Facilitating Medical Information Search using Google Glass connected to a Content–based Medical Image Retrieval System

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Abstract— **Wearable computing devices are starting to change the way users interact with computers and the Internet. Among them, Google Glass includes a small screen located in front of the right eye, a camera filming in front of the user and a small computing unit. Google Glass has the advantage to provide online services while allowing the user to perform tasks with his/her hands. These augmented glasses uncover many useful applications, also in the medical domain. For example, Google Glass can easily provide video conference between medical doctors to discuss a live case. Using these glasses can also facilitate medical information search by allowing the access of a large amount of annotated medical cases during a consultation in a non–disruptive fashion for medical staff.**

In this paper, we developed a Google Glass application able to take a photo and send it to a medical image retrieval system along with keywords in order to retrieve similar cases. As a preliminary assessment of the usability of the application, we tested the application under three conditions (images of the skin; printed CT scans and MRI images; and CT and MRI images acquired directly from an LCD screen) to explore whether using Google Glass affects the accuracy of the results returned by the medical image retrieval system. The preliminary results show that despite minor problems due to the relative stability of the Google Glass, images can be sent to and processed by the medical image retrieval system and similar images are returned to the user, potentially helping in the decision making process.

I. INTRODUCTION

With the increasing availability of smartphones, users are getting accustomed to access information from anywhere. Now, wearable devices are getting on the market allowing users to access information in an even more interactive and less disruptive way. For example, smart watches show notifications or messages directly on their screens, letting users get information without looking at their phones on any additional device. As another wearable device, Google introduced Google Glass able to interact with different online services. As illustrated in Fig. 1, Google Glass features a camera taking photos at 5 MPixels and recording video with 720p, a prism in front of the right eye, a touchpad on the right side of the frame as well as speakers and microphone. As an Android device, Google Glass are able to connect to the Internet through Wi–Fi or Bluetooth and they are capable to understand spoken commands and read text aloud. At the moment, only 8000 pairs of Google glass are available worldwide through the Google Explorer Program.

As a new wearable device, Google Glass uncovers many new applications, also in the medical domain, that can ease the work of medical staff from paramedics, nurses to surgeons. Research papers involving Google Glass for medical applications already exist in the literature [1], [2]. Researchers used Google glass during 4 weeks in a hospital [1]. They focused on a limited usage of the built–in capabilities of Google Glass. They tested voice recognition as well as latency, lag time and visual quality of local and transatlantic videoconferencing. Their findings demonstrate that Google Glass could be useful in various medical tasks. However, the current version of Google Glass lacks battery life and Internet connection stability. Similarly, other researchers used Google Glass for documenting medical findings during forensic examinations [2]. They created their own small application for Google Glass to take pictures of body parts hands–free. Using these pictures, they compared the quality of the results to pictures acquired by the state–of–the–art procedure using a DSLR camera. Their results show multiple interesting findings. First, the Google Glass procedure was significantly slower than the state-of-art procedure. Second, pictures taken by Google Glass were not good enough for documenting medical findings compared to the picture taken by a DLSR camera. Still, some of these points can simply be avoided by users having experience with the device and applications being really adapted to the user groups.

Despite a few limitations of Google Glass, we believe that these augmented glasses have the potential to facilitate handling of patients in different stages of treatment. For instance, connected to a content–based image retrieval (CBIR) system, such devices can allow medical staff to search for information or to go through medical history while discussing with a patient. CBIR systems in the medical field give access to large amounts of medical images of cases for later use such as for teaching, research or in diagnosis [3], [4], [5]. Research has shown that CBIR can facilitate diagnosis for radiologists, especially if they are less experienced [6]. Despite a few limitations, Google Glass could allow medical staff to conduct a diagnosis in a non–disruptive way. A medical doctor can talk to a patient while retrieving data from a CBIR system. Google Glass has raised some concerns about patient confidentiality and privacy. In the current case, both patient's consent and protection of patient's data on Internet are achievable. To the best of our knowledge, there are currently no publications on the combination of Google Glass with a CBIR system. Therefore, this paper presents a novel interface to CBIR allowing medical staff to search for images, potentially aiding the decision making. As preliminary assessment, we conducted three tests to examine whether using Google Glass influences the results returned by the CBIR and can be used without problems.

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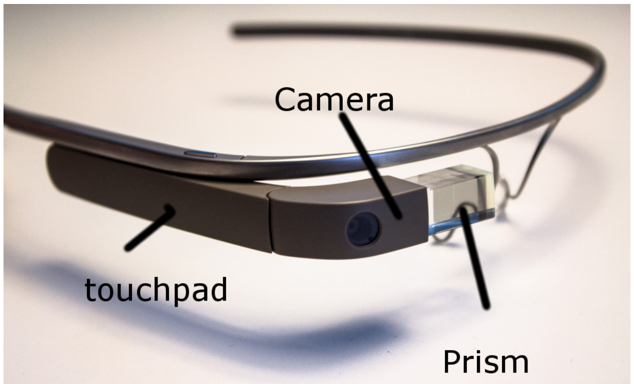


Fig. 1: The Google Glass and their main components.

II. METHODS

A. ParaDISE framework

The retrieval system used in the backend of the Glass application is called ParaDISE [7] (PARAllel Distributed Image Search Engine). This system combines text and content–based medical image retrieval. The service layer of ParaDISE is composed of several web services that use a REST–style (REpresentational State Transfer) architecture. Communication is achieved through standard HTTP (Hypertext Transfer Protocol) requests, using both the GET and POST methods. The use of HTTP, combined with the standard JSON (JavaScript Object Notation) data exchange format, facilitates the interaction between ParaDISE and client applications which access the system (Web–based or desktop applications, Google Glass and other Android devices, etc.) such as Khresmoi for professionals[1].

Below are some details about the various parts of ParaDISE (shown in Figure 2) :

- The caption web service is responsible for searching images by keyword and uses Lucene[2], the open–source information retrieval library which is supported by the Apache software foundation. It is used for user queries as well as querying the captions of provided relevant/irrelevant image examples.
- The visual web service is responsible for the content–based image retrieval. It uses the visual features of an image in order to find similar results in the dataset. It also provides a relevance feedback mechanism, which allows a user to provide relevant and irrelevant image examples to refine a query.
- The fusion web service is responsible for combining result lists from 2 or more data sources (caption, visual, etc.). It can work with a variety of fusion rules, both score–based and rank–based.
- The compound figure web service is responsible for finding links between subfigures and their parents. These subfigures are obtained by separating a compound figure (multiple figures in a single image) into its subparts. Using this Web Service, it is then possible to retrieve the context in which a given subfigure exists in the parent image.
- The global web service acts as a facade for client applications and hides some of the complexity of the individual Web Services, instead allowing the client to make a simple request that will then use one or more of the underlying Web Services as needed.

[1]http://professional.khresmoi.eu/
[2]http://lucene.apache.org/

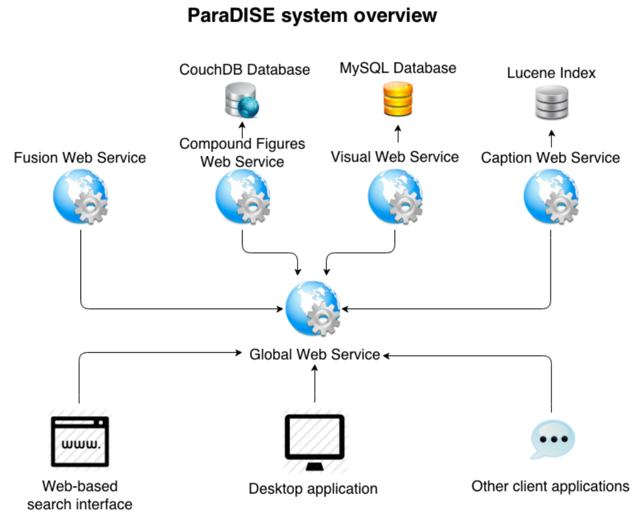


Fig. 2: The ParaDISE service layer architecture.

Fig. 3: List of results images as seen in the Google Glass.

Overall, the ParaDISE system is designed to be modular (independent components), expandable (easy to add new features) and scalable (through the use of parallel and distributed computing and optimized data structures). The ParaDISE system was used to participate in ImageCLEF 2013 [7]. The ImageCLEF benchmark evaluated image retrieval systems on more than 300'000 images of the medical literature. The ParaDISE system obtained best results in compound figure separation and second best for visual image retrieval. Among the top runs in ImageCLEF in 2011 and 2012 [8], [9], the CBIR techniques developed by the medGIFT group [10] were used. A filtering by image modality was included using the modality classification proposed in [8]. Detailed quantitative evaluations of the retrieval algorithms can be found in [7]

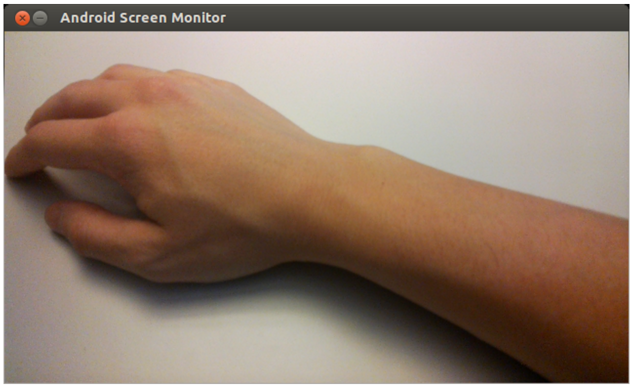


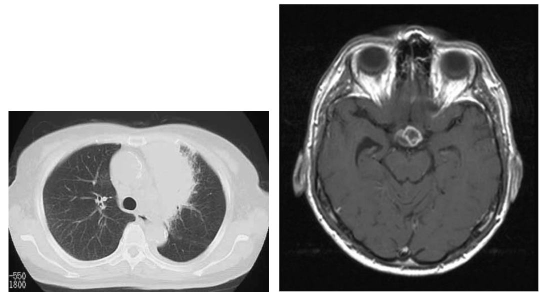
Fig. 4: Photo of a forearm taken by the camera of the Google Glass.

Fig. 5: An example of a retrieved image and caption in the Google Glass.

B. Application for Google Glass

We developed an Android application specifically for Google Glass using Glass plateform XE12. The scenario of the application is as follows:

1) The user starts the application by saying "'ok, Glass, search ParaDISE"'.
2) Google Glass starts the application and activates the camera showing the preview in the prism.
3) When ready, the user can take a photo by tapping on the touchpad on the side of Glass.
4) Once the photo is taken, the user can add spoken keywords if he wishes.
5) The photo is then uploaded to ParaDISE.
6) The request string including keywords, the link to the uploaded image and the number of results (currently 10) is formed and sent to the ParaDISE service.
7) The ParaDISE service searches images that match visual features contained in the uploaded photo and images associated to captions including the keywords in the request.
8) The 10 most relevant results from ParaDISE are sent to Glass. Glass creates visual cards containing the result images with their captions. The user can navigate among them by swiping the touchpad forward or backward as illustrated in Fig. 3.



(a) CT scan of a lung used as test. (b) Brain MRI image used as test.

Fig. 6: The two images used as test of the described system.

C. Protocol of the tests

To investigate the behavior of the application, we designed three tests. The first test examines the retrieval of images containing skin pictures. The goal of this test is to assess whether the system could help dermatologists in their diagnosis. In this test, we used a photo taken by the camera of the Google Glass illustrated in Fig. 4. We then sent this photo to ParaDISE in two scenarios: once with no keyword and once with the following keywords: skin and forearm. The second and the third test explore the retrieval of images using photos of printed radiology images and photos of images displayed on a 24 LCD monitor. The goal of these qualitative tests is to evaluate whether using the camera of Google Glass affects the results returned by ParaDISE. To examine this, we printed two different images, one representing a CT scan of the lungs and the other one representing an MRI of a brain, as shown in Fig. 6a and Fig. 6b, respectively. The CT scan of the lungs was selected outside of the dataset used by ParaDISE whereas the MRI of the brain was randomly selected in the ParaDISE dataset. Similar to the first test, the two images acquired by the Google Glass camera are sent to ParaDISE in two scenarios: once with no keyword and the other one with two keywords: lung + CT and brain + MRI, respectively. In addition to the 2 conditions, we added an extra condition as control condition. Under the control condition, we directly sent both images to ParaDISE without using Google Glass. As a preliminary assessment, we computed the ratio of the number of accurate results returned over the total number of results (in this case only 10 results are returned). An accurate result is an image that contains the exact modality and anatomic region of the source picture. This is not a valid evaluation for diagnosis aid but rather a test to see whether the camera of the glass negatively influences results. The retrieval performance in a benchmark is described in [9], so the used algorithms were among the best in the benchmark and here only a possible degradation due Glass was tested.

III. RESULTS

For the first test examining the image retrieval of the skin of a forearm, there are 3 images showing an arm out of the 10 results sent back by ParaDISE under the condition with no keyword. Under the condition with the keywords arm + skin, 7 images out of 10 are accurate. This shows the importance of selecting some keywords to send with the photo taken by

Test conditions		# of accurate results
Original photo	No keyword	2/10
	Keywords: lung+CT	10/10
Printed photo	No keyword	0/10
	Keywords: lung+CT	10/10
Photo (LCD screen)	No keyword	1/10
	Keywords: lung+CT	7/10

TABLE I: Accuracy of results for the different testing conditions when searching for a lung CT image.

Test conditions		# of accurate results
Original photo	No keyword	2/10
	Keywords: brain+MRI	8/10
Printed photo	No keyword	1/10
	Keywords: brain+MRI	7/10
Photo (LCD screen)	No keyword	1/10
	Keywords: brain+MRI	6/10

TABLE II: Accuracy of results for the different testing conditions when searching for a brain MRI image.

the Google Glass. Table I and Table II display the results for the second and third test, respectively. Under these two tests, the effect of taking a photo with Google Glass can be observed in comparison to using a digital version of the original image sent directly to ParaDISE. In both tests, sending images with no keyword yielded consistently lower results, whereas, using keywords significantly increased the accuracy of the results in all conditions, as shown in Table I and Table II. Taking a photo of a printed image did not affect the number of accurate results returned by ParaDISE compared to the original photo condition. However, taking a photo of an image on an LCD screen produced a smaller number of accurate results compared to the two other conditions.

IV. DISCUSSIONS

The preliminary results highlight two main observations. First, it is important to add keywords to the photo taken by the camera to improve the accuracy of the system. This can easily be added by the medical doctor during the consultation by saying them aloud to be understood by Google Glass. Second, the results show that Google Glass does not seem to significantly alter the response from a CBIR system. This is encouraging to continue developing applications combining Google Glass with similar systems. However, we encountered several small difficulties while developing and using the system. Google Glass still has in the current beta version a few hardware problems. The Wi-Fi connection is not always very stable, making the image retrieval process slower than needed. Second, the camera does not have an autofocus, decreasing the overall quality of the photo that is otherwise in very good quality. The overall battery life is still quite short. These hardware problems are similar to the ones described in the literature. Nevertheless, these problems can be addressed in the public version of the Google Glass and developing applications can also limit these difficulties.

As this paper only describes a pilot application to using Google Glass for image retrieval, we have identified several areas for improvements: (1) The system needs to become less sensitive to lighting environments, for example by adjusting the contrast and/or brightness of the photo taken by the camera to improve the search results. (2) The speed and ease of interaction with the Google Glass needs to be improved to make this application usable by medical staff in routine work. (3) A better evaluation needs to be designed to extensively explore the behavior of the overall system in a realistic setting. (4) A user study involving physicians needs to be carried out to ensure the benefit of such a system on information search in clinical situations.

V. CONCLUSION

This paper describes a an application developed for Google Glass accessing an existing CBIR system in order to retrieve medical images. Despite the limited evaluation the system is exploring shortcomings but also the potential of using Glass for accessing medical information in clinical situations, taking advantage of the built–in camera and the possibility to obtain information on the prism in a non–disruptive way. Physicians can keep the contact with the patient while obtaining additional information. Still in a beta version, Glass can have a large variety of applications scenarios and the medical field is one of them if used in the right way.

ACKNOWLEDGMENT

This work was supported by Khresmoi (257528).

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