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# Video Chat with Multiple Cameras

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## Abstract

This work provides the first rigorous investigation of multi-camera video chat, concentrating especially on the ability of a user at one end of the conversation to switch between multiple views at both ends of the conversation. A user study of 23 individuals and comprehensive benchmark experiments employing up to four webcams simultaneously demonstrate that multi-camera video chat is both desirable and feasible on consumer hardware.

## Author Keywords

Consumer video chat; multiple cameras

## ACM Classification Keywords

H.5.1 [Multimedia Information Systems]:  
Evaluation/methodology; C.4 [Performance of systems]:  
Design studies

## Introduction

This extended abstract analyzes the use of multiple cameras in consumer video chat applications. Figure 1 demonstrates some of the possibilities enabled by the MultiCam software package described later. In each case, a laptop running Skype has two or more USB webcams connected, and the chat participants at *both* ends of the conversation are able to switch at will between individual views of each camera or a tiled view of all simultaneously.

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That is, the remote view can be altered by the local participant or the remote participant.

The research questions addressed by this work are:

- Is multiple-camera video chat useful and/or desirable? Answer: Yes, for certain scenarios.
- Is remote control of the viewpoint useful and/or desirable? Answer: In many cases, no. But a minority of users prefer remote control in at least some scenarios.
- Is multiple-camera video chat feasible on commodity hardware, using existing consumer chat software (e.g. Skype)? Answer: Yes, but with some caveats.

To the best of the author's knowledge, these three questions are novel in the context of *consumer video chat*. Of course, multiple cameras and remote changes of viewpoint have been used extensively in videoconferencing and immersive telepresence systems (e.g. [1, 2, 3, 5]). However, the markedly different hardware and physical scenarios employed by consumers using standard video chat software such as Skype mean that the use and control of multiple views require re-examination in this context.

### The MultiCam software package

The experiments described later employ a software package, called MultiCam, written by the author specifically for this research. The MultiCam software itself is not a primary contribution of the work. No single feature of MultiCam is novel, but it does provide more convenient remote camera-switching than any previously-existing software plug-in for consumer video chat. MultiCam is free and open source, and the accompanying technical report [4] describes some

interesting trade-offs relating to the design of multiple-camera software.



**Figure 1: Typical MultiCam usage scenarios.** Webcams are highlighted by green circles. (a) Two forward-facing cameras. (b) Forward- and rear-facing cameras. (c) Wide shot, headshot, and close-up. (d) Two cameras for whiteboard discussion (e) Remote tiled view of (c). (f) Remote tiled view of (d).

## Results

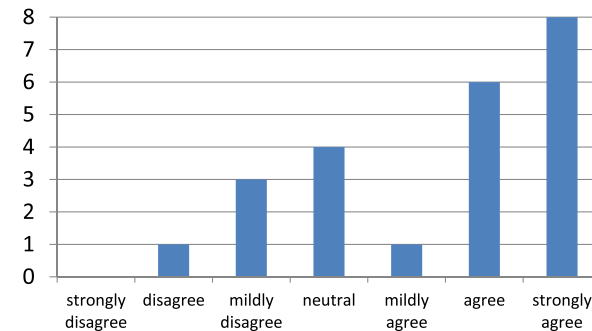
### *Experience with MultiCam*

This subsection summarizes the author's experience with dozens of MultiCam chats (primarily social interactions with friends and family) over several months. These results are anecdotal, complementing the results of the rigorous user study described in the following subsection. Figure 1(a)–(c) shows the three camera setups that proved most useful in these conversations. Note that one of the cameras is often picked up and directed manually for some portion of the conversation. Remote participants rarely chose to control the switching of cameras, leaving the burden of camera-switching with the author. But compared with single-camera chats, in which the only camera must be constantly redirected to the current region of interest, the burden of camera management appeared smaller for multi-camera chats. In addition, remote participants consistently reported increased enjoyment of multi-camera chats, compared with single-camera chats. Finally, the MultiCam package is downloaded hundreds of times per month at the time of writing, suggesting there is a reasonable level of demand for multi-camera video chat.

### *User study*

A user study was conducted to examine some of the benefits and drawbacks of using multiple cameras with video chat, focusing especially on a comparison between speaker-controlled and listener-controlled camera-switching. The participants comprised 23 individuals ranging in age from 20 to 70 (median 40), located in three continents. Participants viewed two brief lectures using the setup shown in Figure 1(d) and (f). In one lecture, the lecturer controlled all switches between the camera views (whiteboard, sofa, tiled). In the other lecture, the participant had exclusive control over the

camera view. Figure 2 shows the participants' level of agreement with the statement "When the speaker controlled the camera, the overall experience was more satisfactory."



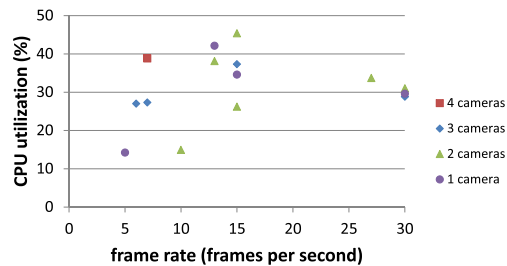
**Figure 2: User preferences for speaker-controlled camera-switching vs listener-controlled camera-switching.**

Clearly, there is a strong preference for the lecturer controlling the camera view in this scenario. The main reasons for this, elicited via open-ended questions, are that the participants were distracted by having to change cameras and found it more difficult to concentrate on the content of the lecture. In addition, the lecturer can anticipate the need for a switch and thus switches at the right time.

On the other hand, a non-trivial minority (17%) of participants preferred to control the view, mainly for two reasons: (i) they enjoyed the feeling of being in control; and (ii) they could switch back to the whiteboard when desired. Hence, it is clear that the remote switching functionality does enhance the experience for a significant fraction of users.

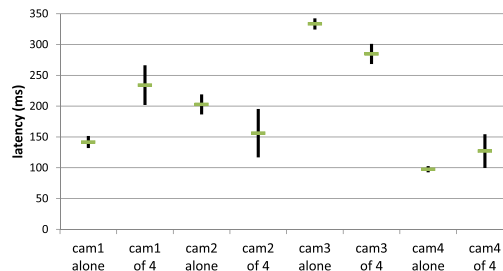
### Benchmark experiments

The technical report [4] describes comprehensive experiments demonstrating the performance of multi-camera video chat on commodity hardware. Two typical results are shown here. First, we see that CPU utilization and frame rate are generally acceptable when using up to four cameras, though with a great deal of variability:



**Figure 3:** Benchmark of CPU and frame rate with varying number of cameras.

Second, we see that adding extra cameras does not typically add latency to the video display:



**Figure 4:** MultiCam display latency for single and multiple cameras. Horizontal lines show the mean and vertical lines show the standard deviation.

### Conclusion

This appears to be the first study rigorously analyzing multi-camera video chat. It provides evidence that (i) multi-camera chat is useful and desirable; (ii) remote control of the viewpoint was not desired by most users in the scenario tested, but does enhance the experience for a minority of users; (iii) multi-camera chat is feasible on commodity hardware.

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