Video interaction: a research agenda
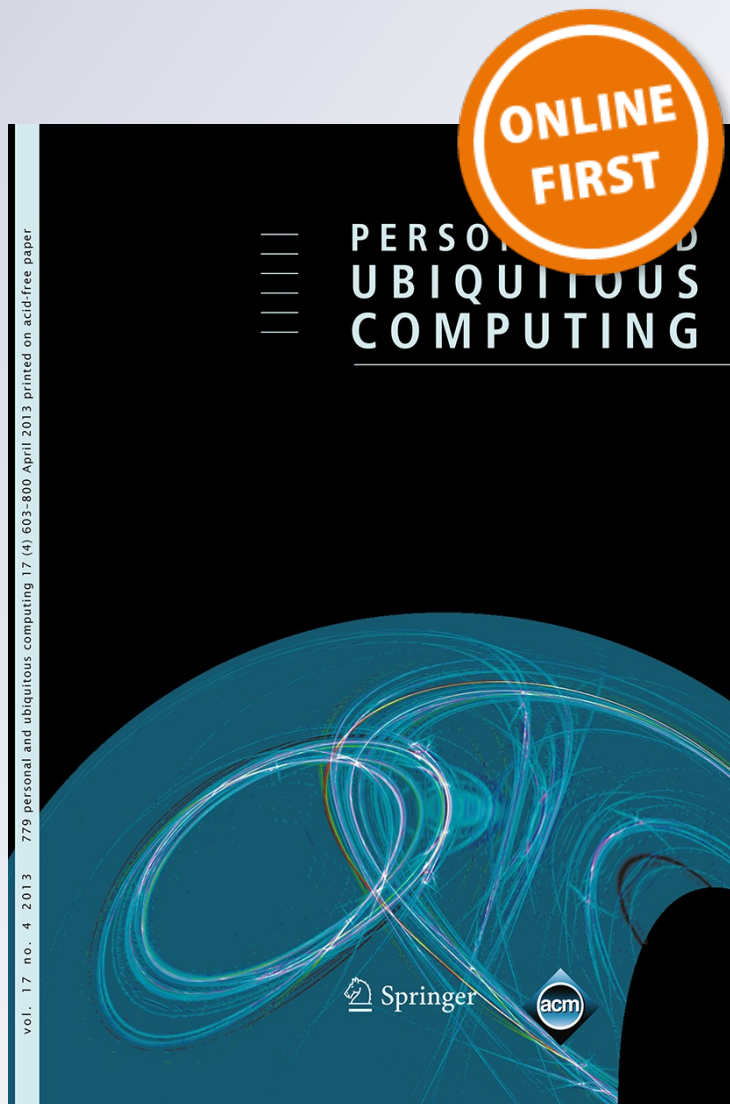
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Video interaction: a research agenda

**Oskar Juhlin · Goranka Zoric · Arvid Engström ·
Erika Reponen**

1 Introduction

The topic of this special issue is the broadened use of video
and the need to articulate a research agenda that addresses
its new opportunities and challenges. This agenda, which
we argue should be labelled "video interaction," is influ-
enced by both emerging practices and technical develop-
ments. In the widest sense, we refer to video interaction as
a research area concerned with emerging technologies and
social practices in an increasingly flattened hierarchy
between, on the one hand, what used to be a well-defined
group of production professionals, and on the other hand,
the masses of passive viewers of the same media.

This transition happens at the same time as video traffic
has become the bulk of data communication on the Internet
[2]. The same shift is now happening in mobile data. Cisco
reports that mobile video traffic exceeded 50 % for the first
time in 2012. They predict that the numbers for video will
continue to increase dramatically. In 5 years, the amount of
mobile video data is projected to increase 16-fold, ending
up at over two-thirds of the entire data traffic [12]. Obvi-
ously, downloading and streaming of movies and TV series
are the big drivers in this development, but there are a
number of other things happening that warrant a new

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approach to understanding interaction with video content,
beyond the notion of the user as a viewer in the traditional
sense.

The practices surrounding moving image technology are
now transcending consumption of traditional media, and
becoming integrated with other interactive services and
social media [2]. In this massive growth of video online,
there are a number of parallel trends regarding how video is
consumed, produced, shared, and interacted with that we
argue require a re-conceptualisation of the area. In the
following, we will map out the changed use of video and
then analyze its opportunities and challenges, and explain
the need for a coherent research approach to video inter-
action. In particular, the trends we want to align are a shift
to user-generated video content and to mobile technology,
as well as a continuation of the trend of increased inter-
action in viewing (iTV).

First, new ways of producing video content has
emerged, enabled by the availability of cheap production
tools and high bandwidth communication networks. It
emerged with the use of both analogue and digital video
cameras for consumers, and continued with video record-
ing facilities on mobile phones [30]. The cost and effort of
sharing and distributing the content have also diminished
with the expansion of the fixed Internet. Live video pro-
duction is now on the verge of the same kind of democ-
ratization of means of production and broader adoption by
nonprofessional users. Through highly visible examples
such as live broadcasts from the Arabic Spring and other
news events around the world, as well as more mundane
practices of broadcasting from university lectures and local
events, live video has shown potential for communicating
and sharing experiences with remote viewers.

Second, we see an expansion of services that utilize
mobile technology in a broad sense, and that are catering to

mobile and socially connected users. The video medium has become integrated with large social media sites. New formats are emerging such as the Vine application, which extends Twitter's familiar 140-letter microblog model to video, though limiting clips to 6 s of length. Even though many of these applications are available both on mobile devices and on desktop computers, mobile technology allows users to capture content from many different settings as well as gain physical control of the camera. This trend increases the variety of ways in which video is interacted with, in new media.

Third, the most mature area that motivates the conceptualization of video as interaction is that of interactive television (iTV), and the related commercial development of online video and broadband TV. Historically, television was equal to network-owned, mass media broadcasting, whereas video was the physical format for either recorded television or "home videos"—recorded everyday events that were shown and shared with a select few. The explosion of video content online has brought about a diversity of content, production formats, and viewing habits, and has in effect erased the distinction between the two terms "television" and "video." In their place, we now have a highly dynamic and diverse video medium spanning from massively mediated live events to video as a form of dialogue on YouTube, from high-end cinema to brief video loops and mobile broadcasts shared in the moment in social media.

Conceptualizations of interaction with video and television, in both the iTV research field and in the commercial online video, are linked to the notion of the user as a TV viewer, a consumer. Hence, as far as interaction design has been concerned with video, it has largely been in terms of selecting content to view and controlling features in the viewing situation. Application areas include interface design for television sets and video players, from traditional television over broadband TV to online video players in various forms. The past 10 years of research in this area display a range of advanced interactive features, such as intelligent ways to summarize and browse large volumes of video material (see e.g., [1] for an overview of methods) and authoring the direction of the storyline in interactive dramas ([16, 47]). While increased interactive control in the viewing situation is an important development, these interactive features remain in the space of video consumption.

If peoples' engagement with video, or moving image media, has ever been a form of passive consumption in a TV sofa or a chair in a movie theatre, this way of understanding interaction no longer accounts for a growing variety of contemporary and emerging practices. If we continue to see video use as noninteractive and passive TV viewing, we miss not only that viewers' interaction depends on active interpretation and that they increasingly

select the content or make judgments about it, i.e., iTV. More importantly, we would miss that the interaction with video is now transcending the separation of viewers and producers. For some, it might seem like a paradox to combine the two concepts of video and interaction into a single theme, but the use of such a concept is therefore necessary to articulate the move in video production and consumption that even challenges the underlying assumption in iTV research of a mass viewer and selected producers. We need to encapture the possibilities and challenges that lie in making video a successful social medium. Whereas human computer interaction has always been abundant in professional TV production [8, 18, 41], this has only been the concern for a few. Now, when production becomes of importance for large numbers of users outside of the professional domain, the way that is supported through digital media becomes a much more important concern. Video interaction focuses on the interaction that is occurring in the closing gap between video production and video consumption.

In the following, we will in more detail discuss the three trends that together add up to the concept of video interaction, i.e., the shift to user production, the shift to mobile technology, and the continuation of the interactive TV-trend.

1.1 User production of video

In the past two decades or so, with the disappearance of barriers to the production and distribution of digital content, a new class of "amateurs" has emerged in a wide range of fields from journalism and photography to computer programming. A variety of terms have been suggested in order to illustrate the new and intermediary categories that have emerged between professionals and amateurs, between media producers and the public that used to be thought of as their audience. The idea can be traced back to McLuhan and Nevitt [37], who suggested that new technology would make consumers into producers and to Toffler [50] who coined the term *Prosumer*. Benkler [4] has used the term commons-based peer production, for the new production modes enabled by information networks, and the multidirectional social structures that they have brought with them. Leadbeater and Miller [31] introduced the term *Pro-Ams*, for amateurs who work to professional standards. They are diverse in their practices, but share a high level of skill, commitment, coordination, and use of new technology. The last point, their being avid adopters and users of new technology, is an important common denominator and is what makes it relevant to talk about the phenomenon in terms of a shift occurring over the past few decades, coinciding with the spread of the Internet and digital technology.

All these terms highlight the co-dependence of social and digital networks, and digital technology, in the shift in media usage from mere consumption to a mix of production, consumption, and sharing. Video and photography are among the fields that have been affected the most, due to inexpensive mass-market digital cameras and camera phones. The increased use of video for production and sharing warrants an increased attention to production practices, an attention that has been largely absent in research in the past. With some exceptions of key studies on professional production ([7, 8, 23, 38]), research on television has been largely concerned with the text (the broadcast or program) and the audience.

Kirk et al. [30] take a holistic view on video work and explore how video is produced, edited, and consumed on consumer devices. They show how, in all of these aspects of its use, video production is an explicitly social process and how its end use is a key driver in video production. For "lightweight" devices, such as camera phones (as opposed to "heavyweight" video recorders), video is typically captured spontaneously, shared in the moment, and primarily meaningful in the context of that shared experience. Editing after the event is regarded as cumbersome and happens very rarely. Live streaming, the ability to broadcast video to a remote audience in the instant that it is captured, is among the most significant new features made available by the combination of digital cameras and networks. A multitude of new services have emerged in the area and serve as an example of video use where interaction entails both production and viewing practices. The properties and affordances of live streaming video have been explored in diverse contexts such as groups of friends [44] music performances [46] and emergency response work [5]. Following the emergence of early online services for live broadcasting from mobile phones, early adoption of these services has been studied through analysis of use practices and produced content [15, 26, 45]. Reponen et al. [45] argue that mobile broadcasting of live video is an act of sharing context rather than content and discuss implications of this for privacy and acceptance among people in that context. Juhlin's et al. [26] content analysis of mobile live broadcasting services shows that many early adopters struggle with both the technology and the concept of live broadcasting. At the time of the study, there were more people on these sites who are just testing the technology than were actually broadcasting content, and much of the latter's productions had very low production value. Although most people are already accustomed to professional live broadcasts and, in that sense, have an idea of what this medium could be, it seems that taking the step to actually providing such broadcasts on one's own is very difficult.

This increase in user-generated video is paralleled with a process where the audience is spread out over an increasingly large number of TV channels, which has been discussed by Anderson [3] who labelled it "long tail TV." By this, he meant mechanisms, such as television on demand and pay per view, which allows producers of niche content, unavailable through traditional distribution channels, to reach TV viewers. Thus, the traditional broadcast model, where a limited number of people prepare and produce media which are then viewed by a passive mass audience, is changing. The new production practices we point to here add to this trend. The expansion of mobile broadcasting and other emerging video services makes the tail both longer and narrower by adding broadcasts by a mass of video producers. With these services, we are witnessing a step where capture and live broadcasts are released from the constraints of the professional studio.

These early examples are relatively sparse in their use of the features of the medium as compared with professional video production—broadcasts are typically one person accounts, using a single unedited video stream as a window into an event. Professional video production, by comparison, typically involves highly organized collaboration in order to take advantage of multiple perspectives, audio, and editing in the end result, the broadcast. What we are now witnessing in research is the advancement of a second generation of live systems, which allow for collective production, either inspired of professional practices or inspired by so-called crowd sourcing. All these systems flatten the previous hierarchies by massively increasing the number of producers.

Live video sharing applications has acquired some attention in research. Juhlin et al. [26] have provided a qualitative content analysis of mobile broadcasting. Engström et al. [19] and Reponen [44] have conducted field experiments to investigate how it supports group communication. Bergstrand and Landgren [5] conducted a design investigation to explore how live video could be used in rescue operations. The possibilities of extending the concept to include multiple cameras have been suggested to support citizen journalism [49] as well as for VJing [17].

In all, we need to encapture the possibilities and challenges that lie in making video a successful social medium. Whereas human computer interaction has always been abundant in professional TV production [8, 18, 41], this has only been a concern of a few. Now, when production becomes of importance for large numbers of users/prosumers/pro-ams, the way that is supported through digital media becomes a much more important concern.

1.2 Shift to mobile

Mobile video has seen a massive growth and much attention in commercial development, following the proliferation of HD-capable cameras in smartphones and high

bandwidth mobile networks. Video is often seen as the "next big thing" after the success of mobile photography and sharing of images in social media. Most notably, Instagram has brought snapshot photography, augmented with easy-to-use colour filters, to the top of social media with a reported 32 % of all iPhone users actively using the service on a monthly basis in early 2013 [35]. Following this success story, there has been great anticipation for video to transfer into the social mainstream. Whether there will be an "Instagram for video" or something quite different that can make this happen remains to be seen.

From the individual's point of view, the costs for producing and distributing digital content have nearly disappeared. Video cameras have become affordable, small enough to carry with you at all times, and are coupled with networking capabilities for sharing images instantly. The means are now easily available for individuals to capture images and video from wherever they are, begin to collaborate with others, and/or to distribute their work on a large scale. Nowhere has the shift to digital been more prominent than in video technology. Analog video cameras recording on VHS tape were first replaced by equally heavy and low quality digital ones, but within just a few years, the same basic video recording capabilities had proliferated into first point-and-shoot digital cameras, and then into mobile phones. Ten years after the first crude camera phone appeared on the market, its successors are now in effect replacing point-and-shoot digital cameras in most everyday camera use, both for photos and video, and the image quality available to ordinary consumers has risen to what had been professional levels just a few years earlier.

As a consequence, we are seeing a massive growth of use of photography and video, and the materials produced are being seen by large audiences. An abundance of images from sites of breaking news around the world—from 9/11, the 2004 tsunami, and the 2005 London subway bombings to the Arab Spring riots in 2011—shows us that the moving images that stay with us from those events are the ones that capture the immediacy and the raw authenticity of being there. More often than not, they were captured by bystanders, on camera phones or consumer-grade digital cameras.

In HCI, recent years have seen a growing interest in camera use in mobile settings. O'Hara et al. [39] investigate the social practices surrounding consumption of video on mobile devices and highlight a range of underlying motivations and values in various contexts. Lehmuskallio et al. [32] suggest, based on a content analysis and comparison to camera phone photography, that most mobile video practice is more closely related to snapshot photography than to traditional videography and filmmaking. Puikkonen et al. [42, 43] study mobile video work in real

life and reveal usage patterns, as well as challenges and barriers mobile videographers face. Licoppe [34] specifically brings out the affordances of the mobility of the device in mobile video telephony; how everything within the video frame is available for scrutiny and can therefore be potentially relevant to the ongoing conversation.

1.3 Increased interactive control in TV viewing—iTV

The final aspect of changed video use is that of continuously changing TV viewing practices, where the viewers are getting increased control and influence of what they are looking at. iTV has already become both an established research area and a set of commercial services. This body of research illustrates how theoretical accounts of viewing practices have started to transgress the border in between media studies and research in human computer interaction. Media theory has for a long time pointed to viewers' active interpretation of the broadcast content. Now, it moves into accounting for iTV that involves changing the states of the TV and its content per se, similar to the way the area of HCI sees computational interaction as the work going into the engagement, or the doings, with a machine, whether it is a computer screen or a TV set [14].

The concept of iTV has been used to account for systems that attempt to support interactivity in the consumption process end of mass broadcasts, as exemplified in research on making more choices available for the consumer [25], such as affecting the programs being watched [24], making TV viewing more social [36], providing games [10], mobile television [40], and so on. In the area of HCI, effort has been spent on investigating how to handle and gain overview of massive volumes of digital video, e.g., through summarization [6, 11, 48] and browsing techniques [13, 33]. Such techniques would then make it possible to interact with big and bulky video streams of various kinds, and provide viewers with ways to interact with it. Some recent systems [9, 21] provide richer means for interacting directly with the live broadcast image, adding abilities for what may be called "content interaction," beyond the more common interactive "system controls" typically found in iTV [51]. This is an ongoing development that points to a viewing experience that is interactive on more levels, but the examples are still relatively few.

In all, this research is derived from the broadcast industries' attempts to provide for interaction and still is largely concerned with the audience as consumers, and located in a home environment. iTV research is therefore to be seen as a piece in the puzzle of video interaction, but only contributes in parts to the understanding of the changing video environment. In the following, we will discuss the included articles' contribution to framing this area and the research agenda.

2 Interaction in video production

The shift toward consumer-based media production raises a number of new research issues, such as how existing production practices operate and spurs new design challenges. Three articles, included in this special issue, address this by focusing on the opportunities to provide more meaningful content by sharing and on the collaboration in the production. The underlying hypothesis seems to be that some topics could be made more meaningful and interesting to broadcast, if it was possible to switch between visual perspectives, similar to how a professional live broadcast is often done.

The paper by Mudassir A. Mughal and Oskar Juhlin (Mobile Life Centre) investigates delay and synchronization problems in mobile collaborative video production systems by studying user practices as well as by conducting delay tests with the existing prototypes—the Instant Broadcasting System (IBS) and the Mobile Vision Mixer (MVM) [20]. These lightweight and mobile production systems basically allow users to produce live broadcasts using video feeds from multiple mobile cameras. The effects of delay in such systems are described, and design suggestions to cope with it are presented.

The paper by Marco de Sá, David A. Shamma, and Elisabeth F. Churchill (Yahoo! Research) presents a mobile collaborative video production prototype, Caleido, which offers users the ability to coordinate their video capturing for a certain geo-based live event. Relying on ad hoc co-operation and awareness of what is being captured around, it allows a higher diversity of quality video created during the event. A qualitative analysis of the design process is provided including lessons learned that apply to collaborative media production systems.

Although both papers deal with mobile collaborative production systems, more complex versions of plain live broadcasting, they differ in their nature. In the former, the broadcast video is produced and organized in a manner similar to how professional live TV production provides tight and visual storytelling, whereas in the latter approach, video is captured through a crowd-sourced and ad hoc approach. The design of systems, like the Instant Broadcasting System and the Mobile Vision Mixer, is inspired by the professional TV production [18, 41]. By providing mechanisms as live video mixing or editing, amateur video producers are given tools which support more advanced user-generated live broadcasts. By providing mobile vision mixer, a group of users are given opportunity to co-produce and broadcast a live footage while being mobile and moving around. Crowdsourcing in general is the outsourcing of tasks over the Internet to a large group of people. Caleido makes use of the phenomena that at the same event, e.g., a concert, many people use their mobile devices to capture it and share it on the Internet. The media captured at the specific event covers it often through various angles, perspectives or with varying video quality and motivation behind.

From the technical perspective, these two approaches face different challenges—inclusion of other sensor data into video feeds and delay and synchronization in complex multimedia systems. In the crowd-sourced approach, although many videos might be captured during the event, it is still hard to find the desired videos since they are often spread through a variety of services and locations. By using sensors that come as a part of standard mobile phone equipment, such as compass directions, GPS locations, or accelerometers, the additionally captured metadata can provide insights into shot and scene detection, camera angles, and location densities, mitigating the search and finding of videos. In the case of mobile amateur live TV production, two types of delays affect the mixing of the streams—the difference in delays in multiple streams causing asynchrony among streams, and the delay between the events itself and its presentation in the mixer. The later one affects the mixing in the case a director is at the same time also a participant of the event, the case that never happens in the professional TV production.

Besides the technology around the video production, in both the crowd-sourced and the pro-style approaches, questions concerning the mobile video production practices become visible. Camera angles, cuts, storyline, or location are just some of the concerns. The third paper in this special issue presented here is the paper by Alexandra Weilenmann, Roger Säljö (University of Gothenburg), and Arvid Engström (Mobile Life). A new generation of users is growing up for whom video is an easily accessible and commonly used media, for both consumption and production. While the educational system is still relying heavily on consumption and production of text, and fostering literacies in relation to older media [29], new notions of media literacy have been formulated, emphasizing participation and media production skills alongside more established skills like being a critical and competent reader ([22, 28]). The authors draw on these updated concepts of media literacy and discuss how they could be developed further into more medium-specific literacies. They present a study that explores the ways in which the widespread use of video among young people could be brought into a learning context. Through a design intervention where groups of young visitors at a science center were given the task of broadcasting their experience of an exhibition to remote viewers, the authors observed how the participants managed the different aspects of live video production. They draw on these observations to bring out practices and skills that would constitute an emerging "mobile video literacy."

3 Interaction in video consumption

So far, we have concentrated on the video capturing, production, and distribution, while here we turn to interaction in video consumption. Nowadays, viewing context is more important than ever. The era of videos consumed mostly by couch potatoes in their living room has passed, and today, video can be consumed anywhere. A particular concern here is how the variation of viewing locations changes how we interact with video. The living room has a set of characteristics that is oriented to looking at a screen. The soft and cosy couch is of course important, together with the way in which the screen is placed along a wall to provide for relaxed watching. The screen is often located in a room, such as the living room, which provides a quite space shutting out noise from ordinary household chores. And the location of the living room inside a private house separates the watching from everyday demands by co-workers, teachers, etc.

The paper by Kevin Mercer, Andrew May, and Val Mitchel (Loughborough University, UK) presents the results of a field study in combination with the literature study investigating whether and how users engage with content in different public and private spaces. A set of contextual cues that characterize distinctive viewing situations is provided, pointing to complex social interactions and temporal happening.

4 A research agenda

We are now at the stage where we can begin to put together a research agenda, which investigates video interaction. We will do that based on the available research in this issue, as well as on previous joint discussions among several researchers in the HCI area during a workshop series, summarized in [27]. Making the most out of increased interaction with video, as emerging out of democratization of the means of production, the ubiquitously available mobile technology, and the increasingly active viewers, depends on that we invent and investigate within the following areas:

Literacy: To close the gap in between traditional broadcast video and user-generated social media, we need to address, for example, that people struggle with finding interesting topics to broadcast and managing the camera in a way that presents it in a broadcastable way. Allowing people to collaboratively produce video is one step ahead, but as the article in this issue of PUC by Weilenmenn et al. shows, this is not the only answer. What we do have learnt is that providing the technical opportunity to broadcast live video from almost anywhere is not enough, and there is

now a need to discuss the barriers and resources for this area.

Delay, synchronization, and image quality: Emerging broadcasting reiterates the issue of acceptable image quality. Achieving better quality than what we currently have is a constant challenge due to technical limitations like limited network bandwidth and throughput and limited processing resources. As pointed out in the article by Ahmad Mughal and Juhlin in this issue, it is now necessary to consider also delays and latency, which also affects the experience of the broadcasts.

Co-ordination and awareness: Video interaction is closely related to the research on video communication, where this media's ability to provide awareness of collaborate activities has been a long-term concern. Drawing on recent research on supporting aggregation of multiple live videos them, as well as enabling collaboration between broadcasters, would enable richer view on the event, and potentially more viewers. This topic is investigated both in the article by De Sá et al. and the article by Ahmad Mughal and Juhlin in this special issue. Extending video interaction to provide more complex broadcasts partly depends on the development of new coordination mechanisms in the production setting. Furthermore, live broadcasts are hard to find; they often receive minimal audiences, but the numbers increase with integration into other social media platforms. These new services could provide support also for collaborative distribution tasks.

Consumption and utility: Overarching the typical HCI question of usability for video-based systems lies the perhaps more fundamental question of such system's utility and usefulness. It is not enough to point to interesting interactional mechanisms or display formats, but we need to ask what values the use of video media adds to the users. Mobile broadcasting services enable a unique combination of mobility and live streaming in a consumer device. Control over visual and audio content selected from multiple visual feeds, and the temporal aspects of broadcasting image sequences (e.g. instant replay) are creating new possibilities. The effects of this on broadcasters cannot be dismissed, with potential commercial impacts, for example, on content branding, broadcaster guidelines on content provision, and advertising models.

Designing for variability in use practices and use contexts: The success of video interaction depends on how well the systems fit with use practices and use contexts. First, the system needs to support users' narrative demands. Applications that are used to cover an amateur sailing race might need to include other features than a system covering a crisis situation. Second, supporting user-generated video might depend on integrating video production in new use practices, and move video techniques from disciplined and

trained professionals to amateurs who differ both in their motivational setup as well as in their competence.

Novel hybrid formats: The ability to experience remote events, as they happen, is a strong perceived value in live video, from traditional live television to newer forms of online and mobile media. Broadcasting capabilities in inexpensive camera phones mean that the range of events that can be shared and experienced remotely in real time is multiplied. Looking at the mediation of live events, video and audio have been the dominant media. But the proliferation of sensors, GPS, and mapping devices is another source of real-time data. Combining these sources with video into hybrid formats could produce more diverse ways of experiencing remote contexts.

Augmentation: Interacting with video material became popular, with recent advances in image processing. This technology enables, e.g., augmented layers of information for selected objects, addition of clickable hotspots on video, or conversational videos. Live video brings new challenges and a need for novel types of interaction to the field.

Ecosystems: Although this medium emerged out of new capabilities in handsets and telecom networks, it is already integrated in the larger economy of Internet services. Companies are working out their business models in the online video domain. Video streams are embedded on Web sites and integrated into social media, enabling wider viewership but also making them subject to copyright and other legal issues.

Privacy: Mobile video sharing can be applied in any mobile network setting. When the material is made available on social platforms, this reaches out to a broad spectrum of our everyday lives. How does this distribution of mobile video affect issues of how we are consuming and being exposed to video? Considering that videos are easy to share digitally, we need additional discussion on how mobile videos also impact our perception of intimacy and privacy.

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