Mobile Vision platforms to aid the visually impaired

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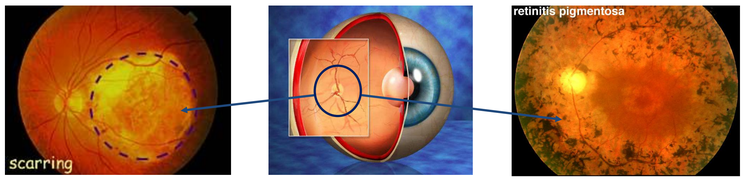
Introduction

Vision is a highly important sensing mechanism for humans. As such, a large part of the brain is dedicated to visual processing. People with visual acuity impairment suffer from a range of problems affecting their mobility and quality of life. There are thought to be 38 million people suffering from blindness worldwide and this number is expected to double over the next 25 years. Additionally, there are 110 million people who have severely impaired vision. In the developed world, disorders such as cataracts and Glaucoma are becoming more treatable. However, there is now an increasing prevalence of Age Related Macular Degeneration (AMD) due to our ageing societies. In many countries, new treatments are being offset by increasing prevalence of diabetic retinopathy as waistlines are increasing. Additionally, retinitis pigmentosa (RP), an untreatable hereditary condition, continues to affect 1 in 3500 people across the world.



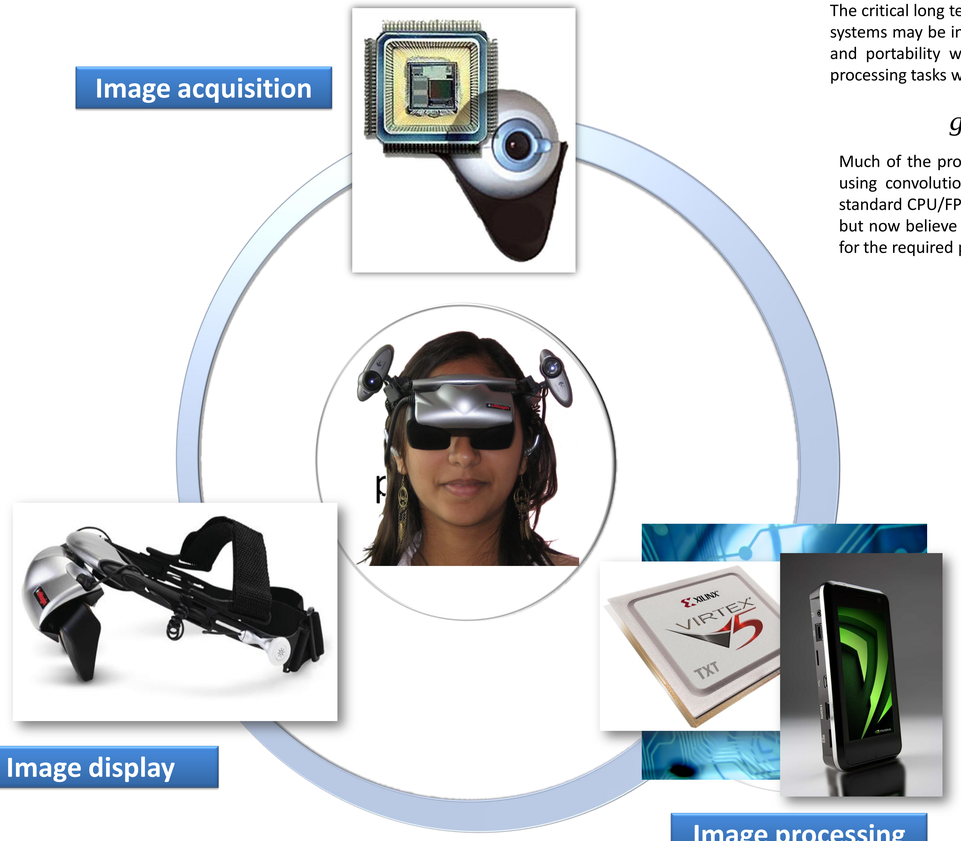
Patient with AMD
Loss of central vision, reading difficult and patient have to learn to read with peripheral vision

Original Image

Patient with RP
Peripheral vision goes flat followed by gradual loss of central vision

In the Neurobionics group, Imperial College, we are developing optogenetic prostheses for the fully blind and portable visual augmentation systems for those with partial retinal degeneration. Key to both systems is the ability to image the visual world, and modify the image so as maximize the useful information content to the observer. Advanced salient image processing is presently very difficult, even more so on mobile computational platforms. However, certain levels of basic processing are possible provided efficient computational platforms can support them.

Mobile vision processing system



The critical long term aim is to develop portable, wearable system which can be used in daily tasks. Early phase systems may be initially used in static situations where the user is stationary, but nevertheless, the electronics and portability will be paramount to uptake. Key to this will be the ability to perform advanced image processing tasks with high efficiency, thus requiring minimal (heavy, bulky) battery support

$$g(x,y) = \sum_{i=0}^{m-1}\sum_{j=0}^{n-1} f(x-1+j, y-1+i)H(j+3i)$$

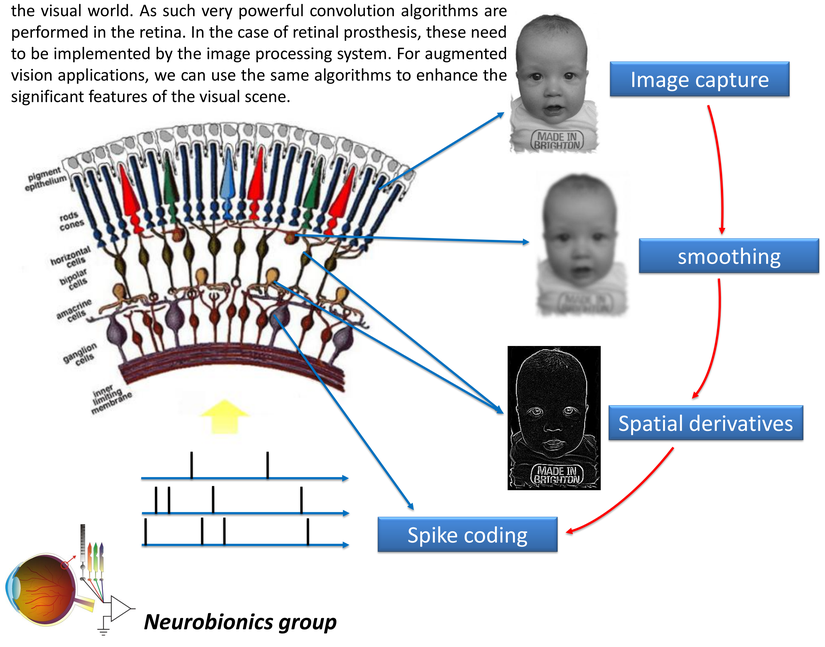
Much of the processing tasks such as ascertaining spatial derivatives and anisotropic filtering can performed using convolution operators given above. These can consume large amounts of computational power on standard CPU/FPU systems. We have investigated dedicated CMOS and FPGA parallel processing architectures, but now believe that GPU technology incorporating CUDA functionality can provide a highly efficient platform for the required portable image processing.

Optogenetic retinal prosthesis will require the genetic re-engineering of the retinal ganglion cells to express light sensitive channelrhodopsin proteins. The portable processor will need to support both the image enhancement/retinal processing and drive the optoelectronic stimulator

Augmented vision systems will largely enhance the remaining vision of the patient. For macular degeneration, the key tasks will be to enhance landmark recognition, and face recognition. The two critical factors to patient wellbeing i.e. mobility and social contact. Nevertheless, the system must be functional, and private so as not to advertise the disability.

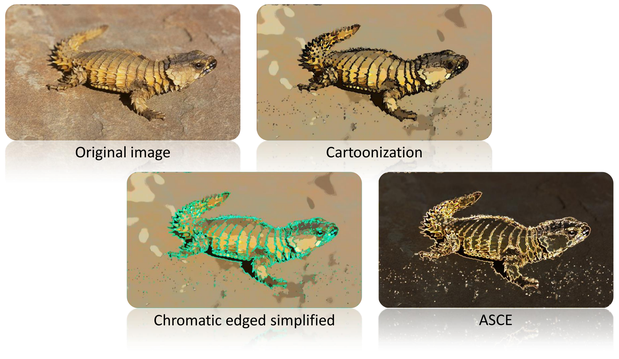
Retinal processing

The eye is not simply a camera! It is the first stage in understanding the visual world. As such very powerful convolution algorithms are performed in the retina. In the case of retinal prosthesis, these need to be implemented by the image processing system. For augmented vision applications, we can use the same algorithms to enhance the significant features of the visual scene.



Neurobionics group

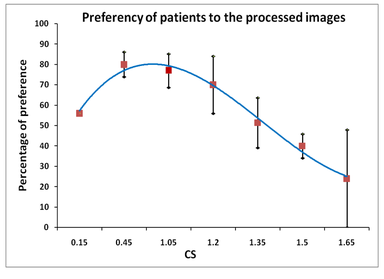
Image Augmentation concepts

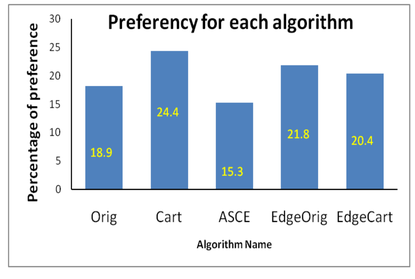


Cartonization	creates stylized images that facilitate viewer recognition of the shapes by reducing visual clutters such as shadows and textures details.
Advanced Scaled Chromatic Edge (ASCE)	Focuses on increasing the contrasts between objects by highlighting the edges of the moving objects or the edges between distinguish objects while suppressing the other homogeneous pixels in the scene.
Edge Overlay	Overlays the extracted edges, using optimized chromatic contrast, over simplified or original images.

Preliminary evidence from Low vision patient trials

27 patients were tested at the Oxford Eye hospital, John Radcliffe Hospital UK. 9 were diagnosed with Retinitis Pigmentosa (RP), 1 each with Pseudoxanthoma Elaspicum and Lebers Hereditary Optic Neuropathy and the remaining had macular pathologies predominantly Stargardt's disease. Median visual acuity (VA) in the better eye for the sample was 6/36 (Range: 6/120-6/6) and the median contrast sensitivity (CS) in the better eye was 1.20 (Range: 0.15-1.65).





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