A Taxonomy of Spectator Experience Augmentation Techniques

Olivier Capra, Florent Berthaut, Laurent Grisoni

A Taxonomy of Spectator Experience Augmentation Techniques

Olivier Capra
CRIStAL, CNRS,
University of Lille, France
olivier.capra@univ-lille.fr

Florent Berthaut
CRIStAL, CNRS,
University of Lille, France
florent.berthaut@univ-lille.fr

Laurent Grisoni
CRIStAL, CNRS,
University of Lille, France
laurent.grisoni@univ-lille.fr

ABSTRACT

In the context of artistic performances, the complexity and diversity of digital interfaces may impair the spectator experience, in particular hiding the engagement and virtuosity of the performers. Artists and researchers have made attempts at solving this by augmenting performances with additional information provided through visual, haptic or sonic modalities. However, the proposed techniques have not yet been formalized and we believe a clarification of their many aspects is necessary for future research. In this paper, we propose a taxonomy for what we define as Spectator Experience Augmentation Techniques (SEATs). We use it to analyse existing techniques and we demonstrate how it can serve as a basis for the exploration of novel ones.

Author Keywords

audience experience, augmentation techniques, taxonomy, performance

CCS Concepts

•Applied computing → Sound and music computing; Performing arts; •Human-centered computing → *Mixed / augmented reality;*

1. INTRODUCTION

While digital interfaces open numerous possibilities for artistic expression, they may have a negative impact on the experience of spectators. In particular, previous research has shown that digital interfaces, in particular Digital Musical Instruments (DMIs), may diminish the perceived liveness [23], the attributed agency [5], the perception of error [8] and the perception of the performer's skill [16]. A first solution to this issued is to shift the audience focus towards the aural aspect of electronic performances [24]. A second solution is to take into account the audience experience in the design and evaluation of DMIs [3, 18] and to ensure that instruments are sufficiently transparent [14]. As an alternative solution, artists and researchers have designed techniques which *augment* performances with additional information for the audience without requiring changes in the design of DMIs, therefore preserving their expressive power. The goal of these Spectator Experience Augmentation Techniques (SEATs)[12] is not necessarily to "explain" the instruments and "demistify the apparatus" [2] but to enrich the performance for spectators who wish it. They range from textual information [4] and pre-performance demos [7], to augmented reality displays [6, 20] and haptic feedback devices [1, 25]. These techniques may be essential in order to ensure the accessibility and enjoyment of performances with existing and future interactive systems. However, to our knowledge no formal analysis has been conducted yet, restraining the development of such techniques.

In this paper we propose a taxonomy for Spectator Experience Augmentation Techniques (SEATs). This taxonomy is aimed at artists and researchers as it can help inform the design of performances with the experience of spectators in mind.

NIME'20, July 21-25, 2020, Royal Birmingham Conservatoire, Birmingham City University, Birmingham, United Kingdom.

1.1 Related work

Most classifications related to DMIs are defined from the musician or instrument designer point of view, such as the dimension space proposed by Birnbaum et al. [9].

Previous work on audience experience has led to classifications such as challenges for the design of DMIs from an audience perspective [17] and to a 2D space for the analysis of action and effect perception [21]. In non-performance contexts, previous work has explored the use of visual and haptic displays to enhance the listeners experience. In particular Nanayakkara et al. [19] compare haptic and visual representations of music. More specifically on techniques for augmenting the audience experience, Capra et al. describe a number of strategies for augmentation (visual, haptic) but do not provide a formal analysis [10]. Bin et al. provide the evaluation of a technique which uses a pre-concert demo to increase the level of comprehension [7] . Benford et al. discuss the effect of diverse techniques (before, during and after the performance) on the audience journey [4].

However to our knowledge, no formal classification of existing techniques for the augmentation of spectator experience, nor analysis of their components has been performed.

1.2 Contribution

In this paper, we describe a taxonomy of Spectator Experience Augmentation Techniques, which constitutes the first formal analysis of the strategies that researchers and artists use to compensate for the alteration of audience experience in performances with digital interfaces. We demonstrate how it can be used to analyse, extend or create techniques, and how it can be useful for artists and researchers.

2. SPECTATOR EXPERIENCE AUGMENTATION TECHNIQUES

It is essential to point out that, by using the term *augmentations*, we focus on techniques which have no impact on the design of the performer's interface, i.e. they do *not change the way performers interact.* Rather, they provide addi-

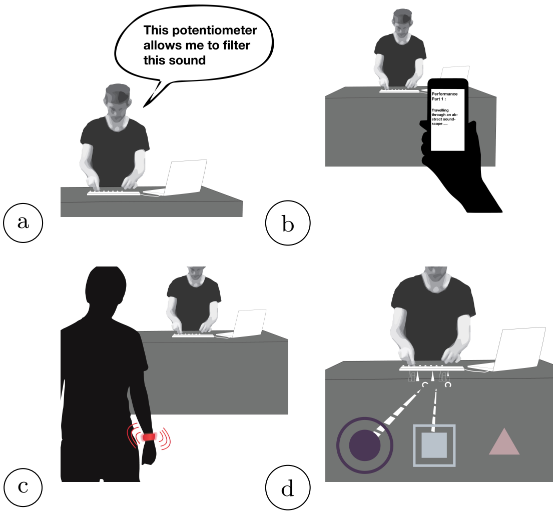

Figure 1: Spectator Experience Augmentation Techniques: a) pre-performance explanation, b) textual information on mobile, c) haptic wearables, d) visual augmentations

tional information to the audience on various components of the performance, such as performer's equipment, gestures or intentions. They are also not imposed on spectators, who should be able to attend the performance without the augmentations. SEATs may be designed with various goals in mind : pedagogical, with a focus on helping spectators understand the performers' interactions; aesthetic or engaging, with a focus on increasing the implication of the audience; or even disruptive, so that performances appear as magical or secretive [22]. Although SEATs may be combined with an interface that allows for audience participation in the performance, i.e. the music produced is altered by spectators, we chose to keep this aspect outside our taxonomy to focus on transmission of information to the audience.

Thus, the values chosen for each dimension of our taxonomy may have an impact on multiple aspects of the audience experience. For genericity reasons, our taxonomy does not take the display technology into account. For instance, visual augmentations with the same dimensions could be achieved through projection mapping, with video AR on a smartphone or with an optical see-through head-mounted display. Our aim is that this taxonomy will remain usable by designers of performances with future technologies.

Our taxonomy is composed of eleven dimensions, described below. For each of them, we provide the range of possible values and discuss their potential impact.

2.1 Spatial Alignment

This dimension describes how augmentations are spatially aligned with the performance components. Possible values include : *aligned*, when the augmentations are perceived as coming from the component itself; *co-located* when they can be perceived while maintaining the focus on the performance; *distant* when there is a shift in focus required to access them. For instance, visual augmentations of a music performance can be aligned if using a Pepper's ghost augmented-reality display, co-located if projected on a screen behind the musician, or distant if displayed on the spectators' mobile devices. While aligning augmentations seem ideal because it preserves the focus on the performance, the presentation of complex information might cause sensory or cognitive overload for the audience, in which case a more distant presentation is preferable.

2.2 Temporal Alignment

This dimension pertains to when spectators can access to the augmentations: *before*, *during* or *after* the performance. For instance, in the case of verbal explanations, they may be provided as a pre-performance demo, as comments during the performance, or as a post-performance discussion. If presented before the performance, augmentations may provide cues for the audience without any alteration to the performance. However if they are too complex or given too long before, some of the information may not be remembered when needed. If presented during, the information is given when needed but it might distract or overwhelm the audience. If presented after, the information might be lacking to understand events when they happen, but the magical aspect [22] of the performance is preserved.

2.3 Temporal Density

This dimension relates to the temporal range that the augmentations cover. It can be broadly defined as a *low*, *medium* and *high*. For example, augmentations of a music performance can range from displaying only the last played note to displaying the whole score. While a high density will help the audience forge a stronger sense of performer's intentions or actions over time, and may help them in perceiving virtuosity or errors, providing too much information might also distract them from the current actions.

2.4 Temporal Control

This dimension describes the possibility for the audience to control the temporal range covered by the augmentations, i.e. on which part of the performance they will access information. It ranges from *none* to *full*. An example would be textual explanations provided one by one either synchronously with events of the performance or on request, with spectators being able to freely scroll through them. From a design perspective, allowing for temporal control may help spectators build a better understanding of the performance, but it might also lead them to miss augmentations that should be perceived at a specific time.

2.5 Semantic Density

This dimension relates to how much information is provided by a SEAT. It can also be seen as the information level-of-detail. Like temporal density, it can be broadly classified *low*, *medium* and *high*. For instance, augmentations on a digital musical instrument may range from only showing which synthesizer is being played, to showing the detailed audio graph including the activity of all synthesis parameters. This dimension is essential as one needs to ensure that the density is sufficient to provide useful information but not too high so that it does not result in sensory or cognitive overload for the audience.

2.6 Semantic Control

Symmetrically to temporal control, this dimension indicates if the level of semantic detail can be chosen by the audience, allowing for a personalized access to narrative elements [4] or for information that matches the expertise of the spectator [11]. It ranges from *none* to *full*. In the case of textual explanations, it can for example go from a single level of detail given to all spectators to multiple versions targeted at different levels of expertise, e.g. children / adults or novices / experts. This level may also be automatically selected according to emotional or cognitive states measured through wearable physiological sensors [10]. Regarding the accessibility of the augmentations, increasing the control helps

	Spatial Alignment	Temporal Alignment	Temporal Density	Temporal Control	Semantic Density	Semantic Control	Pres. Nature	Pres. Modality	Content Nature	Content Reactivity	Agents
Perrotin [20]	co-located	during	medium	none	medium	none	abstract / conceptual	visual	technical / gestural /	reactive	avatar / origin
Benford [4]	co-located / distant	before / during / after	high	full	medium	limited	abstract / linguistic	visual	technical / intentional	semi-fixed	—
Armitage [1]	distant	during	low	none	low	none	figurative	haptic	gestural	reactive	—
Turchet [25]	distant	during	low	none	low	none	figurative	haptic	gestural	reactive	—
Bin [7]	aligned	before	medium	none	low	none	linguistic	auditory / visual	technical / gestural	fixed	—
Berthaut [6]	aligned	during	low	none	medium	none	abstract	visual	technical / gestural / causal	reactive	—

Table 1: Analysis of Spectator Experience Augmentation Techniques along the dimensions of our taxonomy

avoiding too simple or too complex information depending on spectator's expertise, but it also increases the complexity of implementation for the performance designers. One also needs to ensure that the control interface is not too difficult or that it does not distract spectators from the performance.

2.7 Presentation nature

This dimension relates to the form given to the information provided to the audience. Possible values include *figurative*, *abstract*, *conceptual*, and *linguistic*. For instance, to indicate that a certain key was played by a musician the augmentation can display respectively a close-up of their hands and the keyboard, a colour changing shape, the note on a scale or the note name. This dimension involves a trade-off between the information explicitness, maximised with linguistic or figurative augmentations, and its compactness which can be optimised with abstract or conceptual augmentations showing only essential information. It also has implications on the aesthetic integration of the augmentations in the performance.

2.8 Presentation modality

This dimension describes how the augmentations are displayed. The modality can be *visual*, *auditory* and *haptic*. For example, the subtle gestures of a performer on a sensor can be amplified using changes in a visual shape that represents the sensor or through vibrotactile feedback reproducing the gestures. The choice of modality depends on the type of performance and its scalability. While visual and auditory displays can be generalised, haptic ones imply more restrictions as individual devices need to be designed.

2.9 Content nature

This dimension pertains to the nature of the content displayed by the augmentations, i.e. on which aspects of the performance the SEAT provides information. We identified four possible aspects: *technical* to reveal the mechanisms of the interface [6]; *gestural*, to amplify subtle/hidden movements [20]; *intentional*, so that the audience understand what performers are trying to accomplish [15]; *causal*, so that spectators have a clear perception of who from the performer or autonomous processes is responsible for variations in the sound. The choice of content nature depends strongly on the aim of the augmentations. Showing the intention can highlight the performer's virtuosity or affect the audience emotional response, while technical augmentations may increase the level of comprehension of the audience.

2.10 Agents

This dimension describes the representation a SEAT can give of the agents in a performance and of their interactions. Agents are entities that can interact with instruments and interact together, like 3 musicians on stage or a composite crew including virtual agents. We envision 4 values for this dimension. *Origin*, so that spectators perceive who is the source of events in the performance, for example amongst members of an orchestra [20] or between the performer and automated processes. *Avatar* indicates the use of representations of the agents to provide additional information. This modality can be used in performances where the musicians are not physically located in the same place or when an agent is virtual. *Communication* when musicians exchange information not directly linked to sound production, such as synchronisation or support signals. *Interactions* indicates when the SEAT augments the interactions between agents. This can be useful for instruments with shared controls and rich musician-to-musician interfaces such as bf-pd [13].

2.11 Content reactivity

This dimension describes the relation between the augmentations and the performance. It can be *fixed* when the augmentations are pre-defined and do not change with the performance, *semi-fixed* when some elements of the augmentations change according to the performance, and *reactive* when augmentations are generated from information extracted in realtime during the performance. For instance, visual augmentations can be pre-recorded videos provided at pre-defined moments or synthetic graphics triggered and adapted dynamically based on the performers actions. While a reactive content guarantees that the augmentations will adapt to changes in the performances, it involves a technical complexity not always achievable. For example performers intentions can not be extracted dynamically during the performance. It may also lead to information being provided in a less accessible way than fixed content if it is not designed carefully, e.g. with multiple visual indications overlapping.

3. ANALYSIS OF EXISTING SEATS

Table 1 provides a decomposition of the following SEATs from the literature. Perrotin et al. [20] use visual augmentations projected behind a digital orchestra to display the musical parameters (e.g. notes) played by each musician. Benford et al. [4] use visual augmentations, both conceptual and textual, projected on stage and available on spectators' mobile devices to provide an overview of the structure and intentions in a musical performance. Armitage [1] uses haptic augmentations to provide the audience with vibrotactile feedback that amplifies the performer's key presses in a live coding performance. Berthaut et al. [6] use visual augmentations to reveal the mechanisms of a DMI (including sensor values, sound processes activity and sensor to processes mappings) to the audience with an augmented reality display. Bin et al. [7] uses pre-concert explanations of the instrument to increase the spectators' level of enjoyment and comprehension. Turchet et al. [25] use a wearable haptic device to provide vibrotactile feedback to the audience to amplify the musician's gestures.

4. USING THE TAXONOMY FOR DESIGN

When creating SEATs for a performance, our taxonomy can be used to explore designs with various effects on the audience experience. Starting from a common visual display of information behind the performer, the following directions could be chosen, depending on the desired effect:

In order to improve the perception of the performer's control, i.e. the audience's attributed agency [5], value of the *Spatial Alignment* dimension can be increased, for example using augmented reality displays which would place the information directly on top of the performer's gesture, therefore improving the causal link between actions and effects. However, attention must then be paid to the quantity of displayed information, so as not to overload visually the performance and reduce the visibility of the performer's gestures. In order to increase the audience engagement in the performance, the *Presentation Modality* dimension can combine visual and haptic feedback, through the use of belts or wristbands providing vibrotactile feedback. This direction however poses issues for implementation, as it requires to equip each spectator with a device or constrains them to fixed positions (e.g. seats) with built-in feedback. Finally, one can choose to adapt the augmentations to spectators with levels of expertise. In that case, the value of the *Semantic Control* dimension can be increased. This would however require an individual or grouped device for the selection of the level of information provided by the augmentations.

5. CONCLUSION

Spectator Experience Augmentation Techniques (SEATs) are techniques that add information to digital performance interfaces in order to enrich the audience experience. In this paper, we proposed a taxonomy for these techniques, we detailed its dimensions and showed how it can be used for the analysis and design of SEATs. As future work, we believe a formal evaluation should be conducted which would precisely determine the impact of each of these dimensions on the audience experience, and how they would be appropriated by artists and researchers.

6. REFERENCES

[1] J. Armitage. Revealing timelines: Live coding and its gestures. *Proceedings of ICLC*, 2016.

[2] P. Auslander. *Liveness: Performance in a mediatized culture*. Routledge, 2008.

[3] J. Barbosa, F. Calegario, V. Teichrieb, G. Ramalho, and P. McGlynn. Considering audience's view towards an evaluation methodology for digital musical instruments. In *Proceedings of NIME*, 2012.

[4] S. Benford, C. Greenhalgh, A. Hazzard, A. Chamberlain, M. Kallionpää, D. M. Weigl, K. R. Page, and M. Lin. Designing the audience journey through repeated experiences. In *Proceedings of ACM CHI*, 2018.

[5] F. Berthaut, D. Coyle, J. W. Moore, and H. Limerick. Liveness through the lens of agency and causality. In *Proceedings of NIME*, 2015.

[6] F. Berthaut, M. Marshall, S. Subramanian, and M. Hachet. Rouages: Revealing the mechanisms of digital musical instruments to the audience. In *Proceedings of NIME*, 2013.

[7] S. Bin, A. McPherson, N. Bryan-Kinns, et al. Skip the pre-concert demo: How technical familiarity and musical style affect audience response. In *Proceedings of NIME*, 2016.

[8] S. A. Bin, F. Morreale, N. Bryan-Kinns, and A. P. McPherson. In-the-moment and beyond: Combining post-hoc and real-time data for the study of audience perception of electronic music performance. In *Proceedings of INTERACT*, 2017.

[9] D. Birnbaum, R. Fiebrink, J. Malloch, and M. M. Wanderley. Towards a dimension space for musical devices. In *Proceedings of NIME*, 2005.

[10] O. Capra, F. Berthaut, and L. Grisoni. Toward augmented familiarity of the audience with digital musical instruments. In *Proceedings of CMMR*, 2017.

[11] O. Capra, F. Berthaut, and L. Grisoni. All you need is lod : Levels of detail in visual augmentations for the audience. In *Proceedings of NIME*, 2020.

[12] O. Capra, F. Berthaut, and L. Grisoni. Have a seat on stage : Restoring trust with spectator experience augmentation techniques. In *Proceedings of DIS*, 2020.

[13] L. Dahl, F. Berthaut, A. Nau, and P. Plenacoste. bf-pd: Enabling mediated communication and cooperation in improvised digital orchestras. In *Proceedings of CMMR*. Springer, 2017.

[14] S. Fels, A. Gadd, and A. Mulder. Mapping transparency through metaphor: towards more expressive musical instruments. *Organised Sound*, 7(2):109–126, 2002.

[15] A. C. Fyans, M. Gurevich, and P. Stapleton. Spectator understanding of error in performance. In *Proceedings of ACM CHI*, 2009.

[16] A. C. Fyans, M. Gurevich, and P. Stapleton. Examining the spectator experience. In *Proceedings of NIME*, 2010.

[17] M. Gurevich and A. C. Fyans. Digital musical interactions: Performer–system relationships and their perception by spectators. *Organised Sound*, 16(2):166–175, 2011.

[18] W. T. Hsu and M. H. Sosnick. Evaluating interactive music systems: An hci approach. In *NIME*, 2009.

[19] S. C. Nanayakkara, L. Wyse, S. H. Ong, and E. A. Taylor. Enhancing musical experience for the hearing-impaired using visual and haptic displays. *Human–Computer Interaction*, 28(2):115–160, 2013.

[20] O. Perrotin and C. d'Alessandro. Visualizing gestures in the control of a digital musical instrument. In *Proceedings of NIME*, 2014.

[21] S. Reeves. *Designing interfaces in public settings: Understanding the role of the spectator in Human-Computer Interaction*. Springer Science & Business Media, 2011.

[22] S. Reeves, S. Benford, C. O'Malley, and M. Fraser. Designing the spectator experience. In *Proceedings of ACM CHI*, 2005.

[23] W. A. Schloss. Using contemporary technology in live performance: The dilemma of the performer. *Journal of New Music Research*, 32(3):239–242, 2003.

[24] C. Stuart. The object of performance: Aural performativity in contemporary laptop music. *Contemporary Music Review*, 22(4):59–65, 2003.

[25] L. Turchet and M. Barthet. Haptification of performer's control gestures in live electronic music performance. In *Proceedings of Audio Mostly*, 2019.