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EXTENDED-ABSTRACT

Redirection Masking Strategies: Understanding Attentional Diversion Methods for Redirection Techniques

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Redirection Masking Strategies: Understanding Attentional Diversion Methods for Redirection Techniques

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ABSTRACT

Imagine you can explore virtual space just by regular walking, even if you are in the very confined tracking space of your living or bedroom. Redirection techniques aim to overcome physical space limitations and enhance capabilities for natural motion when exploring large-scale virtual environments, improving the sense of presence. Techniques include the covert manipulation of user position or rotation to altering the geometry of a virtual environment. Several methods are used to mask redirection techniques, such as the obstruction of view of a user, to using visual or auditory elements to divert the attention of users away from the redirection technique. One recurring masking strategy is the utilisation of a distractor, which attracts user attention by a visual or auditory object, or interactors, an object which engages the user in a series of focused interactions. We provide a simple framework to categorise various masking strategies, to create a general understanding of the usage and implementation of these masking techniques. To validate and demonstrate the usefulness of this framework, we map it against a collection of papers that use masking strategies in different contexts. We identify the types of masking strategies and provide a generalised implementation outline. This provides further insight and understanding of the inner workings of these attentional diversion methods.

CCS CONCEPTS

• **Human-centered computing** → **Virtual reality**; Mixed / augmented reality; • **Computing methodologies** → **Perception**; **Virtual reality**.

KEYWORDS

virtual reality, redirection techniques, redirection masking strategies

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1 INTRODUCTION

Research within the field of redirection techniques aims to overcome physical tracking space limitation and enhance the capability for using natural locomotion to navigate potentially large virtual environments, increasing sense of presence [15]. Additionally, researchers have implemented virtual objects within their experiments to divert the user's attention away from the redirection technique or engage the user into some sort of interaction. Visual or auditory objects can be used to mask subtle changes in orientation or alterations to the geometry of the virtual environment.

However, within the field of redirection techniques, there is a problematic proliferation of new definitions, especially regarding distractor objects, each adding a new label to the literature pool resulting in ambiguous terminology within the domain. To our knowledge there is only one paper which attempts to categorise the numerous amount of redirection techniques, Suma et al. (2012) [14]. However, this work is limited to the likelihood of detecting the redirection and its geometric flexibility.

During our research we have found numerous redirection masking strategies, one of which being attention diversion methods. Within this work we categorise these methods into distractors and interactors. To create a general understanding of the usage and implementation of these masking techniques we gathered papers through informal snowballing, using the work of Suma et al. (2012) [14] as a key starting point, complemented with later papers which inspired us to create the framework. Our results and the corresponding blueprints allow both researchers and developers to identify and utilise attention diversion methods optimally, and allowing them to speak a common language.

The remainder of this paper is structured as follows. In section 2 we provide a very short review of key concepts and related work on frameworks and definitions of masking strategies. We then present our framework in section 3, where we elaborate on the aspects of the attention diversion method and its components. Finally, we validate our framework against several papers in section 4, and end the paper with a discussion and conclusion (section 5 and 6).

2 RELATED WORK

The literature we gathered for related work, as well as for informing and validate the framework was collected through informal snowballing methods, within the domain of interest. To our knowledge, only Suma et al (2012) provides a taxonomy of redirection techniques, so we used this as a seed paper [14], alongside a number of other classical papers [1, 11–13, 17], and gathered relevant papers that either cite these papers or were cited by these, and then iterated, alongside more regular paper search strategies. See the start of section 4 for more detail.

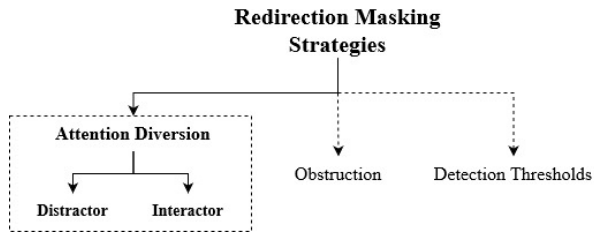


Figure 1: Overview of the redirection masking strategies

2.1 Redirection masking high level overview

To compress a large virtual environment within a smaller physical space, many studies have introduced redirection techniques to mitigate the space problem. This ranges from altering the geometry of an environment [12, 13, 17] to manipulating rotations and translation movements of a user during movement [9, 18]. Additionally, researchers include objects within their experiments to divert the user's attention away from the redirection technique. Initially introduced by Peck [8], the distractor manifested itself as a visual object moving around the user diverting their attention away from a rotating environment. Later works introduced methods more integrated within the narrative of the experience [1, 11] to adaptations being labelled as 'interactive distractors' [3, 4].

2.2 Categorisation frameworks for redirection masking

Aside from introducing new terminology, some researchers have provided more structure to the domain. One example included the categorisation of redirection techniques according to the likelihood of detection by the user against their geometric flexibility [14]. Additionally, several researchers have given an overview of specific redirection techniques [6, 16]. Here, each individual technique is explained in their initial experiment and no implicit instruction regarding the implementation is given. Apart from these works, few categorisations explicitly cover redirection masking strategies and provide guidance regarding their implementation.

3 REDIRECTION MASKING BY ATTENTION DIVERSION

This section introduces our framework regarding attention diversion methods used to mask redirection techniques. As seen in figure 1, these are part of a range of specific redirection masking strategies. Each of these can be most suited to minimise detection of redirection techniques at a specific key point within a particular VR experience.

The obstruction strategy utilise the overall geometry of the environment or objects to block the user's view to mask the technique, and detection thresholds involve the utilisation of perceptually undetectable gains applied to the user's movement. In addition, we identify attention diversion methods, which form the scope of this paper. The method utilises objects such as distractors and interactors, which aim to divert the user's attention away from the redirection technique. The use of these masking techniques results in a more seamless experience, preferably while being integrated

within the environment, aesthetics, or narrative of the experience [4]

Masking strategies occurring in experiments are often segmented throughout the experience. Therefore, this paper will refer to such a segment as a redirection 'encounter': spatial-temporal segments of the VR experience where the user encounters a redirection technique, including a masking strategy. Within these encounters, masking objects are often assimilated within the environment or narrative to enhance user engagement during the VR experience.

In the following sections, we present a structure for the framework regarding the attention diversion methods using interactor and distractor objects. These objects aim to lower the chances that redirection gets detected, and can be instantiated statically, by the placement of the developer, or dynamically, by a system-specified location within the encounter. Furthermore, we will elaborate on how these encounters are frequently implemented within the experiments, further referred to as 'blueprints'. This framework is beneficial to developing redirection masking strategies as a joint theoretical and practical framework for developing experiments and formulating hypotheses.

Examples of our hypotheses are as follows. Firstly, the literature primarily refers to objects as being an "interactive distractor", yet these would be static interactors which are custom-made specific to their experiments. Secondly, we hypothesise that dynamic objects have a more intricate complexity over their static counterparts, as the objects must be designed and implemented for usage in encounters initiated by the system; Thirdly, we hypothesise that complex interactors and distractors, which use sequences of interactions and diversion objects, are most suitable to retain user attention within custom-made experiences.

3.1 Interactors and Distractors

Distractors are virtual objects with visual or auditory features or a combination of both. Note that these virtual objects are not necessarily visible; they could appear as a gust of wind or a sudden uttering of words coming from an opposite direction within the environment. Distractors are used for multiple redirection techniques when their implementation and appearance are altered befittingly. They may be fixed in place or have the possibility for dynamic movement within the virtual environment, but their goal, diverting the user's attention, remains the same.

During our observations, we discovered some objects being labelled as distractors. However, they had different characteristics which did not conform to the distractor characterisation as they enticed the user into interacting with the object. Nevertheless, these objects also belong to the family of attention diversion methods, as they share the same goal.

Therefore, we introduce the interactor, a strictly visual object that attracts the user's attention by enabling interactivity. They share some of the characteristics of the distractor, manifested as virtual objects with visual and auditory features. However, they differentiate themselves by not being fleeting and not depending on the element of surprise to divert attention effectively. Instead, interactors engage users in the interaction and are often embedded within the narrative's goal by completing tasks. e.g. solving a puzzle to open the door to the next section of the environment. Refer to

Table 1: Distractor and Interactor Characteristics

Interactor	Distractor
Attracting attention to the stimulus	Diverting attention to the stimulus
Active engagement with the object	Passive engagement with the object
Object mostly immobile	Object mostly mobile
Object must be visible	Object could be auditory

	Static	Dynamic
Distractor	Visual / Auditory cue(s) emitted at a pre-defined location	Visual / Auditory cue(s) emitted at a system-specified location
Interactor	Interactive object(s) positioned at a pre-defined location	Interactive object(s) positioned at a system-specified location

Figure 2: Categorisation of objects according to their types.

table 1 for an overview of the disparities between the distractors and interactors.

We define interactors and distractors as follows:

Distractor: *Decreasing the noticeability of the redirection technique by creating, or awaiting opportune moments within the Virtual Environment.*

Interactor: *Decreasing the noticeability of the redirection technique by diverting the user's attention to the task or interaction.*

As seen in figure 2, they can both be static or dynamic. When one is a static interactor or distractor, they appear at a particular location or during an event within the encounter. Examples include most custom-made VR experiences where events need to happen in a sequence for the redirection technique to have the most effect. However, dynamic distractors or interactors appear at system-specified locations or moments in the encounter when conditions are being met. For instance, experiments where users naturally traverse significant distances often include masking strategies invoked on dynamic occasions, e.g., when the user strays away from the optimal path. Furthermore, in the following sub-sections, we will delve further into the implementation blueprints of these attention diversion methods.

3.2 No Diversion Blueprint

During the encounter, the user is more likely to notice the redirection technique when no diversion object is included in the implementation blueprint. However, other redirection strategies such as 'detection thresholds' or 'obstruction' could be implemented to mask the redirection technique.

3.3 Simple Diversion Blueprint

The main characteristic of this diversion blueprint's implementation is the utilisation of a distractor or interactor. In most cases when employing a distractor, the user needs to enter a specific area within the environment that would trigger the distractor object's instantiation. In contrast, interactor objects are placed at specified locations for the user to engage with.

An example of a visual distractor utilising a simple blueprint is a bird flying around the user, and a gust of wind is an auditory one; of course, the two can be combined to create even better distractions. In figure 3, one can see some examples of interactors adhering to the simple diversion blueprint. During exploration, the player stumbles upon these objects, which could be picked up. Shortly after the interaction, the geometry of the environment behind the user is altered, enabling the user to explore a different region of the environment. This is because attention was diverted from the redirection technique to the object of interest.

3.4 Complex Diversion Blueprint

Complex diversion blueprints, however, are more enigmatic in their implementation. These often include multiple distractors, multiple interactors, or an interactor with a subset of several interactions, or a combination of the two. While its implementation is somewhat ambiguous, its effectiveness in masking the redirection techniques is paramount, especially when the object's appearance is in close correlation to the surroundings and aesthetics of the overall VR experience, or the interactivity closely linked to the experience's narrative.

4 VALIDATION OF FRAMEWORK AGAINST LITERATURE

To validate our hypotheses made in section 3, we conducted a preliminary literature survey [1–5, 7, 10–12, 17, 19]. A sample of candidate papers were selected using the following criteria: usage of a distractor or an interactive object (interactor) within the experiment, implementation of the distractor or interaction integrated within the nature of the VR experience or being tested in isolation.

The experiences from the papers are divided into encounters, each time a occurrence of redirection masking is presented. These occurrences are categorised as distractors or interactors and whether they are statically or dynamically instantiated. Furthermore, we indicate each occurrence into their respective type of diversion strategy. Finally, we create interaction blueprint diagrams which indicate the general flow of the encounter.

From the 11 candidates we have identified 18 encounters introducing the user to the masking strategy. Table 3 presents the results regarding the categorisation of the types.

4.1 Results

As we can observe in the second column in table 2, researchers are using a wide variety of definitions regarding the taxonomy of the distractor. New patterns can be observed with our set definitions and more strict classification. For example, papers 9, 10 and 11 define their objects facilitating the attention diversion as 'interactive' distractors. However, they are essentially static interactors, as seen from the fourth column, apart from one encounter from paper



Figure 3: Three interactors used in a experiment reduced the detection of a redirection technique considerably

10. Here the user needed to focus on a moving object, which are characteristics of the distractor. Therefore, making the distinction between a distractor and an interactor is the right choice, thus supporting our first hypothesis.

Secondly, we observe that static interactors and distractors are most frequently used within the encounters (see also within table 3). This is due to the fact that most experiments within the literature survey were custom-made, by the researchers or by the developer. However, the dynamic types were the most complex in their encounters, as these are often developed to be used in larger virtual environments. Here the chance of the user entering the boundary of the tracking space is higher, therefore the diversion needs to be instantiated dynamically. As not many dynamic objects were extracted from the survey, the second hypothesis will have to be addressed in our future work. Consequently, we think that with the emergence of procedural-generated VR content with redirection techniques, the majority of the diversions would be dynamic.

Thirdly, when observing table 4, we see that both simple and complex blueprints are used at similar frequencies. Within the simple blueprint column, we can see that the static distractor is most commonly used, with the static interactor as the runner up. However, in the complex column we can see a clear preference for the static interactor blueprint. Supporting our third hypothesis regarding the inherent effectiveness of the static interactor within custom-made experiences.

Using our framework, we could find extra patterns and derive implementation blueprint diagrams using the generalised encounters from across these papers. We have extracted the following interaction blueprints from the analysis of the encounters within figures 4 and 5. When observing figure 4, most encounters are initiated when the user enters a pre-defined location before triggering the distractor, or engaging with the interactor. After this user attention is diverted resulting in the redirection technique being masked. However, within figure 5 we see some slight alterations to the implementation flow. Here the distractor and interactor objects are accompanied with an action sequence containing multiple steps, each time the user performs an action their attention is diverted, resulting in multiple masking moments.

5 DISCUSSION

In this work we have conducted a survey with the aim to understand attention diversion methods such as distractors and interactors,

which greatly reduces the detectability of redirection techniques. We have analysed recent works regarding the utilisation of the diversion methods and categorised them according to their object type and implementation blueprint. Within our framework we have laid the foundation of understanding the inner workings of attention diversion methods. We have defined the attention diversion strategy, categorised the difference between the objects and their types and extracted a generalisation of the implementation blueprints.

Our current work is mostly limited to academic publications. In future work, we would like to explore other redirection masking strategies being used in commercial VR games. Secondly, we would like to investigate the relationship between the masking strategies, the context of the encounter and the aesthetics of the environment, and the impact on perception of presence and immersion. Thirdly, we assume that more variants of blueprints will emerge when implementing multiple redirection techniques. We would like to experiment with the blueprint structure in various encounters and narratives with different sets of redirection techniques. Finally, we would like to include obstruction and detection threshold masking strategies to our framework.

6 CONCLUSION

This study aims to develop a basic understanding of attention diversion methods used to mask redirection techniques. We categorise the occurrences of distractors and interactors in relevant research, provide an overview how users are introduced to a masking strategy during an encounter, and describe how these encounters manifest themselves within the virtual environment.

Using our categorisation, we have identified the interactor, an attention diversion method sharing characteristics with a distractor but attracting user attention by enabling interactivity. We have discovered that distractors and interactors sharing a complex interaction blueprint are most suitable to retain the attention of a user within custom-made experiences. Using this framework we have developed best-practice that game researchers and developers can use to gain insight on effective utilisation and application of the encounter flow-diagrams when leveraging distractor and/or interactors.

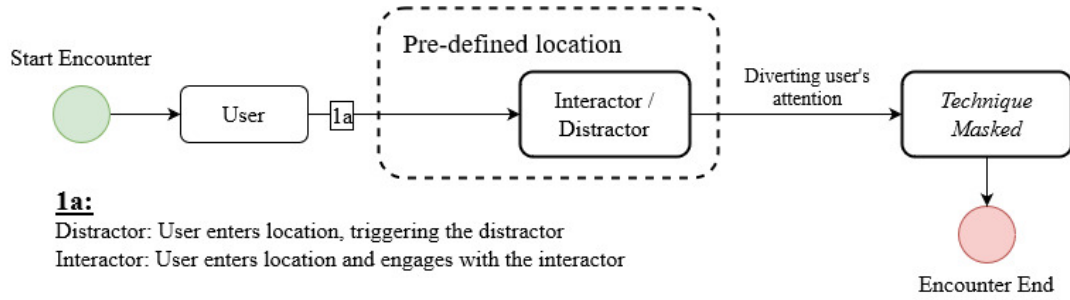


Figure 4: Simple Diversion Blueprint implementation flow.

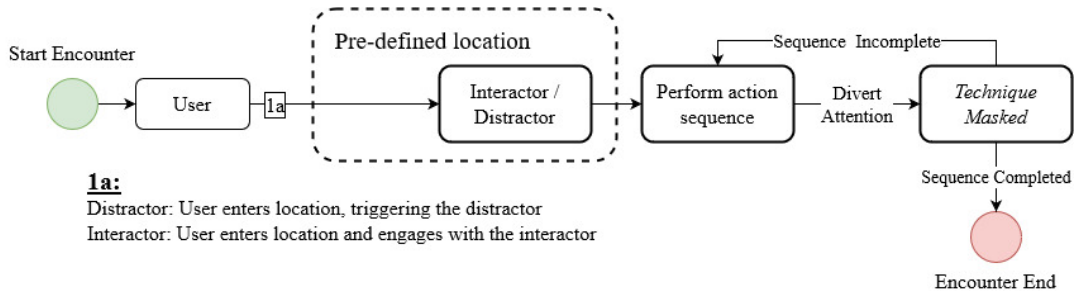


Figure 5: Complex Diversion Blueprint implementation flow.

Table 2: Context Dissection Diagram

Author	Taxonomy	Encounter ID	Type	Blueprint
Suma et al, 2011	-	1a	Static Distractor	Simple
Vasylevska et al, 2013	-	2a	Dynamic Interactor	Simple
Chen & Fuchs, 2017	Immersive Distractor	3a	Dynamic Distractor	Simple
		3b	Dynamic Interactor	Complex
Yu et al, 2017	-	4a	Static Interactor	Simple
Sra et al, 2018	Attractor	5a	Static Interactor	Complex
		5b	Static Distractor	Complex
		5c	Static Interactor	Complex
Langbehn, 2019	Task	6a	Static Interactor	Complex
Cools & Simeone, 2019	Distractor	7a	Static Distractor	Simple
		7b	Static Interactor	Simple
		7c	Static Interactor	Complex
Ciumedean et al, 2020	Challenge-Based Distractor	8a	Static Distractor	Simple
Paulmann et al, 2021	Interactive distractors	9a	Static Interactor	Complex
Schmelter et al, 2021	Interactions as distractors	10a	Static Distractor	Simple
		10b	Static Interactor	Simple
		10c	Static Interactor	Complex
Coelho et al, 2022	Distractor / Interactions	11a	Static Interactor	Complex

Table 3: Type Frequency Analysis

Type	Static	Dynamic
Distractor	5	1
Interactor	10	2

Table 4: Blueprint Frequency Analysis

Type	Simple	Complex
Static Distractor	4	1
Static Interactor	3	7
Dynamic Distractor	1	0
Dynamic Interactor	1	1

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