International Journal of Research in E-learning
Vol. 6 (1), 2020, pp. 1–13

https://doi.org/10.31261/IJREL.2020.6.1.09

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Hybrid Reality in the Internet of Things as an Environment for Transferring Knowledge

Abstract

The paper presents features and applications of hybrid reality technology and the Internet of Things. The analysed thesis states that such a solution is a favourable environment for the dissemination of knowledge through the concept of interaction of objects of postulated environment with the theoretical model of knowledge objects. The article discusses an initial version of the potential information system method. The method, in the form of a mathematical formula, makes it possible to evaluate objects in the postulated space. The article presents the case study implementing a similar environment in the service of advanced industrial equipment. The results of the analysis indicate a high potential of the postulated solution, which requires further refinement and research. At the same time, the practice of the implementation case points to technological and organisational threats which should be neutralised to ensure a high probability of the project's success.

K e y w o r d s: virtual reality, augmented reality, knowledge management, accumulation of knowledge

Due to the development of new interaction methods with devices, it seems important to ask questions about the possibilities of using technology in broadly understood education. The aim of this article is to present a new measure of the objects ability to accumulate knowledge in the light of the conditions that new technologies (hybrid reality and Internet of Things) bring, and also to present a case study based on the technologies mentioned in the article. The article discusses the features of augmented reality, presenting the application of an additional visual layer to the observed reality together with the concept of the Internet of Things as a network of people, processes, data, and objects. The concept of using artificial intelligence supporting the transfer of knowledge as well as the classification and valuation of objects in such an environment that combines the above-mentioned technologies will also be presented.

Classification of Artificial Reality

When we analyse the history of the development of user interfaces for information systems, we notice a constant trend to approach the methods of communication and interaction between man and machine, reflecting the natural capabilities of the human senses and the way in which the human functions in the real world. The objects in the paper are understood as physical objects (devices, people, creatures, places, symbols) and digital objects (entities, properties, activities and processes).

Augmented Reality

Augmented Reality (AR) is based on the integration of digital information into the user's real-time environment. Augmented Reality does not create a new, full, virtual 3D world (for it deals with virtual reality), but it extends and complements the one we know. In other words, it converges and connects digital and physical worlds into a uniform visual impression (Żur, 2013). It is important to preserve the physics of objects and proper orientation in relation to the reference system as well as other spatial relations. AR applications are written in 3D programs that allow programmers to associate animation or contextual digital information in a computer program with an AR tag in the real world. When an application or browser plug-in of a computing device receives digital information from a known tag, it begins to execute the tag code and places the correct image or images.

Virtual Reality

Virtual Reality (VR) is a fully computer-generated simulation of a 3D image or environment with which it is possible to interact in a seemingly real or physical way. It is also the use of information technology to create the effect of an interactive three-dimensional world in which each object has the sense (property) of being present in this space (Bryson, 1999). The user is equipped with special electronic equipment, such as a helmet with a built-in screen or/and gloves with sensors. It is a completely artificially created space. The interaction of the observer and objects that most often reflect the physics of such interactions in the real space are important. Direct references to real space usually do not occur at all.

Mixed Reality

The hybrid reality (Mixed Reality) is a combination of the real world and the virtual one, in order to create a new environment where physical and digital objects can interact. It, in fact, a combination of augmented and virtual reality (de Souza e Silva & Sutko, 2009). Objects superimposed on a real image may have more opportunities to enter into a variety of relationships with each other and with an observer. In a perfect world, devices used to apply artificial reality to a perceived image should be transparent. The Google Glass market experiment was the first step towards the dissemination of this mode of operation. On the glasses, there was a picture that provided contextual information needed by the user. There was no current specific spatial relations and extensive interactions in this solution, but the platform constituting the foundations of such a solution in the future was commercialised and made available to a wide range of users. The product has not gained much consumer recognition (Reynolds, 2015). Its implementation for technical reasons differed somewhat from the assumption of transparency. Glasses definitely differed from other frames. In addition, they caused asymmetries in the face image, which in the medical sciences is often described as a symptom of dysmorphia indicating various diseases. In social communication, the image of the face and the ability to read information from it is extremely important. Devices that allow the use of AR should not build a barrier in this regard.

Assuming that the physical layer should be transparent, an interesting solution seems to be the concept of contact lenses with a built-in liquid crystal display. In daylight, the backlight of such a matrix could be passive. It is a device that uses a small amount of energy so it could be powered through a communication channel, for example, RFID 5.8 GHz. It would not only provide data exchange, but also provide electricity by induction (Adhikari, 2016). As for the interaction of the observer with the objects superimposed in space, the sensor could be supplemented by sensors glued to nail plates. Such a solution would ensure precise interpretation of various gestures. The operating procedure in hybrid reality mode is as follows:

1. Identification of the object through a marker.
2. The graphic representation in the added reality layer is displayed by means of appropriate devices imposing an artificial image on the real one.
3. The object maintains the appropriate spatial relations.
4. The object presents various possibilities of interaction as part of the internet formula of the universe.
5. The object exhibits spatial relations with the observer through various sensors that map the observer's movements.

Internet of Things and Connection with Artificial Reality

The Internet of Things is comprised of three kinds of connections: machine-machine, human-machine and human-human. For the Internet of Things to become a reality, it is necessary to develop and implement technologies that, on the one hand, will allow unconnected elements of the physical world to be connected together, and on the other, they will enable the use of a huge amount of data generated by them. Nowadays, the most common method of connecting physical objects with internet is QR Code (Koreňová & Hvorecký, 2018). Meanwhile, it is estimated today that 12.5 billion devices are connected to the Internet, which is only 1 percent of objects that could potentially be plugged into the network. It is estimated that in 2020, between 25 and 50 billion devices will be connected to the network (Jaślan, 2015). The integration of data, processes, people and devices (Figure 1) along with artificial intelligence opens up many new opportunities in the area of acquiring knowledge and using it (Ravi & Shalinie, 2020). Processes that combine existing data with objects and individuals ultimately form the so-called intelligent spaces (Brachman, 2017), collections of beings of various types, which interacting with each other generate information and knowledge resources.

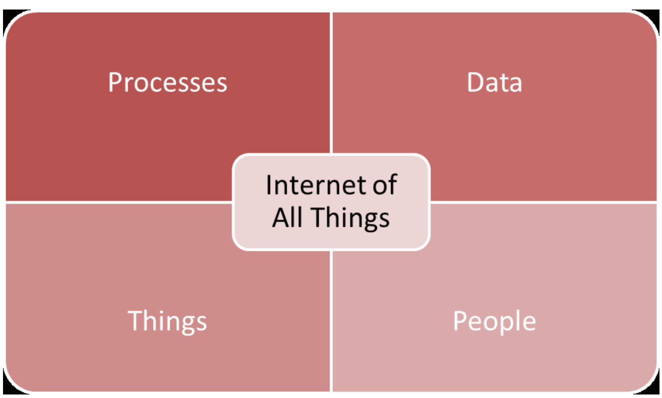

Figure 1. The Internet of Things

Source: the authors' own study based on Cisco materials.

The subject of this study is to present the possibilities of combining hybrid reality and the Internet of Everything in the context of knowledge management. Merill, Li and Jones identify four types of knowledge objects: entities, properties, activities and processes: "Beings are represented by physical objects such as devices, people, creatures, places, symbols, etc. Properties mean measurable and irrational attributes of beings" (Merill, Li, & Jones, 1991). Activities are actions that the learner can undertake towards beings. Processes, on the other hand, correspond to events that change the values and properties of beings and are triggered by activities or other processes.

The above classification is very similar to the list of components of the Internet of Things. It seems natural, therefore, to extrapolate this classification in terms of technology in which knowledge facilities can be given new properties. To automate the process of acquiring knowledge in objects, one can refer to the notion of inheritance known from computer science. The classes of objects are indispensable for this. A given physical object, for example, a refrigerator, would belong to the classes of knowledge: refrigeration, mechatronics, etc., then sub-classes: refrigerators, a specific line of refrigerators and a specific type and specimen. After identifying such an object in a hybrid reality by the use of the Internet of Things, that is, through the process of combining data and objects, the knowledge would be inherited from the classes to which it belongs. A physical object that does not have to be a device at all (see, for example, the field of wheat and the definition of being within the framework of knowledge objects in the further part of this article) may not have the ability to accumulate knowledge or even record data in itself. In order for the inheritance and "learning" of the object to take place, it is necessary to have a virtual representation of the object on the Internet of Things in the form of a specific avatar or simulator.

In the proposed concept, explained above, it seems necessary to introduce an application layer in which an avatar of an individual object is created ad hoc and based on inheritance from its classes and then through interactions with other objects, such as technical documentation, instructions or courses. If we allow the possibility of incorporating advanced artificial intelligence into this layer, the appropriate connections could form spontaneously. It is necessary in this case to have a fairly complete semantic network, which identifies through metadata within the ontology: first, belonging to classes, second, making the contents of the knowledge object or its avatars readable for devices, which allows verification of the usefulness of establishing interactions.

The authors of this study suggest the introduction of a new value: the measure of the accumulation of object knowledge. The indicator (measure) is most often understood as a number expressing the level of a given phenomenon. The most important feature of the indicator is the comparability of its value, allowing to determine the position of a given object compared to other objects (Rogala & Rycharski, 2006). In this case, it will be the term *saturation* of an object with knowledge in the context of others as a function of interaction with other objects and inheritance in the classroom. It is, therefore, a function of several features, also called diagnostic variables. There is a multiplicity of attributes so we can define the meter as synthetic or aggregate. The characteristics that influence the index can be included in the set of stimulants, that is, variables whose higher value indicates a higher level of the phenomenon (object) and thus works in a way that stimulates development (Kompa, 2009).

The measure of the accumulation of knowledge by the object is postulated to refer to the number of interactions with other objects, their quality and weight, plus the value of the measure of accumulation of knowledge resulting from inheritance in classes.

$$A_m = \sum_{i=1}^{n} q_i a_i + D A_m = \sum_{i=1}^{n} q_i a_i + D$$

The A_m measure is the value corresponding to the accumulation of knowledge of the object *m*.

q_i – quality of i-th interaction expressed in time, assessed on a scale or based on the analysis of measurable results,

a_i – a measure of the accumulation of knowledge of the i-th object with which the interaction took place,

D – measure of the accumulation of knowledge resulting from inheritance in classes.

The measure of the accumulation of object's knowledge is nothing but a measurable property of being (compare with the classification of knowledge objects), and interaction is an activity leading to the process of transforming the properties of an object (being). It seems possible to develop a comprehensive standard, method and system using these technologies, which would become common on a similar scale as Google search, but limited to the aspect of acquiring and accumulating the knowledge of all entities. The possibility of registering this type of transformations and building the weight of objects in the context of their importance as objects of knowledge would give rise to new possibilities. A network that fosters the development of knowledge can arise spontaneously. In the context of the presented method, it is postulated to consider two levels of interaction, the first one – associated with the area of skills, and the second one – with broadly understood knowledge:

The first level:

– objects are presented in relation to the context of their use;
– the object itself offers information and knowledge about itself in accordance with the context;
– the object provides knowledge and information in the area of skills depending on the role of the being with which it interacts, for example, the fridge helps the user or the serviceman.

The second level:

– the object itself presents the areas of knowledge related to it based on the analysis of previously registered user's relations with other objects, their regularity of duration and detail.
– in this way, the object can indicate areas of knowledge necessary to achieve a full understanding of both the object itself and the accompanying phenomena, for example, by offering courses, postgraduate studies or majors (this type of link would be possible within the inheritance of knowledge areas in classes).

It is important to emphasise that each time it is not a physical object that leads a "conversation," only the previously mentioned object avatar in the application layer of the postulated knowledge transfer environment, containing artificial intelligence that associates behavioural patterns and context and initiates interaction based on the evaluation of existing relationships. Figure 2 illustrates an example of human interaction with an object that is part of nature, namely, of a wheat field:

Figure 2. Interaction of a natural object with a human being

Source: the authors' own study (translation: "I have noticed that you have been searching recently for the difference between wheat and rye. I am wheat. It is nice to meet you. We are almost like sisters with rye. But not twins. If you wanted to see rye, it is not far from here… Would you like me to give you directions?")

In the above example the user has a specific dialogue with an object that is identified in a hybrid reality through the techniques of the Internet of Things, connected with the avatar of its type of existence, and having a certain classification and inheriting knowledge interacting with other beings (rye) that match the profile of previous interactions human. The activity initiated and "proposed" by the object is aimed at starting a process that will lead to a change in the properties of being (human), that is, the state of knowledge in the area.

Case Study

Figure 3 presents an analysis of the case of the implementation of the system combining the Internet of Universes with Hybrid Reality, made by the Polish company PSC Transition Technologies for Fiat Chrysler Automotive. The aim of the project was to use the hybrid reality and the Internet of Things to support knowledge of the robotic production lines. The implementation was started with support for maintenance and maintenance through the IoT solution combined with the use of Mixed Reality for employees of this department. The project was implemented with the use of a tablet and glasses for Augmented Reality as a user interface, which significantly improves the performance of daily tasks by employees. In everyday operations, the objects that are avatars of the essential components of machines used for car production are identified before employees' eyes. Facilities have multiple connections with sources of knowledge. Glasses can display the process of device replacement taking place in three dimensions, preserving spatial relations with reality. It is a simulation of three-dimensional objects in motion. The process is initiated by the action of interacting the serviced device with other related knowledge objects, such as instructions or technical specifications, presented contextually.

The project, after extending it to all elements of robotics on new lines, reduces the operational costs of the service by automating and unifying service tasks and optimising the structure of the internal maintenance service as well as internal communication. As a consequence, it shortens the duration of service procedures by increasing their effectiveness. The completely unexpected but desired result of the project was the development of new purchasing procedures, so that the necessary elements needed to attach new machines and robots to the system were available along with the installation of production machines on the hall (e.g., relevant 3D CAD drawings of machines). On the basis of reports and post-implementation data, made available by PSC Transition Technologies and the interview with implementation participants, the authors of the study carried out a SWOT analysis of the applied solution.

Table 1
SWOT analysis of the implementation case in FCA

Strenghts	Weaknesses
S1 – employees receive one environment to obtain the necessary information and knowledge.	W1 – knowledge base available within one environment.
S2 – the environment is very ergonomic and intuitive because access is carried out through activities simulating reality.	W2 – lack of reference to employees' habits regarding traditional sources of information and knowledge acquisition, including informal ones.
S3 – all information and knowledge are given in context, which eliminates time-consuming searches.	W3 – dependence on technologies and specific devices that require expensive service and maintenance.
Opportunities	Threats
O1 – opportunity to better profit by reduction of service operational costs through automation and unification of service tasks.	T1 – a threat to production continuity in the event of technical failures.
O2 – opportunity for be flexible in labour market by shortening the time of adapting new employees to applicable procedures.	T2 – over-routine procedures that do not take informal knowledge, which is not collected in any way.
O3 – opportunity for better cooperation with machinery producers by development of new purchase procedures, so that the necessary elements needed to connect new machines and robots to the system were available together with the installation of the machine on the hall (e.g., appropriate drawings of 3D CAD machines).	T3 – non-adjustment of accessory manufacturers due to the lack of knowledge objects associated with the product, which increases the cost of adjustment.

S o u r c e: the authors' own study

The components from the SWOT table were subjected by the authors to the analysis of their own impact using a three-point scale from 0 to 2 (no impact, weak, strong). Conclusions regarding the impact force were taken during the discussion with the authors of the post-implementation reports and on the basis of the analysis of their conclusions and the data cited.

Table 2

Point analysis of the SWOT ties strength

	O1	O2	O3		T1	T2	T3
S1	2	2	0		1	2	0
S2	1	2	0		0	1	0
S3	2	2	0		0	1	1
W1	0	0	0		0	1	1
W2	1	1	0		0	2	1
W3	0	0	1		2	0	1

S o u r c e: the authors' own study

Point analysis of relationships from individual quarters of the Table 2:
S/O = 11, S/T = 6, W/O = 3, W/T = 8

The highest score of the first quadrant suggests that thanks to the new technology used, the company is dominated by strengths, and in its environment strongly associated with them – it is a strategy of strong expansion and development using both factors. At the same time, the high point score of the fourth quarter shows a certain paradox and commands exceptional attention while minimising the strength of links between weaknesses and external threats.

Summary

The publication presents a combination of hybrid reality technologies and the Internet of Things. The thesis attempts to establish that such a combination is a favourable environment for spreading knowledge. In the course of the study, it was possible to combine the concepts of the interaction of objects of the postulated knowledge transfer environment with the measure of the accumulation of knowledge objects. The initial version of the method is presented in the form of a mathematical formula that allows valuing objects in such space. The case of implementation of a similar environment in the service of advanced industrial equipment has been presented and analysed. In conclusion, one should note the high potential of the postulated solution, which requires further refinement and research. At the same time, the practice of the implementation case points to technological and organisational threats which should be neutralised to ensure a high probability of the project's success.

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Rzeczywistość hybrydowa w Internecie Wszechrzeczy jako środowisko do transferu wiedzy

S t r e s z c z e n i e

W publikacji przedstawiono cechy i zastosowania technologii rzeczywistości hybrydowej oraz Internetu Wszechrzeczy. Przeanalizowano tezę, że takie zestawienie stanowi korzystne środowisko do rozprzestrzeniania wiedzy poprzez koncepcję interakcji obiektów postulowanego środowiska z teoretycznym modelem obiektów wiedzy. Przedstawiono wstępną wersję metody potencjalnego systemu informatycznego. Metoda ta, w postaci formuły matematycznej umożliwia wartościowanie obiektów w postulowanej przestrzeni. Przedstawiono przypadek wdrożenia zbliżonego środowiska w praktyce serwisowej zaawansowanych urządzeń przemysłowych. Wyniki analiz wskazują na wysoki potencjał postulowanego rozwiązania, które wymaga dalszego uściślania i badań. Jednocześnie praktyka przypadku wdrożenia wskazuje na zagrożenia technologiczne i organizacyjne, które należy neutralizować, aby zapewnić wysokie prawdopodobieństwo sukcesu przedsięwzięcia.

S ł o w a   k l u c z o w e: Rzeczywistość wirtualna, rzeczywistość rozszerzona, zarządzanie wiedzą, akumulacja wiedzy

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Гибридная реальность в интернете вещей как среда для передачи знаний

А н н о т а ц и я

В статье представлены особенности и применения технологий гибридной реальности и Интернета вещей. В анализируемом тезисе утверждается, что такое решение является благоприятной средой для распространения знаний через концепцию взаимодействия объектов постулируемой среды с теоретической моделью объектов знаний. Представлена первоначальная версия метода потенциальной информационной системы. Этот метод в форме математической формулы позволяет оценивать объекты в постулируемом пространстве. Представлено тематическое исследование внедрения аналогичной среды в обслуживании современного промышленного оборудования. Результаты анализа указывают на высокий потенциал постулируемого решения, что требует дальнейшей доработки и исследования. В то же время, практика реализации проекта указывает на технологические и организационные угрозы, которые следует нейтрализовать, чтобы обеспечить высокую вероятность успеха проекта.

К л ю ч е в ы е   с л о в а: Виртуальная реальность, дополненная реальность, управление знаниями, накопление знаний

Hybrid Reality in the Internet of Things as an Environment for Transferring Knowledge

Tomasz Woźniakowski, Arkadiusz Orłowski

**Realidad híbrida en Internet de todas las cosas
Como un ambiente para transferir conocimiento**

Resumen

El documento presenta características y aplicaciones de la tecnología de realidad híbrida e Internet de todas las cosas. La tesis analizada establece que dicha solución es un entorno favorable para la difusión del conocimiento a través del concepto de interacción de los objetos del entorno postulado con el modelo teórico de los objetos de conocimiento. Se presenta una versión inicial del método potencial del sistema de información. Este método, en forma de fórmula matemática, permite evaluar objetos en el espacio postulado. Se presenta el estudio de caso que implementa un entorno similar al servicio de equipos industriales avanzados. Los resultados del análisis indican un alto potencial de la solución postulada, que requiere un mayor refinamiento e investigación. Al mismo tiempo, la práctica del caso de implementación apunta a amenazas tecnológicas y organizativas que deben neutralizarse para garantizar una alta probabilidad de éxito del proyecto.

Palabras clave: Realidad virtual, realidad aumentada, gestión del conocimiento, acumulación de conocimiento