

ImTV: Towards an Immersive TV experience

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Abstract. The media marketplace has witnessed an increase in the amount and types of viewing devices available to consumers. Moreover, a lot of these are portable, and offer tremendous personalization opportunities. Technology, distribution, reception and content developments all influence new “television” viewing/using habits. In this paper, we report results and findings of a transnational three year research project on the Future of TV. Our main contributions are organized into three main dimensions: (1) a user survey concerning behaviors associated with media engagement; (2) technologies driving the social and personalized TV of the 21st century, e.g. crowdsourcing and recommendation systems; and (3) technologies enabling interactions and visualizations that are more natural, e.g. gestures and 360° video.

1 Introduction

Current media entertainment and traditional television are now being delivered through different communication vehicles (e.g. Wi-Fi, 3G, DVB, and cable) and are accessible through multiple devices. The Web has also enabled viewers to interact with content through revolutionary applications, and content itself is no longer exclusively delivered by broadcast or cable channels. Given the complexities of this new media environment, researchers have begun to grapple with the dynamics of contemporary media usage.

The ImTV project¹ is set in the middle of this media revolution. To realize the full potential of these numerous changes, we envision a future where TV delivers an

¹ <http://imtv.di.fct.unl.pt/>

immersive entertainment experience. Viewers will be socially immersed in the media chain by producing media and related content (i.e., crowdsourcing moves to TV), increasing their sense of belonging and enjoyment. Technologies will enable an immersive viewing experience for an increased sense of presence and engagement. ImTV is a socio-technological research project involving university and media partners from the US and Portugal. The new interactions afforded by current technologies are helping to change the role of TV from a traditional “spectatorial culture” to a “participatory culture”, where users are not only consumers but also producers of information.

This paper summarizes the project’s most relevant contributions.

Future viewers are very different from the “TV zapping or VCR” generation. A US/Portugal user survey with over 1,000 participating subjects (Section 2) provides a picture of the media consumption habits and trends of the future media market.

Viewers seek greater social interaction in the consumption of entertainment media. They comment, tag, rate, chat and create new content about other media. Technologies to better capture and explore this social feedback and interaction will be discussed in Section 3. Hardware technologies and TV sets with rich interactive features have changed traditional TV. From context-aware TVs to 360° experiences, our work concerning future interaction and viewing experiences will be discussed in Section 4.

In the past, the TV industry has been driven by technical standards, but the current trend disrupts the monolithic and incumbent industry bias that standards-setting processes favor. How will traditional media players cope with this fast changing scenario? Section 5 tries to answer this question.

2 Getting to know viewers: A user survey

Our study decodes the behaviors associated with media engagement among university student populations in two distinct locations: a large research-based university in the southern United States and three similar institutions in Portugal. Young people are in the vanguard of new ways of engaging entertainment, and we believe their responses are good e-predictors of patterns that will be present in the rest of the population eventually. Our intent is first, to describe some of the new “viewing” behaviors among this group of users/participants, and second, to understand the influence of industrial settings (e.g., services available), cost, and platform on patterns of engagement. The broader goal of this study is to unpack how interactivity operates at this moment in time, and to broaden discussions around the idea of platform and choice. The background of media industries and their ability to structure choices is highlighted by the opportunity to compare two different environments, those of the US and Portugal, where viewing/using opportunities vary.

Engagement: Devices

In response to our concern regarding how viewers/users engage with “television” or visual entertainment, we found strong evidence of a shift from the usage of television content on standard audiovisual devices such as the television and DVD player to portable multi-purpose platforms, especially the laptop computer. The student population by and large views media on their laptop devices, but also opts for television secondarily as a ready-made system for display. The Portugal sample is statistically significantly more likely to use a “normal” television as a display device than is the U.S. sample (75% versus 47% report they frequently or very frequently use televisions as a display device). Approximately 71% of the overall sample indicated using a laptop frequently or very frequently as their primary medium for watching entertainment fare, with an average 59.2% giving comparable responses for “television” (multiple responses were accepted on this item since we assume people use multiple devices). Surprisingly, very low percentages reported using desktop computers or tablet computers for entertainment viewing; about 11-12% of U.S. and Portuguese students reported using mobile phones for this purpose.

Engagement: Content sources

In terms of what constitutes the source of visual material, cable television material is still highly popular, although more so among Portuguese students than U.S. students (78% versus 63.5%), while web-based films (such as available from Amazon or Netflix) were most popular for American students (78% use these services regularly). The most striking statistic, however, comes from a query regarding how frequently people use certain content sources: There, while “television” (cable or broadcast) is certainly cited (24.1% weekly and 48.5% daily use), downloaded or streaming fare is also very high (33.9% weekly and 32.3% daily use). Web-served content is obviously surging.

The young people in this sample create their own content to share with others. In response to “What services do you use to share your creative work,” students focused largely on Facebook (87.6%), YouTube (57.9%) and email (64.9%). Other options such as Vimeo, Flickr, Photobucket, Picasa, personal blog/site, Google Docs, Twitter, MySpace, and Hi5 were mentioned by some, but in numbers far behind the top three.

Among U.S. students, who had better Internet access and also more individualized viewing settings, Facebook use for responding to others’ content dwarfs all other services: 95% of the US sample report using Facebook to share or comment on content created by others, and over half the same (66%) do so several times a day. In other words, this secondary circulation of commentary is extremely common.

Mobility

Are people taking advantage of the mobility inherent in laptops and mobile phones for entertainment purposes? When we cross-tabulate use of the mobile phone with use of Facebook, YouTube and email - which are primary platforms used for

entertainment for the sample - we see mixed results. First, the use of Facebook is so dominant that the device platform does not appear to matter: people are on Facebook a lot, wherever they happen to be and whatever technology is in their hands. YouTube is a somewhat different story. The people creating and sharing content via this video platform rely more heavily on mobile phones; their frequent use of the mobile is associated with YouTube content creation. The 100 or so people who report being heavily dependent on the mobile phone also frequently use Google Docs, Picasa, MySpace, and Hi5 to share content.

Facebook is central

For U.S. students, Facebook was cited by 95% of the sample as a service used to share or comment on content created by others, with U.S. students somewhat more intensive users than Portuguese students. We find 81.3% of the latter used it as a sharing/commenting service. In terms of where people shared their own work, Facebook again was the primary venue. About 94% of the U.S. and 84% of the Portuguese students indicated it was their primary location for presenting work. Given this, it may not be surprising that in the combined sample, 52% reported that they use Facebook multiple times per day. Everyone uses it and nearly everywhere as well. Facebook is the dominant medium for sharing and commenting on others' content and for sharing one's own content as well.

Usability factors

When assessing comparative qualities of various content delivery systems, we asked about issues such as cost, ease of use, the graphical interface, the physical interface (if applicable), content availability, image and audio quality, and recommendation systems (if any). On these dimensions, Facebook, YouTube, and email received very high ratings compared to many other competing services, particularly in terms of ease of use. For instance, the entire sample agreed email was extremely easy to use (an "excellent" rating), compared to the 32% of the sample who said the same about gaming consoles, or the 27% who rated "television" as excellent. Facebook does not compare as well in terms of content availability, however, compared to streaming media or YouTube, although it receives a rating that is higher than "conventional" television.

Access and Downloading

Authorized downloading services like Netflix (27.2%) and Hulu (13.8%) are ranked highly by U.S. respondents as their most frequent method of accessing media, with nearly 40% of the U.S. surveyed population using one of these two services. Cable TV is the preferred medium of just 16.2% of the U.S. respondents. Only 6% of U.S. respondents indicate that other streaming services serve as their primary media choice.

In contrast, the Portugal media system does not feature access to Netflix or Hulu,

nor do people have access to a popular authorized streaming service at the time of the survey. Instead, Portugal respondents turn to cable TV at a rate of 45.5%, followed by 28.4% who choose streaming media for their primary source of entertainment.

3 The *New Social TV*

The viewer/user results indicate that the convergence of TV and the Web has empowered TV viewers and made them active contributors towards a more inclusive TV. Not only do users chat online about TV shows, but they also rate them, tag, comment, or create new content through Wikis, YouTube, Facebook or other fan-dedicated sites. We are witnessing the emergence of crowdsourcing via social networking platforms, thus enabling new mash-up applications merging information from the crowds.

3.1 Augmented TV and Web in crossmedia environments

In the ImTV project, finding relevant and possibly unexpected video-based content created by traditional producers or the users can be of great value. User generated data (ratings, tags and content) can be created while media is being played. We have explored cross-media environments, ranging from TV to PCs, and mobile devices in different contexts [Prata 11a] [Prata 11b], where users access additional and related content or add data in cross-media environments in real-time. Our prototype system allows the creation, access and sharing of flexible web personalized informal learning environments via different devices, as additional information to the video being watched, and as an answer to the informal learning opportunities created by video and iTV. When watching a TV program or a video, viewers can select topics that are presented and catch their attention in the video content (e.g. what the characters are talking about), or they can select information about the program (e.g. actors, director, shooting locations). They can get a short piece of information right away or alternatively, a more detailed webpage, created with information about all the items selected during the viewing, later on. Users may then access, add to, and share these contents with other users, anytime and anywhere. For instance, they can add a picture captured from their mobile device at the same location of a specific scene of a movie they have watched, and comment about this related information.

User evaluation in [Prata 11a] and [Prata 11b] provided encouraging results in terms of usability and user acceptance, through indicators such as utility, ease of use and user satisfaction, in contexts of use where the main affordances of the different devices can be more adequate, in isolation or combined. Content classification and metadata, as well as human-centered design in HCI are central aspects in this work.

3.2 Listening to viewers: Sensing the audience mood

We set out to develop a Social-TV system prototype that allows users to chat with each other, in an integrated way. Our prototype system analyses chat-messages to detect the mood of viewers towards a given show (i.e., positive vs. negative). This data is plotted on the screen to inform the viewer about the show's popularity. Although the system provides a one-user / two-screen interaction approach, the chat privacy is assured by discriminating information sent to the shared screen or the personal screen.

In our system [Martins 12], we infer the sentiment of the message towards the show, illustrated in Fig. 1 and Fig 2. In the proposed system, user messages are processed in real-time by a sentiment analysis algorithm, allowing the plot of the emotions felt by viewers. An advantage of the proposed visualization method is that viewers can get a quick glimpse of the show's popularity in the last few minutes.



Fig. 1. Chat interaction in a tablet device.

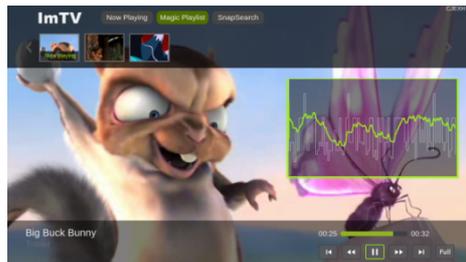


Fig.2. Chat sentiment analysis graph.

3.3 Mash-up-TV: Rating, tagging and commenting

As illustrated earlier, television is becoming more connected, more social and linked. Valuable information is available in external applications and services that make up a cloud of information around TV providers and users. Comments on social networks can be used to infer the mood of a user or the number of followers of a TV show [Martins 12]. IMDb, TV.com and other related sites can provide extra metadata to characterize content and enable better recommendations [Peleja 12]. A Mash-up-TV solution that is able to use the cloud of information to create new content is the final, integrated stage of our system. This amount of data can be provided to recommendation engines to enhance the viewing choice decision process. Users' feedback such as ratings, tags and comments, are scattered across many different Web applications.

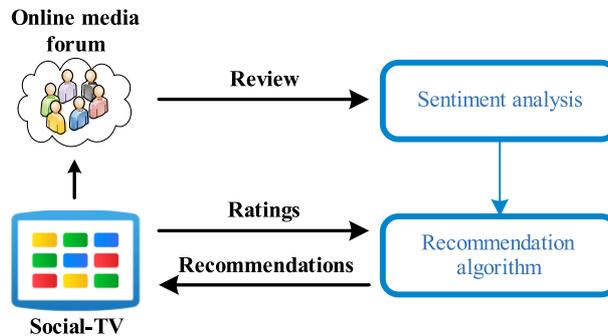


Fig. 3. Recommendations based on ratings and reviews.

Besides exploiting traditional approaches to Recommender Systems, ImTV project also explored recommendations to groups [Dias 11], diversification of recommendations [Dias 12], comments-based recommendations [Peleja 12] and evaluating the quality of recommendations [Soares 12]. In [Peleja 12] we developed a system, Figure 3, that uses machine learning techniques to analyze user reviews and infer their preferences from these comments/reviews. A recommendation algorithm is then responsible for exploring these comments to compute collaborative recommendations.

4 Immersive viewing and interaction technologies

As display devices such as “televisions” start to come fitted with multi-core processors and camera devices, their processing power opens the way for new interaction technologies. Gestures and face recognition, and tablet-based control are already in the market. We have researched other engagement mechanisms including 360° video, awareness interaction and multiple-screen entertainment, towards more immersive interactive experiences.

4.1 Multiple screens: How to merge them?

Designing an integrated user experience for watching TV across multiple screens requires considering that the number of participants, screens, and locations can vary and change. For instance, users can start watching a football match at home alone using their laptop, then continue watching in their mobile phones in the subway, and finally meeting their friends at a sports bar where they all watch multiple large shared screens in combination with their personal devices. In this scenario, the characteristics that define a “session” are fluid. Separating sessions by screen location or number of participants can break the flow of the activity.

In order to manage different combinations of screens, contexts and participants, it

is necessary to abstract the concept of “session” and make it available to different devices as necessary. As people might engage with different screens in different ways, each device needs to be aware of the state of the multiple activities in the overall session (or sessions). At the same time, screen changes are important as they often signify important transitions in terms of context and participants, and the session needs to be aware of the affordances, constraints and context of the involved devices. In [Martins 12] we developed an entertainment system spanning multiple screens for the same session. All users share one main screen and each user can have a private screen (to browse extra info, communicate with others, and control the main screen).

Certain devices are better suited for interaction paradigms such as push-content (e.g., traditional TVs work well with channels and pre-scheduled programming). Other devices are better suited for pull-content paradigms (e.g., online video providers support interactions based on recommender systems as the ones developed in [Peleja 12]).

Interacting with TV goes beyond engaging with a particular program or video clip. It involves activities such as browsing, searching, sharing, rating, and commenting. In circumstances where multiple screens are available, it is possible to match the activities to the screens. For instance, consider modern smart TVs that allow using tablets as smart remote controls such that viewers can see the program schedule and select channels using a separate screen, less intrusive of the TV viewing experience.

4.2 Immersive viewing and interactivity

Highly immersive cinema and video have stronger impact on viewers’ emotions [Visch 10] and their sense of presence and engagement. 360° video has the potential to create highly immersive video environments since the user is no longer locked to the angle used during the capture of the video, and 360° video capturing devices are becoming more common and affordable to the public. Hypervideo² stretches boundaries even further, allowing the viewer to interact with the video, to explore and navigate it, and to get related information through links defined in space and time, towards stronger interactive and engaging experiences [Douglas 00].

As a first approach, we designed and developed an interactive interface for the visualization and navigation of 360° hypervideos based on the web. The interface allows users to pan around to view the interactive video content from different angles and to effectively access related information through the hyperlinks. One challenge for presenting this type of hypervideo includes providing users with an appropriate interface capable of exploring 360° contents, where the video should change perspective so that the users actually get the feeling of looking around. Another

² Hypervideo refers to the true integration of video in hypermedia, through links defined in space and time, allowing to navigate videos and related info.

challenge is to provide the appropriate affordances to understand the hypervideo structure and to navigate it effectively in a 360° hypervideo space. The main navigation mechanisms, Figure 4, include drag interface (to pan around the 360° video), view area and minimap (for 360° orientation), link awareness cues (to spot the links even when out of sight), image maps (to summarize and index the video), and a memory bar (to know where the user has been). User evaluation [Neng 12] has provided very encouraging results in terms of usability, orientation and cognitive load, which are related with the main challenges. Perceived usefulness, satisfaction, and ease of use were also highly rated in the evaluation [Neng 12].



Fig. 4. Navigation in the 360° Hypervideo Player. Left: details about points of interest on the left, image map below, with link to another part in the video; Right: View with minimap below, link hotspots on the video.

As a next step, we are designing and developing immersive interactive videos as extensions of the first 360° hypervideo. Moving out of the box, by stretching or breaking the window boundaries, allows for a higher level of immersion, potentially full 360° [Neng 12]. We are exploring increasing levels of immersion, from settings closer to the current TV viewing environments, towards more immersive ones. In terms of output: 1) accessing HV 360° in full screen and in larger screens; 2) extending the user workspace across more than one screen side by side towards a circular alignment; 3) using video projections in large walls; and later on 4) developing video projection in an immersive Cave environments (e.g. the Portuguese science center: www.lousal.cienciaviva.pt), with varying angles of projection, possibly towards full immersion, in cylinder or spherical (e.g. allosphere.ucsb.edu) environments will be pursued. In any case, HD videos and surround sound can increase the sense of immersion. In terms of input, moving away from the desktop towards more natural interactions may also increase the feeling of immersion. As a first step, we are using a cordless mouse with gyroscope that works in the air (Logitech Max Air), mainly in scenarios 1) and 3), with promising results that allow for unrestricted and flexible interactions with a sense of control and increased immersion. Other modalities might be explored, including gestures, or gloves,

especially in 3D videos.

5 Standards: How to keep-up the pace?

Metadata and video formats pose major challenges to service providers. In what concerns 3D metadata, major difficulties arise from the lack of a unique approach for video coding, which has a direct impact on metadata. Moreover, although 3D has been around for quite a long time (on video games and computer graphics), it is still a child in what concerns immersive cinema and television and de-facto standards are expected to have a strong impact. The question is “who will survive?” or “is there a killer solution?”

In 3D immersive environments, multiple views of the same scene are often captured using multiple cameras, to enable wide field-of-view (FOV) and 3D reconstruction, requiring considerable resources for storing and transmission. The main approaches for 3D video coding include conventional stereo, video plus depth, multi-view or combinations of each of the basic techniques [Ozbek07] [Schreer10]. Most promising formats are MVC (Multi View Coding), 3DVC (3D Video Coding) and FVV (Free Viewpoint Video). The diversity of formats greatly jeopardizes interoperability, and content adaptation techniques may assume vital importance. In multi-view 3D video, visual and audio attention modeling approaches can be considered interesting alternatives for designing scalable and adaptable systems. The viewing angle and/or audio may provide important information driving visual attention, and hence should be considered for adaptation purposes. Approaches based on color texture, or the multi-view depth information can also be considered. Adaptation can also be employed to increase the user quality of experience and to establish interoperability across different compression formats and ensuring quality presentations in diverse client terminals [Kim 03].

New aspects introduced by 3D have a direct impact on metadata that enables describing, using and adapting content efficiently. Re-usability of metadata and consequently of the content itself, strongly depends on the availability of standardized schemes. In the recent past, different initiatives have produced rich standards, usually covering different areas of application. For instance, the MPEG7 standard offers tools to describe both high-level concepts, as well as intrinsic characteristics of content trying to address the multimedia community at large. Its complexity compromised its acceptance within the broadcasting industry. Organizations like SMPTE, TV-Anytime and EBU, proposed their own solutions, and no solution can be singled out as the winner at this time. Mapping and gateways are often the solution to integrate different applications or different areas of the workflow.

6 Pruning: Which services will survive?

ImTV research suggests that the audience is evolving into one that expects to create and use content in various forms and in various places. While students may not typify the adult audience since they typically have fewer economic resources and possibly limited time to spend with media, they are early adopters of technology, and they may set the agenda for how other generations engage with entertainment programming of various sorts. We found evidence that user-generated content is popular, and the two to three hours per day of use, common among our sample, is spent in a “lean forward” fashion, rather than a “lean back” fashion: leaning forward to create and interact, rather than leaning back to just consume.

As the interplay of media interaction mechanisms and multiple device configurations evolves, new services emerge. For instance, social-TV interaction applications, such as SentiTVchat [Martins 12], will be part of every entertainment service. Other excellent examples of the “lean forward” attitude are the fan-groups Web sites, where users leave long traces of their thoughts towards a given show. This rich user feedback is extremely valuable for many innovative applications [Peleja 12].

An increased number of screens available to users is another emerging trend. New user interfaces and interaction paradigms will rely on distributed architectures. New types of media will emerge, such as 360° video [Neng 12], to provide users with immersive and realistic experiences. However, the most interesting aspect is that these screens are not just screens – the manufacturers of these multiple screens use it as an extension to reach end-users and offer them new content, services and applications. Thus, TV manufacturers (an old passive player of the TV industry) are now more active and suddenly closer to users than most TV broadcasters. They can actually drive viewers into their online Web entertainment services in a much smoother way.

Although standards are an essential step towards interoperability, the time required to produce a solution is not compatible with the urgency for new types of content and experiences that the new generation of users requires. Industry-imposed standards and new products coming directly from the universities are expected to have a great impact in the near future.

We are currently witnessing a massive change in one of the most successful media industries. TV manufacturers are pushing technology into the market at a faster pace than it can absorb: they all want to offer the “killer app”, but it will be the social interaction among viewers that will decide the winner.

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7 References

- [Dias 11] P. Dias, "Recommending media content based on machine learning methods," M.Sc. Thesis, Universidade Nova de Lisboa, 2011.
- [Dias 12] P. Dias, J. Magalhães, "Greedy vertex-angle maximization for multi-user diverse recommendations," Technical report, Universidade Nova de Lisboa, 2012, *submitted for publication*.
- [Douglas 00] Y. Douglas, and A. Hargadon, "The Pleasure Principle: Immersion, Engagement, Flow," ACM Hypertext'00, 153-160, 2000.
- [Harboe 08] G. Harboe, C. J. Metcalf, F. Bentley, J. Tullio, N. Massey, G. Romano, "Ambient social tv: drawing people into a shared experience," SIGCHI conference on Human factors in computing systems (CHI '08).
- [Lane 11] N. D. Lane, Ye Xu , H. Lu , S. Hu, T. Choudhury and A. T. Campbell, "Enabling Large-scale Human Activity Inference on Smartphones using Community Similarity Networks (CSN)", Intl. Conf Ubicomp, Sept. 2011.
- [Martins 12] F. Martins, F. Peleja, J. Magalhães, "SentiTVchat: Sensing the mood of Social-TV viewers", " EuroiTV' 2012, 10th European Interactive TV Conference, Berlin, Germany, July 4-6, 2012.
- [Narasimhan 09] N. Narasimhan, T. Horozov, J. Wodka, J. Wickramasuriya, and V. Vasudevan. 2009. "TV clips: using social bookmarking for content discovery in a fragmented TV ecosystem," Intl. Con. on Mobile and Ubiquitous Multimedia (MUM '09).
- [Neng 12] L. Neng, T. Chambel, "Get Around 360° Hypervideo: It's Design and Evaluation," in "Ambient and Social Media Business and Applications", Special issue of IJACI, International Journal of Ambient Computing and Intelligence 2012.
- [Otebolaku 11] A. Otebolaku, M. T. Andrade, "Context Representation for Context-Aware Mobile Multimedia Content Recommendation". In proceedings of IMSA 2011 – The 15th IASTED International Conference on Internet and Multimedia Systems and Applications, May 2011, Washington DC, USA.
- [Peleja 12] F. Peleja, P. Dias, F. Martins, J. Magalhães, "A recommender system for the TV on the Web: the power of user reviews", Technical report, Universidade Nova de Lisboa, *submitted for publication*, 2012.
- [Prata 11a] A. Prata, and T. Chambel, "Going Beyond iTV: Designing Flexible Video-Based Crossmedia Interactive Services as Informal Learning Contexts". EuroiTV' 2011, Lisbon, Portugal, June 29-July 1, 2011.
- [Prata 11b] A. Prata, and T. Chambel, "Mobility in a Personalized and Flexible Video Based Transmedia Environment". International Conference on Mobile Ubiquitous Computing, Systems, Services and Technologies, Lisbon, Portugal, Nov 20-25, 2011.
- [Soares 12] M. Micael Soares, P. Viana, "TV Recommendation and Personalization Systems: integrating broadcast and video on-demand services," European Conf. on the Use of Modern Information and Communication Technologies, Gent, Belgium, March, 2012.

- [Strover 12] S. Strover, W. Moner and N. Muntean, "Immersive television and the on-demand audience," Intl. Communication Association Conference, May 2012, Phoenix, USA.
- [Kim 03] M.B. Kim, J. Nam, W. Baek, J. Son, and J. Hong, "The adaptation of 3D stereoscopic video in MPEG-21 DIA," Signal Processing: Image Communication, vol. 18, pp. 685-697, Sep. 2003.
- [Ozbek 07] N. Ozbek, A.M. Tekalp, and E.T. Tunali, "A new scalable multi-view video coding configuration for robust selective streaming of free-viewpoint TV," IEEE Intl. Conference on Multimedia and Expo, pp.1155-1158, July 2007.
- [Schreer 10] Schreer, Oliver. Final Report of the 3D@SAT project. European Space Agency, Future Projects and Applications Division, September 2010.
- [Visch 10] T. Visch, S. Tan, D. Molenaar, "The emotional and cognitive effect of immersion in film viewing," Cognition & Emotion, 24: 8, pp.1439-1445, 2010.