A Multilayer Approach for Recommending Contextual Learning Paths

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Abstract

Nowadays, distance learning is achieved through new technological systems, which are able to give several advantages in the training process. Modern e-learning environments exploit technologies capable of designing increasingly specific learning paths. This approach could be interesting in the field of Cultural Heritage. In this scenario, the introduction of a framework able to automatically design tailored learning paths to be used during the visit of archaeological sites could be engaging. The proposed framework aims to exploit contextual graph approaches, such as Ontology and Context Dimension Tree and probabilistic graph approaches such as Bayesian Networks for inferring adapted and contextual learning paths. In particular, it supports learners during their visits in real scenarios as archaeological parks or museums. This engine selects contents and services according to the learner's profile and the context. The main advantage of the proposed system is to design and suggest tailored learning paths to be used on-site in order to improve the training process. Besides, the proposed approach can exploit context modelling and predictive techniques, which can improve the ability to recommend learning paths. A prototype has been developed and tested in real scenarios as the archaeological parks of Paestum, Herculaneum and Pompeii. In particular, several aspects have been tested, such as performance, usability and effectiveness, and more specific tests have been performed measuring the accuracy in learning path recommendations with promising results.

Keywords: Context-Awareness, e-learning, Recommender Systems

1 Introduction

In recent decades, e-learning platforms have been enriched with new tools for improving the training process. A significant contribution to the introduction of new formative and effective approaches in the e-learning field is related to the introduction of the Internet of Things [2]. In this way, new services can support the formative processes. This approach is really useful in the field of Cultural Heritage: learners need real experiences and a tailored approach. So, Context Awareness, Internet of Things and engines for adaptive learning path building can improve the learning process. Such learning paths could also be developed during visits in museums or archaeological sites, which would make it possible to combine two purposes: the promotion of cultural heritage culture and the enhancement of the learning process.

Italy has the most significant number of world cultural heritage sites; some areas are so rich in well-preserved cultural assets that a visit to an archaeological site or a museum is an excellent starting point for developing an educational experience. In southern Italy, the Campania region has always been a fertile area and therefore rich in human settlements. The human presence in Campania has been documented since the Palaeolithic period. The arrival of the Greeks in the 8th century B.C. was decisive for the cultural aspect of the coastal area, as a result of which were born settlements of which we still have well-preserved archaeological sites. Among the most visited are those of Pompeii, Herculaneum and Paestum.

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The archaeological park of Pompeii is the most visited archaeological site. The city was submerged in 79 A.D. by several meters of volcanic material, and today it is entirely preserved. The archaeological park of Herculaneum has archaic origins. Today the urban structure, the thermal complex, a magnificent gymnasium, the distribution of houses, some of which facing the sea, and finally a monumental basilica is still well preserved. Finally, the archaeological park of Paestum, a UNESCO World Heritage Site since 1988, of which Nietzsche wrote: "It is as if a god, here, had built his house with huge blocks of stone". This complex perfectly preserves three temples and various archaeological finds of inestimable value; it represents a time travel to discover the ancient Greeks and Romans.
Like Cicero who loved to walk and memorize his speeches, using the loci technique, modern students could walk in the archaeological finds and take part in learning tours using new technological tools capable of designing tailored educational paths. These innovative tools would exploit modern techniques rooted in the past. The proposed framework aims to suggest at the right time, in the right context, modular learning paths that fit the user. The characteristics of such a formative path would be to exploit modern techniques of Digital Storytelling, augmented reality and gamification. These techniques would adequately support the education path to be performed on archaeological sites, bringing considerable advantage in the training process of users. In contrast to classic e-learning approaches, one of the main advantages of the proposed system is to build and suggest tailor-made learning paths to be used on-site in order to improve the training process. In addition, other advantages of the proposed approach lie in the system's ability to exploit techniques capable of managing context awareness and probabilistic forecasting techniques. The use of these techniques implies a better ability to analyze the real needs of the user and better accuracy in suggesting the right solutions at the right time.

2 Background

There are many techniques today aimed at improving the learning paths. As Cicero used to walk and memorize by associating physical paths to Storytelling, new systems are increasingly aware of the power of Digital Storytelling in e-learning. Digital Storytelling represents a traditional-modern vision of oral Storytelling; combining the ancient tradition of oral Storytelling with today's technological tools. There are many studies in the literature concerning the application of Digital Storytelling techniques in learning paths [30, 32]. In [29], the guidelines for the development of an advanced framework for e-learning using Digital Storytelling techniques are proposed. Another fascinating field where Storytelling is applied is represented by e-tourism and museums to enhance cultural heritage [8, 6, 21].
In some cases, Digital Storytelling approaches are complemented by gamification [15]. In [27], a Content Management System for digital storytelling to support knowledge acquisition and fruition is proposed. This approach has obtained interesting results in young patients with specific health problems able to influence their emotional sphere. Many studies in the literature propose the use of e-learning systems that are able to use gamification approaches [1, 28].
The use of such approaches aims at consolidating the educational path, exploiting the capacity of modern technological systems, which, if well exploited, can adapt to users' needs [22]. According to this, an interesting application is to combine gamification with augmented reality to make the gaming experience more meaningful and immersive [4]. In particular, in [25], augmented reality has found a considerable response in its use in learning paths definition, especially outdoors. Considering that the use of these methodologies is valid in the field of e-learning, another aspect not to be underestimated is the use of such methodologies for the enhancing of cultural heritage. These methodologies are used to process and interpret both personal and contextual information of the user. For this purpose, the context can be used to create applications [14, 26] able to filter the relevant data providing the right information at the right time and continuously updated [23]. In addition to personal interests, modern applications can adapt

contents to the user's profile [16], differentiating for example between a child and an older person, can learn from the previous choices and provide real-time updates according to the context [19, 18].
Therefore, there is a need to create a methodology that combines the effectiveness of new technological devices for the creation of educational paths on-site. The innovation of the proposed approach is to exploit the capabilities of the new devices, the amount of data they produce and the REST services to automatically design context-sensitive learning paths useful to different categories of users. These learning paths, to be held in archaeological sites, address the issue of distance education by collecting many innovative techniques in e-learning such as Digital Storytelling, augmented reality and gamification. Moreover, the proposed system, compared to the systems previously analyzed, besides the advantage of exploiting more methodologies used in e-learning brings advantages in terms of context sensitivity. The proposed approach exploits technologies able to model the context making the system able to recommend training paths not only according to the preferences and needs of the user but also according to the context, this involves not only exploiting the physical position of the user to make the learning path more performing but also being able to adapt it to the needs such as time available, closing hours of museums or archaeological parks, weather conditions, etc. In addition to context awareness, the system, in order to improve the recommendations provided to users, also uses probabilistic techniques able to predict context changes in the future.

3 The Proposed Approach

This work aims to introduce a framework-based learning methodology, which could provide learning paths using a high degree of context-awareness. This approach is able to bring together several methodologies which are at the basis of models working in different fields, such as smart cities [13] and the enhancement of cultural heritage [5]. In particular, in contributing to the objective of recommending the right educational path to users according to the context, reference is made to Ontologies, Context Dimension Tree (CDT) and Bayesian Networks (BN). These methodologies, used in the management of complex scenarios [12, 7], are part of the proposed framework in order to provide users with illustrated and augmented reality stories close to the places visited and according to various factors that can determine the learning path, such as time available, weather conditions and attitudes of the user. As shown in Figure 1, the proposed architecture is composed of three main blocks:

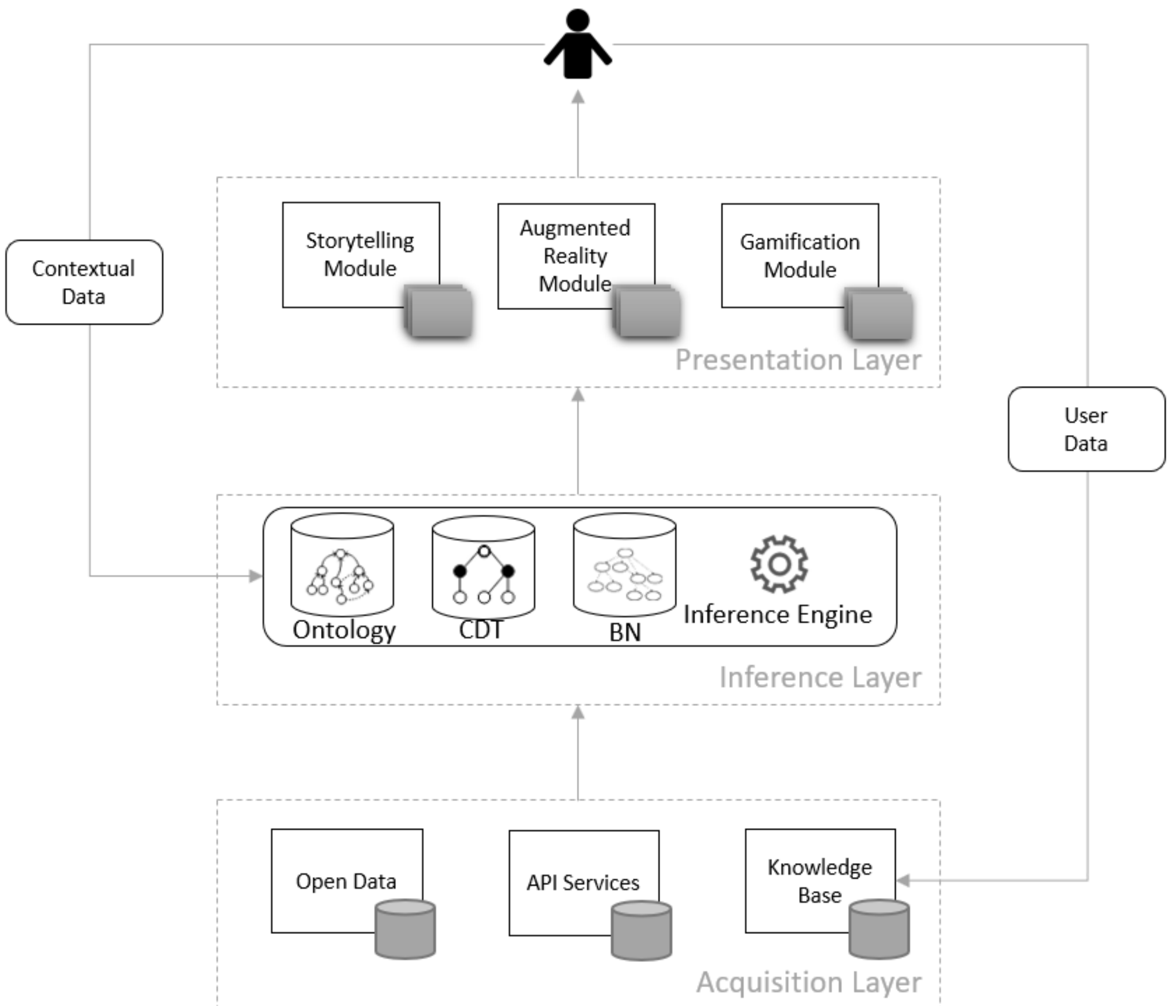
- Acquisition Layer
- Inference Layer
- Information Layer

3.1 Acquisition Layer

The acquisition layer collects methodologies and techniques for the recovery of data from a variety of sources. The purpose of this layer is to collect as much data as possible, homogenizing it and making it accessible; all this data will constitute a valid and useful knowledge base for the inference layer. Subsequently, this data is harmonized, through an orchestration algorithm, and transmitted to the next layer.
The global knowledge base is composed by open data, API services (built ad hoc or already available) and a knowledge base specific to the system, allows the system to provide more relevant answers than other services [20]. Therefore, information related to different support services such as maps, weather conditions, descriptions of artefacts, narrations of places of interest, stories about personal experiences, etc. are combined. Besides, for further education, information about commercial services is integrated

through APIs such as booking and purchase of additional learning materials, tickets for educational shows or admission to museums that would complete the educational experience. All these data are processed and combined with user needs and preferences. This process aims to obtain a complete picture of the points of interest in the area, which will be processed by different tools [31, 24, 9].

Figure 1: System Architecture



3.2 Inference Layer

In order to define suitable learning paths, useful for the different target users, it is necessary to properly manage the data coming from the information layer, according to the contextual data. The central core of this layer is the inferential engine, which is able to use different methodologies. The inferential engine exploits some methodologies, the Ontologies and the CDT, based on context description and awareness and, the Bayesian networks, a methodology with predictive capacity. The purpose of this layer is to provide the user with tailored learning paths at the right place at the right time. For example, if it rains, it provides learning paths with indoor sightseeing, if the user has an event planned it reduces the learning

path to allow the user to leave the place visited in time to be able to enjoy other activities.
One of the main objectives of this phase is to model the context. This is achieved through two graph approaches, the ontology [3] and the Context Dimension Tree (CDT) [10]. Ontologies allow a domain of interest through a formal, shared and explicit representation. More in detail, it is an axiomatic theory of the first order that can be expressed in a descriptive logic. Ontologies, especially in their graph form, can communicate with tools such as CDT and Bayesian networks [17]. The CDT allows managing all possible contexts through a decision tree composed by a triad <r; N; A>where r indicates its root, N is the set of nodes of which it is composed, and A is the set of arcs that join these nodes. In particular, the nodes within CDT are divided into two categories, namely dimensional nodes and conceptual nodes. The dimension nodes describe the possible dimensions of the application domain; the concept nodes collect all the possible values that a dimension can assume. This model is able to interface and query a database efficiently in order to select the right services according to the possible context selected. A further fundamental element, present in the inferential engine, is the predictive capacity. Prediction is performed through the use of Bayesian networks. Bayesian networks are graphical-probabilistic models that represent a set of stochastic variables with their conditional dependencies through the use of a direct acyclic graph (DAG) [11]. Such models exploit the Bayes theorem and can predict the probability of occurrence of a given event. Moreover, due to their structure, Bayesian networks are able to interface adequately with the CDT [7].
The proposed approach can be divided into three main phases. The first phase is the design of the Ontology and the CDT. This phase gives the system context awareness, which is achieved through the description of reality and the identification of all possible contexts of application. The second phase deals with the construction of the Bayesian network, which is built through experts in the field and automatic learning algorithms. This structure allows us to evaluate the probability of occurrence of a given event. The last phase concerns the interaction between the different graph approaches proposed. From these interactions arise the system's responses that respond to the different personalized and contextually valid training paths for users. The proposed architecture is able to create customized training paths able to adapt to the context and update real-time according to the different needs of the user. Moreover, different services are proposed to the user:

- Planning of modular automated modular training courses. Also, it is possible to access a customization section for assisted and simplified design of the training path, allowing the user to choose among alternatives more suitable to the characteristics of his profile.
- Organization of educational tours. The possibility to access services to book museum visits or activities to be carried out according to the time available and avoiding queues.
- Dynamic reprogramming of the training course according to the user's behaviour, context or possible emergencies.
- Adventure paths, through which through the gamification technique training experiences are proposed for the enhancement of cultural insights by visiting unusual places, promoting the local heritage.

3.3 Information Layer

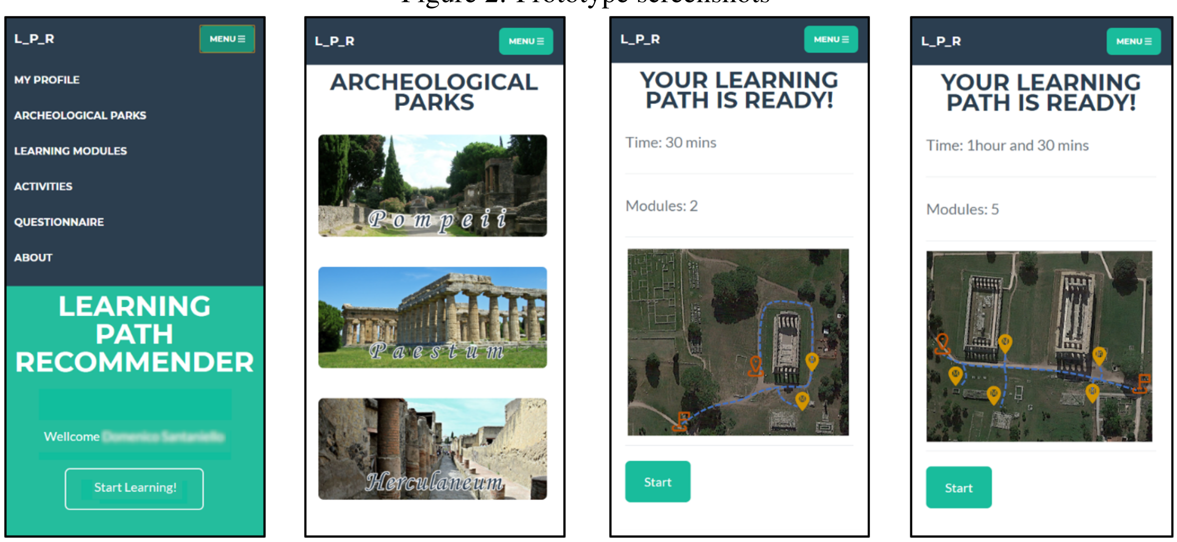
This layer is designed to present the recommendations of the inferential engine to the user. This information is presented to the user through a simple and intuitive interface with detailed information about the learning paths and the choices made. The aim is to present personalized results with storytelling techniques that combine images, game narratives and interactions using augmented reality techniques that make it easy and intuitive to memorize the critical phases of the learning path. The result of this process is a multimedia educational content that includes:

- Information on the forms to be completed;
- Relationship between learning paths and itineraries;
- Quizzes and games aimed at evaluating the learning or deepening the learning paths.

4 Experimental Results

The evaluation process of the proposed methodology was performed through the development of a prototype based on the proposed architecture. The technologies used are the Ibernate framework, based on Java, to build the Rest API server-side service; the Apache Cordoba Framework for mobile application development. The experimental phase was developed in three archaeological parks in southern Italy, the Archaeological Park of Paestum, the Archaeological Park of Herculaneum and the Archaeological Park of Pompeii. Although the proposed architecture allows the system to access several open data on the web, in this first experimental phase, the prototype was modelled with particular attention to the three archaeological sites. Several learning modules linked to the archaeological parks considered have been included, which allow the system to build the respective educational paths. The different training modules have been inserted in order to collect the needs of different users (children, adults and experts) during the training path. The prototype developed, of which some screenshots are shown in Figure 2, has been distributed and tested by several users. Although in a preliminary form, as shown in Figure 2a,

Figure 2: Prototype screenshots



(a) (b) (c) (d)

in the main menu, each user is able to manage profile by setting personal information and preferences. Moreover, it is also possible to navigate through the app by exploring the various activities, performing the questionnaires and discovering the several learning paths related to the different archaeological parks (Figure 2b). In Figure 2c, it is possible to see how the system can recommend a quick learning path, based on the context (closing time of the archaeological park, characteristics and preferences of the user). Furthermore, Figure 2d shows a full learning path of longer duration with five learning modules.

This path is the result of an expert user recommendation, inside the archaeological park of Paestum, on a sunny day. The user was interested in deepening various aspects related to the influence of Greek culture in the south of Italy. The experimental phase involved a total of 230 users, in order to divide them homogeneously for different age groups and characteristics which were unknown to the purpose of the research. Each participant was provided with a mobile device, equipped with the prototype of the application, and attended different learning modules within the specific archaeological parks. Users were divided into three different groups, as follows:

1. Pompeii Archaeological Park (95 users)
2. Paestum Archaeological Park (65 users)
3. Archaeological Park of Herculaneum (70 users)

Following the experience of using the content, all users were offered a questionnaire divided into the following sections:

A Presentation

B Reliability

C Recommendation

D Performance

E Usability

Each section of the questionnaire, based on the Likert scale, presented two statements to which five possible answers were associated: I totally disagree - TD, I disagree - D, undecided - U, I agree - A, I totally agree - TA. The answers have been summarised in Table 1. In addition, a further and smaller number of participants were asked to participate in the experimental phase in order to assess the effectiveness of the system in proposing the services. For this purpose, five training modules were selected, for each archaeological park, and users were allowed to indicate whether this proposed module was relevant according to their needs and context. The participants who participated for the second time in the experimental phase are divided in groups as follows:

I Pompeii Archaeological Park (43 users)

II Paestum Archaeological Park (32 users)

III Archaeological Park of Herculaneum (34 users)

In this experimental phase, the knowledge base of the system was increased from data coming from previous users' experience. The results, which show the adequacy of the proposed educational modules according to the context and needs, have been collected in a confusion matrix (Figure 3, Figure 4 and Figure 5). Table 1 shows the degree of satisfaction of the 230 participants. Users agree that the system is able to provide tailor-made learning modules in line with the context. In Figure 6, the results obtained are shown graphically. The users are mainly satisfied with the ability to recommend the right training path concerning the context. The confusion matrices in Figure 3, Figure 4 and Figure 5 show that the system was able to recommend the right learning modules to users according to the users' profile and time needs. All confusion matrices show an overall accuracy of more than 70 %, which is very encouraging. Figure 3 shows an overall accuracy above 85 %; this remarkable result may be due to two factors. One factor could be the choice of training modules which are particularly suitable for the selected location.

The second factor could be related to the size of the Paestum Archaeological Park, which differs from other sites, due to its medium-large size and the position of the archaeological finds lends itself better to itinerant training courses and the use of augmented reality. However, all the results obtained are very encouraging and could improve over time according to users' experiences.

Table 1: Questionnaire answers

Section	Answer				
	TD	D	U	A	TA
A	18	21	89	187	145
B	20	27	55	230	128
C	18	3	26	239	174
D	11	65	82	203	99
E	37	28	46	205	144

Figure 3: Confusion Matrix I

Prediction \ Reference	M1	M2	M3	M4	M5
M1	75	5	4	0	2
M2	3	73	5	4	1
M3	1	7	69	6	3
M4	3	0	4	72	7
M5	0	2	5	2	77

Overall Accuracy : 85,12%

Figure 4: Confusion Matrix II

Prediction \ Reference	M1	M2	M3	M4	M5
M1	48	6	2	5	1
M2	7	37	9	4	5
M3	1	5	44	4	8
M4	2	6	5	47	2
M5	1	6	4	3	48

Overall Accuracy : 72,26%

5 Conclusion

This paper introduces a novel methodology for building adapted and contextual learning paths within archaeological parks. The main result of the proposed methodology lies in the use of graph-based tools such as Ontologies and Context Dimension Tree, able to provide a high degree of context-awareness. The proposed architecture could be applied in different contexts and mobile applications. The experimental results are promising and encouraging, showing that the system is able to effective design training paths and that the prototype developed is efficient from different points of view. The degree of reliability, the usability of the prototype was evaluated very positively by the users involved in the experimental

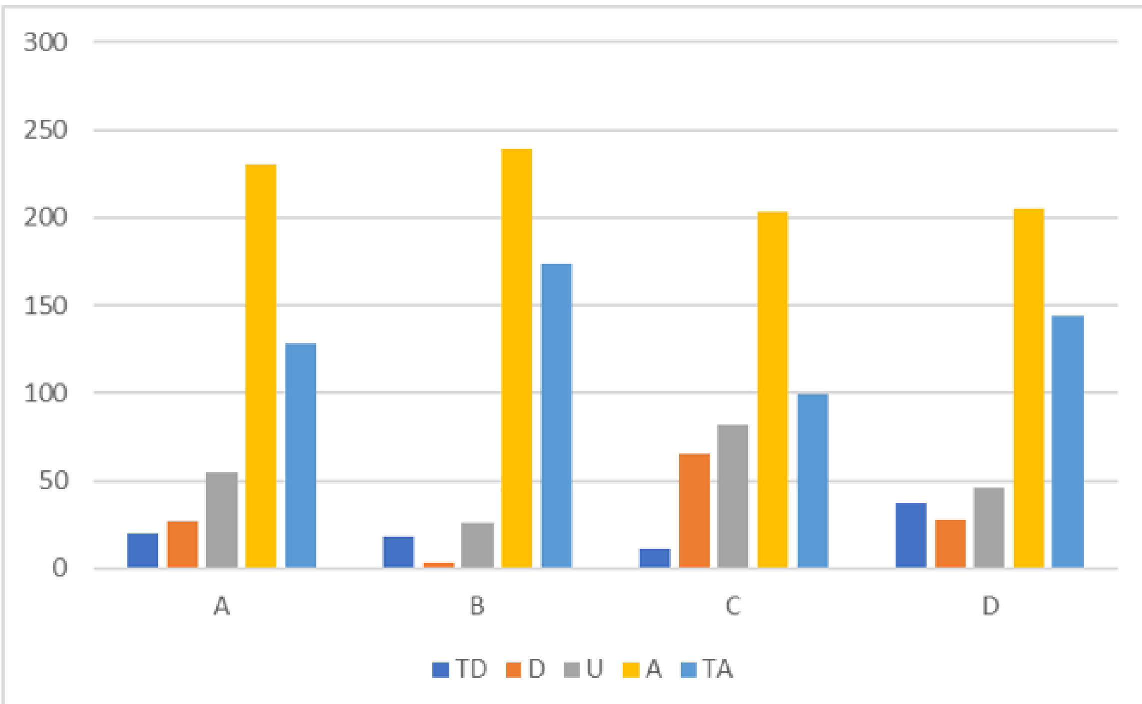
Figure 5: Confusion Matrix III

Reference

Prediction	M1	M2	M3	M4	M5
M1	48	6	2	5	1
M2	7	37	9	4	5
M3	1	5	44	4	8
M4	2	6	5	47	2
M5	1	6	4	3	48

Overall Accuracy : 72,26%

Figure 6: Questionnaire answers trend



campaigns. In addition, the system's recommendation capability has reached a high level of accuracy. Future developments include improvements to the developed prototype, the expansion of the database, the addition of more training modules to expand the learning paths, and services to deepen the topics covered in the learning.

References

[1] A. Amriani, A. F. Aji, A. Y. Utomo, and K. M. Junus. An empirical study of gamification impact on e-learning environment. In *Proc. of the 3rd International Conference on Computer Science and Network Technology (ICCSNT'13), Dalian, China*, pages 265–269. IEEE, October 2013.

[2] K. Ashton. That 'internet of things' thing. *RFID journal*, 22(7):97–114, June 2009.

[3] C. Bolchini, C. A. Curino, E. Quintarelli, F. A. Schreiber, and L. Tanca. Context information for knowledge reshaping. *International Journal of Web Engineering and Technology*, 5(1):88–103, May 2009.

[4] E. M. Bonsignore, D. L. Hansen, Z. O. Toups, L. E. Nacke, A. Salter, and W. Lutters. Mixed reality games. In *Proc. of the 13th ACM conference on computer supported cooperative work companion (CSCW'12), Seattle, Washington, USA*, pages 7–8. ACM, February 2012.

[5] M. Casillo, F. Clarizia, F. Colace, M. Lombardi, F. Pascale, and D. Santaniello. An approach for recommending contextualized services in e-tourism. *Information*, 10(5):180–196, May 2019.

[6] M. Casillo, F. Clarizia, G. D'Aniello, M. De Santo, M. Lombardi, and D. Santaniello. Chat-bot: a cultural heritage aware teller-bot for supporting touristic experiences. *Pattern Recognition Letters*, 131:234–243, March 2020.

[7] V. Cassani, S. Gianelli, M. Matera, R. Medana, E. Quintarelli, L. Tanca, and V. Zaccaria. On the role of context in the design of mobile mashups. In *Proc. of the 2nd International Rapid Mashup Challenge (RMC'16), Lugano, Switzerland*, pages 108–128. Springer, Cham, June 2016.

[8] H. C. Chen, Y. F. Kao, and C. L. Kuo. A multimedia storytelling in a rural village: The show taiwan e-tourism service using tablet technologies. In *Proc. of the 3rd IIAI International Conference on Advanced Applied Informatics (IIAI-AAI'14), Kitakyushu, Japan*, pages 525–526. IEEE, August-September 2014.

[9] N. Choi, I.-Y. Song, and H. Han. A survey on ontology mapping. *ACM SIGMOD Record*, 35(3):34–41, September 2006.

[10] F. Clarizia, F. Colace, M. De Santo, M. Lombardi, F. Pascale, D. Santaniello, and A. Tuker. A multilevel graph approach for rainfall forecasting: A preliminary study case on london area. *Concurrency and Computation: Practice and Experience*, 32(8):1–12, May 2019.

[11] F. Clarizia, F. Colace, M. Lombardi, F. Pascale, and D. Santaniello. A multilevel graph approach for road accidents data interpretation. In *Proc. of the 10th International Symposium on Cyberspace Safety and Security (CSS'18), Amalfi, Italy*, volume 11161 of *Lecture Notes in Computer Science*, pages 303–316. Springer, Cham, October 2018.

[12] F. Colace, M. De Santo, M. Lombardi, F. Pascale, D. Santaniello, and A. Tucker. A multilevel graph approach for predicting bicycle usage in london area. In *Proc. of the 4th International Congress on Information and Communication Technology (ICICT'19), London, UK*, pages 353–362. Springer, Singapore, January 2020.

[13] F. Colace, M. Lombardi, F. Pascale, D. Santaniello, A. Tucker, and P. Villani. Mug : A multilevel graph representation for big data interpretation. In *Proc. of the 20th IEEE International Conference on High Performance Computing and Communications, 16th IEEE International Conerence on Smart City and 4th IEEE International Conference on Data Science and Systems (HPCC/SmartCity/DSS'18), Exeter, UK*, pages 1410–1415. IEEE, June 2018.

[14] A. K. Dey. Understanding and using context. *Personal and Ubiquitous Computing*, 5:4–7, January 2001.

[15] A. DomíNguez, J. Saenz-De-Navarrete, L. De-Marcos, L. FernáNdez-Sanz, C. PagéS, and J.-J. MartíNez-HerráIz. Gamifying learning experiences: Practical implications and outcomes. *Computers & education*, 63:380–392, April 2013.

[16] J. Fink and A. Kobsa. User modeling for personalized city tours. *Artificial Intelligence Review*, 18:33–74, September 2002.

[17] N. Friedman, D. Geiger, and M. Goldszmidt. Bayesian network classifiers. *Machine Learning*, 29:131–163, November 1997.

[18] D. Gavalas and M. Kenteris. A web-based pervasive recommendation system for mobile tourist guides. *Personal and Ubiquitous Computing*, 15(7):759–770, October 2011.

[19] G. Ghiani, F. Paternò, C. Santoro, and L. D. Spano. Ubicicero: A location-aware, multi-device museum guide. *Interacting with Computers*, 21(4):288–303, August 2009.

[20] S. Heo, S. Woo, J. Im, and D. Kim. Iot-map: Iot mashup application platform for the flexible iot ecosystem. In *Proc. of the 5th International Conference on the Internet of Things (IOT'15), Seoul, South Korea*, pages 163–170. IEEE, October 2015.

[21] Y. Ioannidis, K. E. Raheb, E. Toli, A. Katifori, M. Boile, and M. Mazura. One object many stories: Introducing ict in museums and collections through digital storytelling. In *Proc. the 1st Digital Heritage International Congress (DigitalHeritage'13), Marseille, France*, pages 421–424. IEEE, November 2013.

[22] E. M. Jianu and A. Vasilateanu. Designing of an e-learning system using adaptivity and gamification. In *Proc. of the 3rd IEEE International Symposium on Systems Engineering (ISSE'17), Vienna, Austria*, pages

1–4. IEEE, October 2017.

[23] J. Jin, J. Gubbi, S. Marusic, and M. Palaniswami. An information framework for creating a smart city through internet of things. *IEEE Internet of Things Journal*, 1(2):112–121, April 2014.

[24] M. Lombardi, F. Pascale, and D. Santaniello. An application for cultural heritage using a chatbot. In *Proc. of the 2nd International Conference on Computer Applications & Information Security (ICCAIS'19), Riyadh, Saudi Arabia*, pages 1–5. IEEE, May 2019.

[25] L. Pombo, M. M. Marques, L. Afonso, P. Dias, and J. Madeira. Evaluation of a mobile augmented reality game application as an outdoor learning tool. *International Journal of Mobile and Blended Learning*, 11(4):59–79, September 2019.

[26] M. Raento, A. Oulasvirta, R. Petit, and H. Toivonen. Contextphone: A prototyping platform for context-aware mobile applications. *IEEE Pervasive Computing*, 4(2):51–59, May 2005.

[27] V. Rossano and T. Roselli. Game-based learning as effective learning method: An application of digital storytelling. In *Proc of the 22nd International Conference Information Visualisation (IV'18), Fisciano, Italy*, pages 542–546. IEEE, July 2018.

[28] A. Sanina, E. Kutergina, and A. Balashov. The co-creative approach to digital simulation games in social science education. *Computers and Education*, 149:103813, May 2020.

[29] N. Smeda, E. Dakich, and N. Sharda. Developing a framework for advancing e-learning through digital storytelling. In *Proc. of the 4th IADIS International Conference e-Learning (EL'10), Freiburg, Germany*, pages 169–176. IADIS, July 2010.

[30] N. Smeda, E. Dakich, and N. Sharda. The effectiveness of digital storytelling in the classrooms: A case study. In *Proc. of the 13th IEEE International Conference on Advanced Learning Technologies (ICALT'13), Beijing, China*, pages 491–492. IEEE, July 2013.

[31] S. Tomasiello, M. Gaeta, and V. Loia. Quasi–consensus in second–order multi–agent systems with sampled data through fuzzy transform. *Journal of Uncertain Systems*, 10(4):243–250, November 2016.

[32] J. F. Weng, H. L. Kuo, and S. S. Tseng. Interactive storytelling for elementary school nature science education. In *Proc. of the 11th IEEE International Conference on Advanced Learning Technologies (ICALT'11), Athens, Georgia, USA*, pages 336–338. IEEE, July 2011.

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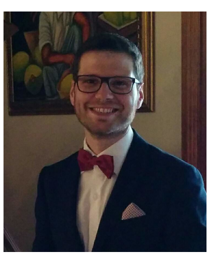
She is a member of the research group Knowman (http://www.knowman.unisa.it/). She participates in several projects funded by the Italian Ministry of University and by the European Community.



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