Constellations of Movement: An Interactive Application to Visualise Research in Motor Imagery Decoding

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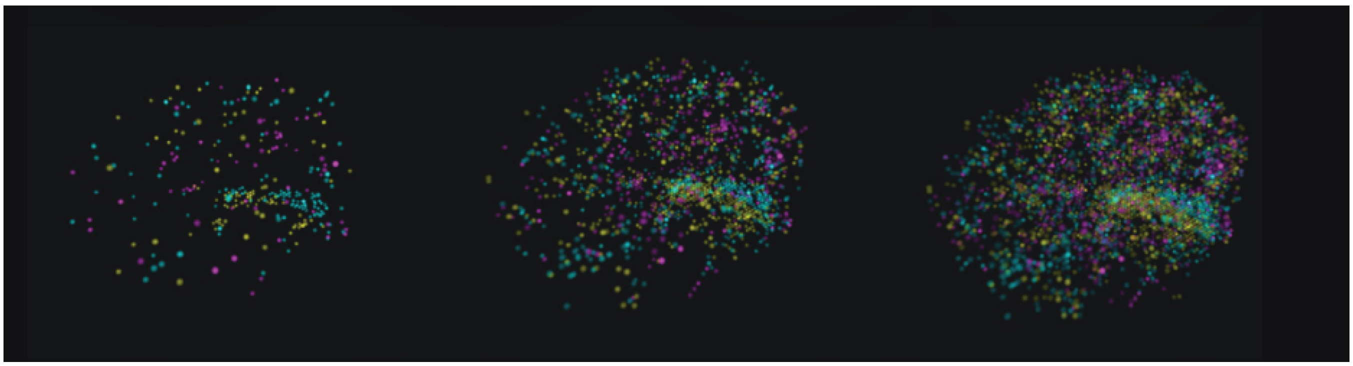

Figure 1: Mapping of Comparison Data within Unity3D.

ABSTRACT

With advancement in research in a given field, there should be parallel development in visualisation methods to understand the data accrued. 3D visualisation and interactive visual applications can facilitate synthesis and understanding of high dimensional data. This concept has been applied within varying fields of research, though it has yet to be explored significantly in the field of functional neural mapping. This project documents the development of an interactive application for mobile and tablet devices visualising multivariate functional mapping of fMRI data within a 3D structural model of the brain. The application is developed as a proof of concept for the efficacy of interactive 3D visualisation for representing research in functional mapping, as well as the potential for Unity 3D game enginefis use as a visualisation tool for the complex data involved in the research of functional neural activity.

CCS CONCEPTS

•Computer Methodologies →Interactive Visualization;

KEYWORDS

Interactive visualisation, functional mapping visualisation, representing functional activity, data visualization for mobile technology

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1 INTRODUCTION

Human cognition remains a final frontier in the field of scientific research. Because much of the brainfis function cannot be determined using observational dissection, research in this area is reliant on a combination of advanced imaging technology, complex algorithms, filtering processes and statistical analysis [Goldstone and Börner 2015]. An important tool for providing insight into functional activity is the visualisation of neurological activity within the context of its anatomical structure in a process called functional mapping [Belliveau and Rosen 1991]. With the emergence of multivariate functional mapping, researchers are able to distinguish definitive patterns of activity following specific cognitive tasks. Research conducted at the Institute of Neuroscience and Psychology at the University of Glasgow is attempting to unravel the meaning behind varied patterns of activity within the Motor Cortex using Multi-voxel Pattern Analysis (MVPA), a method of statistical analysis that allows the identification of specific patterns of activation resulting from a given cognitive task [Norman and Haxby 2006].

Effective representation of functional activity is a complex problem [Goldstone and Börner 2015]. However, ever-evolving tools in imaging technology have allowed further exploration into effective methodologies for visualisation. Many of the current visual representations for research in this field are 2D depictions of flattened or inflated cortical surfaces. However, there has been increased use of 3D visualisation and interactive applications for data visualisation, utilizing the high graphics quality and multiplatform capabilities of game engines. Game engines have recently gained reputation as a data visualisation tool. Their fast prototyping capabilities allow for rapid application development for multiple platforms and their virtual reality (VR) capabilities provide an immense array of immersive methods for viewing research.

Interactive visualization encourages user engagement with the data, while the ability to view the application on a tablet interface, independent from the extensive neuroanalysis software, allows for wider accessibility of the presented information.The development of touchscreen and tablet media have granted anyone with a smart phone access to a vast wealth of knowledge. This resource can be applied to scientific visualisation, making research accessible to a wider audience [Isenberg and Tang 2013].

2 MOTIVATION AND APPROACH

Newfound methodologies for 3D interactive visualisation of neural activity could be applied to the field of Multivariate Functional Mapping as well as to research into imagery decoding to assess the efficacy of such technology in the understanding and exploration of the high dimensional data acquired from fMRI and resulting MVPA analysis. The use of game engine capabilities can promote further evolution and development of innovative methodologies for data visualization, and multiplatform development tools can expand the mobility and accessibility of data acquired from this field of research. The aims for this project were the development of a visualisation framework for multivariate functional mapping of neural activity for an interactive visual application usable on a tablet device as well as a proof of concept for Unity game enginés efficacy as a rendering tool for functional data. The main challenges explored was the development of an optimized visualisation pipeline for rendering multiple data source files of functional activity within the Unity engine, the determination of a model and structure for a visualisation that effectively expresses spatial distribution of functional activity, the integration of the visualisation into an intuitive interface for use on a tablet device, and the evaluation of the potential of the proposed development, including its efficacy to inform a target audience, through qualitative assessment.

3 METHODS

Data from functional and structural MRI scans were acquired from the Center for Cognitive Neuroimaging at the University of Glasgow. Functional data consisted of 3 comparisons of imagined fine motor movement of the hand. A visualisation pipeline for the functional and structural data was developed through review of current visualization methodologies. The project followed an agile design approach to develop and pilot test outcomes through iterative prototyping involving neuroscientists, psychology students from GU, and technologists and developers from DDS/GSA. Finally, the project explored the usability of the system through heuristic evaluation to assess the efficacy of the development and enhance the understanding of functional brain mapping through 3D visualization and advanced interaction paradigms. The evaluation of the system involved a sample of professionals and students that tested and rated aspects of functionality of the application.

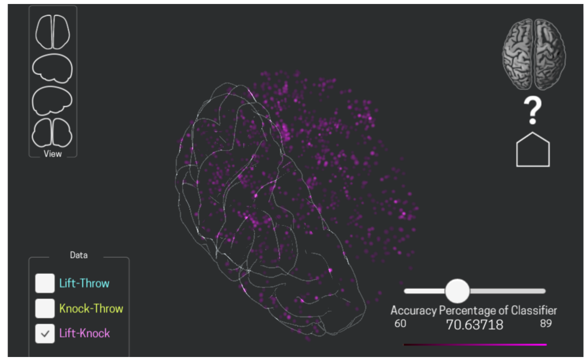

Figure 2: Interface for functional comparisons showing Lift-Knock activation pattern.

4 CONCLUSION AND FUTURE WORK

The project concluded in the development of an application expressing multivariate functional mapping of fMRI data in a 3D space, supplemented by a structural model of the cerebrum for structural reference. The application is a proof of concept for a framework to represent research conducted on multivariate functional mapping (Fig 2). The development of such was guided by a central concept accrued from relevant literature; that interaction with a complex dataset and viewing such information in a 3D space facilitates user understanding. Through user testing and subsequent evaluation, the project has shown the potential for development and further exploration of 3D interactive applications as a tool for visualization functional neurological activity as an intuitive method to understand the data. Further testing will be beneficial to more accurately assess the efficacy of the proposed framework. There is also potential for Unityfis use in rendering of large datasets in an interactive environment. The reproducible nature of the data processing as well as Unityfis interface lending itself to fast prototyping capabilities contribute to the engines efficacy for data visualisation.

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