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WanderCouch

A Smart TV Approach Towards Experiencing Music Festivals Live from the Living Room

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Abstract Attending music festivals is a popular pastime. However, there will unfortunately always be a share of fans who, for a wide variety of reasons, are unable to visit a festival of their choice in person. This article reports on the expectations users have about being able to immersively experience music festivals from the comfort of their living room. Out of these expectations, we distill an approach for remote festival engagement that is centered around the concept of blending respectively professional and user-generated content. We then crystallize our approach into a Smart TV application called WanderCouch and let prospective users evaluate it in a simulated live setting. The resulting findings suggest that the proposed solution, among other things, exhibits the potential to improve on the experience provided by traditional (TV) coverages of music festivals, to have a positive impact on both immersion and level of engagement with concerts, and to transfer a veracious impression of the festival's general theme and on-site atmosphere.

Keywords immersive experience · music festivals · expectation solicitation · Smart TV · user-generated content · 360 degree video

1 Introduction

Physically attending a real-world event is not always practically feasible. Potential impediments include, but are not limited to, excessive traveling overhead, ticket shortage, accessibility issues due to personal disabilities, and lack of interest among your friends to accompany you. By disclosing the event in the virtual domain, such inhibiting factors can effectively be overcome. Virtual attendance can be achieved by capturing the event on-site using cameras and microphones and then streaming the resulting footage to off-site users.

This article focuses on a special type of real-world event, namely (large-scale) music festivals that involve performances happening in parallel at geographically spread out locations. The spatially distributed nature of such events imposes challenges on both visitors and organizers. Visitors are forced to devise a personalized schedule of the

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festival line-up, as it is impossible to attend multiple temporally overlapping concerts. From the perspective of the event organizer, it might not be an option to professionally capture each individual concert, for example due to budget limitations or logistical issues. A crowd-sourcing approach might help here, in particular one where visitors are allowed to share the recordings they produce at the festival (e.g., via a smartphone and 4G connection). Such a user-generated content (UGC) solution benefits the organizer, as it extends the coverage of the festival in terms of both breadth (people tend to record the concerts they attend) and depth (there is a high probability that visitors will record interesting things, potentially non-concert-related, that escape the attention of the professional capture crew). Visitors on the other hand benefit as well, as suitable UGC for example might assist them in easily discovering what is happening at other festival stages.

The goal of the work presented in this paper is not to replace a real visit to a music festival, but instead to provide a *substitute TV-mediated experience* that is able to, to some extent, immerse home users in a music festival from the comfort and convenience of their living room. An important design objective that we set forth when starting our research is that this substitute sensation must go beyond the sort of experience that is conveyed by traditional TV broadcasts of music festivals. Such broadcasts typically take the form of linear programs, presented by one or more hosts, that cover the highlights of the festival, show snippets of musical performances (as opposed to integral concerts, often due to rights issues), include interviews with performing artists, and potentially also show some exemplary shots of the on-site atmosphere. Whenever we will be talking about traditional festival broadcasts later on in this article, we will be referring to exactly this interpretation. Please note that there also exist more sophisticated broadcasting approaches, both academic and commercial, for disclosing real-world events, including music festivals (see Sections 2.1 and 2.2 for a representative sample). Unfortunately, such solutions are far from universally available and were therefore deemed less suitable to serve as a ground truth against which to compare our work.

When starting our study, many contemporary innovations in the technical domain came to mind as meaningful candidates to be incorporated in our envisioned approach. Examples, other than the previously mentioned UGC exploitation, included the 360 degree video format (see, for example, [20]), multi-angle video recordings (enabled by cheap capture equipment), spatial audio, and real-time communication options. However, it remained to be seen whether end-users consider such technological options to be actually useful in the context of virtualizing a visit to a real-life music festival.

Therefore, informed by findings from desk research, we conducted an online survey, in-depth interviews and mock-up assessments to accumulate quantitative as well as qualitative knowledge concerning the expectations potential users have of a new generation of immersive applications for remote music festival attendance. With this knowledge in mind, we then developed WanderCouch, a Smart TV application that enables users to experience music festivals from a distance (see Fig. 1). WanderCouch's feature list includes, but is not limited to, the blending of professional audiovisual footage with UGC, the ability to alternate between vantage points while watching a musical performance, offering glimpses of the events that happen in the margin of the music festival, and diverse functions to virtually navigate the spatial area occupied by the festival in the real world. The target audience for the proposed approach consists of music enthusiasts in general and fans of music festivals in particular who, for any reason whatsoever, are unable to personally attend a specific festival.

To validate the potential of our proposed approach, we performed an evaluation in which 11 representative users were observed while they freely exploited WanderCouch to

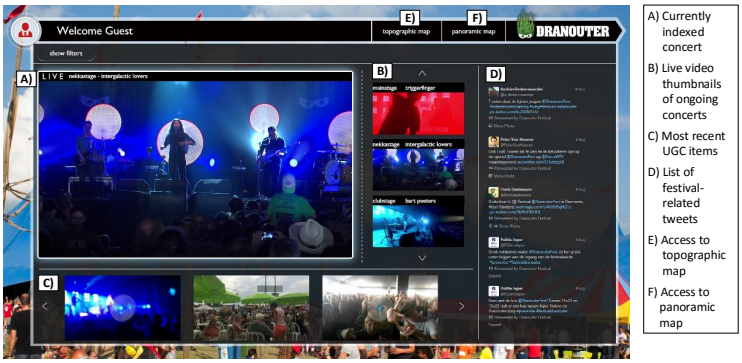

Fig. 1 Annotated screenshot of the main screen of the WanderCouch application.

remotely experience a simulated live music festival scenario. These users tested the application for 45 minutes on average using a monolithic setup consisting solely of a Smart TV (i.e., without second screen functionality or the like). The user study findings hint that the application in general resonates well with members of its target audience and that it has potential to transcend conventional TV broadcasts or live streaming solutions when it comes to coverage, conveyed festival impressions and overall provided experience.

In summary, the contribution of this article is threefold:

1. We present insights into the interest end-users have in a Smart TV application for attending music festivals from a distance, as well as into the sort of functional features that such an application should exhibit for them to be inclined to adopt it.
2. The developed application itself. WanderCouch integrates the gathered learnings (see contribution 1) into a holistic solution. To the best of our knowledge, no commercial offering nor academic prototype for remotely experiencing real-world events exists that is (i) conceptually so well-informed and (ii) functionally so extensive and symbiotic, especially not when taking the TV deployment context into account.
3. An evaluation of the high-level effect that the proposed concept (manifested in the form of WanderCouch) has on the experience of the target audience of music enthusiasts in terms of, for example, engagement and immersion. Our results reveal that the proposed concept shows promise to deliver a compelling experience that enables users to enjoy a music festival from a domestic setting using purely a TV screen.

The outline for the remainder of this manuscript is as follows. After surveying related work in Section 2, we will, in Section 3, describe both the methodology and the outcome of our preparatory three-way inquiry into the expectations end-users have with respect to a (Smart TV) application for virtual music festival attendance. Next, Sections 4 and 5 will deal with respectively the functional features and the implementation of WanderCouch, the Smart TV application that emerged from the findings of our preparatory study. The user-centric evaluation of our approach will be presented in Section 6, after which Section 7 will discuss our results and put them into the correct perspective.

2 Related Work

This section will review contemporary efforts in the most relevant research domains that conceptually overlap with our work. Solutions tailored to deployment contexts that

differ fundamentally from the (Smart) TV setup envisioned in this article (e.g., public or shared displays, second screens, VR) will be largely omitted from the discussion.

2.1 Remotely Experiencing Real-world Events

The BBC integrally covered the London 2012 Olympic Games with up to 24 parallel live HD streams [5]. BBC Sport also offers a Smart TV application to supplement the broadcast coverage of major sporting events with over-the-top (OTT) content, such as additional live feeds and video highlights, the latter of which are transmitted to the viewer in an on-demand fashion [4]. Eurosport, a popular pan-European broadcaster of sporting events, offers a comparable subscription-based service called *Eurosport Player* [10].

Cisco's *StadiumVision* product [6] is advertised to be a cost-effective networking solution to deliver HD video and other digital content to any combination of monitors that are dispersed among the real-world venue where an event is taking place. The underlying concept could be extrapolated to enable off-site event disclosure.

VenueExplorer, proposed by Paradis et al. in [19], offers users remote exploration of an athletics sporting event in real-time. The solution's enabling technologies include ultra-high-definition panoramic video and object-based spatial audio rendering. Users can freely explore a wide-angle overview of the interior of the athletics stadium using Pan-Tilt-Zoom (PTZ) interaction. As a user modifies his viewport, the audio output is adapted accordingly. For example, in case a viewer zooms in on the discus-throwing competition, only audio pertaining to this specific sub-event will be outputted.

Stokking et al. have studied means to synchronize both video UGC and relevant social media content with broadcast TV signals [24]. The UGC needs to be provided by attendees of a real-world event and is purposed to supply people at home with alternative views of the event. The content scraped from social media on the other hand is intended to draw remote users into the conversation surrounding the event. The proposed approach seems promising, yet remains to be evaluated. In contrast, user-centric evaluation plays a central role in the work presented in this paper.

The use of UGC as a tool to convey the ambiance at an event has been investigated by Bauwens et al. [3]. Their *Wall of Moments* platform provides distant users with a 2D matrix of short video clips recorded by people attending the event. A viewer's Facebook profile influences which clips appear in the matrix.

Bridging the divide that exists between on-site and remote event experience via the use of UGC has been advocated by *CoStream@Home* [7]. A full-duplex communication channel is set up between users at the event and at home to foster engagement and social interaction between both types of spectators. As an example, a home user can request an in-situ visitor to start streaming the event from his or her perspective using a smartphone. No studies have been conducted thus far to corroborate the authors' hypotheses concerning the impact of *CoStream@Home* on co-experience and the co-construction of shared memories about a real-world event.

Quite recently, social media platforms have also started experimenting with remote look-in on live events. Facebook is currently exploring a real-time event coverage service that thus far has been rolled out as part of one practical field trial involving the 2015 Lollapalooza music festival [25]. The service aims to "help people get the feel of an event when they're not there" by combining public content related to the event with Facebook posts from on-site friends. Similarly, Snapchat's so-called *Live Stories* feature

[22] allows attendees to contribute to (curated) photo and video mash-ups pertaining to a real-life event, this way giving rise to "a story told from a community perspective".

2.2 Remotely Experiencing Music Festivals

Although the work presented in this article is likely to be applicable to heterogeneous types of real-time and real-life events, our efforts thus far have been focused exclusively on the specific use case of large-scale (outdoor) music festivals. There exists a limited amount of related efforts that are also geared specifically towards a music festival context.

YouTube has provided live coverage of the 2015 Coachella Valley Music and Arts Festival [2,29]. Viewers could watch live performances taking place at three stages in parallel, with multiple viewing angles being available for a subset of the captured concerts. The dedicated YouTube channel additionally offered modest social media integration in the sense that Instagram posts and tweets were (very roughly) pinpointed on a topographic map of the festival terrain. It was also possible for viewers to create a personalized schedule of musical performances they did not want to miss.

Velt et al. have conducted a multimedia diary-driven self-reporting study in combination with cultural probing to explore (i) the ways in which users today experience the broadcast coverage of large-scale music festivals on a TV screen, and (ii) users' future expectations and desires in this regard [27]. Interesting findings from the study to which our approach readily adheres are the following: remote festival experience is mostly a home-based activity, there is a need for social media integration in applications for remote festival experience, complementing the professional footage of the festival with UGC is highly advocated, the fact that users expect the coverage of the festival to be sufficiently broad, and the fact that the inclusion of ambient media in the festival coverage assists viewers in creating an atmospheric sense of the event. Our approach however also violates some of the outcomes of the study, the most important one probably being the finding that users preferred the convenience of time-shifted viewing over the liveness of the festival content. Our solution is deliberately designed to maximally mimic the temporal constraints that are associated with an actual physical visit of a music festival (i.e., (remotely) consuming a concert is only possible at the time the artist or band is actually performing). As is evidenced by the findings from our own qualitative study, this live approach holds promise to positively impact both users' involvement in and commitment to the festival and its composing concerts.

2.3 User-Generated Content (UGC)

The proliferation of portable consumer devices with audiovisual capture capabilities (e.g., smartphones) has transformed nearly every real-world event visitor into a potential content author. Periscope (`https://www.periscope.tv/`), Meerkat (`http://meerkatapp.co/`) and Vine (`https://vine.co/`) are three examples of recently launched mobile live streaming services that indicate that the industry is actively trying to capitalize on this evolution. These services are rather coarse in terms of the functionality they provide and lack dedicated features for real-world event disclosure. This subsection will touch on a few academic efforts that revolve primarily around UGC.

Jacucci et al. have performed a field study in which the UGC authoring behavior by groups of spectators of a rally sporting event was explored, as well as its implications on

intra-group interactions and on the construction of shared experiences [15]. Important findings from the field study include the necessity of context to be able to correctly interpret UGC, the fact that many UGC items were emotionally charged, and the observation that only about half of the authored UGC items directly pertained to the event at hand (with the other half depicting topics related to "being there").

Flintham et al. have analyzed the UGC footage that was captured by spectators of a public marathon along three distinct axes: comprehensiveness of coverage of the event, footage quality, and footage contents [11]. Of special interest in the context of the presented work is the finding that the UGC video corpus produced by as few as 17 test users resulted in a close to 100 percent temporal documentation of the marathon race (albeit only at geographically appealing locations along the running trajectory). This observation suggests that there is great potential in complementing professionally produced content with UGC to improve the coverage of spatially distributed real-world events.

The *CoStream* system scaffolds real-time exchange of user-generated mobile live video between on-site visitors of the same real-world event [8]. The *CoStream* field trials have confirmed that the live, synchronous sharing of distinct vantage points of a single physical event holds potential to induce fundamentally new experiences for in-situ spectators, as well as to support the on-site co-construction of shared experiences.

2.4 Design Guidelines for (Smart) TV Applications

Designing for (Smart) TVs differs fundamentally from designing for other deployment contexts like PCs or tablets. In this subsection, we will review two sets of (Smart) TV design guidelines that have recently been described in the academic literature.

Google has published a list of 8 empirically mustered rules that are best taken into account when designing interactive TV experiences [1]. The rules for example stipulate that consuming audiovisual content must remain the primary activity in any interactive TV experience, that the traditional remote control (RC) is still the preferred interaction device for operating the (Smart) TV, and that live viewing remains to play an essential role in content consumption on a TV screen. Our approach, to a lesser or greater extent, complies with all the enumerated guidelines, with the exception of the last one ("TV can be a private retreat"). In effect, privacy control falls beyond the scope of our research.

As part of their quest to develop a service that mixes elements from linear TV with Video on Demand (VoD) functionality, a UK-based digital product design agency has drafted a collection of Smart TV design recommendations [14]. The majority of these recommendations are grounded on the contemplation that linear TV's long track record has left its mark on consumers' attitudes and expectations when it comes to (Smart) TV viewing. One of these expectations that users over the years have cultivated is that a TV screen must be "always and instant on". Our application caters to this design principle, as its start-up screen immediately presents viewers with (live) audiovisual feeds pertaining to the festival's different stages. Users have also become accustomed to the concept of "channels" when it comes to TV viewing; another important guideline therefore reads that it might be good practice to keep this concept of curating and combining (somehow related) content intact when transitioning to an interactive TV context. Our application satisfies this proposition, in the sense that stages in our application conceptually correspond with channels. For example, while watching the performance that is taking place at a particular stage, only UGC items pertaining to that stage are directly consumable.

2.5 Social TV

The Social TV research domain aims to incorporate provisions for communication and social interaction in the TV viewing ecosystem. Setting up either synchronous or asynchronous (audiovisual) communication channels between physically dispersed TV viewers who are consuming the same content is one canonical example of a Social TV feature. Notable academic contributions to the Social TV research discipline include *CollaboraTV* [18], *Ambient Social TV* [13], the sociability heuristics put forward in [12], and the work by Ducheneaut et al. which led to the identification of relevant Social TV design guidelines [9]. The Social TV literature has inspired us to consider the inclusion of communication and social media provisions in our approach. Please note that the recent evolution from plain to Smart TVs has paved the way for mainstreaming the Social TV mindset.

2.6 The TV Viewing Device Ecology

Over the years, the ecology of TV viewing devices has expanded well beyond the TV set. Arguably the most notable example of a disruptive means of consuming TV(-related) content (based on the substantial attention it is receiving from not only the academic world but also the industry) are second screen schemes or so-called companion devices. Narasimhan sketches a good overview of the opportunities that are associated with (partially) offloading TV content to personal handheld devices such as tablets [17]. A more experimental innovation in this regard concerns the consumption of (360 degree) TV content using Virtual Reality (VR) goggles.

Despite these disruptions, the work presented in this paper focuses exclusively on probably the most basic TV consumption context there exists, namely that of a single user interacting with solely a TV set. The motivation for this decision is twofold. First, we wanted to prevent the results of our research from being contaminated by variables linked to the employed viewing device(s) and context. For example, the level of familiarity with innovative approaches for TV content consumption is likely to vary considerably among individual users, which in turn undoubtedly would have influenced our findings. Secondly, the results put forward in this article are deliberately intended to serve as a solid foundation on top of which further studies could be engrafted. In effect, the subjective results reported in Section 6.3 confirm that a bare (Smart) TV setup already suffices to, to some degree, convey an immersive and engaging music festival experience to users at home. Extending such a monolithic consumption context, for example by including second screen technology, is expected to hold promise to further improve the end-user experience with regard to remote musical festival attendance, yet is left as future research.

3 Understanding Users' Expectations

The development of our approach and the resulting Smart TV application adhered to the principles of user-centered design. This process started with collecting users' expectations concerning our goal of surpassing the types of experiences offered by traditional broadcast coverage of music festivals. The expectation elicitation study was implemented as a three-stage pipeline and was grounded on the insights mustered from our literature review (see Section 2).

3.1 Online Survey

As a first step, an online survey was deployed to gauge user interest in a (Smart TV) application for remotely experiencing music festivals and to probe respondents with regard to the functional features that such an application should possess for them to adopt it. The survey was distributed via Twitter as well as via internal and public mailing lists, in both English and Dutch. In the survey's announcement, we expressed to be specifically interested in responses from music enthusiasts in general and seasoned music festival-goers in particular, yet responses from people who did not fit these profiles were welcomed as well.

The survey encapsulated a total of 20 (potentially composite) questions: 3 demography-related ones, 16 questions pertinent to our research question, and 1 concluding open question where respondents could provide extra comments. The pertinent questions were implemented as statements which respondents had to rate on a 5-point Likert scale. We asked people, for example, to grade their level of agreement with a specific statement, to subjectively rate the importance or relevance of specific features, and to indicate the frequency with which they perform certain activities such as watching TV.

The survey attracted 111 respondents (47 female) in a time window of approximately 3 weeks. 63.9 percent of the respondents were between 20 and 34 years of age; in terms of their level of education, 88.2 percent indicated to possess at least a high school diploma.

3.1.1 Analysis Methodology

In terms of annual music festival visits, 18.2 percent of the respondents indicated to never attend such events in person, 60 percent specified to physically participate in at most 2 festivals yearly, and 21.8 percent claimed to visit 3 or more music festivals per year. We analyzed the effect of this demographic factor in our sample set on the different aspects considered in the survey. We resorted to the one-way ANOVA method in those cases where Bartlett's test did not show a violation of the homogeneity of variances and to the Kruskal-Wallis method (χ^2) for the rest of the cases. If a statistically significant effect of the factor on the variable under evaluation was found with the one-way ANOVA, we used a pairwise t-Test with Bonferroni corrections as a post hoc method to compare the groups. We used the Wilcoxon test, also with Bonferroni corrections, if the Kruskal-Wallis tests showed a statistically significant effect.

3.1.2 Results

To get an idea of the audiovisual content consumption habits of the respondents, we asked them to indicate how much time they devote on a regular day to watching respectively broadcast content and VoD content, the latter via services such as YouTube or Netflix. Table 1 summarizes the responses. In general, informants were found to consume (live) broadcast content primarily on a TV set, while they tend to resort to PCs and mobile devices for VoD viewing.

We also asked respondents to indicate which methods they use to control their TV set. As can be seen in Table 2, in our data set, the traditional remote control (RC) turned out to be, by far, the most popular interaction device among respondents. 47 respondents (42.34 percent) stated to own a Smart TV; 24 of those respondents indicated to never use a smartphone app to control their TV.

The results for the part of the survey most pertinent to our research question are clustered in Table 3 and Table 4. This section of the questionnaire surveyed participants'

Table 1 Daily consumption (in hours) of respectively broadcast content and on-demand content, grouped per type of device. The values are expressed in respondent percentages.

Device	0	Less than 1	Between 1 and 5	More than 5
TV sets	15.69 / 64.71	27.45 / 21.57	55.88 / 13.73	0.98 / 0.00
Personal computers	49.09 / 18.18	30.00 / 52.73	18.18 / 28.18	2.73 / 0.91
Mobile devices	62.04 / 30.84	28.70 / 56.07	7.41 / 12.15	1.85 / 0.93

Table 2 Usage frequency of different types of TV set interaction devices. Values are expressed in respondent percentages. Bold values highlight the largest response categories per queried device.

Device	Never	Almost Never	Occasionally	Frequently	Always
Remote control	3.60	4.50	4.50	13.51	**73.87**
Smartphone	**62.16**	18.02	13.51	3.60	2.70
Mid-air gestures	**96.40**	1.80	0.00	1.80	0.00
Voice	**94.59**	4.50	0.90	0.00	0.00

attitude towards specific types and sources of music festival content, and furthermore asked them to grade the desirability of specialized functional features of a hypothetical application for remotely staying in tune with a music festival. Table 3 shows a breakdown of the responses without discriminating between the three considered respondent groups in our sample set (see Section 3.1.1). Table 4 on the other hand summarizes the results of the statistical analysis of the compiled data set.

To remove all potential ambiguity concerning the way the data in Table 3 and Table 4 must be interpreted, we will briefly detail the results for two of the queried variables.

The first row in Table 3 and Table 4 pertains to the question whether respondents like to watch the videos that their friends have produced at a real-world music festival, irrespective of the fact that they personally did or did not attended that festival themselves. Table 3 does not show a strong preference in this regard: the percentage of respondents (39.63 percent) that rated UGC video consumption positively (score of either 4 or 5 on the 5-point Likert scale) is not significantly larger than the percentage of respondents (34.24 percent) who assigned low scores (1 or 2) or remained neutral (26.13 percent). However, in Table 4 we can observe that in our data set there exists a statistically significant difference in attitude between those respondents who visit 3 or more festivals per year on the one hand and the two other respondent categories on the other hand. No statistically significant difference was found between respondent groups that visit respectively not a single and at most 2 festivals per year. This finding implies that, compared to more "casual" festival-goers, avid festival visitors applied a higher rating to the importance of this statement in the survey and, intuitively speaking, are thus more likely to appreciate the ability to watch videos of the festival produced by its attendees.

The fourth row in Table 3 and Table 4 relates to the consumption of "official" videos published by the organizers of the festival. Table 3 reveals that, compared to the just described use case of UGC video consumption, the preference for watching this type of videos is in general higher in our data collection: 65.77 percent of the respondents rated this statement with either a 4 or 5 on the 5-point Likert scale, 21.62 percent remained neutral, and only 12.61 percent assigned a low score (1 or 2). Table 4 in addition informs us that probed respondents who claimed to visit at least 3 festivals on a yearly basis are more inclined to consume official festival videos than participants who never visit festivals in person (with statistically significant difference). The scores

Table 3 Overview of the responses to the pertinent part of the online survey. Values in this table represent respondent percentages.

	Aspect	Score 1	2	3	4	5
	Content consumption habits in the context of music festivals					
1	UGC videos from friends	6.31	27.93	26.13	31.53	8.10
2	UGC pictures from friends	1.80	11.71	15.32	54.05	17.12
3	Official festival news feed	7.21	18.92	27.03	39.64	7.21
4	Official festival videos	3.60	9.01	21.62	50.45	15.32
5	Official festival pictures	3.60	12.61	22.52	51.35	9.91
6	Social media	4.50	23.42	21.62	40.54	9.91
7	Follow live stream	4.50	7.21	14.41	50.45	23.42
	Device preference with respect to the consumption of music festival content					
8	Smart TV	8.11	17.12	18.92	43.24	12.61
9	PC	4.50	9.91	13.51	58.56	13.51
10	Mobile device	4.50	18.02	14.41	45.95	17.12
	Preferred moment to consume music festival content					
11	In real-time	2.70	13.51	25.23	44.14	14.41
12	Daily summary	4.50	13.51	24.32	46.85	10.81
	Desirability of Smart TV features to enable festival attendance from a distance					
13	Text chat with visitors	14.41	23.42	23.42	31.53	7.21
14	Video chat with visitors	18.02	30.63	26.13	24.32	0.90
15	UGC video from friends	5.41	13.51	21.62	47.75	11.71
16	UGC pictures from friends	5.41	12.61	24.32	46.85	10.81
17	Tweets from friends	8.11	22.52	26.13	36.94	6.31
18	Topographic map view	1.80	7.21	15.32	49.55	26.13
19	Timeline of concerts/events	1.80	2.70	14.41	56.76	24.32
20	Social networks integration	3.60	22.52	36.94	34.23	2.70
21	Surround sound	5.41	13.51	27.93	31.53	21.62
22	Informative video overlays	3.60	9.91	36.04	42.34	8.11
23	Support for 360 degree video	7.21	9.91	32.43	35.14	15.32

allocated by respondents belonging to the middlemost user cluster (i.e., people who attend at most 2 music festivals per year) were not found to be statistically significantly different from either of the two other considered respondent categories.

3.1.3 Result Highlights

The online survey revealed the following salient findings and tendencies:

- There was considerable interest in the use of a Smart TV application to remotely participate in a music festival (56% interest versus 19% neutral versus 25% no interest). In addition, the TV set was found to be the generally favored context to consume live (broadcast) content (recall that live event disclosure is the focus of this work).
- The RC is by far still the preferred way to interact with a TV set (see Table 2).
- Providing a timeline (i.e., schedule) of the events happening at the festival was deemed valuable functionality (statistically significant result), as was offering a geographic overview of the festival site using a topographic top-down map.
- Concerning the ability to communicate in real-time with festival attendees (i.e., via either text or video chat), the results were inconclusive; the same holds for the use

Table 4 Summary of the statistical analysis of the data set compiled from the online survey. We considered 3 respondent groups and 111 responses. Only those aspects are reported for which the analysis revealed statistically significant differences between respondent groups. Such differences are encoded in the "Average score" column by listing values corresponding to one question in different sub-rows. If two groups' scores appear in the same sub-row, these groups were found not to be statistically significantly different from each other.

		Group comparison		**Average score**		
	Aspect	F	p	Never	1-2	3+
	Content consumption habits in the context of music festivals					
1	UGC videos from friends	15.34	1.57×10^{-4}	2.76	2.86	3.91
2	UGC pictures from friends	7.06	4.37×10^{-3}	3.40	3.65	4.20
3	Official festival news feed	14.22	2.65×10^{-4}	2.62	3.19 3.19	3.75
4	Official festival videos	10.34	1.71×10^{-3}	3.19	3.64 3.64	4.08
5	Official festival pictures	12.22	6.86×10^{-4}	2.95	3.54	3.90
	Preferred moment to consume music festival content					
12	Daily summary	10.41	1.12×10^{-3}	3.04	3.39	4.00
	Desirability of Smart TV features to enable festival attendance from a distance					
19	Timeline of concerts/events	$\chi^2=13.84$	9.85×10^{-4}	3.38	4.04	4.38

of surround sound as well as the inclusion of 360 degree video captures of musical performances in the Smart TV application.

The most drastic design implication imposed by the outcome of the online survey unarguably is the use of the RC as sole interaction device. From a research perspective, RC input often has a pejorative connotation associated with it. Before commencing with the study, we were considering to integrate other input techniques for the Smart TV application (e.g., gestures, smartphone-as-remote, ...). The survey results however convinced us to abdicate these plans and to focus exclusively on RC-driven interaction.

3.2 Structured Interviews and Co-Design

The next stage in our expectation elicitation study was implemented as a series of structured interviews. We narrowed down the pool of survey respondents to those people who indicated to attend at least two festivals per year (cf. our target audience). From this subset, 8 respondents (4 female) were randomly selected and invited to partake in in-depth interviews; all participants were between 20 and 40 years of age. Every participant was interviewed separately, with each of the resulting interviews lasting around 2 hours.

3.2.1 Methodology

After welcoming the participant and obtaining his or her consent to video tape the interview, we provided the necessary context and clarified the purpose of the interview. Then the actual interview commenced, which conceptually spanned two stages. Both

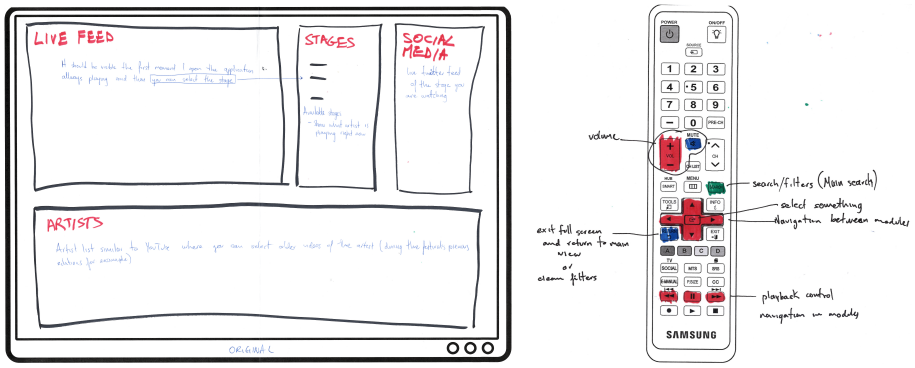

Fig. 2 Example paper-based mock-ups produced by interviewees during the co-design sessions.

stages were implemented by exploiting the participant's responses in the online survey as starting point to kick off the discussion before covering each of the constituting topics in more depth.

The first interview phase was geared towards investigating attitudes and habits related to music festival attendance. In particular, we here aimed to obtain a better understanding of (i) the preferences participants have when visiting a music festival in person, (ii) the type of devices they carry with them at a festival, and (iii) the way they interact with their friends whilst attending a festival, both those on-site and at home. In addition, we inquired the participants about their typical behavior when they are unable to physically attend a music festival of their liking. Addressed topics in this context included the methods they adopt to remotely follow the music festival, the type of festival content they are primarily interested in (e.g., videos, pictures, social media posts), and whether or not they tend to explicitly ask friends who visit(ed) the festival to share the content they recorded there.

The purpose of the second stage of the interviews consisted of more thoroughly exploring the concrete expectations and (functional) requirements that representatives of the target audience have with regard to our envisioned approach for remotely experiencing music festivals. We hereby focused specifically on a Smart TV deployment context. A secondary objective of this interview phase consisted of applying co-design principles to map user expectations to practical and usable implementations of those expectations.

The second interview phase was initiated by asking the participants to draw a mock-up (on paper) of what they thought the Smart TV application should look like, as well as of the way they envisioned themselves interacting with the application via a standard RC (see Fig. 2). We then let the participants revisit each of the functional features that were covered in the online survey and also confronted them with a limited number of previously untreated features. Addressed topics included, but were not limited to, the use of UGC, live communication with on-site visitors, social media integration, and the use of 360 degree video. Each topic was discussed in detail to allow us to compile a thorough understanding of the perceived usefulness of the feature under consideration. For most of the discussed features, the participants were presented multiple paper-based mock-up designs in order to stimulate their imagination, to elicit detailed feedback, to substantiate the pros and cons of the alternative approaches, and to foster co-design. Finally, once all topics in the investigated feature list had been

treated, we requested the interviewees to revise their initial mock-up(s) based on the additional insights they had gained from the in-depth feature discussions, if any.

A person other than the interviewer reviewed the video recordings and validated the notes taken by the person who conducted the interviews. This second researcher also drafted a summary of the features that were appreciated most by the interviewees.

3.2.2 Results

A valuable first lesson that we learned from the conducted interviews is the importance of auditory fidelity when it comes to remotely experiencing a music festival, for example through a TV set at home. In this context, the interviewees nearly unanimously mentioned that *"festivals are all about the music"* and that the audio recordings of the music concerts must consequently be of sufficient quality. This observation also made the study participants question the usability of UGC footage of concerts, given the poor aural quality that is typically associated with such content. On the other hand, the study participants indicated to be receptive to the use of UGC to transfer (snippets of) non-concert-related events and atmospheric impressions of the festival, as such things usually suffer from underexposure in the professional coverage of the festival. Other important findings concerning UGC were the fact that the interviewed users envisaged themselves consuming this type of footage in an on-demand rather than live fashion, that they deemed UGC particularly interesting and valuable when coming from friends, and that they thought it would be beneficial to substitute the audio component of UGC items with the high-quality sound that is captured as part of the professional coverage, if this would be somehow feasible.

In terms of communication features, text as well as video chat with on-site visitors was found to be either not necessary or not useful. The participants mentioned that video chat might disrupt the viewing experience, could be inconvenient (e.g., due to high sound levels at the festival), and would hurt the battery lifetime of festival attendees' smartphones. Text chat on the other hand was considered to be cumbersome if input would have to occur via an on-screen method on the TV; an external keyboard or a second screen solution rated much higher in this respect. The envisioned length of exchanged text messages was also rather short.

With regard to social media integration, the interviews revealed that users are primarily interested in social media contributions made by their friends (as opposed to posts from strangers), that social media items would need to be presented in real-time, and that such content would need to be adequately filtered (e.g., display only those messages that pertain to the concert currently being watched). Additionally, the majority of the participants found the Smart TV context to be chiefly suitable for quickly glancing at relevant social media posts, and much less so for actually engaging in social media discussions surrounding the festival (primarily due to input-related issues); for the latter purpose, they preferred to keep on using their personal handheld devices.

The concept of 360 degree video was welcomed by the interviewees, on the condition that visual cues are present to inform users about viewport interaction options. The front of the stage as well as "over the crowd" were deemed suitable locations to deploy a 360 degree video camera. Also, inspired by an illustrative mock-up, the idea of exploiting live 360 degree video as background footage for an immersive map (cf. Section 4.4) largely appealed to the participants.

Finally, at a higher level of abstraction, we would like to emphasize that the structured interviews revealed great acceptance of the envisioned Smart TV approach for

remote festival attendance, even though preference for the Smart TV deployment context was not a participant selection criterion for the interviews. Each of the participants who had either a negative or neutral attitude towards the Smart TV setup prior to the start of the structured interview (as ascertained from his or her online survey responses) was effectively convinced of its potential by the time the interview was completed.

3.3 Usability Evaluation

Based on the insights and findings accumulated through the online survey and structured interviews, the development of WanderCouch was initiated. Two months later, the same 8 test users who were recruited for the interviews were asked to individually evaluate a functional prototype of the Smart TV application. In summary, the objective here was to collect user feedback early on in the development process, to optimize the usability of the application, to streamline its user interface, to compare alternative implementations of specific features, and to polish the RC-driven interaction.

The evaluation was structured in two parts and lasted 2 hours on average. We started each session by familiarizing the participant with the list of available functional components in the Smart TV prototype application, and by explaining the tasks he or she was expected to perform. Then, during the first part of the session, we asked the informant to test each of the features implemented in the prototype. Participants were given complete freedom to explore the prototype, could ask questions at any time, were encouraged to freely express their thoughts while testing, and were stimulated to actively comment on the usage of the remote control as a means to interact with the application. Once all implemented features were covered, the second part of the usability study commenced, where a member of our team discussed with the participant each one of the available functions in the prototype application in detail. In addition, we requested participants to rate, on a 5-point Likert scale, their appreciation of different aspects of the user interface, such as the employed color combinations, the font size, and the on-screen size of icons and menus.

We also confronted participants with different versions of specific functional features. Participants were requested to comment on alternative implementations of each feature and to pick their favorite among them. As an example, we asked informants to compare instantiations of the main screen of the application (see Section 4.1) where respectively static images (i.e., a snapshot or poster) and live video was exploited to visualize an ongoing concert. Participants unanimously expressed a clear preference for the latter approach, which consequently was adopted in the final version of the application. As another example, alternative means to access the composing items in list-based widgets in the GUI were investigated. In particular, users tested alternative versions where explicit interaction (i.e., button press on the RC) either was or was not required to highlight the first constituting item when navigating the cursor to the encompassing list. The explicit interaction option was preferred by the majority of the informants and was therefore adopted.

4 Functional Design of the WanderCouch Application

Informed by our literature review (see Section 2) as well as the exploratory study described in Section 3, we completed the design and development of a Smart TV application that we have named WanderCouch. The application is composed of a number of

discrete screens, each of which will be discussed next in dedicated subsections. Some general interaction remarks and a high-level discussion of the application will also be given.

Before initiating the description of the functional design of the application, it is again explicitly stressed that WanderCouch primarily revolves around *live* conditions. Whereas UGC contributions can be consumed in an on-demand fashion, professional recordings of concerts can only be watched in real-time. Also, performing activities other than concert watching causes the timeline to progress, and spent time can never be recuperated. For example, time allocated to festival exploration using the panoramic map (see Section 4.4) will cause the user to miss out on (parts of) the concerts that are taking place at that same time. That being said, as will become apparent later in this section, we incorporated measures to mitigate this chance of missing out on interesting things and hence to help users cope with the potential "stress" induced by the imposed temporal constraints.

4.1 Main Screen

The main screen is the central hub of the application and in a way acts as a "collage" of the application's principal functional assets. As is shown in Fig. 1, it provides live video thumbnails of the musical performances that are currently taking place, houses a list of tweets related to the music festival, displays the 3 most recently shared UGC items (in the lower part of the screen), and provides direct access to both the topographic map and the panoramic map screens (see Section 4.3 and Section 4.4, respectively). Both the Twitter feed and the UGC list are updated dynamically and in real-time as respectively new tweets and new UGC content are being published. Interacting with any of the entries in the concerts overview widget causes the selected concert to be rendered in the larger video player on the left. It also causes the application's sound output to switch to the audio recording of the indexed concert. Interacting with the large video player itself triggers the full-screen playback of the corresponding concert (see Section 4.5). Selecting a UGC element on the other hand initiates a transition to the UGC playback screen where the highlighted element will subsequently be rendered (see Section 4.2). Finally, the Twitter feed is a read-only, non-interactive element, conform to the users' expectations in this regard, as discussed in Section 3.2.2.

The main screen provides a content filtering feature that scaffolds targeted search. Interacting with the "show filters" widget in the top-left corner of the screen unfolds a hierarchical menu in which filter criteria are divided logically into categories (e.g., location, date, rating, ...). Criteria from multiple filter categories can be active at the same time. Only the currently ongoing concerts and 5 latest UGC items that satisfy all installed filters will be visible on the main screen.

4.2 UGC Playback Screen

As its name suggests, the UGC playback screen is primarily dedicated to the presentation and rendering of UGC items pertaining to the music festival. The layout of the screen is illustrated in Fig. 3. The essence (i.e., image or video) and metadata of selected UGC elements are rendered in the top-left and top-right portion of the GUI, respectively. The presented metadata encompasses the author name, a textual description of the location where the content was created (e.g., "Main Stage"), and the creation timestamp. The metadata portion of the GUI also visualizes the community

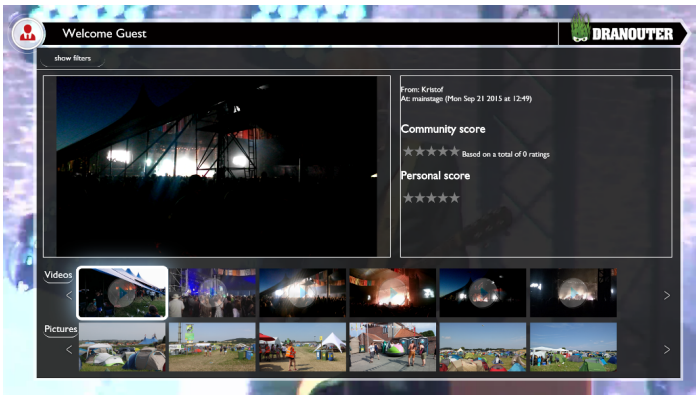

Fig. 3 The UGC playback screen (with concert playback continuing in the background).

score of the currently selected element (i.e., the average of all the ratings that users of the WanderCouch application have assigned to it), and there is the option for users to provide their personal rating. At the bottom of the screen, per UGC type (i.e., pictures versus videos), the 20 most recent items that abide the currently applied filters are presented in a scrollable list, in inverse chronological order. With respect to filtering, the UGC playback screen offers the same options that are also available in the main screen.

In case the application is redirected to the UGC playback screen coming from the full-screen playback of a concert (see Section 4.5), the video of the referring concert will continue in the background (see again Fig. 3). This design decision is motivated by the fact that it allows viewers to keep a link to the musical performance they were watching in full-screen mode before transitioning to the UGC playback screen. In such situations, the audio output of video UGC items will always be given precedence over the audio recording of the concert that is playing in the background. In effect, as soon as the user selects a video UGC element from the list, the background concert will be muted, with its audio output only being re-enabled as soon as the playback of the UGC item has finished.

Please note that, compared to the main screen, the scrollable list of UGC items in this window is considerably more extensive. Indeed, the UGC playback screen supports the exploration of at most 40 user-contributed items, versus only 5 in the main screen. As such, the UGC playback screen affords more opportunities for serendipitous discovery of interesting footage shared by festival visitors.

4.3 Topographic Map

The topographic map scene offers viewers a two-dimensional, top-down overview of the festival terrain. As can be seen in Fig. 4, the live professional video feed of each of the currently ongoing concerts is superimposed on the map and linked visually to (the location of) the stage where that musical performance is taking place. Users can cycle through the stages, with audio output being enabled for the currently highlighted stage only (cf. the approach taken in the main screen). By choosing the currently indexed stage, the viewer is taken to the full-screen playback of the associated concert.

The two video annotations on the left-hand side of the map in Fig. 4 are non-interactive. These video feeds are originating from festival locations other than stages

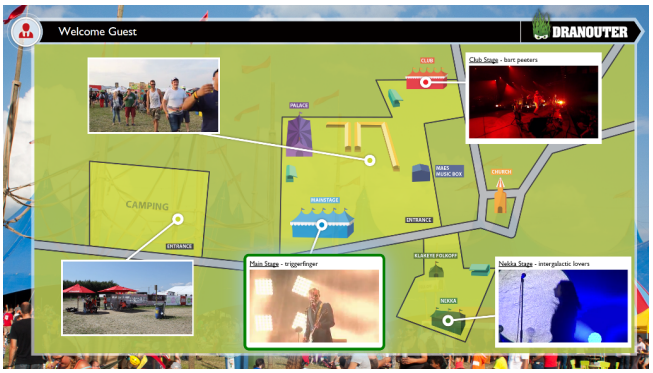

Fig. 4 The topographic map screen (pinpointing video feeds captured at 5 locations).

Fig. 5 The panoramic map screen; overlays visualize outbound traveling directions.

and are purely meant for ambiance communication by providing viewers a sense of the non-concert-related activities and events that are taking place on the festival grounds.

4.4 Panoramic Map

The panoramic map can best be summarized as offering a virtual navigation experience akin to Google Street View, yet hereby relying on 360 degree video instead of static imagery. The map links together a finite number of discrete locations that collectively form a mesh-like topology spanning the most interesting spots on the festival terrain. Live 360 degree video footage is available for each location featured in the panoramic map, with users being able to perform unconstrained PTZ viewport modification at each single location. A 2D mini-map, complemented with graphical icons overlaid on top of the 360 degree footage, inform the user of the outbound traveling options. In particular, each location that is reachable from the currently visited one is represented by a digit; by pressing the corresponding button on the remote control, the viewer "teleports" to the selected location. A screenshot of the panoramic map is provided in Fig. 5.

The panoramic map supports navigation not only to other panoramic map locations, but also to the full-screen concert playback screen. For example, in Fig. 5, the 4th

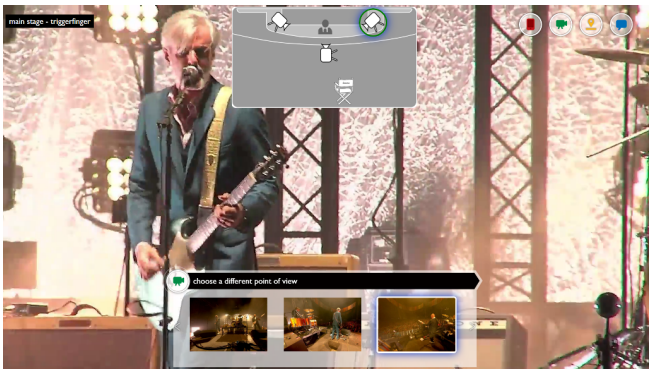

Fig. 6 Professional camera feed selection during full-screen concert playback.

Fig. 7 Tweet visualization, UGC exploration, and UGC PiP playback during concert playback.

outgoing direction points to a festival stage. Activating such a link transfers the viewer to the full-screen playback of the concert that is taking place at the involved stage.

4.5 Full-screen Concert Playback

This scene aims to maximally immerse the viewer in a musical performance. To this end, and in contrast to all the other screens, it lacks any form of surrounding decoration. Besides full-screen playback of professional concert footage (captured in either a traditional or a 360 degree video format), this scene offers four additional functions. These functions are hinted at by 4 color-coded icons in the top-right corner of the screen. The hues employed in the color coding scheme match the colors of the four function buttons that are available on typical remote controls (e.g., in Europe, these buttons were originally intended for teletext purposes). The execution of a specific function is initiated by pressing the correspondingly colored function button on the remote control.

First of all, there is the camera selection function that allows users to control their perspective of the concert. When activating this function, a mini-map representation of the involved stage is shown (see Fig. 6, at the top). The mini-map illustrates both the position and orientation of the professional cameras covering the concert in question so that the viewer can make an informed decision about which vantage point to select. The second function involves a specialized version of the social media integration that was already mentioned as part of the discussion of the main screen. In effect, it is possible to visualize a Twitter feed in a semi-transparent way on top of the video playback (see leftmost image in Fig. 7). This Twitter feed is tailored to the consumption context at hand, as it will encapsulate only those tweets that refer to either the current concert or involved stage. Thirdly, while watching the concert, the user is able to explore relevant

UGC (central picture in Fig. 7). A UGC item is classified as relevant if it is semantically linked to the watched concert and/or the corresponding stage. As is the case in the main screen context, only the 5 most recently published relevant UGC elements are included in the UGC list, with the list being refreshed dynamically at run-time. Selecting an item from the list triggers Picture-in-Picture (PiP) playback of that item (Fig. 7 on the right). In case the rendered UGC is a video, its audio output will be disabled. Again selecting the UGC item during its PiP playback will initiate a redirection to the UGC playback screen (see Section 4.2), where the concert playback will continue in the background (as was discussed previously). Finally, it is possible to access both the topographic and panoramic map from the full-screen concert playback scene.

4.6 Practical Considerations

An effort was made to render the RC interaction as intuitive as possible by logically mapping actions to RC buttons. The `arrow` keys are used to move between the composing widgets of a single screen, to navigate through lists, to pan and tilt the viewport in the case of 360 degree video playback, and so on. Pressing the `enter` button (which is positioned in between the `arrow` keys on a typical RC) triggers the selection of the currently highlighted element on the screen. The `back` button takes the user back to the previously visited screen, whereas the `home` button immediately transfers the user to the main screen of the application. Finally, adjusting the audio volume is achievable via the RC's default volume control buttons.

The description of its functional design reveals that WanderCouch leans heavily on the data that emanated from our expectations elicitation study. It should also be apparent that the application cherry-picks concepts from related systems, possibly in a modified form and possibly complementing them with extra functionality. WanderCouch hence not necessarily innovates in terms of the features and functions it provides. On the other hand, to the best of our knowledge, none of the related solutions for remote event experience are as extensive as ours in terms of breadth and depth of event coverage, variety of content sources, viewpoint personalization opportunities during content consumption, atmosphere and ambiance communication, and/or map-related provisions.

5 Implementation

WanderCouch is implemented as a fully standards-compliant Web application, with each of the application's constituting screens corresponding with a dedicated HTML page. We used CSS to control the page layout and to stylize the application, while all application logic is handled at client side via JavaScript.

The application is deployed on a low-end Windows 8.1 PC with a small form factor (i.e., an Intel NUC) that is directly connected to a TV screen via an HDMI cable. Conceptually, the PC fulfills the role of a set-top box, a common type of device in the current TV viewing ecosystem. The PC runs an Apache HTTP server to host the application and its composing media content. All content (except for the Twitter feed) is currently hence served from local storage, with the live nature of the content being simulated entirely in software. A more realistic solution would encompass the streaming of content from a remote location (e.g., using an adaptive HTTP streaming scheme, see for example [23]). The client-side execution environment for the application consists of a

commodity Web browser (i.e., Google Chrome) that is also running on the PC and that is displayed in full-screen mode on the TV. Remote control input is captured using an infrared receiver that is connected via USB to the PC. A combination of the WinLIRC[1] and Mote-Keys[2] open-source tools is exploited to convert RC button presses into JavaScript keyboard events, which are then acted on by the application. The Twitter feed is populated via an Embedded Timeline widget [26]. Finally, the annotations that are overlaid on top of both the topographic and panoramic map are realized using the JavaScript API of the Augmented Video Viewing (AVV) framework [28].

The PC-based deployment context was chosen due to the comfort with which Web applications can be developed and debugged on such a setup. The application could however readily be converted into a native Smart TV application by leveraging any of the proprietary SDKs provided by Smart TV manufacturers (e.g., [21]). Furthermore, Smart TVs are increasingly being shipped with built-in HTML5-compliant Web browsers that could directly render the client-side part of our implementation to the TV screen.

A significant benefit of a purely Web-based implementation is its platform independence. In effect, the application could be ported with minimal effort to deployment contexts other than the PC and Smart TV setup considered in this article (e.g., tablets or low-cost, non-PC-based set-top boxes). At the same time, the Web-driven approach allows for "branding" of the application, simply by changing some HTML mark-up and CSS instructions. As such, designers and artists need to possess only generic Web development skills to be able to thematically tailor the appearance of the application to the music festival at hand.

Content-wise, WanderCouch is currently populated with footage that was accumulated during the 2015 Dranouter music festival (`http://www.festivaldranouter.be/`) in Belgium. The content set encompasses directed feeds of 3 integral concerts, extended with 5 professional recordings depicting 2 of these concerts from different perspectives (respectively 3 and 2 static cameras per concert), amounting to more than 10 hours of professional video footage in total. Exactly one of these video recordings is in the 360 degree format, covering the performing artist, the integral stage, and (the front of) the attending audience. Besides professional material, we also collected 103 UGC contributions produced by actual festival visitors (76 videos and 27 pictures). These contributions were manually curated and selected, in the sense that a human editor scanned through the individual items and discarded the ones that contained inappropriate content or that did not satisfy predefined audiovisual quality standards (e.g., video too blurry or shaky).

Our decision to target a *simulated* instead of an *actual* live scenario stems from practical considerations. Streaming all the content that is currently featured in our prototype in real-time would require a substantial (and hence expensive) network uplink at the real-world event, which unfortunately was not feasible in our Dranouter field trial. Also, opting for a simulated live setting facilitated our evaluation (see Section 6) by allowing us to conduct (in-depth) studies with individual users sequentially instead of in parallel. Similarly, it considerably simplified the recruitment of test users as it enabled us to more flexibly cope with participants' agenda restrictions. Finally, the simulated approach made it possible to conduct the evaluation in a controlled test setting, which in turn empowered us to reduce noise in the resulting data set by keeping important side variables such as TV screen size and loudspeaker setup consistent across individual tests.

[1] `http://winlirc.sourceforge.net/`

[2] `http://sourceforge.net/projects/mote-keys/`

Fig. 8 The simulated living room used in our study.

6 Evaluation

The WanderCouch application has been applied as an instrument to evaluate the potential of the approach we are proposing in this article towards remotely experiencing geographically spread and concurrent events, notably music festivals. We were particularly interested in investigating whether the proposed approach is capable of improving on the types of experiences conveyed by traditional TV broadcasts of music festivals.

The evaluation metrics that we applied in the study involve feeling-related criteria such as enjoyment and immersion, complemented with measures that are inspired by the following behaviors, all of which are frequently observed at real-life music festivals and which we believe to be essential determinants of the experience this type of event offers to physical visitors:

- There are multiple concerts and noteworthy side events happening concurrently at spatially distributed locations, forcing visitors to selectively compile a personalized schedule and inevitably causing them to "miss out" on parts of the festival program.
- People divide their time between respectively "being part of the crowd" when attending a musical performance and "freely" roaming the festival terrain.
- When attending a concert, fans tend to seek out suitable vantage points, potentially changing their location in the course of the musical performance to optimize their view and/or as a reaction to developments on stage or in the crowd.

6.1 Methodology

The user study took place in a dedicated room at our research institute that was furnished to resemble a traditional living room. As can be seen in Fig. 8, the room contained a cozy couch, a 42" TV screen, the PC-as-set-top-box, stereo loudspeakers, and two CCTV cameras. The couch and the TV were spaced approximately 2 meters apart.

The work flow of the user study was comprised of four successive parts, which every test participant completed sequentially. The study started off with a welcoming phase, in which participants were requested to comfortably install themselves in the couch, were

asked for their permission to be video recorded during the study, and were informed about the context of the study. Next, the participants needed to complete a tutorial phase in which they were instructed on how to use every functional feature of the application. This hands-on training was performed by populating the application with alternative content that did not reoccur in the actual test stage, which the study seamlessly evolved into once participants were acquainted with the application and had no further doubts about interacting with it. At this point in the study, we notified participants about the fact that three concerts would simultaneously commence 5 minutes after the start of the test, and we also asked them to imagine that all the featured content was being captured and broadcast live from a music festival at a remote location. In this actual test step, participants were given no specific task other than to enjoy the available concerts and the overall festival experience offered by the application as they saw fit. During the test, the participants were left alone in the room, with a member of our team observing them in real-time from a nearby location through the CCTV system. The observer took note of the body postures participants assumed during the test, of (the duration of) their usage of the different features of the application, and of all of the individual actions they performed. The resulting notes were later verified by a second team member who independently reviewed all the video recordings. Participants were told they could test the application until it ran out of professional footage (i.e., 84 minutes in total) or that they could let the observer know (via a gesture) if they wanted to end the test session prematurely. Upon completion of the test phase, the observer again joined the participant in the study room, asking him or her to fill in a post-usage questionnaire, and then subjecting the user to a semi-structured interview based on the observed behaviors.

The post-usage questionnaire and interview phase was deliberately kept informal. For example, we did not resort to specialized methods like the ITC-SOPI scale [16] to implement immersion and presence assessment; instead, we formulated easily understandable, high-level statements to gauge informants' opinions concerning these measures. This decision is grounded on the fact that the overall intent of the user study was to evaluate, at a rather high level of abstraction, the *potential* held by our approach, crystallized in the shape of the WanderCouch application, towards convincingly experiencing distant music festivals. Also recall that our approach does not aim to accurately imitate a real-world event visit but instead is designed to produce a *novel* type of substitute event experience, which further convinced us not to factorize complex measures like immersion and engagement into their contributing components in the post-usage evaluation stage.

6.2 Participants

We invited 11 participants to take part in our study (3 female) with ages ranging from 22 to 45 years old, all of them music enthusiasts and avid festival-goers. None of the test subjects ever personally visited the Dranouter music festival (whose content was featured in the tested application, see Section 5). The recruitment criteria for the participants involved (i) prior experience with real-world music festivals, both in terms of physical attendance and their broadcast coverage on TV, and (ii) affinity for at least two of the three musical artists appearing in the study. We are well aware that people might have motives other than pure artist affinity when considering to physically attend a music festival (e.g., discovering new artists, socializing with their friends, and so on). However, artist aficionados form an important segment of our target audience that we decided to focus on as a first step, leaving the evaluation of other types of festival visitors up to future research.

6.3 Results

The performed evaluation yielded two types of results: quantitative findings that emanated from the observational part of the methodology, and subjective findings that were collected during the post-experience self-reporting and interviewing phase. Both types of results, each in their own way, provide an insight into the experience test users had while using WanderCouch.

6.3.1 Observational Study

Recall from the methodology description that the observational study commenced with a 5 minute time interval in which no concert footage was available. During this time period, participants spent an average of 2 minutes and 40 seconds on exploring the festival terrain through the panoramic map. Post-usage comments revealed that the goal here was *"to get a grasp of the festival's general atmosphere"*. Another meaningful way in which test users "*filled up the idle time*" during the pre-concert interval, was by examining the content provided by visitors of the music festival. These UGC items depicted (fragments from) previous concerts as well as general festival impressions. Participants consumed on average 4 user-supplied video recordings and 1 picture, resulting in an average time allocation of 1 minute and 37 seconds to the UGC screen. Post-usage comments from participants revealed that they found both these observed pre-concert behaviors to be a "meaningful" devotion of their time, as *"*[the panoramic map provides] *a look from within the crowd"* (P09) or *"people sometimes capture completely different things* [compared to the professional coverage of music festivals]*"* (P08).

The main screen was also visited quite often by participants during the 5 minute period when there were no concerts ongoing (i.e., 1 minute and 24 seconds on average). In contrast to the two behaviors described above, these visits were "functional" rather than "meaningful". In particular, test users were found to actively navigate through the application's composing screens in the pre-concert phase. In this process, they tended to return to the main screen, mostly for short periods of time, to use it as a functional bridge to reach other screens and features. At the same time, time spent on the main screen allowed users to verify whether any of the concerts had already begun.

Once the three parallel concerts had started, the application's most used feature was the live concert playback scene (26 minutes and 37 seconds on average), where participants could watch the concert of their choice in full-screen mode. This result is perhaps not so surprising, given the fact that participants were deliberately recruited based on affinity with the three bands featured in the study. We could observe a clear predilection among test participants for one of the involved bands, as their performance was watched for an average of 17 minutes and 9 seconds, with the other performances attracting less attention (respectively 5 minutes and 50 seconds, and 3 minutes and 38 seconds). The 360 degree footage that was available for one of the artists was watched for 2 minutes and 14 seconds on average (out of the total 3 minutes 38 seconds screen time that this concert on average received via the live concert playback scene).

While the musical performances were ongoing, the average time spent on the main screen amounted to 5 minutes and 48 seconds. Participants were observed to exploit this screen to, in one stroke, check up on the developments in the three parallel concerts. The typical sort of behavior we witnessed in this regard involved participants mainly focusing on one of the bands (i.e., by watching their concert in full-screen mode), yet once in a while switching back to the main screen to be able to glance at the other

performances. In case the concerts overview provided by the main screen then informed participants about something interesting going on at another stage, they shifted their attention to that concert. As an example, P04 was found to switch from one concert to another when he or she noticed that the performing artist at the latter concert jumped down from the stage and started walking into the audience.

In the during-concerts phase, participants spent 4 minutes and 43 seconds on average on the UGC screen, hereby consuming an average of 17.9 videos and 14.9 pictures. Only 4 participants applied personal ratings to user-contributed content (with a total of 7 video recordings being rated). In the tutorial phase of our methodology, users were informed that personal ratings are not persisted when navigating away from the UGC screen in the current proof-of-concept implementation, which might explain the low uptake of this feature. 7 out of the 11 participants installed a total of 19 filters while sifting through the UGC material. In terms of (spatial) exploration of the festival in the during-concerts phase, the screen time allocated to the panoramic map exceeded that of the topographic map. Although the topographic map allows users to quickly cycle though the ongoing concerts (analogous to the main screen), the time devoted to this screen accumulated to a mere 1 minute and 49 seconds on average. On the other hand, the panoramic map was used for an average of 3 minutes and 5 seconds, mostly towards the end of the test session.

In all, participants virtually visited the festival for 44 minutes 48 seconds on average.

6.3.2 Self-reported Experience

We included 3 types of questions in the post-usage questionnaire that was used to solicit feedback from test subjects regarding the experience they had while using WanderCouch: yes/no, open, and 5-point Likert scale questions with the middle response option indicating a neutral position toward the statement at hand. In the following analysis of the questionnaire results, we will, whenever possible, intertwine the description of the quantitative results with qualitative feedback from the post-usage interviewing phase to further put questionnaire findings into context.

When asked if they felt like they had visited the festival in person after using the application, participants responded rather neutrally (average value of 3.45). The general comment participants made in this regard was that the application is not able to replace a real-life festival experience. On the other hand, quoting participant P03, the application *"nicely communicated the festival feeling"*. This fact is confirmed by the score for self-reported immersion and enjoyment of the festival (average rating of 4.09 and 3.91 respectively). When participants were confronted with the statements that the application let them discover interesting content of the festival and that the application offered a good impression of the festival, average ratings of 4.18 and 4.63 emerged, respectively.

When we asked participants to consider their real-life experiences regarding music festivals, they agreed with the fact that our application let them see more things from the festival (average rating of 4.18). This result was to be expected; for example, checking out different concerts at a real-world music festival involves physically traveling between stages, whereas WanderCouch allows users to do this at the touch of a button. As is the case in a real-life experience, participants indicated that they had to carefully choose which of the performances to watch (average rating of 4.0). This result can be attributed to the "live" nature of the application. Another direct consequence of this live approach is that it gave participants the feeling that they could miss out on things. In this context, P03 argued that *"it makes you feel more as if you were really there"*, P04 stated to be *"afraid of watching other stuff, because I did not want to miss*

a good song", while P10 mentioned that WanderCouch reduced his fear to miss a good performance as the application let him quickly change from one stage to the other (which is a clear benefit of our approach compared to a real-life experience).

Participants were found to enjoy the musical performances they watched (average rating of 4.45), and they succeeded in grasping the prevalent atmosphere at the concerts. In particular, they could estimate the magnitude of the audience that attended the concerts, as well as the degree to which the crowd was involved in the concerts.

Test users also managed to adequately describe the general theme and ambiance of the festival, using adjectives such as cozy, relaxed, and family-friendly. Indeed, these adjectives are highly consistent with both the UGC footage and the panoramic map content that appeared in the test. Please note that the probability that the reported impressions were rooted in either cultural preconceptions or empirical knowledge is low, as none of the participants had any prior personal experience with the Dranouter music festival.

When we asked participants to write down between 3 and 5 non-concert-related things they recalled from their experience using the application, they mentioned the presence of families with baby trolleys at the festival, the fact that the festival took place in the middle of a village with the village's church acting as one of the stages, seeing a bumper car and several street performers among the crowd (which P10 recalled to have seen in some other festival before), and the fact that weather conditions were very attractive (i.e., warm and sunny). P04 for example mentioned the moment when one of the performers walked into the crowd as something to remember.

All study participants were familiar with traditional TV broadcasts of music festivals (cf. the interpretation stipulated in Section 1) and were therefore able to frame the evaluation of their WanderCouch experience in terms of this previous knowledge. The participants highly agreed with the claim that the experience offered by WanderCouch transcends the kind of experiences that are attainable with classic TV coverage (average rating of 4.81). In the same context, they also agreed with having more content consumption freedom (average rating of 4.54), with having more variety of content (average rating of 4.36), and with the fact that they were able to see more non-concert-related things from the festival (average rating of 4.72). In contrast to WanderCouch, traditional TV coverage of music festivals also does not allow viewers to, on-the-fly, change their point of view when watching concerts, which was found to be an important feature to improve the experience for the participants (average rating of 3.91). Including 360 degree video recordings of concerts in the festival's (TV) coverage was also rated positively (average rate of 3.91).

The panoramic map concept included in WanderCouch is another example of a feature that contributed positively to surpassing a traditional TV coverage of a music festival. The panoramic map helped participants to get an impression of the festival (average score of 4.27). Being able to watch content captured at locations other than stages was found to improve the experience for the participants in our study (average rating of 4.0).

Combining UGC and professionally captured content was *"a nice extra, especially when there is no concert in progress"* (P01) or *"*[useful] *for getting an idea of the atmosphere at the concerts, the camping and festival"* (P03). When asked whether content produced by real-life festival attendees improved their experience, test participants gave an average value of 3.45 to this feature. The post-usage interview phase uncovered two potential explanations for this relatively low score; both of them pertain, in a different way, to the quality of UGC contributions. First of all, some of the test participants mentioned to dislike UGC because of the low(er) audiovisual fidelity that is typically associated with such content. Secondly, the actual contents of (especially video) UGC was sometimes found to be of questionable quality and importance, particularly if the

content was produced by a stranger. When we delved deeper into this latter remark, participants mentioned the option to differentiate between footage shared by friends versus non-friends to be an important factor in the overall usefulness and value of UGC. This result confirms the outcome of our exploratory study as well as the findings from our literature review (e.g., [27]). Finally, the necessity of a filtering mechanism to help the user in distilling relevant UGC content was rated with a 3.18 average score.

Participants responded neutrally to the statement that the integration of social media (i.e., Twitter) is a valuable feature (average rating of 3.27). On the other hand, they were more convinced that the use of surround sound would improve their experience (average rating of 4.45). Including the option of on-demand consumption of professional concert recordings was a desired feature for all the participants.

P02 was skeptical at first, but admitted to having enjoyed the experience in the end and also got convinced of the advantages WanderCouch offers over traditional festival broadcasts. One of the participants (P06) lost track of time during the study.

7 Discussion and Conclusions

There was consensus among the study participants concerning the fact that the proposed approach does not replace the real-life experience of visiting a music festival, as this would require a much more complex solution involving, for example, olfactory and tactile stimuli. However, our results demonstrate that the proposed approach shows great promise to improve on traditional TV broadcasts or the OTT live streaming of music festivals in terms of breadth of the coverage and atmosphere conveyance. Both UGC and the panoramic map of the festival venue were found to be useful exploration tools; to put it in the words of the participants, they *"nicely communicated the festival feeling"*.

Participants also agreed that the provided map-driven virtual navigation functionality helped them in creating a "mental map" of the festival environment and to grasp the spatial layout of the festival terrain. Although this is not necessarily essential for a home user, it nonetheless contributes to his or her overall experience.

The scenario that we evaluated in our study (i.e., emulating a live festival consumption context) was found to have a positive impact on participants' level of engagement with and immersion in the festival. On the other hand, it also reproduced the fear of missing out on things among participants, as could happen in a real-life festival visit. The proposed approach, materialized in the WanderCouch application, however offers extra tools to deal with this fear (and resulting stress), which are not at the disposal of in-situ festival attendees. In our study, both the main screen and the topographic map were found to facilitate "concert exploration" as they granted participants a summary of all ongoing concerts (and also of the latest UGC in the case of the main screen). This in turn enabled participants to make well-informed decisions about when to "zap" from one stage to another. In this context, P05 mentioned that *"it seems easy to miss something which causes you to switch channels more often"*. P10 in this regard stated that *"*[the application] *gives you the opportunity to switch between concerts in an easy way. When you are at the festival you have to really walk over to the other stage, which takes a lot of time"*.

The ability to manage the viewpoint while consuming a musical performance was appreciated by the test audience: it allowed them to frame the concert depending on their personal preferences and it inspired them to deeply engage and interact with the musical performances. For example, P01 mentioned that *"being able to see the concert from the artist's point of view is pretty cool, I often wonder how they see the crowd"*.

Both P03 and P4 like to play the guitar, causing them to comment how much they liked the fact that they could select the camera feed that provided them with the best close-up of the band's lead guitarist. As a final example, the 360 degree footage that was available for one of the concerts in the tested application was rated as a valuable feature.

Content quality emerged as another important aspect to keep in mind. The outcome of the exploratory study and the comments participants provided after using WanderCouch highlight users' concerns in this regard, especially when talking about UGC. Participants had their doubts about UGC quality not only in terms of audiovisual fidelity, but also in terms of substance. For example, watching a group of people having lunch at the food court of the festival might be of interest to you only if you know them.

7.1 Limitations and Opportunities for Future Research

There is still room for improvement regarding the features offered in our approach. Mechanisms for content recommendation have been found to be important in a number of previous works [1,14,27] and were also mentioned to be useful by multiple participants of our study. We therefore plan to add a "Featured" or "Recommended for you" element to our design to address this hiatus. The goal here would be to propose profile-driven personalized content to viewers in an easily accessible way (i.e., consumable after a minimal number of button presses).

Surround sound output for the concerts as well as the panoramic map is another important feature that is currently missing in WanderCouch. Participants in our study thought that spatial sound support would improve their witnessed level of immersion.

Thus far, our approach has only been tested by a single user at a time. However, TV screens are often considered to be shared devices. A promising avenue for future research therefore lies in investigating the sort of behavior that would emerge if the proposed approach would be exploited to let multiple co-located users jointly experience a music festival from the same distant location. It remains to be studied whether such a consumption scenario would trigger interpersonal interactions and communication among the co-located users that are comparable to those occurring among on-site festival visitors. Analogously, studying the impact of incorporating and exploiting Social TV affordances (see Section 2.5) in the presented approach might be a very worthwhile research topic.

The content set that was used in our study encompassed just three concerts. This relatively low concert count allowed us to neatly arrange the available video footage in an easily surveyable fashion on both the main screen and the topographic map. Having more than three stages would require a different strategy to achieve the same level of overview. One possible solution for the topographic map case could be to reduce the space consumed by the widgets carrying the (professional) concert captures, and then to dynamically increase their size only when they are pointed at. In this way, the topographic map, which was found to not have that much of a positive contribution to the afforded festival experience in our results, could increase its value in more complex scenarios involving larger numbers of stages. Based on this contemplation, we argue that it will always be possible to devise strategies that will enable our approach to sustain the "concert zapping" behavior observed in our study as the parallel performance count rises.

Professionally capturing performances during music festivals might face legal barriers and copyright issues. Furthermore, it goes without saying that UGC capture intrinsically suffers from privacy concerns. Such issues need to be addressed in order to warrant successful adoption of our concept, but lay out of the scope of this work.

A significant subset of our study participants were skeptical about the usability of UGC footage of music concerts, primarily due to the poor aural fidelity that is typically associated with such recordings. It would be interesting to investigate whether this opinion still holds in case not all of the concerts would be exposed via professional feeds (as was the case in our evaluation). Similarly, investigating UGC acceptance levels in the context of real-world events where audio quality plays less of a role seems advocated.

UGC authoring is currently a privilege available only to physical event visitors. From a technical perspective, it would be perfectly feasible to open up UGC creation to people who are following the event from their living room. Doing so might be an interesting way to increase home users' sense of involvement in the festival, yet this remains to be investigated. Also, one can put forward the question whether home-produced UGC would hold extra value (for either other remote festival participants or on-site visitors).

The results of the exploratory study and the evaluation hint at a promising future for our proposed approach. However, a more elaborate study, involving a larger sample set and longer usage periods (e.g., to eliminate the "novelty effect"), is necessary to verify to what extent the findings presented in this article can be generalized. Analogously, it could be informative to test the proposed approach in a live instead of a simulated live setting, preferably via in-the-wild testing. Finally, the evaluation of WanderCouch has thus far been centered solely around an artist affinity use case; testing the application with users who visit music festivals for reasons other than artist affection might be worthwhile.

Finally, even though this article has exclusively considered a music festival context, we believe our approach to be useful in other scenarios as well, yet this remains to be investigated. One promising candidate of an alternative type of real-world event that could be virtually disclosed via our approach are sports contests like tennis tournaments or the Olympic Games (multiple spatially distributed venues, various competitions happening in parallel, lots of opportunities in terms of UGC creation, etcetera).

7.2 Broader Implications

Despite the previously described adoption and positive attitude towards the viewpoint customization possibilities when watching a concert in our approach, participants were found to spend the majority of their time watching the directed feeds (our content set encompassed exactly one directed feed for every featured concert). This implies that people still seem to like the option of handing over the control of the framing to a director, who they trust to produce a compelling video scene on their account. Manually controlling the camera angle breaks the traditional "lean backward" setting of a TV setup and increases the cognitive load on the viewer. Further analysis of lenient solutions that are able to strike a balance between respectively "lean backward" and more interactive "lean forward" types of experiences therefore seems of paramount importance.

For quite some time now, the relevance of the TV set as a content consumption device is increasingly being questioned by media innovators and technological evangelists. The combined results presented in this article contradict, at least to some extent, this view. In particular, our work has highlighted that (Smart) TVs still hold some important merits, are broadly adopted and accepted by the general population, and for the time being seem to remain a device type to be reckoned with, not only in the context of remote event attendance, but also more generally in terms of content consumption.

It is also worth mentioning that there appears to exist large interest among organizers to disclose their real-world event in the virtual domain. As soon as the collaboration

with the Dranouter music festival was announced in the press, our research consortium received invitations from other music festivals to conduct an analogous trial in the context of their event. Besides event organizers, various stakeholders in the media industry have also expressed to be enthusiastic about our approach. For example, we have received highly positive feedback on the WanderCouch application from public broadcasters as well as (Smart) TV manufacturers.

7.3 Summary

We have studied the implications of combining professional content with UGC in the context of a Smart TV application for experiencing music festivals from a distance. We have also reported on the expectations potential users have when it comes to enjoying this type of spatially distributed and multi-threaded events from their home. Finally, we have performed a first validation of our approach using realistic content, with the results indicating that our approach shows promise in offering a compelling TV-mediated alternative for a real-world festival experience.

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