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EXTENDED REALITY INTEGRATED INTO TRADE SPACE EXPLORATION

Abstract

Trade space exploration (TSE) supports architectural choices by comparing large numbers of architectural design points and avoids design-point fixation. Trade Spaces are often represented as 2-D scatter plots where an architectural utility metric varies with mission cost. TSE becomes harder when multiple stakeholders are engaged in architectural decision-making as stakeholders have unique objectives, interests, and expected costs, while Arrow's theorem prohibits a general global utility ranking. Additionally, exploring large scatterplots can be overwhelming for the untrained eye.
M.E. Fitzgerald introduced a general Multi-Stakeholder TSE framework by combining concepts from conflict management and visual analytics to steer negotiations away from zero-sum-games and decrease the time-to-agreement.
We bring forward this concept by introducing Immersive Trade-Spaces. The idea is to increase the effectiveness of multi-stakeholder TSE by employing Extended Reality (XR) technology. XR enables the collaborative exploration of large trade-spaces boosted by the spatial awareness that comes with stereoscopic rendering. Beyond stereoscopic immersion, XR combined with hand tracking enables unique data interaction methods that can be easily picked-up by non-digital-native stakeholders who might not be comfortable with controllers. A prototype tool capable of displaying in real-time up to 10^5 architectural points has been built using the Unity game engine and an Oculus Quest 2 VR headset. The tool imports the results from a Trade-Space generation algorithm and draws them with GPU instancing. Gesture recognition enables different data manipulation modes, such as hand colliders, repulsion spheres, or pointing. The "selection" functionality provides detail on-demand by showing what architectural choices lead to a particular data-point upon stakeholder request. Additionally, the plot's parameters are customizable. Stakeholders can choose what figures of merit are plotted, apply color and transparency maps to increase communication efficiency, and observe architectural patterns. We also present a case study where this tool was employed to extract insight on a CubeSat mission's Trade-Space. We conclude that the immersive and intuitive nature of XR environments promises to support multi-stakeholder negotiations, and more broadly, multi-variable human-data interaction.