Display Pixel Caching

Clemens Birklbauer, Tianlun Liu, Oliver Bimber
Johannes Kepler University Linz *

Max Grosse, Anselm Grundhöfer
Bauhaus-University Weimar †

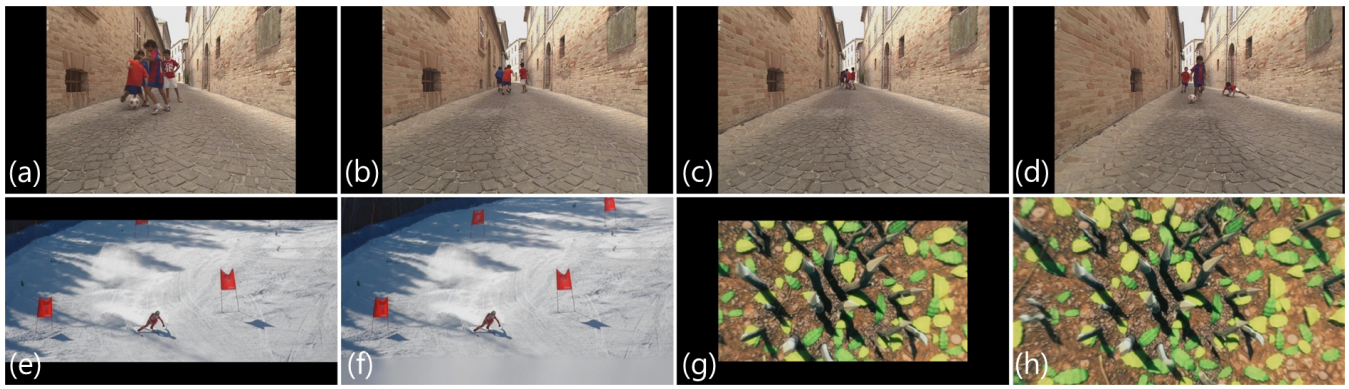

Figure 1: *Results of DPC for 4:3 content on a 16:9 screen after several frames of leftward camera motion while empty cache regions (left and right borders) are left blank (a-d). Result of DPC for a cinemascope format and downward camera motion while empty cache regions (bottom border) are pre-filled with a smooth color transition (f). Result of DPC for a 16:9 format and forward camera motion (h). Frames a,e, and g are the original frames while frames b,c,d,f, and h were computed by DPC. The original frames are always unmodified and embedded in the center of the DPC output.*

1 Introduction and Motivation

A variety of standard video modes that stretch or zoom lower resolution video content linearly to take full advantage of large screen sizes have been implemented in TV sets. When content and screen aspect ratios differ, format proportions may be compromised, video content may be clipped, or screen regions may remain unused. Newer techniques, such as video retargeting and video upsampling, rescale individual video frames and can potentially match them to the display resolution and aspect ratio. However, none of these methods can display simultaneously more than is contained in a single frame.

2 Our Approach

With *display pixel caching* (DPC), we take a completely different approach. Instead of zooming, stretching, or retargeting individual frames, we merge the motion information from many subsequent frames to generate high-resolution panoramas in an ad-hoc and fully automatic manner. Thus, we cache pixels in border regions as long as they are visually reasonable. In contrast to conventional video mosaicing, however, the challenges to DPC are achieving real-time rates for high-resolution input content, and ensuring spatial and temporal consistency in complex local and global video motion patterns.

The DPC video processing pipeline can be summarized as follows: Motion patterns of input video frames are analyzed and segmented into motion layers. The different motion layers are warped and accumulated to fill border regions (i.e., the display cache). Border regions that remain empty can optionally be initialized (e.g., by a smooth extrapolation). Uncertain cache content that accumulates vivid registration errors is identified and is temporally faded out. If shot transitions are detected the cache content undergoes the same transition as the original frames. Subsequent cache states are temporally smoothed and finally displayed together with the original frames. The result is a high-resolution panorama that successively fills the empty screen borders while leaving the original frames untouched, rather than a framed video as in common video modes.

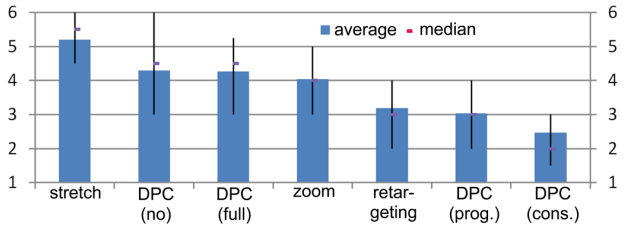

Figure 2: *User preferences for various video modes over the original (unmodified) content: The scores range from 1 (strong preference) to 6 (low preference). The bar chart displays, average, median, the lower, and the upper quartiles. For retargeting, we used Rubinstein's multi-operator media retargeting with face detection.*

3 Results

DPC achieves real-time rates for high-resolution video content (e.g., 50fps for PAL videos displayed on a 720p screen, 29fps for PAL when displayed on a 1080p screen, and 26fps for 720p displayed on a 1080p screen) while processing complex motion patterns fully automatically.

We compared DPC to related video modes in the context of a user evaluation with 59 subjects. Thereby, different options for initializing empty cache regions were also tested (see supplementary videos): no initialization leaves empty cache regions blank, full initialization smears cache edges towards screen edges, progressive clipping initializes only the regions between original cache content and its outermost extent, conservative clipping cuts cache content at its inner limit. We found, that DPC is preferred most when straight and screen-aligned cache edges are preserved.

* {firstname.lastname}@jku.at
† {firstname.lastname}@uni-weimar.de