Exploring Google Glass for the Future Wearable Social Network and Applications

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Figure 2. Social wearable device enables users to get more interesting context and interactions while exploring objects.

ABSTRACT
In this paper, we have explored Google Glass, a modern wearable computing device, and developed a real-time system for the next decades of wearable computer. The system helps maximize the user interactions via wearable computer user interfaces, augmentation services and social network services. In our proposed system, we utilized Glass Development Kit/Mirror API, open source social network engine, and the augmentation of face recognition to analyze the human behavior/interaction while adapting to wearable computers in the coming era of Wearable Social Network. We expect it to alter how human behaves and interacts with each other in the near future, as the wearable computers are getting more popular in our daily life. Moreover, some issues of system performance, recognition techniques, user’s privacy and limitation are also discussed in this paper.

Author Keywords
Google Glass, user interaction, augmented reality, social network.

ACM Classification Keywords
H.5.2 User Interfaces: Interaction styles.

INTRODUCTION
In recent years, it has become more and more popular that almost everyone has at least a smart device like smartphone. People are switching from a desktop or laptop computer to a mobile computer. Moreover, recent blooming technology in wearable computer such as smartwatch, smartband, shirt, ring and glass has already drawn the huge attention from mass media, investors, developed as well as many potential users worldwide.

Many social network sites such as Facebook, Twitter and Google Plus have being playing vital roles in many people’s daily life. People can have their own personal friendship, photo sharing, and information exchange as well as group communication online via those platforms. Many smartphone applications based on Android and iOS also provide the features by adding web scripts in any mobile/web applications for sharing with friends such as adding plus on Google+, giving like on Facebook, leaving short messages on Twitter, online gaming, electronic commerce and recommendations, and so on.

Our proposed system, in Figures 1, 2, focuses on analyzing the behavior of meeting a new friend in person, who is likely having the same friend of the experimental user, or the person who has common interests with the experimental user, by the augmentation of face recognition in real time. Ordinarily, both parties are required to exchange their social information at the beginning, look for the perspective contacts, and send the invitation to the right person via their smartphones if both are interested in each other. Our system could possibly eliminate the subtly complicated process with great satisfactions. The investigations have shown that people are switching from a desktop or laptop computer to a mobile computer. Moreover, recent blooming technology in wearable computer such as smartwatch, smartband, shirt, ring and glass has already drawn the huge attention from mass media, investors, developers as well as many potential users worldwide.

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Figure 1. The WSN Systems alter the way of human social interactions as a “glass-to-glass” example.
potential users’ feedbacks tend to be positive in our survey (16/23).

We believe the way of people’s communication and friendship building could be much smarter and easier than what we have done today through such a future Wearable Social Network (WSN) system while also considering proper friendship circles and recommendations.

The backend services of our proposed WSN system, which provides services of user-centric, augmented reality and recommendation as Platform-as-a-Service (PaaS) shown in Figure 3 in Cloud Computing (where PRAS stands for Pattern Recognition Analytical Service, and AR Service as Augmented Reality Service) are capable of leveraging current foundations of technology to offer people more specific, context-aware, interactive and convenient life in the next decades.

**RELATED WORK**

**Context-Aware System**

Interactions, contextual information and ideas conveyed between human beings are quite successful and appropriate. In order for improving the computer’s access to context, research projects conducted to understand human richness of context and sophisticated ability transferring to computers have been investigated for quite a long time in the past years. Many researchers had started the works [17, 18, 20, 21] since decades ago. More are still looking for building a system taking more advantages of the context of humans for more advanced and intellectual human-computer interaction [19].

**Google Glass and Wearable Devices**

After Google released the Explorer Edition of Google Glass (Glass Developers [27]) in 2012, more research works [1, 2] have been talking about the Point-Of-View (P.O.V.) technology in medical functions initially. The research papers in pediatric surgery and Parkinson’s assistive device were published especially in 2014. Moreover, more people are looking at more entertainment when wearing the ‘head-mounted’ and ‘versatile’ wearable device in sports, such as GoPro sports camera [16], and so on.

**Social Network Analysis**

Since social networks have tremendously become so popular and important in terms of friendship, information exchange and sharing, some research works such as [7] presented by Rahman and Kim had showed the system that provides recommendations of community of interest through context-aware services from one’s body sensor network. Various research works [3, 8, 9] had also denoted the understanding of strength of social relationship by analyzing the resources from communication logs, social interactions and semantic data as well as further friends recommendation based on the systematic analysis of people’s tag on photos [15].

**Augmentation of Face Recognition**

Many research projects in Computer Vision focusing on object detection and recognition had been done significantly in the last decades [28, 29, 30, 31]. For instances, Iwamura and Kune in [10] demonstrated a real-time memory assistive system through a face recognition system. Utsumi and Kato in [5] had shown the human memory support system by face recognition via a wearable device with head-mounted display and camera. Furthermore, many research works have also investigated some possible methods to automatically organize photos by the approach of face recognition as well as analyzing the context of large-scale social network and some security issues [11, 14].

**Mobile Social Network and Wearable Social Network**

After many researchers had published research works in Mobile Social Network (MSN) [6], the notion of WSN in [4] has been receiving much attention centrally since the wearable computer was designed and released as an early prototype system recently. In our expectation, more research works discovering the intersections and combinations of wearable, social networking, augmented reality such as object detection/recognition and so on will be gaining more attention in the upcoming future. Compared with the research work [12] by Kurze and Roselius, our proposed system would pay more attention on not only the current contacts/friends in the personal social network, but more possible friendship beyond current circle (for instance, sharing common friends and interests), better recommendations based on the power of social network as well as the effectiveness/User Interface (UI) of new social behavior. Consequently, we start to think of building a system, Hero, which could mitigate traditional interactive computing, and expect our proposed system brings and transfers more conversational, contextual and recommending bandwidth or social contacts from much helpful computational services.

**SYSTEM OVERVIEW**

To observe and analyze user’s behavior on WSN systems in
the future, our proposed system, *Hero*, in Figure 4, has been implemented as the following three *Subsystems*:

- Wearable Subsystem (WS)
- Social Network Subsystem (SNS)
- Augmentation Subsystem (AS)

Here the *User* refers to the Glass wearer and opposite candidates. ‘Interface Cloud AWS Service API’ represents the interface to external services; the *Components* mean our enhanced software components in the system to improve overall system performance. Each part of those Subsystems/Components is responsible for a specific function in order to collaborate with the whole work of *Hero*.

**The Wearable Subsystem**
The major task of WS is to capture a face photo of the observing candidate in front of the experimental user. A wearable device, Google Glass, worn by an experimental user helps to perform the task of taking a picture face to face through voice commands. The default or our designed glassware application is triggered to take a picture by two paths. In Path 1, the process starts when it hears the command ‘ok glass ‘take a picture’ in front of the candidate. The taken picture is then saved locally and submitted to a remote AS server with Google Drive Installation. By the voice commands of ‘ok glass, share this with...’ and ‘Google Drive Image Loader’, the further steps will start to be processed. In Path 2 based on our developed APK (Android Glassware Application) with Glass Development Kit (GDK) [27], the glass will save the taken photo and send it to a remote AS server immediately once it hears ‘nice to meet you’ voice command. Then, AS server will start to handle and process the image file once the submission has been completed.

**The Augmentation Subsystem**
After the work of photo submission is completed and detected by the augmentation subsystem (AS) for its arrival, AS server will handle the first step of image processing to identify the face rectangle area of the submission. Since the photos of SNS members were previously fetched to external AWS repository, AS server needs to access them via our designed URL API. Then, the following face recognition step is turned on for searching the identity of the user in the photo from a pool of candidates retrieved from our designed SNS. Finally, the score list of feature matching is returned and the individual with the highest score is selected. The selected result pointing to its retrieved candidate information will be sent to the ‘timeline’ as ‘static-card’ on the glass device and our running instance of Mirror API glassware authenticated by Google Mirror API. At that moment, the experimental user will see the results on the display of Google Glass; the ‘timeline’ application will fetch a new ‘static card’ showing a piece of retrieved message in front of the user’s eyes in Figure 5.

**The Social Network Subsystem**
The main task of SNS is to supply an opening gateway for user’s registrations as well as our experimental purpose on
the analysis of our private social network. Meanwhile, it structures the relationship/friendship (following and follower) of social network of each registered user and provides a set of open APIs for AS’s interactions. In our work, we had previously surveyed several open-source social network systems, such as Elgg [23], Social Engine and an open source Java social project, eXo platform [24], as our potential selections. Eventually, we decide to host a testing server of Social Engine (SE) [22] in our experiments for its ease of use of API and our familiarity in PHP programming.

BEHAVIOR ANALYSIS

The user behavior/interfaces in building the friendship with our Hero system is described in Figure 6, and explained in the following use case with the Glass wearer (blue) and an opposite user Z as our observing candidate (red).

Starting from wearing the Glass with our installed glasswear application, the wearer triggers the Glass to take the picture from opposite candidate by the voice commands. Then, the photo is immediately taken and submitted to the remote AS server by either Path 1 or Path 2.

The response of face recognition should be completed with a returned answer, either “Found” or “Unknown” displaying on wearer’s tiny screen based on if the opposite candidate is the member of SNS resource. Only when the “Found” answer is returned, the wearer could decide if sending an invitation of friendship is needed while the candidate has not become his/her friend yet. A ‘static-card’ with ‘menuItem’ containing a ‘REPLY’ action will let the wearer decide if he/she likes to follow user Z as in Figure 7.

If the wearer’s speaking of “Yes” is detected to send an invitation for further process where our WSN administer Google account is dealing with the speech-to-text processing, the response will be back after the opposite candidate confirms either “Accept” or “Pending”. If the wearer says “No” in response, no event will be sent to the opposite candidate. Currently we use a simulated instance to play the role of opposite candidate’s action, either accepted or pending.

When the “Accept” decision from the opposite Z arrives, the Glass wearer will see a message showing “Complete following Z and followed by Z”, which means user Z has become the wearer’s new friend in the circle on our SNS private social network in Figure 8.

Here we have demonstrated possible subscribed ‘timeline’ information of device-to-device case for user Z. He/she will have decision-making options to send to our Hero server in Figure 9. Currently, the simulated instance acts the behavior of user Z instead.

Figure 5. The Hero System for face recognition referenced from [25] as the Vision Help system.

Figure 6. The interaction of User Interface on Hero System shows how the wearer completes the task. Here black background refers to Glass display and white for backend processing.

Figure 7. The retrieved result returns with a “menuItem” for user’s feedback.

Figure 8. The wearer is following and followed by Z.

Figure 9. Simulated subscription information for the decision of user Z.
Suddenly, the atmosphere becomes much relaxed. While...
probably is due to its low-dimensional subspace compared with Fisher and Eigen that both require higher image space. The accuracy rate is around 82% in a set of 150 trials with brighter light settings. Fisher (62%) and Eigen (67%) are also with the same physical conditions. Thus, with LBPH algorithm we are given good start to observe the recognition process for more performance analysis and tuning.

In addition, we have been continuously looking for better recognition accuracy from many research works. In [30] from Gao and Yin, the work provides us with a promising approach to recognize faces through its learning-base descriptor. The pose-adaptive approach enables us to take additional user photos from various angles (forehead, left cheek, right cheek, mouth) as the training data. Moreover, its Component-level face alignment does help to produce better similarity transformation among eyes, nose, mouth, and so on. Thus, our second approach is implemented as FRLBD for further benchmarks.

In FRLBD, each of 20 candidates is taken 6 photos from various angles in front of their faces (forehead, left eye, left lower cheek, right eye, right lower cheek, mouth, and lower chin) in Figures 12 and 13. The accuracy achieves 90% but FRLBD slightly slower than FaceIntelliJ, so that we incorporate with these two approaches to build up our PRS.

### MULTITHREADING

When we experiment and simulate the conditions of data-intensive computation, we design several use cases to benchmark the system in order to decide which model should be applied under some conditions.

In order to optimize the performance, a reasonable response time should be considered to satisfy the conditions for our real-time system. In FaceIntelliJ, Java Concurrency library is applied to simulate large datasets of images. We compare several approaches in Threads, ThreadPool, ForkJoin, and ParallelArray to process images. Compare with a sequential image loading that consumes 1056ms, the enhanced results shows that Threads (404ms, 2.61x), ThreadPool (295ms, 3.58x), ForkJoin (293ms, 3.60x) and ParallelArray (364ms, 2.90x) are achieved.

In FRLBD, C++ Standard Library Thread is included to help provide multithreading capability. On a server of Windows 8 64-bit with Intel i7 2600K, the execution time of experiments to detect and recognize moving users’ faces has been reduced to 1/4 with 15 threads in Figure 14 (each user is taken 8 pictures continuously in 5 seconds by a Logitech Webcam 500 device). We believe the multithreading enhancements will benefit the conditions of large-scale and data-intensive computation, and wish the performance would be very applicable while more users are using the system.

### PRIVACY AND LIMITATION

The issue of privacy had been raised and discussed more seriously since the era of social networking began. People care about their private information falling into the wrong hands. On the other hand, most people prefer revealing personal information to their friends, ‘one-step’ friends (people sharing common friends but not yet in one’s circle) and those who are attractive and near their circles with similar interests. People with newly building relationship could easily open up new conversations as well as expand their social networks in reality with more potential benefits. In our research, our designed private social network SE sets each user displaying some public and default information for the purpose of following/followed by new friends only, such as ‘Name’, ‘Affiliation’, ‘Research Interests’, ‘Citizenship’, and ‘H-Index’. Since our event background is about participating in a research conference, or a party with new friends telling ‘Interesting things’ and ‘Interested persons’, released information of participating authors and extending networks with friends’ friends should not be any private issue, but meliorate more interactions between researchers and friends in social life. However, it may be prohibited and not applied to the public social network in reality under the circumstance of protections of human rights, policies and laws of many countries and companies providing software devices, services, platforms, and so on.
SURVEY
We have evaluated the testers’ feedbacks we approached during the experiments and our party events with 23 individuals totally. Our proposed system, Hero, is trying to demonstrate and relax the user behavior, assist people in accessing more context and easier to recall names and faces while adapting to the Wearable Social Network. Meanwhile, with proper considerations of friendship building in social network, people would expect to receive more fun, easy, natural, and interactive social relations in reality. Moreover, it would also help to alleviate the embarrassments when people are not well ready for the new friendship online. After the users experience in Wearable Social Network system, our survey is prepared to realize their opinions in the interviews. From possibly adopting a new wearable device with PaaS, the way to manage and maintain social network via a wearable computer, privacy concerns, to convenience, and user-friendliness, the interviewers’ feedbacks with the new social behavior are reported in Figure 15.

Figure 15. The interviews for 23 testers show that they are expecting wearable computer coming to their lives with more positive impacts in the coming future.

DISCUSSION
We learn that people expect wearable computers to bring more interesting and useful services to their living surroundings; however, the concerns regarding personal privacy fraud and theft have not been credited by many of us so completely yet. In other research works, the discussions in many novel and challenging applications like “novel-privacy and security-enhancing applications” in [32] have specifically focused on the design and development for the different approaches to gently improve the authentication process of privacy. In our user-interactive case, the business process taking care of ‘leveraging personal views’ and ‘encrypted content’ as well as ‘implicit authentication’ should be very applicable by tomorrow.

CONCLUSION AND FUTURE WORK
Our contribution to the proposed system by experiments and study of Glass, the techniques of augmentation service, and the analysis of user’s social network as well as the exploring applications between glasses has shown the systems of bringing better user experiences. The users’ behaviors in Wearable Social Network are within a social network group of users as well as some casual parties. It demonstrates the possibility of leveraging more frameworks to give various and stronger impacts on the future behavior of our social relations and interactions physically. We believe our work can be extended to other larger interactive interfaces to make more people participate and collaborate together with one another in the future.

The designed User Interface/Interaction on wearable computers would also likely have the big opportunity for offering more user-friendly/user-interactive wearable applications. From the interviews, we also understand that people expect the wearable computers between both convenience and privacy issues that need to be dealt with carefully and properly.

Future work will make us pay more attention to not only the private social network, but the public social network with proper permissions and considerations of privacy, object detections and recognition accuracy that are AR related, device-to-device applications, real-time surveillance/GPS systems, social network in things (Internet of Things), wearable computers, semantic information retrieval, and security-privacy applications as well as many extended themes of Wearable Social Network in the real world.

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