more detail in [6]. When designing augmented reality object tracking systems, all approaches for object tracking and scene anchoring can be divided into marker and markerless tracking [7].

To organize the operation of augmented reality system, four main types of agents have been identified:

- Device agents that process image from the camera or aggregate data from other types of sensors.
- Surface agents that are responsible for detecting and classifying surfaces for the purpose of anchoring, object placement and occlusion.
- Rendering agents that are responsible for visualization of 3D models.
- Application logic agents that are responsible for implementing user interaction scenarios and handling user input.

Later in this work, we also present examples of designing augmented reality systems based on semantic representation. When implementing concrete applications, in addition to designing the operation of the augmented reality system as an interface for the user, it is also necessary to describe relevant user scenarios. Designed scenarios can also be included into the ostis-system knowledge base and presented using an ontological description.

A. Application of augmented reality for technical device manuals

Technical device manuals and instructions are necessary elements of any type of hardware or equipment. Usage of augmented reality systems in the implementation of these kinds of manuals and instructions provides advantages in terms of clarity and visibility - for example, the user does not need to compare schemas, images or diagrams with the operating object in order to find the necessary structural elements and understand required operational, technical and maintenance procedures they need to perform. In addition, complex scenarios can be implemented: resolving non-standard situations can be presented in a sequence of steps, and intelligent visual analysis from the technical vision system can be used to spot and diagnose various issues. Many manufacturers are already implementing these types of applications, but at the moment all solutions in this area are limited to select products and distributed as narrowly-scoped standalone mobile applications. Using ontological representation of the technical specification and manual of the device [8] [9] makes it possible to design scenarios for personnel training, equipment diagnostics and repair. OSTIS Technology allows to extract an ontological description, associate it with a specific subject area and with the semantic representation of the augmented reality environment. As a result, ready-made user scenarios based on data received from the technical vision system are obtained. For the practical implementation of object recognition possible to use additional solutions or use the algorithms described in the knowledge base directly. The following entities can be described:

device
:= [subject of technical manuals and descriptions]
⇒ *includes**:
{
part of the device
⇒ includes*:
{
device component
:= [A separate element responsible for specific functionality and having an additional description. Example: power button]
}
}

Each entity can be highly nested and must have a description and visualization provided in the database. A system component can be an integral part of the device. If it is necessary to project the corresponding 3D device models during AR environment modelling, these entities can be compared with entities within the framework of the semantic representation of 3D scenes and objects [6]:

3D object

:= [a set of points in space connected to each other and having a shared semantic representation]

3D composite object

:= [object in 3D representation that supports decomposition into separate individual objects]

part of an object in 3D

:= [a set of points in space belonging to some object in a three-dimensional representation, which can be distinguished by its geometric or semantic representation]

3D scene

:= [collection of several objects in three-dimensional representation and data about their features and relative position in space, including absolute and relative referential oriented and unoriented relations]

The following entity types are also introduced to describe user interaction:

equipment status

:= [a set of technical characteristics of equipment related to the specifics of its operation and determining its performance]

equipment operation
:= [a sequence of actions designed to achieve a specific user goal; examples of operations can be switching on, diagnostics, repair, installation, dismantling, transportation, etc.]

equipment action
:= [user interaction with one of the device components in a specified way; example of an action would be pressing a button, plugging into an outlet.]

Based on these entity types, an arbitrary custom scenario can be described. For example: turning on (operation) of new equipment (equipment status) is carried out by the following sequence of operations and actions: unpacking (can be an operation or action depending on the device), installation (operation), plugging in (action), pressing the power button (component). Device diagnostics or repairs can be described in the same way. The connection of each component to its visual display and semantic 3D representation allows to display descriptions of the stages aligned with the corresponding components using augmented reality, for example, on a smartphone screen.

As a practical implementation, an augmented reality training application based on markerless technology was developed with a technical manual of the oscilloscope for use during laboratory work. This application allows to visualise equipment operating instructions in AR, and also provides repair instructions using a mobile device that supports iOS 16. Device, surface and rendering agents implemented in this system are based on the ARKit SDK [10]. After the application is launched, the scene is initialized and a surface agent is used to find a surface matching the appearance of the device. When required surface is found, a WorldAnchor is set, and descriptions of individual device components that are present in the frame are displayed on the smartphone screen. While working with the application, the user can move in space, and appropriate component descriptions are constantly updated to correctly match location and spatial orientation of the device. Position recalculation is a computationally expensive task, so it is performed in 0.4 second increments. The user can also choose one of the operations to indicate how they want to interact with the device. In this case, the application enters instruction mode, and user can perform all the steps in order or view the entire sequence of actions.

B. Augmented reality quest

One of the most commonly used formats for augmented reality systems is gaming. Characteristics of this format can be used in educational systems, marketing campaigns, tours, and many other areas. One of the examples of designing an augmented reality applications presented in this paper is an augmented reality quest app - an educational and marketing application designed to familiarize applicants with an educational institution.

To create such an application, a set of scenes and interaction scenarios associated with them are described and added to ostis-system knowledge base, which will later be used as a data source.

Interaction implementation is based on a common location - some part of the space of the real world, which is described in terms of semantic scene representation and object relationships. These relationships provide a shared description of separate scenes and objects of these scenes in the real world. To design a scene in AR, additional relations are established between the objects of the real world and the virtual modelling space. Objects superimposed onto the scene are generated by the rendering agents, that use the same semantic description for the scene to work in a shared space. To perform visualisation of the resulting rendered scene, objects in the shared description and must be first located and recognized.

AR quest is formed as a sequence of the scenes and their respective descriptions. Each of these scenes also contains a description for a certain number of individual, which are, in turn, attached to the objects of the scene and can be presented to the user. An example of such a task is a set of questions about the observed object, a mini-game, an instruction to find a specific object, an instruction to move to the different location to change the scene. Application keeps track of task execution status using device agents that supply information about end user device spatial characteristics from device sensors. When the task is completed or scene change is detected, application may suggest new tasks.

To implement device, surface and rendering agents for proposed application, Unity platform and Vuforia software package [11] for AR were used. Developed system uses a combination of marker and markerless technology for tracking and searching for objects in a real scene. Application is designed to work under the Android OS. Managing content for describing scenes, objects of a real scene and supermposed objects of AR, as well as tasks for the user, can be performed using ontological representation of OSTIS knowledge base by implementing appropriate data mapping for translating ontological representation to the format used by corresponding platform APIs.

VI. CONCLUSION

The paper considers the possibilities of using OSTIS Technology for designing virtual and augmented reality systems, and discusses the possibility of using ontological descriptions of related subject areas as a basis for implementing these systems. For proposed concepts, descriptions of applications designed with the proposed approach are also provided.

The advantages of using OSTIS Technology for the presented tasks are:

- Introduction of a common concept and description system for different methods in a unified and consistent form.
- Support for convergence of VR and AR application design subject area with other applied subject areas, 3D scenes and environment modelling subject area, and computer vision subject area.
- Simplification of virtual reality systems development by selection of necessary scene elements according to scene semantic description to implement user interaction and achieve maximum user immersion.
- Ability to build a complex design technology using intelligent agents that rely on proposed description and utilise data about individual algorithms and user scenarios from the shared knowledge base.
- Ability to create integration tools for individual components, describe stages of various methods and build different types of internal representations in a unified way.

Using proposed approach enables to design dynamically expandable VR and AR systems that provide a greater immersion degree for the user, while using proposed semantic scene description for objects and their relations can be used to model various rendering and interaction scenarios without tightly coupling the implementation to specific hardware.

Building realistic scenes in virtual and augmented reality is a rather complicated process that must be able to achieve necessary degree of realism, while taking limitations on real-time scene rendering into account. Using OSTIS Technology to enable the possibility to use developments in related areas allows to form a new approach for developing less resource-intensive interaction scenarios.

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Проектирование пользовательского взаимодействия в иммерсивных системах нового поколения

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Данная статья посвящена рассмотрению вопросов проектирования интеллектуальных систем, использующих технологии дополненной и виртуальной реальности. Данные технологии основаны на использовании трехмерного представления окружающей реальной или спроектированной сцены, особенностях систем определения ориентации человека и объекта в пространстве, алгоритмах интеллектуального анализа и машинного обучения. Сложность разработки отдельных алгоритмов, необходимость учета специфики предметной области для каждой прикладной системы, отображение на основе трехмерных и других видов представлений вызывает необходимость разработки новых подходов и принципов проектирования. В статье основное внимание уделено возможностям Технологии OSTIS для использования в данных задачах, а также приводятся примеры построения системы технического описания оборудования и квеста в дополненной реальности.

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