MPEG-L/MRP: Implementing Adaptive Streaming of MPEG Videos for Interactive Internet Applications

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Abstract

Existing multimedia streaming technologies offer no specific support for user interaction like jumping to bookmarks in a video, or switching to reverse play. When the users, e.g., jump to a bookmark, the player requests frames for the new presentation point from the server and resumes playing only when the data has arrived. Our solution for this problem is the client prefetching and buffering strategy, *MPEG-L/MRP*, that ensures that the frames which are needed for a response to a possible user interaction are already

in the client's buffer, which leads to quick and smooth reaction to user interactions. In case of variable bandwidth, our MPEG-1 streaming approach selects only a subset of all frames to be fetched from the server and supports a smooth presentation at a reduced frame rate with correct timelines. The technical demonstration shows the interactive streaming of MPEG-videos and illustrates our buffering and prefetching strategy.

Contents

Introduction

Our research project ``Gallery of Cardiac Surgery'' (Cardio-OP) [1] aims at the development of a database-driven, web-based educational multimedia system providing access to interactive multimedia content from heterogeneous system environments. In the future, users will probably have to pay for the content of multimedia systems like Cardio-OP and, as a consequence, they expect a high Quality of Presentation. Long startup latencies after user interactions and jittering videos are unacceptable and in case of temporarily scarce bandwidth the users may rather tolerate a reduced frame rate than stagnating playback with skewed timelines. With the *MPEG-L/MRP* strategy [2], we developed an adaptive prefetching algorithm for the MPEG-1 video format to continuously deliver MPEG-1 video streams over an IP network in combination with an intelligent buffering technique that supports smooth and quick reactions to user interactions with the stream. Though streaming technologies exist in the commercial field (e.g., RealNetworks [3]) and also in the research field (e.g., Quasar [4] and Hess et al. [5]), that are capable of adapting to varying bandwidths, they do not provide quick reactions to user interactions with the continuous stream, but only support forward-oriented streaming.

The MPEG-L/MRP Algorithm

The focus of MPEG-L/MRP is the support of user interactions on the continuous stream in a satisfying way, i.e., to reduce the round trip time from the client to the server after a user interaction. For this, the MPEG-L/MRP strategy ensures that those frames that are likely to be played directly after a user interaction are available in the client's presentation buffer. As illustrated in Figure 1, for a current presentation point *p* and a bookmark *b*, for each of the possible interactions, play forward, fast forward, play reverse, and jumping to a bookmarked frame, the frames are shown which must reside in the client's buffer to immediately continue the presentation after one of these interactions.

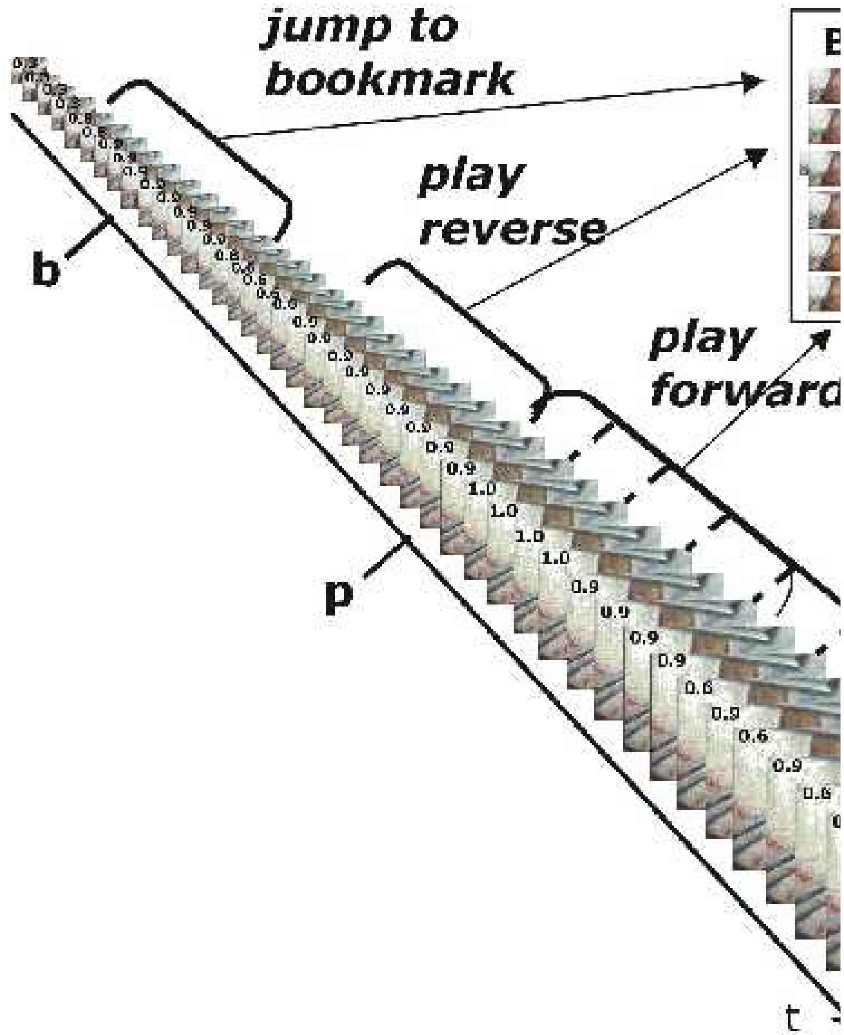

Figure 1: Relevant frames for interactive streaming

To achieve this, the strategy calculates a *relevance value* for each MPEG frame depending on the current presentation state which expresses how relevant the frame is for the future interactive presentation. Based on these relevance values, a buffer manager prefetches the frames that are most relevant for the presentation and removes those frames from the buffer that are least relevant. In this respect, the strategy is based on the L/MRP (least/most relevant for presentation) strategy [6] that, however, supports only homogeneous continuous data streams like Motion-JPEG. Hence, we adapted the formal model in the

MPEG-L/MRP [2] strategy to the specific features of MPEG-1 with its different frame types and inter-frame dependencies. Figure 2 illustrates for play forward that I-frames have much higher relevance values than P- and B-frames as they are more important for decoding and presentation than P- and B- frames. To support various playback modes, we defined the relevance functions for additional interactions like fast forward, play reverse, and bookmarks in [2] and how the *global relevance value* for each frame is determined.

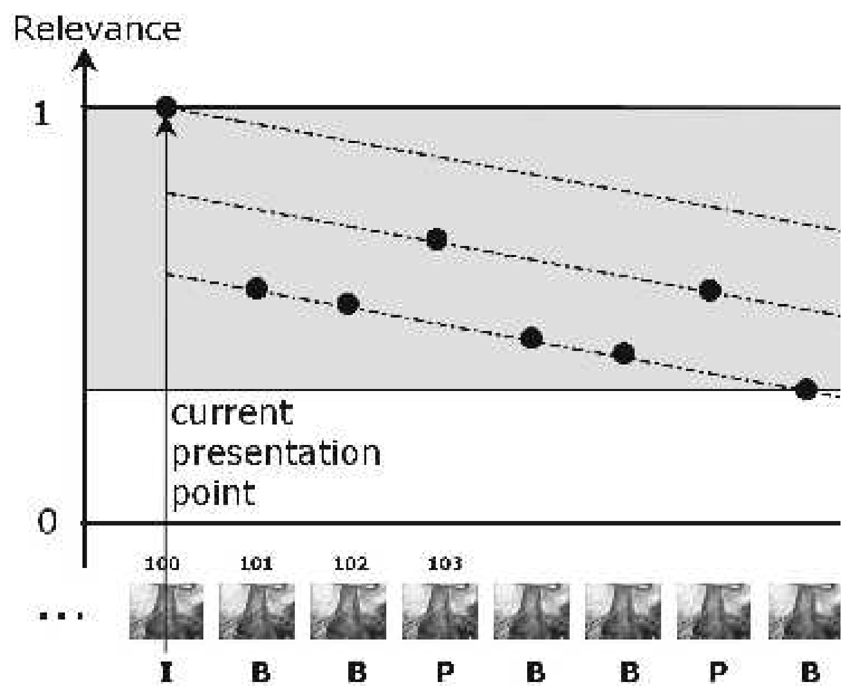

Figure 2: The relevance function for play forward in MPEG-L/MRP

Implementation of interactive MPEG streaming

We have implemented the MPEG-L/MRP strategy in Java employing a client/server architecture over an IP network. We realized the client buffer providing an interface that meets the requirements of the the Java Media Framework (JMF) [7] players such that the standard MPEG player of JMF can be connected. On the basis of the relevance functions, the client buffer prefetches the frames from the server corresponding to our strategy and delivers a correct MPEG-1 data stream to the player. The fact that the relevance functions are monotonously decreasing is used for a very efficient computation of the global relevance function. In case of insufficient bandwidth, the implementation performs an adaptation of the medium by ordering only the most relevant frames from the server. If a frame is missing at the client, the buffer manager substitutes it according to the MPEG-1 specifications and delivers a correct data stream to the player instead of stopping the presentation and waiting for the missing frame.

The Demonstrator

Figure 3 shows a screenshot of the demonstrator. The graphical client front end shows the video presentation and, in additional windows, provides the user interaction with the video and visualizes the prefetching and buffering strategy: The player window on the left shows the actual video presentation. Among others, we will show a video taken from a bypass surgery as it contains parts in which a bypass is sewed with waferthin threads to the heart to show that our adaptation of the MPEG stream down to a certain bandwidth still provides an acceptable quality of presentation. The window on the right provides the interaction functionality with the stream and the lower window gives a graphical visualization of the buffer state by means of little colored strokes each representing a buffered frame. In the screenshot one can see that around the bookmarks set so far the buffer contains the most important ``surrounding'' frames even though the current presentation point has proceeded. When jumping back to such a bookmark one can clearly see how our approach is superior to other streaming approaches: The player quickly resumes the presentation at the bookmark without indicating that it is ``rebuffering''.

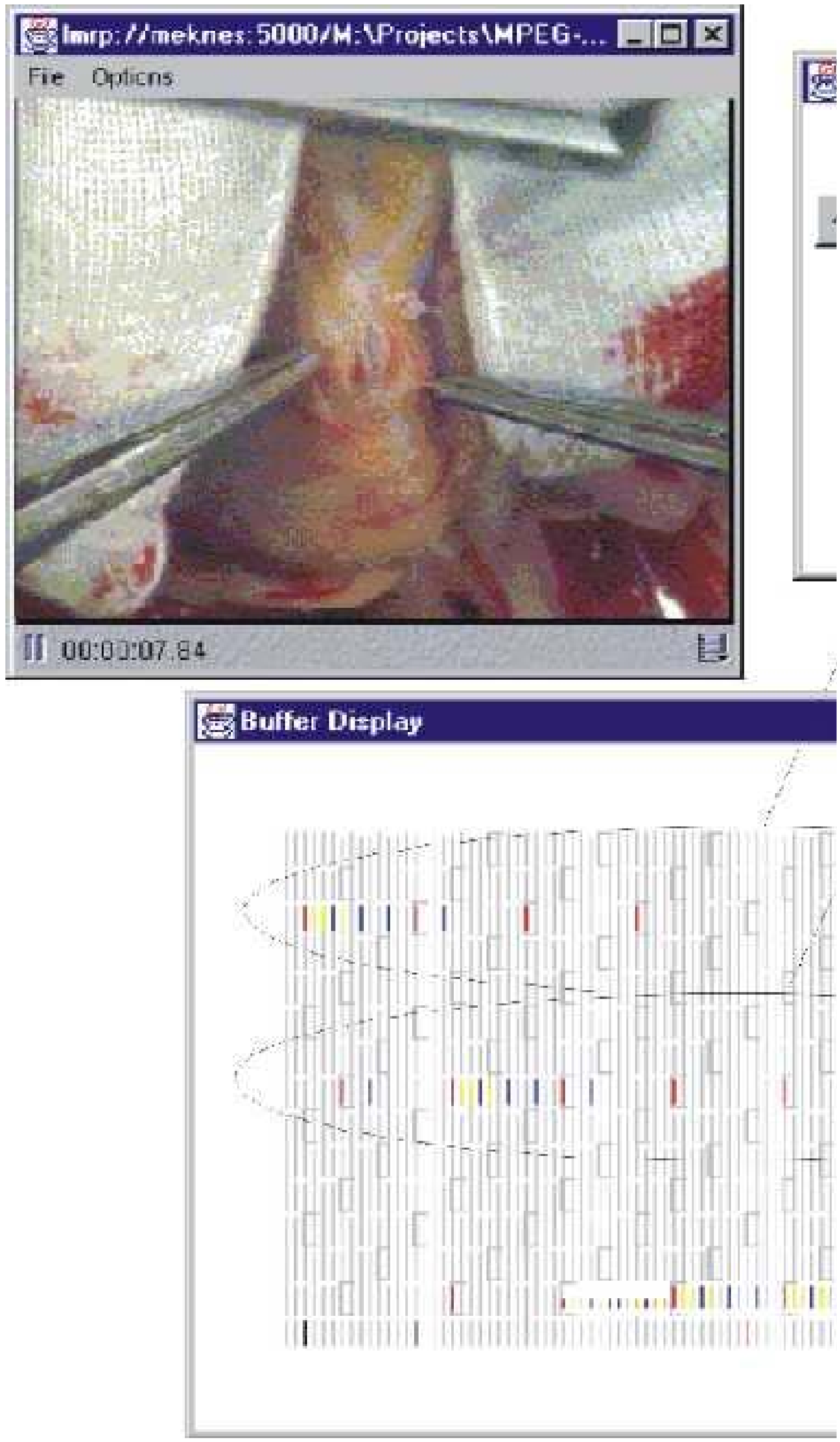

Figure 3: The MPEG-L/MRP demonstrator

Conclusion

With MPEG-L/MRP embedded in a multimedia (information) systems's architecture, a much better *Quality of Presentation* can be delivered than achieved so far with commercial and research approaches due to little startup latency after user interactions.

Acknowledgements

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