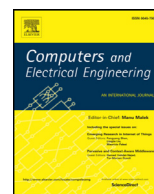




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Phivos Mylonas

Department of Informatics, Faculty of Information Science & Informatics, Ionian University, P.C. 49100, Corfu, Greece

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ABSTRACT

This survey paper attempts to study the existence, importance and impact of the notion of context in modern humanistic computing. Given its inherent diversity, the term is nowadays widely acknowledged among computer science tasks and has become a major topic of interest in several of its sub-fields, ranging from contextual semantics to social networks, social media and recently emerged innovative applications, such as travel routing. We start by presenting a brief review of contextual semantics as nowadays they are considered suitable for most common content analysis problems. Focus is also given within the next survey sections on the impact of context within the social networks and media field that came into sight over the last years. A short, closing discussion on the identified challenges and potential future research directions concludes this survey.

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1. Introduction

We may well claim that, from the computer scientist's point of view, our era is rather dominated by modern computing applications and systems that place human beings in the center of their attention. In general, the next big thing in computer science is *information handling* and, in particular, the type of information deriving from human-generated actions or tasks that are interconnected by definition. Thus, it is easy to understand that information no longer arise in seclusion, leading to new, innovative ways of interpreting them. In this framework the term *context* came into serious play within relevant computer science tasks a little more than 15 years ago, although its true origins date back to the beginnings of computation [5].

In the field of humanistic computer science, which ranges from the theoretical branches of computer science and information theory to artificial intelligence and multimedia analysis tasks, contextual information plays an ever increasing role. To the best of our recent knowledge researchers and students are eager to obtain comprehensive and insightfully written reviews of related studies on modern computing information handling. This survey attempts to provide a rich source of ideas for them and a good point of reference for those who want to start studying contextual information in depth within the framework imposed by the latest computer science advances. Among its goals is the identification of different types of contextual information in humanistic informatics and the provision of an overview on the definition and utilization of context variations exploited within semantics and the modern social media/networks content analysis approaches and applications.

The structure of the rest of this paper is as follows: in [Section 2](#) we explain in brief detail the motivation behind investigating context in modern computing tasks and applications. [Section 3](#) discusses contextual semantics, whereas the most recent trends in the social media world are summarized in [Section 4](#). [Section 5](#) discusses the resulted findings, conclusions

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E-mail address: fmylonas@ionio.gr

and future perspectives of each one of the contextual building blocks of the survey, whereas Section 6 concludes this work and presents potential future directions of expanding the current survey research.

2. Motivation

It would not be absurd to acknowledge that we currently live within a world dominated by "humanistic computing". This observation clearly motivated researchers to focus their research on humanistic computing tasks, in an attempt to provide solutions to the - mostly digital - problems that arose. Within a very limited time-frame of a few years, humans, either in the form of researchers or in the form of content users/producers/consumers, came into the need of efficiently storing, organizing, searching and retrieving huge amounts of information.

In the seek of scalable ways to handle this rather chaotic pile of data in a semantic meaningful and efficient manner, an ever increasing amount of researchers and computer scientists has fled to the *contextual aspects of information* to help with the effort. Taking into account respective social human interactions, we may identify and categorize different contextual information categories while social networking sites users generate, produce, share and publish their own digital content online. Research shifted towards advanced exploitation of metadata information and/or additional kinds of knowledge. The latter is nowadays clearly encompassed by the broad term *contextual information*, which although might increase complexity, e.g., of retrieval tasks [17], it allows for a more scalable, semantically enriched, digital ecosystem.

In the following sections of this manuscript we attempt to present related research works deriving from the field of humanistic computing, roughly classified based on the exploitation of the notion of context they perform and the utilization of all kinds of metadata and targeted applications in the process. More specifically, in an effort to understand the meaning of information, the combination of contextual parameters extracted from low-level features with high-level concepts and interpretation (e.g., fuzzy sets) to facilitate additional semantic knowledge processing tasks is also of great importance, and thus, works that tackle the notion of contextual semantics are discussed in Section 3 of this paper. In addition, it is rather self-evident, that social networks' popularity has rapidly increased over the past few years and it would not be radical to claim that they have changed our digital world in an unprecedented manner. Social networks provide many kinds of services and benefits to its users like share opinions with like-minded people and stay in touch with old friends and colleagues, thus constituting the related contextual researches discussed within following Section 4 a trending topic and definitely a field of future research.

3. Contextual semantics

One of the characteristics of human nature that current humanistic computing applications and systems are here to engage is the ability to perceive, mingle, process and respond to information in real-time. Especially in the framework of modern computing, content semantics play a crucial role in this process, by, among others, including all interactions and contextual cues that by definition are full of ambiguities. We may identify these traits ranging from the multimodal nature of expressions [4] to intra- and interpersonal relational context [9]. Nowadays, ontologies, the current, modern form of Semantics, which is utilized as the main building block of Web 3.0, are still typically built in an inefficient, manual, rather than automated, manner, heavily involving humans in the process up to an extent. Researchers invested in automated development of contextual information in the form of the so-called domain ontologies [28,16] that consist of concepts, semantic relations among them and sets of inference rules.

Still, without any further doubt the role of context in semantics is today applied to a broader range of modern computing tasks. Starting with the very basic building block of computing, i.e., programming, contextual semantics do influence the composition, location and flows of operative code within a programming task. There are also cases where contextual information is interpreted from a unified architectural model and a taxonomy for context data distribution perspective. Within the new framework of social computing the need for better social communication capabilities motivates the introduction and utilization of context in tasks like intelligent information accessing from/to social media [10], as well as their respective semantics mining. In another interesting work closely related to the scope of contextual semantics [27], authors conduct a user survey on the impact of user-contributed contextual information in archival research. Being in the spotlight of attention lately, the field of personalized services provision is dominated by works utilizing semantic context in the process, like for instance the one [22] focusing on the grounds of a smart home environment; the latter being also the field of expertise for [19], where the challenge of integrating spatiotemporal contextual information with human and technical sensor information is discussed. In an attempt to illustrate the basic components of aforementioned approaches, Table 1. summarizes their primitive tasks, methodologies, as well as their pros and cons, in addition to the depiction of a utilized dataset.

4. Context in social networks

Over time the interference of computational semantics evolved towards the main building block of today's modern humanistic computing, i.e., social media and networks. In an attempt to define and identify them, we may refer to the corresponding Wikipedia¹ article, which mentions that "social media are computer-mediated tools that allow people or com-

¹ https://en.wikipedia.org/wiki/Social_media.

Table 1
Semantic context approaches.

Work	Task(s)	Method	Pros	Cons	Dataset
[4]	detection of involvement in a conversation	situational interactional patterns analysis	novel approach, valid by experimental results	not clear type nor contribution of context	TableTalk corpus
[9]	affective computing, emotion communication, social interaction	interpersonal relational context	novel approach	not clear type of utilized context	–
[28]	knowledge representation	ontology extension through non-taxonomic relations	contextual representation through non-taxonomic relations	potentially costly implementation	3 taxonomies
[16]	knowledge representation	ontology construction and evaluation	detailed methodology	limited evaluation	–
[10]	social networking services (SNS)	survey on social networking services (SNS)	4 types (content-based, media-based, geo-location-based, context-based) SNS	–	–
[27]	social media	survey on archive users	4 primary areas of interest tackled	–	695 respondents
[22]	context-based personalized services	case-based context ontology construction	solid fuzzy logic utilization	minor contextual exploitation in the process	5000 case instances
[19]	smart cities	spatiotemporal contextual information integration in smart cities environment	integrating contextual info into geospatial analysis	no real evaluation	–

panies to create, share, or exchange information, career interests, ideas, and pictures/videos in virtual communities and networks". Given the above definition, the actual research challenge lies on the diversity of past, current and future services that arise around social networks. In a further effort to enchant them, we may elaborate them as the main carriers of user-generated content shared over the Internet for easy access by other impressionable consumers. Data-centric humanistic computing for social media-aware of contextual information presents remarkable research challenges, whose tackling may lead to better personal human-computer interactions, support of information-seeking behavior, and optimization of related search results [7].

Today, social media are dominated by the so-called *user information exchange* principle supported by constantly emerging new applications and services, such as mash-ups, media and content syndication, tagging, wikis, web forums, user ratings and evaluation systems and blogs. Well-established social networks, like Facebook² or Twitter³ are considered part of the everyday routine of millions of humans worldwide, whereas innovative applications and services such as travel-related user reviews incorporated within popular dedicated web portals (e.g., TripAdvisor⁴ and Booking.com⁵) define new research and application sub-domains. Last, but not least, traditional online sharing of multimedia content has seen a huge increase over the last decade mostly through the YouTube⁶ service and combined with the new trending travel applications and services, opened new research horizons and resulted into brand new research fields, like tourism-related research, focusing on monitoring and understanding the impact of social media content and context processing in transforming typical travel practices [24].

4.1. Social context

It is common knowledge that in the framework of Web 2.0 communities contextual information plays a key role in understanding human preferences and intentions with respect to user-generated multimedia content manipulation. Furthermore, a large portion of humanistic computing approaches are founded around the meaningful junction of computer science and socio-linguistics domains of expertise; the latter may be well defined by exploiting the primitive human social nature, according to which socio-linguistics analyzes the many and diverse ways in which humans and computers intermingle with each other.

In this framework social context includes approaches dealing with contextual information born and raised within the social media and networks environment. The most representative ones are those who encompass related human-computer interactions in the social graph. It clearly differentiates itself from other types of context (e.g., verbal context), since it de-

² <https://www.facebook.com/>.

³ <https://twitter.com/>.

⁴ <https://www.tripadvisor.com/>.

⁵ <http://www.booking.com>.

⁶ <https://www.youtube.com/>.

Table 2

Social context approaches.

Work	Task(s)	Method	Pros	Cons	Dataset
[6]	social media engagement analysis	framework to study Return of Investment (ROI) in social media	novel approach, recent research work	focused solely on Twitter social network	–
[20]	pervasive social context survey	STiPI taxonomy	taxonomy definition	–	–
[2]	query expansion based on socio-semantic context	semantic network of hashtags	social-semantic context extraction algorithm	limited evaluation	63 related terms in 24 distinct events
[18]	social rating influence	Twitter account discovery and recommendation	utilized ontological schema	Twitter-oriented only, limited evaluation	–
[21]	social networks privacy issues	notion of contextual integrity	4 parameters proposed to conceptualize context-relative information norms	no evaluation	–
[29]	social media behavior analysis	temporal context-aware mixture model	temporal context modeling	–	4 real-world social media datasets: MovieLens, Douban Movie, Digg, Delicious

mands domain knowledge to construct a priori known contextual characteristics with rather individual values. To further illustrate this, typical user-generated contextual information within the social graph may be considered the rate of social activity (e.g., the personal status update) exploited in [6], focusing on the study of related social experiences. On the contrary, a different, rather single-minded representation of social context is encountered in domain-specific applications. The so called *contextual personalization* sub-domain is tackled in [20], where the notion of pervasive social context is introduced.

Still, social context definition may be expanded to include additional traits like locations and contextual activities, whereas in [2,18], the contextual aspect is used to identify semantically important user-generated content via a crowdsourcing-oriented methodology. Tackling the domain of social computing, Shi et al. [21] aim to provide further details about human information boundaries within the social networks framework. And finally, a recent study on social media user behaviors introduced a temporal context-aware model under the same contextual perspective [29]. Following Table 2. presents the herein discussed social context approaches according to their type and illustrates each one's main features.

4.2. Context-aware recommendations

When tackling the notion of context in social networks another standalone research sub-domain is the one imposed by the so-called *context-aware recommender systems*; the term appeared for the first time in the 90s when context was described as "location, identities of nearby people, objects, and changes to those objects". The tremendous impact of contextual information with respect to accurate recommendations has been widely acknowledged in our era. The benefit of such an interpretation is more evident within today's social networks framework, which is dominated by swift changes of interests; in principle it is typically the case when real-time contextual conditions are not aligned with or are even obsolete in comparison to the actual recommendations presented to the user due to the rapid exchange of information. To illustrate this in an approach focusing on mobile music recommendations, context based on daily activities plays a crucial role [26]. In another diverse approach, Baltrunas et al. [3] claim that relevant recommendations could only be produced if the system exploits information about the specific contextual situation in which the recommended item will be utilized. Taking this a step further, Jiang et al. [11,12] propose a novel social recommendation model utilizing social contextual factors, such as individual preferences and interpersonal influence. Again, a brief summary of the aforementioned studies is provided in Table 3., which classifies them according to the predefined columns introduced herein.

4.3. Mobile/travel context

The last group of context to be identified within the scope of this survey under the umbrella of modern social networks is the one of *mobile/travel context*. We actually decided to follow both notations, since the term appears in the literature under both designations. Its origins derive back more than a decade and is aligned to the increasing human need to seek (online) travel information. In other words, worldwide traveling has increased over the last years and has grown hand-in-hand with the social media burst.

Currently, the very fundamental "building blocks" of a travel depend on contextual information, both in the identifiable case of tourism design needs [8], and the so-called travelling context-awareness [13,14]. Travelers are now offered a bunch of innovative technological applications and services that affect the travel itself with respect to both the physical and the digital dimension [24]. For instance, current (as of late 2017) social networks endorse emerging technologies and applications mixing augmented and physical reality characteristics that provide travelers with essential contextual information. In this

Table 3

Context-aware recommendations.

Work	Task(s)	Method	Pros	Cons	Dataset
[26]	context-aware music recommendation	5 context daily activities	probabilistic model	application/domain specific	24,224 songs (Grooveshark / YouTube)
[3]	context relevance assessment	rating influence by contextual factors	analytical context factors survey	subjective user evaluation	1664 ratings, 30 POIs, 20 users
[11]	context-aware recommendation	examination of individual preferences and interpersonal influence	novel social recommendation model utilizing social contextual factors	–	2 real social network data sets: Renren, Tencent Weibo
[12]	context-aware recommendation	social contextual recommendation	social recommendation model utilizing social contextual factors	similar to [122]	2 real social network data sets: Renren, Tencent Weibo

Table 4

Mobile/Travel context approaches.

Work	Task(s)	Method	Pros	Cons	Dataset
[8]	purpose-destination recommender systems	study on personal characteristics influence on travel information search & decision-making	a tourism-specific theoretical framework	theoretical study with short practical impact	–
[13]	context awareness in tourism	innovative ontological model for context information management	new model presentation, focuses on dynamic context	no evaluation of proposed ontology	–
[14]	context-aware research	rule-based semantic contextual information system for tourism	user evaluation, mathematical notation	controlled laboratory environment user testing	30 participants, lab simulation
[24]	context-based recommendations	smartphone push recommendations study	real-life user evaluation	short timeframe	275 participants
[25]	smartphones impact on travel	adaptive structuration theory	real-life user evaluation	limited dataset (interviews)	24 interviews ("informants")
[1]	mobile battery life prediction	application-centric definition of context	–	–	–
[15]	travel behavior monitor	context definition for mobile tourism environments	robust conceptual framework	–	–
[23]	social media analysis	harvesting geospatial information from social media feeds	exploitation of ambient geographical information	no comparable evaluation of proposed approach	PostgreSQL database

manner, the notion of ubiquitous computing is fully deployed, since current humanistic computing achievements allow for new opportunities in travel planning and increasing social interactions in the process [25], by assisting travelers on a pre-trip, on-site, and post-trip basis.

Under the same mobile/travel context framework fall also research efforts and applied approaches that focus on contextual information, either about the actual hardware device capabilities [1], or the mobility context providing user location-based information. In all cases, though, the concept of context is becoming increasingly important within today's technology-supported travel and tourism environment and this is acknowledged in recent related studies like [15], where the relation between the notion of tourism context and the latest developments in context-aware systems design are depicted. Last, but not least, the geographic footprints of microblogs are investigated in [23] in an effort to address the emergence of such new analysis techniques that take advantage of ambient geographical information to support situational awareness as it relates to human traveling activities. Table 4. summarizes all above observations, respectfully.

5. Survey discussion

In this paper we attempted to follow a twofold approach by summarizing both previous noteworthy research works and the state-of-the-art with respect to the notion of contextual information utilized within humanistic computer applications, systems and methodologies that support gathering, evaluation and dissemination of such information. In order to better understand the contextual aspects that are inherent in modern humanistic computing, we examined herein two major distinct fields of affected computer science fields, namely computational semantics, and the popular social networks and social media sphere. From the herein conducted discussion and findings it is rather obvious that existing approaches to context

information handling differ in the expressive power of the context information models they use, in the support they provide for semantics interpretation, and in their computational performance.

In the particular field of humanistic computing, semantic interpretation of context plays a significant role in the social media era, has drawn a lot of attention recently and forms a broad area for potential research opportunities that we believe will be of great public and market-oriented interest in the near future. Herein we briefly presented and discussed several types of social media related contextual information suitable for utilization, exploitation and usage within social networks, namely social context, the domain of context-aware recommendations, as well as the extremely popular aspect of mobile/travel context. We observed and analyzed why contextual information may be extremely helpful in computational tasks relating to social media analysis, especially with respect to handling typical information search and retrieval problems when adopted in the social media sphere framework. A clear trend and at the same time a great future challenge is to be identified here, leading the research community towards the incorporation of contextual information as a means of information handling optimization within the Internet-based social networks framework.

6. Conclusions and future work

Keeping in mind that in this survey paper we attempted to briefly report an analysis of indicative solutions that span across different research areas and cover quite diverse research directions by showing that most presented scenarios need efficient and effective context data distribution, the overall conclusion drawn may be summarized in the following quotation: when dealing with humanistic computing applications and systems, researchers should in principle initially target more flexible and rather generic approaches and then try to identify additional but inherent sources of meaningful information to boost and enhance their findings in a qualitative manner. Since contextual information is now widely accepted to have many forms and depictions, *the era of extremely focused and domain-specific applications and systems is over*.

By assimilating the herein briefly presented works and by providing a short discussion and interpretation for each identified context group, we believe and hope that the implemented categorization will be used by fellow researchers in the seek of future useful research directions. Our goal was to be able to utilize and exploit our current efforts as a future point of reference for the interested parties. Our future plans include the examination of contextual information in narrower, yet trending, application domains, like specific popular social networks (e.g., Twitter, Instagram, etc.) or even AI-enabled gaming, so as to be able to monitor evolving trends in context utilization and identify potential new emerging context models in the process.

Clearly, it is not possible to tackle all aspects of modern humanistic computing in a single paper nor discuss all contextual manifestations in the process; several open remaining issues are to be identified by the experienced reader. Still, if the final statement of this work would be to select the most significant one, we may identify a rather fruitful unexplored research area, i.e., the one of designing and developing self-adapting contextual mechanisms by dynamically combining contextual information at different processing levels. Of course, the main argument behind the lack of this type of solutions derives from the actual complexity of the problem, but we believe that modern humanistic computing is close enough to achieve such a milestone in contextual research in the near future.

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Phivos Mylonas received his Diploma and Ph.D. in Electrical and Computer Engineering from the National Technical University of Athens and his M.Sc. in Advanced Information Systems from the National & Kapodestrian University of Athens. He is currently a tenured Assistant Professor at the Ionian University. His research interests include context & knowledge representation, knowledge-assisted multimedia analysis, and content-based information retrieval.