

# Introducing Basic Principles of Haptic Cinematography and Editing

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## Abstract

*Adding the sense of touch to hearing and seeing would be necessary for a true immersive experience. This is the promise of the growing "4D-cinema" based on motion platforms and others sensory effects (water spray, wind, scent, etc.). Touch provides a new dimension for filmmakers and leads to a new creative area, the haptic cinematography. However design rules are required to use this sensorial modality in the right way for increasing the user experience. This paper addresses this issue, by introducing principles of haptic cinematography editing. The proposed elements are based on early feedback from different creative works performed by the authors (including a student in cinema arts), anticipating the role of haptographers, the experts on haptic content creation. Three full short movies have been augmented with haptic feedback and tested by numerous users, in order to provide the inputs for this introductory paper.*

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Categories and Subject Descriptors (according to ACM CCS):  
H.5.2 [HCI]: User Interfaces—Haptic I/O

## 1. Introduction

Today only two senses are stimulated when being in a movie theater: the visual and auditory senses. The next big step to increase a movie experience could be through the addition of the sense of touch. In 1962, Heilig introduced the *Sensorama*, a system where one could watch a 3D movie, sense vibrations, feel the wind and smell odors [Hei62]. This was probably the first haptic cinema experience. It opened the path for new human-computer-interfaces (HCI), and haptic technology is now intensively used, especially for virtual reality applications. It took longer to see haptic feedback in a multimedia context. O'Modhrain and Oakley in 2003 have demonstrated that the benefits of haptic feedback observed in virtual reality are applicable to multimedia applications [OO03]. Then, in 2011, El Saddik et al. proposed that the combination of haptics and audiovisual content becomes a complete field of study: "haptic-audiovisual (HAV)" [ESEC11, DLG\*13]. Danieau et al. more recently extended those concepts to propose the "Haptic Cinematography", i.e. augmenting the movie experience with haptic effects [DFG\*14]. Those haptic effects for the cinema may have different nature each stimulating various aspects of the human haptic system [MP12]. Actually three categories of haptic effects may be considered:

1. Tactile: the perception of vibrations, pressure and temperature through the skin;
2. Kinesthetic: the perception of positions and movements of limbs and forces from spindles and tendons;
3. Proprioception: the perception of position and posture of the body in space.

Those sensory capabilities can then be advantageously used to bring the haptic experience to the user thanks to dedicated haptic devices [LC13, AMS11, GMS06, IP11, DFG\*12]. However, content creators lack guiding principles for creating such effects. Israr et al. recently proposed a first library of usable haptic vocabulary [IZS\*14]. They also defined a *feel effect* as an explicit pairing between a meaningful linguistic phrase and a rendered haptic pattern. Similarly some companies, such as D-Box<sup>†</sup> or CJ 4Dplex<sup>‡</sup>, started creating haptic content dedicated to their rendering systems and based on proprietary editing tools. But no lesson from those releases are available.

This paper aims at going further by covering all haptic sensations whatever the rendering device, by proposing guidelines for the narrative of haptic content and by serving as support for education on haptic cinematography. The proposed editing rules are inspired by the *12 Basic Principles of Animation* from Ollie Johnston and Frank Thomas [TJ95], as well as some rules for the cinema [TB09], by numerous creative works from the literature, and

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by experiments we conducted with user studies and public demonstrations. It leads to 9 basic principles we believe are fundamental for a good user experience. The paper is organized as follows, section 2 first describes the authoring workflow we have designed to create the haptic effects and to test the proposed principles. Section 3 details the proposed 9 basic principles with different illustrations, and finally the last section concludes this introduction to haptic cinematography.

## 2. Haptic Authoring

A haptic-audiovisual (HAV) workflow may be seen as an extension of the traditional audio-visual (AV) workflow [DLG\*13]. The authoring process can be split into three stages.

### 2.1. Haptic Cinematography

The first stage is the production of the content, i.e. how haptic effects can be created (or generated) and synchronized with the audiovisual content. It includes the acquisition from sensors [DFC\*12], the automatic extraction from a component of the AV content [RSLLO8] or the manual authoring [DBF\*13]. Hence, haptic effects may be created from existing data, leading to a better realism, or from scratch, giving more freedom to the artist. These two types are illustrated in Figure 1 where the top image is an excerpt from a movie and at the bottom the temporal 2D signal represents one haptic data channel. Ideally haptics should be better considered at the early stage of the movie creation (i.e. when writing scenario, storyboarding) in order to maximize the viewers' experience.

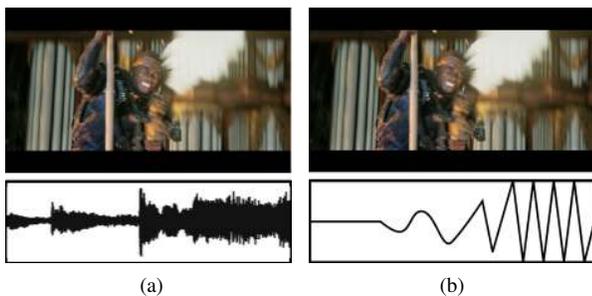


Figure 1: A haptic effect associated to a machine gun may be generated from data provided by an accelerometer attached to a actual gun (a), or may be manually designed (b). Bottom figures are the 2D temporal representation of the haptic effect or the signal from a sensor. Excerpt from Tears of Steel (08:12). ©Blender Foundation.

### 2.2. Haptic Editing

The second stage is the editing of the haptic effects, usually done at the post-production after the shooting. It will be done by a specialist that we propose to name *haptographer*, i.e. a professional who master haptics (perceptual properties and mechanical devices), and who is able to support the director of photography, the producers and the writers. The haptographer would have a role similar to the stereographer for 3D content [RT10].



Figure 2: Movies of the Blender Foundation used [Ble08].

In this experimental work, three movies created by the Blender Foundation, about 10 to 15 minutes long, were used [Ble08]. The different types of movies, i.e. animation and action (see Figure 2), are relevant to evaluate action type effects as well as more subtle effects such as caress, camera motion, illusion of flying, etc. We have then added haptic content using a dedicated editing tool (see Figure 3 from [DBF\*13]) associated to a 3DoF force-feedback device for pre-visualization of the effects. This tool allows to ingest or to synthetically create various types of effects, synchronized with the AV content. It generates an XML file which is then played back with a dedicated player. Alternative solutions exist to create and distribute haptic data, such as [GMS06, WRTH12, Kim13].

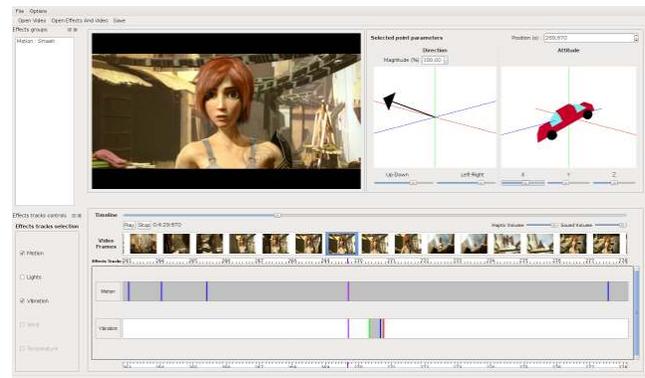


Figure 3: Editing software tool for creating haptic content for movies. The synchronization is done at the frame level.

### 2.3. Haptic Rendering

Finally the encoded haptic effect is decoded and rendered on a specific haptic actuator (after adaptation to the capabilities of the end device): wearables/vests [LCB\*09, LC13], handheld/gloves [KCRO10, GMS06], desktops/tablets/smartphones [AMS11], motion platforms or seats [IP11, DFG\*12]. In this paper we have used the *HapSeat* because of its capability to generate the three types of haptic effects [DFG\*12]. It is a three points device, one for the head and two for the hands, in order to stimulate respectively the vestibular system for the proprioception, and the two hands for the kinesthetic and tactile channels.

### 3. The 9 Haptic Basic Principles

Haptic creation refers to the intent of creating haptic effects, coherent with the narrative world of the film, that the audience should clearly understand in order to feel immersed in the movie. It means that the actors, the action and the ambiance should be taken into account to create a haptic experience that serves the story and improves the user experience.

In order to achieve a successful global experience there are some rules to know and follow. This section is an attempt to list and to explain them based on the experience learned during our studies, but also during several conferences and public demonstrations where more than 200 people tried the system and provided feedback. Some of those rules directly re-use concepts and naming proposed by Ollie Johnston and Frank Thomas [TJ95] since they still apply, and some others are new and dedicated to the haptic effects. We have also based those rules on existing methods to combine audio to video. Music and sound effects can be used in different way to support the narrative [Mas98]: there are diegetic sounds which belong to the world of the story such as characters' voices or noise made by objects, and non-diegetic sounds not directly related to the action such as voice-over or ambiance music).

Note that, for each principle, we have used snapshots extracted from the AV content (Figure 2) and added below a schematic 2D temporal representation of the associated haptic effect illustrating the principle (extrapolation to multi-channels or more complex 3D signals is possible, but is not considered here).

#### 3.1. Staging

The staging directs the audience's attention to the story or an idea. Usually the content creator uses cinematographic techniques to drive the viewer attention and engage him into the story. For instance the framing, the camera motion, the point of focus or the music are technical elements that can be used. Thus, haptic feedback should be also used as a mechanism to enhance the original artistic intent, and to help to focus on the targeted element. It should not drive the attention to something else, nor disturb the audience. Therefore it is recommended to specify only one haptic effect at a time, and this effect should be related to the main narrative element.

To drive the creator, one can use the three categories of haptic effects proposed by [KCRO10]: first-person, third person and background. They observed in experiments that first-person effects were the most preferred by the users. In our work on haptic cinematography we go further and propose a taxonomy of these different elements better fitting the staging principle [DFG\*14]. For instance Figure 4 depicts a scene where a dragon is falling behind the main character. A haptic effect simulating a fall (see the signal below the picture) is added to stress the original intent.

#### 3.2. Continuity

The continuity is derived from the well-known five C's rule of filmmaking [Mas98]. It states that a logical coherence between shots should be established in both time and space. The "180-Degree rule" is an implementation of this principle, that should also be considered for haptic feedback. The main difference is that the coherence is linked to the physical point of view specified by the artist.



Figure 4: Example on Sintel (02:54). A dragon is falling behind the main character. A haptic effect associated to this fall should drag the user's attention toward the background. ©Blender Foundation.

Once set, the type of effect should not change during the scene nor between shots.

For instance if the effect is linked to an object, it should be still linked to it even when the camera angle changes. It is not possible to switch to another target, otherwise the viewer will be disturbed by the change and would be distracted from the narrative. Figure 5 shows that in the case of a succession of shots between two characters, the haptic effect should be associated to only one of them (depending on the narrative) and stay related to him all along the scene.



Figure 5: Example on Sintel (04:11). The dragon, followed by the main character, is chasing a chicken. There is a succession of shots where the dragon and the main character are shown. Haptic effects cannot be associated to all physical events happening to both characters without confusing the audience. They should be associated to one character and stay related to it all along the scene (to the dragon here). ©Blender Foundation.

#### 3.3. Realism

In animation, a main principle is the so-called "squash and stretch". The goal is to increase the realism of the dynamic of an object by deforming its shape. For instance, when hitting a wall, a ball would be squeezed then stretched. Realism is a key factor in our context. Oh et al. conducted in-depth interviews with 35 participants having experienced 4D movies [OLL11]. They observed that the realism of the effects in the key component of the feeling of presence.

While haptic feedback does not need squash and stretch, it is however important that the applied effects remain compatible with the physical laws in terms of intensity, direction and type. A big jumping man would not be designed the same way as for a thin girl pussyfooting. This should be reflected by the haptic feedback, adapting the strength and intensity accordingly (Figure 6).

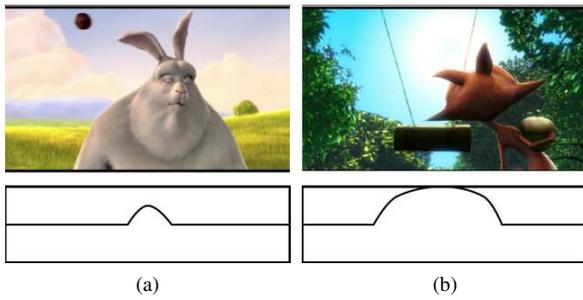


Figure 6: Example on Big Buck Bunny (02:54). (a) a big character is hit by a small object, thus a light haptic effect is designed. (b) a small character is hit by a big object, so a strong haptic effect is designed. ©Blender Foundation.

### 3.4. Perception

The touch, as the other senses, is constrained by the human perception [HS04]. There are some perceptual thresholds that need to be taken into account when designing an effect. In particular, when applying an effect or motion, it should be done with an intensity (in term of acceleration or range) that is sufficient to be perceived. Figure 7 depicts an example of a character hit by different objects with different masses. The differences can only be perceived if the differential strength of the haptic effects are higher than the perceptual threshold. Besides, it is possible to use the properties of the human haptic system to create haptic illusions. This is typically the knowhow of the *haptographer*. He knows the limitations, the perception thresholds, the haptic illusions (such as self-motion, pseudo-haptic, sensory saltation, etc.) [LJ11]. He may thus recommend specific images and sound content and associate dedicated haptic feedback to create perceptive illusions.

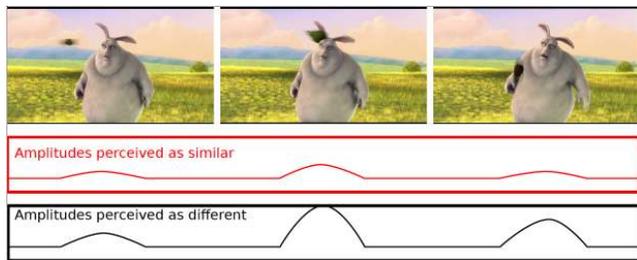


Figure 7: Example on Big Buck Bunny (03:02). The character is hit by several objects (a nut, a pear, a pine cone, etc.). The mass of these objects is slightly different, so haptic effects associated to the impact should be different. However if the differences between the effects are below the differential thresholds the intensity of the effect will not be perceived. ©Blender Foundation.

### 3.5. Anticipation

This movement prepares the viewer for a major event that is going to happen in the movie. It could be related to an action of a character, a surprise or an accident. The anticipation role is to prepare

the event in order to increase its impact on the audience, to be sure to catch the audience attention to important parts of the movie and to empathize the action. The anticipation intensity is also linked to the action speed.

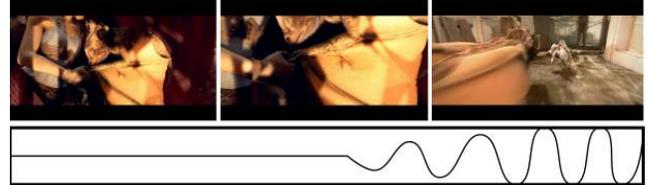


Figure 8: Example on Sintel (04:07). A haptic effect starts before the scene where the dragon is chasing a chicken, with an increasing intensity. It facilitates the transition between the scene where the dragon is sleeping and the chasing scene, but also increases the anxiety linked to this event. ©Blender Foundation.

Vibration is a signal particularly relevant for this, since this type of metaphor is often used with music ambiance to prepare the audience. The amplitude and/or frequency of the vibrations can be used to represent how strong or important is the coming event. A typical example is provided in Figure 8 where the effect starts early to prepare the audience to an action (chasing a chicken here).

Similarly, Chang et al. discussed the combination between haptic and audio feedback [CO08]. They proposed four principles to design haptic-audio feedback. One of them is "temporal linearization" which is a concept similar to anticipation. A stimulus (i.e. haptic) is started before another one (i.e. audio) to create a feeling of causality.

### 3.6. Exaggeration

As for animation and editing, exaggeration is an interesting tool to accent certain actions or to underline events so that the audience does not miss the intent. All the components of a scene can be exaggerated: the design of an object or character, the intensity of a movement, a color, or a sound. This is also the case for the haptic feedback, whatever the type, i.e. for a motion, a shot, or any other non-diegetic effect. To illustrate that, Figure 9 depicts a scene where a character (Bunny) is walking. In order to stress the weight of Bunny, a haptic feedback representing a walk could be added, with a high amplitude to reflect the weight. In addition, the *haptographer* may associate a haptic footprint (or haptic signature) to different characters, allowing the audience to recognize them with the haptic feedback only. However, it should be used with care, exaggeration should stay realistic and physically plausible. Exaggeration should not be used too often otherwise the audience will be confused and may not understand the reason of this exaggeration. Finally, it should be balanced and coherent between all the elements of the scene.

Another principle of Chang et al. is the "synchresis" [CO08]. Haptic and audio are combined to add value to the moviegoing experience.

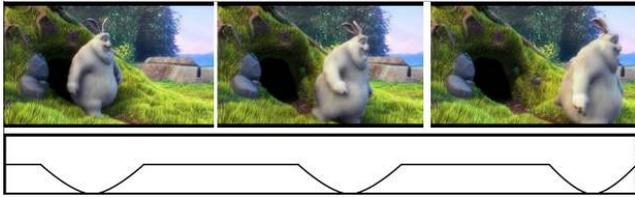


Figure 9: Example on Big Buck Bunny (00:53). The haptic signal corresponds to the character walk and is voluntarily amplified to stress his weight. ©Blender Foundation.

### 3.7. Synchronism

All senses should be stimulated at the same time for the same event. It means that particular care should be taken to adjust the impact of a force on the final user to happen at the same time as what he is seeing and hearing. In previous work [DFC\*12] we have shown that random effects are not appreciated by the users because they are not synchronized with the video. Participants were not aware of the nature of those effects and they tried to interpret them, without success. Kim et al. used a saliency map to drive an array of vibration motors [KLC12]. They observed that the synchronization is important between visual and haptic feedback. However their automatic technique is not aware of the semantic of the scene and they showed that a wrong combination may distract the user. From subjective comments of Kim et al.'s experiments, it appears that the synchronization between AV content and haptic feedback is important. Thus, similarly to the fact that the sound of an event cannot be disconnected from the image of this event, a haptic effect of an object hurting a character or the ground, that the content creator wants also to be felt by the user, cannot be desynchronized from the video shown. Otherwise the viewer will not understand what is happening and it will create discomfort. This is illustrated by Figure 10 in the case of an apple falling down. From a technical point of view it means that the latency of the rendering device should be taken in account.

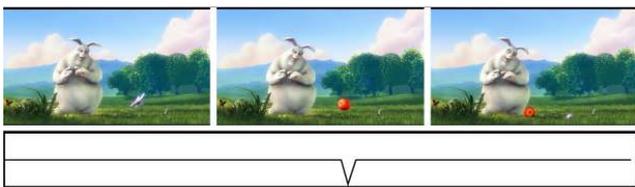


Figure 10: Example on Big Buck Bunny (01:32). An apple falls and hits the ground. The corresponding haptic effect should be perfectly synchronized with the event. ©Blender Foundation.

### 3.8. Kinetics

Johnston and Thomas defined two principles called the "Slow-IN Slow-OUT and ARCS" which relates to the best way to interpolate trajectories and motion in time. The Slow-IN Slow-OUT principle is used in animation to soften the action and refers to the second and third-order continuity of motion. The ARCS is the visual path of an action described by an arc, and better represent the natural

motion of an object or character. They both relates to the kinetic control of an action. This is exactly the reason why it should also be used for haptic feedback especially when dealing with motion and vibrations. A typical illustration would be a car, when a driver accelerate or brake, the car speed response is not linear with the command. This is principally due to the inertia of the car. Then it should be taken into account, and again it relates to the rule stating that any effect should be physically plausible. Figure 11 is an example with two characters: a human and a robot. Different kinetic trajectories will be used to represent the human or robot's motion.

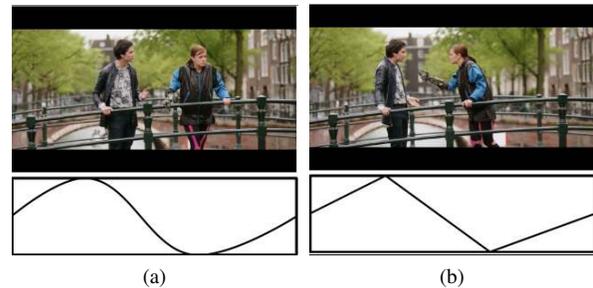


Figure 11: Example on Tears of Steel (00:26). (a) Haptic effect associated to the boy may be smooth, with slow-in and slow-out. (b) Effects associated to the girl, a robot, may be sharper, more abrupt to reflect the robotic motion properties. ©Blender Foundation.

The interpolation of trajectories assumes that key frames are defined. It generally applies to the first and last frames of a shot, but intermediate frames can also be used depending on the duration of the shot. Slow-IN, Slow-OUT and ARCS are mechanisms to compute the intermediate positions, and spline techniques with parameters adapted to the expected kinetics properties are particularly suitable.

### 3.9. Diegesis

Diegetic and non-diegetic effects are generally related to the sound. A diegetic sound is any sound presented as originated from the action of the film. For instance, the voice of characters, the sound made by objects, the music from instruments within the story space. A non-diegetic sound has not been implied to be present in the action and is often related to the background. For instance, the narrator's voice or a mood music. This distinction is also valid for haptic feedback but with a slightly different meaning. A physical effect related to the direct action or character is a *diegetic haptic* effect, such as an impact, a collision, a punch or a character motion. Whereas a *non-diegetic haptic* effect would be related to different narrative elements of a movie such as camera effects (dutch angle, vertigo), editing (cuts, pacing), non-diegetic sound (music, voice-over) or context (semantic). This taxonomy of haptic effects is detailed in [DFG\*14].

Thus a *haptographer* should decide which type of effect to stress with haptics, and then follow previous rules (especially staging and continuity). Therefore, haptic diegesis is part of the creation and narrative, and as such needs to be considered with particular attention. To illustrate this principle, let us consider that if the camera

motion is used to increase a drama, as the zoom in Figure 12-top, the content creator would then choose to consider the camera motion for the haptic rendering device. In the opposite during an action scene, it would be more efficient to consider the character dynamic, such as in Figure 12-bottom the balls impacts on them. Similarly, a haptic effect may occur as a consequence of a visual action, instead of directly representing the action.

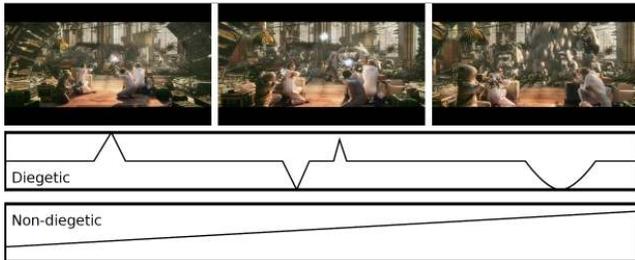


Figure 12: Example on *Tears of Steel* (07:53). A camera zoom is used to focus on the action and the coming characters. Soldiers try to shoot those characters. A diegetic haptic effect can be associated to the shoots to simulate the impact (top), or a non-diegetic haptic effect may be associated to the camera zooming to increase the dramatic intensity (bottom). ©Blender Foundation.

#### 4. Conclusion

The proposed basic principles for Haptic Cinematography Editing are based on early feedback from public demonstrations we conducted where more than 200 people experienced movies augmented with haptic effects. We also collaborate with some professionals from the cinema (academics and creatives). From these works, we propose guidelines consisting of 9 basic principles. They will help to design relevant haptic effects leading to a comfortable and immersive experience. We also introduce a new role in the movie production workflow that we named the haptographer, i.e. the professional who master haptic perceptual properties and haptic devices, and collaborate with the director of photography, producers and writers. This work should be seen as an introduction to haptic creation. Further user studies and research work are needed to validate those principles.

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