Smart cities, Urban / Architecture / Civil engineering, DX

MR w/ AI: Assessing future landscapes using enhanced mixed reality with segmentation by deep learning

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Abstract

Architecture, engineering, and construction projects need to be promoted in harmony with the natural environment and with the aim of preserving people's living environment. At the planning and design stage, decision-makers and stakeholders share and assess landscape images during and after construction in order to avoid as much uncertainty as possible when performing environmental impact assessment. Given the lack of a standard visualization method for future landscapes that do not yet exist, mixed reality (MR), which overlays virtual content onto a real scene, has attracted attention in the field of landscape design. One challenge in MR is occlusion, which occurs when virtual objects obscure physical objects that should be rendered in the foreground. In MR-based landscape visualization, the distance between the MR camera and real objects located in front of the virtual objects might vary and might be large, causing difficulty for existing occlusion handling methods. In the process of landscape design, an evidence-based approach has also become important. Landscape index estimation using segmentation by deep learning, which can recognize the surrounding environment, has been actively studied for landscape assessment. In this study, segmentation by deep learning was integrated into an MR system to enable dynamic occlusion handling and landscape index estimation for both existing and designed landscape assessment. This system can be operated on a mobile device with video communication over the internet by connecting to real-time segmentation on a high-performance personal computer. The applicability of the developed system is demonstrated through accuracy verification and case studies.

Significance of the research and Future perspective

We are using deep learning to improve the performance of mobile mixed reality, which is expected to be applied in the industrial and urban planning fields, especially in construction DX toward Society 5.0. In the future, we will automate the definition of occlusion targets and improve the level of detail from the class (type) to the object (individual object of the same type) level.

Background & Results

We propose an MR future landscape assessment system that includes dynamic occlusion handling for more accurate geometric consistency and landscape index estimation for evidence-based design. For occlusion, model-based methods have been proposed for realizing large-scale MR in outdoor areas, but they are not applicable in cases where occlusion targets move or change shape. In contrast, methods using depth information, which enables dynamic occlusion, are difficult to achieve for large-scale MR that examines outdoor landscapes because the depth information that can be obtained is limited. For landscape evaluations such as GVI, image processing methods can be integrated with MR to evaluate the current and post-design states, but there are issues such as parameter setting, unextracted tree branches and trunks, and incorrect extraction of artificial green objects. On the other hand, the use of segmentation solves these problems, but a landscape evaluation method integrated with MR for both current and post-design landscapes has not yet been realized. Therefore, the novelty of this research is the development of a method for achieving dynamic occlusion and quantitative landscape assessment for both current and post-design landscapes by integrating MR and segmentation.

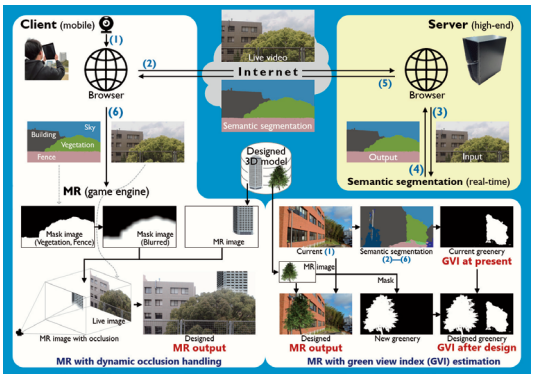

Fig. 1 Proposed MR system: Integration of semantic segmentation into MR

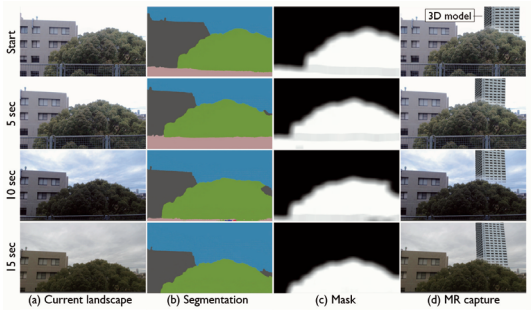

Fig. 2. MR-based visualization with dynamic occlusion handling in field validation.

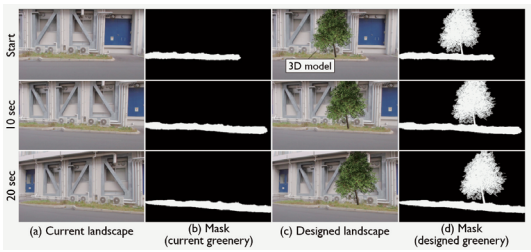

Fig. 3. Planting simulation with MR and greenery estimation.

Patent

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Keyword mixed reality, deep learning, landscape metrics and indices, environmental design, systematization