MixMeet*Wear*: Live Meetings at a Glance

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Abstract
We present MixMeet*Wear*, a smartwatch application that allows users to maintain awareness of the audio and visual content of a meeting while completing other tasks. Users of the system can listen to the audio of a meeting and also view, zoom, and pan webcam and shared content keyframes of other meeting participants' live streams in real time. Users can also provide input to the meeting via speech-to-text or predefined responses. A study showed that the system is useful for peripheral awareness of some meetings.

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Introduction
Meetings, once the exclusive domain of offices and boardrooms, are becoming increasingly distributed across space, time, and devices. To explore the potential of wearables to support meeting participation we built MixMeet*Wear*, a system that allows meeting participants to maintain basic awareness of the audio and visual content of a meeting from a wearable device. MixMeet*Wear* also provides essential interaction mechanisms so that a remote, mobile user can interact with a meeting without disrupting their other tasks.

We ran a study to determine how well people can use MixMeet*Wear* to participate in a remote meeting while also simultaneously completing another task. We tested two types of tasks, one less demanding (requiring low attention) and the other more demanding (requiring higher attention). Participants reported that MixMeet*Wear* is especially useful when the concurrent task requires low attention.

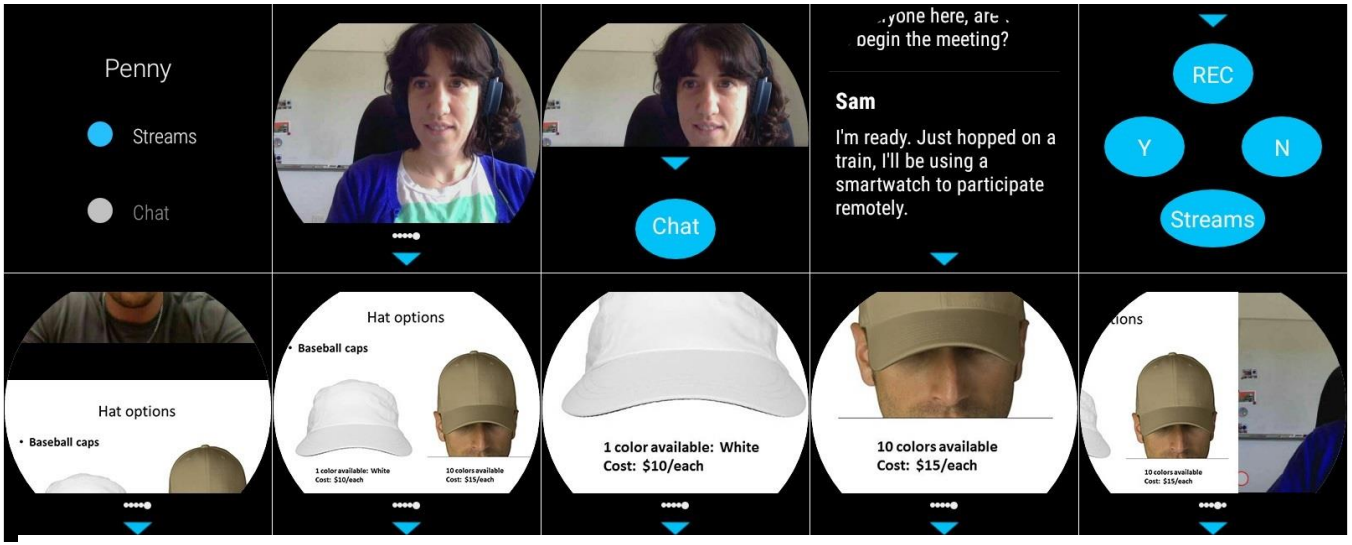

Figure 1: *First row:* Main menu; Pressing "Streams" opens a view displaying a keyframe from the first stream; Dragging the triangle at the bottom opens the control panel; Touching the chat button opens a view displaying messages; Touching the triangle at the bottom opens the chat control panel. *Second row:* Swiping a keyframe moves to a different participant's stream; In this stream the participant is sharing a slide image; Double tapping zooms the keyframe view; Zoomed-in keyframes can be panned; Swiping horizontally moves to a different keyframe within a stream.

Related Work

The focus of our work is supporting distributed meetings with wearable technology. Other work has investigated technology such as Google Glass in face-to-face conversations as a way of presenting additional information to a conversation partner [3].

Smartwatches in particular could be advantageous for enabling peripheral awareness of a meeting. For example, consider the scenario in which a meeting participant is commuting or otherwise on the go. Participating fully in a meeting may not be possible (e.g., on a crowded train), due to either physical or social constraints. In other cases, individuals may be engaged in a primary task that absorbs most of their attention [4], but would like to remain peripherally engaged in a conversation that is occurring, or wait for a specific point in the meeting where their input is needed. This type of behavior has been observed in teleconference participants' multitasking: They work on a 'foreground' task while listening in the 'background' for an item of interest [5].

For both of these scenarios, the advantage of using a smartwatch for peripheral meeting awareness is that the device is less obtrusive and faster to access than a smartphone [2]. While many commercial meeting systems have rudimentary smartwatch apps, none of

them broach the difficult design challenges of interacting with and displaying persistent visual information (beyond, for example, a notification) [6]. While smartwatch notifications may be easier to read and glance at than those on a mobile phone [2], it may be that using a smartwatch to view and peruse more complicated information (such as a longer amount of text or a webpage) is more difficult.

MixMeet*Wear*

MixMeet*Wear* is an Android-based smartwatch application (Figure 1). It is designed to extend WebRTC-based meeting systems that support live audio, video, and chat. In particular, we built MixMeet*Wear* to extend MixMeet, a web-based meeting system that also performs live content analysis and archives important keyframes from each participant's stream on-the-fly [1].

Our goal is for MixMeet*Wear* to run independently on a smartwatch. However, current smartwatch hardware requires that networked applications send and receive data via an associated mobile device. Therefore, the system currently consists of two applications, a mobile app and a wearable app. The mobile app interoperates with MixMeet to join meetings, handle the data between the server and the watch, and streams audio from the server. The mobile is not directly needed during a meeting. The wearable app displays visual content from the meeting and allows for simple input.

The wearable app takes advantage of the keyframes generated by the MixMeet system. Keyframes are screen captures of a user's shared screen during meetings, which are stored for later reference. Keyframes are generated in the server, and parameters used are varied based on what a user is sharing. For instance, when sharing a standard webcam view, a certain level of change in a view is required for a new keyframe to be generated in order to avoid identical uninformative frames displaying. On the other hand, when sharing a slide show, for example, any change in view will generate a new keyframe.

MixMeet*Wear*'s UI includes a main menu and two other views; the stream view and the chat view (Figure 1). The main menu offers access to both views, however users can also move between the two views without having to go back to the main menu. Both views contain a control panel that can be opened by pressing or dragging an arrow icon at the bottom of the screen.

The stream view consists of a series of keyframes that can be scrolled, zoomed, and panned. Keyframes are sent over to the watch whenever a new keyframe is generated in MixMeet for any meeting participant. On the watch, keyframes are divided into user-specific streams. Swiping up and down changes to a different user's stream, and swiping left and right cycles between keyframes within a particular stream. If the wearable is not being interacted with, it automatically displays new keyframes as they are received. Double-tap zooms in and out of a keyframe. A zoomed-in frame can be panned freely. Using the control panel, users can open up the chat view.

MixMeet*Wear* also supports essential interaction mechanisms so that the watch-based participant can interact with the meeting's separate chat channel. The app supports basic yes/no responses as well as open-ended speech-to-text-based comments. Both types of responses are triggered via the control panel. Yes/no

The smartwatch meeting application was useful	6.5
The smartwatch meeting application was easy to use	5.5
The smartwatch is suitable for short meetings	6
The smartwatch is suitable for long meetings	3

Table 1. Median responses to questions about the smartwatch meeting application (1=strongly disagree; 7=strongly agree)

Quotes from user study:

[Likes] Being able to follow and see slides as I complete other tasks. Being able to respond and give input during other tasks.

It really allowed me to do two things at the same time. The second task, however, I think was too demanding …I couldn't do any of the two tasks at my 100%, but the watch part was great: only a few amount of information.

responses are sent directly to the chat after pressing the corresponding button.

The speech-to-text function displays a view instructing the user to speak and then displaying the interpreted result. Afterwards, a confirmation timer is displayed, allowing user time to cancel the action. When the timer finishes, the result is sent to the chat.

Study

We conducted a study with 12 participants (7 males, 5 females). The participants were asked to complete a *meeting-based* task, while also carrying out two *parallel* tasks on a laptop (one task followed by another task). The participant's meeting-based task was to stay aware of a meeting, trying to pay attention to what was being discussed and what was being shown on the watch. Furthermore, at key points during the meeting, participants were expected to react to a situation in the meeting using the watch app's chat functionalities.

The meeting was divided into two parts of roughly equal length, one for each parallel task. The *low attention* parallel task simulated traveling in a metro and getting off at the right stop. The *high attention* parallel task involved users preparing a short slide show that was based on a template.

Results

The watch app was generally seen to be both useful and easy to use (see Table 1). More optimal situations for using a watch are those that require low levels of mental effort, such as traveling or physically moving. Otherwise users' performance in the parallel task is significantly lowered. Participants also found the watch to be more useful in short rather than long meetings.

Conclusions

As smartwatches are increasingly adopted and gain the ability to function without the need for a paired mobile phone, their lightweight and unobtrusive form factor make them ideal for enabling peripheral meeting awareness alongside parallel tasks. Our work gives insight into the potential for increased awareness and improved communication among physically and attentionally distributed teams through the use of wearable devices.

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