NeuraSearch: Neuroscience and Information Retrieval

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1. Abstract

Information Retrieval (IR) process is complex because it involves a gap between the representation of an Information Need (IN) (i.e. the formulated query) and the actual IN. This gap can become widen when searchers are experiencing an ill-defined IN. As a result of this phenomenon, searchers were left unsatisfied with the results obtained in response to their initial retrieval formulation [1], and must engage in further interaction with the system to resolve their needs.

In the past, to close the gap between an actual IN and its representation, IR systems have employed feedback techniques. An example of such an approach is the relevance feedback technique where feedback is gathered through explicit [2], implicit [3], affective and/or physiological feedback [4]. Despite the robustness of explicit feedback in improving retrieval effectiveness [2], it is not always applicable or reliable due to the cognitive burden that it places on users [5]. To overcome this cognitive burden, implicit feedback is proposed where relevance is inferred from the interactional data indirectly and unobtrusively [6]. For example, researchers try to understand how task [3], dwell time [7] and click-through [6] relate to relevance. However, a problem occurs when actions are taken as an indication of relevance without sufficient evidence to support their effectiveness [8]. For example, Kelly and Belkin [9] show that the implicit feedback measures based on user interaction with the full content of documents can often be unreliable and difficult to measure or interpret.

Our position is that if we can monitor brain regions activated during an Information Seeking and Retrieval (IS&R) process, we can reduce (or possibly eliminate) the gap between a formulated query and its IN. This would then help searchers better satisfy their IN. To do so, we need to be able to identify brain regions activated from the early stages of an IN (i.e. at its visceral level [10]) until the termination of the IS&R process, either as a result of IN satisfaction or search abandonment. The identification and utilisation of the neural processes that underpin the IS&R process, termed "NeuraSearch", has recently drawn increasing interest in the Information Retrieval and Science communities [11, 12, 13, 14, 15, 16]. This interest has focused on gaining an understanding of how the different components of IR emerge from measurable activity in the brain. These studies have employed a wide range of brain imaging techniques to probe brain activity related to brain states involved in processing relevance and information need. Moshfeghi et al. [11, 17, 18, 19, 20] conducted a series of studies using fMRI to understand brain regions activated during relevance judgement and information need. Results from one study [11] revealed that brain regions, including the inferior parietal lobe, inferior temporal gyrus, and superior frontal gyrus, are activated during the relevance judgement process. Also, another study from this series [17] indicated that IN reflected a process of switching between internal and external information sources. Another study [19] revealed how transitions between different segments of an information search task were reflected in activity changes in large-scale brain networks. While having a high spatial resolution, the fMRI technique does not have a high temporal resolution. Thus such techniques are instrumental in localising brain regions associated with phenomena such as relevance judgement or information need realisation rather than monitoring their changes in real-time.

Apart from the fMRI technique, other studies have applied different brain measurement techniques in order to investigate the concept of IR, especially relevance. For example, the technique of Magnetoencephalography (MEG) has been used to understand the concept of relevance of visual information [14]. The related technique of Electroencephalography (EEG) has also been applied in several studies to investigate the concept of relevance to text information [21, 13, 22, 23, 24, 25]. EEG technique has high temporal resolution but lacks high spatial resolution. Thus such techniques are crucial for real-time monitoring of the phenomena of interest.

With the encouraging results obtained from these studies, the IR community now better understands the possibilities and limitations of employing neuroscience for IR. However, this is still an open research problem. Therefore, it is important to further study the brain activity underlying IR processes and how they can be harnessed and used to improve and help searchers in their search tasks and experience. This would be possible via a collab-

DESIRES 2021 – 2nd International Conference on Design of Experimental Search & Information REtrieval Systems, September 15–18, 2021, Padua, Italy

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orative effort to understand what exactly happens inside the human brain in real-time while they are performing a search process, from the realisation of an IN, till stopping a search process, including engaging, comprehending, perceiving, processing and judging the information they encounter during this process and how they ultimately contribute to the satisfaction of the realised IN.

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