Model-based autosegmentation of the central brain of the honeybee, Apis mellifera, using active shape models

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The Honeybee Brain Atlas serves as 3D database and communicative platform to accumulate structural data, i.e. reconstructed neurons, derived from confocal scans (Brandt et al., 2005) (www.neurobiologie.fu-berlin.de/beebrain/) (1). Transforming neurons into the atlas requires manual segmentation of neuropils within confocal images, a time-consuming task requiring expertise in identifying biological structures which can result in different outcomes from various segmenters.

Recently we investigated a method to build a statistical 3D shape model of a substructure of the honeybee brain, the median calyx, which can be used for automatic image segmentation using a-priori knowledge about the shape that is to be segmented (3). The shape model is generated from a set of segmented calyces, representing an average shape including shape variations within the training data. The statistical modeling is based on a principal component analysis (PCA). Correspondence between the individual structures is established via a common patch decomposition of the surfaces of anatomical regions (2). For automatic segmentation, the shape model integrates characteristic image information at the boundaries. Surface displacement vectors were computed by analyzing grey value profiles within the image data and fitting the shape model to the data (4).

A newly developed procedure for enhancing contrast in wholemounts of the brain based on Lucifer Yellow (LY) added to the fixative helps us to improve signal to noise in the confocal images. Contrary to the original antibody method used for the BeeBrain Atlas (1) the LY method is less time consuming (2 h versus 1 week incubation time of staining agents). Volume and shape of brain neuropil which will be included in the shape model are roughly the same for both methods.

We are aiming to expand the current statistical 3d shape model of the median calyx to the whole protocerebrum (central brain), including eight brain neuropils. The advantage will be to develop a displacement algorithm with a more efficient pattern recognition based on more a-priori knowledge of the bee brain. Currently the collection contains 25 LY datasets.

Additionally an expanded 3d shape model of the bee brain needs a hierarchical strategy, which is able to separate sub-elements of the model, thus allowing the autosegmentation of single brain structures based on high-resolution confocal scans.

References

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