

Computational Analysis of Diffusion MRI Data in Military Service Members Following Brain Injury

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UW Department of Neurological Surgery Summer Student Neuroscience Program

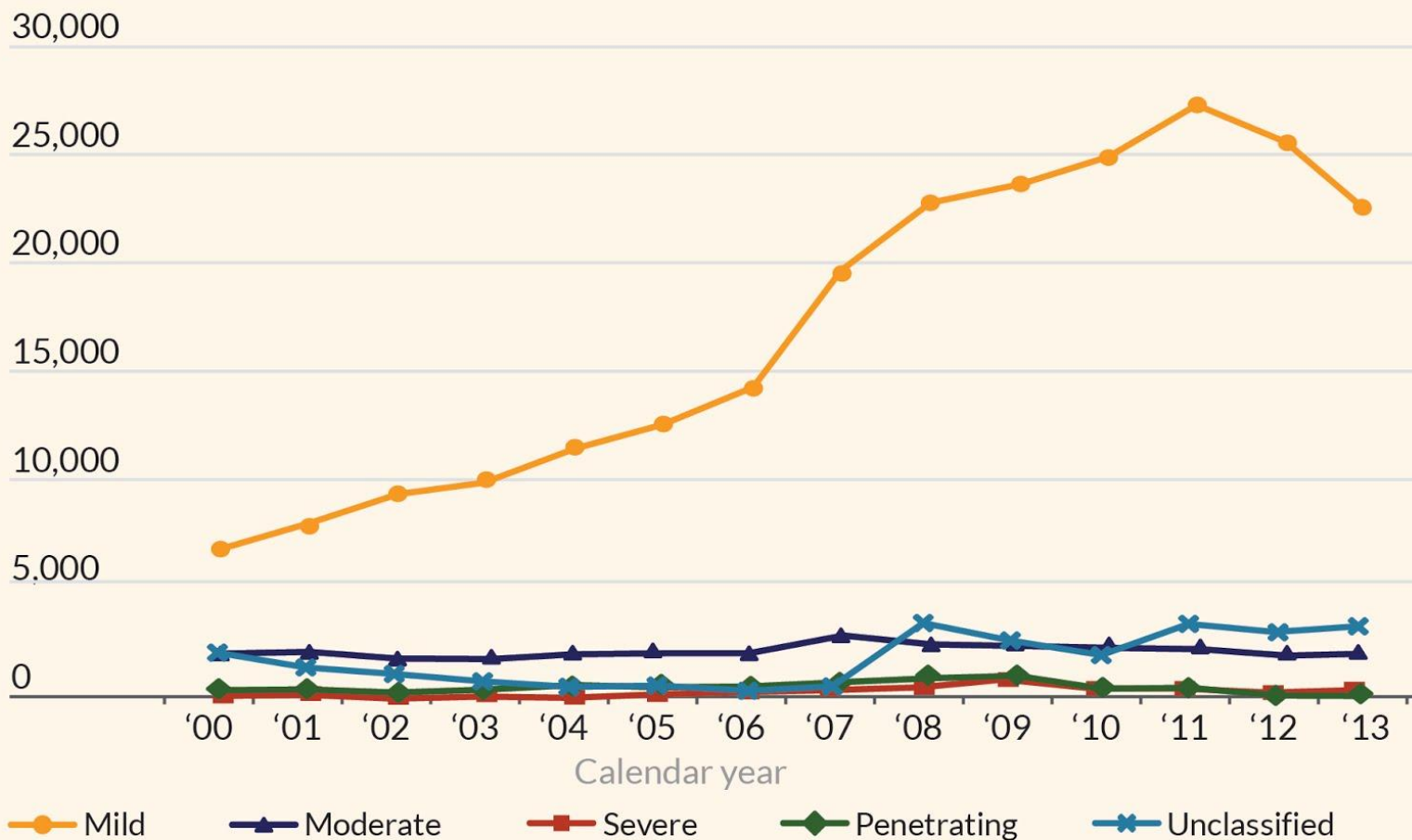
Motivation

- ◇ A TBI is caused by a bump, blow, or jolt to the head or a penetrating head injury that disrupts the normal function of the brain (1).
- ◇ Most TBIs are of mild severity, and are known as concussions
- ◇ In 2009, ~248,418 children (19 or younger) were treated in U.S. EDs for sports/recreation-related injuries that included a diagnosis of concussion/TBI.
- ◇ Annually there are ~2.5 million new TBI cases (1)
 - ◇ 2.2 million ED visits
 - ◇ 280,000 hospitalized with TBI
 - ◇ >50,000 deaths



DoD Numbers for Traumatic Brain Injury Worldwide - Incidence by Severity

No. of cases



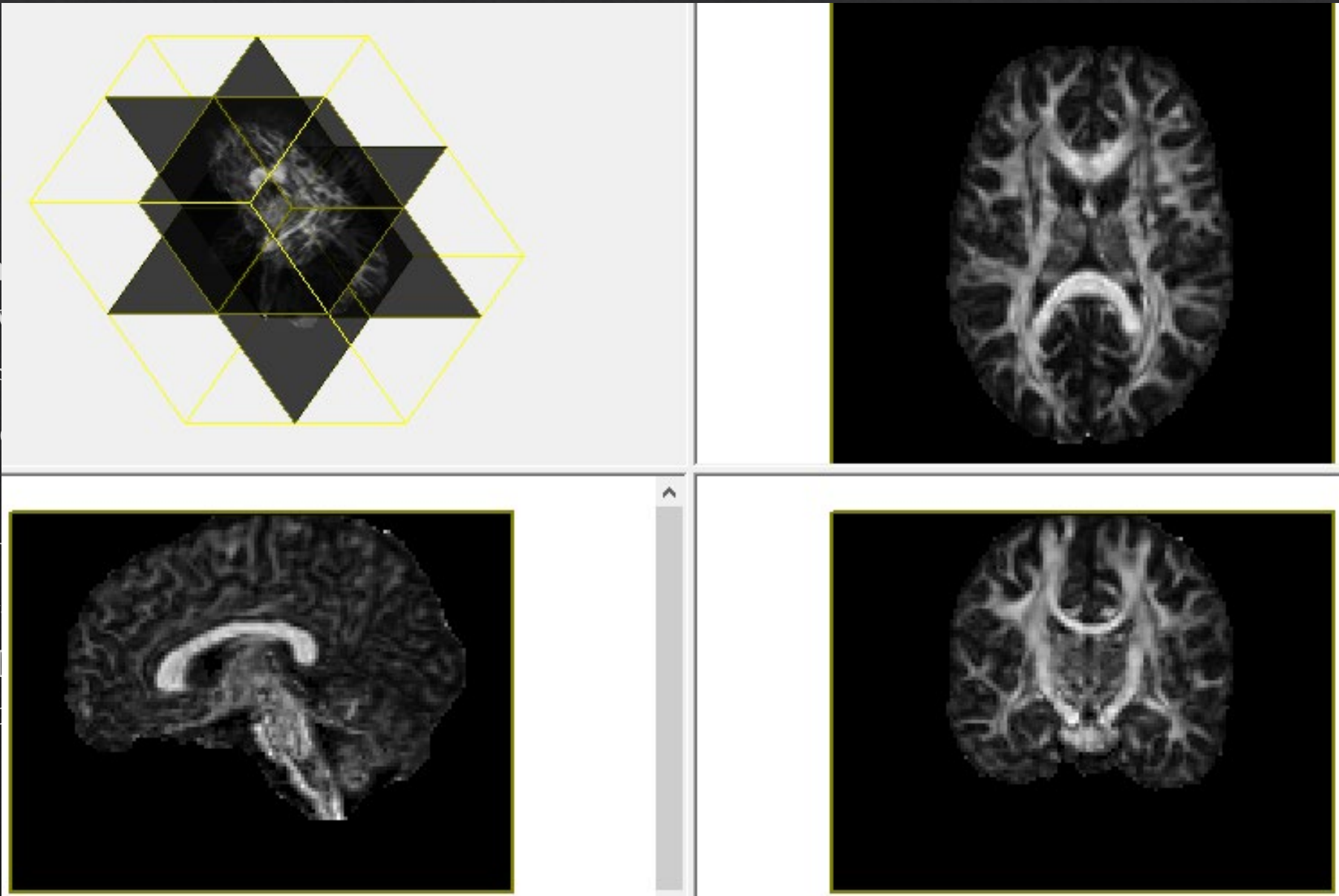
Source: Defense Medical Surveillance System (DMSS), Theater Medical Data Store (TMDS) provided by the Armed Forces Health Surveillance Center (AFHSC)

Prepared by the Defense and Veterans Brain Injury Center (DVBIC)

2000-2014 Q1, as of May 7, 2014

among others

- ◆ Con
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Brownian motion graphic- http://upload.wikimedia.org/wikipedia/commons/6/6d/Translational_motion.gif

Acquisition of Diffusion Images

- ◊ In DTI, an electromagnetic pulse is emitted that magnetizes the hydrogen nuclei of all water molecules is excited creating spin precession (5)
- ◊ After a brief period of time, that allows for molecular relaxation in the tissue, the MRI machine records the remaining electromagnetic pulse
- ◊ This is different in different tissue e.g. grey vs. white matter to distinguish different brain anatomy
- ◊ This information is collected for each voxel in the brain (i.e. 3D pixel)
- ◊ Complex computer programs and algorithms process and analyze the dMRI data
- ◊ DTI data can then be extracted from these images giving us more sensitive measures to changes in the brain like injury/pathology that happens following TBI

Computational Methods

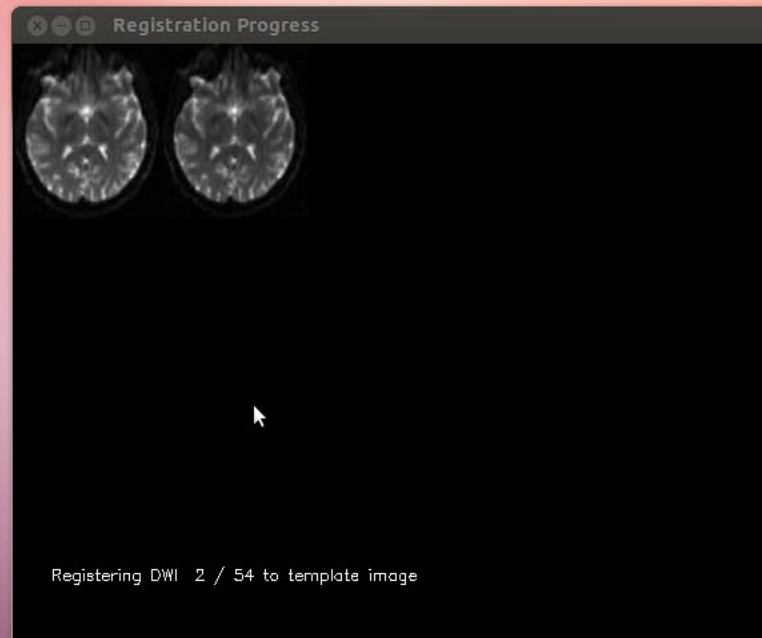
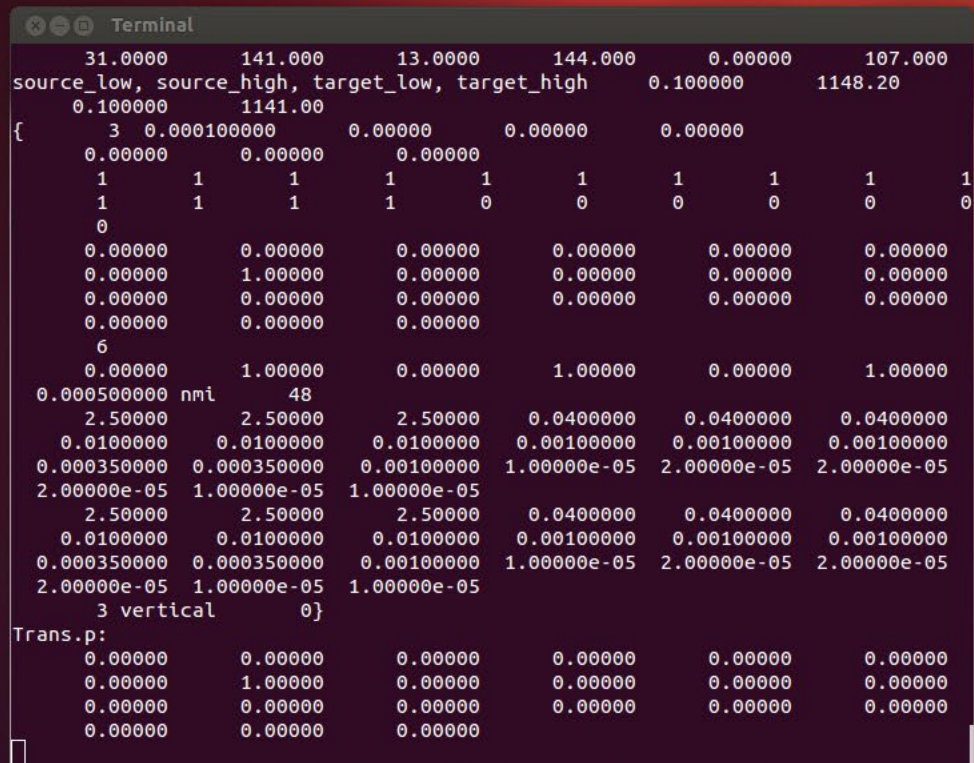
- ◆ Diffusion data is very complex and requires many steps of regression and analysis
- ◆ My job at UWMC was to help prepare diffusion data through a variety of analytical pipelines
- ◆ Purpose: Explore new post-processing techniques in order to identify diffusion abnormalities in US military following mild/concussive brain injury
- ◆ Diffusion data analysis is subject to many pitfalls that can distort and compromise the data, so many forms of regression are needed
- ◆ This work focused on a very large data set of 938 scans that needed to be run through these analytical pipelines

Computational Methods

- ◆ MRI scan data are transferred from the scanner in DICOM formatted files
- ◆ First, DICOMs are converted into file formats that can be used for further analysis (NIFTI files).
- ◆ In addition for diffusion data, I extract the diffusion encoding directions that were used during the acquisition and create both the BVAL and BVEC tables which contain these directions and the diffusion weightings. This is done with a program called MRICConvert
- ◆ Next I used tools from a software program called FSL to apply a matrix manipulation technique for concatenating the data (6)
- ◆ For the majority of DTI processing I use a software package called Tolerably Obsessive Registration and Tensor Optimization Indolent Software Ensemble aka 'TORTOISE'. This is a sophisticated program that prepares the data sets for tensor calculation, the basis of DTI analysis (7)

6 - <http://fsl.fmrib.ox.ac.uk/fsl/fslwiki/>

7 - <https://science.nichd.nih.gov/confluence/display/nihpd/TORTOISE>



Future Directions

The study will follow the service members for years to come to better understand how these early imaging measures affect long-term outcome. The research being conducted will hopefully identify imaging abnormalities that better inform diagnosis, prognosis, and decisions about return to duty.

Overall impact

- ◆ To use these imaging findings for more sensitive diagnosis, to guide treatment and rehab, and to provide diagnostic support to the providers evaluating these patients mild/concussive brain injuries.
- ◆ To assist in the screening of disability
- ◆ Hopefully this data and these methods will be included in clinical exams in the future
- ◆ Will help struggling service members as well as the TBI community overall in shedding light on what is often called the 'invisible injury'.

Acknowledgements

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