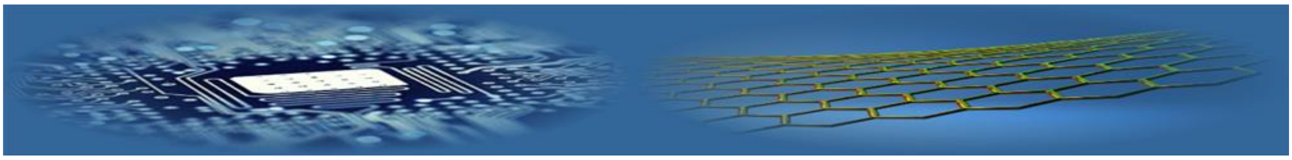

Development of the augmented reality applications based on ontologies

Yersain Chinibayev, Tolganay Temirbolatova*

International IT University, Manas Str. 34A/8A, 050040 Almaty, Kazakhstan

**Corresponding author: ttemirbolatova@gmail.com*

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Abstract

This article presents an analysis of the existing popular libraries for the development of augmented reality applications. Based on the analysis we propose a universal technology of construction of augmented reality applications using ontology. The technology is based on the geolocation using GPS and communicates with the resource through Linked Open Data.

Keywords

Augmented reality
ontological modelling
ontological engineering
Linked Open Data

1 Introduction

One of the applications of modern information systems and technologies – creation of qualitatively new features augmented reality with a view to their application in various branches of human activity [1, 2].

We know that in real life, a person receives 83% of information visually, 11% through the organs of hearing, and 6% through the channels of touch, smell and taste [3]. Modern development of hardware and software for Human Machine Interface (HMI) and computer graphics allow you to create a qualitatively new virtual worlds, enabling the use of all channels of perception of the information. Nowadays the main means displaying augmented reality (AR) are mobile devices, based AR solutions are used in all industries: tourism, medicine, etc. [4, 5].

Among the existing technologies in the construction of augmented reality applications (ARA) the most common solutions, demonstrating different approaches to the development of the ARA are: ARTAG [7], ARTOOLKIT [8], Layar [9], QUALCOMM AR PLATFORM [10], belonging to both the marker, so and markerless approaches [11]. Table 1 shows the description of the above systems.

The mentioned systems are used in the development of a specific task. However, existing solutions are only applicable in a certain area. The development of the ARA should take into account a several of specific issues of all AR systems. This problems are associated with the construction of virtual objects:

1. the organization of repository of the virtual objects and the means of access to it;
2. ensure the necessary degrees of realism of virtual objects;
3. matching of virtual objects with the scene.

TABLE 1 Description AR system

	Based on the markers	Advantages of the system	Disadvantages of the system
ARTAG	+	1. It supports multiple libraries to recognize the marker.	The following issues haven't been resolved: - general architecture,
ARTOOLKIT	+	2. Precisely defines the coordinates of the location of additional content.	- development of user interface, - the user's location in space
Layar	-	1. Determination of location using the GPS. 2. It contains detailed documentation and examples for creating layers. 3. Change shall be entered at the API level.	1. There is a difficulty in solving problems of the ARA with multiple user locations. 2. The complexity of application settings for a specific user. 3. The complexity of in calculating the specifics of a particular subject area.
Qualcomm AR	+	Recognize different types of objects in the video stream.	It doesn't recognize the user in the space

AR system can operate a whole set of virtual objects that are reproduced depending on the specific situation. Therefore it is necessary to organize the storage of objects in such a way that the system can get quick access to them.

Modern smart phones such as iPhone, HTC, Samsung have constant access to the Internet, and thus ensure the positioning of the user in the space. Defining user geolocation is done in two ways, the first category is an already stored specific location in the form of a cloud of linked data, in the second category user coordinates are being extracted in real-time and linked to user data. All the operated data is metadata, which can help you build an ontological model for future use.

2 Ontological modeling as an approach to overcome the limitations of existing solutions

The advantage of using ontology modeling in technology development in the AR adapted applications is based on the change of an ontological module. It provides:

1. Software easy adaptation to changes in the subject area (SA - Many subject areas and problems solved).
2. Easy adaptation of the software to the needs of specific user / user group.
3. The ability to reuse ontological models and their fragments on different layers of a complex system.
4. The ability to make changes in the behavior of the system during operation, without the need to recompile the code.
5. Ontological model types can be reused at all stages of the software development of the ARA.
6. The user interface of the software has the ability to of intellectualization.

3 Technology of creation of the ARA, based on ontologies

The proposed constructing ARA technology uses multi-level ontology of Figure 1. The upper level ontology are:

- The real space - defined by the user geolocation.
- Stage space - set of objects of the scene formed (image).
- Replacement point - augmented object placement in real space.

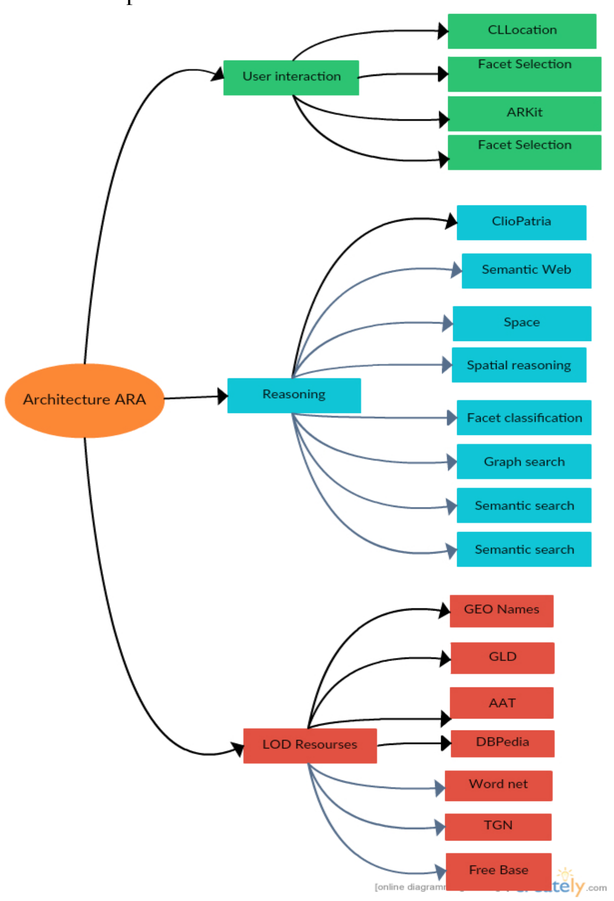

FIGURE 1 Architecture ARA

The scene in the applications of augmented reality is formed by combining a picture of the real world and objects augmented. Therefore, the real world - the space in which the user is moving, can be called complemented, and the set of all objects that are being augmented - space of addition. Space that is being augmented is discrete and divided into locations.

Functional description of the ARA presented in Figure 2. The proposed architecture creates applications where the user route depends on current preferences and interests, shows the user the information he needs, and helps to navigate in difficult situations. Thus, even the same path in real space, between the same objects, could be accompanied with different information, that allows the application to be configured as for the user and also for the current goals of content owners.

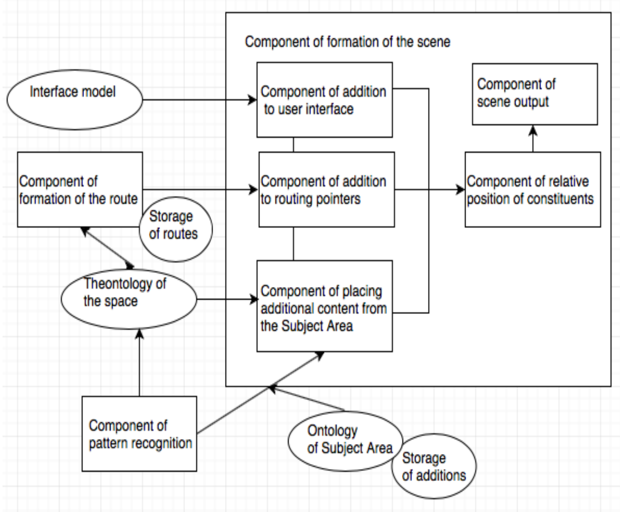

FIGURE 2 Architecture ARA based on ontologies (arrows denote the main directions of data streams)

The component that forms the scene is central in the application of augmented reality. It is responsible for the placement of the three types of add-ons:

1. The component of user interface additions forms user interface.
2. Component of addition for route pointers with the help of data provided by the components that form the route, allows you to display tips on the desired direction of movement and the distance between them.
3. Component of placement of the additional content from SA on the basis of data received from the pattern recognition component, determines where and how will the special content be reflected. This content is associated with a user's current position, as well as with specific objects of SA.

Formed additions should be located within the scene and displayed on the screen of the device, for which, the component of the mutual arrangement of additions and output component are responsible. The AR applications use extremely limited space on the screen to display the system functionality. However, it is possible to create interactive additions, the behavior of which will depend on explicit user action. This elements will be the user interface of AR applications. The declarative character of the interface model can significantly simplify the process of its development. This approach simplifies the division of responsibilities between the designers and programmers.

In order to highlight the place of ontological models in the ARA, main challenges are considered in Fig 3, resulting in the development of the ARA, and the possibility of using semantically powerful tools to solve them. Identified the following tasks:

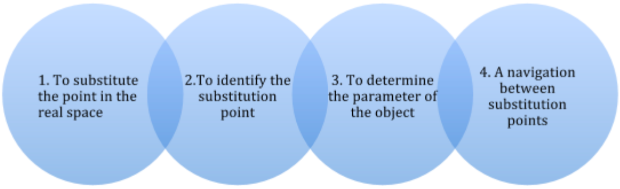

FIGURE 3 Defining the problem of constructing ARA

To solve the problem 1, it is required to construct an ontology domain concepts. Next, we need to build an applied ontology of real space using the concepts of the ontology.

For a more accurate indication of places of substitution points, it is prompted to enter the relative coordinates of the grid in separate locations. Built for solving the problem 1, the ontology can be used to simplify the solution of recognition problem of substitution points. To do this, use image recognition algorithms that can take into account not only the results of the analysis of the video stream, but the data about the place of location of the user in space.

Solution 3 requires use of the knowledge about supplement objects. This knowledge can be represented as a domain ontology. Subject ontology provided therein semantic existence metrics can be used to solve the problem of semantic navigation.

Based on the analysis of problems it is concluded about the need to describe the ontology model of SA and ontology of the space. Ontology SA (OSA) describes the basic concepts of SA and relations between them. As part of the OSA introduced semantic metric that allows to determine the proximity of concepts. Every concept is a set of possible additions. The ontology supports basic paradigmatic types of bonds (class-subclass instance of class, part-whole, necessary part- whole class attribute), connection type "contextually linked", as well as types of communication required for this domain.

4 The formal presentation of the solution of SA

Formal description of the visualization system is presented below. Multiple data in the system is displayed via the following formula:

$$\Sigma : \Xi \to \Xi , \quad (1)$$

$$O = \Sigma(I), \quad (2)$$

where $I = (i_1, i_2, ..., i_n)$ – the set of input data, $n \in N$, $O = (o_1, o_2, ..., o_m)$ – the set of output data, m∈N.

Elements of I and O has a heterogeneous structure and are represented as a string. Ξ – a plurality of data, then $i_a \in \Xi$, $o_b \in \Xi$, $a = 1, n$, $b = 1, m$.

We introduce the variables:

– set of supported graphics visualization system objects in the scene, $U = (u_1, u_2, ..., u_k), k \in N$. Elements of U are the mathematical models of visual objects: three-dimensional bodies, raster images, diagrams, etc.

Specific scene is a subset U of U.

– set of supported imaging system of a Graphical User Interface (GUI), $M = (m_1, m_2, ..., m_l), l \in N$, moreover $m = \sigma 1^d, \sigma 2^d, ..., \sigma ld^d$ – a set of states that can accept interface element m_d, $d \in 1$, l, $l_d \in N$ in response to user actions.

A specific set of interface elements that serve to control the visualization, is a subset of M the plurality of M, $M = \{mc1, mc2, ..., mct\}$, $mcg \in M$, $cg \in N$, $g = 1$, t, $t \in N$, $t \le l$.

– $S = \{m_1 \times m_2 \times ... \times m_l\}$ – the set of conditions that can make all the interface elements in response to user actions.

– the set of all possible user actions, $E = \{e_1, e_2, ..., e_q\}$, $q \in N$, E. It is a subset of E.

The module Γ organizing interactive user interface with graphical visualization of the system can be represented as a mapping of the set of all possible actions the user E, and all supported elements M interface to the set of states S of these elements:

$$\Gamma : E \times M \to S . \quad (3)$$

Then the specific scene setting set in response to a user action at the time of its next reference to imaging system can be obtained using this mapping to the set M:

$$S' = \Gamma(E, M). \quad (4)$$

Multiple S' of all possible sets of scene settings in turn may be obtained kind of the union

$$S' = \cup E' \subset E\Gamma(E', M). \quad (5)$$

Visualizer Φ can be represented as a mapping of all supported visual objects Uand all possible setups scene S' on the P raster image, which is a matrix of dimensions $w \times h$, the elements of which are the color-coded using a color model (more often – RGB):

$$\Phi : U \times S' \to P, \quad (6)$$

$$P : W \times H \to C, \quad (7)$$

where $W = \{1, 2, ..., w\}$, $w \in N$, $H = \{1, 2, ..., h\}$, $h \in N$, C – a variety of colors used by the color model.

Getting the image P' with smooth boundaries of objects can be written as a superposition of the visualizer Φ and the smoothing operator Δ:

$$P \to P, \quad (8)$$

$$P' = \Delta(\Phi(U, S')) . \quad (9)$$

The module Ψ interaction the visualization system can be represented as a map of input and output data in the solver set of visual objects:

$$\Psi : \Xi \to U . \quad (10)$$

When the integration takes place only with the data set U of specific objects to be rendered can be written as follows:

$$U = \Psi(I \cup O) . \quad (11)$$

Each element of this set corresponds to an element of I input. Then feedback the visualization system can be written as follows: $U = \Psi(\Gamma(N) \cup \Sigma(\Gamma(N)))$.

Using the notations entered tuned to a specific imaging system Y can be represented as follows:

$$Y = \langle \Phi, U, \Delta, \Gamma, M, E, \Psi, M, N \rangle . \quad (12)$$

Components of the model Φ, Δ, Γ, M, E, M unified:

- Φ – imaging operator, displaying a plurality of graphical objects U.
- Δ – smoothing operator acting on the finished bitmap and generating a new image with smooth borders of objects.
- Γ – operator to organize a GUI that allows the user to set various settings using the graphical controls regardless of the logic of further use of the values of these settings.
- M – unified set of controls, such as buttons, text boxes, radio buttons, and so on. etc.
- E – set of supported user interaction with a plurality of elements M.
- M – once a certain set of controls needed to navigate through the displayed scenes. model components U, Ψ, N generally depend on the system:
- U – a set of objects that are visible the data system.
- Ψ – the operator carrying out the conversion of input and output data of the system into objects suitable for visualization module Φ.
- N –set of controls that provide feedback to the system.

The investigation of the applicability of the ontological engineering methods to the problem of describing the visual objects. Elements of U are connected to each other in relation to the parent-child relationship (inheritance of properties), the part-whole class- and instance. In this connection, the conclusion on the adequacy of applied ontology without axiomatic to address the objectives of the study. Therefore, $U = \langle T_U, R_U \rangle$, when T_U – thesaurus visual objects, R_U – a finite set of connections between visual objects. The set N can be obtained by comparing the types of elements of the sets I and M with the help of the operator Π select items from the set M, suitable for editing the corresponding data:

$$\Pi : \Xi \times M \to M , \quad (13)$$

$$N = \Pi(I \ , M) . \quad (14)$$

The practical implementation of such an operator in a software module is trivial comparison. Showing Ψ can be obtained by the operator kind of Ω.

$$\Omega : \Xi \times U \to \Psi \quad , \quad (15)$$

where Ψ – converting the set of operators.

In this case:

$$\Psi = \Omega(I \cup O \ , U) . \quad (16)$$

The software implementation of the visualization system mapping Ψ can be generated semi-automatically, after the user has specified the relevant elements of the sets I and O object properties of a variety of U.

To unify the software implementation of the operator Θ can also be used an approach, based on ontological engineering. The operator will be modified as follows:

$$\Theta : K_{\Sigma} \times L \to \Xi , \quad (17)$$

where L – ontology, describing syntax input-output programming language operators.

Θ denotes a unified parser, which is controlled by the ontology L.

The investigation of the applicability of the ontological engineering practices to the task of parsing the source code in a given language in order to extract input and output variables. To automatically generate a parser must submit Backus-Naur Form (BNF), the language of ontology. To represent the BNF, as well as for the presentation of visual objects of applied ontology enough without axiomatic. Therefore, $L = \langle T_L, R_L \rangle$, when T_L – thesaurus construction, and R_L - a finite set of relations between them. Total formal model of the system is represented as follows:

$$Y^* = \langle \Phi, U, \Delta, \Gamma, M, E, \Theta, L, \Omega, \Pi, M \rangle . \quad (22)$$

5 Conclusions

This article presents the application development technology of augmented reality, based on ontologies. The results of the analysis of existing approaches to the development of augmented reality applications, demonstrated the need for a high-technology systems for building augmented reality. The article proposes the technology of constructing the application based on the ontological analysis to solve problems arising in the development of augmented reality applications.

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AUTHORS	
	**Yersain Chinibayev, 1986, Kazakhstan** **Current position, grades:** PhD candidate **University studies:** MSCS at KBTU **Scientific interest:** Augumented Reality **Publications:** 3 **Experience:** more than 7 years
	**Tolganay Temirbolatova, 1988, Kazakhstan** **Current position, grades:** PhD candidate **University studies:** MSCS at NSU **Scientific interest:** Big Data, Integration data, Ontologie, Mashine Learning **Publications**: 10 **Experience**: more than 6 years