Immersive Sampling: Exploring Sampling for Future Creative Practices in Media-Rich, Immersive Spaces

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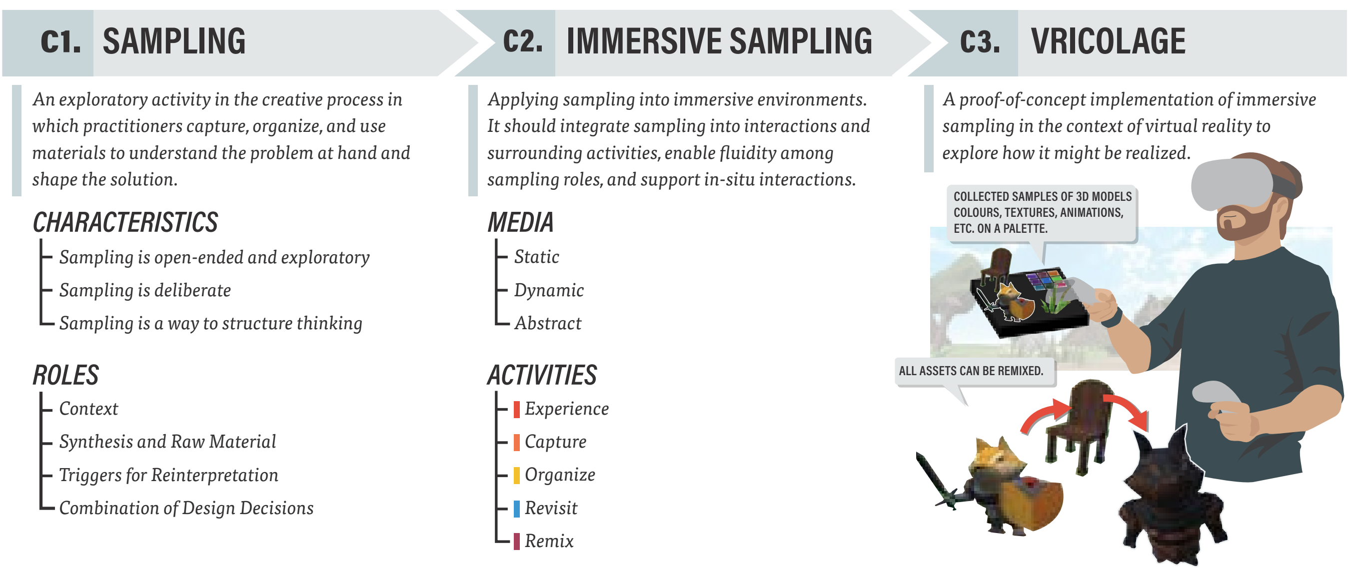

Figure 1: We explore *Immersive Sampling* as a way to support creative practitioners in immersive environments, grounding this concept in characteristics and roles found in the literature. With Immersive Sampling, we focus on a set of media types and activities that are relevant for immersive environments and embrace the opportunities they may provide for creative practitioners. Based on this subset, we present VRicolage, a proof-of-concept implementation of a set of VR interactions to experience, capture, organize, revisit, and remix content in immersive environments.

ABSTRACT

Creative practitioners rely on *sampling* to understand, explore, and construct problems; or gather resources for later use. Despite practitioners' ability to *experience* immersive environments, *sampling* from them remains limited to primarily visual captures (e.g., screenshots, videos), which overlook the richness and variety of available media. To address these challenges, we describe "Immersive Sampling" as a new way to frame information gathering in the context of immersive environments. In the context of Immersive Sampling, practitioners engage in experiencing immersive environments while capturing, organizing, revisiting, and remixing found content. We situate this subset of tasks in literature and argue for their importance for emerging, future content creation domains. To further explore how Immersive Sampling might take place, we created VRicolage, a proof-of-concept prototype showcasing a set of interactions in Virtual Reality to sample, revisit, and remix captures. Given the democratization of immersive environments, Immersive Sampling provides practitioners with a means to collect, revisit, and remix digital materials.

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CCS CONCEPTS

• **Human-centered computing → Human computer interaction (HCI)**; *Mixed / augmented reality*; • **Applied computing →** *Media arts.*

KEYWORDS

Creativity Support Tools, Immersive Environments, Creativity Support Environments, Sampling, Immersive Sampling, Remixing, Virtual Reality, Mixed Reality, VRicolage

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1 INTRODUCTION

As part of the creative process, practitioners sample the real world as a way to understand and approach the problem at hand [17, 40]. Sampling is thus a component of what is known as *problem construction* [95]. Given how creative practice is rooted in open-ended problem solving, both problem and solutions co-evolve [22], and practitioners will have unique approaches given their lived experience, expertise, environment, and other influencing factors [3]. Part of what shapes these individual approaches lies on what frames the problem – the existing alternatives, prior solutions to similar problems, instigators for ideas, and comparable notions. These elements can largely come from collected materials and resources such as collected clippings and found objects [40, 70], digital captures such as photos made via the camera [2, 93], or through digital collections from the web [42, 76, 121]. Thus, the process of sampling can help inspire new directions, evolve current ideas, or enable the combination of past ideas [40].

One source of untapped potential for sampling are *immersive* environments, as they provide media-rich spaces that can be explored in first-person and at scale. Immersive environments have access to a whole sleuth of data and information about the existing environments, which, if treated similarly to the DOM in web design (i.e., open and transparent to end-users), can democratize and empower a new generation of content creation as creators can access and work with materials anytime, anywhere. Past work (e.g., [50]) shows that a wide variety of media can and is used for inspiration. However, there are no established methods for conducting sampling within immersive environments. In fact, with existing sampling methods, creative practitioners are limited to 2D approaches, such as relying on screen captures as photos (e.g., [84]) or videos, and other approaches such as camera-based capture [93] are designed for specific, phone-based contexts. These approaches enable accessing minor metadata at best, and do not enable ways to re-engage with the content or its context. In addition, while sampling is somewhat understood across domains such as music production [54], design [9, 17, 40], and manufacturing [29, 90], it is not clearly articulated within creativity literature. The term is typically associated with a very particular context in music, i.e., working with existing recordings [99]. The missing link between applied contexts that discuss sampling [17, 40], and creativity literature is that sampling can be seen as different stages and activities in the creative process coming together. If we are to articulate sampling in the context of immersive environments, sampling itself also needs to be characterized and better understood.

In this paper, we specify and explore *Immersive Sampling*, a potential future practice for creatives in immersive environments (Figure 1). To support and contextualize Immersive Sampling, we first provide a characterization of sampling in creative practice. We then leverage the values of sampling to shape immersive sampling as a concept. Immersive Sampling is meant to transfer established sampling-based workflows to immersive, digital spaces, while transcending the boundaries imposed on them through physical environments. To explore how immersive sampling might take place today, we demonstrate relevant interactions in a VR proof-of-concept (VRicolage), an environment that can foster open-ended exploration, the capture of materials, organization of assets, revisiting of contexts, and remixing of materials. We then reflect on and discuss how these techniques may function and evolve as creativity support tools and environments, how Immersive Sampling further alters ownership and attribution, and how it might co-exist with and augment existing practices.

Specifically, we contribute:

C1. **A characterization of sampling in creative practice** which focuses on its roles in creative processes and the characteristics that it fulfills.
C2. **Formalization of *Immersive Sampling*,** a sampling paradigm for media-rich immersive environments, full of untapped potential for creative practitioners, situating existing practices and enabling exploration of future opportunities for creative practitioners.
C3. **VRicolage, a proof-of-concept set of interaction techniques for Immersive Sampling**, illustrating how one can explore, capture, organize, revisit, and remix materials for creative practice in immersive environments.

2 WHAT IS SAMPLING?

We define sampling as *an exploratory activity in the creative process in which practitioners capture, organize, and use materials to understand the problem at hand and shape the solution. This activity involves collecting materials, organizing them, and transforming them by decomposing, re-contextualizing, and combining them.*

While sampling might typically be associated with early stages of the creative process, Sawyer describes how models of the creative process attempt to articulate steps but often take place throughout the entire process [99]. One of the primary ways of constructing problems in creative processes is by immersing oneself into the situation [52]. This activity can be found in the literature under different terms such as: acquiring knowledge, gathering information, and incubation [99]; immersion and play [113]; information gathering and concept search [101]. We choose the term "sampling" over the former alternatives due to it implying both the collection and usage of the materials (similar to Eckert and Stacey's take on inspiration [25]), and its use within Human-Computer Interaction [40].

2.1 Characteristics of Sampling

Past literature describes different characteristics that distinguish sampling from a simple information-gathering process, such as in broader knowledge work.

Sampling is open-ended and exploratory. Mumford et al. [80] describe information gathering as an exploration with openness to new experiences. Sawyer articulates that creativity is rooted in an awareness of the unexpected and seemingly unrelated information in the environment: *"Creativity involves being aware of a variety of information in your environment, and being able to spot opportunities to link new information with existing problems and tasks"* [99].

Sampling is deliberate. Both Wallas [119] and Kaufman [52] describe problem construction as a deliberate, voluntary, and regulated process. Kaufman [52] adds that while the process is often automatic and people may gravitate towards particular ways of framing problems, more creative individuals actively engage in this stage. Problem construction is described as an often overlooked stage, but one where more experienced practitioners spend a significant amount of time compared to novices [52]. Sampling becomes a part of a creative practitioner's deliberate practice [99].

Sampling is a way to structure thinking. Past work discusses how people are more creative when they can structure informational search and keep relevant information at hand [78]. To absorb relevant categories and information requires critical thinking and evaluation in deciding what to look for [79]. Moreover, the ability to look and learn helps practitioners uncover implicit assumptions and search for inconsistencies [7]. Scott et al. discuss how collected information can inspire conceptual combination - stimulating new ways of thinking such as analogies, metaphors, and feature comparison [101]. Sampling acts as an anchor for structuring mental representations of designs [25].

2.2 Roles of Sampling

Greenberg et al. [40] describe "sampling the real world" as a technique for early stages of the design process. They discuss how found objects, camera samples, and physical collections can inspire new directions, evolve existing ideas, or remix a variety of ideas. Another term that is often used when describing sampling is *inspiration*. Eckert and Stacey [25] describe sources of inspiration as elements such as a *starting point* (a design that gets modified to make a new design); *precedent* (the establishment of a type of solutions to a problem), *reuse* (using existing components in a new context), *pattern* (an abstraction of a solution), and *primary generator* (a feature that shapes the design direction). They briefly outline how sampling can hold different roles, which we expand upon next.

Sampling as Context. Sampling acts as a context in which new designs are created, and outlines a space to situate new designs [25]. The context might include past solutions, and interesting concepts that can be adapted (e.g., moods). Moreover, the increased evaluation in selecting what to sample [79] means that both the problem space and solution space become constrained or bounded by the context outlined by the practitioner. This context setting serves to explain the importance of different kinds of formalization of information, such as through mood boards, and why they support framing, aligning, paradoxing, abstracting, and directing [69].

Sampling as Synthesis and Raw Material. Sampling enables synthesis of collected materials into new designs [25]. Sampling can be used to explore and collect references, raw materials, and mediums. Nowadays, The extraction and decomposition of a sampled material, whether it is the colours and typography of an image, or the notes or rhythm of a song, can be used as individual elements that integrate into the new solution: the sources of inspiration hold chunks of information [25]. Ultimately, this view on sampling frames creative practice similar to the Bricolage movement in that creation happens with the materials available, whether they are tangible or abstract in nature [23, 64], namely, a *remix*. *Remixing* holds a long history as a practice leveraging and reusing materials [10, 35, 81], and applies to practices including 2D collages in architecture [1], assemblage for 3D objects [71], kitbashing in prop and set design [74], and re-designing 3D-printable artifacts [29]. Because of the different abstractions, remixing can serve as a way to lower the barrier of entry to a particular practice [14, 29, 111]. This is why HCI has taken direct inspiration from Bricolage and remixing, such as in the domains of digital fabrication [29, 87, 109, 110], web design [60], craft [26], and interaction design [117].

Sampling as Triggers for Reinterpretation. Lucero's studies on design practitioners showed how inspiration plays a key role in providing new perspectives for a problem, and a way to step outside what they know and let ideas percolate [68]. Eckert and Stacey [25] describe how inspiration sources can work similarly to creating sketches, as each time one interacts with the information leads to a new way to look at the materials in the context of the problem and solution. Indeed, the combinatorial nature of inspiration material is discussed in the literature [78, 80, 99, 101]. In particular, sampling can foster emergent designs [18] while structuring means to think about combination, metaphor, analogy, and first principles [98].

Sampling as Combinations of Design Decisions. Every found object or clipping used as inspiration holds a series of successful design decisions that were brought together, creating a complex array of interconnected design elements [25]. One can reflect on the ideas that led to the particular solution, or tear down the object to see in more depth how different ideas were brought together [92, 123].

3 IMMERSIVE SAMPLING

Distilling and defining sampling not only provides motivation for this work, but also informs what to consider when adapting sampling to immersive environments. While there are known techniques for sampling in the physical world and in 2-dimensional screens, such as by cutting clippings, taking photos with a camera, taking screenshots and videos on the computer [20, 69, 84], there are no methods for sampling in immersive environments besides adaptations of 2-dimensional screen grabs and video captures, though one could consider spatial sampling methods [2, 93] as a potential starting point.

3.1 Design Rationale

The first step to define immersive sampling, is to draw boundaries as to the core design decisions that frame how a practitioner might work in that space.

DR1. Experience. *Integrate Sampling into Immersive Environment Interactions and Surrounding Activities.* The open-ended and exploratory nature of sampling means that the operations that support the collection and (re-)mixing of media should be available at all times. It is important to note that, unlike the real world, immersive environments are not bound by the laws of physics, which means that it is possible to clone objects, alter the flow of time, or arbitrarily change scales [75]. When sampling is woven into the experience itself, it might become more accessible with less friction, as it will not be a visuals-only workflow (e.g., screen-capture tools like OBS or NVIDIA Ansel [84]), or require domain knowledge (e.g., game asset "ripping" [127]) to collect assets.

DR2. Materials. *Enable Fluidity Between Context, Synthesis and Raw Material, Reinterpretation, and Combination of Design Decisions.* A typical sample defines a particular focus and framing: taking a photo of a place will focus on, for instance, a landmark; this might ignore related or tangential aspects. Yet, the practitioner may have been inspired not only by the landmark but also by the surrounding journey and ambiance. That means that the capture acts as a visual memento [115]. Another augmentation lies in decomposing media objects to their parts, whether the decomposition is about extracting parameters such as meshes and colours (e.g., as done in [50, 59]), or parts of a whole (e.g., grabbing only the wheels of a car model). Through these types of augmentations, it is possible to stay true to and expand the roles of sampling while supporting discovery, serendipity, and inspiration through these elements, that may have stayed hidden in a fully-composed interactive experience.

DR3. Interactions. *Enable In-Situ Interactions.* Given the three-dimensional nature of immersive environments, the way media is presented is akin to the real world [75] – one interacts in first-person and in space. In the same way a person in the physical world can grab their camera or sketchbook, or physically collect objects, we believe it should be possible to do the same in an immersive environment. This is in contrast to applications that are isolated design environments (e.g., products [39] or academic prototypes [4, 61]). We envision that *any* immersive space can be a design and sampling environment for a creative practitioner. Such an environment would enable the collection of material or references, their organization in a margin space [30] within the experience, yet separate from it, and enable the transfer of samples to the creative practitioners' various workspaces and tools [89].

3.2 Media

Considering the design rationale DR2, it becomes important to note that immersive environments act as rich compositions of media. This media can include visual elements, including motion, as well as sound, behaviour, and interactivity. The interactions take place in-situ (DR3), which means practitioners can manipulate objects (DR1) in ways that they can create new contexts, synthesize the media, repurpose it, reinterpret it, and distill how the virtual object came together (DR2). Given the dimensions of contemporary immersive environments, we separate media types into three categories: static, dynamic, and abstract media. While immersive sampling is grounded in past literature, it is by no means complete, and future work could explore other aspects, such as haptics, as experienced in physical and future immersive spaces [102].

Static Media. refers to media elements that do not change over time. Systems such as Window-Shaping [48], CATS [104], VRFromX [49], and MoodCubes [50] show ways for media to be decomposed, such as meshes, skeletons, textures, images, or colours.

Dynamic Media. refers to elements of a scene or object that change over time. For instance, this includes sound as well as animated motion [120], interactive behaviour, or other changing properties (e.g., colour or shape change).

Abstract Media. is a category of media that cannot be reliably classified as static or dynamic. This refers to moods or feelings evoked that people might feel as they experience an immersive environment, akin to the notion of "mise-en-scène", emerging from *combinations* of media elements. One way to "author moods" is by the co-located arrangement of different objects and colours [50]. Alternatively, one can leverage lenses (e.g., colours or textures) to change the perception of a scene.

3.3 Activities

Immersive Sampling consists of a set of *activities* that we deem crucial for sampling in immersive environments. They are both derived from the roles of sampling and their characteristics (section 2), along with the inherent opportunities immersive environments may entail for creative practitioners, formulated in the design rationale (subsection 3.1). Shneiderman presented four phases for creativity-supporting technologies: collect, relate, create, and donate [106]. Immersive Sampling is meant to support these steps, but primarily focuses on collecting (through sampling), relating (through organization and revisiting), and creation (through remixing).

Experience. *Open-Ended Explorations of the Environment.* This involves the conscious engagement and experiencing of environments as the first step [80]. While this type of engagement is potentially enabled by any immersive experience, having practitioners enter the space with an exploratory mindset, and knowing that there are tools available to carry out sampling, changes how they will interact with it, and what they will look out for.

Capture. *Collecting Found Virtual Objects.* Capturing involves the selection and collection of specific elements of a virtual object or scene, with the goal of retaining these aspects in accordance to DR2. Sampling can also be augmented by simultaneous suggestions, based on the object being sampled, or other preemptive capturing [56]. This step is present in both commercial products [2, 93], and academic research [38, 104]. The other aspect to consider when it comes to capture is the "what" of the capture – is it the object as a whole (e.g., a 3D model of a car), a part of it (e.g., the 3D model for the wheel), or decomposition of the elements and parameters of the object (e.g., colours, textures, motion)?

Organize. *Giving the Samples a Place.* While gathering samples from different environments, practitioners need to organize and sort their collection of samples. Some of these materials will go deep into cold storage, while others may stay "hot and active" [72], which can lead to externalizations such as scrapbooks [47], moodboards, or other asset databases [50, 96].

Revisit. *Going Back to the Source.* We consider ways to revisit the source environments of sampled assets to be a relevant addition to sampling-oriented creative processes. Revisiting is meant to link samples and their original environments in a way that lets the creative practitioners freely transition between these spaces [126]. This is a core benefit of Immersive Sampling, which facilitates almost instantaneous "travel" to different environments and experiences.

Remix. *Combining Samples.* For sampling that is targeted at gathering assets, the remixing step becomes an indispensable way to "apply" materials, properties, or assets that have been sampled to other samples or artifacts designed by the creative practitioners themselves. The remixing step is present in literature, and focuses on sampling the physical environment [66] or digital artifacts [111] to alter and combine sampled materials [10, 29, 81].

3.4 Design Space

Combining the activities outlined in 3.3 with the types of media presented in 3.2 yields a design space to arrange prior work and the novel interaction techniques of VRicolage within Table 1. With this design space, we follow the notion outlined by Wiberg and Stolterman of "generic design" [125], to illustrate the potential of Immersive Sampling, to map out the respective dimensions, and situate representative interactions in the space [125]. We further engage with "proof-of-concept design" [125] through the development of VRicolage, to verify the notion of Immersive Sampling and demonstrate a probe of this design space. With VRicolage, we primarily focus on sampling, revisiting, and remixing, but implicitly cover the experience step, as it is covered by any VR application that provides the user with sensory input. We similarly cover the organization step, by providing a rudimentary set of interactions necessary for it. The Y-axis of the grid lists the three media types from subsection 3.2. VRicolage provides interactions for all three categories. Albeit, as outlined in Table 1, there is a rich variety of media that could be interacted with additionally or differently.

Aspects of this space are covered by prior art (e.g., [28, 48–50, 66, 104]. This list is not exhaustive, but consists of recent works that highlight interactions that are either situated in creativity-support tools (e.g. [50, 104]), or are situated in mixed reality research (e.g., [28, 66]). These two distinct approaches can be unified under the notion of Immersive Sampling. Sampling is supported by several creativity-support tools, but is often tailored toward *literal* captures of static media. Sampling, especially of the real world, is similarly reflected in systems that focus on authoring of VR or AR experiences (e.g., [49, 82, 122]) to ease the burden of manual design of such experiences. Organization is a relevant step for moodboard-like applications (e.g., [50]), while revisiting of scenes [66] and re-living of events [28] is a focus of works that do not concern themselves of being a creativity-support tool or environment. Remixing, in turn, is present in both creativity-support-oriented works (e.g., [50]) and more technical ones (e.g., [66]), where, as before, static media is highlighted more than dynamic or abstract ones.

We chose to focus on *immersive* sampling within this framework which has led to an emphasis on virtual reality and interactive experiences provided by this technology. However, immersive sampling applies to more "realities" beyond purely synthetic ones. We envision the act of sampling as a part of everyday creative practice. Beyond augmenting sampling (e.g., through suggestions or decomposition), such tools may facilitate meaningful revisiting (e.g., by digitally capturing entire scenes and providing this data to users on demand), and remixing (e.g., situated remixing processes that reference material in users' environments [66, 111]). This would cover sampling-focused engagement with the real world, as supported by creative practitioners' mobile devices (e.g., through camera apps or tools like [2, 93]). Additionally, the entire remainder (i.e., the real world, augmented reality, and augmented virtuality) of Milgram's and Kishino's mixed reality continuum [75] could be covered, ideally by applying the same techniques across all points and transitions [8] in this spectrum.

3.5 Related Work

VRicolage and Immersive Sampling can further be situated in several areas of prior research. Section 2 focused on the act of sampling in creative practice. The notion of Immersive Sampling was contextualized with prior art in section 3.4. The following sections outline the relationship between VRicolage and a set of research domains: augmented creativity support tools, immersive creativity support tools, and sampling and remixing in mixed reality.

3.5.1 Augmented Creativity Support Tools. Various novel digital systems have been developed to act as tools to support the practices of creative professionals and other end-users. These tools are generally labeled as "creativity support tools" (CSTs), and aim to support aspects like sketching [67], ideation [92] or later, more precise stages of design activities. Belakova and Mackay presented SonAmi, a CST for the context of writing, where a tangible interface generated audio to support the users' writing process [5]. Schlagowski et al. presented a VR tool focused on creativity support for music production, which leveraged the immersive environment to provide a highly customizable environment to end-users [100]. VRBox by Fröhlich et al. similarly leveraged VR to provide a sandbox-like interaction that incorporates real, tangible materials at the same time [34]. Moodboards were a point of consideration for several systems: Ivanov et al. presented MoodCubes, an approach to embed different media types into a spatial moodboard [50]. Kim et al. approached CSTs from a different perspective: one that embraces failures during design and ideation, supporting *experimentation* [53]. Several prototype systems further leverage AI (artificial intelligence) to enrich the interaction with moodboards or support a co-creative design process [56–58], for instance through intelligent suggestions [44], which we tried to replicate in a comparable fashion in VRicolage. Lastly, various works take a meta-perspective to evaluate and understand the state of tool adoption [89], research approaches and domains [16, 31, 32], creativity support in and through the context of search [13] or the use of web-based collection applications such as Pinterest [65]. VRicolage aims to augment and enrich creative practice, not only by adding novel functionality but also by

	EXPERIENCE	CAPTURE	ORGANIZE	REVISIT	REMIX
STATIC MEDIA	Experience static environment ...	3D-models, textures, colours ... *Window S. [48], CATS [104], VRFromX [49]*	Arrange, sort, compose ... *MoodCubes [50]*	Peek, re-immerse ... *Remixed R. [66], Async. R. [28]*	Arrange, scale, re-compose, transfer ... *MoodCubes [50], Remixed R. [66]*
DYNAMIC MEDIA	Experience + interact with animated environment, manipulate objects ...	*Motion, animation, physical properties* ... *CAPturAR [122]*	Arrange animated elements, compose group, sort ...	Peek, re-immerse ... *Remixed R. [66], Async. R. [28]*	Transfer, alter speed ... *Remixed R. [66]*
ABSTRACT MEDIA	Experience environment as a whole, engage with multisensory compositions ...	Mood, lighting, colour palettes ... Emotions ...	Create distinct arrangements by mood ... *MoodCubes [50]*	Peek, re-immerse ... *Remixed R. [66], Async. R. [28]*	Re-light scene ... *MoodCubes [50]*

Table 1: Overview of a framework to situate the activities of Immersive Sampling, with representative academic works (systems and toolkits) positioned in select cells. We consider this depiction to be a *slice* taken from Milgram's and Kishino's mixed reality continuum [75], focusing on immersive, virtual reality. The same media types and activities are applicable to concepts like augmented reality (AR), mobile devices, and to the interactions creative practitioners have with their physical environments. They would similarly apply to transitions between these paradigms, like sampling material from the real world into VR [49], or vice-versa [111].

providing a rich source for sampling. VRicolage shares a common motivation with these works, namely the support of innovation and creativity of users through digital technologies [105, 106] and asynchronous, distributed, and scalable *collaboration* between creative entities [35, 87] through sampling.

3.5.2 Creativity Support Tools in Immersive Environments. Several research prototypes focused specifically on creativity support in virtual and immersive environments [96, 97]. Zünd et al. used tablet-based AR to develop applications to support children's creativity and learning through musical apps, or AR-based colouring [129]. Simões et al. chose augmented reality to support the *design* of projection-based applications [108], focusing on designing *for* immersive environments. Lee et al. found that their VR design tool enhanced creative processes over the use of a 2D baseline in the fashion design domain [63]. VR-Design-Space by Zarei and DiPaola enhanced collaboration and creativity through a collaborative virtual reality setup [128] within an architectural context. Obeid and Demirkan found similar effects [85] comparing immersive and non-immersive (i.e., 2D, screen-based) versions of Gravity Sketch [39]. Herman and Hutka explored this dichotomy by focusing on the requirements of 2D artists working in VR [45]. Spacetime by Xia et al. presented a set of interactions to support collaboration between designers in VR, and allowing them to resolve conflicts while operating at arbitrary scales [126]. The aforementioned works helped inform the design of VRicolage. In contrast to these works, VRicolage aims to treat (Immersive) Sampling as the core component of any type of engagement a creative practitioner may have with non-design-focused virtual environments, similar to creative practitioners "sampling the real world" [40].

3.5.3 Sampling and Remixing in Mixed Reality. Concepts like mixed reality [75] have been used to augment design processes. The core benefit lies in the spatial and situated nature of these tools, which do not require mapping spatial samples to their 2-dimensional representations. Huo et al. presented WindowShaping, which is an in-situ design tool for 3D objects that allows designers to work in and with a real environment for a digital design [48]. Remixed Reality by Lindlbauer and Wilson leverages depth cameras and a head-mounted display to allow users to acquire their physical environment, and digitally alter it spatially (e.g., duplication of features), visually (e.g., recolouring), or temporally (e.g., looping a motion) [66]. Several works employed sampling as a means of authoring or prototyping virtual and augmented reality experiences: VRFromX allows designers to generate VR experiences from point clouds [49], CAPturAR supports the authoring of activity-recognition-based applications [122], and ProtoAR supports users in allowing them to author AR applications using tangible media [82] These approaches leverage outsourced design effort [111].

With VRicolage, we explicitly want to frame sampling and remixing in immersive environments as a creativity-support mechanism, and not necessarily a tool meant to yield finished designs. VRicolage and comparable approaches can therefore be considered a way to provide margin spaces [30] for users to collect and remix samples. This opens up a broader space for creative practitioners to engage in *"Sampling the Real World"* [40] – embracing *any* environment that may provide inspiration, references, and assets to sample.

Figure 2: Overview of Immersive Sampling through the lens of VRicolage

4 VRICOLAGE

The implementation of VRicolage demonstrates and explores our proposed interactions, and illustrates how they may operate within a sampling-focused creativity support environment (Figure 2). We envision VRicolage to serve as a creativity support tool in immersive environments, for instance, to support users in designing environments or interactive applications (e.g., games and experiences) for "traditional" and immersive applications alike.

We further assume that future immersive spaces will – and ought to – provide open access to their relevant design elements. A parallel to draw here is the web (2.0), where its elements (i.e., HTML for structure, JavaScript for functionality, and CSS for visuals) can be openly inspected to inspire practitioners and allow them to analyze, understand, and remix design and functionality [91, 103]. Despite attempts to obfuscate these components, they are ultimately transferred to the client and can be decomposed. This has supported techniques like "Mashups" [43, 91], combining entire applications. This openness also supported (web-)designers in their inspiration-gathering practices [55, 77]. We argue that this type and level of openness is essential for creative expression and creativity support in the domain of immersive environments and engage with this future through the lens of VRicolage.

The interactions within VRicolage are functional, but function within a scene specifically designed and prepared for them (i.e., one that is open to and tailored towards sampling and remixing). VRicolage was implemented using Unity3D, supported by a server component written in Python (using flask), connected to a MongoDB instance. The Unity application handled interactions and rendering for an HTC Vive Pro headset, the server component provided endpoints for suggestions and colour palette calculations, and the database stored the metadata for the stock photo dataset [116].

4.1 Experiencing

Immersive Sampling generally starts with users engaging with an immersive environment – they *experience* it and are, in turn, influenced by it. VRicolage allows users to move around 4 scenes (i.e., environments with a specific theme) in total, while also being able to freely move around in these scenes using room-scale locomotion or teleportation. Users can interact with the environment to explore and inspect objects in more detail.

4.2 Capturing

VRicolage provides several mechanisms to capture or sample elements within the scene.

4.2.1 Capturing Objects and 3D-Models.

Complete Objects. Users are able to sample entire objects from their environment by selecting and "collecting" them, as seen in Figure 3a. Within our scene, we avoided any optimization technique[1] that would compromise a designer's intended segmentation. Objects are an accessible way to segment a scene into logical units, and resemble the creative practice of collecting *physical* artifacts [6, 42].

[1] e.g., ones needed for techniques like draw call batching https://docs.unity3d.com/Manual/DrawCallBatching.html, Accessed: May 4, 2023

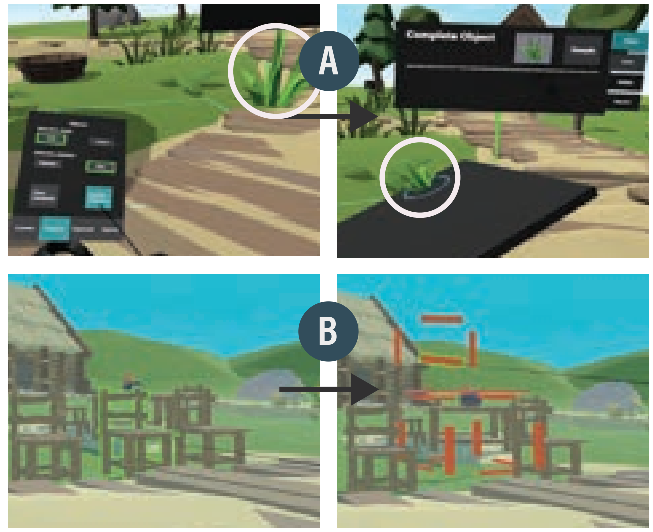

Figure 3: Sampling of scene objects using VRicolage. A) Sampling complete objects in a scene; B) Decomposing an object into parts to sample individually.

Parts. The sampling of parts is a level of decomposition that goes beyond the sampling of entire objects. It represents a method to capture parts of objects, or whichever logical unit is appropriate. The technique consists of 2 parts: allowing users to *see* parts of an object, and *capture* them separately if desired, seen in Figure 3b. To demonstrate this technique, objects in our scenes are designed with a hierarchical approach, common in 3D modeling, allowing the user to select from "assembled" or "nested" components.

Figure 4: Colour sampling. 1) selecting a region to sample colour from; 2) sampled colour with sampled and generated palettes, along with suggested stock photos below.

4.2.2 Sampling Colours.

Single-Colour Samples. The process of sampling separate scene colours is depicted in Figure 4. A user can trigger a ray-based selection of colour, by pointing at an object and pressing the grip of the controller. This accesses the texture coordinate of the ray-hit and interpolates the correct colour based on that. On click, the camera samples an image, which is quantized to its 5 most dominant colour clusters, of which the most commonly found one is returned, even if it may not be the one pointed at by the ray. Unlike the texture approach, the region-based camera approach incorporates colours as they are affected by lighting. These 2 approaches represent either a perceptual or a more technical approach, and provide an abstraction of colour information from the environments they are situated in. With this function, VRicolage provides methods found in products (e.g., [2]) meant for real-world sampling and applies them to the context of an immersive environment.

Palette Sampling. Users can also sample palettes of colours, in addition to individual colours. Each sample of a (single) colour taken, is automatically sampling additional colours to compose a palette. This allows users to sample the colour scheme present across a scene or multiple objects. To enable that, VRicolage uses a virtual camera, oriented in the same direction as the ray from the controller. On demand, it samples a low-resolution image, clusters colours, and picks the dominant one along with the 4 next common ones. Additionally, the palette is enriched through split-complementary and complementary colours to the dominant colour. Through this, users can capture more abstract and complex compositions. This can facilitate capturing more abstract aspects, such as mood — this is reminiscent of mood conveyed through tone-on-tone paintings [50].

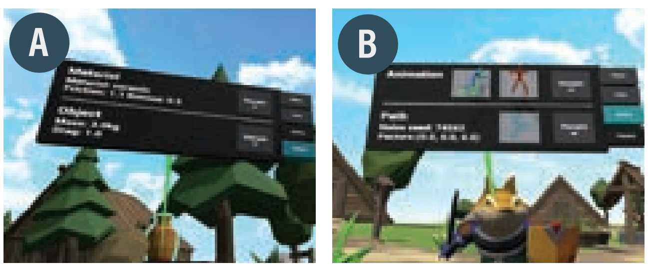

Figure 5: A) Sampling physical properties: selecting an object with physical properties opens an information display showing its properties; B) Motion-visualization for sampling: An avatar's motion in place and its walk-path.

4.2.3 Sampling Physical Properties. Physics in immersive environments are generally an approximation, and, as a design element, does not have to follow reality-based laws of physics. This still provides value for interactive experiences specifically because their design space is even bigger than what creative practitioners may find in the real world. In VRicolage, physics sampling is split into 2 categories: material properties and object properties.

Sampling Material Properties. Users may sample the properties of a specific *material* used to describe an object. For instance, objects that are meant to behave like wood, have a certain friction and elasticity associated with them. When selecting an object with such properties, users are presented with a list of these and can sample them (Figure 5a, top). This aspect leverages basic functionality provided by the physics engine used by Unity, and allows setting physics-related behaviours through sampled configurations.

Sampling Object Properties. Given that a material does not describe the physical properties of an object in their entirety, VRicolage also provides ways to sample the general configuration of an object (Figure 5a, bottom). This refers to variables like mass, drag, or inertia, which are dependent on the density of the object, or its geometry. Similarly to the material properties, users leverage the physics engine to retrieve and sample this configuration.

4.2.4 Sampling Animation.

Character Animation. To cover more dynamic aspects of media, VRicolage allows users to sample the motion of humanoid avatars, namely their animation clips. Internally, the generic representation of an animated avatar is duplicated and stored for later use. We limit the application to human-like figures only, which covers any biped character. To support users in understanding the animation in isolation, VRicolage presents the animation applied to a neutral mannequin figure if the user selects a character from which an animation can be sampled (Figure 5b, top). By allowing users to sample animations, VRicolage supports them in discovering how motions may be designed and which may fit other sampled characters.

Path Motion. In addition to avatar animation, motion *paths* provide another mechanism to capture and remix dynamic media. Unlike avatar-based animations, path motion may apply to other objects, like vehicles. In VRicolage, path motion describes fixed paths a character or any other moving object may follow in a loop. They are described as Bezier-Curves and are visualized through a smaller version in the interface, to support the user in grasping the overall shape (Figure 5b, bottom).

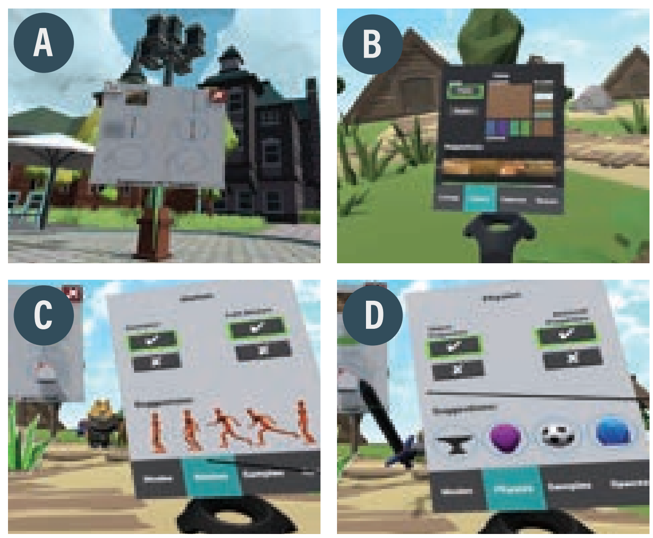

Figure 6: In-situ suggestions in VRicolage. A) 3D-models and stock photos suggested from labels; B) Stock photos suggested from sampled colours; C) Suggested default motions; D) Suggested physical properties (e.g., mass, friction)

4.2.5 Sampling from Suggestions. VRicolage further aims to provide system-initiated, preemptive approaches to sampling. This is facilitated through 2 types of suggestions: literal and abstract ones. Literal suggestions are based on names of objects around the user, which can be used to execute text-based searches for content based on the context of the user [11, 112]. Abstract suggestions avoid this relationship, and, in the case of VRicolage, use sampled colours to retrieve suggestions that exhibit similar colours.

Suggested 3D Models. VRicolage provides literal suggestions in the form of 3D models. Based on the name–as encoded through the original designer–of the object present in the scene, a search of the public API of poly.pizza[2] is conducted. This yields a set of 3D-models, and the most relevant 3 are presented to the user in a suggestions pane positioned close to the object (Figure 6a). This pane is triggered by the user's view direction and a dwell-time.

Suggested Stock Photos. The suggestions pane for the 3D models is also populated by suggestions of stock photos (Figure 6b). They are retrieved from the stock photo provider Unsplash. Based on the Unsplash (lite) dataset [116], labels of the photos and objects recognized within them are searched, and potentially relevant ones are presented to the user. Alternatively, users may receive stock photo suggestions based on the colours they sample from the scene. Here, the database is searched for photos via the sampled colour.

Suggested Animations. VRicolage provides a set of basic animation cycles, like idling, and different walking or running speeds (Figure 6c). We consider these to be so-called sensible defaults with respect to character animation. As with all other suggestions they are visualized to the user prior to sampling, in this case using the same neutral mannequin used throughout the application to represent (humanoid) avatar animation.

Suggested Material Properties. Lastly, when interacting with the environment through the physics lens, users are able to pick from 5 default suggestions for physics configurations (Figure 6d). VRicolage offers an anvil (high mass), a balloon (flotation, light), a block of ice (low friction), or a ball (high "bounciness"). While they are exaggerated, they can serve as a starting point for further alterations, like picking the low-friction nature of ice while adding the flotation of a balloon. The suggestion for physical properties focuses on material properties, instead of specific object configurations.

4.3 Organizing

Having collected a set of samples, users can move their collection to a dedicated environment for organization and arrangement. This collection space serves as an extension of the palette, and allows users to create immersive compositions out of the captured materials, or remix them with their help. The overall structure was inspired by a MoodCube [50], and consists of three planes combined into a half-cube, with a floor and two walls defining a background (c.f., Figure 14). Users can move freely within this space, and arrange compositions of captured samples from other environments.

4.4 Revisiting

Following the sampling of artifacts in an immersive environment, users may accumulate a collection of samples. VRicolage augments this collection by providing meaningful links to the sources of these samples. Namely, by allowing users to peek through a window into the source context, to quickly re-immerse themselves in that source context, or to view depictions of how other creative practitioners may have used or remixed an object.

[2]https://poly.pizza, Accessed May 4, 2023

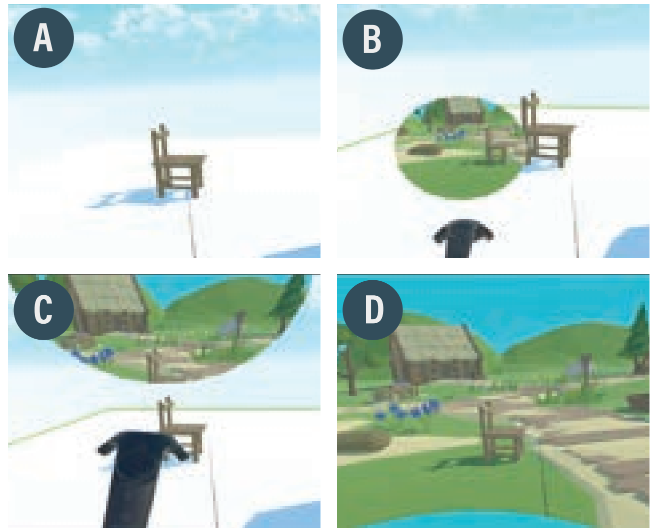

Figure 7: Revisiting source contexts with VRicolage. A) Selecting a sampled asset; B) Peeking into a sample's source environment through a hand-held window; C) Re-immersing oneself into a sample's source environment, by pulling the window over one's head; D) View immersed in the original environment.

4.4.1 Context Peeking. VRicolage provides a way to re-engage with a sample's original environment through a hand-held window [27] into the source environment of a sample (Figure 7a+b). It is spatially aligned and can be moved by the user to observe different perspectives around the sample. This allows them to glimpse into the source context, which presents the sampled object in an unaltered state. To enable this technique, position data is stored when a user samples an object. To render the window, a virtual camera renders an aligned view on a circle attached to the user's controller. Peeking into the source context allows users to understand the original context of a sample further, instead of relying on an isolated sample that potentially may have been altered.

4.4.2 Re-Immersion. As a continuation of peeking, users can immerse themselves in the original environment of a sampled object. This immediately transfers them to the environment and location where the sample was taken (Figure 7c+d). To do so, users pull the window over their heads and are transported to that environment. Reversing this gesture returns the user to the remixing space.

This allows meaningful re-engagement with the context, if users are interested in understanding the source of a sample. Users are also able to quickly travel back and forth, for instance, to gather additional samples to remix.

4.4.3 Context Lens. VRicolage also provides a way to view what other creative practitioners may have made from an object, or by using features from it. The *context lens* shows a set of environments an object was used in. This aspect of VRicolage is mocked and presented through images stored upfront in select scene objects. Showing alternative uses augments the space from which creative practitioners may draw inspiration from. This may provide additional inspiration that is bridged and connected to other environments and creative practitioners [105].

4.5 Remixing

To support remixing, VRicolage provides several ways to manipulate objects in an isolated, immersive moodboard-space, which we consider to be part of the "organizing" activity. This involves basic manipulations like positioning and scaling, but also more advanced ones, such as the transfer of visual or physical properties. In the next sections, we focus on more complex alterations, that involve the transfer of properties of sampled material (i.e., *remixing*).

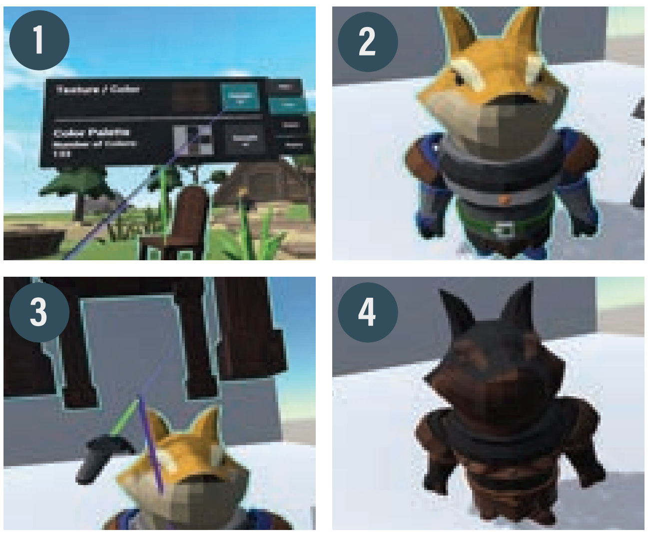

Figure 8: Applying the texture of a sample (wooden chair) to another sampled asset (character).

4.5.1 Transfer of Visual Properties. Figure 8 depicts how users may transfer visual properties from one sample to another using VRicolage. A user grabs an object with a colour or a texture from the palette, and drags it toward the target. A line visualizes the closest valid target to transfer the visual properties to, and as soon as the user releases the held button, the remix is applied. To provide reasonable defaults for what is being applied, the default 'pasting'-behaviour for such transfers focuses either on pasting all applicable dimensions, or on the one the user has focused on while sampling.

VRicolage further offers room to alter an entire scene, instead of separate objects. By using sampled colour palettes, users may apply them as a global colour scheme to the remixing space (Figure 9). This sequentially applies all colours in the sampled palette to all objects present, either completely recolouuring them, or adding a coloured tint to their main texture. Depending on the sampled palette, this leads to colourful and contrast-rich, or tone-on-tone compositions through a "global" remixing operation.

4.5.2 Transfer of Motion. Previously sampled motion can be applied to other, compatible objects. With compatibility, we assume a certain commensurability between the source and target. In its

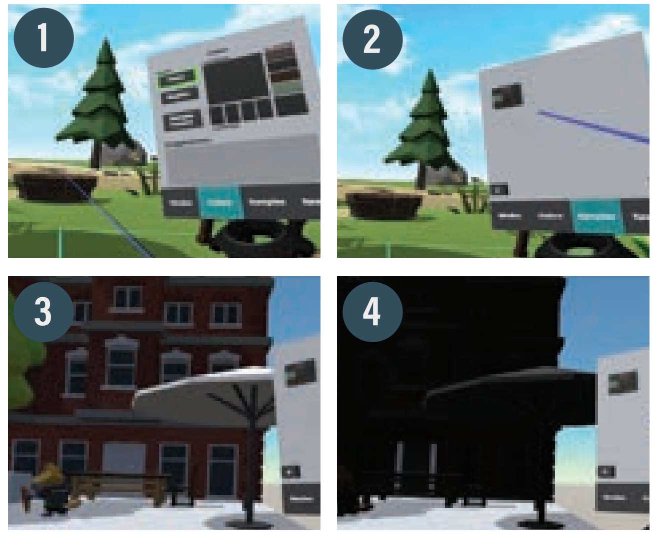

Figure 9: Scene-wide remixing based on a sampled palette. 1) Sampling dark tones from a wooden tub in a scene; 2) Resulting 9-colour palette object; 3) unaltered environment with sampled palette; 4) altered environment with the palette used to recolour objects and lighting.

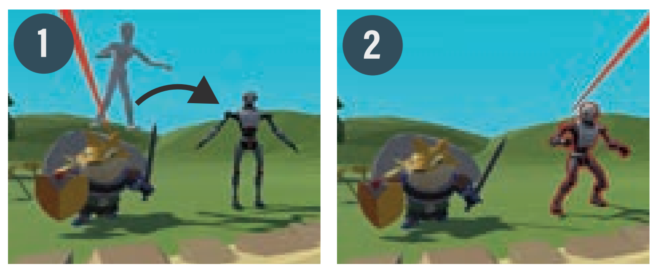

Figure 10: Copying and applying avatar-animation/motion to a different character. 1) Source and neutral visualization; and 2) result.

current form (Figure 10), avatar-based animation can only be transferred to other, similarly (i.e., humanoid) rigged characters. When in the correct mode, a user selects the source, and drags a representation of it to the target, which immediately starts to move in a synchronized fashion to the source.

4.5.3 Transfer of Physical Properties. Figure 11 depicts a transfer of physical properties from a source object (sampled) to a target object (remixed). In this case, the user has sampled the configuration of a helium-filled balloon in the environment. Its properties can be (selectively) transferred to a different, seemingly incompatible object in the user's remixing space: an anvil. To transfer physical properties, VRicolage offers 2 ways, differing in granularity and speed. For quick transfers, users can grab the source object with one hand, point to the target object with the other, and trigger the copying of all properties through a button press. Alternatively, users may selectively choose which properties of the source material to transfer.

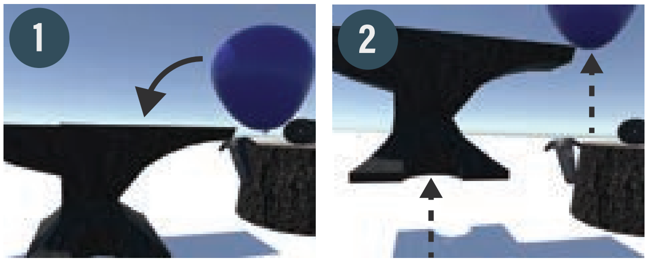

Figure 11: Transferring physical properties. 1) initial state: heavy anvil and a helium-filled balloon; 2) Resulting scene, with both objects floating towards the sky.

5 USAGE SCENARIOS / APPLYING VRICOLAGE

The following sections describe three walkthroughs we generated with our implementation of VRicolage. They depict the process and opportunities that emerge for creative practitioners when they are provided with more ways to sample immersive digital environments. The walkthroughs aim to *demonstrate* potential workflows and have been generated by the authors using the prototype implementation within the context of the scenes assembled for it. This aims to present what is possible with VRicolage and valuable about Immersive Sampling (c.f., [62]) by combining the individual activities and techniques outlined in section 3 and section 4.

5.1 W1 – Sampling Characters and Motion

Figure 12: Exploring character-animation-combinations. 1) Sampling a set of characters; 2) sampling a moving character in a different scene; 3) positioning characters in a neutral environment; 4) characters with the same animation applied.

Immersive Sampling can be used to rapidly explore different options for the creation of a particular asset, especially if they have one particular material they would like to be working with. In exploring motion (Figure 12), the creator has sampled the motion of some humanoids (Figure 12.1) and a warrior dog (Figure 12.2) from immersive stories they had been experiencing. They bring that motion back to their own workspace, where they are interested in exploring which of the character designs may work for a game they are designing. The user arranges the avatars from their own game in a neutral environment (Figure 12.3) and applies the sampled motion to all others to compare them side-by-side (Figure 12.4). They find, surprisingly that even though there is a size mismatch between the fox and their avatars, the resultant motion was just what they were looking for.

5.2 W2 – World-Building

Figure 13: VRicolage for environment concepts. 1) Sampling a small diorama from a suggestion; 2) sampling additional props from environments and suggestions; 3) collected assets; 4) assets arranged to a scene.

A creative practitioner is working on building their own immersive experience that has a feel that is both man-made and natural (Figure 13), and so they use VRicolage for active engagement with and exploration of other experiences as reference. While exploring a small village environment, VRicolage automatically suggests a scene of a forest, based on the term *wood*, which in turn was retrieved as the user was inspecting a wooden tub in the scene (Figure 13.1). In a different environment, the user samples a parasol model from suggestions offered while exploring a patio set, and also samples chairs from the scene, (Figure 13.2) along with other elements of vegetation (Figure 13.3). The elements are then brought into the practitioner's workspace and arranged to rapidly compose a scene (Figure 13.4).

5.3 W3 – Sampling to Transfer Atmosphere

Immersive Sampling can also be used to try and alter the feeling or atmosphere of an experience (Figure 14). The creative practitioner is working on a scene composed of sampled assets, and would like to make the scene feel a bit more somber, and would like it to feel

Figure 14: Exploring atmospheres through scene-wide colour palette application. 1) Original arrangement of assets; 2) dark palette applied; 3) sampling an oak-brown colour, which yields desert-related photo suggestions; 4) Sampled palette applied to the arranged scene.

more like a desert than a lush landscape. The sampled assets have a bright and cheerful tone initially (Figure 14.1). Applying a darker palette with little contrast that was sampled from a previously experienced scene leads to a similarly dark result, which is not what the practitioner intended (Figure 14.2). After sampling the ground of a different, but similarly cheerful scene, the user receives a bright, oak-brown colour. The suggestions of VRicolage also return a set of stock photos with depictions of deserts or animals found in the Savanna (Figure 14.3). The user then samples this tone-on-tone palette and applies it to the previously composed scene. This yields a reasonably consistent impression of a dry climate (Figure 14.4).

6 DISCUSSION

The variety of interaction techniques presented within VRicolage allow creative practitioners to sample, revisit and remix various media assets from immersive virtual worlds. This expands upon the established notion of experiencing only (often merely followed by sampling immersive content into 2D-representations). We initially outlined 3 design rationales (section 3.1). While VRicolage largely fulfills these goals, it remains a probe into the diverse and promising space we outline with the notion of Immersive Sampling. In the following sections, we discuss a set of aspects and limitations that we deem relevant for the emerging context of Immersive Sampling, while looking back at established definitions of sampling and the design rationales for Immersive Sampling and VRicolage.

Integrating Immersive Sampling in Everyday Experiences. While immersive experiences are rich in materials to capture, they are primarily meant to be experienced. They combine different types of media with a high degree of interactivity and immersion, with the ultimate goal of resembling what we experience in real, physical spaces. It is reasonable to question whether and how the engagement and immersion in such an environment change when we enter it with the goal of *sampling*, over the goal of *experiencing*. Greenberg et al. framed sampling (from physical environments and interfaces) as "[...] all about becoming a hunter and gatherer" [40]. This deliberate practice is meant to change and sharpen the practitioners' gaze towards physical environments, and we argue that this applies to Immersive Sampling. Just as a smartphone enables a rather low-friction sampling act from a *physical* environment, concepts like VRicolage may do so for *digital* and particularly *immersive* environments. While we may not sample content all the time, having this option and margin space [30] available (i.e., with low friction) in immersive spaces, in addition to the physical world, may foster "cross-fertilization" [40] and augment creative practitioners' everyday experiences that they will increasingly be having in immersive spaces (DR1).

Embedding Immersive Sampling in Creative Practice. The techniques in VRicolage are inherently spatial and multimedial in nature (DR3). The sampling tools are embedded within the immersive world (DR1), and support the sampling and remixing of static (e.g., colours, geometry), dynamic (e.g., motion paths, animations), and more abstract content (e.g., lighting that captures a certain mood). By providing these tools to practitioners in the immersive environments themselves, VRicolage aims to close the gap between the sampled content and how it is stored and organized by the creative practitioner: storing the media itself, as experienced, rather than a "flattened" (e.g., spatially, or temporally) representation.

Several techniques demonstrate VRicolage's support for fluidity and flexibility between capture and remix time (DR2). In particular, the three revisiting interactions provide different levels of support for understanding context and gaining new inspiration based on others' use of the media. With context peeking, creative practitioners can quickly view the sample's original environment – perhaps giving them a quick reminder of why they sampled that particular asset. With re-immersion, they can fully revisit the location of the original sample, perhaps to regain inspiration or look for new materials from that same environment. These aspects highlight how immersive environments can be seen as equally valuable compared to physical spaces for creative practitioners, but can be further enriched with interactions that may not be possible or feasible with current sampling techniques (DR1).

To provide creative practitioners with the ability to decompose and understand assets VRicolage provides both literal decomposition tools, and more abstract tools. The ability to sample parts of objects through hierarchical decomposition not only allows creative practitioners to physically decompose a geometric object into its constituent parts to select a sub-element, but it can allow them to see how those assets were assembled and how the original creator may have created it. Additionally, the more intelligent suggestion tools (e.g., suggestions of colours, 3D models, stock photos) can provide creative practitioners not only with novel sources of inspiration [58], but it might help them understand why they may like a particular asset, as the system can find similar and adjacent materials to help them contrast and compare.

Attribution, Authorship, and Access. As with other forms of sampling in the arts and creative domains, the issue of authorship and ownership is of concern [37, 41, 86]. With Immersive Sampling, there are many more parameters, media types, and mechanisms to decompose and remix the work of others. The question of how to properly attribute each contribution to the resultant work remains an open challenge, as does the issue of ownership of the final assets. These issues are beyond the scope of this paper, but are crucial to investigate going forward. Related to the issues of ownership and attribution, are issues of access and openness. While there are technical challenges to overcome to ensure environments and media can be sampled in their full depth, the community of creators must also be willing to share their designs [29, 118]. To support this move to openness, further research could investigate mechanisms to visualize an asset's provenance – where each component was borrowed from, how it was remixed, or what was created from scratch [91, 103]. This would allow creators to be acknowledged even in works derived from their original creations, ideally fostering an open culture of remixing and derivative works [33, 73, 114]. While this was successfully adopted in music, ranging from hobbyist acts to professional productions, conflicts, and shortcomings remain unsolved, even in this arguably more progressed domain [36, 41, 86].

6.1 Limitations

While VRicolage provides a probe into the rich and promising space of Immersive Sampling, it did not yet provide definitive answers as to how exactly we may sample specific media types and apply remixing operations in an easy-to-grasp way. Immersive environments encompass this multitude of media into cohesive experiences, demanding proficiency in their creation, but also complicating the process of sampling and remixing. Spatial domains like manufacturing [29], or auditory domains such as music [14, 36] evolved rich remixing-based cultures. However, with "modding" of digital games, we have observed the emergence of multimedia remix cultures, while also operating in a domain that is often restrictive in terms of copyright, or fair (re-)use [24, 36]. With Immersive Sampling, we further assume explicit or implicit openness of any design element in an immersive environment, akin to what is the state of the art in the web. This can be achieved through sophisticated scene understanding algorithms to extract the desired media elements, or through "openness by design". Neither of these can be guaranteed and are not always given, but should be strived for to foster innovation [107]. Lastly, Immersive Sampling may not exist in a vacuum, but rather be part of an *ecosystem* [89] that supports it and transcends – whenever needed – the boundaries of immersive environments to suit the needs of creative practitioners (DR3).

While the implementation is robust enough to explore the concept, some technical challenges still need to be addressed before VRicolage can be deployed. First, VRicolage was built in Unity, using Unity assets, some of which were annotated with data (e.g., specifying a model hierarchy). While few modifications were done to the scene and assets to make them addressable and decomposable, there is still an amount of pre-processing that is necessary to enable generic sampling and remixing, along with entire infrastructures to do so. While our own use of the tool and the exploration of the presented workflows (section 5) provided insights into how the approach could be used [88], it would be valuable to see VRicolage used by creative practitioners in their everyday workflows. Deployment with a group of practitioners has the potential to reveal new workflows or use cases and practices that have not yet been explored through our experimentation.

7 FUTURE WORK

Immersive Sampling can add the yet untapped, rich digital worlds into sampling processes to support creative practitioners. Evaluating VRicolage in a user study to determine how it may affect creative processes in detail would provide valuable insights for Immersive Sampling. In addition to user experience and sentiments, more quantitative measures such as the creativity support index [12, 15] could reveal further insights into how immersive sampling may support creative practitioners in sampling and remixing. To further expand how the world (both digital and physical) can be sampled, more sophisticated tools for scene understanding [94, 124] and decomposition [50] are needed. Augmenting sampling from the real world through embedded revisiting and remixing capabilities is likely a meaningful addition to VRicolage, which focuses on immersive environments. We further aim to explore interactions in VRicolage beyond the scenes built specifically for it, while considering the effects of derivative and collaborative multimedia remixes (c.f., [46]). With the ever-increasing depth and diversity of virtual worlds, the potential contexts from which creative practitioners may draw inspiration from are similarly increasing in richness and number. We, therefore, call for openness to sampling and decomposition to be woven into future standards, systems, and technologies that will embody concepts like "the metaverse" [21], or "ubiquitous XR" [51] to support the needs of creative practitioners who not only design *for* immersive environments, but also designing *inside* – and, therefore, *with* – them.

8 CONCLUSION

With this work, we engaged with the notion of sampling, focusing on the emerging context of immersive environments and through the lens of VRicolage. We provided a characterization of sampling in creative practice, which is deliberate, exploratory, and a way for creative practitioners to structure their thinking. We further formalized Immersive Sampling as an emerging domain for creative practitioners, consisting of interactions with a diverse range of media types, as provided by immersive environments. Lastly, we presented VRicolage, a proof-of-concept implementation for Immersive Sampling. VRicolage consists of interaction techniques that leverage the spatial, multimedial, and immersive nature of virtual reality experiences to allow creative practitioners to engage in Immersive Sampling to sample or remix content or revisit the content's source environments. Situating sampling in immersive environments allows creative practitioners to benefit from decomposition support, suggestions for sampling based on their context, multimedia remixes, spatial interaction across any scale [126], and immediate access to the context of captures.

Sampling and remixing have facilitated continuous evolution in music [10], arts [54], 3D-printing [29], programming and application development [19, 43, 46, 60], and design [54, 83]. This was only possible through appropriate communities, methods, and structures.

With the right means, resources, and inspiration surrounding us become accessible and valuable to creative practitioners, enabling open-ended, deliberate processes. With immersive experiences increasingly becoming parts of our lives, they will similarly become part of the toolkit available for creative practitioners, requiring consideration for and embedding in the diverse workflows of creative practitioners to further support and empower them.

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A RESOURCES USED

For the design of VRicolage, we relied on several core assets (in addition to the poly.pizza and Unsplash databases) that provided material for the design of our demonstration environments. For provenance, attribution, and to support revisiting and remixing of those, we list them below:

[A1] *Dog Knight PBR Polyart* by Dungeon Mason, Unity Asset Store (Accessed May 22, 2023)

[A2] *Colorful City* by Triangularity, Unity Asset Store (Accessed May 22, 2023)

[A3] *Low Poly Brick Houses* by Broken Vector, Unity Asset Store (Accessed May 21, 2023)

[A4] *RPG Poly Pack - Lite* by Gigel, Unity Asset Store (Accessed May 22, 2023)

[A5] *Distant Lands Free Characters* by Distant Lands, Unity Asset Store (Accessed May 22, 2023)

[A6] *Simple City pack plain* by 255 pixel studios, Unity Asset Store (Accessed May 21, 2023)