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# Introduction

This document is based on **N19589** (MPEG-I Phase 2 Use Cases, [1]) that lists use cases for immersive media. The use cases in this document focus on haptics. These use cases have been augmented with a more extensive description of the use of haptics. The objective is to inform the reader about the role of haptics in immersive media and to derive requirements for haptics playback in immersive applications and services.

For some more background on the use of haptics in immersive media and the various design approaches, see Annex A “Haptics in Immersive Media – A Tutorial”.

# Use Cases

For each use case, only the haptic-specific parts are described in this document with just the requisite background of the use case retained from **N19589** . The reader is referred to **N19589** for a full description of the audio/video aspects of the original use case. The potential requirements section of each use case also follows the same principle – just the haptic-specific requirements are described. The full set of potential requirements for each use case are to be found in **N19589** .

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| **Combined Point Cloud and Video 6DoF Contents** |
| Description  A user is watching a sports match, or a concert, using a device with the capability to provide input from the user to enable him/her to change his/her viewpoint location and direction within the sport or concert venue, without restriction.  For example, the user has the possibility to select a viewpoint from a 1st person perspective of a sports player, or a 3rd person perspective viewpoint similar to that of more traditional TV broadcast sports contents (Figure 1).  A baseball stadium  Description automatically generated A baseball player swinging a bat at a ball  Description automatically generated  Figure 1: An example of 2 different viewpoints which could be selected by a user. Left: 1st person player view. Right: 3rd person commentary view [2].  The 6DoF content which the user is viewing is rendered using a combination of both point cloud media data, and video media data. The whole sports or concert venue is captured using multiple high resolution cameras, such that the video data captured can be processed to create a point cloud scene of the center of the sports or concert venue (e.g. the sports pitch, players and other dynamic objects are represented by point clouds in the scene). This processing can be performed either at the venue itself, or remotely on a dedicated network. The venue may also be equipped with sensors that can capture Tactile Essence (SMPTE st2100-1-2017 (Coding of Tactile Essence)).  By creating such point cloud media data, a user has the freedom to navigate within the sports or concert venue (i.e. the defined scene boundary here) and is able to view different players and objects from all viewpoints and positions.  Since such venues are traditionally very big, and include massive crowds of spectators, it is possible to represent such non-interactive parts of the scene background using video media data.  The result is that the user views both point cloud and video media rendered at the same time in order to create an immersive experience. |
| Haptic schema |
| 1. Haptics associated with point cloud media – A haptic track may be associated with a set of point cloud media data.    1. Subsets of the point cloud may be indexed against specific objects/participants.       1. This information can be used to associate haptics with specific subsets of the point cloud.       2. Alternatively, each discrete subset of the point cloud could be encoded as a separate media stream with its own haptic track.    2. This haptic track can be activated, deactivated, or modulated based on the user’s viewpoint.       1. Activated/deactivated - If the point cloud media is within the user’s field of view, the haptic track can be activated, and if the point cloud media moves out of the user’s field of view, the haptics can be deactivated.       2. Modulated – As the point cloud approaches the center of the user’s field of view, and/or as it approaches the 3D coordinates of the user’s perspective, the haptic track can be increased in magnitude (volume). As the point cloud moves away, it can be decreased in magnitude.    3. When transitioning from one haptic track to another based on shifts in visual perspective, the haptic tracks may be mixed to minimize tactile artifacts and ensure a smooth transition. 2. Haptics associated with video media – One or more haptic tracks may be associated with the background video media    1. A global haptic track may be associated with the video media so that it plays continuously during the live event    2. Two or more haptic tracks may be associated with the video media, for example, one haptic track associated with crowd noise, and one associated with on-field noise. A gradual transition may be made between these tracks based on whether a segment of video media is included in the user’s field of view or excluded from the user’s field of view. 3. Haptics associated with a capture device – A haptic track may be associated with a capture device such as a sensor or camera that captures Tactile Essence (SMPTE st2100-1-2017):    1. This haptic track can be activated, deactivated, or modulated based on the user’s viewpoint.       1. For example, if the haptic track is generated by an inertial sensor embedded in a baseball bat, the haptic track may play always, or only if the bat is in the field of view, or only if the user has taken the first person viewing perspective of that player.       2. Modulated – As the 3D coordinate associated with the source of data (camera or sensor) approaches the center of the user’s field of view, and/or as it approaches the 3D coordinates of the user’s perspective, the haptic track can be increased in magnitude (volume). As the point cloud moves away, it can be decreased in magnitude. 4. Smooth haptic transitions – When transitioning between haptics associated with point cloud media, video media, and capture devices, the haptic tracks may be mixed to minimize tactile artifacts and ensure a smooth transition.    1. For example, an element of the content that is being rendered locally based on point cloud media that transitions to being of type video would have its associated haptic track smoothly transition from one type to another. 5. User configurable haptics – In addition to a default haptic schema, the user may choose among alternative schemas. For example, the user may only activate haptics during a first-person perspective, enable only haptics associated with point clouds, etc. |
| Potential Haptics Requirements and Specifications |
| The MPEG-I 6DoF system may provide functionalities to support this use case through the following key haptic-specific requirements:   * The system shall support the processing (for media distribution), of different media types. * The system shall support the storage of different media types. * The system shall support the presentation and playback of different media types. * *Note: Media types may include,2D video, spherical video, point cloud, haptic data, and various audio media data* * The system may support rendering of haptic media based on available hardware at the client. * The system shall support mixing and modulation of haptic tracks. |

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| Scene and object feature based 6DoF media change |
| A user is watching a sports match produced in 6DoF on a mobile device which is capable of rendering 6DoF media content but is only available to capture 2D media by its camera module.  In the middle of the match, there are some moments to replay the important shots of a player. When the player is zoomed in and the camera moves along the player, changing the player’s face to the user’s face can be provided as an entertainment purpose.  For example, the player’s crying face can be replaced by user’s face which is transformed from the 2D image or short video taken by the camera installed in user’s mobile device.  Regardless the expression of user’s face or skin colors and textures, and regardless the lower DoF of user’s face data, the user’s face is naturally absorbed into the 6DoF player’s face so that user’s crying face is shown with the player’s body. |
| **Haptic schema** |
| 1. **Haptics associated with user-selected 3D object** – The player selected for 2D overlay activates the haptic track associated with that player, regardless of that player’s position relative to the viewer’s perspective. |
| **Potential Haptics Requirements and Specifications** |
| The MPEG-I 6DoF system may provide functionalities to support this use case through the following key haptics requirements:   * The system shall support metadata for associating haptics with objects or object features in the scene. |

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| Remote pre-rendering for 6DoF contents |
| This use case reflects the full immersive content experience which will be enabled through live captured content. When a live sports game, such as Super Bowl, is offered as 6DoF immersive content, a user would receive a 6DoF volumetric video and watch the game from a perspective of his favorite player in the game. In some cases such as a mobile terminal, content are sent to a remote renderer at the mobile edge clouds for pre-rendering according to a user’s selected viewport, the network conditions, and/or the device capabilities and delivered to a client terminal. |
| **Overlap with other use cases** |
| **Haptic schema** |
| 1. Haptic effects may be rendered at the source or mobile edge cloud for pre-rendering and streamed to the client depending on user metadata such as the haptic device capabilities. 2. Haptic effects may be defined in metadata or parameterized data at the source and rendered on the client side 3. If the haptic renderer shifts among source, mobile edge cloud, and client, the haptic tracks are mixed to minimize tactile artifacts and ensure a smooth transition. |
| **Potential Haptics Requirements and Specifications** |
| * The system shall support transcoding as part of pre-rendering of haptic media |

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| Full Immersive Content: 6DoF with full 3D 360 video |
| Description  This use case reflects the full immersive content experience which will be capable through real-life captured content in the future (defined by MPEG-I). Full 6DoF immersive content allows the viewer to navigate his/her location within the content space, freely without limitation, with natural change of the corresponding rendered video and audio. The media data will involve new data concepts (such as light fields), most likely requiring needs for new capturing technologies, video, audio, and haptic codecs, delivery systems as well as new display technologies. The result of using these new technologies will provide a high quality, realistic immersive experience.    **Figure 2: An example of full 6DoF immersive content where a viewer may change his or her viewpoint to any location within the scene boundary** |
| **Haptic schema** |
| 1. **Haptic profiles are associated with objects**.    1. The haptic profile may be based on the 3D object’s geometry. For example, when part of a user’s avatar interacts with the object by colliding with it, a haptic effect may be displayed that:       1. Signifies the collision       2. Prevents the user’s interaction gesture from crossing the boundary of the 3D object    2. The haptic profile may be based on the 3D object’s surface features.       1. These surface features may be explicitly defined at design time such as in the case with a haptic texture being associated with a 3D object       2. Alternatively, the surface features may be derived from other object attributes such as its surface geometry, applied textures/shaders, or virtual material, visual appearance, context, past interactions, etc.    3. A virtual thermal profile may be created based on the virtual material. For example, the virtual heat flux (sensed by the human body through thermoreception) of a virtual wood material, presented through the user through thermal feedback, can be distinct from the virtual heat flux associated with a virtual metal material. |
| **Potential Haptics Requirements and Specifications** |
| * The system shall support collision detection suitable for enabling haptic interaction * The system shall support association of haptic texture with a 3D object for enabling haptic interaction. * The system may support server-side identification and encoding of material properties. |

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| A Mobile Subject looks around a statue Object |
| A single person moves around a still statue object in a room and looks at the statue. |
| **Haptic schema** |
| 1. A haptic profile is associated with the statue.    1. Derived with machine learning or computer vision techniques based on visual appearance 2. The statue media is divided into number of solid angles *s* and there are *s+1* haptic profiles, one per solid angle and one global track. 3. The user may engage with the haptic profiles in different ways depending on the interaction model of the player    1. Touching part of the screen that contains the visual elements with which the haptic profile is associated    2. Using a “virtual probe” or “laser pointer”, common in VR interaction: an on-screen indicator similar to a cursor that shows where in the scene the user is pointing. |
| **Required features** |
| The media content is of sphere type, the object is inside the sphere, and the subject looks at the object from outside of the sphere, and has the 3 rotational DoFs plus 2 translational DoFs (no movement in the z-axis). |
| **Potential Haptics Requirements and Specifications** |
| Media Format shall support   * association of haptic media with media geometry types (e.g., by nested sphere)   Orchestration Format shall support   * orchestration of multimodal media presentation (e.g., audio, video, and haptics) |

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| A Mobile Subject looks around a statue Object with up-close views |
| A single person moves around a still statue object in a room and looks at the statue, with the capability to look closely. |
| **Haptic schema** |
| Each nested sphere may be divided into respective numbers of solid angles. The haptic track of the solid angle being exited is mixed with the haptic track of the segment being entered.  For example, a statue depicted on a sphere may have a gross shape, surface features, and a fine material texture.   * As the viewer interacts with the outermost sphere, haptic effects associated with the gross shape of the statue may be used. * After the viewer transitions into the next-smallest nested sphere that provides visual detail of the statue’s surface features, haptic effects associated with surface features may be used. * After the viewer transitions into the next-smallest nested sphere that provides visual detail of the statue’s texture, haptic effects associated with the fine material texture of the statue may be used. |
| **Required features** |
| The media content consists of multiple nested spheres with the same center, and the object is at the center of the spheres, the subject looks at the object from outside of the spheres, and has the 3 rotational DoFs plus 2 translational DoFs (no movement in the z-axis). The subject is capable of view changing from sphere to sphere. |
| **Potential Haptics Requirements and Specifications** |
| Media Format shall support   * association of haptic media with media geometry types (e.g., by solid angle)   Orchestration Format shall support   * orchestration of multimodal media presentation (e.g., audio, video, and haptics) |

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| Multiple subjects look around in a Room with a tour guide |
| A group of people stand still in a center of a room of the museum and looks around, audio guided by a tour guide. |
| **Haptic schema** |
| A global haptic track may be associated with the experience. |
| **Required features** |
| The media content is of the sphere type with audio, subjects are at the center of the sphere, looking from inside out, each with the 3 rotational DoFs, but their views can be synchronized by the guide audio – a social media experience. |
| **Potential Haptics Requirements and Specifications** |
| Media Format shall support   * association of haptic media with media geometry types (e.g., by solid angle)   Orchestration Format shall support   * orchestration of multimodal media presentation (e.g., audio, video, and haptics) |

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| Multiple subjects look around a statue with a tour guide |
| A group of people move around a still statue object, all looking at the statue, with different viewpoints, but audio guided by a tour guide. |
| **Haptic schema** |
| A global haptic track may be associated with the experience. |
| **Required features** |
| The media content is of sphere type, the object is inside the sphere, and multiple subjects look at the object from outside of the sphere, with potentially different viewports, but their views can be synchronized by the guide audio – a social media experience. |
| **Potential Haptics Requirements and Specifications** |
| Media Format shall support   * association of haptic media with media geometry types (e.g., by solid angle)   Orchestration Format shall support   * orchestration of multimodal media presentation (e.g., audio, video and haptics) |

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| Inter-change experiences |
| People can change their touring experiences between looking around within a room and looking at a statue. |
| **Haptic schema** |
| **Smooth haptic transitions** – When transitioning between interacting with one part of a room and another part, or one object in the room and another object, haptics associated with each will be mixed to minimize tactile artifacts and ensure a smooth transition. |
| **Required  features** |
| Switching between 3DoF/3DoF+ navigations and converging navigations around an object |
| **Potential Haptics Requirements and Specifications** |
| Orchestration Format shall support  The orchestration format is one used for organizing and orchestrate captured and processed media content potentially from one or more sources onto one or more display devices   * It shall support orchestration of multimodal media presentation (e.g., audio, video and haptics) |

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| VR Video Calling |
| 1. Panoramic video calling : Alex and Bob are at different physical locations, and they are having a video calling, Alex send 360 video to Bob while Bob send 2D video cause his devices with limited capabilities (cannot take 360 videos)  * Bob wears an HMD to watch the 360o video sent by Alex * If Bob does not have an HMD, he can only play the 360o video on other terminals (mobile phone, PC, etc.)     (https://www.insta360.com/)   1. Alex and Bob in the same VR environment while Bob send 2D video  * Alex can be present in the VR environment through some form of user-embodiment while Bob’s 2D video will be present as a VR object (virtual screen, etc.) in the VR environment, which Alex can interact with (move, zoom in/out, etc.)   C:\Users\cmri\AppData\Local\Temp\1553443447(1).png  (https://www.facebook.com/spaces) |
| **Haptic schema** |
| Users may send haptic effects to each other in the following ways:   1. Through gesture, for example:    1. by touching the user’s avatar image (representing the VR user) or the region of the video that includes the image of the person (representing the video user).    2. By touching objects in the remote user’s environment 2. By attaching and sending an external media element with an associated haptic track or haptic effect such as a haptic sticker, GIF, animation, video clip, or virtual object. |
| **Overlap with other use cases** |
| * Multiple users in VR environment * Social TV and VR * Multiple users in VR environment, 6DoF * VR Conferencing |
| **Required  features** |
| * Interactions with VR objects * Synchronization of audio and video of users and the scene * Users whose devices with limited capabilities (without motion tracking) can get into a shared VR environment |
| **Potential Haptics Requirements and Specifications** |
| * Haptic effects can be associated with 2D video, and subsections of the 2D video. * Haptic effects can be associated with VR objects and VR environments. |

# References

[1] ISO/IEC SC29 WG11 (MPEG), ***N19589*** *MPEG-I Phase 2 Use Cases,* July 2020

# Annex A: Haptics in Immersive Media – A Tutorial

## A.1 Introduction

This annex is intended to provide a foundation to better understand the haptic use cases described in this document.

Haptics provide value to end users in immersive media by engaging the sense of touch. Immersive media endeavors to change a user’s sense of place by presenting a convincing sensory illusion. The goal then of such an interface is to occupy and control as much of a person’s sensory bandwidth as possible by engaging many afferent nerve endings with high resolution signals. Immersive media that engages only the eyes and the ears can never be as immersive as that which also engages touch, because the sense of touch is a salient element of people’s sense of place.

The role of haptics in VR environments has been studied extensively since VR first emerged as an area of technology R&D. Haptics has been definitively shown to enhance end-user assessments of immersion, presence, realism, performance, emotional state, among others.

## A.2 Value of Immersive Content with Haptics

By providing access to an additional sensory channel, haptic technology provides content creators with a powerful tool to create differentiated and highly engaging user experiences. The variety and depth of content are increased when haptics is available in the content creator’s design palette.

When choosing which elements of an immersive experience to include in a piece of content, creators must account for the availability of devices capable of rendering immersive content. Fortunately, almost all devices targeted for distribution of immersive content have some amount of haptic capability built in.

Mobile handsets have haptic actuators that are increasing in quality year over year, now allowing for rich, dynamic vibrations that are closer in experience to a texture than to a buzz. The APIs and SDKs that enable haptic apps and content are increasing in number and sophistication.

Console game and VR controllers are also adopting advanced haptic features. Dual-motor rumble feedback, the standard for many years, has given way to HD vibration actuators and force impulse actuators, engaging more nerve endings in the skin and muscles of the hand. Interaction design patterns for VR user interfaces have come to rely on haptic confirmation of user actions, and developers are increasingly incorporating advance haptics into games to enhance immersion.

## A.3 Typology of Haptic Immersive Content

Haptic immersive media may be divided into four types that relate the content type to a preferred haptic design approach.

### A.3.1 Story-driven Content

In story-driven content, the immersive experience draws the viewer along a narrative storyline similar to linear 2D content like TV shows and movies. In this type of content, the camera is likely to move. While the viewer may have the freedom to view the scene in any direction in 360 degrees, there is one focal point of action that is assumed to be the center of attention. This focal area is where the action of the story takes place – for example, a child playing in a park, and other actions consist of a background that helps create a sense of immersion – for example, leaves in the surrounding trees moving with the wind.

An example of this type of content is HELP[[1]](#footnote-2), an immersive film by 360 Google Spotlight Stories that follows a classic dramatic arc.

In this type of content, haptics will follow the action. Salient events like explosions and crashes will have haptic effects that enhance the drama and intensity of the experience. Haptics may also be used to accentuate moments when a scene turns, or a significant storyline development takes place. The actions of main characters will be prioritized. The design approach will convey “cinematic realism,” where actions and their haptic correlates may be exaggerated for dramatic effect. Haptic effects may correlate to action that is off axis from the expected viewing angle, but this too is used as a story element that prompts the viewer to look in another direction to discover some new story element.

### A.3.2 Experience-driven Content

In experience-driven content, the design goal is to make the viewer feel like they are inside the action of the scene. A story is usually not required, because the end-user value of the content is about feeling present in an exciting or unusual reality. All viewing angles are important, because part of the appeal of the content is that the user can suspend their disbelief by looking in any direction and experience a complete illusion.

An example of this type of content is Experience the Blue Angels[[2]](#footnote-3) by USA Today, which makes you feel as if you are inside an aircraft in an aerobatic jet squadron.

In this type of content, haptic effects will be used to heighten the viewer’s sense of immersion without prioritizing one viewing angle over another. Haptic actions will affect the entire virtual body of the perspective taker, for example, the vibration and shake of a vehicle being ridden by the viewer.

### A.3.3 Event-driven Content

In event-driven content, the design goal is to make the viewer feel present at a single location where the action is unfolding.

In this type of content, focus on a specific part of the scene is so critical that it is not always necessary to provide detailed environmental cues. In fact, some of this content limits viewing angles to 180 degrees. The action often comprises a sporting event or artistic performance that takes place on a playing field or stage.

An example of this type of content is NextVR[[3]](#footnote-4), a cross-platform app that provides live event video feeds for VR headsets.

In this content type, haptics heightens the excitement of the event by providing ambience. The roar of a crowd and the shake of the stands would be candidates for haptic effects.

### A.3.4 Interaction-driven Content

In interactive content, the viewer is a participant in the scene. A controller, gestural interface, or other mechanism of engaging with the content is provided to the user. Scenes are often rendered with 3D game engines, and a key user desire is to be able to freely interact with the environment and characters.

In this type of content, haptic effects are usually designed to simulate interaction of content elements with the user’s body. Even if an event is very salient, if such an event would not give rise to touch sensations in real life, they would not have haptic effects associated with them in the content.

An exception is made for haptics related to usability. For example, a common design pattern in VR is for the user to use a light beam pointer to select menu items, with haptic pulses confirming when a target is acquired, or a button is activated. In this case, haptic effects are not related to immersion in the scene, but nonetheless play a key role in supporting the user’s comfort and performance during the experience.

## A.4 Content Consumption Modalities

Immersive media can be consumed in several ways. Creating haptic tracks for spherical media must account for multiple modalities of interaction with spatial video and interactive content. There are three primary interaction modalities, and in each one, different parts of the user’s body are in contact with the playback device, so each modality implies its own set of haptic design criteria.

The challenge with this situation is that immersive content player software can operate in any of the three modalities. Therefore, it may be often necessary for the immersive content to contain multiple haptic tracks, each one created for a different consumption modality, and for the player to select between the tracks based on currently active content consumption modality.

### A.4.1 Finger Gesture

The first, most common interaction modality is finger gesture interaction. The orientation of the viewer’s point of view is controlled by dragging the finger to reorient the view. The finger may also be used to touch, tap, or otherwise interact with objects in the scene.

In this modality, haptic effects are felt in both the supporting hand and the fingertip of the primary hand. Because more surface area of the supporting hand is in contact with the device, more nerve endings are stimulated, and the sensation in the supporting hand dominates the haptic experience. At the same time, the conscious attention paid to the location of the fingertip, in terms of both finger gesture and visual focus, often cause haptic effects to be correlated to finger actions. The user’s correlation of haptics to the background scene and the foreground interaction is unstable and context-dependent, necessitating a design approach that considers the use case.

### A.4.2 Hand Gesture

Immersive content may also be experienced by orienting the entire device to control the viewing angle. The orientation of the user’s point of view is controlled by moving the device to “scan” the environment.

In this modality, both hands are generally engaged by haptic effects, which makes haptics readily interpretable when they relate to the environment or ambience of the scene. For example, in lived reality, if a person is near an explosion, there would be a resultant vibration that might be felt in nerve endings throughout the body, regardless of whether the person were looking directly at the explosion when it occurred. Thus, to make the experience of an explosion more engaging in immersive content, a haptic effect can be played that synchronizes with explosion event regardless of the user’s viewing angle at the moment the explosion occurs. In fact, some content uses this as part of the story by using offscreen haptics to prompt the user to reorient their device and find the source of the haptic event.

In other cases, for example when a scene has a lot of action, creating haptic effects for all the events in the sphere would confuse the viewer and overwhelm their sense of touch. In these cases, it is better to design haptics that correlate to only certain parts of the action, for example, only the most prominent action that is included within the current viewing angle.

### A.4.3 Head Gesture

That same immersive content may additionally be experienced with a headset. In this case, the orientation of the body and head are used to shift viewing angles. In some cases, the headset itself has integrated haptic actuators, allowing the person to feel touch sensations on the face, through the eye mask, or head, through the strap. The user may or may not also be holding a controller, or a pair of controllers.

In this modality, haptics played at the headset might be used to reinforce presence in an environment, for example, weather patterns like rain or snow. If near an explosion, haptics at the headset might represent both the air pressure gradient and a light peppering of dirt particles. In both these cases, the haptic effects are attempting to simulate what the person’s head would be feeling if they were really in the scene.

At the same time, haptic effects related to manual gestures like pointing, selecting, or interacting with virtual objects could be played in the handheld controllers.

## A.5 Dimensions of Haptic Design

Haptic designers work with a set of design dimensions that map to the overlap between haptic playback technology capability and human interpretation of touch stimuli. Audio designers work with concepts like volume, panning, and EQ, and have tools that provide access to these design dimensions. Haptic designers have similar practices.

Here are some key haptic dimensions for interactive content:

* Intensity, spanning from light to strong.
* Crossfade curves.
* Timbre, which includes frequency and waveform for high bandwidth actuators.
* Timing, which allows cross-modal events to be synchronized and latency accounted for.
* Expressivity, which includes changing haptic parameters based on real-time input.

## A.6 Haptic Playback for Immersive Media

User expectation for haptic playback is influenced by two main elements: the viewer’s location in the scene and viewing orientation. Depending on these elements, haptic effects that are contingent on these two variables may be modulated, mixed, or both. Modulation refers to changing effect parameters, such as intensity or frequency. Mixing refers to combining multiple haptic effects into a single actuator signal that preserves the design intent for the role of haptics in the scene.  

1. <https://www.youtube.com/watch?v=G-XZhKqQAHU> [↑](#footnote-ref-2)
2. <https://www.youtube.com/watch?v=H6SsB3JYqQg> [↑](#footnote-ref-3)
3. <https://www.youtube.com/watch?v=CY_wiN626ac> [↑](#footnote-ref-4)