Research Style: APA 6th Edition

A Portable Computer Vision Device for Improving Social Interactions of the Visually Impaired

Gemstone Team FACE
Thesis Proposal

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We pledge on our honor that we have not given or received any unauthorized assistance on this assignment.

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Abstract:

Human communication can be divided into two subunits: verbal and nonverbal cues. While most sighted individuals are able to communicate in both forms, visually impaired individuals cannot receive most nonverbal messages. The visually impaired are thus handicapped in their social interaction capabilities. To address this handicap, we propose to develop a computer vision device with facial recognition and expression analysis capabilities in order to convey useful nonverbal messages as audio and tactile feedback to a visually impaired user. The device will communicate the names of familiar communication partners, as well as their expression states, differentiated as the six universal macroexpressions (i.e. happiness, sadness, disgust, surprise, fear, and anger). We will then test the device with the visually impaired to evaluate its accuracy and usefulness.

Introduction:

Human communication can be divided into two parts: verbal and nonverbal.we humans seem to rely heavily on verbal messages to relate our ideas, over 65% of two-person communication is carried out through nonverbal messages (Krishna, Colbry, Black, Balasubramanian, & Panchanathan, 2008). These nonverbal messages include facial expressions, hand gestures, and haptics. In the U.S. alone, there are 1.3 million people who are legally blind, with a total of 11.4 million with any degree of visual impairment (Krishna, 2008). This visually impaired population is at a disadvantage when it comes to communicating since its members are not able to interpret many nonverbal messages (Krishna, Little, Black & Panchanathan, 2005).

To address this disadvantage, we propose to use computer vision to provide realtime feedback of facial identification and expression for the visually impaired. Since computer vision

technologies have not typically been applied to handicap assistance, our study will provide insight on the feasibility of computer vision as an aid for the visually impaired. We will also examine whether realtime feedback of facial expressions can allow visually impaired subjects to communicate more effectively. We aim to prototype a device that may assist visually impaired users in their social interactions, and we expect that our work may inspire future research in the field of computer-based handicap assistance.

Through this study, we seek to answer the following question: how can computer vision be used to improve the process of communication for the visually impaired? We believe that the use of computer vision to analyze and relay nonverbal messages in an interaction will improve the quality and ease of face-to-face communication for the visually impaired. This will be done by providing realtime feedback conveying the facial cues of those with whom the visually impaired interact. In order to explore this notion, we propose to design a computer vision package that is capable of relating facial data to users. If time permits, we seek to evaluate the effectiveness of this package through focus group studies and user feedback.

Throughout this proposal, we will address current literature, our proposed methodology, our projected timeline, and our budget. Our literature review will focus on facial recognition and expression analysis as well as applicable hardware. Next, we will address our research design and methodology and also discuss our anticipated results. Finally, we will give a brief timeline to explain the structure and proposed schedule for research and data collection and a budget of the expected costs of this research project.

Literature Review:

Previous research in the field of computer vision has yielded many different solutions to the challenges that arise while designing a portable system. We anticipate similar problems arising in our research, and therefore focus on specific resources to aid us with hardware, software, facial recognition, and expression analysis. Similar studies in assistive devices provide us with things to keep in mind while designing a hardware prototype, while resources explaining the various available algorithms feature heavily in our software considerations. Beyond software and hardware, we must build a understanding of how expressions are detected by humans, to build a interface that can best address vision needs.

Hardware

As part of our hardware considerations, we look at previous studies involving similar assistive technology goals to determine the best methodology for our particular project and problems which may arise. These problems include: lack of a stable light source, unsteadiness of the camera or cameras, power requirements, possible shock damage from equipment being dropped, weight, computing power, and user comfort. Each project described below has used a unique combination of hardware and software to develop a solution in an effort to address these concerns and the needs of the visually impaired community.

In 2009, Gemstone Team Vision integrated a GPS chip, an inertial navigation unit, and a low-resolution USB webcam with audio and haptic feedback to provide an easy-to-use navigation and object recognition package for visually impaired individuals. Team Vision mounted the USB camera onto the bridge of a pair of sunglasses, and wired the system to a

laptop computer running Windows XP (Caperna, Cheng, Cho, Fan, Luthra, O'Leary, Sheng, Sun, Stearns, Tessler, Wong & Yeh, 2009).

In 2008, McDaniel and colleages created a haptic belt to convey the location of a person relative to the user's field of view using vibro-tactile signals. This type of feedback is more effective than auditory cues in communicating location because it takes advantage of the sensitivity and reliability of the visually impaired's sense of touch. In addition, vibro-tactile signals are not open to variable interpretation and do not interfere with other activities of the visually impaired (McDaniel, Krishna, Balasubramanian, Colbry & Panchanathan, 2008).

In 2005, Krishna and colleagues developed a wearable face recognition system. They used a pinhole aperture analog CCD camera mounted in a pair of sunglasses. The analog feed was then converted to digital video format through an Adaptec® video digitizer. A tablet PC with an Intel Centrino processor was used to process the images and implement a text-to-speech converter to inform the user of positively matched faces (Krishna, Little, Black & Panchanathan, 2005).

All of the aforementioned studies used a single camera for image acquisition. However, stereo vision has been used in other research to provide better accuracy and versatility when gathering facial data as compared to monocular vision. This method allows for 3-D face tracking and recognition of faces and expressions with improved robustness than a single camera setup, and has not yet been applied in an assistive device for the visually impaired. Stereo vision can also help to stabilize a video feed that comes from a camera that is not mounted on a tripod (Yang & Zhang, 2002).

Software

After choosing which hardware components to use in our system, we need to consider what type of software would be most accurate and efficient for the real-time analysis of a video stream. Software considerations also require a thorough understanding of previous research. Our team has chosen to use the Open Source Computer Vision Library, or OpenCV, as per the recommendation by our mentor, Dr. Chellappa (Chellappa, personal communication, November 2009). OpenCV is an open source library of functions that can be applied to various fields in computer vision, such as object recognition, motion analysis, stereo vision, camera calibration, image processing, and structural analysis (Agam, 2006). It was developed by the Intel Microprocessor Research Lab and is written in the C and C++ languages. OpenCV was developed for real-time applications so that the system incorporating OpenCV can respond to information at the same time as it is receiving it. We will be using functions from the OpenCV library to develop and implement our facial recognition and facial expression algorithms.

Not all recognition algorithms are suitable for a device that proposes realtime feedback to human users. In order to determine the best algorithms for our purposes of facial recognition and expression analysis, we must educate ourselves concerning existing algorithms. The following sections on Facial Recognition and Expression Recognition further describe our software analysis.

Our purusal of previous research in our software considerations serves two purposes. Not only do we create an understanding of popular algorithms in the computer vision field, but a system optimized to recognize signs of emotion has the potential to create a tool for social scientists (Bailenson, Pontikakis, Mauss, Gross, Jabon, Hutcherson, Nass, & John, 2008). These

resources also provide information on how emotions should be defined within a recognition algorithm, all of which will help us develop our own software and system.

Facial Recognition

In the last twenty years, the computer-based facial recognition field has expanded rapidly. Several algorithms have been introduced and improved to the point where computers can rival humans in accuracy of facial recognition (O'Toole, 2007). In order to develop our product, we need to understand how we identify faces, and to understand and evaluate the different existing facial recognition algorithms and examine existing applications of this technology.

Sinha, Balas, Ostrovsky, and Russell outline nineteen basic results regarding human facial recognition, including many of the methods that humans use to identify faces (2006). They show that the study of human processes involved in facial recognition and the artificial algorithms being used for facial recognition systems are inextricably linked together. The human brain can recognize faces in 120 milliseconds (ms) (Sinha, et al., 2006). In order to achieve a useful system, the algorithm we choose must have near realtime feedback.

Several real time algorithms have been developed in recent years. Ross Beveridge of the Colorado State University evaluated the efficiency and accuracy of the major algorithms (2007). He concluded that Principle Component Analysis (PCA), Linear Discriminant Analysis (LDA), Elastic Graph Matching (EGM), and Bayesian Intrapersonal/Extrapersonal Image Difference Classifier (BIC) were the four major baseline algorithms. PCA is effective in recognizing faces based on vector values it computes based on image input (Yang, Zhang, Frangi, & Yang, 2004), while other algorithms may include graph matching methods with a high accuracy rate (Ersi &

Zelek, 2007). A study by Krishna, Little, Black, and Panchanathan also evaluated these algorithms with respect to changes in illumination and pose. The LDA and PCA algorithms were found to be superior. LDA was fastest while PCA was the most accurate (Krishna et. al., 2005). We will be evaluating these four algorithms (PCA, LDA, EGM, and BIC) to determine what works best for our purposes, as our conditions may be slightly different than those of previous studies.

These algorithms may be susceptible to several well known challenges, including pose, illumination, and resolution, as outlined by Zhao, Chellappa, Phillips, and Rosenfeld (2003). However, over the past several years, major improvements have been made to these baseline algorithms. In an experiment by Alice J. O'Toole, seven facial recognition algorithms were compared with humans on face matching tasks. Out of the seven algorithms, three were better at recognizing faces than humans were (O'Toole, 2007). Though illumination still presented problems, O'Toole's study shows that current algorithm capabilities compete favorably with human ability to recognize faces.

Systems for recognizing faces do currently exist. However, many of the existing facial recognition systems are created for information security rather than for the visually impaired (Xiao & Yang, 2009). Even so, these systems show that it is possible for a recognition system to recognize faces acquired under controlled conditions at a recognition rate of 99.2% in near realtime (Xiao & Yang, 2009). One system, developed by Krishna and colleages, uses a PCA algorithm and was designed with the visually impaired in mind (Krishna et. al., 2005). Krishna and colleages' system does not use stereo cameras, nor was it tested on visually impaired users.

This system also did not have a facial expression recognition feature. Our system will incorporate these features.

Another challenge to consider is the movement of visually impaired subjects which may cause the acquired faces to be blurred. We need to develop image deblurring tools and feed the restored face images to the recognition algorihms.

Expression Recognition

In order to use facial expression recognition algorithms to improve social interactions among the visually impaired, we need to understand the biological underpinnings and universality of facial expression, as well as research existing algorithms.

Paul Ekman and Wallace V. Friesen identified six universal facial expressions in an experiment conducted among a group of New Guinea tribe members who had been isolated from foreign cultures. They found that the subjects were able to accurately identify certain expressions – happiness, anger, sadness, disgust, surprise and fear – depicted in pictures of different facial poses. Their findings support the theory of the universal correspondence between certain facial behaviors with certain emotions (Ekman & Friesen, 1971). These expressions are characterized by the facial action coding system which uses 44 small facial movement action units (AU), each of which encodes a specific facial muscle action (Ekman & Friesen, 1978). Since the expressions stated above can be recognized cross-culturally, the primary focus of our computer algorithm will be on detecting these six universal expressions.

Experiments have also been conducted where motion in the major facial areas (the mouth, eyes, and eyebrows) was selectively frozen through videos. These studies concluded that in some expressions, single movements could play the decisive role in differentiating facial

expressions while, in other expressions, multiple movements were necessary in differentiating facial expressions (Nusseck, 2008).

Takeo Kanade, Jeffrey F. Cohn, and Yingli Tian compiled a database of 2105 coded facial expression images using FACS (2000). This database consists of thousands of different faces, all with various expressions, poses, and illuminations. We will test the chosen algorithms and final system on this facial database to ensure accuracy and efficiency.

One prominent expression detector is a parametric optical flow-based algorithm that analyzes facial expressions in realtime, developed by Yacoob and Black in 1997. This algorithm employs facial tracking and facial feature tracking, checking changes against thresholds established by existing databases (Black & Yacoob, 1997).

Methodology:

Research Design

Our research is defined by a product design process, which involves many steps including interviews, surveys, focus groups, and experiments, as shown in Figure 1. While product development in general includes many stages, such as product specification, concept generation, system design, detail design, testing and modification, and production, the main focus of this study will be on system design, detail design, and test and modification. Using the qualitative data gained in interviews, surveys, and focus groups, we will develop our system design and detail design. Once we have a finalized design, we will build a prototype and test it both quantitatively through experimentation and qualitatively through observation (Dally, 2000).

A product design approach will allow us to contribute new methods to solving the proposed research problem. Experimentation, focus groups, surveys, and interviews alone are not

a viable alternative to product design, but rather serve as an integral part of the research process that is required to design the proposed prototype. This research gives us the opportunity to obtain information concerning the most effective way to provide the visually impaired with real time feedback of visual cues. Product development is applied research, therefore, we would be offering a practical solution to address the needs of the visually impaired (Graziano & Raulin, 2010).

While we are striving to minimize drawbacks in our study, we realize our time constraints will limit us in the scope of our project. The wide variety of opinions and ideas regarding the proposed system design may be too broad to address in their entirety. Another limitation we foresee is the limited sample size of subjects available for our studies. As a result, the conclusions we draw may not be entirely generalizable to the population we aim to assist (Graziano & Raulin, 2010).

A product design approach also has many benefits. Existing algorithms for face recognition, such as PCA and LDA (Krishna et al., 2005), and expression analysis, such as optical flow (Yacoob, personal communication, November 2009), provide a solid foundation for prototype software development. The framework created by Team Vision also provides a good hardware-software model base on which we can improve (Caperna et al., 2009). Team Vision integrated a camera, laptop, and haptic belt into a hardware package, and created associated software to assist the visually impaired with navigation and object recognition, which we can adapt to implement our facial recognition and expression analysis.

Research Process

We will utilize both quantitative and qualitative data to address our research questions. The accuracy of the device we will be designing will be measured quantitatively, whereas the overall usefulness and reception of our product will ultimately be measured qualitatively through user feedback. For each step of the research process that involves human subjects, we will need to obtain Institutional Review Board (IRB) approval (Graziano & Raulin, 2010).

In the first phase of our research, we will conduct interviews and focus groups with our target audience, the visually impaired. We will also survey a group of sighted subjects in order to better understand how society may view users of our technology. In order to have a representative sample, we will need to gather feedback from people of both genders, a wide range of ages and socioeconomic backgrounds, and people of varying levels of technological ability (Graziano & Raulin, 2010). These people will consist of the visually impaired and the sighted. Subjects will be recruited through contacts at the Columbia Lighthouse for the Blind and the University of Maryland on an ad hoc sampling basis. While we recognize that these two institutions might have biases concerning age and socioeconomic background, we know that working with these two institutions is feasible, whereas working with others may not be a realistic option.

We will randomly divide visually impaired subjects into either an interview group or focus group. The interview group will consist of around ten to fifteen visually impaired individuals who will be asked a series of questions through one-on-one sessions conducted by a team member. The interviews will take place at the Columbia Lighthouse for the Blind in the Greater Washington D.C. Metropolitan Area and at the University of Maryland, College Park,

and will last approximately fifteen to twenty minutes. Prior to conducting the interviews, we will collect information regarding the age, age at which vision became impaired, gender, socioeconomic status, nationality, and level of education of participants. Questions in the interviews and focus groups will include both close-ended and open-ended prompts. Restricting interviews to closed and scaled questions impedes the collection of valuable data (Burns, 2000). Please see Appendix V for questions that will be included in the interviews and focus groups.

Next, we intend to conduct three or four focus groups, each consisting of five individuals and lasting thirty to forty minutes. These focus groups will also take place at the Columbia Lighthouse for the Blind. The focus groups will be led by two members of our research team. Prior to conducting the focus groups, we will collect information regarding the age, age at which vision became impaired, gender, socioeconomic status, nationality, and level of education of participants. We will ask questions similar to those asked during the interviews; however, the questions will be more direct and will be based on the responses received in the interviews. The focus groups give the team a chance to collect more specific data and allow the participants to build on each other's ideas with the aim to have a more in-depth response from the participants (Krueger & Casey, 2009).

The demographic data for the interview and focus group subjects will provide insight into the social interactions of the visually impaired, as well as provide the team with feedback on how to improve the prototype. For both interviews and focus groups, we will record our conversations with a digital recorder. We will then provide our participants with a Braille transcript within two weeks to reassure them that we did not alter their responses (Burns, 2000). Since we will most

likely be working with the same people during the testing phase, it is essential that we establish this trust.

We also plan on conducting anonymous electronic surveys with sighted individuals in the Washington D.C. Metropolitan Area. The surveys will be anonymous to ensure honest answers (Burns, 2000). We will survey approximately thirty individuals, fifteen of whom are students and professors at the University of Maryland, and the other fifteen of whom are non-University of Maryland students or professors. Surveys should take around five minutes to complete. Prior to conducting the surveys, we will ask participants to report their age, gender, socioeconomic status, nationality, and level of education. Please see Appendix V for the format of an electronic survey.

These attitudes will help us to design a technology that can be smoothly integrated into mainstream society. Ideally, we would like to have a random sampling of subjects, but we do not believe that this is feasible. As a result, the subjects for these interviews will be as representative of the true population as possible, varied in age, gender, level of education, and level of interaction with the visually impaired.

After conducting the interviews, focus groups, and surveys, we will analyze the results and modify our proposed product design. This commences the product development phase of our research process. We will first identify user needs according to the information gathered from the interviews and focus groups. In order to determine the most universally accepted design, we will focus heavily on frequency (how often a suggestion is mentioned), and emotion (how much emotional reaction is given to a suggestion) (Dally, 2000). The need for a certain feature of

functionality will be quantified by taking the frequency into account, as well as the importance participants assign on a nominal scale. The purpose of quantifying this data is to establish the need and justification of certain features of the product over others; design considerations will mostly make use of qualitative data.

The second step is product design. Using the most universally accepted design as determined from the interviews and focus groups, we will build a prototype of our product. This is perhaps the longest stage of our research process. Prototype development involves the selection of hardware and software deemed appropriate during interviews and algorithm evaluations, respectively. Possible prototypes at this time involve stereocamera placement on glasses, headbands, or shoulder mounts in the form of pendants or clasps. Another concept developed during consultations with the National Federation of the Blind technology team (NFB, personal communication, February 2010) involves placement of cameras and vibrotactile devices on a standard white canes. These and other concepts will be thorougly explored during interviews and focus groups.

Some algorithms for facial recognition and expression analysis have already been developed, but we need to effectively interface them with our hardware, which is yet to be determined. We intend to use our own implementation of the PCA-SIFT algorithm for face recognition due to its robust and efficient nature (Ke & Sukthankar, 2004). We will also use a parametric flow model to detect and report facial expressions (Yacoob, 2009). Our mentor, Dr. Rama Chellappa is a world-renowned expert in facial recognition technology. Our personal communication serves as a powerful resource while evaluating algorithms.

Due to time constraints and computer processing power limitations, our expression algorithm will only focus on the six universal expressions; happiness, sadness, anger, fear, surprise, and disgust (Nusseck, 2008). Focusing on these primary expressions narrows our scope and eliminates the need to consider different cultures and interpretations (Nusseck, 2008). We will not attempt to identify and analyze microexpressions, which not only require extra processing power that may not be available, but also have debatable interpretations (Yacoob, 2009).

The hardware design of our system is in its beginning stages, but some progress has been made toward camera selection and user interfacing. For image acquisition, we intend to use a pair of cameras that will provide stereovision capabilities. Compared to monocular vision, stereovision is capable of providing better accuracy and versatility when gathering facial data (Yang & Zhang, 2002). The cameras will be mounted at eye or forehead level to better imitate human vision. For image analysis, these cameras will be interfaced with a Microsoft Windows capable laptop computer via a Universal Serial Bus or IEEE-1394a/b connection.

As far as user interfacing is concerned, pending interview and focus group responses, we plan to incorporate a voice recognition and audio feedback system with text-to-speech capabilities as well as a haptic feedback belt. These systems will allow us to communicate identity and facial expressions to the visually impaired in a non-visual manner. The framework for this interface has already been developed by Caperna et al., (2009) of the Gemstone Team Vision. The haptic belt will be redesigned to provide stronger signals (vibrations), more accurate directional feedback, and increased comfort for the user. It will contain multiple vibrotactile devices that will emit vibrations to convey direction, a compass, and a wireless interface. In

regards to audio feedback, voices, chimes, tunes, varying pitches, tones, and beeps will be investigated and some may be incorporated. Depending on the results from the focus group studies, these designs may change to better suit user needs.

We will then test the system for accuracy and efficiency. The data collected here will be quantitative, as we will record the number of correct identifications, based on definitive data provided by facial recognition and expression databases (accuracy) and the time required to reach such results (efficiency), a method similar to that conducted by Krishna et al. (2005). Please see Appendix IV for a development evaluation rubric for recognition and expression algorithms. We hope to achieve a high accuracy in realtime identification (ninety percent or higher correct identifications); the accuracy of the software will be tested with facial images from the Cohn-Kanade Database (Kanade & Cohn, 2000) before testing with our target population. The PCA algorithm has a 90.33% overall recognition accuracy rate (Krishna et al., 2005). This demonstrates the feasibility of attaining a system with a ninety percent or higher accuracy rate. Due to the availability of very large data sets; we will need to statistical tests such as Analysis of Variance (ANOVA) and Receiver Operating Characteristic (ROC) analyses on our results for accuracy and efficiency to verify validity. The system will be reworked until we achieve a statistically significant accuracy and efficiency rating.

Finally, we will test our prototype with our target population, the visually impaired (Dally, 2000). We will first introduce our subjects to the device and then have them sit in an empty room while various members of our research team, already programmed to be recognized by the device, enter quietly. We will assess the accuracy of the algorithm by observing its detection of faces and the subject's correct identification of the team member. We will also

compare this to how well a subject can identify members of our research team without assistance from the prototype device.

The next testing phase consists of showing the subjects a series of two videos, A and B. These will be monologues performed by two different actors (one male, one female). Between the two videos, all six major expressions will be covered. First, participants will be shown one video without the aid of the device and asked to evaluate their level of understanding of the speaker's feelings. They will then be shown the other video with the aid of the device and asked to again evaluate their level of understanding. We will compare these two sets of responses to measure the effectiveness of our device. Half of the subjects will be shown video A first (without the device) and video B second (with the device), while the other half will be shown the videos in the reverse order. This eliminates possible extraneous variables such as effects that the gender and personality of the actor may have on the interpretation of expression, both by the device, and by the subject (Graziano & Raulin, 2010).

The final stage of testing involves personal interaction between the visually impaired and the unimpaired. We will set up a series of three one-on-one conversations between research team members or actors and subjects aided by the prototype device. A loose script will be provided for the team member or actor, but the conversation will be allowed to flow as naturally as possible. This more accurately depicts a real life implementation of the device. Participants will then be asked to evaluate their social interactions with the aid of the product through interview. They will also be asked if they would use the device regularly. If they are not comfortable, what changes would they recommend to improve the product? From this data we can assess the overall satisfaction with the device.

The final state of data analysis follows the completion of our testing phase. We will take all the data that we have collected from the interviews, focus groups, prototype testing, and final consumer testing in order to determine the effectiveness of our product. If we find that the data (quantitative and qualitative) points to strong reception of the product defined by integration of nonverbal cues in communication between the visually impaired, we will conclude that facial recognition and expression analysis software can be used to aid the visually impaired.

Experimental Concerns

It is important to address extraneous or confounding variables that may affect our data. These variables include a relatively small sample size; the varying characteristics, backgrounds, and interests of the participants; and the age at which the participants acquired visual impairment. The small sample size may prevent us from generalizing our results to the entirety of the population that we wish to study, because they would not be representative of the entire visually impaired community (Graziano & Raulin, 2010). A patient with congenital blindness would not have the recollections of expression that someone who loses sight at a later age in life would have; this may affect the user's interpretation of the data they receive from the product.

The different characteristics, backgrounds, and interests of the participants could also pose some problems in our research. Limited diversity in our interviews and focus groups could skew results, and therefore, our product development decisions (Krueger & Casey, 2009). This could have a major impact on our final results. Since we are introducing a new technology, if the participant does not have very much technological experience he or she will most likely have more trouble using our product than someone more technologically inclined. In addition, the person's gender, race, or age could also play a factor in how much he or she likes or is able to use

the product. A younger person who has only been blind for a short period of time may enjoy using the product more than an older person who has been blind for his or her entire life. Since the older person has lived without vision for a longer time period, he or she has a greater chance of not seeing a need for the technology. Therefore, he or she may have less incentive to learn how to use the product, because it would require a change to his or her way of living (Bugental & Bugental, 1996).

Another variable that could affect our data would be measurement reactivity (Graziano & Raulin, 2010). During an interview, or when participants are observed using the product, they may be influenced by the presence of the interviewer. This introduces bias in their answers, since they are more likely to respond in a manner that they feel is expected by the researchers; this significantly skews collected data. Due to this confounding variable, the initial phase includes focus groups in addition to interviews. People in larger groups are able to react to each other and better generate ideas, eliminating the chances for bias caused by measurement reactivity (Mazza & Berrè, 2007). The combination of focus groups with interviews provides us with adequate feedback for use in our research.

Appendices:

I. Glossary

Algorithm: a process or set of rules to be followed in calculations or other problem-solving operations, especially by a computer.

Congenital Blindness: blindness present from birth.

Computer Vision: the scientific and technological aspects of artificial intelligence systems that extract information from an image or a sequence of images (video).

Haptic: any signal appealing to the sense of touch, including vibrations, motions, and/or forces.

Microexpressions: changes in facial features which last short amounts of time; most often expressed and interpreted subconsciously

Monocular: signal transmission from one source and channel.

Nonverbal Communication: gestures, expressions, and body language which is important within the context of a conversation

Smart Card: card with an embedded microprocessor that provides electronic authentication.

Stereo: signal transmission from two or more independent sources and channels.

Text-To-Speech (TTS): a system that converts normal language text into speech.

Vibrotactile Devices: devices that emit vibrations, usually incorporated in human and computer interaction systems.

Visually Impaired: any visual difficulty which qualifies the person as disabled, includes various degrees of sight loss to complete blindness

II. Budget

Device Hardware:		**Cost**
Lenovo Laptop		$800.00
Dragonfly 2 Cameras		$1,500.00
Camera Lenses		$100.00
Firewire Cables		$40.00
Firewire Express Card		$20.00
Wires		$50.00
Microphone		$80.00
Circuit box		$80.00
Mounting Rod		$100.00
Haptic Belt		
Wires		$10.00
OceanServer Compass		$200.00
Belt Material		$15.00
Vibrotactile devices		$10.00
Tape		$3.00
	Subtotal:	**$3,008.00**
Miscellaneous Supplies:		
Digital voice recorder		$30.00
Logitech Webcam		$70.00
	Total:	**$3,108.00**

III. Timeline

	3/11/10	3/31/10	4/1/10	7/15/10	9/1/10
Facial Recognition					

Software					
Research facial recognition algorithms					
Test for accuracy and time					
Pick the algorithm we're going to use					
Hardware and Software					
Integrate algorithm into existing system					
Test with final prototype with human subjects					
Modify prototype					
Finalize prototype with both groups					
Facial Expression					
Software					
Research facial expression algorithms					
Test for accuracy and time					
Pick the algorithm we're going to use					
Hardware					
Integrate algorithm into existing system					
Test with final prototype with human subjects					
Modify prototype					
Finalize prototype with both groups					
Team Goals					
Revise IRB					
Preliminary interviews and focus groups					
Conduct surveys after testing with subjects					
Revise thesis proposal					
Attend Junior Colloquia					
Undergraduate Research Day					
Test and retest system					
Write thesis					

Timeline Continued

	11/10/10	4/1/11	9/1/11	11/25/11	4/1/12	5/10/12
Facial Recognition						
Software						
Research facial recognition algorithms						
Test for accuracy and time						
Pick the algorithm we're going to use						
Hardware and Software						
Integrate algorithm into existing system						
Test with final prototype with human subjects						
Modify prototype						

Finalize prototype with both groups						
Facial Expression						
Software						
Research facial expression algorithms						
Test for accuracy and time						
Pick the algorithm we're going to use						
Hardware						
Integrate algorithm into existing system						
Test with final prototype with human subjects						
Modify prototype						
Finalize prototype with both groups						
Team Goals						
Revise IRB						
Preliminary interviews and focus groups						
Conduct surveys after testing with subjects						
Revise thesis proposal						
Attend Junior Colloquia						
Undergraduate Research Day						
Test and retest system						
Write thesis						

IV. Development Testing Rubric for Algorithms

Algorithm Evaluation Rubric

Algorithms will be evaluated using a series of tests to determine accuracy and efficiency. The initial testing will be performed using sets of images from the Cohn-Kanade database[1] which will also be used to train the algorithm. After this initial testing, video recordings of members of our research team at various distances and under various lighting conditions will be used. As a last step, we will run experiments using real-time video capture in natural settings.

Expression Recognition

The accuracy of the algorithm is determined by the portion of video clips the system is able to identify correctly out of a data set. Misidentifications, defined as the algorithm repeatedly recognizing a certain expression as another, are counted as a subset of all failed identifications.

$$Accuracy = \frac{CorrectIdentifications}{N}$$

where N is the number of testing images in a given set.

$$MisidentificationRate = \frac{Misidentifications}{FailedIdentifications}$$

Efficiency is based on the number of frames required for a correct identification of expression.

Face Recognition

Our testing set for recognition algorithms is composed of pictures captured of different individuals directly in front of the subject and 30 degrees to the right of the subject.

During the accuracy testing of recognition algorithms, efficiency can be measured as the speed of each test and the number of frames each algorithm requires for optimal accuracy results.

[1] The Cohn-Kanade database is comprised of facial expression data from from 97 unique subjects. Each subject was recorded expressing the six universal expressions, and frames for each of these recordings are made available in the database.

V. Institutional Review Board Application

UNIVERSITY OF MARYLAND, COLLEGE PARK
Institutional Review Board
Initial Application for Research Involving Human Subjects

Name of Principal Investigator (PI) or Project Faculty Advisor *(NOT a student or fellow)*	Dr. Rama Chellappa	**Tel. No**	(301) 405-3656
Name of Co-Investigator (Co-PI)	Dr. Cha-Min Tang	**Tel. No**	(410) 706-2347
E-Mail Address of PI	rama@cfar.umd.edu	**E-Mail Address of Co-PI**	ctang@som.umaryland.edu
Name and address of contact to receive approval documents	Dr. Rama Chellappa Rm. 4411, A.V. Williams Building 115 Paint Branch Drive University of Maryland College Park, MD 20742		

Name of Student Investigator	Kailin Hsu	**Tel. No.**	(240) 380-0831
E-Mail Address of Student Investigator	face.gemstone@gmail.com		
Check here if this is a student master's thesis or a dissertation research project			
Department or Unit Administering the Project	Gemstone Honors Program		
Project Title	Facial Analysis for Communicating Expression		

Funding Agency:

ORAA Proposal ID Number:

Names of any additional Federal agencies providing funds or other support for this research project:

Target Population: The study population will include (Check all that apply):

☐ pregnant women	☐ neonates	
☐ minors/children	☐ prisoners	☐ individuals with mental disabilities
☐ human fetuses	X students	X individuals with physical disabilities

Exempt or Nonexempt (Optional): You may recommend your research for exemption or nonexemption by checking the appropriate box below. For exempt recommendation, list the numbers for the exempt category(s) that apply.

Exempt----List Exemption Category(s)		***Or***	**Non-Exempt**

If exempt, briefly describe the reason(s) for exemption.

Date	**Signature of Principal Investigator or Faculty Advisor**
Date	**Signature of Co-Principal Investigator**
Date	**Signature of Student Investigator**
Date	**REQUIRED** Departmental Signature **Name _____,** **Title_____** ***(Please also print name of person signing above)***

(PLEASE NOTE: The Departmental signature block should not be signed by the investigator or the student investigator's advisor.)

For Internal Use Only (to be completed by the IRB Office) Application #:

Instructions for Completing the Application

The Departmental Signature block should be signed by the IRB Liaison or Alternate IRB Liaison unless there is a conflict of interest. If the Department or Unit does not have an IRB Liaison, the Department Head, Unit Head or Designee should sign the application.

Please provide the following information in a way that will be intelligible to non-specialists in your specific subject area.

1. **Abstract:** Provide an abstract (no more than 200 words) that describes the purpose of this research and summarizes the strategies used to protect human subjects. For HHS sponsored or funded research, you must submit a copy of your grant application for review.

Our goal is to create a device that will aid interaction among the visually impaired by using a combination of facial expression and recognition algorithms and a mounted camera system. We plan to produce a system that will convey the identity and expressions of individuals to the visually impaired.

	By obtaining information through interviews, focus groups and surveys, we will have a better understanding of how such a device would impact the visually impaired community. Thus, we will be able to tailor the product design to provide for the needs of the visually impaired user. There are no known risks for subjects participating in our research. We will work to protect the confidentiality of subjects by assigning a number to each person and referring to participants only by their numbers. We will not disclose any personal information when presenting our research. To ensure the accuracy of information we collect from the interviews and focus groups, transcripts of the interview questions and responses will be emailed to each participant within two weeks following the session; participants will review the transcripts and return feedback/comments to our team email address (face.gemstone@gmail.com) or our mentor's mailing address (Dr. Rama Chellappa, Rm. 4411, A.V. Williams Building, 115 Paint Branch Drive, University of Maryland, College Park, MD 20742). Sighted individuals will complete online surveys; they will not be asked to provide their names to promote confidentiality.	
2.	**Subject Selection:**	
	a.	Who will be the subjects? How will you recruit them? If you plan to advertise for subjects, please include a copy of the advertisement. The subjects will include visually impaired and sighted individuals. The visually impaired participants will be recruited from the Columbia Lighthouse for the Blind and the University of Maryland. At the Columbia Lighthouse for the Blind, participants will be recruited through an announcement by the staff (please see Appendix A for a copy of this announcement). At the University of Maryland, visually impaired participants will be contacted through the Disability Support Service via email announcements (please see Appendix B for the email language). Sighted individuals will be recruited through an email to the families and friends of Team Facial Analysis for Communicating Expression (FACE) members (please see Appendix C for the email language).
	b.	Will the subjects be selected for any specific characteristics (e.g., age, sex, race, ethnic origin, religion, or any social or economic qualifications)? We will not select participants based on any characteristics listed above, with the exception of age. We will have two groups of participants over the age of 18: sighted and visually impaired.
	c.	State why the selection will be made on the basis or bases given in 2(b). We will select participants over the age of 18 because they are a more accessible population and they are able to sign their own consent forms.

		The sighted participants will be selected from the University of Maryland community and from outside of the University of Maryland community. We are using University of Maryland students and faculty due to the accessibility of this population, and non-university individuals in hopes that we may be better able to generalize our data.
	d.	How many subjects will you recruit? We will recruit at least thirty sighted individuals and twenty-five to thirty visually impaired subjects. We will recruit no more than a total of 100 participants in each group.

3. Procedures: What precisely will be done to the subjects? Describe in detail your methods and procedures in terms of what will be done to subjects. How many subjects are being recruited? What is the total investment of time of the subjects? If subjects will complete surveys and/or other instruments on more than one occasion, state this in the procedures section. If you are using a questionnaire or handout, please include a copy within each set of application documents. If you are conducting a focus group, include a list of the questions for the focus group.

We will randomly divide visually impaired subjects into either an interview group or focus group. The interview group will consist of around ten to fifteen visually impaired individuals who will be asked a series of questions through one-on-one sessions conducted by a member of Team FACE. The interviews will take place at the Columbia Lighthouse for the Blind in the greater D.C. metropolitan area or University of Maryland, College Park, and will last approximately fifteen to twenty minutes. Transcripts of the interview questions and responses will be provided to the interviewee within two weeks following the interview. Prior to conducting the interviews, we will collect information regarding the age, gender, socioeconomic status, nationality, and level of education of participants by asking participants to complete a demographic questionnaire via email (Please see Appendix D for a copy of the questionnaire). The questions which will be asked during the interview consist of the following:

- How do you describe your social interactions with other visually impaired people? Sighted people?

- Do you currently use any assistive technologies (devices) that help you in social interactions? If yes, what do you use? Rate how effective this device is from 1-5, 5 being the highest. Explain your rating.

- Using a scale of 1-5 (5 being the highest), rate how important it is for you to recognize emotional cues in your daily social interactions.

- Rate your interest, on a scale of 1-5 (5 being the highest), in a portable device that could recognize faces and convey identities to you. Explain.

- Rate your interest, on a scale of 1-5 (5 being the highest), in a portable device that could recognize and analyze facial expressions and convey these cues to you. Explain.

- What would be the best way for a device to convey facial expression cues to you, for example, via haptic (vibration) feedback, audio, beeps, chimes, etc.? What methods would pose significant inconveniences to you? Explain.

- On a scale of 1-5 (5 being the highest), how comfortable would you be wearing sunglasses embedded with cameras which connect to a laptop in a backpack in public? Explain.

- If you had such a device, would you wear it when interacting with other visually impaired people? With sighted people?

We will ask follow-up questions as necessary. (Please see Appendix E for our interview protocol).

We intend to conduct three focus groups, each consisting of five individuals and lasting thirty to forty minutes. These focus groups will also take place at the Columbia Lighthouse for the Blind. The focus groups will be led by two members of Team FACE. Prior to conducting the interviews, we will collect information regarding the age, gender, socioeconomic status, nationality, and level of education of participants by asking participants to complete a demographic questionnaire via email (Please see Appendix D for a copy of the questionnaire). During the focus group, we will ask open-ended questions similar to those asked during the interviews:

- How do you describe your social interactions with other visually impaired people? Sighted people?

- Do you currently use any assistive technologies (devices) that help you in social interactions? If yes, what do you use? How effective is/are this/these device(s)? Explain.

- How important it is for you to recognize emotional cues in your daily social interactions? Explain.

- How interested are you in a portable device that could recognize faces and convey identities to you? Explain.

- How interested are you in a portable device that could recognize and analyze facial expressions and convey these cues to you? Explain.

- What would be the best way for a device to convey facial expression cues to you, for example, via haptic (vibration) feedback, audio, beeps, chimes, etc.? What methods would pose significant inconveniences to you? Explain.

- How comfortable would you be wearing sunglasses embedded with cameras which connect to a laptop in a backpack in public? Explain.

- If you had such a device, would you wear it when interacting with other visually impaired people? With sighted people?

We will ask follow-up questions as needed. (Please see Appendix F for our focus group protocol).

We also plan on conducting anonymous online surveys with sighted individuals. We will survey at least thirty individuals by sending out an email with the attached survey link to family and friends, and asking email recipients to forward the email to their family and friends. The surveys should take around five minutes to complete. Prior to conducting the surveys, we will ask participants to report their age, gender, socioeconomic status, nationality, and level of education (Please follow the link provided in Appendix C to view our survey). The following questions will be included in these surveys:

- How often do you interact with the visually impaired? Never, rarely, sometimes, or often?

- Do you think there are any societal stigmas associated with the visually impaired? Explain.

- How would you react if you saw a person wearing sunglasses embedded with cameras which connect to a laptop in a backpack?

- How do you think you would react if you knew that such a device was analyzing your facial expressions and identifying your face? Explain.

- Would such a device negatively affect any interactions you may have with the visually impaired? Explain.

4. **Risks and Benefits:** Are there any risks to the subjects? If so, what are these risks including physical, psychological, social, legal and financial risks? Please do not describe the risk(s) as minimal. If there are known risks, please list them. If not, please state that there are no known risks. What are the benefits? If there are known risks associated with the subject's participation in the research, what potential benefits will accrue to justify taking these risks?

The interviews, focus groups, and surveys will pose no known risks to the subjects. While there are no immediate personal benefits, their participation will help Team FACE develop a facial recognition and expression aid that facilitates social interactions between the visually impaired and sighted, as well as among the visually impaired community.

5. **Confidentiality:** Adequate provisions must be made to protect the privacy of subjects and to maintain the confidentiality of identifiable information. Explain how your procedures accomplish this objective, including such information as the means of data storage, data

location and duration, description of persons with access to the data, and the method of destroying the data when completed. If the research involves audio taping, videotaping or digital recordings, state who will have access to the tapes or recordings, where the tapes or recordings will be kept, and state the final disposition of the tapes or recordings (i.e. Will the tapes or recordings be destroyed? If so, when will the tapes or recordings be destroyed?). Please note that as per the University of Maryland policy on records retention and disposal, all human subject files, including work done by faculty, staff, and students, must be retained for a period of no less than 10 years after the completion of the research and can then be destroyed. Human subject files include IRB applications, approval notices, consent forms, and other related documents. For more information on records retention, go to: http://www.dbs.umd.edu/records_forms/schedule.php (Faculty and Academic Records) or contact Michelle Solter Evers, Assistant to the Director of Business Services at 301.405.9277 or mevers@mercury.umd.edu.

Team FACE will take all possible actions to keep participants' personal information confidential. In order to help protect participants' confidentiality, all computer data entries will be kept on password-protected computers and all files, including the team notebook, will be kept locked up in the team's office. No one will be referred to by name; each participant will be assigned a number and be referred to by that number for all data entry and data analysis. Only the Gemstone team mentors and Gemstone team members will have access to this data.

If any report or article is written on this project, participants will not be identified by name; if the team does refer to a particular participant, they will identify him/her by number.

This research project consists of recording answers to the questions. These tapes will be stored in a locked team office and only Gemstone team mentors and Gemstone team members will have access to the recorded tapes.
Participants will be informed and asked to state if they agree to be audio taped during their participation in the study, or if they do not agree to be audio taped during their participation in the study.

Participants' information may be shared with representatives of the University of Maryland, College Park or governmental authorities if anyone is in danger or if the team is required to do so by law.

6. Information and Consent Forms: State specifically what information will be provided to the subjects about the investigation. Is any of this information deceptive? State how the subjects' informed consent will be obtained. Will you obtain informed consent in a language other than English? If so, list the language(s) in which you will obtain informed consent. Provide consent forms in all languages that will be used. Refer to the attached consent form template, sample consent form and additional consent form guidance on pages 9 to 18. If a consent form has more than one page, please add a signature and date line and the number of pages (e.g., "1 of 2," "2 of 2") to each page. Please allow a 2-inch bottom margin to accommodate the IRB approval stamp. If you plan to obtain consent over the telephone (e.g.

	consent for a telephone survey), include a copy of the consent script. In the consent form, participants will be provided with information concerning the goals of the research project, as well as any risks and benefits of participation. All information will be straightforward with no deception for the purpose of research. The terms of their participation and confidentiality will also be outlined in the consent form. (Please see Appendix G for a copy of the consent form for visually impaired participants). The consent form will be written at a comprehensive level and provided to visually impaired participants via email. These will be distributed to participants before interviews and focus groups are conducted. The consent form for sighted participants of our online survey will appear before the survey begins; sighted participants will be asked to type their names in the online consent form to indicate their consent (Please see Appendix H to view our online consent form).
7.	**Conflict of Interest:** Describe the potential conflict of interest, including how such a conflict would affect the level of risk to the study participants. Please consult the University of Maryland policy on conflict of interest as defined by the University of Maryland Policies and Procedures III-1.11and II-3.10. These may be viewed at: http://www.usmh.usmd.edu/Leadership/BoardOfRegents/Bylaws/SectionIII/III111.html. If there is no anticipated conflict of interest, please state "No conflict of interest." This section must be included in your application. No conflict of interest.
8.	**HIPAA Compliance:** State whether you are using HIPAA protected health information (PHI). Currently, researchers employed by the University of Maryland Center or who are working within or under the auspices of the University Health Center are subject to specific HIPAA requirements regarding the creation, use, disclosure, or access of PHI. Please consult the University of Maryland's Summary of HIPAA's Impact on University Research. For more information on HIPAA, go to: http://www.hhs.gov/ocr/hipaa/ If you are not using HIPAA protected health information, please state "Not Applicable." This section must be included in your application. Not applicable.
9.	**Research Outside of the United States:** Provide responses to the following questions. Separate responses are required for each country where the research will be conducted. If you are not conducting research outside the U.S., please state "Not Applicable." This section must be included in your application. a) Did the investigator(s) previously conduct research in the country where the research will take place? Briefly describe the investigator's knowledge and experience working with the study population. b) Are there any regulations, rules or policies for human subjects research in the country where the research will take place? If so, please describe and explain how you will comply

with the local human subject protection requirements. The United States Department of Health and Human Services, Office for Human Research Protections (OHRP) has an International Compilation of Human Subject Research Protections with a listing of the laws, regulations and guidelines of over 50 countries. This compilation can be accessed on the OHRP website: http://www.hhs.gov/ohrp/international/HSPCompilation.pdf

c) Do you anticipate any risks to the research participants in the country where the research will take place, taking into account the population involved, the geographic location, and the culture? If so, please describe, including any physical, psychological, social, legal and financial risks. Do you anticipate that subjects who participate in this research will be placed at risk of criminal or civil liability? If so, please describe.

Not applicable.

10. Research Involving Prisoners: Provide responses to the following additional IRB criteria for research involving prisoners. If you are not conducting research involving prisoners, please state "Not Applicable." This section must be included in your application.

a) the research under review represents one of the categories of research permissible described below;

i. study of the possible causes, effects, and processes of incarceration, and of criminal behavior, provided that the study presents no more than minimal risk and no more than inconvenience to the subjects;

ii. study of prisons as institutional structures or of prisoners as incarcerated persons, provided that the study presents no more than minimal risk and no more than inconvenience to the subjects;

iii. research on conditions particularly affecting prisoners as a class (for example, vaccine trials and other research on hepatitis which is much more prevalent in prisons than elsewhere; and research on social and psychological problems such as alcoholism, drug addiction, and sexual assaults); or

iv. research on practices, both innovative and accepted, which have the intent and reasonable probability of improving the health or well-being of the subject.

b) any possible advantages accruing to the prisoner through his or her participation in the research, when compared to the general living conditions, medical care, quality of food, amenities and opportunity for earnings in the prison, are not of such a magnitude that his or her ability to weigh the risks of the research against the value of such advantages in the limited choice environment of the prison is impaired;

c) the risks involved in the research are commensurate with risks that would be accepted by nonprisoner volunteers;

d) procedures for the selection of subjects within the prison are fair to all prisoners and immune from arbitrary intervention by prison authorities or prisoners. Unless the principal investigator provides to the Board justification in writing for following some other procedures, control subjects must be selected randomly from the group of available prisoners who meet the characteristics needed for that particular research project;

e) the information is presented in language which is understandable to the subject population;

f) adequate assurance exists that parole boards will not take into account a prisoner's participation in the research in making decisions regarding parole, and each prisoner is

clearly informed in advance that participation in the research will have no effect on his or her parole; and

g) if there is a need for follow-up examination or care of participants after the end of their participation, adequate provision has been made for such examination or care, taking into account the varying lengths of individual prisoners' sentences, and for informing participants of this fact.

Not applicable.

SUPPORTING DOCUMENTS

Each copy of the application must include the IRB application cover sheet, the information required in items 1-10 above, and all relevant supporting documents including: consent forms, letters sent to recruit participants, questionnaires completed by participants, and any other material germane to human subjects review.

For research funded by the Department of Health and Human Services (DHHS), submit a copy of your HHS grant application. If there are discrepancies between the research proposed in your IRB application and your grant application, include a memo listing these discrepancies and the rationale for them.

NUMBER OF COPIES

Please send 1 original application including the signed cover sheet and 1 copy of the signed, original application unless your research requires full Board Review. For applications which will require review of the full Board, please submit 1 signed original application and seventeen (17) copies. Full Board reviews are required for initial applications involving greater than minimal risk to the subjects (i.e. more risk than subjects would generally encounter in their routine daily activities).
IRB Campus Mailing Address: 2100 Lee Building, Zip -5125.

IRB MEETING DATES AND APPLICATION SUBMISSION DEADLINES

To view the dates for upcoming meetings and the final date for submission of applications to be considered for each meeting, please check the following URL:
http://www.umresearch.umd.edu/IRB/IRBdates.html.

STATUS OF THE IRB APPLICATION

You may send an e-mail to irb@umd.edu or call the IRB Office at 301-405-4212 to inquire about the status of an IRB application.

APPENDICES
UNIVERSITY OF MARYLAND, COLLEGE PARK
CONSENT FORM TEMPLATE
ADDITIONAL GUIDANCE FOR SPECIFIC ISSUES

Appendix A: Announcement to be made to recruit visually impaired participants from Columbia Lighthouse for the Blind

University of Maryland Gemstone Team Facial Analysis for Communicating Expression (FACE) is interested in developing a device that would relay facial recognition and expression information to visually impaired individuals. Team FACE wants this device to facilitate visually impaired interaction with both visually impaired and sighted individuals in society.

We would greatly appreciate your participation in a fifteen- to twenty-minute individual interview or a thirty- to forty-minute focus group session to gain insight into your interactions with other visually impaired and sighted individuals.

If you are interested in participating or have any questions/concerns, please email us at face.gemstone@gmail.com

Appendix B: Email announcement to be made to recruit visually impaired students at UMD

University of Maryland Gemstone Team Facial Analysis for Communicating Expression (FACE) is interested in developing a device that would relay facial recognition and expression information to visually impaired individuals. Team FACE wants this device to facilitate visually impaired interaction with both visually impaired and sighted individuals in society.

We would greatly appreciate your participation in a fifteen- to twenty-minute individual interview or a thirty- to forty-minute focus group session to gain insight into your interactions with other visually impaired and sighted individuals.

If you are interested in participating or have any questions/concerns, please email us at face.gemstone@gmail.com

Appendix C: Email to be sent out to prospective sighted participants for online survey

Hi,

We are students at the University of Maryland participating in the Gemstone program, a four-year interdisciplinary research program. Our team, Team Facial Analysis for Communicating Expression (FACE), is interested in developing a device that would relay facial recognition and expression information to visually impaired individuals. Our hope is that this will facilitate visually impaired interaction with both visually impaired and sighted individuals in society.

In order to assess existing interactions between the visually impaired and sighted in society, we would appreciate your cooperation in completing an anonymous survey. Please follow the following link for the survey:

http://spreadsheets.google.com/viewform?formkey=dElDbWluRktGM0otdTdybHZjTUFwV3c6MA

If you have any questions/comments/concerns, please email us at face.gemstone@gmail.com

Best,

Team FACE

**This will be sent through Team FACE's e-mail account, face.gemstone@gmail.com*

Appendix D: Demographic questionnaire (distributed to participants during interviews and focus groups)

Age: _____

Gender: _____

Level of income (please read the choices below and write the most appropriate letter corresponding to your answer):

A. $0-$19,999
B. $20,000-$39,999
C. $40,000-$59,999
D. $60,000-$79,999
E. $80,000-$99,999
F. $100,000+
G. Prefer not to answer

_____

Ethnicity (please read the choices below and write the most appropriate letter corresponding to your answer):

A. American Indian/Alaskan Native
B. Black or African American
C. Asian or Pacific Islander
D. Hispanic/Latino

E. White
F. Other or Not Reported

_____

Level of education (please read the choices below and write the most appropriate letter corresponding to your answer):

A. High school diploma/GED
B. Associate degree
C. Bachelor's degree
D. Master's degree
E. Doctoral degree
F. Other

_____

Appendix E: Protocol for interview with visually impaired participant

1. Distribute consent form and ask visually impaired subjects to carefully read it on their own via email prior to the interview. At the interview, direct them to sign a hard copy if they give consent and collect consent form upon completion
2. Assign participant a number and ask for participant's name
3. Record name and assigned number in Team FACE notebook
4. Write participant's assigned number on demographic questionnaire and give to participant to complete
5. Upon completion, collect questionnaire
6. Inform participant that the interview will begin and that you will be tape recording the interview
7. State participant's assigned number into tape recorder
8. Ask the following interview questions and continue recording answers on a tape recorder; allow participant to elaborate whenever they feel inclined to (ask follow-up questions as necessary):
    a. How do you describe your social interactions with other visually impaired people? Sighted people?
    b. Do you currently use any assistive technologies (devices) that help you in social interactions? If yes, what do you use? Rate how effective this device is from 1-5 (5 being the highest). Explain your rating.
    c. Using a scale of 1-5 (5 being the highest), rate how important it is for you to recognize emotional cues in your daily social interactions.
    d. Rate your interest, on a scale of 1-5 (5 being the highest), in a portable device that could recognize faces and convey identities to you. Explain.

e. Rate your interest, on a scale of 1-5 (5 being the highest), in a portable device that could recognize and analyze facial expressions and convey these cues to you. Explain.

f. What would be the best way for a device to convey facial expression cues to you, for example, via haptic (vibration) feedback, audio, beeps, chimes, etc.? What methods would pose significant inconveniences to you? Explain.

g. On a scale of 1-5 (5 being the highest), how comfortable would you be wearing sunglasses embedded with cameras which connect to a laptop in a backpack in public? Explain.

h. If you had such a device, would you wear it when interacting with other visually impaired people? With sighted people?

9. Thank the participant for their cooperation and inform them that a transcript of his/her interview will be emailed within two weeks
10. Ask participant to provide feedback on the transcript once they receive it
11. Set date and time for pick-up with this participant
12. Email transcripts of interview to each participant on assigned date and time at the Columbia Lighthouse and ask participant to provide feedback/comments to the contact information that we have provided along with the transcript

Appendix F: Protocol for focus group with visually impaired participants

1. As participants come into the room, assign them a letter and number (each focus group will be designated a letter and each individual within the same focus group will be assigned the same letter and a different number), ask for their names, and record their names and corresponding letter and numbers in the Team FACE notebook
2. Distribute consent form to participants and ask them to carefully read it on their own via email prior to focus group meeting. Direct them to sign a hard copy if they give consent
4. Distribute demographic questionnaires prior to the focus group meeting via email and ask corresponding participants to complete along with the consent forms
5. Upon completion, collect consent form and questionnaire
6. Inform participants that the focus group session will begin and that you will be tape recording the focus group
7. State group letter and participants' numbers into tape recorder
8. Ask the following questions and continue recording answers on a tape recorder; allow participant to elaborate whenever they feel inclined to (ask follow-up questions as needed):

a. How do you describe your social interactions with other visually impaired people? Sighted people?

b. Do you currently use any assistive technologies (devices) that help you in social interactions? If yes, what do you use? How effective is/are this/these device(s)? Explain.

c. How important it is for you to recognize emotional cues in your daily social interactions? Explain.

d. How interested are you in a portable device that could recognize faces and convey identities to you? Explain.

e. How interested are you in a portable device that could recognize and analyze facial expressions and convey these cues to you? Explain.

f. What would be the best way for a device to convey facial expression cues to you, for example, via haptic (vibration) feedback, audio, beeps, chimes, etc.? What methods would pose significant inconveniences to you? Explain.

g. How comfortable would you be wearing sunglasses embedded with cameras which connect to a laptop in a backpack in public? Explain.

h. If you had such a device, would you wear it when interacting with other visually impaired people? With sighted people?

9. Thank the participants for their cooperation and inform them that transcripts of the focus group will be emailed to each participant within two weeks
10. Ask participants to provide feedback on transcripts once they receive them
11. Set date and time for pick-up with participants
12. Email transcripts of interview to each participant on assigned date and time at the Columbia Lighthouse and ask participant to provide feedback/comments to the contact information that we have provided along with the transcript

Appendix G: Consent form for visually impaired participants in interviews and focus groups

Page 1 of 3
Initials _____ Date _____

CONSENT FORM

Project Title	***Facial Analysis for Communicating Expression***
Why is this research being done?	*This is a research project being conducted by Gemstone Team Facial Analysis for Communicating Expressions (FACE) at the University of Maryland, College Park. We are inviting you to participate in this research project because you are above 18 years of age, experience visual impairment, and stand to benefit from this study. The purpose of this research project is to make a portable camera and computer system that will allow a visually impaired individual to recognize faces he/she knows, as well as detect whether the person being viewed is happy, sad, angry, surprised, fearful, or disgusted. We are seeking suggestions from possible users of our device so that we can build an effective device which fits all needs.*
What will I be asked to do?	*The procedures involve participating in an individual interview or focus group. An interview will be a one-on-one discussion session with one participant and one researcher,*

	while a focus group will be a discussion setting with five participants and two researchers. Questions in both settings encompass an assessment of existing social interactions between the visually impaired and visually impaired and/or visually impaired and sighted in society, the effectiveness of current assistive technologies in social interaction, and potential design ideas for the device. Prior to conducting an interview or focus group, participants will be asked for information regarding their age, gender, socioeconomic status, nationality, and level of education to provide researchers with background information. *The researchers will conduct interviews and focus groups as is convenient for the participants. The interviews will take approximately fifteen to twenty minutes to complete, while the focus groups will last approximately thirty to forty minutes.* *This research project involves making audiotapes of you to record responses for the researchers' reference. Only Gemstone team mentors and members will have access to these tapes and, upon completion of our project, these tapes will be destroyed.* ___ I agree to be audiotaped during my participation in this study. ___ I do not agree to be audiotaped during my participation in this study.

What about confidentiality?	*We will do our best to keep your personal information confidential. To help protect your confidentiality, we will (1) keep all computer data entries on password-protected computers, (2) keep all files in a locked team office, (3) refer to participants by a number in our data entries and files, and (4) only allow Gemstone Team FACE mentors and members any access to data.* *If we write a report or article about this research project, your identity will be protected to the maximum extent possible. Your information may be shared with representatives of the University of Maryland, College Park or governmental authorities if you or someone else is in danger or if we are required to do so by law.* *In accordance with legal requirements and/or professional standards, we will disclose to the appropriate individuals and/or authorities information that comes to our attention concerning neglect or potential harm to you or others.*
What are the risks of this research?	*There are no known risks associated with participating in this research project.*
What are the benefits of this research?	*The most tangible benefit of this research is the development of a wearable device to detect faces and expressions. We hope that, in the future, other people may benefit from our research through improved understanding of computer vision and how it can be used to aid communications between visually impaired persons, as well as communication between visually impaired and sighted persons.*
Do I have to be in this research? May I stop participating at any time?	*Your participation in this research is completely voluntary. You may choose not to take part at all. If you decide to participate in this research, you may stop participating at any time. If you decide not to participate in this study or if you stop participating at any time, you will not be penalized or lose any benefits to which you otherwise qualify.*

Initials _____ Date _____

What if I have questions?	*This research is being conducted by Dr. Rama Chellappa at the University of Maryland, College Park. If you have any questions about the research study itself, please contact Dr. Chellappa at: rama@cfar.umd.edu or (301) 405-3656* *If you have questions about your rights as a research subject or wish*

	to report a research-related injury, please contact: **Institutional Review Board Office, University of Maryland, College Park, Maryland, 20742; (e-mail) irb@umd.edu; (telephone) 301-405-0678** *This research has been reviewed according to the University of Maryland, College Park IRB procedures for research involving human subjects.*	
Statement of Age of Subject and Consent	*Your signature indicates that:* *you are at least 18 years of age;,* *the research has been explained to you;* *your questions have been fully answered; and* *you freely and voluntarily choose to participate in this research project.*	
Signature and Date	**NAME OF SUBJECT**	
	SIGNATURE OF SUBJECT	
	DATE	

Appendix H: Hard copy of online consent form for sighted participants in online survey

CONSENT FORM FOR SIGHTED PARTICIPANTS

Project Title
Facial Analysis for Communicating Expressions

Why is this research being done?
This is a research project being conducted by Gemstone Team Facial Analysis for

Communicating Expressions (FACE) at the University of Maryland, College Park. We are inviting you to participate in this research project because you are above 18 years of age and do not experience any form of visual impairment. The purpose of this research project is to make a portable camera and computer system that will allow a visually impaired individual to recognize faces he/she knows, as well as detect whether the person being viewed is happy, sad, angry, surprised, fearful, or disgusted. We are seeking suggestions from possible users of our device so that we can build an effective device which fits all needs.

What will I be asked to do?
You are asked to fill out a brief online survey. You will be asked to express your opinion on this project. The purpose of this survey is to understand the perception of the visually impaired by the sighted community.

What about confidentiality?
We will do our best to keep your personal information confidential. To help protect your confidentiality, we will (1) keep all computer data entries on password-protected computers, (2) keep all files in a locked team office, (3) refer to participants by a number in our data entries and files, and (4) only allow Gemstone Team FACE mentors and members any access to data.

If we write a report or article about this research project, your identity will be protected to the maximum extent possible. Your information may be shared with representatives of the University of Maryland, College Park or governmental authorities if you or someone else is in danger or if we are required to do so by law.

In accordance with legal requirements and/or professional standards, we will disclose to the appropriate individuals and/or authorities information that comes to our attention concerning neglect or potential harm to you or others.

What are the risks of this research?
There are no known risks associated with participating in this research project.

What are the benefits of this research?
The most tangible benefit of this research is the development of a wearable device to detect faces and expressions. We hope that, in the future, other people may benefit from our research through improved understanding of computer vision and how it can be used to aid communications between visually impaired persons, as well as communication between visually impaired and sighted persons.

Do I have to be in this research? May I stop participating at any time?
Your participation in this research is completely voluntary. You may choose not to take part at all. If you decide to participate in this research, you may stop participating at any time. If you decide not to participate in this study or if you stop participating at any time, you will not be penalized or lose any benefits to which you otherwise qualify.

What if I have questions?

This research is being conducted by Dr. Rama Chellappa at the University of Maryland, College Park. If you have any questions about the research study itself, please contact Dr. Chellappa at: rama@umiacs.umd.edu or (301) 405-3656

If you have questions about your rights as a research subject or wish to report a research-related injury, please contact: Institutional Review Board Office, University of Maryland, College Park, fMaryland, 20742; (e-mail) irb@umd.edu; (telephone) 301-405-0678

This research has been reviewed according to the University of Maryland, College Park IRB procedures for research involving human subjects.

Statement of Age of Subject and Consent
Your completion of the survey indicates that:
you are at least 18 years of age;,
the research has been explained to you;
your questions have been fully answered; and
you freely and voluntarily choose to participate in this research project.
* Required
Top of Form
Do you agree to the above terms? *You must agree to proceed to the survey questions.

☐ Yes, I agree

☐ No, I do not wish to participate in this survey

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