DatAR: Supporting Neuroscience Literature Exploration by Finding Relations Between Topics in Augmented Reality

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Abstract. We present DatAR, an Augmented Reality prototype designed to support neuroscientists in finding fruitful directions to explore in their own research. DatAR provides an immersive analytics environment for exploring relations between topics published in the neuroscience literature. Neuroscientists need to analyse large numbers of publications in order to understand whether a potential experiment is likely to yield a valuable contribution. Using a user-centred design approach, we have identified useful tasks in collaboration with neuroscientists and implemented corresponding functionalities in DatAR. This facilitates querying and visualising relations between topics. Participating neuroscientists have stated that the DatAR prototype assists them in exploring and visualising seldom-mentioned direct relations and also indirect relations between brain regions and brain diseases. We present the latest incarnation of DatAR and illustrate the use of the prototype to carry out two realistic tasks to identify fruitful experiments.

Keywords: Topic-based Literature Exploration · Data Visualisation · Augmented Reality · Human-centered Computing

1 Motivation and Related Work

An important task for neuroscientists is analysing large numbers of publications to identify potentially fruitful experiments. This process is necessary before undertaking any costly practical experiments; however, it is time-consuming and challenging [7]. Informed by communications with neuroscientist Cunqing Huangfu[1] [5,8–10], utilising topic-based literature exploration, such as finding relations between brain regions and brain diseases, can aid in analysing numerous publications to identify fruitful experiments. Immersive analytics (IA) allows

[1] Dr Cunqing Huangfu, a neuroscientist at the Institute of Automation of the Chinese Academy of Sciences.

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researchers to examine 3D structures, in our case brain regions, allowing neuroscientists to find relations between topics such as brain diseases, brain regions and genes [6]. Augmented Reality (AR) allows researchers to have an immersive and interactive experience during their literature exploration [2].

Four neuroscientists (Cunqing Huangfu, Yu Mu[2], Danyang Li and Yu Qian) proposed several explorative tasks that they felt would be useful to illustrate topic-based literature exploration for identifying fruitful experiments during interviews [5,10]. These tasks include finding seldom-mentioned direct relations between topics. For example, the brain disease *Bipolar Disorder* and the brain region *Cerebral Hemisphere Structure* co-occur only twice among all the sentences of the 414,224[3] titles or abstracts in the repository. These twice direct relations are unusual, indicating that there is as yet no common knowledge about the relation between the topics *Bipolar Disorder* and *Cerebral Hemisphere Structure*. These seldom-mentioned direct relations between topics could offer fruitful directions for further investigation.

Indirect relations occur when two topics do not appear together in the same sentence but co-occur with the same intermediate topic [3,4]. For example, the brain disease *Bipolar Disorder* and the brain region *Cerebellar vermis* lack any direct relation but co-occurs with the intermediate topic *GFAP Gene*, establishing an indirect relation between them. In addition to finding seldom-mentioned direct relations, neuroscientists also proposed that finding unknown or indirect relations between topics (through an intermediate topic) would provide additional opportunities to identify fruitful experiments. We present the DatAR prototype [5,8–10], demonstrating how it can assist neuroscientists in identifying potentially fruitful experiments by explaining a walk-through of two scenarios[4].

2 DatAR Prototype

The DatAR prototype incorporates various functionalities in the form of AR widgets, see Table 1. The widgets provide selection, querying and visualisation mechanisms that allow users to explore the titles and abstracts in the PubMed neuroscience repository through topics. We briefly explain the functionalities of the widgets for finding seldom-mentioned direct relations and also indirect relations between topics.

3 Task Description

We collaborated with the neuroscientist Danyang Li to define representative tasks. Her research topic was the brain disease *Bipolar Disorder*. When she

[2] Dr Yu Mu, Danyang Li, and Yu Qian are neuroscientists at Institute of Neuroscience of the Chinese Academy of Sciences.

[3] Neuroscience publications in PubMed https://pubmed.ncbi.nlm.nih.gov/ as of February 3, 2022.

[4] See also the video https://drive.google.com/file/d/12sMvClw1zcytNPk7zl3J5NTeg22dsm2b/view.

Table 1. An overview of relevant widgets for finding relations between topics.

Name of Widget	Description
Brain Regions Visualisation, Figs. 1 and 2, Label 1	Visualises 274 brain regions sourced from the Scalable Brain Atlas[a] (SBA) as spheres in 3D AR [1]. The position of each sphere is determined by the 3D coordinates of brain regions taken from SBA [10]
Co-occurrences Widget, Figs. 1 and 2, Label 2	Queries the direct co-occurrences between a single brain region and multiple brain diseases or a single brain disease and multiple brain regions in the PubMed repository [10]. The visualisation of direct relations is represented as pink spheres in 3D AR
Max-Min Co-occurrences Filter Widget, Fig. 1, Label 3	Selects few direct co-occurrences by the max-min filter [10]. The visualisation of seldom-mentioned direct relations is represented as yellow spheres in 3D AR
Sentences Extractor Widget, Fig. 1, Label 4	Queries which sentences indicate the direct relation between the specific brain region and brain disease [10]
Indirect Relations Querier, Fig. 2, Label 5	Selects an intermediate topic, such as genes, to find indirect relations between brain regions and brain diseases in the PubMed repository. The visualisation of indirect relations is represented as green spheres in 3D AR

[a] Scalable Brain Atlas (SBA) https://scalablebrainatlas.incf.org/index.php

explored *Bipolar Disorder*, her objective was to uncover seldom-mentioned brain regions, that are not yet common topics related to *Bipolar Disorder*. These seldom-mentioned regions could offer useful inspirations for further investigation. Additionally, she explained that brain diseases can also be connected indirectly to brain regions, through genes. She wanted to find which brain regions are indirectly related to *Bipolar Disorder* to provide additional options for identifying fruitful experiments.

To *find seldom-mentioned direct relations between topics*, Danyang carries out the following steps in the DatAR prototype.

Step 1: She wants to understand the known relations between the brain disease *Bipolar Disorder* and all brain regions, Fig. 1. She queries co-occurrences between topics via the Co-occurrences Widget.

Step 2: To find seldom-explored and lesser-known relations between topics, she filters the brain regions by the Max-Min Co-occurrences Filter Widget. The brain disease *Bipolar Disorder* co-occurs twice with the brain region *Cerebral Hemisphere Structure*, Fig. 1. The seldom-mentioned region *Cerebral Hemisphere Structure* is visualised as a yellow sphere.

Step 3: Finding few co-occurrence relations, such as the relation between *Bipolar Disorder* and *Cerebral Hemisphere Structure*, is not sufficient to convince her to start an experiment. She needs additional contextual information, including sentences and publication dates, that indicate these seldom-mentioned direct relations are indeed useful for her research. She observes the co-occurrence between the brain disease *Bipolar Disorder* and the brain region *Cerebral Hemisphere Structure* in the sentence: "We evaluated the structural changes of the cerebrum in patients with bipolar disorder (BD) by these dMRI techniques," published in May 2019[5] Fig. 1. This sentence provides useful context for the co-occurrence found.

To *find indirect relations between topics*, Danyang navigates the Indirect Relations Querier to find and visualise brain regions indirectly related to *Bipolar Disorder* via genes.

Step 4: She also wants to find unknown indirect relations between topics to provide more options for potentially fruitful experiments. She chooses genes as the intermediate topic, using the Indirect Relations Querier, to navigate indirect relations between topics. The brain disease *Bipolar Disorder* has an indirect relation with the brain region *Cerebellar vermis* via genes, Fig. 2.

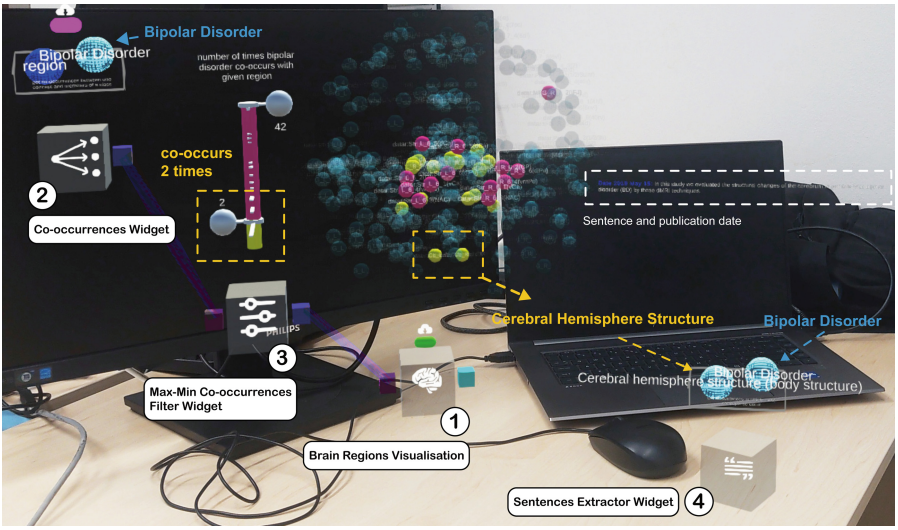

Fig. 1. The brain disease *Bipolar Disorder* co-occurs twice with the brain region *Cerebral Hemisphere Structure*.

[5] DOI: https://doi.org/10.1016/j.jad.2019.03.068.

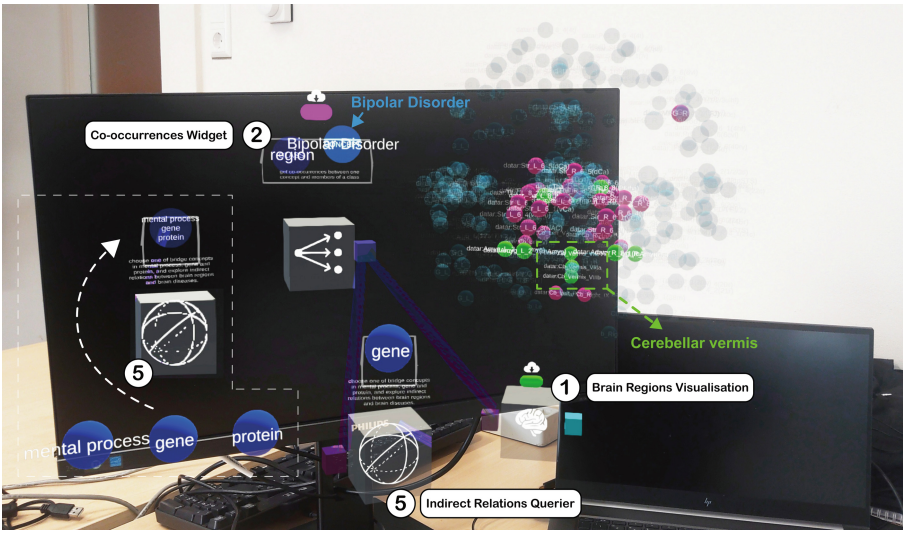

Fig. 2. The brain disease *Bipolar Disorder* has an indirect relation with the brain region *Cerebellar vermis* via genes.

4 Implementation

The topic co-occurrences used in the DatAR prototype are stored in the Knowledge Graphs of Brain Science[6] (KGBS) in Triply. KGBS contains an analysis of sentences in the titles and abstracts of 414,224 neuroscience publications in PubMed[7]. Topics include brain regions, brain diseases, genes, proteins and mental processes. The DatAR prototype is constructed using Unity[8] (v2020.3.15f2) and the Microsoft Mixed Reality Toolkit[9] (MRTK) (v2.7.0) and is deployed offline on a HoloLens 2[10] head-mounted display.

5 Conclusion

We have demonstrated the potential of the immersive AR-based 3D DatAR prototype in assisting neuroscientists in conducting and visualising relation-finding

[6] Knowledge Graphs of Brain Science in Triply https://krr.triply.cc/BrainScienceKG/-/queries/Brain-Region---Brain-Disease/1.

[7] 414,224 neuroscience publications in PubMed https://pubmed.ncbi.nlm.nih.gov/ as of February 3, 2022.

[8] Unity https://unity.com/.

[9] Microsoft Mixed Reality Toolkit (MRTK) https://learn.microsoft.com/en-us/windows/mixed-reality/mrtk-unity/.

[10] Microsoft HoloLens 2 is an Augmented Reality headset developed and manufactured by Microsoft, https://www.microsoft.com/en-us/hololens.

tasks. Neuroscientists involved in previous evaluation studies expressed satisfaction with implemented functionalities for finding seldom-mentioned direct relations and also indirect relations between topics to identify fruitful experiments.

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