Fruit fly functional imaging

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Introduction

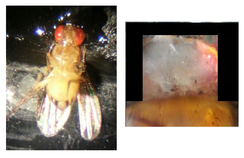
Our goal is to measure activity in a whole brain at once, and identify the best techniques to make sense of the data we obtain. Striking a balance between complexity and tractability, the fruit fly is a powerful model system to achieve that goal. It generates complex behaviors - even head fixed-, but its brain can be observed fully under a microscope. The powerful genetic tools have allowed beautiful work to be done on the function of single neurons and the anatomy of the whole brain. Fruit fly whole brain imaging thus helps bridging the gap between local and global network, as well as anatomical and and functional network.
Here we start exploring behaving flies whole brain activity at about 100Hz with light field microscopy using a variety of assays.

Methods

● Calcium sensor – UAS-GCamp6 – or voltage sensor – UAS-Arclight –

● Pan-neuronal expression (Appl-Gal4,GMR57C10-GAL4, elav-gal4), specific neurotransmitters (cholinergic -Cha-Gal4-, dopamine -TH-Gal4- ...)

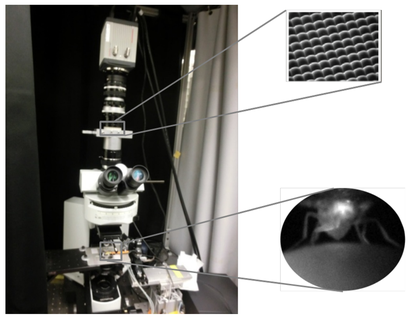
● Head, proboscis and thorax fixed, cuticule, air sacs and brain muscles removed



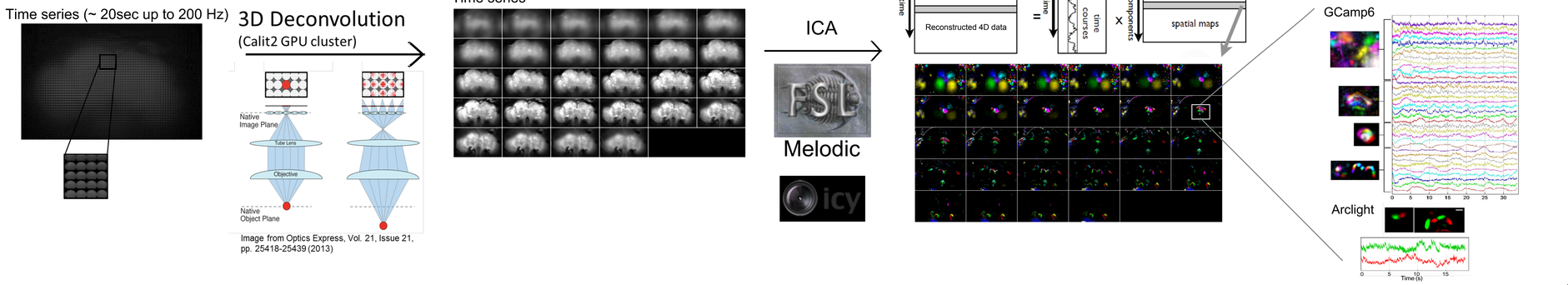
● Light field imaging: microlens array added on the light path, 20x or 40x objective

● Cmos camera, 100Hz

● Fly behaving (walking on an air-supported ball,grooming or resting)



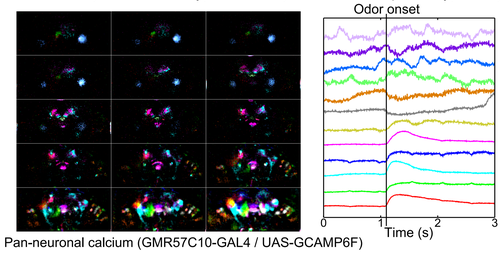
Analysis pipeline



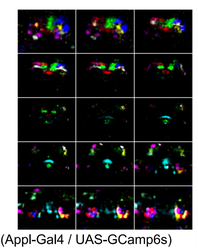
Response to a stimulus

Odor (ethanol)

Antenal lobes, mushroom body, lateral horn, but also fan shaped body, noduli, ellipsoid body, optic lobe inhibition.

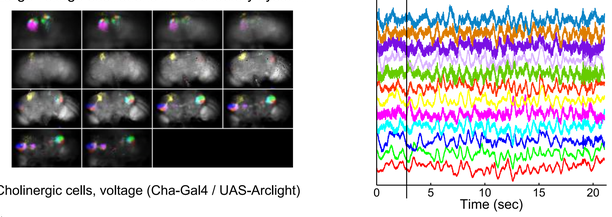


Pan-neuronal calcium (GMR57C10-GAL4 / UAS-GCAMP6F)



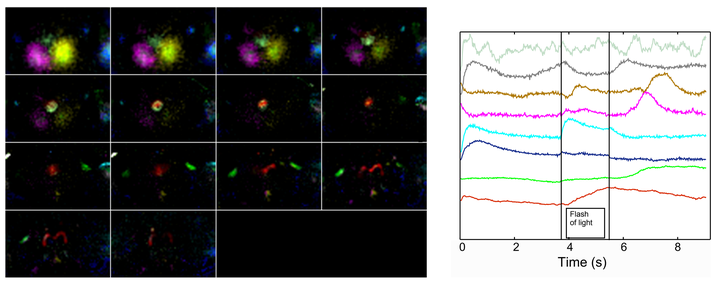
(Appl-Gal4 / UAS-GCamp6s)

Large voltage oscillations in the olfactory system.



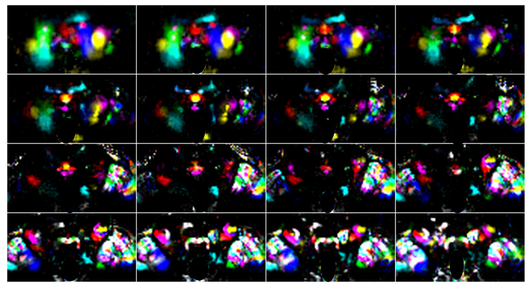
Cholinergic cells, voltage (Cha-Gal4 / UAS-Arclight)

Flash of light

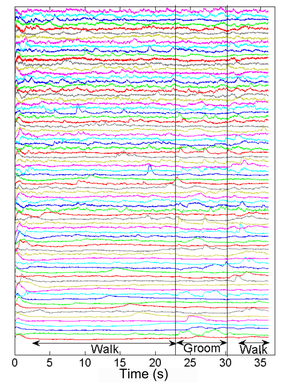


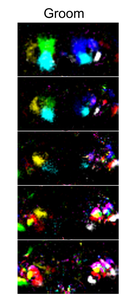
Cholinergic cells, calcium (Cha-Gal4 / UAS-GCamp6F)

Spontaneous activity: Walk, groom and rest

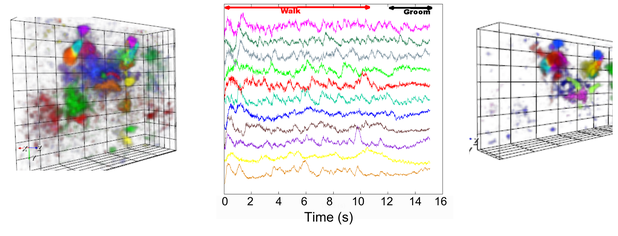


Pan-neuronal calcium (GMR57C10-GAL4 / UAS-GCAMP6F)





Dopamine neuron activity during walking, grooming and rest.



TH-Gal4 / GCamp6F

Conclusion

This method allows extracting (up to 100) functionally relevant components from whole brain fluorescence measurements in behaving flies up to 200Hz.
The next step is to characterize the spatial and temporal relationships between components to understand the interactions between them.

Aknowledgements

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