Automated Camera Planner for Film Editing Using Key Shots

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Abstract

Generating films from 3D animations requires knowledge in cinematography (camera placement, framing and lighting) and editing (cutting between cameras). In applications where the user is already engaged in other tasks, such as playing a game, directing virtual actors, or narrating a story, it appears desirable to build systems that can make decisions about cinematography and editing and automatically generate a grammatically correct movie according to film grammar. In this paper, we introduce a framework for generating a well-edited movie based on the rules of film editing. Specifically, our system computes a sequence of shots *by simultaneously choosing which camera to use, when to cut in and out of the shot, and where to cut to. We cast film editing as a cost minimization problem in the space of possible shot sequences and provide an efficient search algorithm. The method is illustrated with multiple edits of the same footage in different editing rhythms and styles.*

Categories and Subject Descriptors (according to ACM CCS): Computer Graphics [I.3.3]: Virtual Cinematography—

1. Introduction

In this paper, we provide a general computational framework for automatically generating a cinematic editing of a 3D animation. Our framework proposes scores for shots and cuts, independently of the film idioms used to generate them. The score for a shot is based on the Hitchcock principle of showing action from the best angle [ST85] and the score for a transition between shots is based on the working practices of film and television [Tho93, Tho98]. Previous work has described techniques for choosing camera setups and generating virtual footage based on the rules of cinematography [HCS96, ER07, JA10, LCL*10]. Instead, we cast the problem of film editing as selecting a path in time through the collection of takes and precisely deciding when to enter the take and when to exit the take. This is a non traditional shortest path problem. We restrict the complexity by providing a cost function which is semi-markovian, i.e. the cost of a sequence is computed as a sum over its key shots and transitions between successive key shots. We propose a fast search algorithm suitable for online editing under that model.

2. Film Grammar Rules

Evaluating the score of an entire sequence for a movie is built up from the scores of its shots and transitions. We make the assumption that a cost function can be computed for each shot and cut in the sequence. The cost per shot (a shot is a part of a take of duration Δt) is evaluated as a weighted sum of all violations of the rules of frame composition. And similarly, the cost of a cut is evaluated as a weighted sum of all violations of the rules of editing.

We further assume that the cost of a complete sequence $s(t) \in [1,M]$, $t \in [1,N]$ of N shots using M takes is the sum of the costs for all of its shots and cuts :

$$C(s) = \sum_t \left(\sum_k w_k C_k^S(s(t),t) + \sum_l w_l C_l^T(s(t), s(t+1), t) \right)$$

A last term we add in the evaluation of a sequence is a score for the pacing of cuts and the duration of shots, which are important factors in the rhythmic perception of films [Sal03]. When cutting from camera i to camera j at time t, this additional term takes into account the previous cutting time $u(t)$ to estimate if the duration $t - u(t)$ of the closing shot is right, according to a user-defined log-normal law.

3. Online editing as path finding

In our model, film editing is cast as the search for a minimum-cost path through all available cameras, with entry and exit points in time. The cost function is a sum over

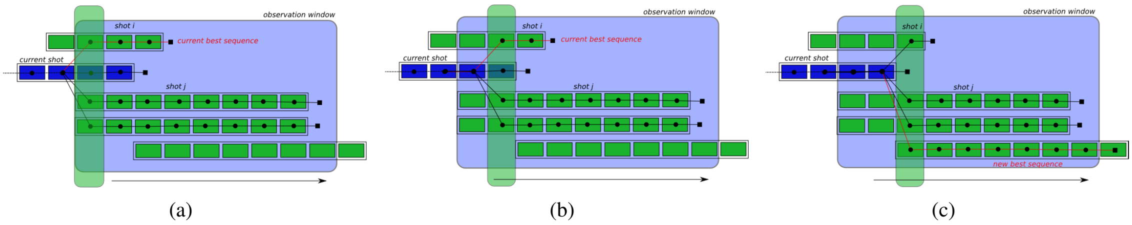

Figure 1: *Searching for the optimal transition in the observation window to decide whether to cut or stay in the shot. In top image, the current optimal shot sequence is drawn in red and recommends to cut at time t. A scanning process over the observation window (in light blue) is performed to seek for a possible better moment. In bottom image, a sequence with a better cost is found (displayed in red). The observation window is then shifted ahead and the process starts over.*

all shots and transitions from shot to shot. As such, it is amenable to a time-efficient, offline dynamic programming solution. In this communication, we instead propose an informed best-first search which uses anticipation to locally decide the best moment for a transition in real time.

At a given depth in the search process, a critical decision needs to be made whether to stay within the current shot, or to perform a transition to another shot. To inform this decision, we rely on an observation window over the next w time steps. We study within the observation window the best transition to be performed, given the knowledge of the shots to come. If the best transition occurs immediately, the transition is performed. If the best transition occurs later in the observation window, we shift the window a step ahead and start the process over.

To compute the best moment for a transition inside the observation window we use an incremental scanning process, illustrated in Figure 1. Given the current shot is c, for a given time t in the observation window and for each shot $i \neq c$, the cost of a possible transition from shot c to shot i is given by

$$C^{CUT}(c,i) = C^{S}(c,0,t) + C^{PACE}(c_d) + C^{T}(c,i) + C^{S}(i,t,w)$$

where $C^{S}(i,t_1,t_2)$, $C^{T}(i,j)$ and C^{PACE} represent resp. the costs associated to the shot i from time t_1 to time t_2 in the window, a transition between two shots i and j, and to the pace, and where c_d represents the duration of shot c. The best cost over all available shots i at time t is compared to the cost of staying in the current shot:

$$C^{NOCUT}(c) = C^{S}(c,0,w) + C^{PACE}(c_d)$$

If the cost of staying in the current shot c is the minimal cost (ie $C^{NOCUT}(c) \leq min_i C^{CUT}(c,i)$), we extend its duration by Δt and the observation window is shifted ahead. If there exists a shot i such that $C^{CUT}(c,i) < C^{NOCUT}(c)$ at time t, we need to know whether to cut at the current time t to shot i, or to wait for a better moment. To implement this, the process explores the successive time steps $t+\Delta t, t+2\Delta t, ..t+w\Delta t$ in the observation window until a cost lower than $C_{CUT}(c,i)$ is found. In such case, the best cut occurs later and the observation windows is shifted ahead. Otherwise, t represents the best moment for a transition and a cut is performed towards shot i.

4. Conclusion

We have introduced a novel framework for virtual cinematography and editing which adds an evaluation function to previous approaches. Furthermore, we have introduced an efficient search strategy for finding the best sequence of shots from a large number of candidates generated by traditional film idioms. In future work, we would like to extend the approach to higher-level criteria, including story advancement, repetition, style and emotion.

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