Retistruct: A package to reconstruct flattened retinas

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\section*{Background \& problem}

The concept of topographic mapping is central to the understanding of the visual system at many levels, from the developmental to the computational. It is important to be able to relate different coordinate systems, e.g. maps of the visual field and maps of the retina. Retinal maps are frequently based on flat-mount preparations. These use dissection and relaxing cuts to render the quasi-spherical retina into a 2D preparation. The variable nature of relaxing cuts and associated tears limits quantitative cross-animal comparisons.

\section*{A solution: retinal reconstruction}

Our “Retistruct” algorithm reconstructs retinal flat-mounts by mapping them into a standard, spherical retinal space.

\section*{Algorithm}

\begin{itemize}
  \item Flat-mount retina with data points
  \item Mark up cuts by hand
  \item Algorithm stitches and triangulates
  \item Display data on sphere in various projections
  \item Move vertices to minimise deformation
  \item Map vertices to curved sphere
  \item Physically-inspired deformation depends on lengths $L_1$ and $L_2$ of corresponding connections $i \in W$ in flattened and spherical retina:

\[
\hat{e}_i = \frac{1}{2} \sqrt{\sum \frac{(L_i - \hat{L}_i)^2}{L_i}}
\]

While moving vertices, extra term to prevent triangles flipping.

\end{itemize}

\section*{Low \& high deformation reconstructions}

\begin{itemize}
  \item Algorithm applied to 297 flat-mounted retinas
  \item 288 reconstructed successfully
  \item 7 failed due to, as-yet unresolved, software problems
  \item 2 rejected because of unsatisfactory reconstructions ($\hat{e}_i > 0.2$)
\end{itemize}

\section*{Deformation statistics}

\begin{itemize}
  \item Distribution of deformations of 288 reconstructed retinas
  \item Relationship between deformation and age
\end{itemize}

\section*{Effect of rim angle}

\begin{itemize}
  \item To determine the rim angle of mouse eyes at varying stages of development, measure the distance $d_2$ from the back of the eye to the front of the cornea and the distance $d_1$ from the back of the eye to the edge of the retina.
  \item Rim colatitude (angle measured from the retinal pole) $\theta_2$ = arcos$\left(1 - 2d_2/d_1\right)$
  \item Alternative approach: infer, for each retina, the rim angle $\theta_2$ that minimises the deformation.
  \item Maximum decrease in deformation is 19.1%; mean improvement being 7.2%.
  \item Improvement does not justify adding refinement of the rim angle to the algorithm.
\end{itemize}

\section*{Effect of rim angle}

\begin{itemize}
  \item Measurement of rim angle
  \item Inferred versus measured angle
\end{itemize}

\section*{References}


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