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An exploration of user needs and experiences towards an interactive multi-view video presentation

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Master of Science in Electronics
Submission date: June 2009
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Problem Description

With the rapid development in computer technology and the drop in prices for cameras, the use of multiple cameras, on the receiver side, has become more attractive. New technologies such as 3D-video, free viewpoint video and omnidirectional video have become popular. This thesis should focused on a multi-view video system where the user receives multiple video streams. The goal for such a system is to provide the user with a highly interactive service. An important criterion for the system is that the user should easily switch between the received video streams. This system is to be implemented according to specifications derived by possible multi-view video scenarios. To get a pinpoint on user needs and expectations towards multi-view video a survey should be carried out. The survey should question the users about experience and expectation towards multi-view video.

The goal of the task is to quantify the possible increased interactivity in a multi-view video player. This should be done by testing the implemented multi-view video player and its functions, by letting a group of people evaluate the multi-view video player. To do this, it is necessary that content is provided. The content should be interactive and has a setting such that multi-view video is natural.

[1] C. Fehn and R.S. Pastoor. Interactive 3-dtv-concepts and key technologies. Proceedings of the IEEE, 94(3):524–538, March 2006.
[2] J. Lou, H. Cai, and J. Li. A real-time interactive multi-view video system. Proceedings of the 13th annual ACM International Conferance on Multimedia, pages 161–170, 2005.

Assignment given: 30. January 2009
Supervisor: Andrew Perkis, IET

Abstract

After a literature review about multi-view video technologies, it was focused on a multi-view video presentation where the user receives multiple video streams and can freely switch between them. User interaction was considered to be a key function for this system. The goal was to explore user needs and expectations towards an interactive multi-view video presentation.

A multi-view video player was implemented according to specifications in possible scenarios and users needs and expectations conducted through an online survey. The media player was written in objective-C, Cocoa and was developed using the integrated development environment tool XCode and graphics user interface tool Interface Builder. The media player was built around Quicktime's framework QTKit. A plugin tool, Perian, added extra media format support to QuickTime.

The results from the online survey shows that the minority has experience with such a multi-view video presentation. However, those who had tried multi-view video are positive towards it. The usage of the system is strongly dependent on content. The content should be highly entertainment- and action-oriented.

Switching of views was to be considered a key feature by experienced users of the conducted test of the multi-view video player. This feature provides a more interactive application and more satisfied users, when the content is suitable for multi-view video. However, rearranging and hiding of views also contributed to a positive viewing experience.

However, it is important to notice that these results are not complete in order to fully investigate users need and expectations towards an interactive multi-view video presentation.

Preface

This master-thesis is carried out at the Norwegian University of Science and Technology (NTNU), Faculty of Information, Mathematics and Electrical Engineering (IME), Department of Electronics and Telecommunications, Trondheim, spring 2009.

The master thesis was proposed by professor Andrew Perkis at the Centre for Quantifiable Quality of Service in Communication Systems (Q2S). Great thanks to Andrew Perkis. I also wish to acknowledge Midgard Media Lab and Marlon Thomas Montejo Nielsen for providing content for the multi-view video player.

Trondheim, June 2009

Eivind Danielsen

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Abbreviations

$3DTV$ 3-Dimensional Television

$3DV$ 3-Dimensional Video

FVV Free Viewpoint Video

GUI Graphical User Interface

IDE Integrated Development Environment

$MPEG$ Moving Picture Experts Group

MVC Multi-view Video Coding

MVV Multi-view Video

QoE Quality of Experience

QoS Quality of Service

QT QuickTime

Chapter 1

Background

Traditional media presentation is based on only one video stream. This video stream can be represented with one camera or clipped together with content from multiple cameras. The red line is that the user receives only one video stream. With the increasing computer power, bandwidth and technology, it opens for use of several video streams received by the user. Also, the has been a price drop on cameras, so that it is cheaper to produce content with multiple cameras. Recently the research in this area has exploded and this has shown some new technologies. Some of them are based on old technologies, but it has not been possible to realize them before. Section 1.1 takes on the most promising techniques with use of multiple video streams.

1.1 Multi-view video technologies

1.1.1 3-D Video

The most common number of views for multi-view video (MVV) is two, which can be used to experience 3-dimensional video (3DV). The ability to perceive depth scenes from a 2-D representation format is a quite old technique. The principle of stereoscopic imaging was already presented in 1838 by Sir Charles Wheatstone [1]. The stereoscopic principle is based upon providing the user two separate images, one for the right eye and one for the left. These images are captured from slightly different viewing positions. Another requirement is that the user must use polarized glasses which filters out the images to each eye. This principle generates the illusion of depth or three-dimensional imaging. This has been used for a long time in, for example, IMAX 3-D theaters. However, the introduction of stereoscopic broadcast television (3DTV) or other home entertainments has not been successful. One reason for its low acceptance is the usage of glasses, which can be perceived as exhausting and as a constraint. This problem is believed to be solved in the future by using autostereoscopic displays which does not require glasses [2].

Another drawback for traditional stereoscopic imaging is the lack of interactivity. Viewers gets the same static 3-D image if they move with respect to the display. This is caused by head motion parallax and it can be solved by installing a head tracker [3, p 534] and then render a new pair of stereoscopic images which corresponds to the new position of the head. This allows

Figure 1.1: An autostereoscopic television

the user to "look around" objects. The number of views in a autostereoscopic display can be in the range from 2-1000. The complexity and the usage of resources increases with the number of views.

Although multi-view video can be used to create the illusion of depth, there exits other technologies which is also capable to this such as Zcam [3]. Zcam uses a high-speed pulsed infrared light source to get depth characteristics. This is done by measuring the time of the emitted and reflected light.

1.1.2 Free Viewpoint Video

Another area of application for multi-view video representation is free viewpoint video (FVV). Multiple cameras are used to capture a scene. With techniques from computer vision, these synchronized video streams can be transformed into a data representation that allows the user to freely choose both viewpoint and direction [4]. This process uses many of the same principles known from 3-D computer graphics (e.g rendering). The difference from 3-D computer graphics is that free viewpoint video is captured from real world objects. Free viewpoint video requires enormous data rates and computer computation power so for broadcast services this will be unpractical. However, for storage applications this can be applicable.

Note that free viewpoint video and 3-D video does not exclude each other. There is possible to make a free viewpoint video with a 3-D video scene representation. This will though be very resource-demanding.

1.1.3 Omnidirectional Video

In omnidirectional video [5] the scene is represented with multiple cameras in a way that mostly of the spherical field is captured in high resolution. This enables the user, with the proper
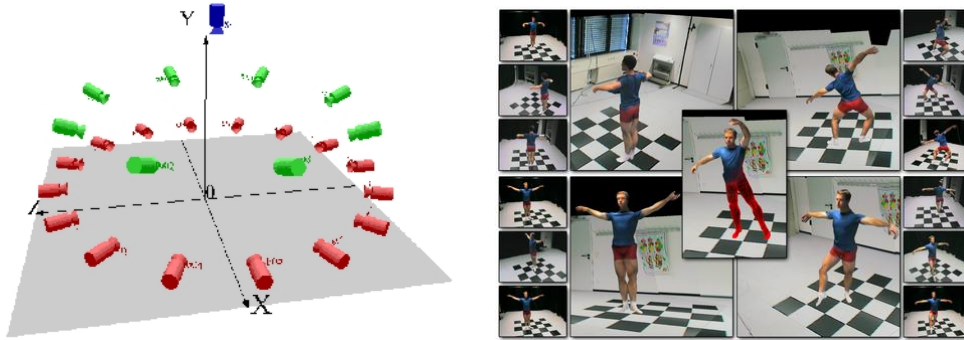
Figure 1.2: Multi-camera setup for FVV acquisition and captured multi-view video.

software, to zoom and rotate around the cameras. This can provide the user with the feeling of being a part of the scene. However, in contrast to free viewpoint video, the user is not able change the position of the viewpoint interactively. The viewpoint may change but this requires that the cameras has been moved during capturing. An example of an omdirectional video is shown in Figure 1.3.

1.1.4 Multi-view Video Coding

Multi-view video is expected to consume a large portion of the bandwidth available in the Internet and storage capacities of the future. Therefore compression is unavoidable. The straight forward method to solve this problem, is to encode each video signal independently using a state-of-the-art codec such as H.264/AVC [6]. Recent investigations done by the Moving Picture Experts Group (MPEG) has shown that further improvements can be done by exploiting statistical dependencies [7], [8], [9] within Multi-view Video Coding (MVC). In a multi-view video system, all of the cameras are set up to capture the same scene and therefore it exits a large amount of inter-view statistical dependencies [10]. These can be divided into two types, inter-view similarity and temporal similarity. Inter-view similarity is predicted from corresponding images in adjacent views, while temporal similarity is detected by temporal neighboring images. Figure 1.4 shows a block diagram for MVC.

All of the proposals from MPEG were extensions of the H.264/AVC codec, so it was decided to make MVC an amendment (Amendment 4) to H264/AVC. There were reported improvements of more than 2dB for the same bit rate. This is a clear sign that MVV will be an important area for interactive multimedia in the future.

1.2 Multi-view Video Presentation

Traditional video representation is in many cases good enough, but for special interactive or entertainment-oriented applications, it has some limitations. For example a live music concert where the user might would like to control the viewpoint. The fixed viewpoint makes the user interaction little or not present and puts the user in a passive position. Users can only watch the event from a not user-selected video sequence. An extension of single-view video is a multi-view video presentation which is generated from multiple cameras, recorded synchronously with different viewpoints [11]. The viewers receive multiple video streams and can then enjoy
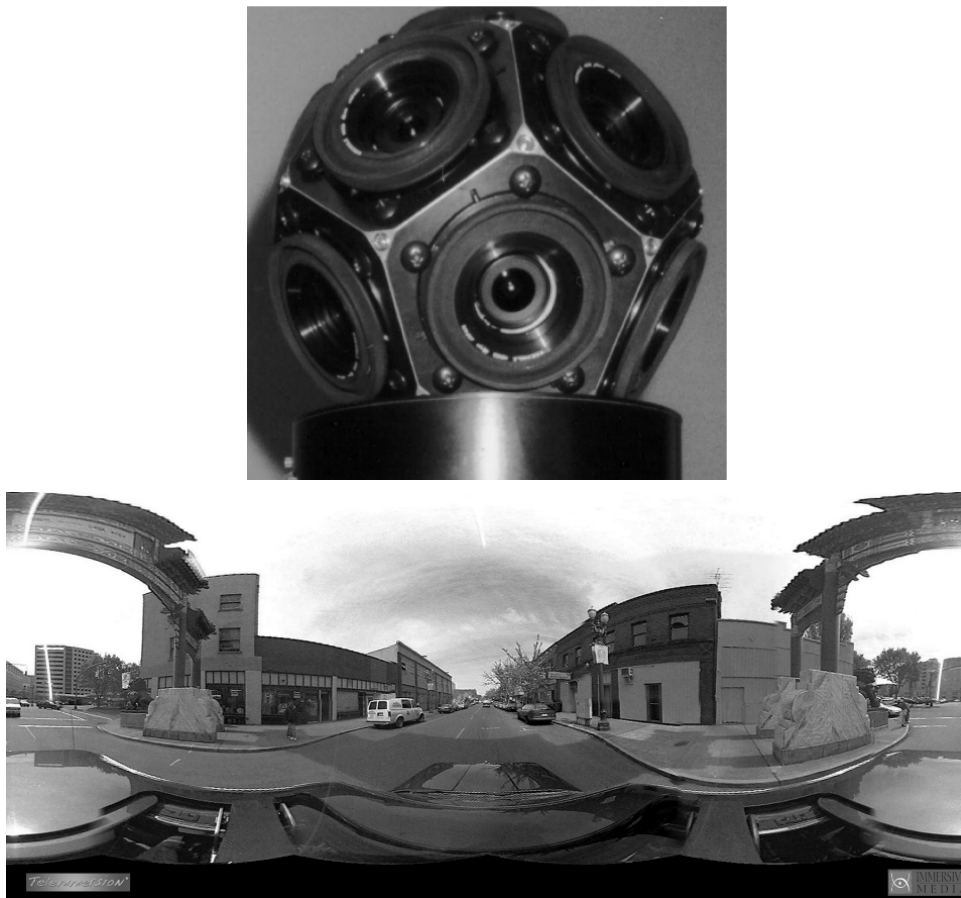
Figure 1.3: Omdirectional camera and a corresponding spherical view.
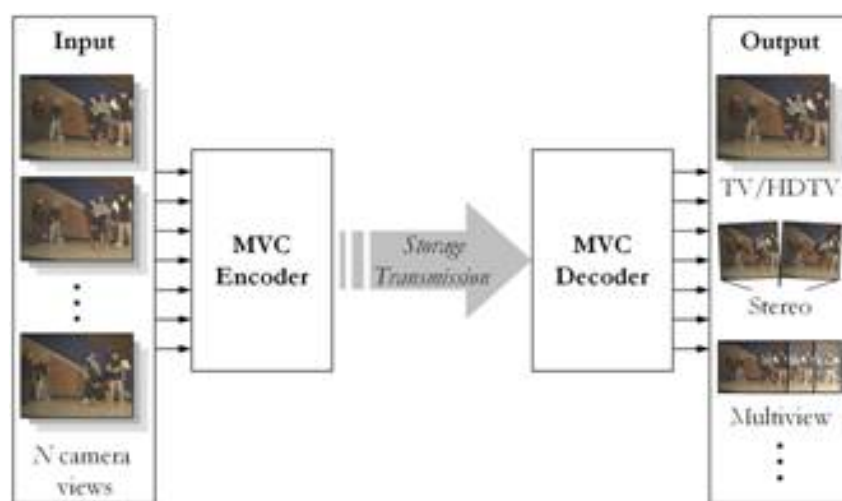

Figure 1.4: Block diagram for MVC

the video from their desired view by easily switching between the views. User interaction is considered a key function in this kind of multi-view video system. When using the term multi-view video later in the report, it refers to this multi-view video system.

This report is based on such a multi-view video system with focus on user needs and expectations. By letting the user to freely switch between different views, the user may feel more in control and satisfied. The idea is to have an very interactive multi-view video media player, where the user can easily switch between views. Chapter 2 takes on a definition of interactivity and presents some possible scenarios. To gather information, based on the scenarios, it has been conducted a survey to get a picture of user needs and expectations. The survey is presented in Chapter 3. The implementation of the media player is described in Chapter 4. To test the interactive multi-view video player and its functions, it is necessary to test the implemented player. This is done in Chapter 5. Chapter 6 sums it all up and gives a conclusion.

Scenarios

To be able to implement an interactive media player, the definition of interactivity must be set. The most common perception is that interactivity is unconditional positive thing. However, interactivity can be split into several dimensions as shown in Figure 2.1.
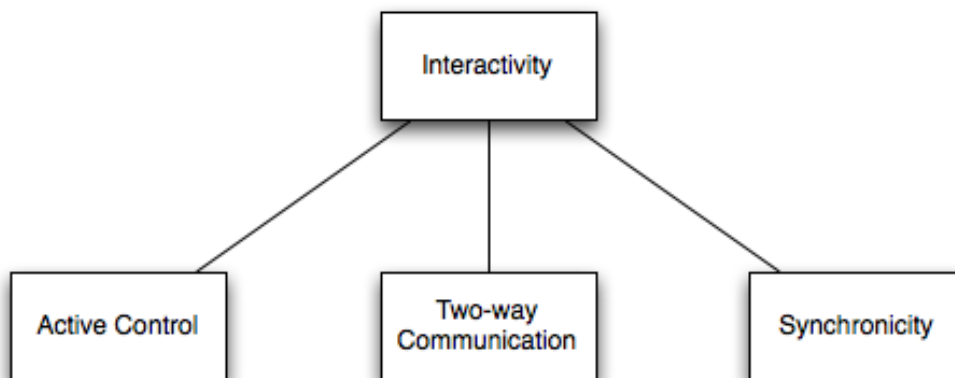

Figure 2.1: Interaction chart

Active control refers to the users voluntary and instrumental action which directly influences the perception of the media/application. In the context of the multi-view video player, this can be the control of which view is presented to the user. In other words, the user has control of which view he/she wants to watch.

Two-way communication is the communication both ways between user and company (or user). Often does the communication only go one way. However, Internet opens for users to, explicit or implicit, give feedback to the company (or user). For a multi-view video player, the communication from the user to the video is non-existent. If there is to be implemented an online multi-view video player, two-way communication could be exploited.

Synchronicity is which degree the users input to a media and the response are simultaneous. This can be the time it takes for the multi-view video player to respond to the users actions. An example is the time it takes to switch video.

To build an interactive multi-view video player, some scenarios are presented below in order to

implement possible solutions.

2.1   Scenario 1 - Multi-view video streaming

Mr.X is an amateur drummer in a garageband and is very interested in finding video recordings of professional drummers in action. Mr.X surfs the Internet to seek after content to help him improve/encourage his drummer skills. He stumbles over a recording of his favorite band, Foo Fighters, playing live in concert. The recording is a pre-edited video sequence, recorded over multiple cameras capturing the event. However, there is only one audio/video stream available at all time. The streamed video is of high quality using H.264 encoding and it requires a decent Internet connection to be able to stream the video without experiencing buffering (interruption). This kind of service should provide Quality of Service (QoS) requirements. For a streaming service, there are certain elements that must be met to guarantee QoS:

- Dropped packets: If routers fail to deliver (drop) some packets, the receiving application may ask for a retransmission of the packets. This can cause severe delays for the applications and can lead to a negative viewing experience.

- Delay: The delay in an IP network the round trip delay for an IP packet within an IP network. The delay can be caused by long queues or by taking a not direct route. When observing severe delays, the audio/video stream might buffer a lot.

- Jitter: When packets arrive with different delays, we observe jitter. This can seriously affect the quality of the audio/video stream.

- Out-of-order delivery: For audio/video streams it is important that packets arrive in the same order which they were sent. If different packets take different routes in the network, this results in out-of-order delivery and special protocols are required for rearranging the packets.

- Errors: While the packets are routed through networks, packets may be corrupted. These errors has to be detected by the receiver and ask for a retransmission. However, this can cause severe delay.

All of these factors play a role in providing QoS for video streaming. The user should be able to watch the content without experiencing buffering, while maintaining a minimal video quality. The degradation of quality should not be caused by the delivery process (such as packet drops, delay, jitter etc). However, one of the best parameter for evaluating quality of a streaming service, is the buffer length. The buffer has to be at a certain length to ensure the users continuous viewing experience, due to minor fluctuations of bandwidth available and the bit rate of the encoded video.

As Mr.X watches the media presentation, he discovers that little time is given to the drummer. The footage is limited to a couple of seconds at a time and he feels that this does not stimulate his particular interest for drumming. Mr.X has heard of a technology which provides the user the possibility to switch between different video streams, called multi-view video. The user receives multiple video streams and there is one active video at all time, which is being showed in a significant larger view than the sub views. The active video is chosen actively by the user's preferences and interests, triggered by the content of the video. The sub-views are arranged in a group below the active video. If Mr.X wants to switch the active video, he simply clicks on the desired sub video and this video becomes the active video. The play progress of the video

stays unchanged, it is at the same time as it was before the switching of the active video. This means that all of the video streams are synchronized in time.

When considering a multi-view video streaming scenario, it has some extra complications compared to single-view video. It it obvious that the bandwidth increases as the number of views increase. The bandwidth can be reduced by letting the user's bandwidth decide how much of the streamed video is sent to the user. This can be done by measuring the user's bandwidth and then offer a selection of video streams based on the measurement. This opens for users with smaller bandwidth to use a multi-view video streaming service. The selection of video streams can be taken further by letting the user configure which video streams he/she finds desirable. One possibility is to tag each video stream. If one of the video streams is tagged "drummer", Mr.X would easily find which video stream that is desirable. Instead of tags, thumbnails can be used to give the user a hint of what kind of content the respective video stream will contain. Another option to give the user a video preview of each video stream. The user holds the mouse over a view, and it would give a sneak peak of the content. This could be either as still pictures or short video clips.

In the case of which the media presentation is not live, there could be an option to download the video streams in prior to playing them. This is a guarantee which prevents buffering because the videos are streamed locally. However, there will probably be some issues regarding copyright of the respective content, but that discussion will not be taken here.

The first interaction with the multi-view media player can be a configuration where the user sets up his/hers desired views according to bandwidth and/or the user's preferences. This configuration can be a way to decide which views is shown to the user or how the content is delivered to the user. As mentioned above, this can be done by tags, thumbnails or video previews. All of these parameters contribute to tailor the shown content according to the users preferences plus reducing bandwidth taken. There could also be an option to choose x video streams from y available streams (where y is greater than x).
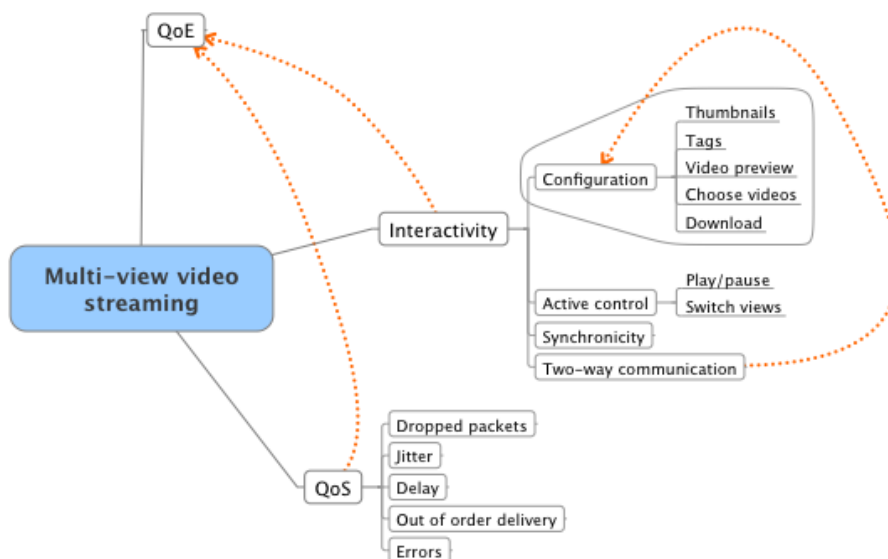

Figure 2.2: Multi-view video streaming

Another requirement for such a multi-view video streaming service, is that the videos are pretty much synchronized. If the delay between the videos is long, this could be an annoying factor for the user. Besides the features provided by traditional video streaming services, a multi-view video streaming service can offer active switching between views.

A multi-view video streaming service is, per date, almost non-existing. Therefore it is necessary to put down some specifications regarding a multi-view video streaming service. First of all, the service should not be worse than a traditional streaming service regarding quality. This means that it should be able to perform as well as a traditional streaming service in terms of QoS. The user should not experience severe buffering and delays and the overall quality of the videos should be satisfactory. The synchronization of the multiple streaming videos should not suffer a high delay so that it infects the viewing experience in a negative manner. The main reason for investigating such a service is to provide a more interactive service compared to a traditional single-view streaming service. The focus should be pointed towards active control, where the user has more control of the content. Figure 2.2 shows a schematic overview over possible ways to interact with the service. The user should be able to arrange the videos as he/she desires. The switching and rearranging of the videos should be intuitive, meaning that the learning curve is gentle.

2.2 Scenario 2 - Multi-view video player

A group of friends are gathered to watch a live recording of their favorite band, The Glosifers. This band play straight rock and has four band members; a vocalist, a bass-player, a guitar-player and a drummer. The friends consider themselves as over average music interested. The recording is on a media storage device which is set up to play on their LCD-screen from a computer. The recording is a typical live concert setup and is mixed and edited together with content from several different cameras capturing the scene, making it a traditional video. The file format of the media is of type MPEG-4 Part 14 [12] which is multimedia container format and is specified as a part of the MPEG-4 standard. This file format can be played by the majority of media players. They use Apples QuickTime media-player, which supports playback for a variety of file formats.

As they watch the recording they feel that they can not keep up with everything that is happening on the scene. With four band members, the crowd and special effects, it is difficult to please all of the viewers and their desires. Some in the group would like to have more focus on the guitar player, while some other wants to see how the crowd and the vocalist communicate. Also they agree upon that the edited video often has focused on a wrong event. One of the viewers has heard about a different media presentation player, called multi-view video. This presentation allows the users to watch several videos at once and even switch between them.

The multi-view video player is a standalone media-player which offers the functionality to watch multiple videos at the same time. The player is designed to have one active view and several smaller views, called sub-views. These sub-views are arranged in a group which are attached to the active view in some way. The active view is the one where the user wants to focus on. This view is significant larger than the sub-views. The switching between the active view and the sub-views are handled by simply clicking the mouse on the sub-view the user wants to watch. The media player also works as a traditional media player since the sub-views can be hidden whenever the user has found a desirable view.

To be able to implement such a media-player, we present some specifications that the player

must meet:

- Intuitive user interface

- Possibility to switch views

- Rearranging of the sub-views

- Synchronization of the videos

- Standalone player

- Use as a traditional media-player

- Media-player functions (play/pause, fullscreen etc.)

- Support for a variety of file formats.

An intuitive user interface means that the user should easily pick up on how to switch/rearrange views, play videos etc. In general the user should not struggle using the functionality of the media-player. The user should have the option to switch the active view with one of the sub-views and also be able to rearrange or categorize the sub-views in his/hers desires. This means that the user can switch places of the sub-views. All of the videos should be of the same length and the player should play these synchronously. There can exist a small delay between the views, but this should be as small as possible such that the user does not pay attention to the delay.

Standalone player means that the player is an application and should not depend on other services to run. By other services, it is meant services like Internet etc. In other words, the media-player runs locally. Also it should function like a traditional media-player. The sub-views can be hidden so the user enters a passive phase and just watches the content with minimal interaction. The player should also support traditional media-player functionality as play/pause, wind, fullscreen etc. To build an even more flexible media-player, it should have support for several common file formats so that the user does not have to struggle with converting.

Chapter 3

Survey on user needs and expectations

A survey (questionnaire) is a good tool to find out if and in which areas multi-view video is desirable. The goal for this survey is to identify user needs, attitudes and current practices regarding multi-view video. The survey is built around assumptions based on the scenarios and the hypothesis described in chapter 2. The survey is split in five parts and the first part takes on demographics about the user, such as age, sex, education and technology attitude. This is to examine user needs and requirements for different user groups.

The second part examines the participants experience regarding multi-view video. It is important for the research to find out if the participants has any experience with multi-view video and if so, how they experienced it. Besides that, it is interesting to question the participants in which areas and contexts multi-view video could be used. Before coloring the opinion of the participants with specific questions regarding multi-view video, it was included a question about their attitude towards multi-view video.

The third part of the survey takes on desired functions and features of a multi-view video service. The participants were questioned in what kind of functions they would like to have in such a service. Also they were examined in how they would like the different videos to be displayed. Different scenarios were presented to get an opinion how they would affect the viewing experience. Buffering, lack of synchronization and video quality were the main factors in the scenarios.

The focus of the fourth part was the content of use in multi-view video. The participants answered questions regarding content type, movie- and music genre as well as interest in the respective areas. As a final question, the preferred length of the content was placed.

Accessibility and price of the multi-view video service was questioned in part five. The participants were asked how they would like to get the service and how much, in comparison to a traditional video service, they would pay for it. This section also included main motivations to watch multi-view video. To sum up the survey, the participants answered whether they would choose traditional video or multi-view video.

3.1 Data-collection

The data was collected through an online questionnaire, Surveymonkey[1]. The complete survey is presented in Appendix A. Facebook, Twitter and various webpages were the main contributions to collect the data. The online survey was open between 05.05.2009 - 22.05.2009.

3.2 Results

3.2.1 General

The total number of respondents that completed the survey was 68. The details of the general and demographics details is shown in Table 3.1. To sum it up, the majority of the respondents were aged between 18-30 years. Mostly of the respondents were males with university education (76.9%). Also, mostly of the males considered their technology attitude as early adopter (40.0%), while females as early majority (61.5%).

3.2.2 Experience

Table 3.2 shows the participants experience regarding multi-view video. 51.5% of the respondents had never heard about multi-view video. 84.6% of the females had never heard about multi-view video in contrast to 42.6% of the males. Even though roughly half of the respondents had heard about multi-view video, 75% had never tried it. Those who had tried it explained that they had watched multi-view video on a DVD or on the Internet[2].

Figure 3.1 shows that 64.7% of the participants has a positive towards multi-view video. 33.8% are indifferent, while only 1.5% are negative towards multi-view video.

What is your attitude towards multi-view video?
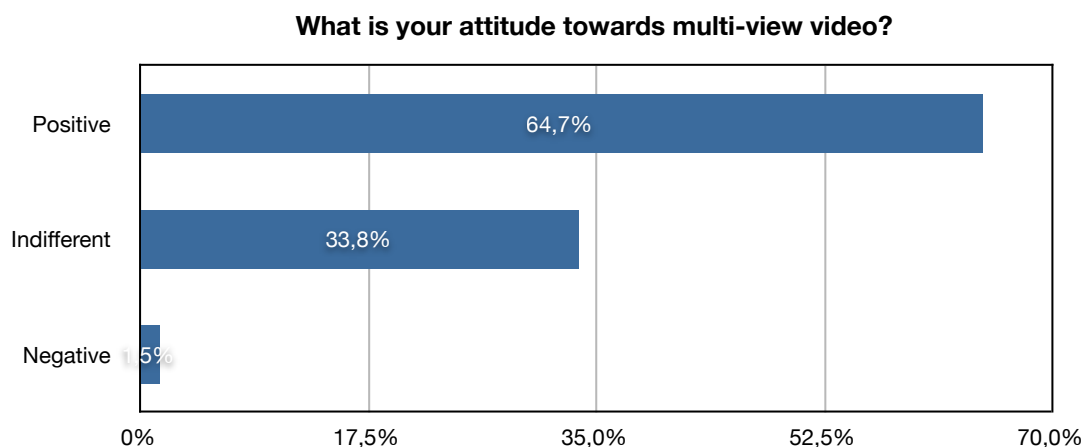
Figure 3.1: Multi-view video attitude amongst the participants

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[1] http://www.surveymonkey.com
[2] http://revision3.com/remix/

Table 3.1: Demographic results from the survey

Multiview video - User needs		
Sex	**Response Frequency**	**Response Count**
Female	19,1 %	13
Male	80,9 %	55
Unspecified	0,0 %	0
Age	**Response Frequency**	**Response Count**
Under 18	0,0 %	0
18-24	32,4 %	22
25-30	48,5 %	33
31-40	10,3 %	7
Over 40	8,8 %	6
Level of education	**Response Frequency**	**Response Count**
Secondary school	0,0 %	0
High school	1,5 %	1
<University	10,3 %	7
University	86,8 %	59
Not specified	1,5 %	1
How do you consider your technology attitude?	**Response Frequency**	**Response Count**
Innovator	14,7 %	10
Early adopter	35,3 %	24
Early majority	32,4 %	22
Late majority	11,8 %	8
Laggards	2,9 %	2
Not specified	2,9 %	2

Table 3.2: Multi-view video experience of the participants

Have you ever heard about multi-view video?	**Response Frequency**	**Response Count**
Yes	47,1 %	32
No	51,5 %	35
Not specified	1,5 %	1
What is your experience with multi-view video?	**Response Frequency**	**Response Count**
Never tried	75,0 %	51
Tried once	11,8 %	8
Tried several times (2-5)	7,4 %	5
Regularly	0,0 %	0
Not specified	5,9 %	4

3.2.3 Features

The majority, with 71.2%, prefers one larger view and the rest of the videos arranged next to it (Figure 3.2).

How would you like the videos to be displayed?

One larger view and the rest of the videos arranged next to it.	71,20%
Only one video is displayed, rest is hidden	30,30%
All of same size.	10,60%
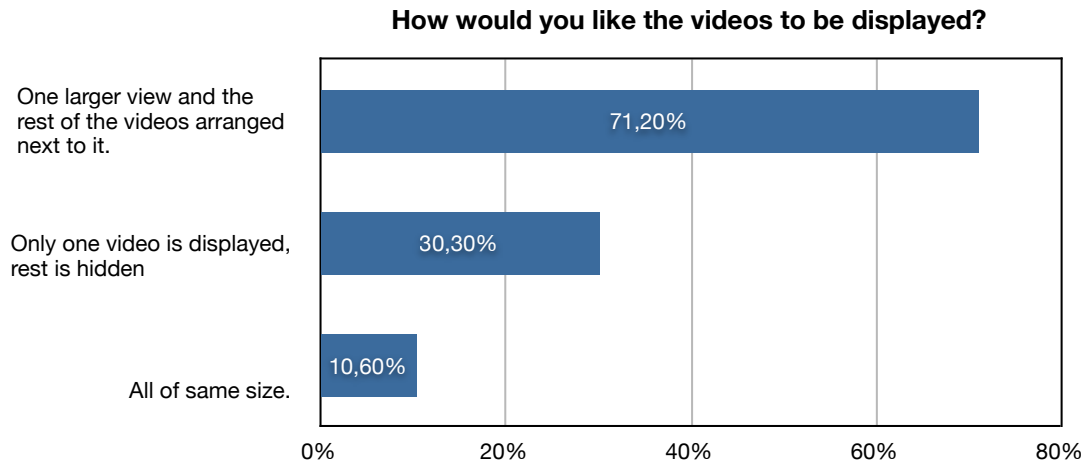
Figure 3.2: Desired video placing of the multi-view video service

Figure 3.3 shows the most desired functions of a multi-view video service. Switching of views stands out as the most desired feature with 82.1%. Rearranging and hiding of the views follows closely, while the use as a traditional media player is a bit behind (40.3%).

Which features would you like to have for a multi-view media player?

Switching of videos	82%
Hide views that you are not watching	66%
Rearranging of the videos (place them where you like)	63%
Use as a traditional media player	40%
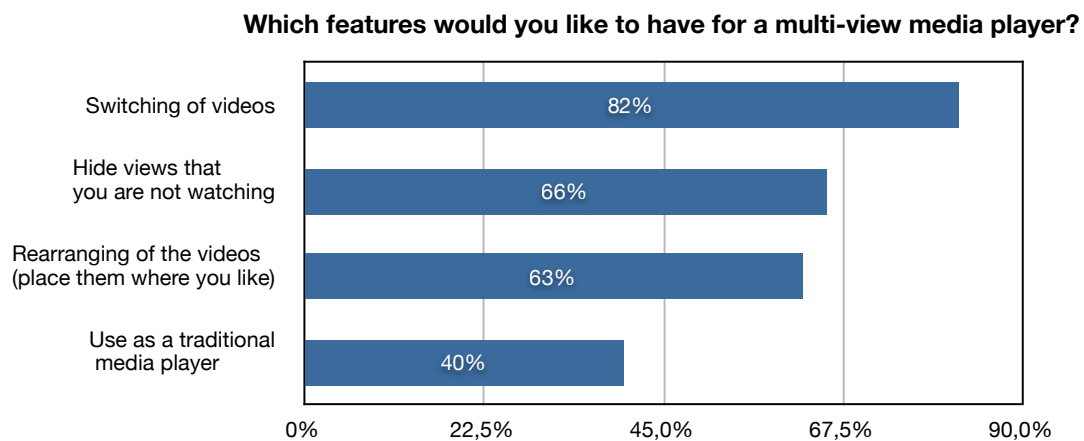
Figure 3.3: Desired functions of the multi-view video service

On the question regarding if the multi-view video player should function as a traditional media player, 51.5% of the respondents thinks that it is a little important (Figure 3.4).

3.2.4 Content

Figure 3.5 shows the most desirable content for a multi-view video service. Sports is number one, followed by music concert/videos, live entertainment and reality TV.

In addition to question content categories, there were also a question about the most desirable movie- and music genre. Figure 3.6 and Figure 3.7 shows the results for respectively movie-

How important is it that the multi-view video player functions as a traditional player?
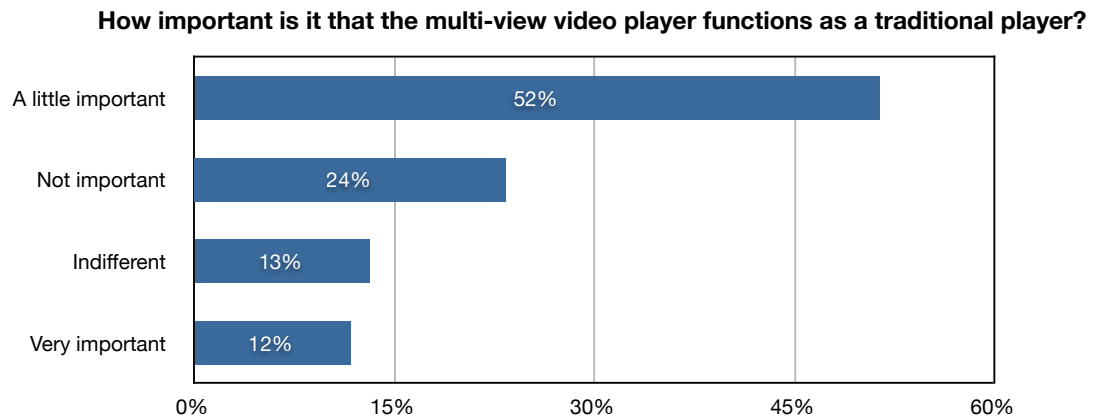
Figure 3.4: The importance that the multi-view player functions as a traditional player

What kind of content are desirable for watching in multi-view video?
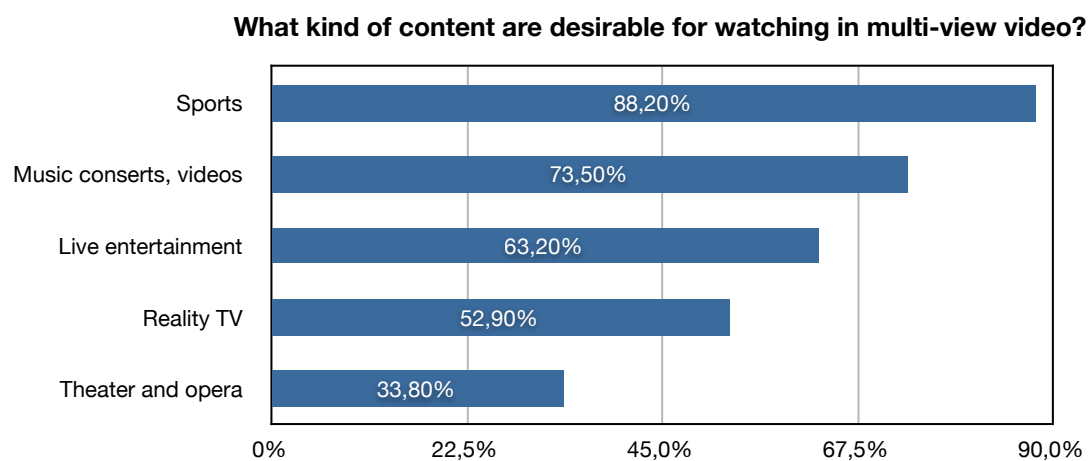
Figure 3.5: The most desirable content for multi-view video presentation

and music genre.

Which genres for movies are most interesting for multi-view video?
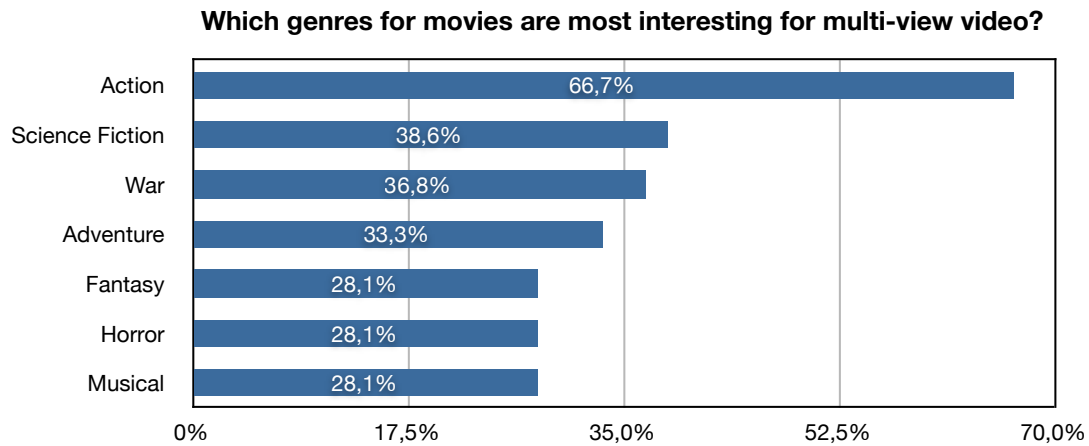
Figure 3.6: Desirable movie genres for multi-view video presentation

Which genres for music concerts/videos are most desirable for multi-view video?
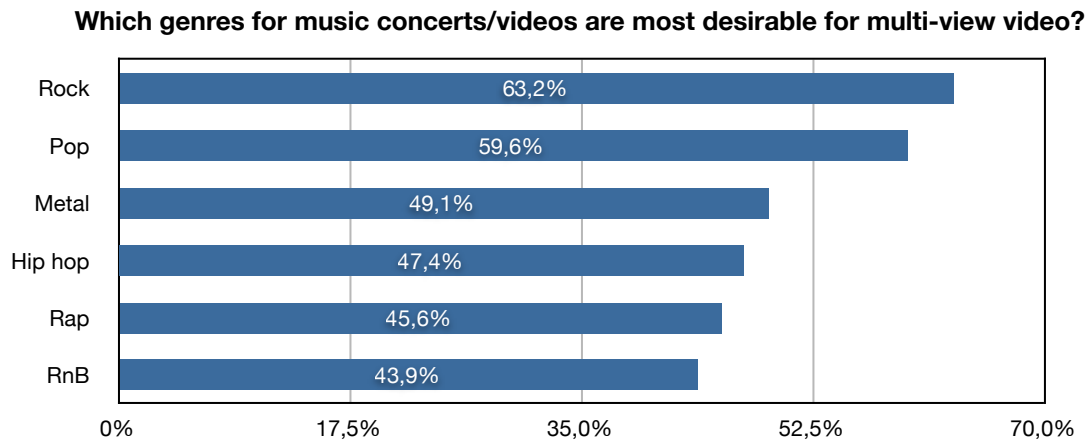
Figure 3.7: Desirable music genres for multi-view video presentation

3.2.5   Service and motivations

Figure 3.8 shows the respondents preferred length of a multi-view video content. 31-60 minutes is the most preferred length with 51.6% of the votes. However, 16-30 minutes and 61-90 minutes is not far behind with respectively 42.2% and 45.3% of the votes.

The results of how the participants would receive the multi-view video service is shown in Figure 3.9. The most popular way, is a streaming service over the Internet (76.9%). Also, television/broadcast is desirable (60.0%).

Figure 3.10 shows the willingness of paying for a multi-view video service compared to a traditional video service. The majority would like to pay the same (45.6%). Another interesting observation is that a significant number of the participants is willing to pay more. 1-10% and 11-30% more has respectively 22.1% and 13.2% of the votes.

The participants motivations to use a multi-view video service is shown in Figure 3.11. To be able to better judge situations better motivates 64.6% of the participants. 60% is motivated by being more present in the event, while 55.4% wants to get entertained.

What is your preferred length of the content?

1-5 minutes	15,6%
2-15 minutes	25,0%
16-30 minutes	42,2%
31-60 minutes	51,6%
61-90 minutes	45,3%
Over 90 minutes	28,1%
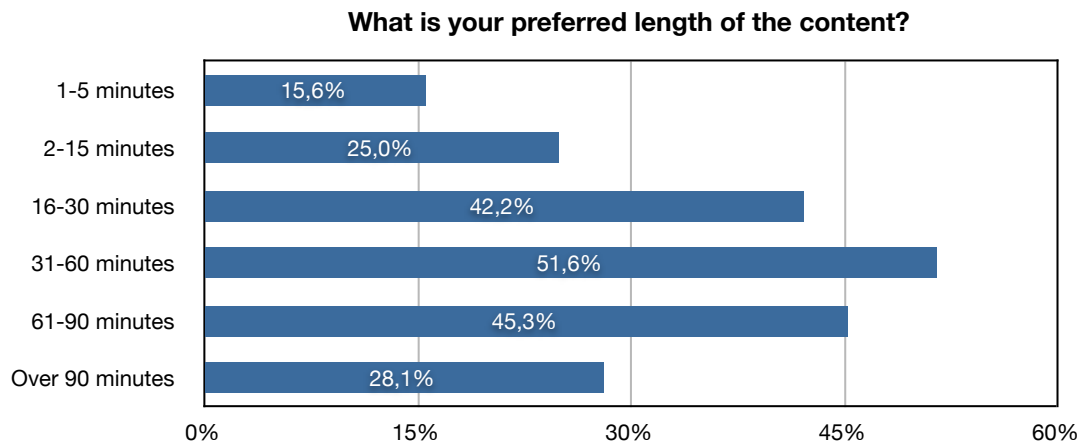
Figure 3.8: Preferred length of a multi-view video presentation

How would you like to get the service?

Streaming service (Internet)	76,9%
Television, broadcast	60,0%
Video on demand (download)	47,7%
Storage device (DVD, Blueray)	33,8%
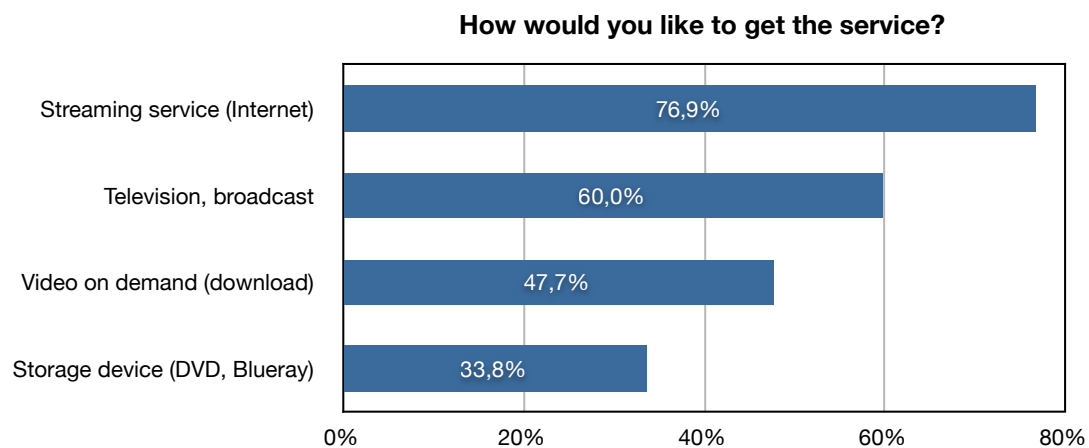
Figure 3.9: In which way the participants would receive the multi-view video service

How much would you like to pay for a multi-view video service compared to a traditional video service?

Over 50 percent less	4,4%
31-50 percent less	2,9%
11-30 percent less	2,9%
1-10 percent less	2,9%
The same	45,6%
1-10 percent more	22,1%
11-30 percent more	13,2%
31-50 percent more	4,4%
Over 50 percent more	1,5%
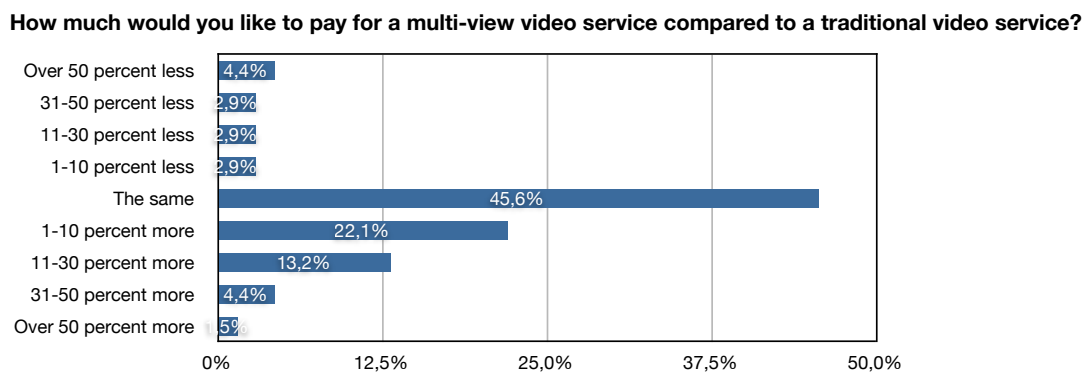
Figure 3.10: How much the participants would like to pay for a multi-view video service compared to a traditional service

What are your motivations for watching multi-view video?
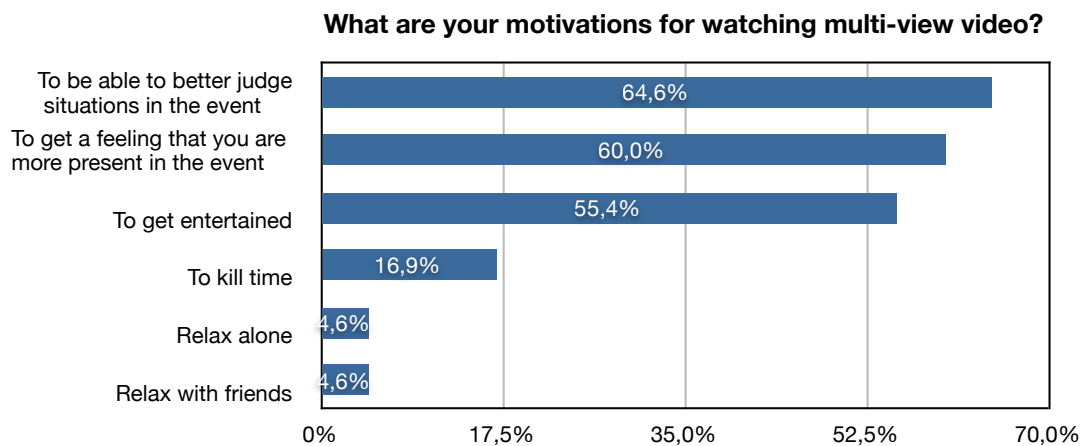
Figure 3.11: Participants motivations for watching multi-view video

Figure 3.12 shows the results of the participants choice between multi-view video and traditional video. 45.6% would choose multi-view video, while 30.0% is indifferent. 23.5% prefer traditional video instead of multi-view video.

If you could choose between traditional video and multi-view video, what is your preference?
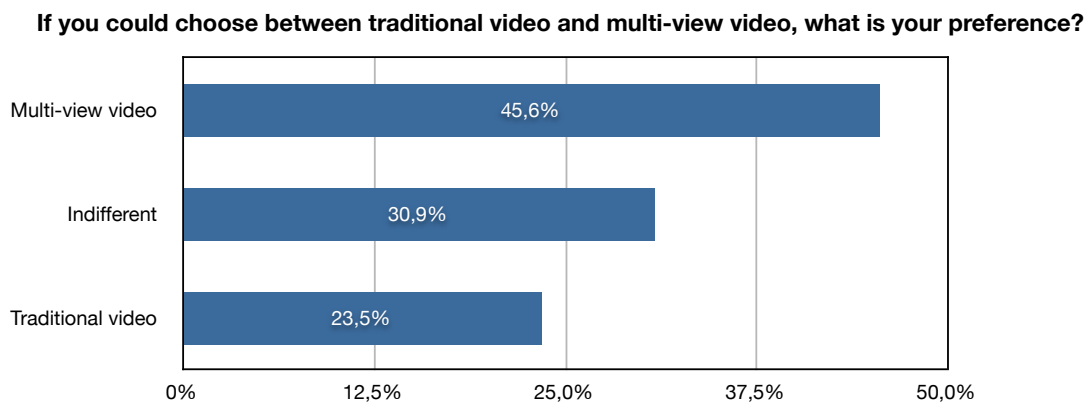
Figure 3.12: Participants choice between traditional video and multi-view video

3.3 Discussion

The results more or less reflects specifications made by the scenarios. It is important to notice that this discussion is based on interpretation by the author of this report.

An overwhelming 86.8% of the respondents had university education. This result may not be representative for a realistic selection of a population. Another variance is possible the majority of males who participated. A more realistic representation would be around half females and half males. The number of participants who completed the survey counted the total of 68. A more precise representation of a population could be made with more participants.

Because the survey was conducted through an online survey-maker and only spread at certain Internet channels, some social groups may have been excluded. When a survey is spread, the survey-maker has not control of who receives it. This can be considered as a disadvantage of online surveys since the control of the respondents are limited. A sign of this can be seen in

Table 3.1 where the majority of the respondents consider their technology attitude as early majority or above. The level of education also reflects this.

Around half of the respondents had never heard about multi-view video and a majority had not even tried it. This indicates that multi-view video is a fairly new area for consumers and a lot of research is to be done to fully investigate this area. Another interesting observation is those that had heard about multi-view video, were more positive towards it than those that never had heard about it. Those who had not heard about multi-view video had a more indifferent attitude towards it, which is natural because it does not affect the consumer in any way. For those of the participants that had experience with multi-view video, had a more positive attitude towards it. This shows that the user is satisfied with multi-view video when he/her has tried it. Also the more experienced users would prefer one active view, with sub-views arranged next to it. This may be an indicator that this is the layout which is most preferred. Participants with no experience regarding multi-view video, were less likely to choose multi-view video over traditional video compared to participants with experience. This adds legs to the assumption that people with multi-view video experience are satisfied with it.

The participants that had a positive attitude towards multi-view video, were willing to pay at least the same as for a traditional video service (90.9%). Respondents that were indifferent, were less exited to pay more for a multi-view video service. This shows consistency in terms that people that are more exited about multi-view video could spend more money on multi-view video than people that are indifferent. Participants with a positive attitude towards multi-view video were less likely to choose traditional video over it. This sounds reasonable and supports the results of the survey.

The assumption in the scenarios that the most important function is the switching of views , seems to be confirmed by the survey (Figure 3.3). This sounds reasonable because switching of views makes the service more interactive. However, 17.9% of the respondents would not like the switching of views as a feature. This may indicate that this group would prefer to be entertained passively. The placing of videos were also discussed in the scenarios section. The specification that was proposed there, was one larger active view and sub-views arranged next to it. The majority of the respondents also agreed upon this statement as shown in Figure 3.2 (71.2%).

The favorite content types (Figure 3.5) were of type where multiple cameras are natural (sports, music concerts). These content types could also be considered as highly entertainment- and action-oriented. In other words, a lot of things happen at once and it is difficult for the viewer to perceive everything. Therefore it is reasonable that the respondents prefer this content. Reality TV is also ranked high. This could be defended by its natural setup of multiple cameras catching every event or participant. The reason for choosing multi-view video in such an environment could be to follow the users favorite contestant at any time. However, this is for particularly interested users. Many participants stated that they would enjoy live entertainment as content for multi-view video. Live entertainment is a vague content type which can include all kind of events. However, since the content is live, there is no time for editing the material and it can be considered as raw. By allowing multi-view video, the users can edit the event as they would prefer.

Figure 3.8 shows the participants preferred length of the content provided for a multi-view video service. The majority of respondents prefer content with length above 15 minutes. This excludes short movies and content types that are easy to make with multiple cameras because of its short length. This can be verified by that only 8.8% of the respondents would like to watch short movies in a multi-view video context. However, it seems like users prefer highly

entertainment- and action-oriented content with length greater than 16 minutes.

The high dissolution for having multi-view video as a streaming service on the Internet (Figure 3.9), may indicate that the users prefer this as an interactive online solution discussed in Section 2.1. This solution is also easier to realize than for instance broadcast. A computer has natural interactive devices like mouse and keyboard which can easier be used to create an interactive multi-view video service. The only device for interacting with a broadcast (TV) is a remote control. It is also interesting to observe that only 33.8% of the participants who wants the service on a storage media like DVD or Blueray. This is the option where the user has to make an effort on getting. The user has to physically get the media in some way (buy in store, order online etc). All the other options could easily be accessed by some interactive web-page, TV broadcast etc. This may imply that the user wants the service to be easily accessed and interactive.

The participants motivations for watching multi-view video were clearly dominated by three factors. To get entertained, to be able to better judge situations in the event and to get the feeling that you are more present in the event got the majority of the votes as shown in Figure 3.11. These factors may indicate that the user wants a more interactive presentation than traditional video. The users may want to be more involved and active in the video presentation. By providing the option to switch between views, the user can judge situations in a different, and perhaps a better, way. Participants that prefer traditional video over multi-view video (Figure 3.12), are more likely to be motivated by killing time than participants choosing multi-view video. This also counts for participants that are indifferent to either multi-view video or traditional video. These participants may be motivated by being entertained in a more passive manner.

3.4 Summary

The users motivations and needs for multi-view video features, functions, contents, service and motivations are summarized here based on the conducted online survey.

Multi-view video is not a common technology amongst the participants and only a minority have tried it. Those who had tried multi-view video had a more positive attitude towards it, which can imply that this is a service which is desirable once it is tried.

Switching of views seems to be the most desired function and this can be considered as a key function for a multi-view video service.

Content for a multi-view video service should be entertainment- and action-oriented to fully exploit the use of multiple videos. Sports, music videos/concerts, live entertainment and reality-TV are desirable content for multi-view video.

A trend of the survey was that the participants with a positive attitude towards multi-view video were more likely to get entertained in an interactive manner. Their main motivations to watch multi-view video were to get entertained, to be able to better judge situations in the event and to get the feeling that you are more present in the event.

The multi-view video service should be easily accessed by the user. The most preferred way of receiving the service is by streaming over the Internet. The cost of such a service should not be a lot more expensive than for a traditional video service. However, the most dedicated users, could pay a 1-10 percent more than for a traditional video service.

However, it should be noted that this survey may not be representative for a realistic population of consumers. The low attendance of participants and the narrowness of the group taking in consideration, makes this results a bit weak. However, they can show correlation between the scenarios in chapter 2. Future work should get a hold of different user group to get a fully perspective of needs and expectations of multi-view video.

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Chapter 4

Implementation

The developing platform for the MVV media player was on a Macbook Pro with operating system Mac OS X version 10.5.5. Hardware specifications are listed in Section 5.1.

Preferably, the MVV media player would have used an open source media player as a foundation. However, the lack of documentation and support for open source projects, made it easier to use a closed source application.

4.1 Tools

4.1.1 XCode

The application is written in Cocoa which is an objective-C language for developing Mac OS X applications. XCode [13] is Apple's developing tool for several programming languages. It has support for many different functions, such as debugging, building, compiling and linking, also called an IDE (Integrated Development Environment). The version of XCode used in this report is version 3.1.1 and is only compatible with Mac OS X.

4.1.2 Interface Builder

To build the GUI for the MVV media player, it has been used Interface Builder version 3.1.1 [14]. Interface Builder is a graphical editor for designing the GUI and connects the code to the interface in a graphical way. Buttons, sliders, windows etc can easily be placed by drag-and-drop methods. Interface Builder is only compatible with Mac OS X Cocoa and Carbon applications.

4.1.3 QTKit Framework

The Application is based on Apple's QuickTime (QT version 7.5.5) framework, QTKit [15] and is written in objective-C, Cocoa. This is a powerful and well-documented framework with support for display, import, export, modify and capture for a lot of different media formats (H264,MPEG-4,AVC,AAC etc). QTKit opens for usage of QT's core functions. QT's file format (.mov) is defined as a multimedia container file which is suitable to store several types

of different data (audio, video, effects or text). MPEG-4 Part 14 is based is a product directly based on QT's file format and is now a standard for multimedia containers.

With these abilities, QTKit is a very suitable interface for developing a multi-view video player. However, it has some limitations when it comes to supported video formats. Basically the file format must be a QT file, which limits the flexibility of the MVV media player. The solution lies in a little plugin application named Perian [16].

4.1.4 Perian

Perian is an open source QT component that adds native support for many popular video formats. The complete list of supported formats is shown in Table 4.1. With this component in addition to the QTKit framework, the most common, both open and closed source media formats is supported.

Table 4.1: Extended QuickTime support for media formats with Perian

File formats:	AVI, DIVX, FLV, MKV, GVI, VP6, and VFW
Video types:	MS-MPEG4 v1 & v2, DivX, 3ivx, H.264, Sorenson H.263, FLV/Sorenson Spark, FSV1, VP6, H263i, VP3, HuffYUV, FFVHuff, MPEG1 & MPEG2 Video, Fraps, Snow, NuppelVideo, Techsmith Screen Capture, DosBox Capture
Audio types:	Windows Media Audio v1 & v2, Flash AD-PCM,Xiph Vorbis (in Matroska), and MPEG Layer I & II Audio, True Audio, DTS Coherent Acoustics, Nellymoser ASAO
AVI support:	AAC, AC3 Audio, H.264, MPEG4, and VBR MP3
Subtitle formats:	SSA/ASS and SRT

4.2 The multi-view video player

The final multi-view video player is shown in Figure 4.1. It consists of five video views, one larger active view and four smaller sub-views attached to the active view. The support for more sub-views is easy extendable, but more views demands increased computer power or a decrease in video quality. Traditional media player functions has not been prioritized. Instead it has been focused on functions that will give the player functionality as a multi-view video player. These functions are described in Subsection 4.2.1.

4.2.1 Functions

Besides standard media player like play/pause, wind, volume control and toggle fullscreen, the list below shows the most important functions for this player to operate as a multi-view video player.
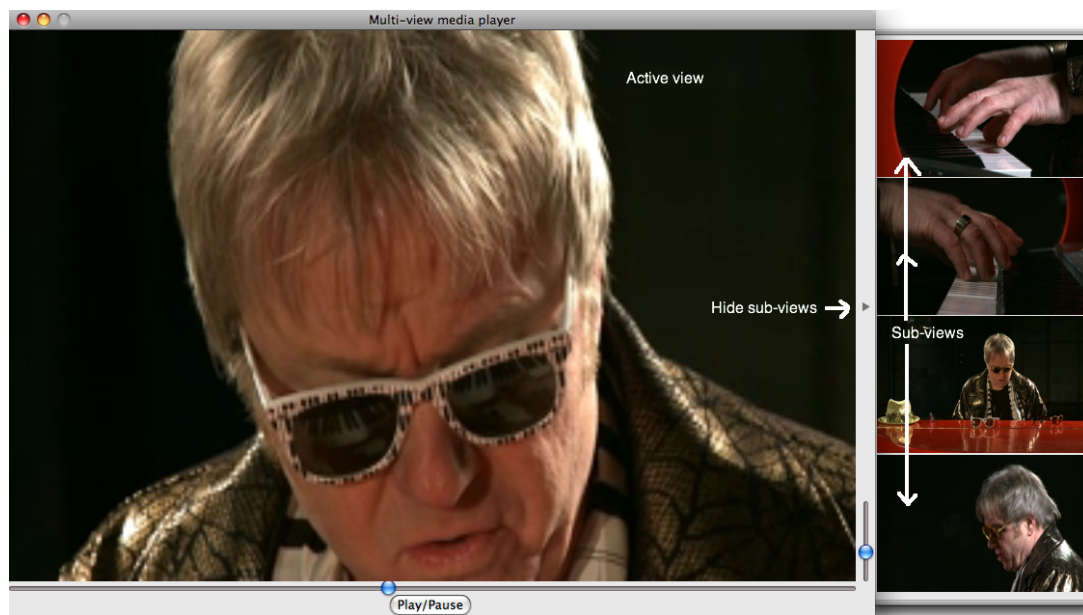
Figure 4.1: Multi-view video player

- Switching of views

- Rearranging of sub-views

- Hide-able sub-views

One of the main functions for a multi-view video player is the ability to switch views. This is done by simply clicking on the desired sub-view. Nothing happens if the active view is clicked. The sub-view changes its position with the active views position. Drag and drop is used to rearrange the sub-views. By dragging a sub-view into another, they exchange places. The button between the active view and the sub-views enables the user to hide the sub-views as shown in Figure 4.2.
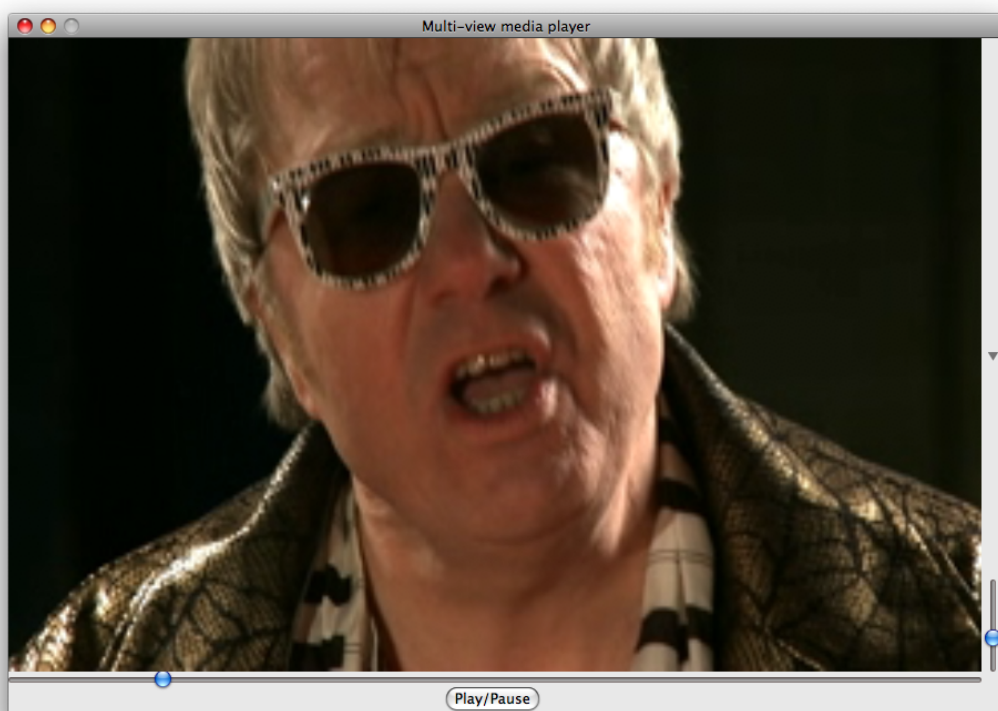
Figure 4.2: Multi-view video player with sub-views hidden

Chapter 5

Test of multi-view video player

Chapter 4 took on the development of a multi-view video player and its functions. To be able to quantify possible increased interactivity for a multi-view video player, a set of people was subject to test the player. A total number of 10 people participated in the test.

5.1 Hardware

For the test, the following hardware were used:

- Macbook Pro

- CPU - Intel Core 2 Duo 2.4 GHz

- Graphics card - NVIDIA GeForce 9400M

- Graphics card - NVIDIA GeForce 9600 GT

- Memory - 2 GB SODIMM DDR3 1067 MHz

- Harddrive - Hitachi HTS543225L9SA02 240GB

- Monitor – BenQ 24" LCD G2400WD TCO03 Black 1920x1200,2ms,4000:1,VGA/DVI/HDMI

- Headphones – Razer Barracuda HP-1 Gaming Headset Razer Fidelity$^{\text{TM}}$ gaming audio engine

5.2 Setup

The test subject was welcomed and given a set of instructions explaining the functions of the multi-view video player and how to proceed with the test. The instruction gave an account of terms like active view, sub-views and multi-view video. He/she was told to focus on and use the following functions:

- Switching of views

- Re-arranging of sub-views

- Hiding of sub-views

The content that was provided was a music clip of a live recording. The clip lasted for 46 seconds with 5 different angles filming a musician playing piano and singing. Due to increased computer computation required for multiple views, the movie clips had to suffer for quality degradation. Each of the clips had a bit rate of 3500 Kbps and was encoded with the multimedia container Audio Video Interleave (AVI). The reason for choosing AVI was because of its simple decoding algorithm, compared to i.e H.264.

The test subject was placed in front of a desk with headphones, a monitor and a mouse as the only interaction devices.

Further on the test subject was instructed to play the clip 3-5 times until he/she felt that the functions were well-known and tried out. Afterwards the test subject was asked to answer a survey given in Appendix C. Results of the survey is shown in Section 5.3.

Section 5.4 discusses the results of the test. It is important to notice that the discussion is based on interpretation by the author of this report.

5.3   Results

The participants were aged between 18-30 years with 70% males and 30% females, as shown in Table 5.1. The majority of the participants had never tried multi-view video before (70%), while 30% only had tried it once.

Table 5.1: Demographic results of focus group survey

Age	Response Frequency
Under 18	0,0 %
18-24	40,0 %
25-30	60,0 %
31-40	0,0 %
Over 40	0,0 %
Sex	**Response Frequency**
Female	30,0 %
Male	70,0 %
What is your previous experience with multi-view video	**Response Frequency**
Never tried	70,0 %
Tried once	30,0 %
Several times (2-5 times)	0,0 %
Regularly	0,0 %

Figure 5.1 shows the participants average rating of the respective features. 1 is listed a very negative, while 5 is very positive. The overall impression of the multi-view video player lies just above 4, which is rated as positive.

How did the following factors influence your viewing experience?
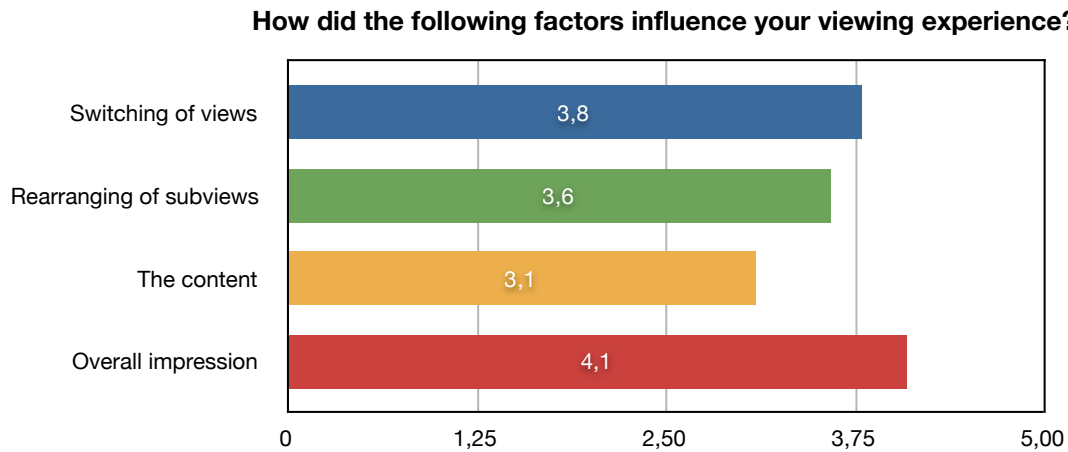
Figure 5.1: Rating scale on how different factors influenced the participants

If you could choose between multi-view video and traditional video, what is your preference?
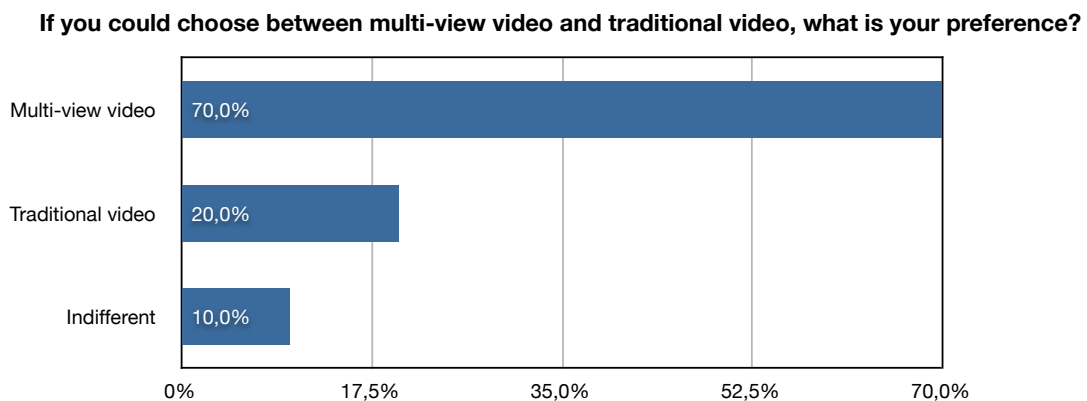
Figure 5.2: The participants choice between traditional video and multi-view video

5.4 Discussion and summary

Based on feedback from the participants, there were some factors which influenced the application in a negative manner. The content that was provided had 5 different camera angles and each camera had a microphone attached to it. This caused that the sound were different on each camera, such that the user experienced different sound when he/she switched view. Another factor, that there was a short pause, when the user switched view, meaning that the switching of views was not seamless. This pause varied between 0 and 0.5 seconds and was caused by the programmatically structure of the application.

In section 3.3 it was stated that when a user had tried multi-view video, he/she was satisfied and had a positive attitude towards it. This can be reflected in figure 5.1 where 9 participants had a positive, and 1 had a very positive overall impression of the multi-view video player. As for the online survey, only 3 out of 10 had tried multi-view video, amongst the participants,

before the test. This shows that multi-view video is a new area for consumers and it needs to be explored more throughly to get a fully perspective.

The most acknowledged function of the multi-view video player was the switching of views. This function can be considered as a key function of this kind of video player and makes the application more interactive. An interesting observation is that not any of the participants were indifferent to this function. This may indicate that switching of views makes an impression on the user. However, this function can be improved by makes the switching seamless. A comment from a user stated: "The delay occuring when switching views was a negative influence".

The hiding of sub-views function makes the application to work as a traditional video player. By hiding the sub-views the user can focus on one view and the content type can be of a traditional edited material. It should be said that the choice between multi-view video strongly depends on the content. Not all content are desirable for a multi-view video presentation as discussed in section 3.3.

The participants were lesser satisfied with the content that was provided for this test. Even though it was a music video/concert, which was rated high amongst the participants of the online survey, it did not get the same rating in this test. Possible factors could be the short length of the content and that it was not a lot of happenings in the scene. This shows that the content has to be chosen carefully and that not all content are suitable for a multi-view video presentation.

Chapter 6

Conclusion

Chapter 2 took on possible scenarios regarding multi-view video and it derived into possible features and functions for such a service. These specifications were questioned in a online survey to verify or reject possible solutions. An multi-view video player was implemented based on the scenarios and the conducted survey. The main functions of the player were:

- Switching of views

- Re-arranging of sub-views

- Hiding of sub-views

A majority of the respondents had no experience with multi-view video. This indicates that this is a new area and further work should be done to fully investigate it. However, those who had tried multi-view video had a more positive attitude towards it, which can imply that this is a service which is desirable once it is tried. The content should be entertainment- and action-oriented, such as sports and music concerts. The multi-view video should be received as a streaming over Internet, as download or by a broadcast (TV).

Further on, a test of the implemented multi-view video player and its functions were described in Chapter 5. Switching of views is to be considered the key function that makes this presentation more interactive. However, hiding and rearranging of sub-views are highly desirable. The participants with no experience regarding multi-view video were overall positive influenced by the application. It is clear that the multi-view video player were positive embraced by the participants. This indicates that it is room for such a service amongst consumers and further work should be done to make improvements to fit a consumer marked.

For further development of a multi-view video player it is important to take in consideration some negative influences of the viewing experience:

- Seamless switching of videos

- Same sound source for all clips

It existed a delay when the user switched videos and this caused a negative viewing experience. Also, the content was recorded with different sound at each camera. These factors should be eliminated to ensure a positive viewing experience.

However, it is important to notice that these results are not fully complete to cover users needs and expectations towards multi-view video. It must be stressed that the results reflects the author's views around them.
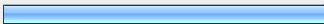
Appendix A

Multi-view video survey

Multiview video - User needs

1. General

Thank you for taking time answering. This survey is a part of a master thesis on multi-view video.

Multi-view video is a media presentation where the user receives several synchronized videos capturing the same event. The user has the option to switch between these videos.

Example of an multi-view video service:
http://revision3.com/remix/

The survey is completely anonymous. You may choose to answer in English or Norwegian when the answer requires typing.

* 1. Sex

- Female
- Male
- Unspecified

* 2. Age

- Under 18
- 18-24
- 25-30
- 31-40
- Over 40

* 3. Level of education

- Secondary school
- High school
- <University
- University
- Not specified

* 4. How do you consider your technology attitude?

- Innovator
- Early adopter
- Early majority
- Late majority
- Laggards
- Not specified

2. Multi-view video experience

Multiview video - User needs

* 1. Have you ever heard about multi-view video?

　ｊｎ Yes

　ｊｎ No

　ｊｎ Not specified

* 2. What is your experience with multi-view video?

　ｊｎ Never tried

　ｊｎ Tried once
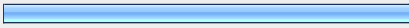
　ｊｎ Tried several times (2-5)

　ｊｎ Regularly

　ｊｎ Not specified

3. If you have tried multi-view video before, please elaborate how and what you watched.

4. In which context do you think multi-view video is or could be used?

* 5. What is your attitude towards multi-view video?

　ｊｎ Positive

　ｊｎ Negative

　ｊｎ Indifferent

3. Features

1. How would you like the videos to be displayed?

　℮ One larger view and the rest of the videos arranged next to it.

　℮ All of same size.

　℮ Only one video is displayed, rest is hidden

Other (please specify)

2. Which features would you like to have for a multi-view media player?

　℮ Switching of videos

　℮ Rearranging of the videos (place them where you like)

　℮ Use as a traditional media player

　℮ Hide views that you are not watching

Multiview video - User needs

3. If you have any other desired features, please specify

* 4. In which way would the following happenings affect your viewing experience:

	Very negative	A little negative	Do not mind
Lack of synchronization (<1 second)	j⌐	j⌐	j⌐
Video buffering	j⌐	j⌐	j⌐
Short delay on switching of videos (<1 second)	j⌐	j⌐	j⌐
Longer delay on switching of videos (1-2 seconds)	j⌐	j⌐	j⌐
Poor video quality (youtube)	j⌐	j⌐	j⌐
Fairly good video quality	j⌐	j⌐	j⌐

* 5. How important is it that the multi-view video player functions as a traditional player?

j⌐ Indifferent   j⌐ Not important   j⌐ A little important   j⌐ Very important

4. Content

1. What kind of content are desirable for watching in multi-view video?

∈ Sports   ∈ Reality TV

∈ Music conserts, videos   ∈ Theater and opera

∈ Movies   ∈ Advertisement

∈ Documentaries   ∈ Weather forecast

∈ TV shows   ∈ Live entertainment

∈ News   ∈ Sitcom

2. Which genres for movies are most interesting for multi-view video?

∈ Action   ∈ Horror

∈ Adventure   ∈ Musical

∈ Animation   ∈ Romance

∈ Biography   ∈ Science Fiction

∈ Crime   ∈ Short movies

∈ Comedy   ∈ Thriller

∈ Drama   ∈ War

∈ Fantasy   ∈ Western

Multiview video - User needs

3. Which genres for music concerts/videos are most desirable for multi-view video?

- Blues
- Classical
- Country
- Dance
- Electronica
- Folk
- Hip hop
- House
- Jazz

- Metal
- Pop
- Punk
- Rap
- Reggae
- RnB
- Rock
- Soul

* 4. Please rate your interest (of watching) in the following areas:

	Not interested	A little interested	Fairly Interested	Very Interested	Extremely Interested
Music videos	⊙	⊙	⊙	⊙	⊙
Music concerts	⊙	⊙	⊙	⊙	⊙
Movies	⊙	⊙	⊙	⊙	⊙
Sports	⊙	⊙	⊙	⊙	⊙

5. What is your preferred length of the content? (multiple answers possible)

- 1-5 minutes
- 2-15 minutes
- 16-30 minutes
- 31-60 minutes
- 61-90 minutes
- Over 90 minutes

5.

1. How would you like to get the service?

- Streaming service (Internet)
- Storage device (DVD, Blueray)
- Video on demand (download)
- Television, broadcast

Other (please specify)

Multiview video - User needs

* 2. How much would you like to pay for a multi-view video service compared to a traditional video service?

◌ Over 50 percent less	◌ 1-10 percent more
◌ 31-50 percent less	◌ 11-30 percent more
◌ 11-30 percent less	◌ 31-50 percent more
◌ 1-10 percent less	◌ Over 50 percent more
◌ The same	

3. What are your motivations for watching multi-view video?

◌ To get entertained

◌ To be able to better judge situations in the event

◌ To get a feeling that you are more present in the event

◌ Relax alone

◌ Relax with friends

◌ To kill time

Other (please specify)

[   ]

* 4. If you could choose between traditional video and multi-view video, what is your preference?

◌ Traditional video

◌ Multi-view video

◌ Indifferent

5. Feedback to this survey and multi-view video are very welcome

[   ]

Appendix B

Multi-view video survey results

Multiview video - User needs

1. Sex		Response Percent	Response Count
Female		19.1%	13
Male		**80.9%**	**55**
Unspecified		0.0%	0
	answered question		68
	skipped question		0
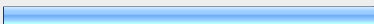
2. Age		Response Percent	Response Count
Under 18		0.0%	0
18-24		32.4%	22
25-30		**48.5%**	**33**
31-40		10.3%	7
Over 40		8.8%	6
	answered question		68
	skipped question		0

3. Level of education

		Response Percent	Response Count
Secondary school		0.0%	0
High school		1.5%	1
<University		10.3%	7
University		**86.8%**	**59**
Not specified		1.5%	1
		answered question	68
		skipped question	0

4. How do you consider your technology attitude?

		Response Percent	Response Count
Innovator		14.7%	10
Early adopter		**35.3%**	**24**
Early majority		32.4%	22
Late majority		11.8%	8
Laggards		2.9%	2
Not specified		2.9%	2
		answered question	68
		skipped question	0

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5. Have you ever heard about multi-view video?

		Response Percent	Response Count
Yes		47.1%	32
No		**51.5%**	**35**
Not specified		1.5%	1
	answered question		**68**
	skipped question		**0**

6. What is your experience with multi-view video?

		Response Percent	Response Count
Never tried		**75.0%**	**51**
Tried once		11.8%	8
Tried several times (2-5)		7.4%	5
Regularly		0.0%	0
Not specified		5.9%	4
	answered question		**68**
	skipped question		**0**
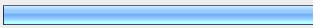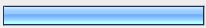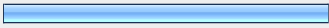
7. If you have tried multi-view video before, please elaborate how and what you watched.

		Response Count
		15
	answered question	**15**
	skipped question	**53**

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8. In which context do you think multi-view video is or could be used?	
	Response Count
	68
answered question	**68**
skipped question	**0**

9. What is your attitude towards multi-view video?		**Response Percent**	**Response Count**
Positive		**64.7%**	**44**
Negative		1.5%	1
Indifferent		33.8%	23
		answered question	**68**
		skipped question	**0**

10. How would you like the videos to be displayed?		**Response Percent**	**Response Count**
One larger view and the rest of the videos arranged next to it.		**71.2%**	**47**
All of same size.		10.6%	7
Only one video is displayed, rest is hidden		30.3%	20
	Other (please specify)		3
		answered question	**66**
		skipped question	**2**

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11. Which features would you like to have for a multi-view media player?

		Response Percent	Response Count
Switching of videos		**82.1%**	**55**
Rearranging of the videos (place them where you like)		62.7%	42
Use as a traditional media player		40.3%	27
Hide views that you are not watching		65.7%	44
		answered question	**67**
		skipped question	**1**
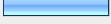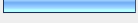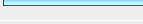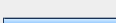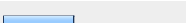
12. If you have any other desired features, please specify

		Response Count
		4
	answered question	**4**
	skipped question	**64**
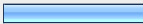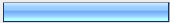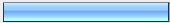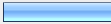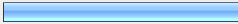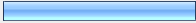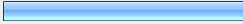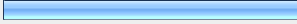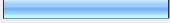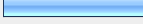
13. In which way would the following happenings affect your viewing experience:

	Very negative	A little negative	Do not mind	Rating Average	Response Count
Lack of synchronization (<1 second)	**67.2% (45)**	29.9% (20)	3.0% (2)	1.36	67
Video buffering	**43.3% (29)**	**43.3% (29)**	13.4% (9)	1.70	67
Short delay on switching of videos (<1 second)	3.0% (2)	47.8% (32)	**49.3% (33)**	2.46	67
Longer delay on switching of videos (1-2 seconds)	**51.5% (35)**	44.1% (30)	4.4% (3)	1.53	68
Poor video quality (youtube)	**52.9% (36)**	45.6% (31)	1.5% (1)	1.49	68
Fairly good video quality	1.5% (1)	38.5% (25)	**60.0% (39)**	2.58	65
				answered question	**68**
				skipped question	**0**

14. How important is it that the multi-view video player functions as a traditional player?

		Response Percent	Response Count
Indifferent		13.2%	9
Not important		23.5%	16
A little important		**51.5%**	**35**
Very important		11.8%	8
	answered question		**68**
	skipped question		**0**

15. What kind of content are desirable for watching in multi-view video?

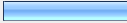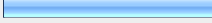|		Response Percent	Response Count
Sports		**88.2%**	**60**
Music conserts, videos		73.5%	50
Movies		20.6%	14
Documentaries		22.1%	15
TV shows		17.6%	12
News		25.0%	17
Reality TV		52.9%	36
Theater and opera		33.8%	23
Advertisement		4.4%	3
Weather forecast		23.5%	16
Live entertainment		63.2%	43
Sitcom		8.8%	6
	answered question		**68**
	skipped question		**0**

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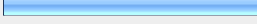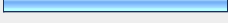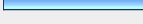
16. Which genres for movies are most interesting for multi-view video?		Response Percent	Response Count
Action		**66.7%**	**38**
Adventure		33.3%	19
Animation		14.0%	8
Biography		21.1%	12
Crime		26.3%	15
Comedy		10.5%	6
Drama		12.3%	7
Fantasy		28.1%	16
Horror		28.1%	16
Musical		28.1%	16
Romance		5.3%	3
Science Fiction		38.6%	22
Short movies		8.8%	5
Thriller		22.8%	13
War		36.8%	21
Western		14.0%	8
	answered question		57
	skipped question		11

17. Which genres for music concerts/videos are most desirable for multi-view video?		Response Percent	Response Count
Blues		28.1%	16
Classical		33.3%	19
Country		28.1%	16
Dance		33.3%	19
Electronica		33.3%	19
Folk		22.8%	13
Hip hop		47.4%	27
House		19.3%	11
Jazz		38.6%	22
Metal		49.1%	28
Pop		59.6%	34
Punk		33.3%	19
Rap		45.6%	26
Reggae		22.8%	13
RnB		43.9%	25
Rock		**63.2%**	**36**
Soul		28.1%	16
	answered question		**57**
	skipped question		**11**

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18. Please rate your interest (of watching) in the following areas:							
	Not interested	A little interested	Fairly Interested	Very Interested	Extremely Interested	Rating Average	Response Count
Music videos	16.4% (11)	31.3% (21)	**32.8% (22)**	17.9% (12)	1.5% (1)	2.57	67
Music concerts	7.5% (5)	16.4% (11)	**34.3% (23)**	29.9% (20)	11.9% (8)	3.22	67
Movies	6.0% (4)	11.9% (8)	17.9% (12)	**44.8% (30)**	19.4% (13)	3.60	67
Sports	13.2% (9)	20.6% (14)	14.7% (10)	**32.4% (22)**	19.1% (13)	3.24	68
					answered question		**68**
					skipped question		**0**

19. What is your preferred length of the content? (multiple answers possible)		Response Percent	Response Count
1-5 minutes		15.6%	10
2-15 minutes		25.0%	16
16-30 minutes		42.2%	27
31-60 minutes		**51.6%**	**33**
61-90 minutes		45.3%	29
Over 90 minutes		28.1%	18
		answered question	**64**
		skipped question	**4**

20. How would you like to get the service?

		Response Percent	Response Count
Streaming service (Internet)		**76.9%**	**50**
Storage device (DVD, Blueray)		33.8%	22
Video on demand (download)		47.7%	31
Television, broadcast		60.0%	39
Other (please specify)			0
		answered question	65
		skipped question	3

21. How much would you like to pay for a multi-view video service compared to a traditional video service?

		Response Percent	Response Count
Over 50 percent less		4.4%	3
31-50 percent less		2.9%	2
11-30 percent less		2.9%	2
1-10 percent less		2.9%	2
The same		**45.6%**	**31**
1-10 percent more		22.1%	15
11-30 percent more		13.2%	9
31-50 percent more		4.4%	3
Over 50 percent more		1.5%	1
		answered question	68
		skipped question	0

22. What are your motivations for watching multi-view video?

		Response Percent	Response Count
To get entertained		55.4%	36
To be able to better judge situations in the event		**64.6%**	**42**
To get a feeling that you are more present in the event		60.0%	39
Relax alone		4.6%	3
Relax with friends		4.6%	3
To kill time		16.9%	11
Other (please specify)			2
	answered question		**65**
	skipped question		**3**

23. If you could choose between traditional video and multi-view video, what is your preference?

		Response Percent	Response Count
Traditional video		23.5%	16
Multi-view video		**45.6%**	**31**
Indifferent		30.9%	21
	answered question		**68**
	skipped question		**0**

24. Feedback to this survey and multi-view video are very welcome

		Response Count
		13
	answered question	**13**
	skipped question	**55**

Appendix C

Multi-view video focus group survey

Multiview video - Focus group

1. Default Section

* 1. Age
- Under 18
- 18-24
- 25-30
- 31-40
- Over 40

* 2. Sex
- Female
- Male

* 3. What is your previous experience with multi-view video
- Never tried
- Tried once
- Several times (2-5 times)
- Regularly

* 4. If you have tried multi-view video before, please elaborate how and what you watched

* 5. If you could choose between multi-view video and traditional video, what is your preference?
- Multi-view video
- Traditional video
- Indifferent

* 6. How did the following factors influence your viewing experience?

	Very negative	Negative	Indifferent	Positive	Very positive
Switching of views					
Rearranging of subviews					
The content					
Overall impression					

7. Comments

Multi-view video focus group survey results

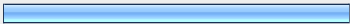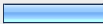Multiview video - Focus group

1. Age		Response Percent	Response Count
Under 18		0.0%	0
18-24		40.0%	4
25-30		**60.0%**	**6**
31-40		0.0%	0
Over 40		0.0%	0
	answered question		10
	skipped question		0

2. Sex		Response Percent	Response Count
Female		30.0%	3
Male		**70.0%**	**7**
	answered question		10
	skipped question		0

3. What is your previous experience with multi-view video		Response Percent	Response Count
Never tried		**70.0%**	**7**
Tried once		30.0%	3
Several times (2-5 times)		0.0%	0
Regularly		0.0%	0
	answered question		10
	skipped question		0

4. If you have tried multi-view video before, please elaborate how and what you watched	
	Response Count
	10
answered question	**10**
skipped question	**0**

5. If you could choose between multi-view video and traditional video, what is your preference?			
		Response Percent	**Response Count**
Multi-view video		**70.0%**	**7**
Traditional video		20.0%	2
Indifferent		10.0%	1
		answered question	**10**
		skipped question	**0**

6. How did the following factors influence your viewing experience?							
	Very negative	**Negative**	**Indifferent**	**Positive**	**Very positive**	**Rating Average**	**Response Count**
Switching of views	0.0% (0)	20.0% (2)	0.0% (0)	**60.0% (6)**	20.0% (2)	3.80	10
Rearranging of subviews	0.0% (0)	0.0% (0)	**50.0% (5)**	40.0% (4)	10.0% (1)	3.60	10
The content	0.0% (0)	20.0% (2)	**50.0% (5)**	30.0% (3)	0.0% (0)	3.10	10
Overall impression	0.0% (0)	0.0% (0)	0.0% (0)	**90.0% (9)**	10.0% (1)	4.10	10
					answered question		**10**
					skipped question		**0**

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7. Comments		Response Count
		8
	answered question	**8**
	skipped question	**2**

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