Technical Requirements Analysis

ATLANTIS Public Report Nr. 3	
Project:	ATLANTIS – AuThoring tooL for indoor Augmented and dimiNished realiTy experIenceS
Website:	http://atlantis-ar.eu
Author(s):	Richard Whitehand & Per Ström (Usability Partners), Dimitrios Zarpalas & Nikolaos Zioulis & Giorgos Albanis & Vladimiros Sterzencenko (CERTH), Werner Bailer & Georg Thallinger (JOANNEUM Research), Julia Parinova & Robert Huemer (ROOMLE)
Publication date:	2021-01-19
Version number:	1.0
Abstract:	This report provides an overview of the initial analysis of technical requirements, based on user research and feasibility assessment. The identified technical requirements are related to the AI services, the authoring application, the AR application, as well as enabling components and requirements related to wider AR adoption challenges.

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement No 951900.

Introduction

For the analysis of technical requirements, the identified user requirements are associated with specific components of the ATLANTIS solution and mapped to specific technical specifications that it needs to support, in order to deliver the required functionalities. Some specifications address multiple requirements, or span across different ATLANTIS components. Finally, the extensive user requirement collection process has extracted various and diverse requirements, which do not necessarily fall within the scope of the ATLANTIS project. Nevertheless, they are an important outcome of ATLANTIS as they indicate the challenges that AR applications need to overcome to achieve widespread adoption.

The identified technical requirements are decomposed according to the main technical ATLANTIS components, the AI services, the authoring application, and the AR application. Finally, we discuss requirements pertaining to components enabled by the ATLANTIS solution that are related to the ATLANTIS use cases, and then discuss the requirements related to wider AR adoption challenges.

AI services

The ATLANTIS AI services comprise the innovation driving next-generation AR experiences that will manifest as an enhanced communication medium. The main technical requirements identified are:

TR1.1	AI-based layout recommendations
TR1.2	Scene 3D reconstruction
TR1.3	Object Segmentation

The AI-based layout recommendations technical requirement (**TR1.1**) aims at providing the layout author (i.e. interior designer, renovator), with automatic suggestions for updating the current scene's layout. Based on the different user requirements, this functionality should be conditioned on two levels, a coarse, which is based on the scene's/room's type, and a fine level, which is reliant on the relative object layout. From a technical standpoint, this requires the extraction of the current scene graph, and a conditional generation of some variations, which will be offered as recommendations.

The three-dimensional (3D) scene reconstruction technical requirement (**TR1.2**) is an important, albeit challenging, capability of the ATLANTIS system. Room measuring is a tedious process, identified as one of the 'pain points' of the planning process, given that it relies heavily on good measurements. Additionally, AR is generally driven by the spatial understanding of the world around us, and thus, such 3D computer vision tasks are the backbone of AR technology. For the ATLANTIS case, metric-scale, accurate 3D scene reconstruction is required both for its particular use case, but also for facilitating metric-scale AR. This refers to the automatic emplacement of AR objects in the scene, with minor manual placement activities. To accomplish this, the scene should be authored in 3D. Towards that end, ATLANTIS will focus on data-driven geometry understanding from spherical panoramas. This greatly simplifies the scanning process, and given the commoditization of spherical cameras, lowers the barrier for entry. The omnidirectional view also offers holistic information, which is very important given the highly under-constrained and ill-posed task of perceiving metric-scale geometry from a single monocular image. The addressed user requirements also signify the challenges that this technical requirement needs to overcome, which is estimating metric-scale high-quality geometry, adapting to the complexity and variety of indoor scenes, and extracting concrete information about the scene's dominant planes.

Finally, the ATLANTIS system will also need to support object-level scene understanding with a two-fold goal, **i)** to drive the authoring aspect of replacing objects by offering rich metadata on top of the 3D reconstructed scene that will allow for snapping, and **ii)** to drive the diminishing aspects by marking the areas to be removed before adding AR content during the experience playback. In addition, the outputs of this technical requirement (**TR1.3**) can be used as the inputs of the AI-based layout recommendation technical requirement, either directly or after post-processing, highlighting a potential synergy.

Authoring application

The ATLANTIS authoring tool will consolidate the AI services results in an annotated 3D view that will offer an elevated understanding of each scene/room compared to traditional photos. It will be used to process the scene by adding and removing elements, with the goal to deliver these suggested alterations through next-generation AR experiences to the clients.

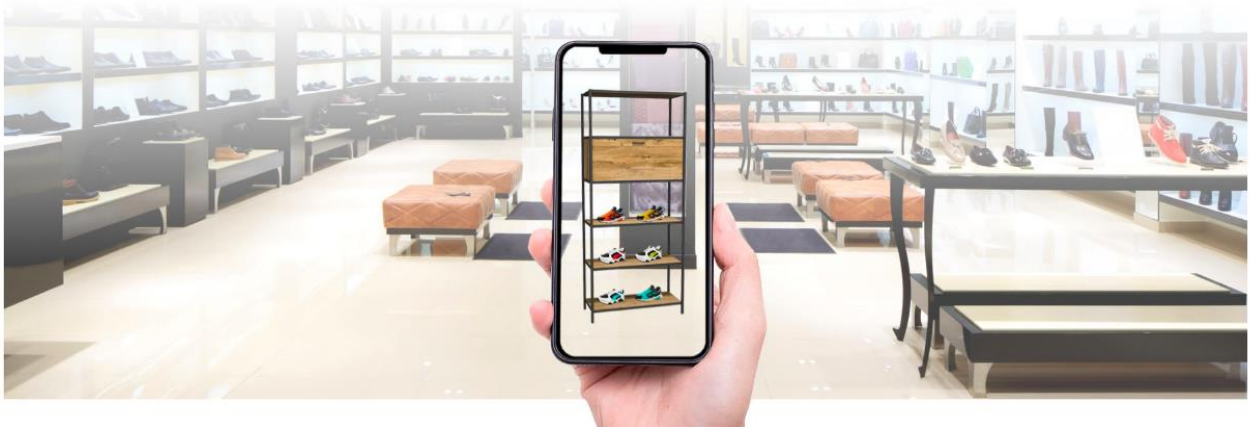
TR2.1	Projections
TR2.2	Multi-layout proposals
TR2.3	Product related information & annotations
TR2.4	Room semantics-based authoring
TR2.5	Generic 3D asset importing
TR2.6 (TR1.3)	Enhanced object annotation

The first technical requirement (**TR2.1**) associated with the authoring tool is related to the different (3D) views it will offer, which aim in aiding the planning and recommendation process. Given that the content will be 3D reconstructed, axis-aligned views should be supported, therefore offering a floor-plan view, as well as other planning-related views.

Apart from different 3D views, the authoring tool should also offer different proposal views (**TR2.2**). This will ease the design and planning workflow, while at the same time offering the clients with multiple proposals. Further, its users should also receive product-related information and annotations (including other similar products), and be able to select which will be delivered to the clients as well. This technical requirement (**TR2.3**) translates to the integration with product catalogues. Capitalizing on the 3D nature of the authoring tool, in tandem with the object-level information, 3D snapping (**TR2.4**) should be supported to further smoothen the authoring workflow. This involves both scene objects (i.e. furniture, appliances), as well as scene structural elements (i.e. walls, floor, ceiling). In addition, while the integration with product catalogues will ensure 3D asset importing, this should not be limited to the catalogue's formats, but expand

to generic asset importing (**TR2.5**), in order to support the embedding of real-sized humans, which will help in perceiving the scale of the recommendations among other qualitative traits. Animation of these imported assets shall be supported, e.g. for showing the effect of movable parts (opening/closing doors) or animating persons moving through the scene.

Finally, while the AI-services will support the authoring workflow, it is also important to provide human-in-the-loop features (**TR2.6**) that will increase the robustness of the authoring experience, by allowing users to manually annotate or correct the AI-services results.



AR application

The ATLANTIS mobile AR application will be the users' delivery point of a renovation/replanning recommendation proposal. Users will be able to view the recommendations within the real-world scenes that will be renovated/refurnished.

TR3.1	User object manipulation
TR3.2	Multi-device support
TR3.3	Offline mode
TR3.4	6DOF playback
TR3.5	Object Removal
TR3.6	Mixed VR experience

To that end, one of the core technical requirements is the capability of manipulating the augmented elements (**TR3.1**), which has been a recurring theme during the user requirement collection phase. To achieve this, a combined UI/UX design approach will need to identify the best options for such a functionality. ATLANTIS aims at minimizing manual user activities and on allowing a 'fire-and-forget' AR experience, i.e., a high degree of automation shall be supported, for example by snapping objects to geometry and providing support for layout automation. However, in cases where users want to explore options, the selection of different alternative objects and/or configuration objects, as well as changing objects' positions shall be supported. In order to simplify the required user interactions in the process of communication between clients and designers/planners, the functionality should allow switching between alternative versions.

At the same time, a standard feature which is multi-device support (**TR3.2**) is also essential for reaching wider audiences. Further, the AR experience should be delivered and stored to the users' devices to allow for offline AR experience playback (**TR3.3**), without requiring internet access.

Another important technical requirement relates to the playback's three-dimensional nature which aligns with AR technology's core, which is natural 3D experiences. While AR technology straightforwardly supports 6 degrees of freedom (6DOF) viewing, applying this 6DOF viewing technical requirement (**TR3.4**) to the ATLANTIS AR application is different, mainly due to its DR capabilities. Thus, the removal of real-world elements should support 6DOF viewing (**TR3.5**). This functionality is the differentiator between the ATLANTIS AR experience and traditional AR. Whereas the latter only superimposes synthetic elements into real-world scenes, ATLANTIS will manipulate the real-scene view as given from the camera in order to provide a more realistic depiction of object replacement. The goal will be to initially remove an object and replace it with background information, before augmenting the scene with its replacement.

Finally, while AR technology has a real-time aspect, it can also be delivered on pre-captured images. This addresses the user requirement to make modifications to the scene (using the AR view) when being off-location or to discuss the scene with people off-location. This allows for pre-emptive AR experiences, which when also considering the 360° nature of the ATLANTIS input, can accommodate augmented 360° panorama experiences (**TR3.6**). This technical requirement refers to delivering the layout recommendation as a re-composed media which can be viewed with traditional VR means, while containing the author's edits (i.e. object removal, replacements, and additions), and allows for further editing.

Enabling components

A set of requirements extracted from the requirements gathering activities were mainly related to functionalities required for production use of ATLANTIS technology, but are not part of the technical innovations at the core of ATLANTIS. These functionalities can be covered either by the integration of existing third-party technologies or by developing them as part of the future product. The following categorization refers to **i)** standalone capture-related functionalities that can enhance the resulting user experience with supporting functionalities, **ii)** promotion or client material preparation based on the results of the ATLANTIS authoring, and **iii)** support for next-generation device experiences.

Wider AR Challenges

The requirements gathering activities conducted within ATLANTIS were analytical and conducted methodically to allow for generic and unrestricted requirement extraction. Albeit not all involved users were acquainted with the technology behind ATLANTIS, the discussion allowed for important observations or recommendations, and thus, a set of technical requirements have been identified that are related to the wider technical challenges that AR needs to overcome, but which are considered beyond the scope of ATLANTIS (as defined in the DOA). However, some of them might be addressed in a later stage of the project, if resources to work on them can be made available.

TR5.1	Tiny object detection
TR5.2	Disconnected scene understanding
TR5.3	AR-based collaboration
TR5.4	Scene lighting estimation
TR5.5	Image-based object 3D reconstruction

Usually, rooms also include tiny objects like fixtures that can be replaced. This translates to a challenging technical requirement, providing computer vision algorithms robust to tiny objects (**TR5.1**), an important computer vision problem, currently focused on tiny face detection for crowds. Especially for scene-wide

understanding tasks like semantic segmentation, small or tiny objects are very challenging to correctly detect and label.

Further, when planning for building-wide renovation activities, moving camera scanning processes are cumbersome, with a possible promising solution being single room captures and then automatically connecting these different snapshots (**TR5.2**). In this context, various user requirements entailed inter-room associations, which is a problem connected to large-scale 3D reconstruction.

Another important AR challenge is the spatiotemporal synchronization among users in the same scene, allowing for coherent AR views and live updates, which in turn enable multi-user interactivity and collaboration (**TR5.3**). This way, plans, and layouts can be shared, or even viewed and adjusted simultaneously by users.

Finally, the realistic blending of the virtual (digital content) and the real (actual scene) is the most important challenge that AR needs to solve in order to become a “transparent” technology, a very important trait. The realism of augmented objects is mainly hindered by their lack of realistic relighting within the scenes. To that end, lighting estimation (**TR5.4**) is an important task that can overcome such issues, but also improves the quality of tasks like material/texture transfer as well. Further, single image-based 3D reconstruction (**TR5.5**) of objects, with no multi-view information, can allow for real-world scene edits. In combination with DR and potentially 3D object retrieval solutions, this opens up new opportunities like digitized room re-planning, with no additions or significant changes.

More information

Visit https://atlantis-ar.eu or follow us on Twitter @AtlantisAR.