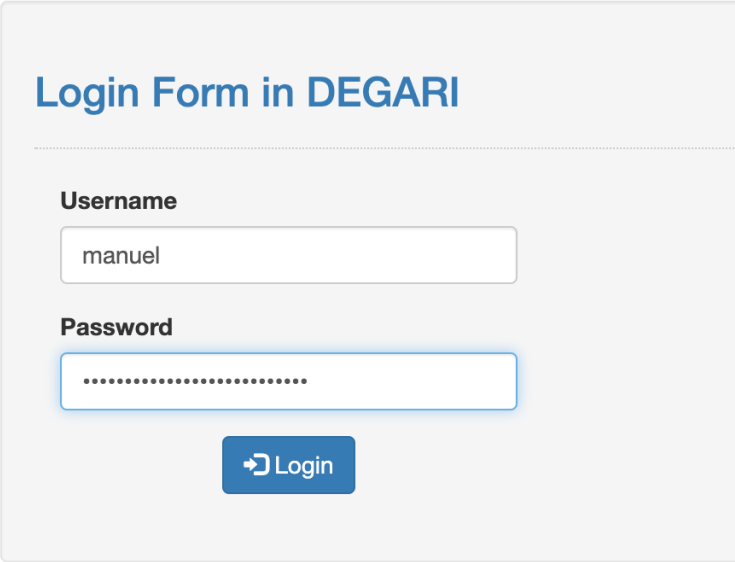


Figure 8 Graphical interface of DEGARI login authentication

Registered users, once they have validated their credentials, can upload the JSON files corresponding to one artifact or to a collection of artifacts directly via the upload form (shown in Figure 9).

Once the upload process is complete, they will receive a confirmation e-mail. The reason behind the development of this additional graphical interface lies in the fact that we also want to make available the system directly to the researchers in SPICE working in the museums (and not only to software applications) that do not necessarily have all the technical skills to use the previously indicated DEGARI pipeline. In this case, museum workers involved in the project can directly upload the JSON file (provided to them) in the system and wait for the result.

Figure 9 JSON Upload module via the graphical interface

Current application of the DEGARI prototype to the case studies

Below we report some initial results of the prototype applications of DEGARI to the datasets provided by GAM, IMMA and Hecht. Overall, 2.6% of the total items were re-classified by the system. It is worth-noticing that the obtained emotional labels refer entirely to "secondary" emotions (18 out of 24 are filled with new items). Therefore, they could not have been extracted without the DEGARI system and represent a sort of additional classification layer that goes beyond the classification of basic emotions (that are possible by using the current state of the art tools). In addition, it is worth-noticing that the JSON files given in input to the system were coming from museum catalogues containing very short linguistic descriptions of the items (from 10 to 138 words). Given the current results, obtained with a very limited number of linguistic data, we are confident that these numbers can increase with the information that will be provided by the users during their actual visits in the museums. A second measure we are considering consists in the inclusion of textual data coming from Wikipedia or DBpedia to extend the amount of information collected about a given artifact (and upon which DEGARI relies on for its computation).

Table 1. DEGARI total stats for the GAM, IMMA and Hecht dataset

Total items (GAM, IMMA and Hecht datasets)	3125 artworks (with a description)
Recommendations	83
Percentage of reclassified and recommended content with emotional label assigned by DEGARI	2,6%

Complex emotions involved by recommendations	18 of 24: Aggressiveness, Anxiety, Awe, Contempt, Delight, Despair, Disapproval, Dominance, Envy, Hope, Outrage, Pessimism, Remorse, Sentimentality, Shame, Submission, Unbelief

In the case of the GAM collection, we have tested the acceptance rate of the overall emotional suggestions provided by DEGARI by implementing them in the GAMGame described in Deliverable 6.2. In short, the GAMGame is an online web application that allows users to share their stories about artworks of the Gallery of Modern Art (GAM) of Turin. Users can select multiple artworks from a list of suggested artworks, and can iteratively add descriptions of their emotions in the form of hashtags, emojis, brief texts, and keywords. Questions are prompted by the application to suggest potential types of contributions (i.e., whether users have memories, what emotions they feel, what strikes them more).
In this case, the UNITO team directly assessed the acceptance of the emotional suggestions provided by DEGARI with the target group of the GAM (i.e., deaf teenagers) with the help of the Istituto dei Sordi di Torino.
With respect to the original version of the GAMGame app, the new version tested included the DEGARI recommendations based on the spatial configuration of the Plutchik's wheel and including recommendations of items i) evoking the same emotion, or ii) evoking similar emotions (i.e., the ones spatially closer in the Plutchik's wheel) or iii) opposite emotion.
The Figure 10 reports an example of this kinds of suggestions for the GAM artefact entitled "Ritorno alla stalla", that, based on DEGARI's output, is emotionally linked to "Maternità" (a statue of the GAM collection triggering the same emotion: "Pride"), with "Contadini al sole" (a painting labelled with the similar emotion "Disapproval". Note that this emotion is considered "similar" according to the Plutchik's model since it is the one spatially adjacent to the category "Outrage" that is one of the categories, a "tertiary dyad" in the Plutchik's theory, to which the system has assigned the original item) and finally the abstract painting "Angles" labelled with the opposite emotion "Shame" (in this case the opposition concerns the label "Pride").
Overall, the system tries to categorize and link the items with respect to any of the original emotional categories found.

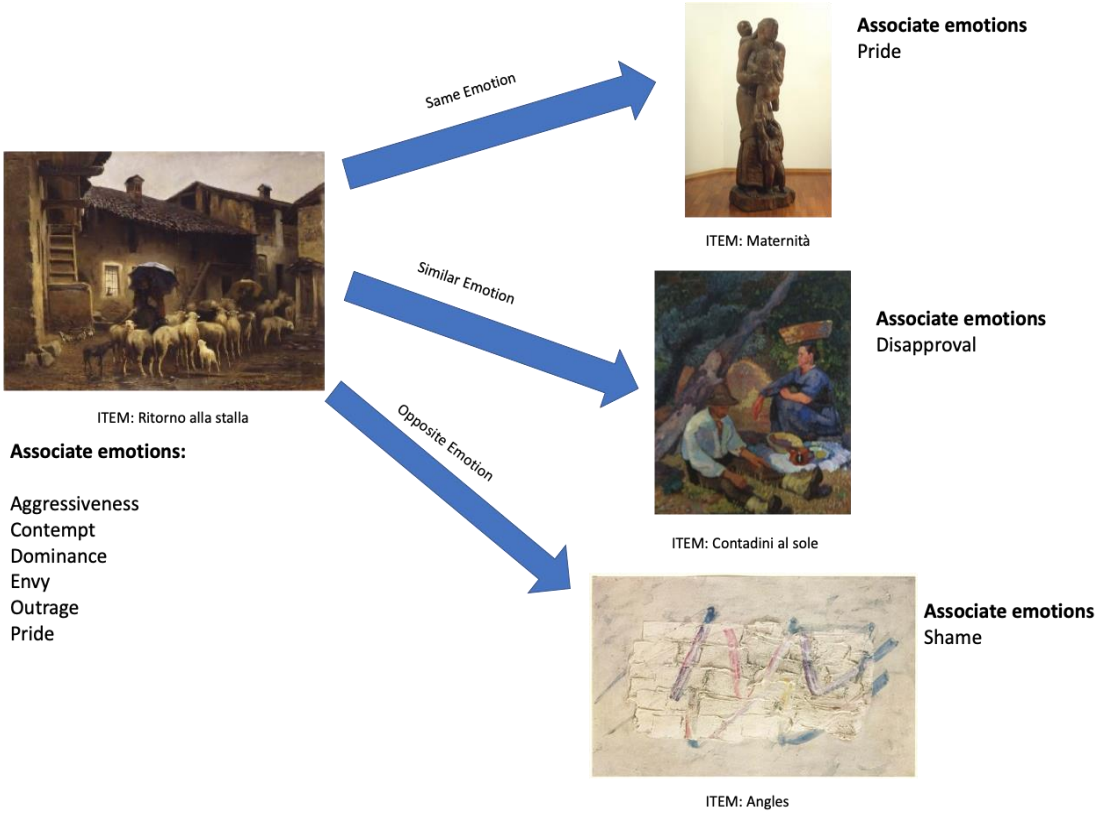


Figure 10 Same, Similar and Opposite emotions from GAM dataset

The overall obtained results about the ratings provided by the deaf users are shown in Table 2. Such data were collected by asking users to compile a questionnaire on the received recommendations, where they had to to rate the association of the item with the emotional category provided by DEGARI on 10-point scale (from 1 to 10). The evaluation lasted one week and involved 72 deaf users.

Mean total score	5,790520833		
median total score	6		
	Same emotion	**Similar emotion**	**Opposite emotion**
mean	5,785892857	6,234027778	5,25
median	6	6	5
standard dev	0,6819219444	0,7122400435	1,060660172

Table 2. Results of the ratings of the deaf group in GAM on the DEGARI recommendations

The users showed a moderate acceptance of the received content suggestions. The average rating assigned to the total set of emotion category proposed by DEGARI was 5.79 with a median value of 6/10. Table 1 shows the mean, median and standard deviation values for each emotion recommendation group (same, similar and opposite emotions). The recommendations that received a better rating were the ones suggesting items linked to the original one through the property "similar emotion". The recommendations of items evoking opposite emotions (with respect to the original item selected in the game) were the ones that received the worst rating. It will be important

to consider this last aspect in the overall project since one of the assumptions upon which it is based the possibility of reflecting upon cultural items (i.e., by being exposed to alternative views with respect to one's own view) is based on the presentation of items/views/interpretations that are somehow opposed to the ones expressed by the original user(s)/groups of users. As expected, there are some mechanisms of cognitive resistance that probably would require to consider, from a methodological and technical standpoint, some mitigation strategies.

In order to investigate the overlapping between the set of emotion categories proposed by DEGARI and the ones assigned by deaf users for each of the items of the GAM GAME, we conducted a second analysis that is shown in Table 3. The results show that, overall, the deaf users were able to generate much more emotions with respect to the ones extracted by DEGARI (126 vs 34). This ratio is indicated in the measure "Total Overlapping" (26,98%). In addition, however, we also measured how many times the emotional labels provided by the system matched the ones in the list provided the users. In this case, for the 58,33% of the cases, at least one of the emotions by DEGARI was also in the list provided by the users. In the last measure we considered an extended vocabulary of the emotional labels provided by the users. In particular, we extended their categorization by considering "similar emotions" obtained by exploiting the different combination of dyads provided by the Plutchik's theory. This datum was considered to assess a more relaxed version of the "perfect" match between human and system labels considered in both the "Total Overlapping" and the "DEGARI Emotion containment". The reason why we recorded this metrics relies on the fact that in many cases the "perfect match" hypothesis left out - in a boolean way - many interesting labels attributed by DEGARI (and semantically related to the ones also selected by human users) that were not exactly the same used by the users. With this measure, we obtained that in 83,33% the emotions attributed by DEGARI is contained in the extended list of emotions considering both user labels and the extended list of "similar emotions" considered. This datum is compliant with the findings shown in Table 2 where the recommendations of items sharing "similar emotions" where the ones that obtained the highest ratings.

	GAMGame
Total user generated emotion	126
Proposed emotion	34
Total Overlapping (% of overlapping of the total emotions provided by DEGARI and the total emotions labelled by users)	26,98%
DEGARI Emotion Containment (how often the emotional labels provided by DEGARI coincide with those provided by the users)	58,33%
Extended DEGARI Emotion Containment (how often the emotional labels provided by DEGARI coincide with the ones provided by the users by considering also extended DYADS)	83,33%

Table 3. Overlapping of the tags provided by deaf users with the ones by DEGARI

Future work

We plan to improve the current results by i) extending the knowledge sources considered about museum items (e.g. by including both user-generated data as soon as they will be available, but also encyclopaedic information, if available, about the museum items) ii) by extending our analysis also to the remaining museum datasets.

In addition, since DEGARI allows grouping items belonging to different collections, the degree of efficacy of these inter-museum recommendations will also be investigated (the current integrated output of the system for the involved museums currently available and queryable on the Fuseki platform: http://130.192.212.225/fuseki/dataset.html?tab=query&ds=/Test_SPICE_DEGARI_Reasoner).

Finally, we plan to integrate the output of DEGARI with the sentiment analysis and user/group modelling results coming from the WP3 in order to augment the interpretation and reflection over cultural items guided by the emotional stance.

In particular, the current version of DEGARI will be integrated with the Semantic Annotator described in the Deliverable 3.2. This integration, despite not yet in place, would allow the system to deal with the multilingual support provided by the Semantic Annotator and, in addition, to enriching the results of the linguistic extractor for what concerns the attribution of emotional labels (please note that, since the techniques adopted for the task of emotion attribution are completely different, the results obtained by these two modules are expected to be complementary).

Thematic Reasoner Prototype

The Thematic Reasoner is a tool able to deduce the thematic subject of a collection of entities (e.g. the artworks located in a room of a museum). This tool enables to carry out non-trivial analyses of the interests of a user or of a community which, in turn, supports tasks such as classifying a user (or a community) according to the artworks she interacts with. Such reasoning capabilities will be offered as a software service that will be integrated with the other tools supporting the IRL processes (cf. D2.1 and D2.2).

Motivations

Detecting the thematic subject of an (a collection of) artifacts a person interacts with allows to classify visitors with respect to their interests. For example, this enables the creation of communities of people with same/similar/connected interests and use the communities to promote a thematic exploration of exhibitions or finding interpretations having themes same/similar/connected to the interests of the community.

Application scenario

As application scenario we considered the case study involving the Hecht Museum. Specifically, we considered an artificially constructed exhibition about the Jewish and t non-Jewish settlement in the 1st century CE and the events of the rebellions in the Galilee and Judea. The exhibition involves 9 different objects (we use the object to indicate artifacts, artworks which can be concrete or virtual) including findings that testifies the destruction caused by the revolts and permanent expositions as the Bust of Hecht or the photos of Jerusalem. The artworks are placed in 6 areas located into 4 different rooms of the museum (Entrance, Corridor, Main Hall and Galilee Rebellion). The arrangement of the collection is depicted in Figure 11.

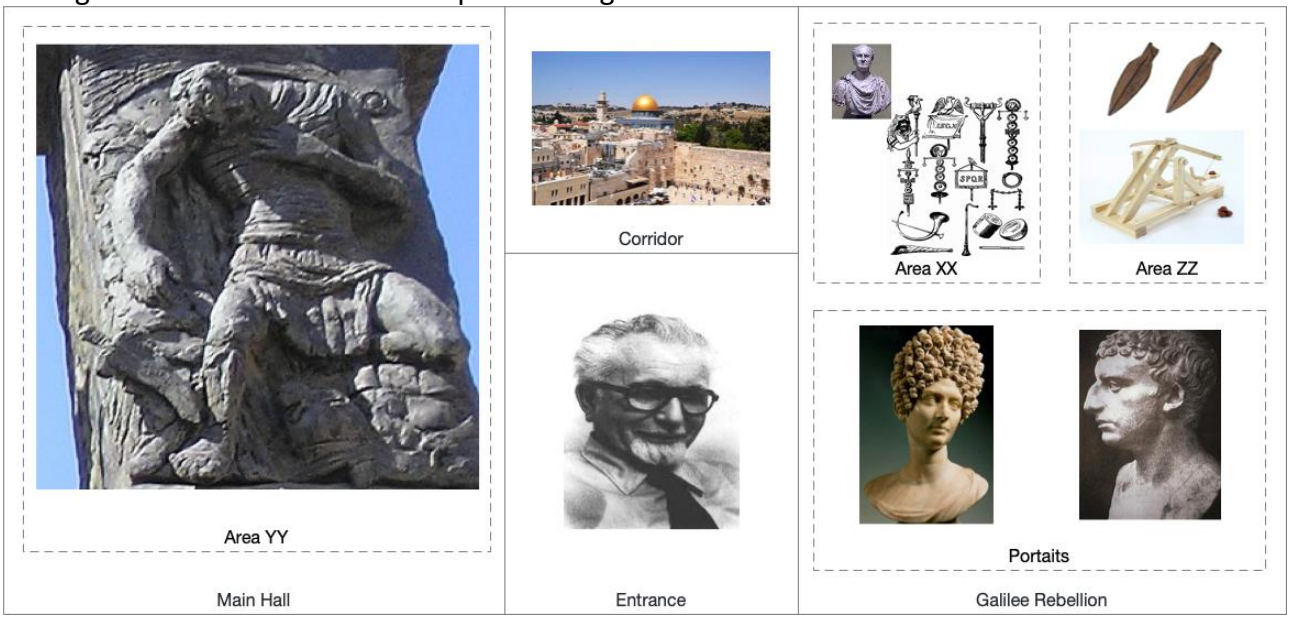


Figure 11 The arrangement of the fictitious exhibition about the Jewish and non-Jewish settlement in the Galilee

The entrance exhibits a bust of Reuben Hecht, the Israeli industrialist who founded the museum. The corridor exposes a series of photos of Jerusalem. The Main Hall is dedicated to the Bar Kokhba revolt, a rebellion by the Jews of the Roman province of Judea, led by Simon bar Kokhba, against the Roman Empire. In this example we suppose that the Area YY of the Main Hall exposes the low relief of Simon bar Kokhba. The Galilee Rebellion room exposes artworks and findings related to the First Jewish-Roman war which was the first of three major rebellions by the Jews against the Roman Empire. The war was fought in Roman-controlled Judea, and it resulted in the destruction of Jewish

towns, the displacement of its people and the appropriation of land for Roman military use, as well as the destruction of the Jewish Temple and polity. The exposed objects are organized in three different areas of the room (i.e. Area XX, Area ZZ and Portraits area). The Area XX exhibits a bust of Vespasian, the Roman general who was given the task of crushing the rebellion in the Judea province, and a collection of findings of Roman military personal equipment (e.g. ensigns, standards, trumpets, swords etc.). The Area ZZ of the Galilee Rebellion room exhibits a few archeological findings including a collection of arrows and a catapult of the Roman army. Finally, the Portraits area collects a series of portrait sculptures of people related to the rebellion (e.g. Josephus and Berenice). The SPICE ontology network (cf. D6.2) allows us to formally specify the exhibition in machine-readable format (RDF/TURTLE syntax) as follows:

```
@prefix bot: <https://w3id.org/bot#> .
@prefix ex: <https://w3id.org/spice/SON/issues/31/> .
@prefix cis: <http://dati.beniculturali.it/cis/>  .
@prefix arco: <https://w3id.org/arco/ontology/arco/> .
@prefix DUL: <http://www.ontologydesignpatterns.org/ont/dul/DUL.owl#> .
@prefix dbr: <http://dbpedia.org/resource/> .
@prefix wd: <http://wikidata.org/entity/> .

ex:HechtMuseum a cis:Museum ; cis:hasSite ex:HechtMuseumBuilding .

ex:HechtMuseumBuilding a bot:Building ; bot:containsZone ex:Entrance ,
        ex:GalileeRebellion , ex:MainHall , ex:Corridor .

ex:Entrance bot:containsZone ex:BustOfHechtZone .

ex:BustOfHechtZone DUL:isLocationOf ex:BustOfHecht .

ex:BustOfHecht a arco:HistoricOrArtisticProperty ;
        DUL:associatedWith dbr:Reuben_Hecht .

ex:GalileeRebellion bot:containsZone ex:AreaZZ .

ex:AreaZZ DUL:isLocationOf ex:Arrows, ex:Catapult .

ex:Arrows a arco:HistoricOrArtisticProperty ;
  DUL:associatedWith dbr:Gamla, wd:Q1493165 .

ex:Catapult a arco:HistoricOrArtisticProperty ;
        DUL:associatedWith dbr:Catapult, wd:Q184393 .

ex:GalileeRebellion bot:containsZone ex:Portaits .

ex:Portaits DUL:isLocationOf ex:PortraitOfJosephFlavius, ex:PortraitOfBerniece .

ex:PortraitOfJosephFlavius a arco:HistoricOrArtisticProperty ;
        DUL:associatedWith dbr:Josephus, wd:Q134461 .

ex:PortraitOfBerniece a arco:HistoricOrArtisticProperty ;
   DUL:associatedWith dbr:Berenice_(daughter_of_Herod_Agrippa), wd:Q466696 .

ex:GalileeRebellion bot:containsZone ex:AreaXX .

ex:AreaXX DUL:isLocationOf ex:RomanWarGear, ex:HeadOfVespasian .

ex:RomanWarGear a arco:HistoricOrArtisticProperty ;
        DUL:associatedWith dbr: Roman_military_personal_equipment, wd:Q17346959 .
```

```
ex:HeadOfVespasian a ex:HistoricOrArtisticProperty ;
        DUL:associatedWith dbr:Vespasian, wd:Q1419 .

ex:MainHall bot:containsZone ex:AreaYY .

ex:AreaYY DUL:isLocationOf ex:BarKochvaRebellionLowRelief .

ex:BarKochvaRebellion a arco:HistoricOrArtisticProperty ;
        DUL:associatedWith dbr:Bar_Kokhba_revolt , wd:Q334502 .

ex:Corridor bot:containsZone ex:JerusalemPhotoZone .

ex:JerusalemPhotoZone DUL:isLocationOf ex:JerusalemPhoto .

ex:JerusalemPhoto a arco:PhotographicHeritage ;
        DUL:associatedWith dbr:Jerusalem, wd:Q1218 .
```

The URI ex:HechtMuseum represents the Hecht Museum as a cultural institution. It is hosted in a building ex:HechtMuseumBuilding which contains four zones one for each room of the museum (indentified by ex:Entrance, ex:GalileeRebellion, ex:Corridor, ex:MainHall). Each of these zones contains (bot:containsZone is adopted for specifying containment relation) in turn the zones where the objects are exhibited (ex:BustOfHechtZone, ex:AreaZZ, ex:AreaXX, ex:Portraits, ex:AreaYY, ex:JerusalemPhotoZone). The property DUL:isLocationOf is used in order to associate an objects with the zone dedicated to its exhibition. All the exhibited artworks are classified as historic or artistic property (arco:HistoricOrArtisticProperty) and associated with a DBpedia/Wikidata entry by means of the property DUL:associatedWith. It is worth noticing that in this example we suppose that the object is already associated with the DBpedia/Wikidata entry, but this association can be automatically discovered in multiple ways (e.g. by analyzing the textual annotations associated with the artworks with a semantic annotator - cf. D3.2). It is reasonable to associate this collection with a theme that refers to Jewish History in the Roman Empire.

Goal

The Thematic Reasoner performs a topical, topological, and statistical analysis of the object of an exhibition:

- to associate each object of the exhibition with a set of themes.
- to associate each zone/room of the exhibition with a set of themes.

An entity (i.e. artwork, artifact, zone or room) might be associated with themes with different strength. For example, the theme “Jewish History in the Roman Empire” is predominant in the exhibition, but it might also be associated with a secondary theme such as “Religion-based wars” or “Military engineering”.

Approach

This section describes the approach implemented by the Thematic Reasoner. The first issue we addressed was the choice of a reference inventory of themes. Then, given a description of an exhibition (e.g., the one presented above), the reasoning process proceeds as follows:

1. Associating object with themes.
2. Associating a zone with themes by aggregating the themes of the objects located in the zone.
3. Associating a zone with themes by aggregating the themes of the zones contained in the zone.

Choosing a reference inventory of themes. Several classification systems are available for the cultural (e.g. ArCo (Carriero et al. 2021) or Getty Vocabularies [4]) or librarian (e.g. Dewey Decimal

[4] https://www.getty.edu/research/tools/vocabularies/

Classification (Mitchell et al. 1996)) domains, but these kinds of taxonomies are very general and mostly unable to categorize themes related to social or historical events. On the contrary, the Wikipedia categories, the terms used for classifying Wikipedia articles, are hierarchically related and form one of the richest taxonomy of concepts available today often used as taxonomic backbone for large scale knowledge graphs. Therefore, we considered the taxonomy of Wikipedia categories as the most appropriate system to adopt as reference inventory of themes.

Associating objects to themes. The Thematic Reasoner associates objects with themes by exploiting the linking structure of the Linked Open Data. In particular, the Thematic Reasoner assumes that each object is associated with (by means of the property DUL:associatedWith) a DBPedia entry (DBpedia is the knowledge graph containing information, like infoboxes or categories, extracted from Wikipedia and specified in a machine-readable format). Linking entities to DBPedia entries is a common practice in the construction of ontologies and knowledge graphs since DBPedia is (de-facto) the most common hub of resources for the Linked Open Data. Therefore, we expect that a large portion of objects are already linked to a DBPedia entry. When this is not the case, an entity linking and relation extraction tools (e.g., the semantic annotator, c.f. D3.2) can be utilized to automatically discover such links. Each DBPedia entry is associated with (at least) a Wikipedia Category which can be interpreted as themes for the artworks/items associated with the entity. The linking structure is summarized in Figure 12.

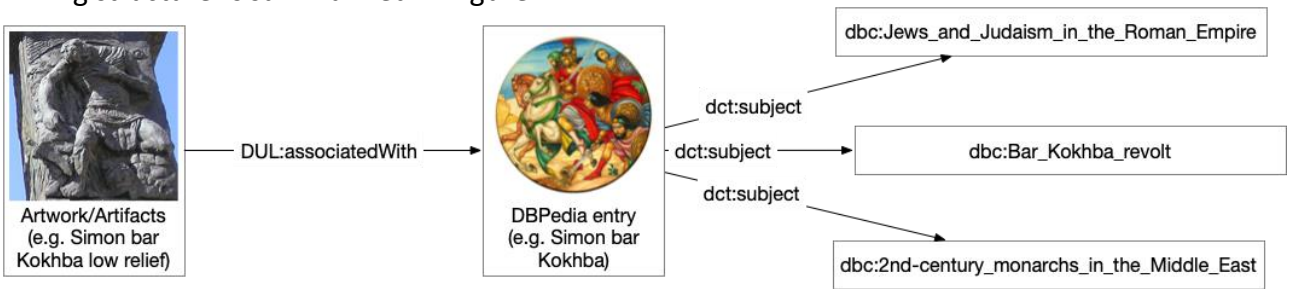


Figure 12 Linking structure exploited for associating objects with Wikipedia categories

It is worth noticing that the predicate DUL:associatedWith allows us to assert any kind of relation which could be: i) an identity relation in case that the DBPedia entry refers exactly to the same real-world object (for example, consider the case of DBPedia having an entity for representing the Simon bar Kokhba low relief owned by the Hecht Museum); ii) or any other relation in case that the DBPedia entry refers to a related entity (e.g. the DBPedia entry for Simon bar Kokhba). Finally, it should be emphasized that the DBPedia categories are hierarchically organized as a taxonomy of concepts. In fact, each category may be associated with (possibly multiple) broader (or narrower respectively) categories. For example, the category dbc:Jews_and_Judaism_in_the_Roman_Empire is a broader concept than dbc:Bar_Kokhba_revolt and is narrower concept than dbc:Religion_in_the_Roman_Empire.
Pragmatically, to associate an object with a set DBPedia categories, the Thematic Reasoner performs three activities:

1. Retrieving from the RDF description of the exhibition all the objects with their related DBPedia associated entities. This can be done with a single SPARQL query.

```
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX DUL: <http://www.ontologydesignpatterns.org/ont/dul/DUL.owl#>
PREFIX arco: <https://w3id.org/arco/ontology/arco/>
SELECT DISTINCT ?a ?cp {
    ?cp a/rdfs:subClassOf* arco:CulturalProperty ;
```

```
        DUL:associatedWith                    ?a                    .
        FILTER          (strStarts(str(?ass),          "http://dbpedia"))
}
```

Note that: the query is evaluated against the union of the RDF description of the exhibition and the ArCo ontology network (which is dynamically loaded before firing the query).

2. For each DBPedia entry retrieved with the previous query (i.e. for each binding ?a), the Thematic Reasoner fires the following query against the DBPedia SPARQL endpoint.

```
SELECT                DISTINCT                ?category                {
     ?a       <http://purl.org/dc/terms/subject>       ?category       .
}
```

Note: the variable ?a is substituted with the results of the first query.

3. The set of categories retrieved with the previous query is enriched with their (direct) ancestors.

```
PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
SELECT DISTINCT ?ancestor {
      ?category skos:broader ?ancestor .
}
```

Note: the query is executed once for each category (variable ?category) retrieved with the previous query.

Once tasks 1,2 and 3 are performed each object is associated with a set of categories. For example, consider the previous exhibition and suppose that the following associations are retrieved:

- ex:PortraitOfBerniece -> {dbc:Roman-era_Jews, dbc:Flavian_dynasty, dbc:Jews_and_Judaism_in_the_Roman_Empire }
- ex:PortraitOfJosephFlavius -> {dbc:Roman-era_Jews, dbc:Jewish_historians, dbc:Jews_and_Judaism_in_the_Roman_Empire }
- ex:HeadOfVespasian -> {dbc:Jews_and_Judaism_in_the_Roman_Empire, dbc:Flavian_dynasty, dbc:People_of_the_First_Jewish–Roman_War}
- ex:RomanWarGear -> {dbc:Ancient_Roman_military_technology, dbc:Ancient_Roman_military_equipment}

Associating zones with themes. The Thematic Reasoner queries the relation DUL:isLocationOf and bot:containsZone in order to build a topological model of the objects of the exhibition. In particular, it first associates zones with the objects (directly) located within it. This can be done by querying the DUL:isLocationOf relation as follows:

```
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX DUL: <http://www.ontologydesignpatterns.org/ont/dul/DUL.owl#>
SELECT DISTINCT ?loc (GROUP_CONCAT(?cp) AS ?cps) {
      ?loc DUL:isLocationOf ?cp
} GROUP BY ?loc
```

The Thematic Reasoner iterates over the zones and for each of them it retrieves the themes of the objects located within the zone. Themes are then aggregated in the sense that for each zone the Thematic Reasoner counts how many times a particular theme is associated with objects located in the zone. In doing this, the zones are associated with themes with different scores depending how many objects of the zone is associated with the theme. For example, the zones ex:Portraits and ex:AreaXX are associated with themes as follows:

- ex:Portraits -> { dbc:Roman-era_Jews (weight=2), dbc:Jewish_historians (weight=1), dbc:Jews_and_Judaism_in_the_Roman_Empire (weight=2), dbc:Flavian_dynasty (weight=1) }
- ex:AreaXX -> { dbc:Jews_and_Judaism_in_the_Roman_Empire (weight=1), dbc:Flavian_dynasty (weight=1), dbc:Ancient_Roman_military_technology (weight=1), dbc:Ancient_Roman_military_equipment (weight=1)}

After that, the Thematic Reasoner computes weighted themes for zones containing other zones by aggregating the themes of the contained zones. To do this, the reasoner retrieves the containment relations with the following query:

```
PREFIX bot: <https://w3id.org/bot#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX DUL: <http://www.ontologydesignpatterns.org/ont/dul/DUL.owl#>
SELECT DISTINCT ?zone (GROUP_CONCAT(?loc) AS ?locs) {
      ?zone bot:containsZone ?loc .
      ?loc DUL:isLocationOf ?cp
} GROUP BY ?zone
```

For example, the zone ex:GalileeRebellion which contains ex:Portraits and ex:AreaXX will be associated with the following themes: dbc:Roman-era_Jews with weight 2, dbc:Jewish_historians with weight 1, dbc:Jews_and_Judaism_in_the_Roman_Empire with weight 3, dbc:Flavian_dynasty weight 2,), dbc:Ancient_Roman_military_technology with weight 1, dbc:Ancient_Roman_military_equipment with weight 1.

Status

A prototype implementation is available on GitHub at the following link [5]. It is currently released as executable JAR file. The executor takes as input an RDF description of an exhibition (like the one presented above) and generates an RDF file in which weighted thematic associations are specified according to the Theme Ontology[6] of the SPICE Ontology Network. The Theme Ontology allows to specify the relation (possibly weighted) between entities (of any kind) and themes. A diagram of the Theme Ontology is showed in Figure 13.

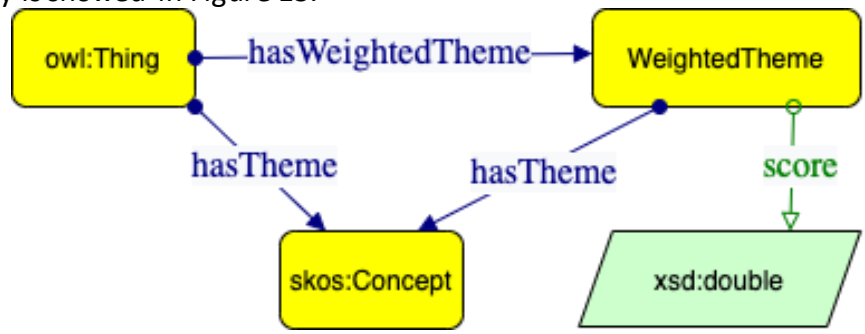


Figure 13 The Theme Ontology

According to the ontology anything (owl:Thing) can be associated with a theme (a skos:Concept). The ontology admits two kinds of entity-theme relations: a direct relation in which the entity is directly linked with the theme by means of the hasTheme property; and a weighted association in which entity and theme are also associated with a score which tells how much the theme is relevant for the entity. Formally, the weighted association is a reification of the property hasTheme and is

[5] https://github.com/spice-h2020/thematic.reasoner
[6] https://w3id.org/spice/SON/theme/0.0.2

implemented as an owl class (i.e. WeightedTheme). For example, the weighted associations of the entity ex:GalileeRebellion with the themes can be specified as follows.

```
@prefix theme: <https://w3id.org/spice/SON/theme/> .
@prefix ex: <https://w3id.org/spice/SON/issues/31/> .
@prefix dbc:   <http://dbpedia.org/resource/Category:> .

ex:GalileeRebellion theme:hasWeightedTheme ex:1, ex:2, ex:3, ex:4, ex:5, ex:6
.

ex:1 theme:hasTheme dbc:Roman-era_Jews ;
            theme:score 2 .
ex:2 theme:hasTheme dbc:Jewish_historians ;
            theme:score 1 .
ex:3 theme:hasTheme dbc:Jews_and_Judaism_in_the_Roman_Empire ;
            theme:score 3 .
ex:4 theme:hasTheme dbc:Flavian_dynasty ;
            theme:score 2 .
ex:5 theme:hasTheme dbc:Ancient_Roman_military_technology ;
            theme:score 1 .
ex:6 theme:hasTheme dbc:Ancient_Roman_military_equipment ;
            theme:score 1 .
```

The Thematic Reasoner is currently being experimented in the case study involving the Hecht Museum and University of Haifa. The full description of the Hecht Exhibition as well as the results of the Thematic Reasoner are published via the Fuseki endpoint. The generated data can be accessed via the following link [7].

Future work

The variety of concepts and relations of the ontology are exploited only to a limited extent. In fact, the tool reasons over the containment relations among zones, the localization of objects, the object-theme associations, and the hierarchy of themes. These relations enabled the Thematic Reasoner to associate objects with themes. Additional relations among themes could be used for enhancing the object-theme relation. A relatedness relation among themes, which could be possibly obtained from the analysis of the embeddings of the themes (cf. (Biswas 2021)), could be used to this end. Likewise, recommending users with artworks associated with themes dissimilar to their interests might encourage them to reflect about alternative viewpoints. Finally, we plan to test the Thematic Reasoner on additional use cases and to expose its functionalities via REST API.

[7] http://130.192.212.225/fuseki/thematic.reasoner.test/data

Value Reasoner

The Value Reasoner is a tool which aims at representing different moral, cultural and personal values of a User in relation to some Item from a Collection. Furthermore, the tool allows to represent Value Recognition, namely the recognition of some value attributed to some artwork by some user, Value Appraisal, namely the positive or negative stance of some user in relation to some specific value, and Value Commitment, namely the first-person commitment of some user to some value. The tool, starting from emotions and values extraction from natural language comments (WP3), enables non-trivial inferences about: 1. conflicting positions among different Users about the same Item; 2. aligned User value profiles stemming from different items, namely users sharing the same values but extracted from different items; 3. possible aligned or counter-value profiled items, namely items which bear same or opposite values to those positively (or negatively) appraised by some User, both relevant in order to foster inclusion and cohesion in the interpretation-reflection loop (WP2). Such reasoning capabilities will be offered as a software service that will be integrated with the other tools supporting the IRL processes (cf. D2.1 and D2.2).

Motivations

Detecting the Value profile of a single/collection of items allows Cultural Heritage Institutions and Curators to cluster them and organize them in a meaningful way according to their design intentions. Furthermore, detecting the value recognition, commitment and value appraisal of single/group of users allows the recommender system to propose in a physical or virtual environment an item bearing values similar or contrastive to those manifested by the User, in order to foster the performance of the interpretation-reflection loop (D2.2).

Application scenario

As application scenario we considered a case study involving the GAM Gallery. In particular, we considered an artificial realization and extension of a user journey script.

Figure 14 "Asfissia" by Angelo Morbelli, 1884

Figure 15 "Schiava" by Giacomo Ginotti, 1877

Ambra and Paul visit the museum to see in person the artworks, in particular they are both interested in the 2nd floor '800 collection, Ambra spends some time admiring the "Asfissia" painting (Figure 14), which depicts the remains of a finished meal, with some peculiar details such as the

withered flowers, the abandoned hat, which, as stated in the gallery painting description, refer to the suicide of the two lovers who have just finished eating. Paul instead focuses on a sculpture: "Schiava" (Figure 15), in which a female figure is carved in the act of trying to break free from the chains.
They decide to take pictures of these artworks and post them online with a caption. Ambra posts the photo with the following comment:

"The idea that such a wonderful piece of art could derive from such a terrible act is insane! This makes me feel very sad. People don't understand that life is a gift from God and that should not be wasted in this way!!! Committing suicide is a one-way ticket to hell, don't do it, don't renounce to your eternal life in heaven! #behappy #godlover #artlover #gamgallery".

Paul instead posts a photo of the "Schiava" sculpture with this caption:

"This masterpiece should remind us all that there are still forms of slavery in our contemporary world, people suffering without human rights, people in chains, unable to speak aloud and protest against awful dictatorships. Democracy is the only choice for a bright future, it should be the most important battle we fight for, every day."

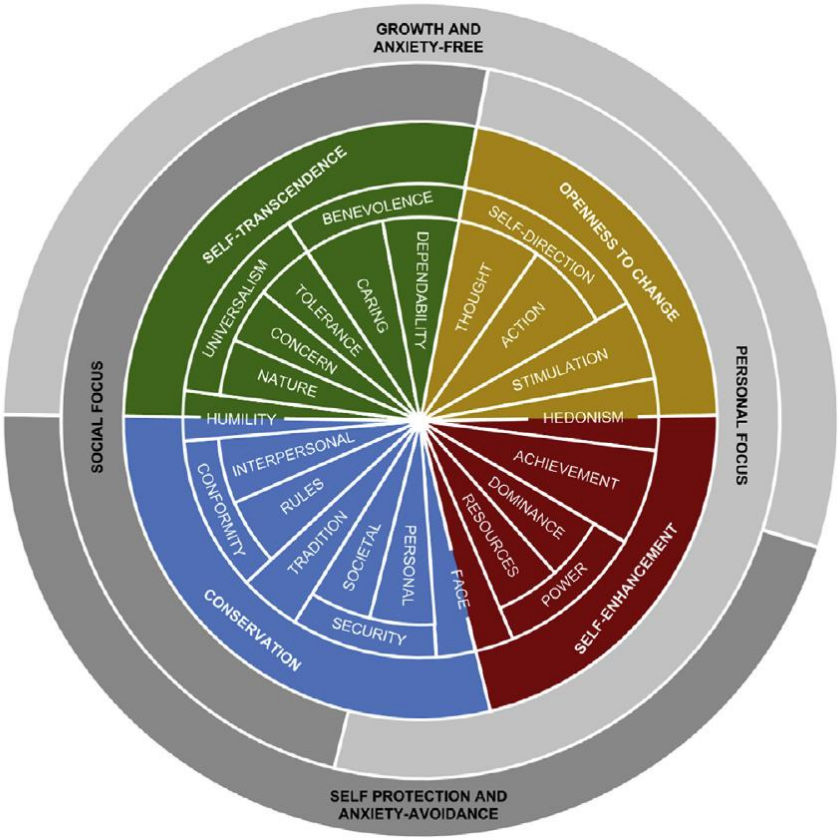


Figure 16 Schwartz Value Wheel of Basic Human Values

From natural language processing of Ambra's caption it was assigned a value commitment to cultural values present in the World Values Survey dataset, modelled in wvs ontology module, like "wvs:Believe_in__God", "wvs:Believe_in__hell" and "wvs:Believe_in__heaven" and it was

furthermore extracted her position against "wvs:Justifiable__Suicide". Thanks to the alignment from these domain specific values to the Schwartz Basic Human values (Schwartz et al. 2001) (cf. D6.2), modelled in the SchwartzValues module according to the value wheel (Figure 16), it is possible to infer Ambra's adherence to general values like "sch:Tradition" (a more conservative attitude) and her positions in disagreement with "sch:OpennessToChange" (a more progressive attitude) and "sch:Action" (the right to freedom of action).
With the same process it is inferred for Paul his commitment to wvs:Political_system__Having_a_democratic_political_system, wvs:Importance_of_democracy, wvs:Democracy__Civil_rights_protect_people_s_liberty_against_oppression cultural values, which are subsumed under Schwartz's values "sch:OpennessToChange" and "sch:SelfTrascendence".

The SPICE ontology network (cf. D6.2) allows us to formally specify this scenario in machine-readable format (RDF/TURTLE syntax) as follows:

```
@prefix dul: <http://www.ontologydesignpatterns.org/ont/dul/DUL.owl#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix occ: <https://w3id.org/spice/SON/OCCEmotion/> .
@prefix gam: <https://w3id.org/spice/GAM/> .
@prefix arco: <https://w3id.org/arco/ontology/core/> .
@prefix sch: <https://w3id.org/spice/SON/SchwartzValues/> .
@prefix script: <https://w3id.org/spice/SON/scripting#> .
@prefix wvs: <http://www.ontologydesignpatterns.org/ont/values/wvs.owl#> .
@prefix owl: <http://www.w3.org/2002/07/owl#> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
@prefix valreas: <https://w3id.org/spice/SON/value_reasoner.owl#> .


### CULTURAL ENTITY


gam:Asfissia a arco:CulturalEntity .

gam:Schiava a arco:CulturalEntity .


### PEOPLE

script:Ambra a script:Agent;
    a dul:Person;
    dul:isClassifiedBy script:social-media-user;
    dul:isClassifiedBy script:visitor .

script:Paul a script:Agent;
    a dul:Person;
    dul:isClassifiedBy script:social-media-user;
    dul:isClassifiedBy script:visitor .


### VALUES


wvs:Believe_in__God fschema:subsumedUnder sch:Tradition ;
    valreas:reprehensibleFor sch:OpennessToChange .

wvs:Believe_in__heaven fschema:subsumedUnder sch:Tradition ;
    valreas:reprehensibleFor sch:OpennessToChange .
```

```
wvs:Believe_in__hell fschema:subsumedUnder sch:Tradition ;
    valreas:reprehensibleFor sch:OpennessToChange .

wvs:Justifiable__Suicide fschema:subsumedUnder sch:Action ;
    valreas:reprehensibleFor sch:Tradition .


wvs:Political_system__Having_a_democratic_political_system fschema:subsumedUnder
sch:SelfTrascendence , sch:OpennesToChange .

wvs:Importance_of_democracy fschema:subsumedUnder sch:SelfTrascendence ,
sch:OpennessToChange .

wvs:Democracy__Civil_rights_protect_people_s_liberty_against_oppression
fschema:subsumedUnder sch:SelfTrascendence , sch:OpennessToChange .


### ACTIVITIES


script:GAM_PicProd a script:PictureProduction .


script:AsfissiaPicProd_by_Ambra a script:Action ;
    script:executesTask script:GAM_PicProd ;
    script:hasParticipant script:Ambra ;
    script:hasParticipant script:AsfissiaPic_by_Ambra .


script:AsfissiaPic_by_Ambra a dul:InformationRealization;
    script:hasCaption script:AsfissiaPicCaption_by_Ambra .


script:AsfissiaPicCaption_by_Ambra a dul:InformationRealization ;
    dul:hasDataValue "The idea that such a wonderful piece of art could derive
from such a terrible act is insane! This makes me feel very sad. People don't
understand that life is a gift from God and that should not be wasted in this
way!!! Committing suicide is a one way ticket to hell, don't do it, don't
renounce to your eternal life in heaven! #behappy #godlover #artlover
#gamgallery"^^xsd:string .


script:SchiavaPicProd_by_Paul a script:Action ;
    script:executesTask script:GAM_PicProd ;
    script:hasParticipant script:Paul ;
    script:hasParticipant script:SchiavaPic_by_Paul .


script:SchiavaPic_by_Paul a dul:InformationRealization;
    script:hasCaption script:SchiavaPicCaption_by_Paul .


script:SchiavaPicCaption_by_Paul a dul:InformationRealization ;
    dul:hasDataValue "This masterpiece should remind us all that there are still
forms of slavery in our contemporary world, people suffering without human
rights, people in chains, unable to speak aloud and protest against awful
dictatorships. Democracy is the only choice for a bright future, it should be
the most important battle we fight for, every day."^^xsd:string .


### VALUES EXTRACTED BY EMOTION/VALUES DETECTOR FROM NATURAL LANGUAGE
```

```
script:AsfissiaPicCaption_by_Ambra valreas:hasValueContent wvs:Believe_in__God ,
wvs:Believe_in__hell, wvs:Believe_in__heaven ; wvs:against
wvs:Justifiable__Suicide .


script:SchiavaPicCaption_by_Paul valreas:hasValueContent
wvs:Political_system__Having_a_democratic_political_system,
wvs:Importance_of_democracy,
wvs:Democracy__Civil_rights_protect_people_s_liberty_against_oppression .



### EMOTION EXTRACTED BY EMOTION - VALUE DETECTOR FROM NATURAL LANGUAGE

script:AsfissiaPicCaption_by_Ambra e:hasEmotionContent occ:Pity .


### VALUES INFERRED AFTER DETECTION

script:Ambra valreas:valueCommitmentTo sch:Tradition ;
    valreas:against sch:OpennessToChange , sch:Action .


wvs:Believe_in__God occ:praiseworthy script:Ambra .

wvs:Believe_in__hell occ:praiseworthy script:Ambra .

wvs:Believe_in__heaven occ:praiseworthy script:Ambra .

wvs:Justifiable__Suicide occ:blameworthy script:Ambra .


script:Paul valreas:valueCommitmentTo sch:OpennessToChange, sch:SelfTrascendence
.


sch:OpennessToChange occ:praiseworthy script:Paul .

sch:SelfTrascendence occ:praiseworthy script:Paul .
```

The proposed scenario shows how two generic users decide to post a comment about an artwork after visiting the museum according to GAM User Journey Script, namely, Ambra is a script:User and performs script:AsfissiaPicProd_by_Ambra which is a dul:Action which realizes the script:GAM_PicProd script ontology Task, while script:AsfissiaPic_by_Ambra and script:AsfissiaPicCaption_by_Ambra are multimedia contents, aligned to Dolce foundational ontology as dul:InformationRealization.
It furthermore shows how it is possible to infer value commitment starting from topic detection and epistemic stance from natural language, namely, the script:AsfissiaPicCaption_by_Ambra has as value content some instances of the domain specific values from wvs ontology module. This allows inferences in two directions: directed toward the artefact which is in the picture, and directed toward the user who wrote the caption.
The inference towards the user is materialized via the property valreas:valueCommitmentTo which is a property chain structured as follows:
Some Agent has valueCommitmentTo some Value if the Agent is script:producerOf some script:MultiMediaContent which valreas:hasValueContent some wvs:WVSVariable (instances of all the domain specific values) which is fschema:subsumedUnder some sch:Value.
The inference towards the artefact and its bearing of conflicting values is part of further

developments and it is explained in the Future Works section, while inference about value recognition is explained in the Approach section.
Furthermore, the properties occ:praiseworthy and occ:blameworthy, taken from the OCC module of Emotions ontology, allows to represent the value appraisal of the user to some domain specific value, used then by the value reasoner to generate triples declaring roles for the valuecore:ValueRecognition frame occurrence.

Goal

The Value Reasoner performs inferential reasoning from the script:MultiMediaContent produced by users about artworks/artifacts (objects in what follows) of an exhibition and allows to:

- Retrieve knowledge about values carried by each artefact, according to a specific user
- Retrieve values shared by users and eventually create clusters of users sharing the same values
- Retrieve information about the amount of attention paid to some artworks (being e.g. the subject of many script:MultiMediaContent from different users)
- Retrieve information about the more "controversial" artworks, by querying the resource looking for those items which are said by some user to carry some value and at the same time to carry some other conflicting value by some different user.

Approach

This section describes the approach implemented by the Value Reasoner.
The first issue we addressed was the alignment of wvs:CulturalValue instances to the general values from the Schwarz model (namely, the alignment of domain related values e.g. "believe in the importance of democracy" to more abstract and general values e.g. "freedom of act and speech") via the use of two properties: fschema:subsumedUnder to express a relation of subsumption and valreas:reprehensibleFor in order to express the relation of conflict.
For the proposed scenario and only for the class wvs:CulturalValue the alignment was done by hand, while for future work and remaining classes in wvs module, computational methods and entity recognition strategies could be investigated.
The ratio behind the reasoning inferences in the Scenario proposed above is structured as follows:

- associating items with both domain specific values and general values via the linking between a multimedia content of an item, namely its picture and caption, and the item itself
- associating users with general values via ValueCommitment, thanks to previous alignment of domain specific values as fschema:subsumedUnder or valres:reprehensibleFor some general values
- associating users clustering them for sharing the same value commitment, conflicting value commitment, the same value recognition, conflicting value recognition, the same value appraisal, conflicting value appraisal according to the interpretation reflection loop

Note that the inference is done about users starting from user comments, so it has different topicalization level of value agreement extraction, e.g. two users could have a local value agreement about the same artifact, having commented in a similar way the same artifact, but a local value disagreement about another one, thus showing both a global commitment to common and opposite values, because of the user value profile partial overlap.
The main relevant accounts of values for linguistic processing have been provided by two main lines of research (see Deliverable 6.2): the Moral Foundation Theory by Haidt, which describes the innate, universal dyadic value oppositions that drive moral behaviour and the Theory of Basic Human values by Schwartz, which is modelled in the Schwartz ontology values module and provides an account of

values in terms of opposition and similarity relations, these opposition and similarity are materialized via the subsumption and conflict in the domain specific values alignment to Basic Human Values.
Pragmatically, in order to do the above-mentioned associations, the Value Reasoner performs the introduction of triples according to the previously mentioned inferences, e.g. introducing the property valreas:valueCommitmentTo between the user and some value when some user's comment shows some domain specific value. This process can be exemplified by the following SPARQL query:

```
PREFIX gam: <https://w3id.org/spice/GAM/>
PREFIX sch: <https://w3id.org/spice/SON/SchwartzValues/>
PREFIX script: <https://w3id.org/spice/SON/scripting#>
PREFIX wvs: <http://www.ontologydesignpatterns.org/ont/values/wvs.owl#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX dul: <http://www.ontologydesignpatterns.org/ont/dul/DUL.owl#>
PREFIX arco: <https://w3id.org/arco/ontology/arco/>
PREFIX fschema: <https://w3id.org/framester/schema/>
PREFIX valreas: <https://w3id.org/spice/SON/value_reasoner.owl#>

INSERT {
    GRAPH ?g2 {

        ?item valreas:hasValueContent ?value .

        ?agent1 valreas:valueCommitmentTo ?value .

        ?agent1 valreas:against ?value .

        ?agent1 valreas:valueContrastWith ?agent2 .

    }

}

WHERE {

    GRAPH ?g1 {

       ?item a/rdfs:subClassOf* arco:CulturalProperty ;
            dul:associatedWith ?itemPic .

       ?itemPic a script:MultimediaProduct ;
             script:realizedBy ?agent1 ;
             script:hasCaption ?itemPicCaption .

       ?itemPicCaption valres:hasValueContent ?domainSpecificValue .

       ?domainSpecificValue fschema:subsumedUnder ?value .

    }
}
```

Furthermore, according to what presented in deliverable D6.2 the Value Reasoner is able to extract from the proposed scenario also the occurrences of the subclasses of the Frame occurrence of some Value, namely a ValueAppraisal, ValueRecognition and ValueCommitment. The ValueAppraisal is in fact extracted from triples like wvs:Believe_in__God occ:praiseworthy script:Ambra, in which a positive or negative appraisal is performed in relation to some value. The ValueRecognition is the occurrence of a frame in which some user recognizes some value in some artwork, and it takes as roles the item in some picture, values recognized in the picture and the user recognizing them.
Furthermore, the ValueCommitment frame occurrence takes as core roles some user and the values he/she commits to.
Pragmatically this can be exemplified by the following SPARQL query:

```
PREFIX gam: <https://w3id.org/spice/GAM/>
PREFIX sch: <https://w3id.org/spice/SON/SchwartzValues/>
PREFIX script: <https://w3id.org/spice/SON/scripting#>
PREFIX wvs: <http://www.ontologydesignpatterns.org/ont/values/wvs.owl#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX dul: <http://www.ontologydesignpatterns.org/ont/dul/DUL.owl#>
PREFIX arco: <https://w3id.org/arco/ontology/arco/>
PREFIX fschema: <https://w3id.org/framester/schema/>
PREFIX valreas: <https://w3id.org/spice/SON/value_reasoner.owl#>

INSERT {
      GRAPH ?g2 {
            ?ValueAppraisal fschema:coreRole ?user , ?value  .
            ?ValueRecognition fschema:coreRole ?item , ?user , ?value .
            ?ValueCommitment fschema:coreRole ?user , ?value .
      }
}
WHERE {
    GRAPH ?g1 {
      ?item a/rdfs:subClassOf* arco:CulturalProperty ;
            dul:associatedWith ?itemPic .
      ?itemPic a script:MultimediaProduct ;
            script:realizedBy ?user ;
            script:hasCaption ?itemPicCaption .
      ?itemPicCaption valres:hasValueContent ?domainSpecificValue .
      ?domainSpecificValue fschema:subsumedUnder ?value .
    }
}
```

Status

We have collected the requirements, realized the ontological modelling from state-of-the-art theories, transposed in ontology format the world value survey dataset (partially aligned as mentioned before) and developed the value_reasoner.owl module providing the inferential rules for the approach.

The Value reasoner will be implemented as software service integrated in the software platform.

In detail, the kind of data we expect to collect are similar to Ambra and Paul example, and the expected output is inferred knowledge in RDF format as shown in the application scenario and Approach section.

Future Work

A particular and interesting case of analysis, allowed by open world assumption, is the one in which ?agent1 and ?agent2, showing conflicting values, are the same user, showing an internal conflict of values which should not be taken as an error, but as an interesting case of study, introducing the notion of "internal value conflict".

Another development is the introduction of the notion of "controversial item" inferred by the assignment of conflicting values to the same item by the same or different users.

A further development is to use a pipeline similar to the one used in the Thematic reasoner in order to localize the spatial “value configuration distribution” of some cultural heritage collection, using

the Value Recognition class to draw a “value roadmap” through items according to users value recognition, considering also the above-mentioned concept of “controversial items”, helping the curators in designing an exposition’s narrative based on a new form of citizen curation structured both by the items’ amount of engagement and their attributed values.
From the ontological point of view further alignment will be provided from instances of the wvs module to Schwartz module, computational methodologies in order to automatize this alignment will be investigated and will be included also the Haidt Moral Foundation Theory (Haidt 2007) in order to introduce a further theoretical perspective.

Outlook

During the months (M18-M30) the described prototypes will be assessed in the context of the data coming from the users involved in real museum experiences. The testing with user-generated content, and the combination of such testing with the ones obtained on the museum catalogues, is crucial for the assessment of the feasibility of the proposed solutions in the context of SPICE. Currently the only data coming from real users (in particular from the deaf community, that is the target community of the GAM Museum, see Deliverables 7.2 and 7.3) are the ones collected through the GAMGame, employed here to test the discovery of hidden links (and consequent groupings) between cultural items via the emotion labels suggested by the emotional reasoner DEGARI. Due to the availability of the system as a REST-service, these results will be extended with tests done with the collaboration of the other Museums involved in the project. Both the Thematic Reasoner and the Value Reasoner will undergo the same process.
The validation of the proposed solutions on user-generated data and on integrated catalogue metadata with Linked Data sources will open the way to the integration of the corresponding sensemaking services in the applications developed in Work Package 5, which will concretely support the Interpretation Reflection Loop in real citizen curation scenarios. The availability of the described services in the form of prototypes will enable their testing to recommend and group items (be them artifacts or interpretations) within the context the logics and user interaction specific to each application (and case study) since the design phase of the latter.
Another crucial part of the technical development that will be done in the next months, will concern their integration with the other software components developed in the context of SPICE. For example, with the Semantic Multilingual Analyzer provided by Work Package 3 and the Linked Data Hub provided by Work Package 4. The integration with the Semantic Multilingual Analyzer will allow solving the multilingual issue and enriching the results of the linguistic extractor, for what concerns the attribution of emotional, narrative and value labels to cultural items, with the knowledge-based support provided by the described prototypes. The output provided by the described prototypes, then, will be accessible via the SPARQL endpoints made available both by the WP 4 Linked Data Hub and by the Research Infrastructure provided by the WP 6 and described in the Deliverable 6.1 (currently, this aspect is only partially integrated in the described systems). The availability of the enriched content on these two SPARQL endpoints will enable all the remaining software modules of SPICE to make use of such output. In particular, the provided mechanisms of inference and discovery shall be integrated in the AI recommender system since they provide complementary elements to consider (with respect to the recommendations based on users and communities) that can be used to foster the interpretations and reflections over content items according to the aims of SPICE.

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