# FaceSpeaker: a Wearable Face Recognition Device for the Blind

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## ABSTRACT

FaceSpeaker is a prototype wearable face recognition device which supports visually impaired users during social interactions by covertly identifying their acquaintances. The prototype is based on a laptop worn in a backpack, running the open source FaceSpeaker software. The user controls the prototype using a small Bluetooth keyboard. The user wears camera glasses, and the FaceSpeaker software speaks an enrolled person's name when his face comes in view of the camera.

### Keywords
Social interaction, visual impairment, augmented communication, computer vision, face recognition.

## INTRODUCTION

Face recognition is the primary method by which humans identify each other. Visually impaired persons cannot perceive faces, which means they are unable to rapidly identify people around them. This puts them at a major disadvantage in social interactions.

The FaceSpeaker project aims to design a wearable face recognition device which supports visually impaired users during social interactions by covertly identifying their acquaintances.

Although this is a technical challenge, all the necessary technology to build such a device is available as of 2013. The main challenge lies in designing a device which is socially acceptable to the user and people around him.

In this paper we describe the FaceSpeaker prototype and provide an overview of related work. We describe the study's methods and research questions, and give an overview of the study's results. The full project report, a video demonstration and the FaceSpeaker software can be found at the FaceSpeaker project website (facespeaker.org).


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**Figure 1FaceSpeaker prototype**

## PROTOTYPE DESCRIPTION

The user wears camera glasses and a backpack. The backpack contains a laptop and the "camera box" which holds the hardware for powering the camera glasses and sending the video stream to the laptop. The user controls the laptop using a small Bluetooth keyboard. Audio is conveyed through bone conduction headphones which do not obstruct the ears.

The laptop runs the FaceSpeaker software. This software constantly monitors the video stream captured by the camera and reacts whenever a face comes in view.

If the detected face is unknown, the program issues a single low pitched beep. If the face belongs to a person enrolled in the database, the software issues a high pitched beep and speaks the person's name about half a second later.

The user can enroll a person into the database by typing that person's name on the small Bluetooth keyboard, hitting enter and looking in the person's direction. The software then captures 20 training images and issues a click for every training image captured, which confirms the camera is pointed correctly.


**Figure 2FaceSpeaker UI**

## BACKGROUND

We identified three related research efforts. A team at Arizona State University developed the iCare social interaction assistant (Krishna & Panchanathan, 2010). Their starting point was a face recognition device similar to the FaceSpeaker prototype. They expanded this prototype with various functions including person localization using a haptic belt and detection of socially disruptive stereotypic body mannerisms. Compared to our one year exploratory study, the results of their 5+ year study are far more advanced. Their design recommendations were a major influence on our study but some of their technical results may be outdated as of 2014.

A student team at the University of Maryland developed a prototype similar to FaceSpeaker. While their device could identify acquaintances, the focus of their research was on facial expression recognition (Astler et al., 2011). Their prototype has far more reliable face recognition functionality than FaceSpeaker, because they relied on the commercial Luxand Face SDK (luxand.com) where as we relied on the open source EmguCV wrapper to the openCV library (emgucv.com). Their prototype utilizes a camera mounted atop the user's long cane and is controlled through speech recognition. In our opinion those design choices are inadequate in a social interaction context. Our prototype relies on unobtrusive camera glasses and is controlled by a small keyboard which we will complement by unobtrusive buttons.

A team from Osaka Prefecture University (Japan) published a paper proposing a covert wearable face recognition device to support human memory (Utsumi et al., 2013). They identified high level requirements for such a device and studied the socially acceptable time limit for identifying people. Their requirements and theory on timing were valuable to our study. We cannot (yet) take advantage of their design recommendations as they target sighted users and lack a working prototype.

The FaceSpeaker prototype design was influenced by Peter Meijer's "the vOICe" sensory substitution system (seeingwithsound.com). Another influence was the emergence of "augmented reality" glasses, such as Google Glass.

In June 2013 the Israeli company Orcam released a computer vision device for the partially sighted which will feature face recognition (orcam.com). Their device is not suitable for totally blind users as the user is required to point at objects.

## METHOD AND RESEARCH QUESTIONS

The FaceSpeaker project was an exploratory, qualitative design study which addresses the following research question:

Q1. Is a wearable face recognition device which unobtrusively identifies acquaintances to its user feasible, and what should be its design?

A working prototype was developed. This involved writing a face recognition program in Microsoft Visual C# using the EmguCV computer vision library (emgucv.com) and acquiring the necessary hardware. Research questions addressed during prototype development include:

Q2. Which face recognition library is suitable for the prototype, and how should it be configured?

Q3. What camera should be used, and how should it be mounted onto the user's body?

Q4. How can the software take advantage of a multithreaded environment while minimizing power consumption and heat production?

We launched a project website (facespeaker.org) including a demonstration video. The website was a powerful tool as we gathered feedback from potential users through mailing lists and other channels, and it helped us to gain wide support for our project. Our prototype was field tested at ICCHP Summer University 2013 (an event targeting blind science students) in Karlsruhe (icchp-su.net). This resulted in a lot of user feedback and a better appreciation of the issues involved in designing this device.

User feedback and literature study served as input for a PACT (people, activities, contexts, technology ) analysis(Benyon, Turner & Turner, 2005) and a scenario to illustrate how the device might be used in practice. The "small conference scenario" depicts a FaceSpeaker device supporting a blind user in the context of a small scientific conference. This scenario served to motivate and illustrate various design recommendations for future prototypes. Research questions addressed include:

Q5. What should be the procedure for enrolling new acquaintances?

Q6. How should the device be triggered to identify a person?

Q7. How should the device convey a person's identity to the user?

Q8. How much time is available for conveying a person's identity to the user?

## RESULTS

The study resulted in a working prototype based on open source software which can benefit future research efforts. We identified 2 overriding requirements the device should meet: 1) unobtrusiveness of the device and 2) economizing on the user's attention. We provided various design recommendations for future prototypes.

Recommendations include:

- An option for covertly enrolling acquaintances.
- A "filtered automatic" approach to identifying people, in which the user has options to configure when the device reacts to a person coming in view of the camera.
- The current prototype issues an auditory signal to announce an identification. This should be replaced / complimented by vibrotactile feedback.

A short video demonstration, our software including source code, our full results and the latest news about the follow-up to this project can be found at http://www.facespeaker.org.

## CONCLUSION

The FaceSpeaker exploratory design study resulted in a working prototype and various novel design recommendations for future prototypes. Follow-up studies should elaborate on those design recommendations and validate them by more systematic means.

## ROLE OF THE STUDENT

After a discussion with supervisor Robbert-Jan Beun on a bachelor research concerning mobile identification, author Tim in 't Veld came up with the idea of developing a face recognition device which could help him identify people despite his visual impairment. He subsequently carried out the FaceSpeaker project independently, supported by occasional advise from the supervisor and feedback from his many contacts within the visually impaired community.

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