Mapping the intersections of nerve fibres in the optic chiasm using MATLAB

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Background:

- Compression of the optic chiasm is associated with bitemporal hemianopia.
- Why crossing fibres are selectively vulnerable is not clear.
- Previous studies have oversimplified the anatomy of the 2,000,000 nerve fibres which pass through the optic chiasm[1].
- Better understanding of anatomy is crucial for accurate modelling.

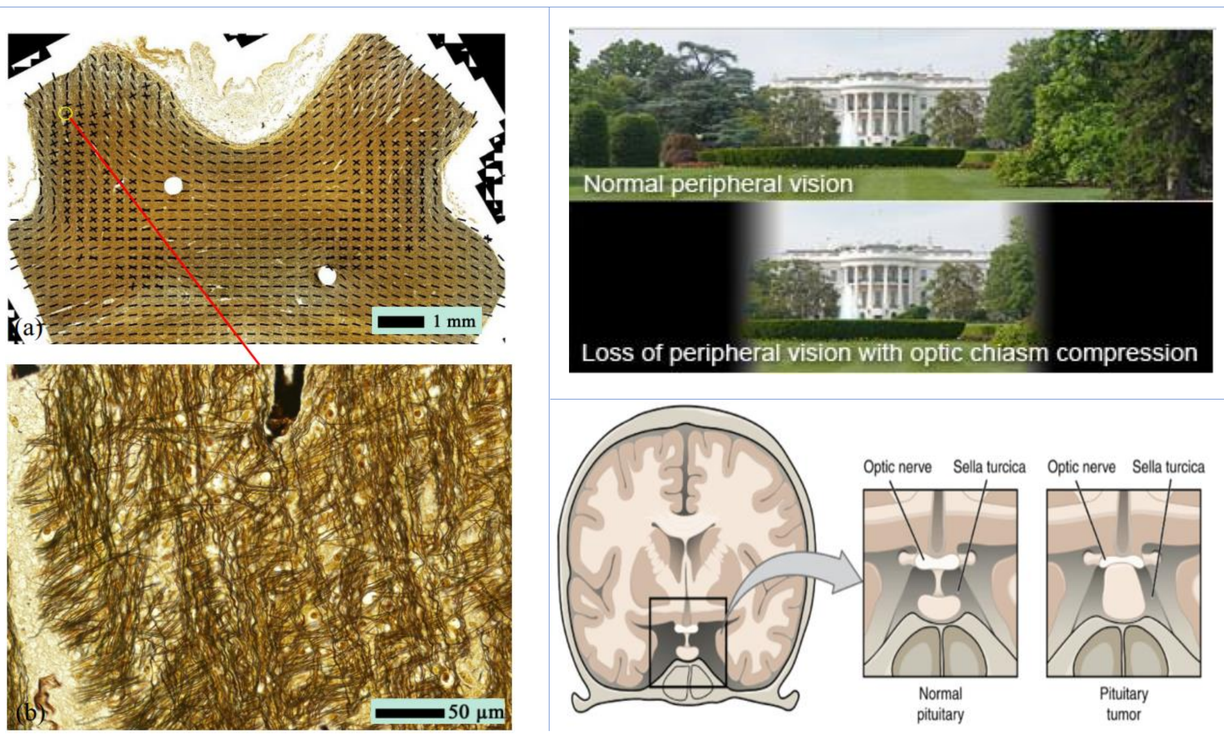

Fig. 1 – (clockwise) photomicrograph of nerve fibres in the chiasm[3], bitemporal hemianopic vision (URL: http://pituitary.ucla.edu/images/site/Visual3.3.jpg) ***and schematic of lesion due to macroadenoma (pituitary tumour)*** (URL: https://worldofmedicalsaviours.com/pituitary-tumour/)***.***

Methodology:

Fibre trajectories were generated in MATLAB based on the following assumptions:

- optic nerves and tracts are angled at 30° to the midline.
- there are equal numbers of crossed and uncrossed fibres.
- nerve fibre trajectories are composed of straight lines and circular arcs.

Procedure:

- Fibre pathways were created and stored as images comprising matrices of 0s and 1s (512 x 512).
- 120 fibre pathways were superimposed in 25 iterations (starting from 4 fibres to 100 fibres in increments of 4).
- Points of intersection were determined and mapped to a coordinate system.
- Locations of crossings and angles of crossings were determined.

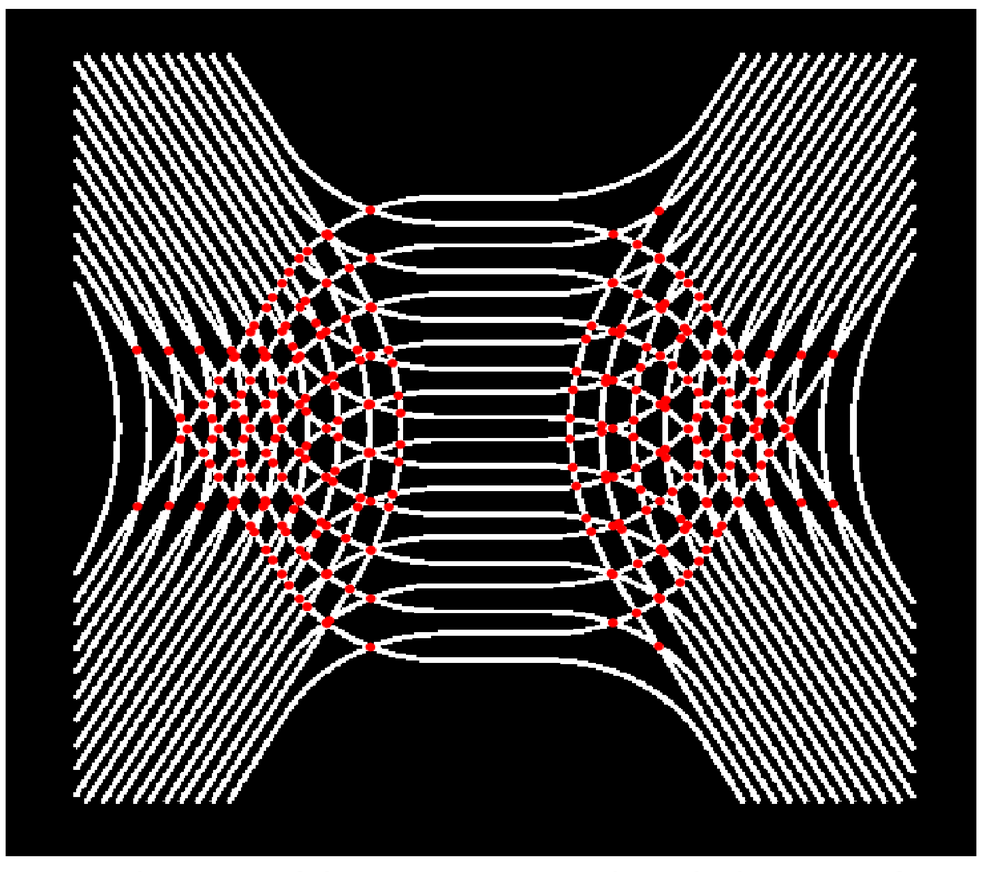

Fig. 2 –Sample output of the programme, marking the locations of crossings

Results:

- The average angle for all crossings was 46.61 ± 7.76 degrees.
- The number of crossings for nasal fibres was twice that of temporal fibres.

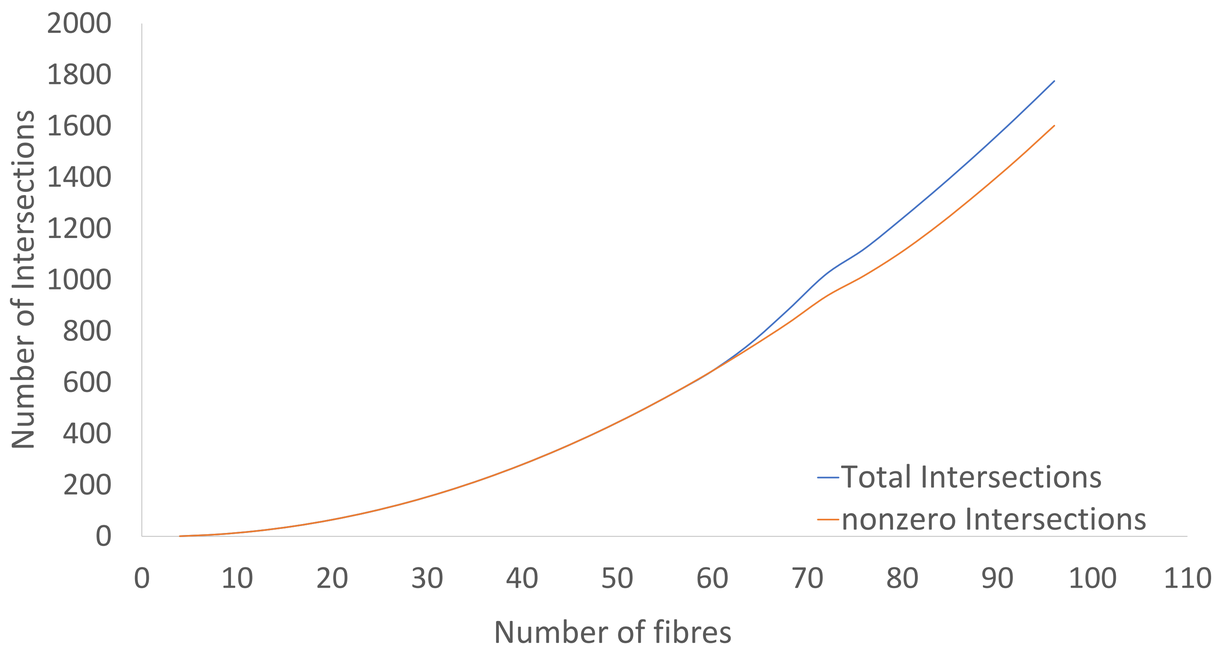

Fig. 3 – Number of Intersections

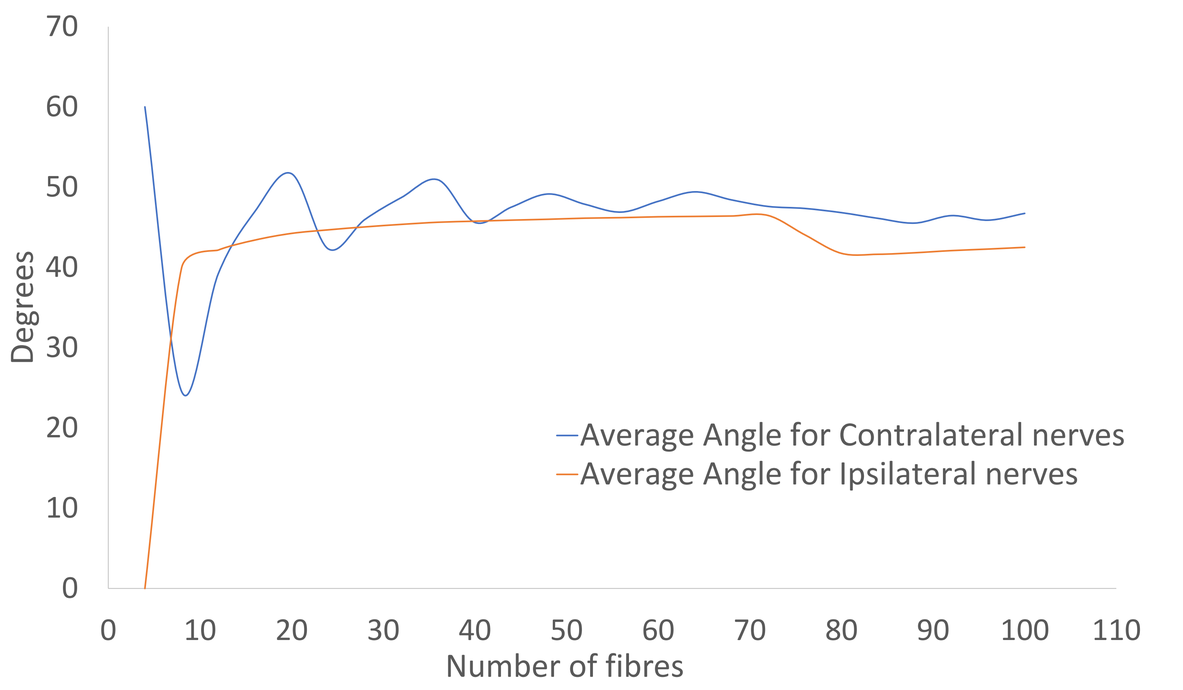

Fig. 4 – Average Angle of Intersections.

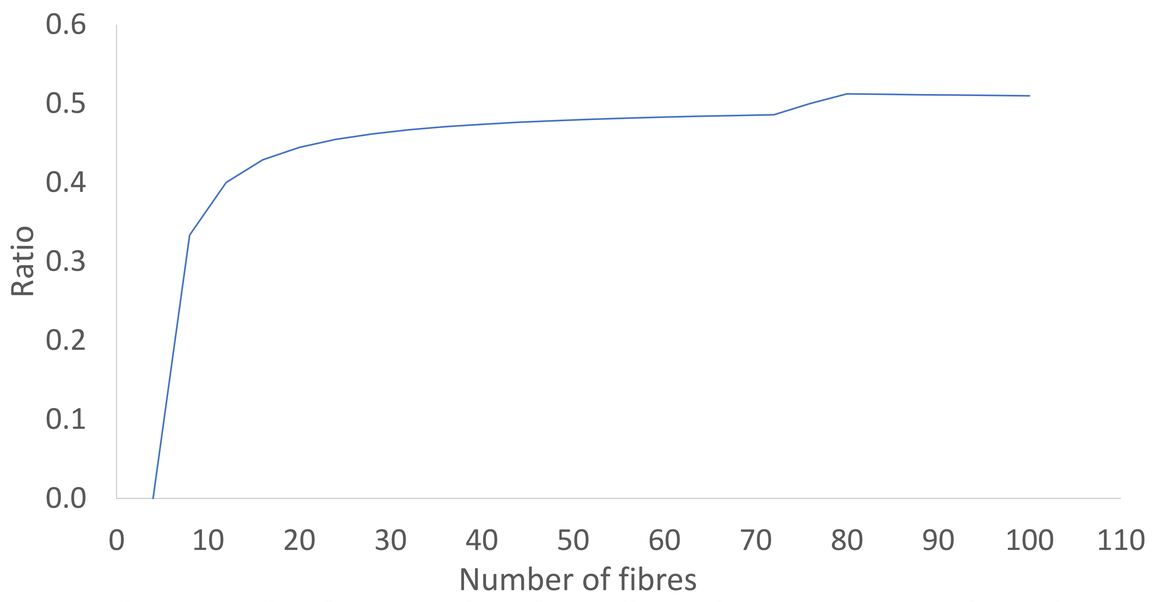

Fig. 5 – Ratio of Intersections for Ipsilateral nerves to Contralateral nerves.

Discussion:

- Location of Crossings – Most of the crossings were concentrated in the paracentral region of the chiasm even as the number of crossings rises exponentially with the number of fibres (figure 3) and agrees with the results obtained by Jain et al[2].
- Angle of Crossings – The average angle of crossing for nasal fibres and temporal fibres (figure 4) was 46.65 and 42.58 degrees respectively. The slightly higher angle of crossing for nasal fibres is in agreement with McIlwaine et al.[3] theory of mechanical damage of nasal fibres explaining bitemporal hemianopia.
- Number of Crossings – The nasal fibres cross cross twice as many times as temporal fibres (figure 5). Then, as per the multiple-crush in this case, the susceptibility of nasal nerve fibres to mechanical damage is higher than that of temporal nerve fibres.

References: (add references for images)

1 Miller, N. R., et al. (2005). Walsh and Hoyt's clinical neuro-ophthalmology, Lippincott Williams & Wilkins.

2 G. G. McIlwaine, Z. I. Carrim, C. J. Lueck, and T. M. Chrisp, "A Mechanical Theory to Account for Bitemporal Hemianopia From Chiasmal Compression," *Journal of Neuro-Ophthalmology,* vol. 25, no. 1, pp. 40-43, 2005.

3 N. S. Jain *et al.*, "Visualization of nerve fiber orientations in the human optic chiasm using photomicrographic image analysis," *Investigative ophthalmology & visual science,* vol. 56, no. 11, pp. 6734-6739, 2015.