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Eyewear-Based System for Sharing First-Person Video to Remote Viewers

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***Abstract*—We present in this paper software engineering details of a wearable system for sharing with remote viewers first-person video captured by eyewear devices. The main component of our system architecture is a node.js server that captures snapshots from producers (represented by eyewear devices, such as camera glasses) and delivers those snapshots to consumers (such as smartphones, tablets, and laptop clients). In our implementation based on JavaScript events and messages, client applications request snapshots from particular video streams corresponding to specific users of eyewear devices.**

Keywords—eyewear; first-person video; video camera; architecture; JavaScript.

I. Introduction

The general expectation for the near future is that Augmented Reality (AR) smart glasses will change the way we perceive and interact with the world. We propose in this paper a prototype system for sharing first-person video captured by eyewear devices to remote viewers. Our system is based on a flexible client-server architecture whose main component is the `node.js` server, while clients are `JavaScript` based.

Smartglasses are increasingly used in various application domains, including medicine [1,2,3], tourism and museums [4], warehouses, construction [5], subtitling and translation, fitness and training, retail [6], or gaming [7]. The four main features of smartglasses leading to this spectacular growth are: hands-free video and audio recording, real-time sharing of wearer's point of view, hands-free on-the-spot access to information, and augmentation of the physical world.

Almost all smartglasses models come equipped with a video camera, optical display, touchpad, and microphone. With a simple touch, gesture, or voice command, users wearing smartglasses could gaze and shoot, capture pictures, video, and audio. Pictures and videos can then be streamed in real time to a supervisor, colleague, friends, etc. Other sensors common for smartglasses are accelerometers, gyroscopes, magnetometers, GPS, light sensors, or eye trackers.

Smartglasses have a variety of uses in telemedicine [1,8,9]. They may improve the efficiency and effectiveness of clinical care by giving clinicians extra information [1,2] (such as the patient's vital signs, personal data) in their field of vision during various procedures making medical care more mobile. Telemedicine applications for sharing first-person video to remote viewers systems include teleproctoring [3], telementoring, and student supervision. For example, surgical telementoring is a concept within telemedicine that involves the use of information technology to provide real-time guidance and technical assistance from an expert physician in a different geographical location. Smartglasses also open up new therapeutic opportunities for people with Parkinson's [10].

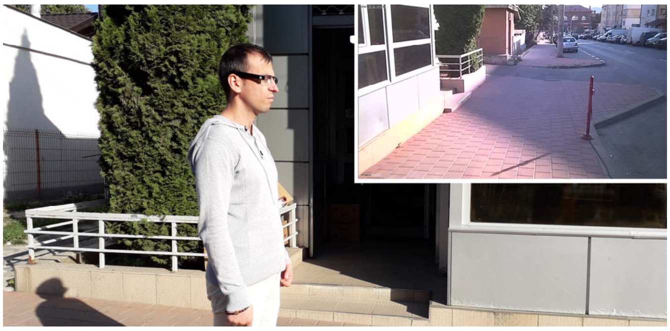

Fig. 1. A user wears an eyewear device with an embedded micro video camera that delivers snapshots to the node.js server. An authorized client can access the video stream (top right) directly from the web browser of any smartphone, tablet, or laptop computer.

In this paper, we introduce a wearable, eyewear-based system for sharing first-person video to remote viewers and various types of client devices that run `JavaScript`-enabled web browsers. The main practical contribution of this work is a software architecture for sharing first-person video to remote viewers, consisting in a `node.js` server, producers (eyewear devices), and consumers (web browsers running on smartphones, tablets, and laptop computers).

II. Related Work

We discuss in this section prior work on sharing first-person video, and we overview the literature on smartglasses-based systems and applications, including applications of eyewear devices for *m*-health and *e*-health.

A. Sharing First-Person Video using Wearable Cameras

Sharing First-Person Video (FPV) in real-time using wearable cameras [7,11,12,13,14,15] has been one of the ultimate goals of telecommunication. Possible application areas are sports, entertainment, education, social networks, and professional assistance. For example, Kono *et al.* [7] presented "JackIn Airsoft," a system for generating maps for multiplayer sport

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activities and sharing their first-person perspectives. In first-person shooting games, maps that are generated for the visualization of the player's location are used for strategic play and discussions. These games provide a virtual experience of military activities, and the display of maps onto a screen is a technique designed for game playing. Another example of a first-person video system is Shared Individual [11], a live collaborative Mixed Reality performance, in which an audience can observe themselves from an individual's point of view. In this system, a performer shares their view with the members of the audience by wearing a head-mounted camera and streaming live video. The audience can look at themselves and follow the performer's instructions. This type of interaction is designed to help the audience synchronize with the performer. Kasahara *et al.* [12] introduced the "LiveSphere" system, where a "Body" user wears headgear and broadcasts images of their surrounding scene that were obtained from head-worn cameras. A "Ghost" user can look around in 360 degree spherical streaming.

A. Smartglasses-based Systems and Applications for Video Processing

Prior work from the scientific literature on smartglasses has addressed video and image processing applications. These include systems that process images obtained from the smartglasses' camera for facial recognition [16,17,18], text extraction from the ambient environment [19], abstracting life [20,21], or for overlapping images [22] with other information obtained from other sensors.

"Life-Tags" [20] is a wearable smartglasses-based system for abstracting life in the form of clouds of tags and concepts automatically extracted from snapshots of the visual reality recorded by wearable video cameras. Life-Tags [20] summarizes users' life experiences using word clouds, highlighting the "executive summary" of what the visual experience felt like for the smartglasses user during some period of time, such as a specific day, week, month, or the last hour. Vo-Ho *et al.* [21] introduced another smartglasses-based system for abtracting life, capable to generate personal diaries. A prototype [22] for vehicle lifelogging captured snapshots from smartglasses regarding the visual reality experienced by the passenger located in the front seat of the car. Over the images capture from smartglasses, various information was displayed, such as metadata from the online radio stream, location, or the speed of the car.

Chatzopoulos *et al.* [19] proposed "Hyperion," a wearable AR system to extract text from the ambient. Hyperion supported Google Glass, and provided offloading to the smartphone and the cloud.

A. Applications of Smartglases in e-Health

Smartglasses enable the transmission of data by augmenting visual perception [1,2,3]. This consolidation of information can lead to increased situational awareness without distraction from the primary task. Vorraber *et al.* [1] presented an exploratory study with medical applications of near-eye display devices. In their work, they described the use of Google Glass during a radiological intervention using an app to display vital physical signs. Interventionists who participated in the study reported improved concentration through reduced head movements. Ruminski *et al.* [2] proposed a general architecture of a smartglasses-based system enabling data integration. In that system, smartglasses integrated data obtained for the patient from health care information systems, from the devices connected to the patient, and from the patient himself. The system proposed three methods of identifying people based on face recognition and the use of graphic markers (i.e., QR codes and color codes). Once a person was recognized, the integrated information was projected on the user's smartglasses. "XpertEye" [3] is a tele-proctoring software equipped with five major functions including live streaming capability, a photo feature that allows the mentor surgeon to take a photograph with higher resolution than provided by the live stream, a drawing function that allowed the mentor surgeon to telestrate or annotate images and project them back onto the field surgeon's visual field via the Google Glass, and a zoom function enabling the mentor to zoom into the live stream.

Exploratory studies using Google Glass were conducted in several areas of medical care, such as pediatric surgery [8] and urology [23]. Muensterer *et al.* [8] presented a study consisting of evaluations of Google Glass over four consecutive weeks. A diary was kept on all activities, uses, drawbacks, snags, and pitfalls. Following their evaluation, the authors concluded that Google Glass had clear utility in clinical settings with potential to impact favorably medical care. García-Cruz *et al.* [23] invited eighty urologists to use Google Glass in their daily surgical and clinical practice as well as to share the device with other college urologists. The professionals engaged in that study identified various uses of smartglasses with potential benefits for their daily practice, particularly in urological surgery. Zhao *et al.* [10] conducted a survey to understand how smartglasses could help people with Parkinson's in order to support daily assistance for the self-management of their symptoms.

In this paper, we introduce a wearable, smartglasses-based system for sharing first-person video to remote clients. Our system consists of a `node.js` server which takes snapshots from producers and delivers them to consumers (remote users) on various devices: laptops, smartphones, or tablets.

III. System

Figure 2 shows a diagram block of our system highlighting eyewear devices, software components, the node.js server, and data flows. In our implementation, we used the NorthVision Technologies NC-C05 camera glasses[1] with a full-HD micro video camera, Wi-Fi operation, and 90° field of view. The camera glasses connect to a router using the built-in Wi-Fi connection. Snapshots and video are captured at a resolution of 1920×1080 pixels via HTTP by a JavaScript application running on the `node.js` server.

[1] http://northvisiontec.com/products/camera-spy/glasses-eyewear-camera/nc-c05glasses-camera19201080-avi-tf-card-videophoto-876.html

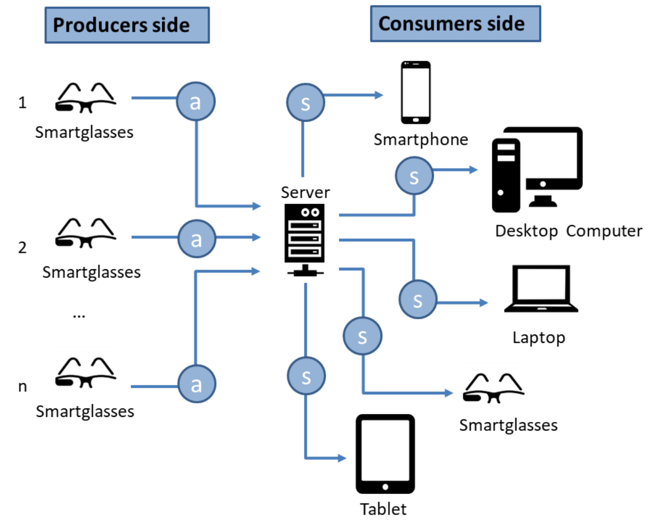

Fig. 2. Block architecture diagram of our system for sharing first-person video to remote viewers. Notes: arrows indicate two dataflow types: snapshot acquisition (a) and sharing video to connected clients (s).

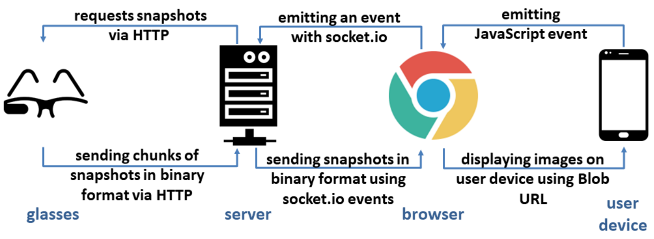

Fig. 3. Snapshot acquisition and sharing to connected clients.

Figure 3 presents the step-by-step procedure of acquiring snapshots from producers and sharing those snapshots to consumers. The server receives snapshots from the camera's glasses via HTTP requests. The bidirectional communication between the client web browser and the server was implemented using `socket.io`, a `JavaScript` library for web applications. We preferred to display snapshots using the Blob URL object. `Socket.io` has two parts: a client-side library that runs in the web browser, and a server-side library for `node.js`. (Note that there are `socket.io` clients implemented for other programming languages as well.) The server requests snapshots only from the devices from which the clients requested them. This way, unnecessary overloading of the server is avoided. The client application is connected to the server using a `socket.io` object, and the user can request snapshots from a particular video stream corresponding to a specific producer (eyewear device). If the server does not have other clients already receiving snapshots of that video stream, the server starts the corresponding stream; see Figure 4. If the server has multiple streams from multiple camera glasses, the user can view all the streams at the same time and the web page is divided into corresponding sections. Figure 5, left presents the `JavaScript` code snippet for listening events from `socket.io` in order to receive snapshots.

```
start() {
  //Check if socket is running or not
  if (!this.isRunning) {
    console.log('start running');
    this.isRunning = true;
  }
  // Acquire snapshots via HTTP
  http.get(this.url, function(res) {
    var data = [];
    res.on("data", function(chunk) {
      data.push(chunk);
    }.bind(this));
    // When recevied last chunk of an image
    res.on("end", function() {
      data = Buffer.concat(data);
      //Send image to consumers
      for (let i = 0; i < this.consumers.length; i++) {
        this.io.to(this.consumers[i]).emit('snapshot', {
          name: this.getName(),
          image: data
        });
      }
      if (this.isRunning)
        this.start();
      else {
        console.log('stop running');
      }
    }.bind(this));
  }.bind(this)).on('error', function(e) {
    console.log('Glasses are not connected!\n', e);
  }).end();
}
```

Fig. 4. JavaScript code snippet implementing snapshot acquisition from the camera glasses via HTTP requests.

```
// Make connection
var socket = io.connect();
// Listen for events
socket.on('snapshot', function(data) {
  for (let i = 0; i < listImgDOM.length; i++) {
    if (listImgDOM[i].alt == data.name)
      imgsDOM[i].src = URL.createObjectURL(new Blob([data.image]));
  }
}
});
```

Fig. 5. JavaScript code snippet implementing snapshot events.

III. Preliminary Evaluation

We evaluated our implementation by running the `node.js` server running on a laptop computer (CPU Intel® Core™ i5-2450M/2.50GHz with 8 GB RAM, Windows 10 Education) and using a smartphone client (Samsung Galaxy J6, CPU Exynos 7870 Octa (14 nm) Octa-Core 1.6 GHz Cortex-A53, RAM memory 3 GB, Android 9, web browser Chrome v76.0.3809.132) in a Wi-Fi network (Archer C60, 2.4 GHz, 450 Mbps). On average, the streaming frequency was 4.26 fps, and the size of the snapshots (encoded in binary) was 311 KB.

IV. Conclusion

We presented a system for sharing first-person video, for which we implemented a `JavaScript` application for routing snapshots captured from eyewear devices to remote viewers. Future work will look at diversifying video streams and sources to include other devices, such as video camera drones, IP video cameras, and Internet live video streams. Also, future work will look at designing user interfaces for multiple video streams by investigating users' preferences and presenting them with several design alternatives [24].

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