A summary description of the project objectives,

Providing sight to the totally blind is undoubtedly a major scientific aspiration. In the last decade, several groups have been conducting preliminary research and clinical trials utilizing modern therapeutic methods that include gene therapy and electrical stimulation of the nerve system. The concept of restoring sensory functionality by means of electrical stimulation is partially driven by the huge success of the cochlear implant that has restored hearing to approximately a quarter of a million individuals worldwide.

A basic requirement for every therapeutic procedure is that there should be an objective and a validated method to assess the benefits of the treatment for the patient. Currently, there is no acceptable procedure to quantify the benefits obtained from visual prostheses. The current situation is that every research group that develops a visual prosthesis uses a different procedure to evaluate the benefit from their device, making comparisons difficult.

During the first phase of the project we realized that object localization is the main benefit of the current retinal prosthesis. To localize object patinet need to act in a body/world-centered frame of reference, but the retinal prosthesis provide a retina-centered image. In the second phase of the project we evaluated the influence of eye movements on object localization tests.

Work performed since the beginning of the project

We initially concentrated on developing experimental setups and constructing a new laboratory for a pixelized vision simulator at the Department of Electrical and Electronic Engineering, Shamoon College of Engineering. In addition, we worked to recevie the ethic approvals to conduct the experiment work.

Experimental setup development (hardware): The pixelized vision simulator is the main hardware for the current research. The simulator is composed of glasses with a binocular display, a miniature camera attached to the glasses, and a computer for real-time image processing.

Experimental setup development (software): The simulator application allows for down-sampling of the image to match the resolution of the retinal prosthesis devices. In addition, the software blurs the image to account for the practical perception of blind patients implanted with retinal prosthesis. Reports from visual prosthetic devices clinical trials, such as the Argus II (Second Sight Medical products, USA) and Alpha-IMS (Retina Implant, Germany), hint that not all implanted patients see a pixelized distinct pattern. Therefore for a pixilized visual simulator to be a useful tool and accurately mimic retinal prostheses, they too must take into account the unpatterned perceived image.

Data collecting: Assessing the utility of visual acuity measures in visual prostheses. Using the pixelized simulator we assessed the visual acuity test by measuring the visual acuity score of the Landolt C test with and without patterned vision. The unpatterned pixelized has the same brightness and size of the original image. In this mode the entire simulated image is viewed as a "one-pixel" system and the resolution is set by the field of view.

Data collecting: Eye movements influence on retinal prosthesis. In collaboration with the Prof Sahel from Paris and Second Sight Medical Products, we collected data from two patients implanted with the Argus II retinal prosthesis. We check the performance to locate objects using a retinal prosthesis with head versus eye scanning

A description of the main results achieved so far,

Visual acuity tests are the principle quantitative measures used to assess the efficacy and cost-effectiveness of ophthalmologic treatments and procedures designed to improve or restore vision. By using our novel pixelized simulator, we evaluated if and under what conditions a measured visual acuity level is truly an indication that the visual prosthesis provides a patterned image. Our measurements showed that visual acuity is not necessarily an indication that the visual prosthesis provides an image with spatial patterns.

We compared visual acuity measurements assets using the Snellen letter chart modified to the resolution of retinal prosthesis currently available for medical procedures versus alternative choices acuity tests such as grating and Landolt C that are used by the companies that develop the retinal prosthesis implants. Using the pixelized simulator at various blurring conditions we showed that for the non-native vision provided by the retinal implant the alternative choices tests aren't consistent as the traditional letter test.

Using the developed pixelized simulator that enable to control the blurring we found, that when resolution is limited, the brain of sighted people can better integrate smoothed, blurred information relative to distinct, square pixelized data. When the resolution is limited, the brain integrates visual information across snapshots. Due to head and eye movements the brain can acquire visual information at different spatial location and improve the detectability. We showed that for the same resolution limit the brain is more efficient to integrate smooth visual information relative to distinct square pixels.

Eye movements: Results collected from two subjects indicates that the performances in locating a target using eye scanning, without head movements, is significantly above chance levels. One subject was surprised to hear that he answered correctly. The report from the subject hints that realignment of spatial coordinates due to eye position takes place subliminally. The second subject said that it is easiest to locate the bar using eye movements relative to head movements, because with head movements he feels that he doesn't have a fixed frame of reference.

The expected final results and their potential impact and use

While there are extensive efforts to develop visual prosthesis devices, less effort is spent in finding ways to evaluate the devices and maximize the benefits that artificial vision can provide. Currently, there are three major European efforts to create a retinal prosthesis implant (Second Sight Medical products, Switzerland; Retina Implant, Germany; Pixium, France). However, there is no acceptable procedure to quantify the benefits obtained from the visual prostheses. The test to assess the benefit of retinal prosthesis must match the usability of the device for the daily living. Currently we suggest that assessments need to focus on localization tasks which are the main benefit of the devices for daily actcvities of the patients.