# Using Iterative Refinement for Out-of-reach Selection in VR

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## ABSTRACT

In Virtual Reality (VR), the action of selecting virtual objects outside arms-reach still poses significant challenges. In this work, after classifying, with a new taxonomy, and analyzing existing solutions, we propose a novel technique to perform out-of-reach selections in VR. It uses natural pointing gestures, a modifiable cone as selection volume, and an iterative progressive refinement strategy. This can be considered a VR implementation of a discrete zoom approach, although we modify users' position instead of the field-of-view. When the cone intersects several objects, users can either activate the refinement process, or trigger a multiple object selection. We compared our technique against two techniques from literature. Our results show that, although not being the fastest, it is a versatile approach due to the lack of errors and uniform completion times.

## CCS CONCEPTS

• **Human-centered computing → Interaction techniques**;

## KEYWORDS

Virtual reality, Out-of-reach selection, Progressive refinement

**ACM Reference format:**
Daniel Mendes, Daniel Medeiros, Maurício Sousa, Eduardo Cordeiro, Alfredo Ferreira, and Joaquim Jorge. 2017. Using Iterative Refinement for Out-of-reach Selection in VR . In *Proceedings of SCCG '17: Spring Conference on Computer Graphics 2017, Mikulov, Czech Republic, May 15–17, 2017 (SCCG '17),* 1 pages.
https://doi.org/10.1145/3154353.3154371

In immersive virtual environments, techniques to select objects outside user's arm-reach often follow an arm-extension metaphor or ray-casting. While, these approaches work for room sized environments, they hardly scale to larger scenarios with many objects, since a small hand tremor or tracker jitter can drastically move the ray away from desired far-away objects. A selection volume can reduce this, but if the size or aperture of the volume is too small the same problem of the ray arises, and if it is too big several objects will be intersected, requiring additional disambiguation steps. Progressive Refinement techniques tackle this later challenge, but often favor closer objects. Also, these techniques usually employ menus or FoV-diminishing metaphors, and were developed for non-immersive and non-stereoscopic scenarios. Thus, they may not be suited for VR as menus might disrupt immersion and small FOVs may lead to cybersickness. To better understand previous selection techniques, we introduce a new taxonomy (Figure 1) that complements existing ones, focusing on cardinality, reach and the strategy followed for progressive refinement.

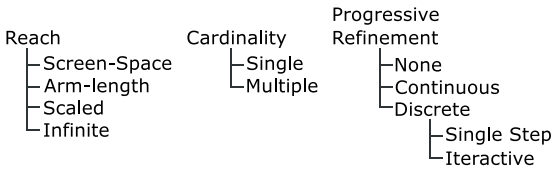


**Figure 1: Our taxonomy of selection techniques' properties.**


*SCCG '17, May 15–17, 2017, Mikulov, Czech Republic*

ACM ISBN 978-1-4503-5107-2/17/05.
https://doi.org/10.1145/3154353.3154371

**Figure 2: PRECIOUS' refinement phase.**

Focusing on Iterative Progressive Refinement, we propose a novel technique that uses natural pointing gestures for selecting out-of-reach objects in VR: PRECIOUS. We use a cone as a selection volume, casted from users' hand. Users can make the cone aperture wider or smaller, and change the cone's reach. Objects that fall inside the cone will be selected. Users are then moved closer to the selected objects for a more accurate selection (Figure 2). As such, this can be considered as a possible VR implementation of Discrete Zoom, although we modify users' position instead of the field-of-view. This process is repeated until a single object is selected or, if users desire, can be stopped at any time to select a group of objects, supporting both Single and Multiple Cardinality.

To validate PRECIOUS, we compared it against two techniques from literature: Stretch Go-Go, which follows an arm-extension metaphor, and Flashlight, that uses cone-casting and an heuristic disambiguation method for single step progressive refinement. Our results suggest that Stretch Go-Go is an impractical technique, and Flashlight, while providing fast execution of standard selection tasks, is prone to incorrect selections when there are objects close to the desired one. Regarding PRECIOUS, we can state that although it was not the fastest, the lack of errors and uniform completion times across all scenarios tested make it a suitable technique.

Full details about this work can be found in [Mendes et al. 2017].

## REFERENCES

D. Mendes, D. Medeiros, M. Sousa, E. Cordeiro, A. Ferreira, and J. A. Jorge. 2017. Design and evaluation of a novel out-of-reach selection technique for VR using iterative refinement. *Computers & Graphics* 67 (2017), 95–102.