Raycasting in Virtual Reality

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Raycasting in Virtual Reality

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Synonyms

3D pointing; Distal pointing; Virtual pointing
metaphor

Definitions

Raycasting is a set of interaction techniques used
in immersive environments for selection of targets
at the distance. Raycasting resembles real-life
pointing with a laser pointer: the user points a
ray of light at the target and confirms its selection
with a motion gesture, a voice command, or a
button click. Raycasting belongs to a family of
interaction techniques known as virtual pointing.
A more general term, 3D pointing, includes
raycasting as one of the common approaches to
selection of objects in immersive environments.
The term "raycasting" should not be confused
with the term used in computer graphics to
describe a rendering technique.

Introduction

Object acquisition is a prerequisite for object
manipulation in 3D user interfaces (Bowman
et al. 2017). Target acquisition technique must
facilitate the indication of an object and confirma-
tion of its selection. It should also provide visual,
haptic, or auditory feedback during the selection
task. A popular technique to realize target acqui-
sition is a family of raycasting techniques.
Raycasting borrows the familiar pointing using a
laser pointer adapting it for acquisition of 3D
objects in an immersive environment.

The Family of Raycasting Techniques

One of the earliest examples of raycasting tech-
niques was called "laser gun" and was introduced
by (Liang and Green 1994). Since then, many
raycasting techniques were developed for a vari-
ety of input devices (Argelaguet and Andujar
2013). A number of specialized raycasting tech-
niques were also developed to address challenges
of 3D interaction, such as accuracy and
speed trade-off, occlusion, or target density. Com-
mon modifications of the technique include
adjusting the shape and the size of the selection
tool or the shape and the number of rays.
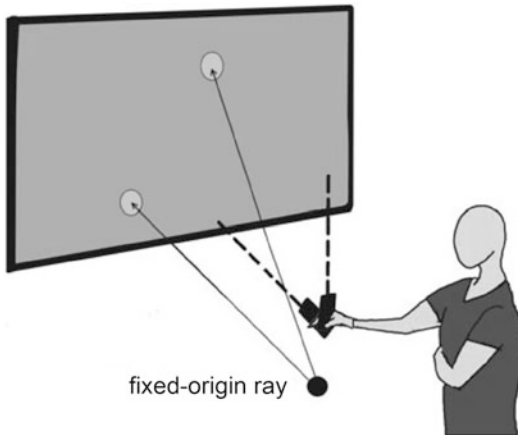
Raycasting in Virtual Reality, Fig. 1 Smartcasting (Pietroszek et al. 2014): an example raycasting technique using off-the-shelf smartphone as an input device

Some techniques combine a ray with a 3D point cursor that is contained along the ray.

Notable examples of raycasting techniques include Depth Ray, Aperture Selection, 3D Bubble Cursor, and Fixed-Origin Raycasting. In Depth Ray (Grossman and Balakrishnan 2006) from all objects intersected by the ray, the one that is closest to the 3D cursor that moves along the ray is the one that is selected. In aperture selection technique (Forsberg et al. 1996), user can manually adjust the selectable areas apex angle. In 3D Bubble Cursor (Vanacken et al. 2007), the size of the spherical cursor at the ray's end expands or shrinks automatically to reach the object closest to its center. In Fixed-Origin Raycasting, the ray originates from a fixed point, rather than the user's hand or input device (Jota et al. 2010; Pietroszek et al. 2014). A comprehensive survey of raycasting techniques was recently published by (Argelaguet and Andujar 2013).

Input Devices

Typically, raycasting requires an input device providing six degrees of freedom (DoFs) – rotation and translation along all thee axis – in order to provide user with full control over the position of the ray origin and the rotation of the ray. High-precision handheld input devices used to implement raycasting include air mouse, magnetic tracker, Oculus Touch tracker, HTC Vive Controller, and PlayStation Move controller. For casual, equitable 3D interaction, techniques utilizing a smartphone or a Wiimote were developed (Pietroszek et al. 2014, 2015). Raycasting can also be realized as a freehand interaction using optical hand tracking, ranging from high-precision motion capture systems, such as VICON or PhaseSpace, to low-cost systems such as Leap Motion and Microsoft Kinect. Alternatively, wearable input devices may be used, including motion capture suits (e.g., Perception Neuron suit), off-the-shelf smartwatch (Pietroszek et al. 2017; Kharlamov et al. 2016), electromyographic sensor (Thalmic Myo), or digital gloves (Senso glove). When the input device does not provide six DoFs, fixed-origin raycasting techniques can be used as an alternative (Jota et al. 2010; Pietroszek et al. 2014), as it requires only three DoFs (Fig. 1).

Conclusion

Raycasting is a family of popular interaction techniques for acquisition of objects presented in virtual reality systems or on large screens. Raycasting techniques offer good accuracy and speed trade-off for 3D target acquisition and a variety of approaches to solve 3D interaction challenges, such as occlusion, fatigue, or high density of objects. For object selection at a distance, Raycasting is de facto a standard 3D selection technique in immersive environments.

Cross-References

▶ Virtual Hand Metaphor
▶ Virtual Pointing Metaphor

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