In search of relevant things: A novel approach for image analysis

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Project Summary

Understanding the relationship between vision and cognitive perception is one of the greatest challenges in neuroscience. Computational modelling can be used to investigate this relationship, addressing the dual aims of understanding the way the human brain works and how a computer system might be used to simulate cognitive processing. This project will help to understand cognitive processes underlying the visual perception in humans and how they interpret images. We will use an eye tracking device (EyeLink Portable Duo) to track the eye movements of participants. This translation would allow an "**expert-like**" computerised and automatic identification of relevant features in any image. This project intends to advance the field of machine-based perception by exploring new ways to understand the neural mechanisms that underpin feature extraction and pattern recognition, with the final aim of obtaining a novel computerised system to automatically detect salient features in any kind of image. Practical examples of region of interest identification by experts in images include: recognition of pathologies in medical imaging by specialists, such as pathologists and radiologists; identification of features, which may look irrelevant to the layperson in paintings by art critics; categorisation of objects in natural scenes for the development of driverless cars.

Experimental Procedure

General Eye Tracking Study: A participant will be sitting still on a chair while watching some images on the computer screen. An eye tracker device (i.e., a camera) connected to a computer screen will record their eye gaze data. They are expected to contribute about 30 minutes per session which will include data collection, guidelines, and experimental preparation. If you are a medical trainee and interested in a longitudinal study, you are welcome to participate 3 times over 3 consecutive years.

Eye Tracking Study with MEG/EEG or fMRI: A participant interested in this part of our experiments will follow the same procedure outlined in the general eye tracking study described above. In addition, the participant will be involved with MEG/EEG/fMRI to record brain activity during image viewing. The participant will lie on a bed in a shielded room for MEG. The MRI procedure involves lying on an imaging table which slides into an opening in a very strong magnet. The MRI does not use any radiation (unlike an x-ray). Participants will be able to listen to us through headphones and speak to us through a microphone. Any magnetic materials in clothing or attached to the body (e.g. wristwatch, earrings) are required to be removed prior to performing MEG/fMRI. A person with permanently fixed magnetic materials (e.g. dental work, certain tattoo pigments, a cardiac pacemaker, metal rods, plates, or screws) cannot participate in this experiment. Participants with a cochlear implant or hearing aid, will be scanned with a special "cochlear implant MEG system". An EEG cap will be used for the EEG experiment. This experiment may require 1 to 2 hours per session including data collection, guidelines, and experiment preparation.

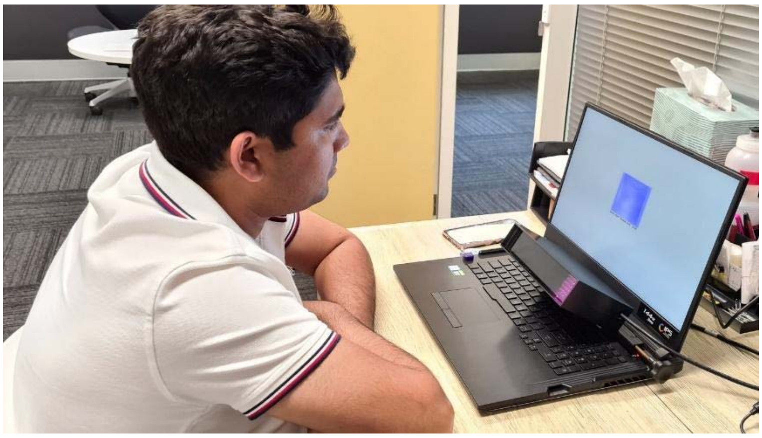

Figure: Portable Duo EyeLink eye tracker at Computational NeuroSurgery (CNS) Lab, Macquarie University.

Inclusion Criteria:
- Having normal or corrected-to-normal vision, normal hearing, and proficiency in the English language.
- Age range: 18-65 years.

Exclusion Criteria:
- Having neurological/neuromuscular or skeletal problems (unable or have limited ability to sit on chair to watch images on computer screen)
- Any history of oculomotor problems or eye surgery
-Any history of psychological or psychiatric problems
- Wearing hard eye contact lenses
- Pregnant woman

Research Outcomes

The project aims to identify features related to areas of interest with the exclusion of surrounding irrelevant objects (i.e., visual noise). This has the potential to be useful in diagnosis in medical imaging and can be easily translated to different fields such as satellite image analysis (e.g. selection of relevant mining locations), paintings (e.g. automatic differentiation of an original painting from a reproduction), and automatic identification of objects in natural scenes (e.g. driverless cars), amongst other applications. With the increasing number of artificial intelligence algorithms for image detection, the approach proposed here can provide an alternative to traditional approaches by merging computational techniques with brain-like cognitive methods to recognise salient features in any kind of image. The proposed method can objectively quantify and score the efficiency of an expert in identifying ROIs in images, proposing a new scoring model for selection of trainees. The methodology can be used to monitor trainee improvement in diagnostics over time (e.g., more visual efficiency to detect relevant features due to training). Moreover, the same computational scores can be used to analyse visual attention in subjects undergoing attitudinal tests in specific situations, e.g., quantification of the cognitive efficiency to visualise visual perturbations in images under stress or after sleep deprivation.