Social Media and Web Sensing with Semantic Integration on the Refugee Crisis

Evangelos A. Stathopoulos
Information Technologies Institute
CERTH
Thessaloniki, Greece
estathop@iti.gr

Sotiris Diplaris
Information Technologies Institute
CERTH
Thessaloniki, Greece
diplaris@iti.gr

Anastasios I. Karageorgiadis
Information Technologies Institute
CERTH
Thessaloniki, Greece
tassoskarag@iti.gr

Alexandros Kokkalas
Information Technologies Institute
CERTH
Thessaloniki, Greece
akokkalas@iti.gr

Stefanos Vrochidis
Information Technologies Institute
CERTH
Thessaloniki, Greece
stefanos@iti.gr

Ioannis Kompatsiaris
Information Technologies Institute
CERTH
Thessaloniki, Greece
ikom@iti.gr

***Abstract*—The refugee crises have been considered as devastating humanitarian incidents throughout human history. They involve forced migrations due to war conflicts, diseases and so on, and are more relevant to nowadays than ever. What changed during the past decades and can be exploited towards greater good is the adoption of web and social media. In this paper, the main focus delves around smart retrieving of information from online sources, such as Twitter, YouTube and culturally-dedicated websites to provide cultural experts with relevant multimedia. The final scope is to build immersive experiences about migrant stories for local communities towards a more inclusive Europe. Moreover, semantic web technologies are deployed to homogenize multi-modal data and metadata into a unified knowledge graph including ontological structures for precise annotations. Additionally, this enables knowledge extraction and insights acquisition from implicit relationships. Finally, a system-wise benchmark for all utilities is showcased to evaluate each framework distinctly.**

***Index Terms*—Social Media Sensing, Web Sensing, Information Retrieval, Semantic Web, Ontology**

I. Introduction

Humanitarian disasters conclude in mass movements of people. Ever since, migrants struggled to be included in host societies. Often, minorities formed that would not mingle harmoniously with locals. Frequently, people are afraid of diversity, though them or their ancestors share some common experiences. Those barriers can be overcome with the up-rise of the internet and the social media widespread usage.

There are big data freely accessible throughout the web. Web 2.0 enabled users to produce huge amounts of data online in daily basis by following certain topics or even by creating new trending ones according to general ”virality”. The channels of communications may vary from personalized feeds in a certain social media platform to public online forums. Original content is always valuable and much appreciated for various reasons. Thus, scientific communities turned their attention towards continuously monitoring and capturing the pulse of the online majority for certain hot topics.

Social media sensing and web sensing consist fields of extensive studies for the past two decades. Technological tools and smart algorithms have been constructed and deployed to serve such purposes. As web infrastructure evolves, more and more sophisticated software emerged, even with artificial intelligence infused, so as to follow the progress and break successively beyond the state-of-the-art. Even online sources helped at bridging the technological gap by offering official free application programming interfaces to be wrapped around. The aggregation of specialised data-sets from online sources, either user oriented or official, is only the first step towards trying to sense the public for various topics. This is usually achieved by the usage of focused crawlers based on either specific traits of the social media posts or on special properties of the structure of a thematic website.

Resources derived directly from the internet usually exhibit multi-dimensionality and multi-modality. The semantic web technologies and more specifically ontologies tackle this problem by homogenising varying pieces of information into a unified ontological model by forming an interconnected knowledge graph. The ultimate goal is for the Web to transcend current standards and move towards Web 3.0, where every entity on the web consists an official interrelated semantified resource dynamically retrieved, combined with other resources and displayed on demand.

We propose a novel methodology for sensing the refugee crisis initiating with a multi-purpose information retrieval framework which crawls data automatically, continues with mapping, populating and semantically annotating them with ontologies and concludes by enriching a knowledge graph. In this paper, we present the related work and how this work differs from others in chapter 2. In chapter 3, we present the overall information retrieval framework whereas in chapter 4 the semantic integration is analysed. The paper continues with evaluation of the entire system in chapter 5 and concludes in chapter 6.

978-1-6654-8727-6/22/$31.00

II. Related Work

Information retrieval from the internet has been a hot research topic for decades. Several efforts have been made towards better addressing this issue. In [1] researchers implemented a social media crawler where all interactions related to every single post were retrieved so as to better understand interaction dynamics and enable informed decisions. In [2], a novel method of clustering HTML paragraph tags and local parent headers to identify the main content within a news article is showcased. In the bibliography, there are also ontology-based approaches for automated web information extraction and semantic description of data contained in a web page such as in the case of [3] or in the case of [4] where information is extracted and integrated from unstructured HTML documents and is converted to standard format (XML) by using ontologies, then mapped to automatically generate RDF descriptions. Another similar technique is the ontological indexing where web pages are stored in XML databases and by using context of words search results are improvised and then mapped to concepts in ontology [5]. In [6], towards social sensing, M3I platform was constructed and was capable of modeling online social phenomena which might develop in one or more stages over a period of time with coordinated use of diverse media types. Systems based on retrieval from Twitter with visualization and topic detection capabilities were also investigated [7]. More particularly for the refugee crisis social sensing, a study was conducted based on Twitter where 35.000 Twitter data were harvested and public opinions, facts and sentiments were investigated on the matter [8].

Apart from research, there are available social media tool-sets offering services on keyword searches and overall statistics like TweetReach[1]. Moreover, Twazzup[2] enumerates top content on multimedia, accounts and keyword responses whereas Social Mention[3] shows top hashtags, sites and keywords. Some other tools worth mentioning that enable users to handle Twitter data are Followerwonk, TweetDeck and IceRocket. YouTube crawling tools are also available such as The YouTube Channel Crawler[4] and TubeKit[5] which in a similar way retrieve data from channels, playlists and videos.

On contrary with the aforementioned approaches, our tool clusters recent and most relevant social media posts from both platforms and targeted thematic websites altogether into unique collections based on topics, accounts or hashtags. Then every retrieved entity along with various metadata is mapped to an ontology, finally populating and residing inside the knowledge graph in the form of RDF triples. This framework has been developed to serve the purposes of the SO-CLOSE[6] project.

[1]https://tweetreach.com
[2]http://new.twazzup.com/
[3]http://socialmention.com/
[4]https://www.channelcrawler.com
[5]https://www.tubekit.org
[6]https://so-close.eu

III. Information Retrieval Framework

The framework presented consists of 3 sub-components: the Twitter crawler which as a tool wraps around the official free Twitter API[7], the YouTube crawler being a complex software which retrieves metadata by wrapping the official YouTube API[8] and multimedia by ethically crawling, and the website focused crawler, which is an extension of the easIE [9] framework. All 3 services attempt to retrieve some key data with common semantic properties, along with unique information per source, to enhance the ontological integration.

A. Social Media Sensing

Social media platforms entail big data flows being generated continuously by users. The thematic of the content may vary in modality, context and metadata, thus, rendering the monitoring of such flows a useful candidate to aggregate data-sets and attempt to sense the masses on various aspects or reuse legally content. The best choices according to users were Twitter and YouTube, because textual and audiovisual items can contribute greatly in the production of immersive experiences.

1) Twitter Framework: To accumulate a sufficient number of tweets which refer to a topic, such as the refugee crisis in Europe, we utilized Twitter's Search Tweets: Standard v1.1[9]. This online service grants real-time access to public posts inside the platform which include any keyword or key-phrase of a predefined collection. There were multiple iterations following the qualitative evolution of those collections providing feedback in a continuous loop for the further development of the tool and whose concluded forms are demonstrated in Table I. The selected terms focus mainly on refugee events, inclusion and racism. The final crawling iteration lasted 1 month and concluded in June, 2022, resulting in a vast collection of tweets. The tool has been officially released and has been online constantly for users to experiment with.

2) YouTube Framework: In the same sense as the previous subcomponent, the YouTube framework has been developed to accumulate a sufficient figure of video entities or metadata pertinent to the project's requirements about specific topics. It supports and provides 2 useful steps, one after the other. Initially, it wraps around the YouTube Search: list v3 API[10], retrieves and stores the responses of videos' metadata based on exact keyword search queries and declared number of videos that the user wishes to inspect. Subsequently, the user can check the validity and relevance of the metadata information and if desired, he/she is able to retrieve and store the actual video footage locally or in a remote server. For legal purposes, this framework has been designed by scratch only to administer videos entitled with all sorts of Creative Commons video licenses officially disclosed in the platform. The quantitative results on the initial execution are showcased in table I.

[7]https://developer.twitter.com/en/docs/twitter-api/v1/tweets/search/overview
[8]https://developers.google.com/youtube/v3/getting-started
[9]https://developer.twitter.com/en/docs/twitter-api/v1/tweets/search/api-reference/get-search-tweets
[10]https://developers.google.com/youtube/v3/docs/search/list

TABLE I
TWITTER/YOUTUBE COLLECTION OF KEYWORDS/KEY-PHRASES DETAILS

Collections Title	Keywords/Key-phrases included	Number of Tweets Retrieved	YouTube Metadata entries retrieved	Videos down-loaded
Definitions of actors in the process of social cohesion	refugee, immigrant, foreigners, asylum seekers, forced displacement	116.174	30	8
Needs and rights of refugees	refugee needs, refugee rights, right to citinzeship, refugee documents, right to work, right to food, access to health, access to education, access to housing	352.012	36	10
Discrimination in host society	social stigma, social exclusion, racism, racial stereotypes, discrimination, steal jobs, blaming refugees	15.282	47	10
Gender	Transphobia refugee, LGBTQIA+ refugee, refugee women rights, transgender refugee, homophobia refugee, gay refugee	496	0	0
Cultural heritage	cultural backgrounds, refugee shared heritage, refugee memorial heritage, workshop refugee, project refugee, refugee inclusion, refugee culture, refugee tradition, documentary refugee, poem refugee, refugee cinema, refugee storytelling, refugee recipes, refugee science, refugee language	3.233	83	15
Emotions	empathy refugee, compassion refugee, anger refugee, refugee nostalgia, fear refugee, emotional heritage	1.170	47	6
Geography	refugee Poland, refugee Italy, refugee Greece, refugee Spain, refugee Catalunya, crossing borders	5.233	46	1
Trauma	refugee support group, refugee violence, refugee trauma, vulnerable refugee	1.980	40	10
Society	social integration, social inclusion, racist society, refugee integration, refugee community, foreign community, social cohesion, refugee acceptance, refugee empowerment, refugee working class, intercultural refugee, refugee oppresion, refugee resistance	28.143	95	20
Religion	muslim minority, islam refugee, hijab refugee, refugee mosque, ramadan refugee	7.156	48	3
Tools	refugee phones, refugee camera, refugee virtual, refugee twitter, refugee facebook, refugee instagram, refuge social media	59.101	50	10
History and memory	European memory, memorial heritage, civil war, colonialism, decolonise, collective memory, dictatorship, exile	565.385	50	7
Approach in working with refugees	Refugee victimhood, refugee assimilationism, ethnicization, folkorization, exoticism, eurocentric	5.246	48	10
Displacement	Refugee homeland, refugee fatalism, refugee journey, country nostalgia	2.238	50	6

TABLE II
WEBSITES COLLECTION

Websites	Short Description	Focus
https://www.amnesty.org/en/	World's largest human rights movement	News Reporting/Policy
https://www.digitalmeetsculture.net	Portal for gathering information about world digital culture	News Reporting on Digital Culture
http://cultural-opposition.eu	Project funded by EU	Cultural opposition/Socialism in Eastern Europe

B. *Web Sensing*

Additionally, we developed a focused crawler to aggregate content from thematic websites. This framework has been designed to detect specific parts of a web page by focusing on technical elements following the paradigm of well structured websites. Initially, the experts formed a list of 55 potential websites to serve as sources for crawling, but they were reduced to 3 based on:

- legal issues on crawling and content re-usability,
- abundance of multimedia content,
- well structured templates and software compatibility.

The final 3 website choices are presented in Table II.

IV. SEMANTIC INTEGRATION

Apart from re-utilization of resources, it seemed vital to semantically annotate online retrieved items and homogenize with other data inside the system. Moreover, multimedia can be manually inserted by the users. The core ontology used was the Dublin Core (DC) [10] which was extended accordingly to satisfy the requirements. The entire ontology[11] is illustrated in figure 1 where the "dcterms:" prefix implies re-usage of established concepts from the DC and the "soclose:" prefix stands for custom concepts created to address custom needs.

Apart from retrieved items, 2 other types of objects are present in the system: the atomic content and the complex content. The atomic content item might be any type of multimedia (text, image, video, audio), whereas the complex content item consists necessarily of more than one atomic content items forming story maps, virtual exhibitions and web documentaries. Consequently, both types share some common properties which can be seen in the white-framed irregular hexagon in figure 1. Additionally, each type of content withholds some unique properties to itself. The green shapes constitute properties only present to atomic content instances, while blue shapes entitle only to complex content

[11] https://github.com/estathop/SO-CLOSE_ONTOLOGY

instances. As for the crawled item individuals (red rectangle) from websites and social media, so as to achieve the semantic integration and due to restrictions of offered metadata, we only selected to include 8 particular datatype properties depicted by the red color in figure 1. Unnamed arrows imply ownage of datatype properties. More details regarding the custom properties created can be found in table III whereas details on the dublin core terms can be found in [10]. The semantic annotation of atomic and complex content items is automated as the framework retrieves information from a platform where the users insert content manually. The crawled items are mapped on-demand from a MongoDB database where data are stored automatically from web and social media.

A. Validation and Inference

Additional logical assumptions arise when combining native OWL 2 RL reasoning which is based on the OWL 2 RL profile semantics (OWL 2 RL/RDF rules [14]). The semantic component supports domain rules residing on top of the knowledge graph so as to enrich relations among entities by using the CONSTRUCT graph pattern, thus identifying extra inferences. For instance, when a complex content individual concerns a specific city and includes several atomic content individuals then the content of the property "soclose:city" is anointed to all of them when the rule is automatically triggered, as shown below:

```
CONSTRUCT {
   ?atom_cont soclose:city ?city
} WHERE {
   ?comp_cont soclose:city ?city.
   ?atom_cont dcterms:haspart ?comp_cont
}
```

We performed validation checking of the semantics to ensure quality in all aspects, both syntactical and morphological. This was achieved by utilizing manually constructed SHACL (a language for validating RDF graphs against a set of conditions [11]) validation rules and native semantic consistency checking. That way validation is fulfilled by considering the semantics at at the terminological level, such as class disjointedness, whereas the first distinguishes constraint problems like imperfect information or cardinality contradictions. For instance, a SHACL shape ensures that all complex content items will have at least 1 atomic content as part, as shown below:

```
soclose:ConShape
   a sh:NodeShape;
   sh:targetClass soclose:complex_content;
   sh:property [
      sh:path dcterms:haspart
      sh:minCount 1;
].
```

V. Evaluation

Initially, a variation of generated social media content in volume is obvious. For YouTube evaluation, the plan for users is to search for several keywords, however, frequently they would deem appropriate only to download less videos than metadata entities retrieved, due to irrelevance thus implying a smaller precision metric. The general idea for retrieval for YouTube was to retrieve at least 100 metadata entries if available per each collection then randomly download between 1 and 20 videos in order to simulate realistic user behaviour.

Currently, a user oriented evaluation is infeasible due to pilots commencing afterwards. Consequently, we focused in a system-wise benchmark. The selected triple store is a GraphDB 9.9.0 Free Edition which is populated with 17.184 triples. From these triples, 6.086 were explicit while 11.098 were inferred and the overall expansion ratio stands at 2,82. 598 distinct items retrieved from online sources are populated in the knowledge base along with 8.489 distinct properties which translate to more than 4 properties per item. The knowledge base resides at a server with CentOS Linux 7 64-bit operating system, an Intel® Xeon(R) CPU E5-2670 0 CPU @ 2,60GHz×8, with 31,3GB RAM and a HDD of 2,5TB capacity.

The evaluation proceeds with response times while trying to eliminate bias. All queries were developed following the SPARQL 1.1 query language [12] and we ensured upon querying that the variables conform to a uniformly distributed pseudo-generator with their range values spanning with equal probability to all valid content. The queries were extracted from the competency questions found in the ontology requirements specification document (ORSD) [13] which was formed prior to the development of the ontology. Indicatively, some are shown in Table IV, along with mean response times and standard deviations, elicited from 1.000 executions for each.

For Twitter, we retrieved everything mentioned in Table I to capture the procedure times. More specifically, we formed 14 collections of keywords/key-phrases and measured the overall time of completion which was 7.590,67 minutes. This time is estimated since the first call of the API until the last tweet object is stored in the database. The mean time per search for each collection was 158,14 minutes with a standard deviation of 439,43. The mean time of retrieval per tweet was 0,006 seconds and 1.931,77 MBs total size of data were amassed.

For YouTube, we used the same keywords/key-phrases and focused on retrieval and storing times at two stages. At first stage, the wrapper retrieved and stored metadata from at most 100 entities each time in an estimated mean time of 1,25 seconds per search. The total number of metadata entities retrieved and stored were 570, whereas the total videos downloaded were 116. The entire procedure lasted approximately 90 hours while taking into account we targeted the highest quality of videos, the videos duration limit maybe be up to 10 hours and finally ensured not to exhaust resources based on ethical crawling principles.

The website crawler was evaluated likewise. An intermediate step is also present where the incoming data are cleaned. For the amnesty.org website one web-page with the latest news, containing 12 news items, was crawled in 4,89 seconds. For the cultural-opposition.eu website 113 web-pages were crawled in 183,29 seconds, containing 5 articles per web-page.

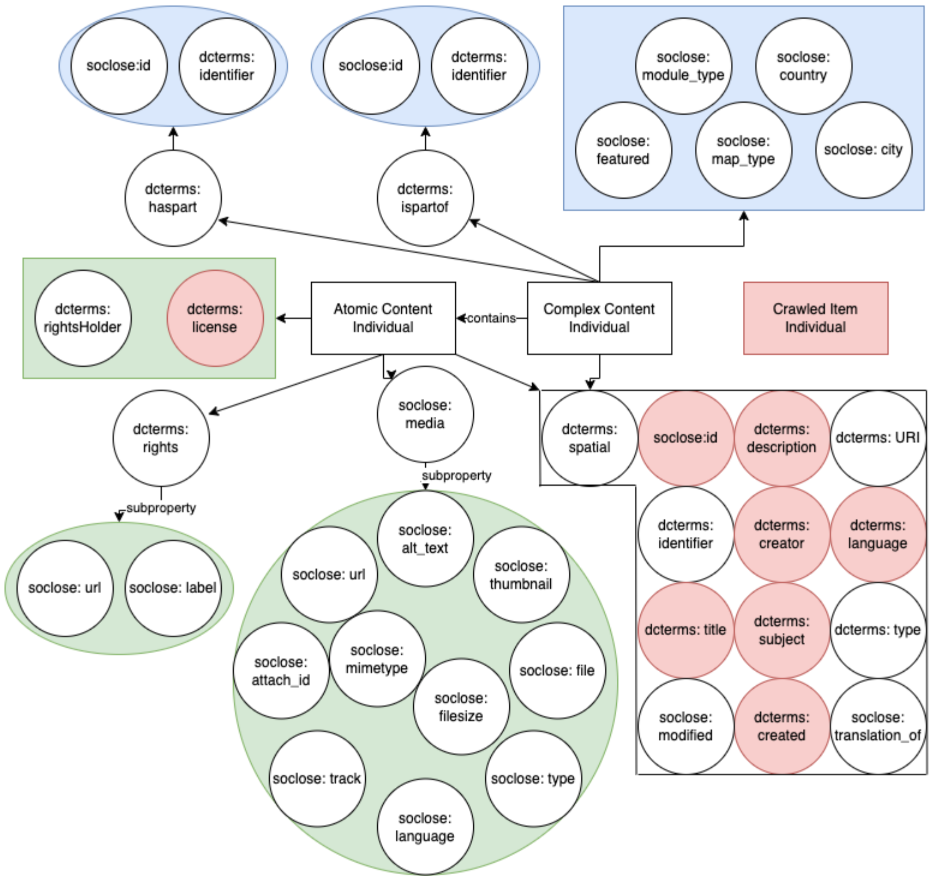

Fig. 1. The SO-CLOSE ontology.

The average time of crawling and retrieving per web-page was 1,62 seconds. For the digitalmeetsculture.net website, 51 web-pages were crawled in 374,72 seconds, containing 8 post items per web-page. The average time of crawling per web-page was 7,34 seconds. The total time to crawl and retrieve all content from all 3 websites and store it in the database was 562,91 seconds and allocated in 2,03 MBs of storage.

The social media and the website crawlers were evaluated in a server with Ubuntu 20.04.3 LTS (Focal Fossa) 64-bit operating system, an Intel® Core™ i9-10920X CPU @ 3,50GHz × 24, 125,5 GBs RAM and a HDD of 4,3TBs capacity. The local database that was utilized was a MongoDB Community Server 3.6.8. The aggregated benchmark evaluation results are shown in table V, in regards of web crawler crawl rate[12], time spent per item in seconds, the total time of the procedure also in seconds and the total items retrieved.

VI. Conclusion

We presented an information retrieval framework from multiple online sources such as Twitter, YouTube and websites, with semantic integration for encapsulating and interlinking online resources with rest local resources towards supporting the creation of immersive experiences for domestic people to more easily accept, understand and include immigrants.

Currently, the work featured is part of a wider tool-set at the hands of experts, where they can create story lines, interactive maps and 360 experiences to connect the past with the present and bring people from so distant to so close. As for future work, the inter-linkage with open data remains unresolved, where for instance potential ambiguation in data might be expunged. The tools will be installed in 4 different locations planned within the SO-CLOSE project pilots and for different context: in Poland, Krakow, on displacements after the Second World War, in Greece at the Trikeri Island Concentration Camp, on political persecution and women internment during the Greek Civil War, in Spain, La Jonquera, on civilian exile and lack of refuge in France during the Spanish Civil War, and in Italy, Marzabotto, on violence against civilians during the Second World and the Italian Civil War. In each occasion tools from among the set will be selected for utilization. Representatives will be responsible for concrete emplacement, to instruct local technicians and ensure proper functioning. Then, cultural institutions will hold an open day event, to which 20 refugees living in the vicinity of each cultural institution will be invited to attend and encouraged to exchange experiences with local communities and share materials such as photos, videos, objects, food recipes and so on.

[12]https://www.ibm.com/docs/en/watson-explorer/10.0.0?topic=activity-web-crawler-crawl-rate

TABLE III
SO-CLOSE CUSTOM ONTOLOGY PROPERTIES

Name of property	Short Description	Value Type
soclose:id	Internal database identifier (ID). Only for internal use.	Non-negative integer
soclose:label	Label of the rights.	String
soclose:url	URL where the rights are described.	String (URL)
soclose:media	Information related to the media file.	Object
soclose:alt_text	Short phrase describing the image's purpose.	String
soclose:thumbnail	URL of a thumbnail image of the media file.	String (URL)
soclose:attach_id	internal unique identifier of the media file.	Non-negative integer
soclose:mimetype	Mime type of the media file.	String
soclose:filesize	Media file size in number of bytes.	Non-negative integer
soclose:track	List of track of the media file (captions, descriptions or transcriptions).	Array of Objects
soclose:type	identifies the type of the track.	Caption, description or transcription
soclose:language	identifies the language of the track.	String (2 letter standard code)
soclose:file	The URL of the track's file.	String (URL)
soclose:translation_of	Internal ID of the original resource when the current resource is a translation.	Non-negative integer
soclose:modified	Last modification date of the resource.	Date in format YYYY-MM-DDThh:mm:ssTZD (ISO 8601)
soclose:featured	URL to the featured image for the exhibition.	String (URL)
soclose:map_type	Identifies the type of the map (only for Stage and Map)	String
soclose:country	Country (only for Stage and Map).	String
soclose:city	City (only for Stage and Map).	String
soclose:module_type	Type of module for stage, section and panel.	textvideo, textimagebig, side2side, imagegallery, 3dgallery, v360, i360, vgallery, quote,map, juxtapose, textimage.

TABLE IV
EXEMPLARY COMPETENCY QUESTIONS

#	Question	Mean (SD) in msec
Q1	Retrieve all registered media individuals	211 ± 37
Q2	Retrieve all related properties to a pseudorandom media individual	127 ± 42
Q3	Retrieve all related properties and all media individuals	237 ± 25
Q4	Retrieve everything	265 ± 112

TABLE V
CRAWLING COMPONENTS BENCHMARKS

Component	Crawl Rate	Time/Item (sec)	Total Time (sec)	Total Items
Youtube	0,002	362,0	42.022,25	116
Twitter	9,278	0,107	126.915	1.177.608
amnesty.org	4,890	4,890	4,89	1
digitalmeetsculture.net	0,136	7,340	374,72	51
cultural-opposition.eu	0,616	1,620	183,29	113

*An item is: For Websites a Webpage, for Twitter a tweet and for Youtube a video downloaded.

ACKNOWLEDGMENT

This work has been supported by the EC-funded project SO-CLOSE (H2020-870939)

REFERENCES

[1] F. Erlandsson, R. Nia, M. Boldt, H. Johnson and S. F. Wu, "Crawling Online Social Networks," 2015 Second European Network Intelligence Conference, 2015, pp. 9-16.

[2] H. J. Carey and M. Manic, "HTML web content extraction using paragraph tags," 2016 IEEE 25th International Symposium on Industrial Electronics (ISIE), 2016, pp. 1099-1105.

[3] I. Jellouli and M. E. Mohajir, "An ontology-based approach for web information extraction," 2011 Colloquium in Information Science and Technology, 2011, pp. 5-5.

[4] Soe Lai Phyue, Myint Myint Thein, Thinn Thinn Win and Mie Mie Su Thwin, "Semantic Web Information Retrieval in XML by mapping to RDF schema," 2010 International Conference on Networking and Information Technology, 2010, pp. 500-503.

[5] K. S. Mule and A. Waghmare, "Context based information retrieval based on ontological concepts," 2015 International Conference on Information Processing (ICIP), 2015, pp. 491-495.

[6] V. Kagan and V. S. Subrahmanian, "Understanding Multi-Stage, Multi-Modal, Multimedia Events in Social Media," 2018 International Workshop on Social Sensing (SocialSens), 2018, pp. 4-4.

[7] Andreadis, S., Gialampoukidis, I., Vrochidis, S., Kompatsiaris, I. (2017). A Topic Detection and Visualisation System on Social Media Posts. In: , et al. Internet Science. INSCI 2017. Lecture Notes in Computer Science(), vol 10673. Springer, Cham. https://doi.org/10.1007/978-3-319-70284-1_33

[8] M. Mahiuddin, "Real Time Sentiment Analysis and Opinion Mining on Refugee Crisis," 2019 5th International Conference on Advances in Electrical Engineering (ICAEE), 2019, pp. 699-705.

[9] Vasiliki Gkatziaki, Symeon Papadopoulos, Richard Mills, Sotiris Diplaris, Ioannis Tsampoulatidis, and Ioannis Kompatsiaris. 2018. EasIE: Easy-to-Use Information Extraction for Constructing CSR Databases From the Web. ACM Trans. Internet Technol. 18, 4, Article 45 (November 2018), 21 pages.

[10] Weibel, S. L., & Koch, T. (2000). The Dublin core metadata initiative. D-lib magazine, 6(12), 1082-9873. profiles. W3C recommendation, 27(61).

[11] Knublauch, H., & Kontokostas, D. (2017). Shapes Constraint Language (SHACL), W3C Recommendation. World Wide Web Consortium.

[12] Pérez, J., Arenas, M., & Gutierrez, C. (2006, November). Semantics and Complexity of SPARQL. In International semantic web conference (pp. 30-43). Springer, Berlin, Heidelberg.

[13] Suárez-Figueroa, M. C., Gómez-Pérez, A., & Villazón-Terrazas, B. (2009, November). How to write and use the ontology requirements specification document. In OTM Confederated International Conferences" On the Move to Meaningful Internet Systems" (pp. 966-982). Springer, Berlin, Heidelberg. ISO 690

[14] Motik, B., Grau, B.C., Horrocks, I., Wu, Z., Fokoue, A., Lutz, C.: OWL 2 WebOntology Language Profiles (2012). https://www.w3.org/TR/owl2-profiles/